# ECONOMETRIC MODEL FOR FORECASTING TRAFFIC ON CROATIAN MOTORWAYS

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**Abstract**

The basic objective of this scientific debate is to develop an econometric model for forecasting traffic on Croatian motorways. After many trial and errors procedures, two econometric models have been developed: one for the average annual daily traffic (Y=-2078,11-280,9GP+0,0012RV+0,695TA+4,129NE, r=0,85) and one for the average summer daily traffic (Y=7452-1097,55GP+0,00746RV+2,076TA-9,5NE, r=0,91). In both models, the GDP was dismissed as a variable which directly affects the traffic on Croatian motorways. In both models gasoline prices(GP), the number of registered personal vehicles (RV), the number of tourist arrivals (TA) and the number of employees (NE) were selected as explanatory variables.

**JEL Classification:** C01, C15, C51, C53

**Keywords:** econometrics, model, Croatian motorways, average traffic

## 1. Introduction

Forming the modern phenomena of global traffic and economic situation, there are numerous infrastructural projects worth millions and billions of dollars. Mega-projects mark the central point of a new policy concerning spatial and temporal distance, so it is hardly surprising that certain infrastuctural projects bring together governments, regional groupings, private equity and development banks. However, there is also a paradox reflected in the fact that costs of these projects often twicely exceed the anticipated costs, while the actual traffic demand is often twice as low than indicated. The truth is that many of the infrastructural projects have become infested with manipulation, deception and lies, and there is little to be trusted, in particular not the ''scientifically based and factual" figures of analysts. For instance, John Perkins in his book *Confessions of an Economic Hit Man* describes the ''accuracy" of an econometric model which he developed with Nadipuram Prasad, his associate: *I brought a young MIT mathematician, Dr. Nadipuram Prasad, into my department and gave him a budget. Within six months he developed the Markov method for econometric modeling. Together we hammered out a series of technical papers that presented Markov as a revolutionary method for forecasting the impact of infrastructure investment on economic development. It was exactly what we wanted: a tool that scientifically "proved" we were doing countries a favor by helping them incur debts they would never be able to pay off. (*Perkins, J., 2004, 102)

When this is taken into consideration, the idea of public debt monetization of Croatian motorways using the mechanism of granting concessions for toll collection and motorways maintenance is not at all surprising. The future concessionaire is supposed to take over the concession for toll collection, regular and emergency maintenance and motorway management from companies HAC and ARZ (1049,7 km of ready motorway network) for a period of 30 to 50 years. One of the assumptions used in the study to calculate the concession fees is the annual increase in traffic on Croatian motorways of 1,5% per year(Monetization AC, 2013, 60). If the public partner guarantees minimal traffic to the concessionaire, that is, if the minimal profitability is guaranteed, they should be extremely cautious and consider the potential increase in traffic realistically. Otherwise, there is a great chance that desired effects might be absent in the future.

Accordingly, the main objective of this paper is to develop an econometric model to function as a more accurate tool for traffic forecasting on Croatian motorways, so that the Government would be able to achieve their goals and get the expected concession fees over the next 30-50 years. In other words, if the investors assess that the expected constant increase in traffic is not realistic, the Government could get the desired concession fees only if the concessionare is to achieve considerable business rationalization of Croatian motorways operators and/or if the tolls are to be raised given the business costs (Grubišić, 2013, 641).

## 2. Model selection and statistical data

The avaibaility of many different models would suggest that the best practice would have been indentified leading to gihg levels of forecatsing accuracy. Unfortonately the accuracy of traffic forecasts is low as shown by table 3 for French motorways.

**Table 1:** Actual against forecast traffic, Franch autoroutes

| Number of autorute | Autoroute section | Acutal/forecast traffic (% error) |
|---|---|---|
| A8 | Aix - Fréjus | -3,2 |
| A61 | Toulouse – Narbonne | +5,3 |
| A10 | Poitiers – Bordeaux | +6,3 |
| A81 | Le Mans – Rennes | -21,6 |
| A40 | Macon – Genève | +54,4 |
| A42 | Lyon – Pont d'Ain | +48,4 |
| A62 | Bordeaux – Toulouse | -5,8 |
| A11 | Angers – Nantes | -25,3 |
| A31 | Toul – Langres | +0,9 |
| A11 | Le Mans – Angers | +69,2 |
| A72 | Cleremont Ferrand – Saint_Étienne | -21,2 |
| A71 | Bourges – Clermont-Ferrand | -12,5 |
| A51 | Aix – Manosque | -11,1 |
| A26 | Reims – Arras | -15,3 |
| Mean | | -2,0 |

Izvor: SETRA, 1993., prema: Quinet, E., Vickerman, R..: Principles of Transport Economics, Edvard Elgar Publishing, Inc. Norfolk, Great Britain, 2008., p. 112.

Although on average actual traffic was overestimated by a small margin of 2 per cent, there were enormous variations with over-estimations of 25 per cent and under-estimation of 70 per cent. The UK National Audit Office (1988) came to the similar conclusion, that traffic forecasts for British motorways. Flyvberg et al. (2003) surveyed 210 projects (27 rail and 183 road) worldwide. For rail projects they indentified that in 85 per cent of cases there was an error of more than 20 per cent in forecasts and on average traffic was 39 per cent lower that that forecas (i.e. a 65 per cent overestimate on average). For road projects forecast more accurate, but there were still 50 per cent of cases where the error was more than 20 per cent. They identified seven reasons for inaccuracy: 1) methodological problems, 2) poor data, 3) behavioural change, 4) unexpected exogenous factors, e.eg. unpredicted changes in fuel prices, 5) unexpected political factor, 6) appraisal bias of consultant, 7) appraisal bias of projects promoter.

The application of econometric models in researches is preceded by the choice of dependent variable. In this analysis, the dependent variable is the average annual daily traffic, and the average summer daily traffic. This is followed by choosing independent variables which will be used to explain the value of dependant variable.

In this analysis, these are: the price of gasoline, the number of registered vehicles, the number of tourist arrivals and the total number of employees.

Empirical analysis of the multiple regression model is based on the values of selected variables. It is assumed that for each variable there is a number of different values at disposal, so the model is written in this form:

$$Y_i = a + b_1 x_{i1} + b_2 x_{i2} + \dots b_j x_{ij} + u_i. \quad (1)$$

Table 2 shows data on the movement of variables to be subjected to regression analysis.

**Table 2.** The movement of values of selected variables from 2000 to 2010.

| Year | GP (HRK) | RV | TA (000) | NE (000) | ASDT | AADT |
|---|---|---|---|---|---|---|
| 2005. | 7,4 | 1790971 | 9995 | 1420 | 19713 | 10584 |
| 2006. | 7,63 | 1866741 | 10385 | 1468 | 21000 | 12000 |
| 2007. | 7,72 | 1949936 | 11162 | 1517 | 22894 | 12541 |
| 2008. | 8,25 | 2021936 | 11261 | 1555 | 21656 | 12102 |
| 2009. | 7,21 | 2005210 | 10935 | 1499 | 22702 | 12155 |
| 2010. | 8,18 | 1969587 | 10604 | 1432 | 21404 | 11321 |
| 2011. | 10 | 1969405 | 11456 | 1411 | 22062 | 11683 |
| 2012. | 10,45 | 1863741 | 11835 | 1395 | 20832 | 11182 |

Source: INA, SLJH, various editions and Hrvatske autoceste Ltd.

Numerous studies confirmed that traffic depends on movement of the gross domestic product. Thus, when drafting the Transport Development Strategy of Croatia (NN 139/99), the starting point taken was the approximate projection of GDP movement. Forecasting road transport demand was based on the assumption of constant Croatian GDP growth until 2010. A similar approach was taken in the published study Public Debt Monetization in Relation to HAC and ARZ Companies. The cited study noted that the increase in traffic is positively correlated with GDP growth, therefore 1,5% was chosen as a long-term average increase in traffic to reflect the current economic development (Monetizations AC, 2013, 61).

Accordingly, and based on statistical data from Table 2, Paerson's correlation coefficient was calculated to determine the relation between the average annual daily traffic and the average summer daily traffic, both being independent variables with selected dependent variables (cf. Table 3).

**Table 3:** Corelation results

| | Correlations (Autoceste1.sta)<br>Marked correlations are significant at p < ,05000<br>N=8 (Casewise deletion of missing data) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | Means | Std.Dev. | GP | RV | TA | NE | GDP | ASDT | AADT |
| GP | 8 | 1,21 | 1,000000 | -0,015682 | 0,767744 | -0,557694 | 0,022035 | -0,075332 | -0,240416 |
| RV | 1929691 | 80486,34 | -0,015682 | 1,000000 | 0,436238 | 0,594558 | 0,880301 | 0,808654 | 0,678449 |
| TA | 10954 | 601,42 | 0,767744 | 0,436238 | 1,000000 | 0,008413 | 0,535489 | 0,464578 | 0,320523 |
| NE | 1462 | 57,11 | -0,557694 | 0,594558 | 0,008413 | 1,000000 | 0,769008 | 0,543424 | 0,772312 |
| GDP | 320 | 13,62 | 0,022035 | 0,880301 | 0,535489 | 0,769008 | 1,000000 | 0,708157 | 0,747870 |
| ASDT | 21533 | 1043,24 | -0,075332 | 0,808654 | 0,464578 | 0,543424 | 0,708157 | 1,000000 | 0,862490 |
| AADT | 11696 | 635,10 | -0,240416 | 0,678449 | 0,320523 | 0,772312 | 0,747870 | 0,862490 | 1,000000 |

The data in Table 3 confirm a statistically significant correlation between the gross domestic product and the average annual daily traffic (r=0,74; p<0,5), or between the gross domestic product and the average summer daily traffic (r=0,71; p<0,5). However, gross domestic product was not selected as an independent variable because of its statistical correlation with the number of registered vehicles (r=0,88; p<0,5) and with the total number of employees (r=0,77; p<0,5) , so the number of registered vehicles and the total number of employees were selected as independent variables. The accuracy of this approach is confirmed by a statistically significant correlation between the number of registered vehicles and the average summer daily traffic (r=0,81; p<0,5) and between the total number of employees and the average annual daily traffic (r=0,77; p<0,5).

## 3. Research results

By feeding the data from Table 2 to Statistica, regression analysis of the average annual daily traffic on motorways was made (cf. Table 4).

**Table 4**. A print of Statistica processing for annual daily traffic

| | Regression Summary for Dependent Variable: AADT (Spreadsh<br>R= ,85831660 R2= ,73670738 Adjusted R2= ,38565056<br>F(4,3)=2,0985 p<,28440 Std.Error of estimate: 497,80 | | | | | |
|---|---|---|---|---|---|---|
| N=8 | Beta | Std.Err. of Beta | B | Std.Err. of B | t(3) | p-level |
| Intercept | | | -2078,11 | 7441,634 | -0,279254 | 0,798195 |
| GP | -0,536350 | 0,978658 | -280,97 | 512,680 | -0,548046 | 0,621806 |
| RV | 0,161982 | 0,438081 | 0,00 | 0,003 | 0,369753 | 0,736126 |
| TA | 0,658515 | 0,847867 | 0,70 | 0,895 | 0,776673 | 0,493967 |
| NE | 0,371346 | 0,660128 | 4,13 | 7,341 | 0,562536 | 0,613047 |

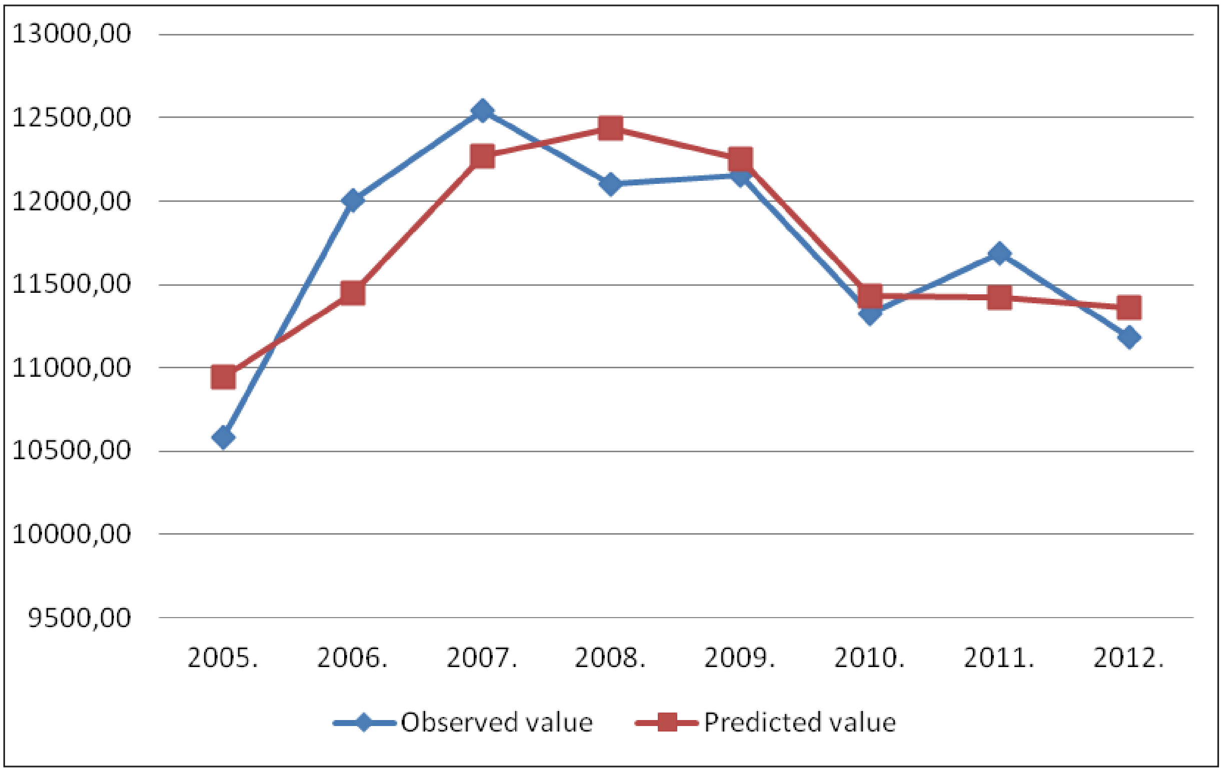
The data from table 4 show negative correlation between the price of gasoline and the average annual daily traffic on Croatian motorways. Other variables have a positive impact on the average annual daily traffic.

Regression analysis of the correlation between the annual daily traffic measured by the number of vehicles, the gasoline prices, the number of registered personal vehicles, the number of tourist arrivals and the total number of employees, offers the following model of multiple linear regression:

$$\mathbf{Y_{AADT} = -2078{,}11 - 280{,}9GP + 0{,}0012RV + 0{,}695TA + 4{,}129NE} \qquad (2)$$

Chart 1 shows the comparison between the real values and model predicted values of independent variable. A satisfactory suitability of model values and the actual values is fairly obvious.

**Chart 1.** The comparison between the results of the econometric model and the actual data for the average annual daily traffic on Croatian motorways




Using the Statistica software and data from Table 2, a regression analysis of the average summer daily traffic was made (cf. Table 5).

**Table 5.** A print of Statistica processing for average summer daily traffic

| N=8 | Regression Summary for Dependent Variable: ASDT (Spreads R= ,91382474 R2= ,83507565 Adjusted R2= ,61517652 F(4,3)=3,7975 p<,15087 Std.Error of estimate: 647,16 | | | | | |
|---|---|---|---|---|---|---|
| | Beta | Std.Err. of Beta | B | Std.Err. of B | t(3) | p-level |
| Intercept | | | 7452,93 | 9674,522 | 0,77037 | 0,497189 |
| GP | -1,27547 | 0,774558 | -1097,55 | 666,511 | -1,64671 | 0,198173 |
| RV | 0,57587 | 0,346719 | 0,01 | 0,004 | 1,66090 | 0,195318 |
| TA | 1,19698 | 0,671044 | 2,08 | 1,164 | 1,78375 | 0,172466 |
| NE | -0,52035 | 0,522458 | -9,50 | 9,543 | -0,99597 | 0,392670 |

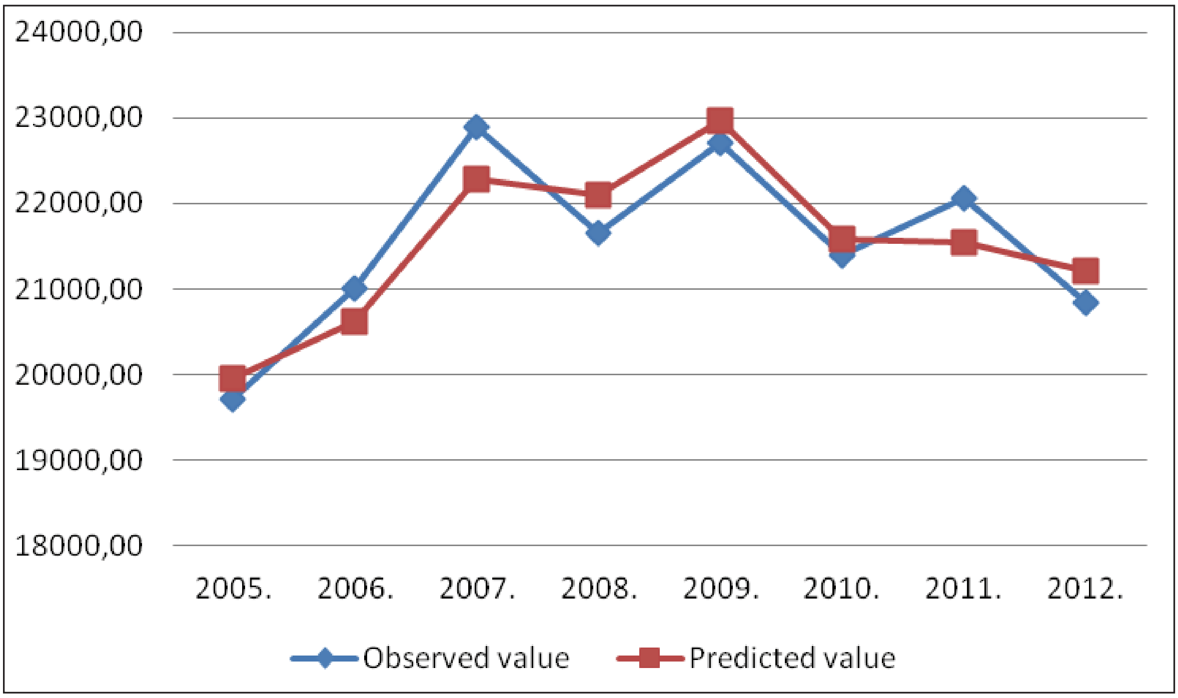
The data from table 5 show a negative correlation between the price of gasoline and the average summer daily traffic on Croatian motorways, which was to be expected. But the surprising fact is a negative correlation between the number of employees and the average summer daily traffic. Other variables have a positive impact on the average summer daily traffic.

Regression analysis of the correlation between the average summer daily traffic measured by the number of vehicles, the gasoline prices, the number of registered personal vehicles, the number of tourist arrivals and the total number of employees, offers the following model of multiple linear regression:

$$\mathbf{Y_{ASDT} = 7452 - 1097{,}55GP + 0{,}00746RV + 2{,}076TA - 9{,}5NE} \qquad (3)$$

Chart 2 shows the comparison between the actual values and model predicted values of independent variable. A satisfactory suitability of model values and the actual values is fairly obvious.

**Chart 2.** The comparison between the results of the econometric model and the actual data for the average summer daily traffic on Croatian motorways



## 4. Conclusion

For effective inclusion of private partners in management and maintenance of Croatian motorways, and in order to calculate a more favourable concession fee, it is necessary to make the assumptions crucial for decision-making as accurate as possible. One of such assumptions is the estimated annual increase in traffic. This means that the correlation between the average annual daily traffic and the average summer daily traffic, as well as all the other variables affecting this traffic should be established.

Such an analysis was presented in this paper, showing that the average annual daily traffic and the average summer daily traffic are determined by: the price of gasoline, the number of registered vehicles, the number of tourist arrivals and the total number of employees. The main defect of this paper lies in the fact that the average price per kilometer of motorway use was not included among the presented econometric models as an independent variable. Its inclusion would allow for consideration of competitiveness of alternative roads.

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