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## INDUCED TRAFFIC AND ITS TREATMENT IN THE EVALUATION OF MOTORWAY PROJECTS

### ABSTRACT

*The purpose of this paper is to define factors that influence the emergence of induced i.e. generated traffic for experts involved in highway feasibility studies. An explanation of the practical methods for forecasting generated traffic is done by reviewing international experiences in the relevant literature. Also, the idea underlying this paper is to explain the different treatments of generated traffic in evaluating highway projects with no tolls, which is based on socio-economic aspects versus the evaluation of highway projects with tolls, which is based on financial aspects. Finally, we propose that since it is hard to measure the economic benefits from indirect effects (in the evaluation of socio-economic aspects) the evaluators could determine the economic benefits of the generated traffic using the same procedure as for normal traffic.*

### KEYWORDS

*induced traffic (generated traffic), normal traffic, coefficient of elasticity, time savings, vehicle operating cost (VOC) savings, the economic surplus*

### 1. INTRODUCTION

The construction of new motorway, due to considerable improvement of traffic conditions and decrease of vehicle operating costs (VOC), primarily due to reduced travel time, creates conditions for accelerated growth of the existing social and economic activities in the influential area of the motorway. This also creates conditions for the development of totally new social and economic activities in the areas along the motorways.

Rapid growth of the existing and the development of new social and economic activities in the influen-

tial area of the motorway, results in the growth of needs for transportation of people and goods in relation to normal growth of needs for transportation in the area without the motorway. Rapid growth of the needs for transportation of people and goods in relation to normal growth leads to the emergence of the induced traffic on the motorway. This means that the total expected (forecast) traffic on the future motorway should be composed of both normal traffic and induced traffic.

For defining the emergence of induced traffic, Chapter 2 explains the most important factors that influence the emergence of the induced traffic and Chapter 3 presents practical procedures for forecasting induced traffic. Chapter 4 is about induced traffic forecasting in evaluating of motorways projects without tolls i.e. evaluating from the socio-economic aspects. Chapter 5 deals with the treatment of induced traffic forecast in the evaluation of motorway projects with tolls i.e. from financial aspects. Finally, Chapter 6 represents the conclusions.

### 2. FACTORS AFFECTING THE APPEARANCE OF INDUCED TRAFFIC

This paper is based on the fact that the construction of roads, especially motorways, which significantly improve the traffic conditions, is the basic precondition for the emergence of induced traffic. Factors that influence the emergence of induced traffic are based on:

- increase of the road networks capacity;

- improvement of traffic conditions on the new motorway compared to the poorer conditions on the existing road network;
- reduction in travel time;
- reduction of VOC;
- increase of the existing social and economic activities in the influential area of the new motorway;
- creating the conditions for the development of completely new social and economic activities in the influential area of the new motorway.

Improved traffic conditions on the new motorway, compared to the existing road network, are reflected in the reduction of travel time and VOC reduction for the expected traffic flows, which are forecast on the basis of normal traffic growth.

This means that an ECONOMIC SURPLUS emerges through savings on travel time and VOC as motorists use the new motorway to conduct the same social and economic activities (related to movement by vehicles) instead of the existing, less efficient road network.

The achieved economic surplus i.e. savings in travel time and/or savings in vehicle operating costs can be used by the vehicle owners in different ways. From the existing practices, it is known that a part of economic surplus (savings) is used for increasing *the existing* social and economic activities in the influential area of the new motorway, which causes traffic growth on the new motorway. This traffic growth on the new motorway is called induced traffic, i.e. *the primary* component of the total induced traffic.

The construction of a new motorway, due to significant improvement of traffic conditions, also creates the conditions for the development of *entirely new* social and economic activities on the influential area of the new motorway.

Development of completely new social and economic activities leads to the appearance of *additional* components of induced traffic on the new motorway, i.e. *the secondary* component of the total induced traffic.

### 3. PRACTICAL PROCEDURES IN FORECASTING INDUCED TRAFFIC

After the construction of a new motorway in principle significant improvements of traffic conditions will arise in relation to the poorer conditions on the existing network. Improved traffic conditions affect the reduction of travel time and VOC reduction

As already stated, the usage of a new motorway compared to the use of the existing roads, to perform the same activities will create an economic surplus in travel time and VOC. This surplus in travel time and VOC can be used for accelerated growth of the existing

social and economic activities related to driving on a new motorway, or for any other activities not related to driving on a new motorway.

What proportion of the surplus in travel time or VOC savings will be reflected in the increasing number of journeys on the new motorway, in the form of induced traffic, is expressed by the corresponding factor which is in the professional literature known as the *coefficient of elasticity*.

Besides induced traffic based on the growth of the existing social and economic activities, due to improved traffic conditions, the new motorway often creates the conditions for the development of entirely new social and economic activities, which further affect the appearance of the additional induced traffic.

Based on these conditions, induced traffic can be analyzed through two components, namely:

1. Through the *primary* component, that is based on rapid growth of the *existing* social and economic activities in the corridor of the new motorway, caused by an economic surplus in travel time and VOC. Induced traffic on this basis usually occurs in the first years after the release of a new motorway into operation.
2. Through an *additional* component that is based on the expected development of *completely new* social and economic activities at suitable locations around the corridor of the new motorway. Induced traffic on this basis usually occurs 3-4 years after the new motorway is put into operation.

Based on empirical examples, which should be noted, the growth of traffic in the first years after the construction of the Zagreb-Split motorway in Croatia, as well as other examples listed in the relevant literature, it appears that the participation of additional components in the total induced traffic can be significant, depending on specific conditions. In general, this participation may vary in the range of 0% -30%.

Based on the previously said, the equation for determining the expected induced traffic on the new motorway is defined. The equation is based on the following attitudes:

- a) Expected normal traffic on the new motorway  $AADT_{normal}^{motorway}$  is forecast in the function of the natural (normal) growth of the existing social and economic activities in the influential area of the road network.
- b) Part of the so-called economic surplus (savings in travel time and/or savings in VOC for the expected normal traffic), achieved due to better traffic conditions will be used for the accelerated growth of the existing social and economic activities in the influential area of the observed road network with the new motorway.
- c) Accelerated growth of the existing social and economic activities on the influential area of motorway

will have impact on the emergence of the basic (primary) components of induced traffic.

- d) After the construction of a new motorway, the conditions for the development of entirely new social and economic activities will be created, which will affect the appearance of additional components of induced traffic.

### 3.1 General equation for practical forecasting of induced traffic

- The general equation for practical forecasting of basic components of induced traffic is:

$$AADT_{induced}^{motorway} = AADT_{normal}^{motorway} \cdot \frac{t_{MBI} - t_{MSI}}{t_{MBI}} \cdot e \quad (1)$$

or

$$AADT_{induced}^{motorway} = AADT_{normal}^{motorway} \cdot \frac{VOC_{MBI} - VOC_{MSI}}{VOC_{MBI}} \cdot e_1 \quad (2)$$

$AADT_{induced}^{motorway}$  – average annual daily induced traffic on the motorway, (vpd);

$AADT_{normal}^{motorway}$  – average annual daily normal traffic on the motorway, (vpd);

$t_{MBI}$  – average travel time of vehicles for forecast normal traffic on the network without the motorway (without investments), (min);

$t_{MSI}$  – average travel time of vehicles for forecast normal traffic on the road network with motorway (network with investments), (min);

$e$  – coefficient of elasticity in the function of saving in time;

$VOC_{MBI}$  – average VOC for forecast normal traffic on the network without the motorway (without investments), (€/km);

$VOC_{MSI}$  – average VOC for forecast normal traffic on the road network with motorway (network with investments), (€/km);

$e_1$  – coefficient of elasticity in the function of savings in vehicle operating costs - VOC.

The values of elasticity coefficients  $e$  and  $e_1$  may vary, but they may also be approximately equal depending on specific conditions, primarily the economic development of the country and the GDP of population. In the economically developed countries with high living standards of the population, more attention is given to the value of time savings than to savings in vehicle operating costs  $e > e_1$ . On the other hand in the economically undeveloped countries with low living standards, more attention is given to the value of VOC savings than to savings in time  $e < e_1$ . In practical application of evaluation of motorway projects, it is often the case that analysts do not distinguish between these coefficients:

- General form of a practical equation for forecasting of the total induced traffic (basic and additional component)

$$\sum AADT_{induced}^{motorway} = AADT_{induced}^{motorway} \cdot f \quad (3)$$

$\sum AADT_{induced}^{motorway}$  – total forecast induced traffic (basic and additional components),

$AADT_{induced}^{motorway}$  – forecast induced traffic by primary (basic) components,

- $f$  – the coefficient which expresses the increase of induced traffic based on the development of completely new social and economic activities in the influential area of the new motorway. This component occurs 3 to 4 years after the opening of the new motorway. The value of coefficient ( $f$ ) is in the range of 1 to 1.3 depending on specific conditions. If a new motorway passes through the area that is unopened to traffic (undeveloped area) the value of coefficient ( $f$ ) can reach even higher values.

### 3.2 Determination of the value of elasticity coefficient (e)

The best procedure for determining the value of elasticity coefficient ( $e$ ) is based on the monitoring of the volume of traffic in the first 5 years and comparing this value with the forecast normal traffic.

It is possible to determine the value of elasticity coefficient based on the determined reduction in travel times, the volume of realized traffic ( $AADT_{realised}$ ) and the volume of forecast traffic ( $AADT_{forecast}$ ) on the new motorway in the first 5 years.

An experiment of monitoring the traffic volume on a new motorway, and comparing it with the forecast values of the normal traffic on the motorway is planned in Serbia for the future *Belgrade-Požega motorway* [1]. This motorway, according to the concession contract, on the section of Belgrade-Lajkovac, should have been completed by the end of 2009. However, due to the failure of the concession agreement, the beginning of construction of this motorway is planned for July 2010. So, instead of having results in 2009 they are anticipated to be available in 2013.

Acceptable estimates of the coefficient of elasticity ( $e$ ) value can be reached on the basis of use of experience from similar examples of the already constructed motorways in other places that have similar environmental and socio-economic conditions.

Due to the non-existence of our own research and the non-existence of the corresponding analogy empirical data and until results of the *upcoming research in Serbia* are available, orienting reliance can be found in the attitudes of the relevant professional literature, in which the coefficient of elasticity

(e) is viewed primarily as the function of travel time reduction. For example:

- According to the Guidelines for making a feasibility study of the road [2], the recommended values of the coefficient of elasticity are:
  - limited value:  $0 < e < 1.5$
  - for passenger traffic:  $0.5 < e < 1.0$
  - for freight traffic:  $0.2 < e < 0.7$ .
- EU - Economic Commission for Europe [3] recommends that the induced traffic be modelled using transport flexibility in relation to travel time and vehicle operating costs.
- Based on research in California [4] Cervera concludes that the elasticity of travel in relation to the speed of travel is 0.64 in the long run.
- Noland [5] states that the increase in the practical capacity of 50% affects the appearance of the induced traffic within the first 5 years, and 80% increase of the practical capacity affects the appearance of the induced traffic in the long run, with elasticity greater in urban than in rural areas.
- Hansen and Huang [6] note that within five years, the induced traffic use 60 to 70% of the increased traffic on the state roads, and about 90% of municipal roads in California.
- The leading UK transport economists (Sacatra, 1994, [7]) estimates the elasticity coefficients of induced traffic compared to the savings in travel time as follows:
  - short-term = 0.5
  - long-term = 1
- Coodwin [8], adopts the elasticity coefficients with respect to savings in travel time:
  - for urban areas = 0.27 short-term and 0.57 long-term
  - for rural areas = 0.67 short-term and 1.33 long-term.
- National Highway Institute - NHI [9], (Washington DC 1995), states that the typical elasticity of transport volume in relation to the generalized costs (travel time and vehicle operating costs) is 0.5 If the traffic congestion of the existing network is greater, then the increase of the practical capacity will cause greater induced traffic.
- The traffic study for the motorway corridor  $V_c$  through B&H [10], for the forecast of induced traffic on the future motorway in the function of growth of the existing social and economic activities adopted the following value of elasticity coefficients:
  - Passenger traffic (personal cars and buses)
    - in the first 5 years (2013 to 2017),  $e = 0.5$
    - in the period from 2018 to 2042,  $e = 0.8$
  - For heavy traffic (HV, AV)
    - in the first 5 years (from 2013 to 2017),  $e = 0.44$
    - in the period from 2018 to 2042,  $e = 0.70$ .

## 4. TREATMENT OF FORECAST INDUCED TRAFFIC IN THE EVALUATION OF MOTORWAY PROJECTS WITHOUT TOLL FROM SOCIO-ECONOMIC ASPECT

### 4.1 The role of economic benefits that are expected on the basis of induced traffic in the economic evaluation of motorway projects

Economic benefits that are expected from the accelerated growth of the existing social and economic activities and/or the emergence of new social and economic activities in the influential area of a motorway are the *indirect economic benefits*. Indirect socio-economic benefits, in principle, are *difficult to quantify*.

As part of indirect benefits can be quantified through the determination of induced traffic, then these indirect benefits in the economic evaluation for practical reasons can also be included in the analysis of the internal rate of return - IRR, as well as direct economic benefits.

In this way, part of the total expected indirect economic benefits is determined using the induced traffic and indirectly depending on the economic benefits expected from normal traffic.

### 4.2 Practical procedures for determining the economic benefits from induced traffic

There are divided opinions regarding economic benefits from induced traffic. The prevailing opinion, which is supported by the World Bank, is to use benefits from induced traffic per 1 vehicle as 50% of benefits obtained from normal traffic per 1 vehicle. Based on this opinion, this commitment is supported in the following paragraphs.

The practical procedures for determining the economic benefits of the forecast induced traffic is illustrated by a curve that defines the impact of improving traffic conditions on the new motorway that includes the creation of an *economic surplus* based on the savings in travel time and/or savings in VOC for the forecast normal traffic. Based on the curves shown in *Figures 1* and *2*, general equations are defined for the calculation of economic benefits related to the induced traffic.

#### 4.2.1 General equation for determining the economic benefits expected from normal traffic on the new motorway

These benefits are represented by rectangle with vertical lines pattern.

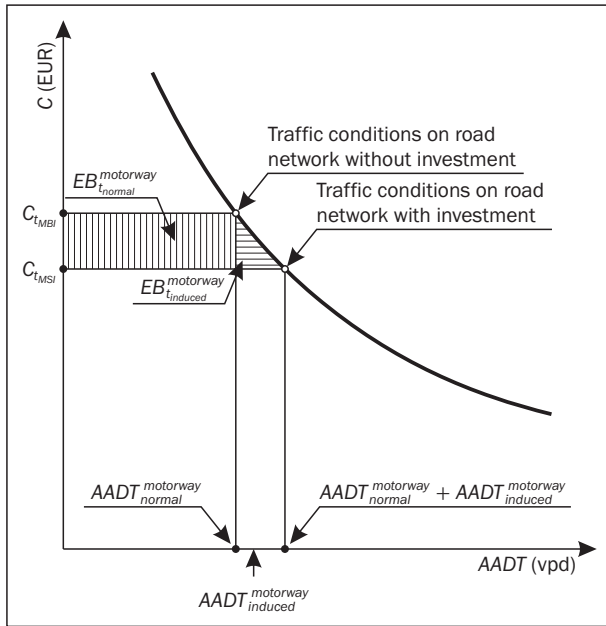


Figure 1

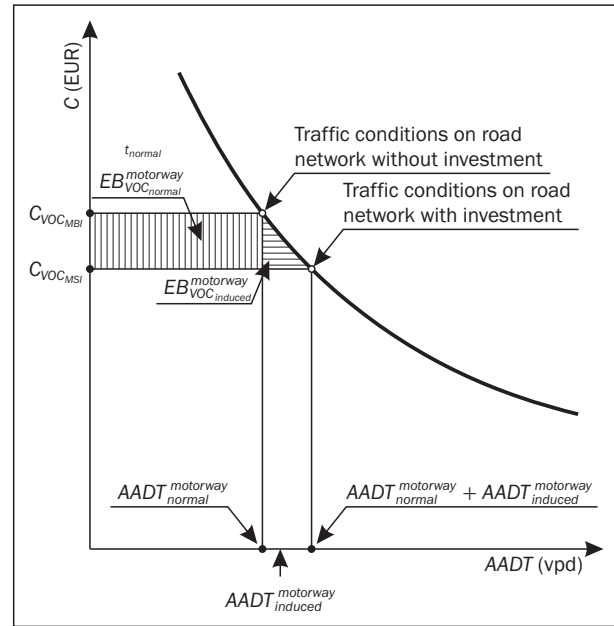


Figure 2

1. Economic benefits - EB (economic surplus) based on the *travel time reduction*

$$EB_{t_{normal}}^{motorway} = (C_{t_{MBI}} - C_{t_{MSI}}) \cdot AADT_{normal}^{motorway} \quad (4)$$

2. Economic benefits - EB (economic surplus) based on the *reduction of VOC*

$$EB_{VOC_{normal}}^{motorway} = (C_{VOC_{MBI}} - C_{VOC_{MSI}}) \cdot AADT_{normal}^{motorway} \quad (5)$$

$EB_{t_{normal}}^{motorway}$  - economic benefits from normal traffic, based on the reduction of travel time;

$C_{t_{MBI}}$  - average cost of travel time on the network without motorway (without investments), (€/km);

$C_{t_{MSI}}$  - average cost of travel time on the network with motorway (network with investments), (€/km);

$AADT_{normal}^{motorway}$  - normal Annual Average Daily Traffic on the motorway, (vpd);

$EB_{VOC_{normal}}^{motorway}$  - economic benefits from normal traffic based on the reduction of VOC;

$C_{VOC_{MBI}}$  - average VOC of forecast normal traffic on the network without motorway (network without investments), (€/km);

$C_{VOC_{MSI}}$  - average VOC of forecast normal traffic on the network with motorway (network with investments), (€/km);

#### 4.2.2 General equation for determining the economic benefits expected from induced traffic on the new motorway

These benefits are represented by a triangle with horizontal lines pattern.

1. Economic benefits - EB (economic surplus) from induced traffic based on the travel time reduction

$$EB_{t_{induced}}^{motorway} = \frac{1}{2}(C_{t_{MBI}} - C_{t_{MSI}}) \cdot AADT_{induced}^{motorway} \quad (6)$$

2. Economic benefits - EB (economic surplus) from induced traffic based on the reduction of VOC

$$EB_{VOC_{induced}}^{motorway} = \frac{1}{2}(C_{VOC_{MBI}} - C_{VOC_{MSI}}) \cdot AADT_{induced}^{motorway} \quad (7)$$

$EB_{t_{induced}}^{motorway}$  - economic benefits from induced traffic on the motorway, based on the reduction of travel time;

$EB_{VOC_{induced}}^{motorway}$  - economic benefits from induced traffic on the motorway, based on the reduction of vehicle operating costs;

$AADT_{induced}^{motorway}$  - induced Average Annual Daily Traffic on the motorway, (vpd);

By comparing equations (4) and (5) with equations (6) and (7), it may be concluded that the economic benefits per one vehicle of induced traffic are equal to one half of the economic benefits per one vehicle from normal traffic.

### 5. TREATMENT OF FORECAST INDUCED TRAFFIC IN THE EVALUATION OF MOTORWAY PROJECTS WITH TOLL FROM FINANCIAL ASPECT

For projects of motorways with tolls, the evaluation is based on financial aspects. In applying Cost-Benefit Analysis (CBA), the main source of revenue expected in the future exploitation of the motorway, comes from the toll. The size of the expected revenue from the toll depends directly on the size of the expected total future traffic flows on the motorway.

The expected induced traffic is included in the total expected future traffic flows on the motorway. The participation of the expected revenue from the toll based on the induced traffic in the total expected revenue from the toll is in direct proportion to the expected participation of induced traffic in total traffic (normal + induced traffic) expected on the future motorway.

From the above it results that, in evaluating of motorway projects (with toll) from the financial aspect, the expected induced traffic has the *same treatment* (weight) as the expected normal traffic.

## 6. CONCLUSIONS

1) The treatment of the expected induced traffic in the preparation of motorways feasibility studies serves the function of goals of the analysis. The goals of the analysis of investment feasibility can be:

- justification of investment in the motorway from the socio-economic aspects, or
- justification of investment in the motorway from financial aspects.

2) In evaluating the projects of motorways without tolls, i.e. in the evaluation from the socio-economic aspects, the participation of the economic benefits from induced traffic in the total expected economic benefits *is not in proportion* to the participation of induced traffic in total traffic expected on the future motorway.

In practice, from the preparation of feasibility studies and according to IBRD recommendations, the economic benefits per one vehicle from induced traffic are worth 50% of the economic benefits per one vehicle from normal traffic.

3) In evaluating the projects of motorways (with tolls), i.e. in the evaluation from the financial aspects, the participation of financial revenues (tolls, etc.) from induced traffic in the total expected revenue *is in proportion* to the participation of the induced traffic in the total traffic expected on the future motorway.

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## REZIME

### NOVOSTVORENI SAOBRAĆAJ I NJEGOV TRETMAN U VREDNOVANJU PROJEKATA AUTOPUTEVA

Ideja članka je da se stručnjacima, koji se bave izradom saobraćajnih studija za projekte puteva, pre svega autoputeva, definišu faktori koji utiču na pojavu novostvorenog saobraćaja, kao i da se, kroz pregled stranih iskustava iz stručne literature, izlože praktični postupci za prognozi-ranje novostvorenog saobraćaja. Takođe, ideja članka je da se stručnjacima, koji se bave izradom studija opravdanosti autoputeva, bez putarine i sa putarinom, obrazlaži različit tretman novostvorenog saobraćaja u vrednovanju projekata autoputeva bez putarine, koji se zasniva na društveno-ekonomskom aspektu u odnosu na vrednovanje projekata autoputeva sa putarinom, koji se zasniva na tržišno finansijskom aspektu. Najzad, ideja članka je i ukazivanje na činjenicu da je za, po pravilu teško merljive ekonomske koristi od indirektnih efekata u vrednovanju efekata sa društveno ekonomskog aspekta iz praktičnih razloga rešenje nađeno u utvrđivanju ekonomskih koristi od novostvorenog saobraćaja po postupku kao za normalni saobraćaj.

## KLJUČNE REČI

novostvoreni saobraćaj, normalni saobraćaj, koeficijent elastičnosti, uštede u vremenu, uštede u operativnim troškovima vozila, ekonomski višak

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