Economic evaluation of negative externalities caused by traffic

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Abstract
Transport and its consequences are evaluated from different points of view of safety, road, vehicle and human factor. However, it is very important to assess the transport impacts also from the economic viewpoint. Incurred considerable negative externalities - socio-economic losses impact upon the government and society.

Goal of the article is description of new approach to economic evaluation of negative externalities caused by traffic under conditions of the Czech Republic. New methodology of loss calculation is defined and stress is laid on current changes, by virtue of which the amount of losses will be put more exactly. Very important change is including the calculation of subjective damages. In the final part, the concrete and explanatory example of the calculation and evaluation of losses, final summary and recommendations are mentioned.

It is important to place emphasis on evaluation of negative externalities caused by traffic and to reckon them on a yearly basis. Loss amounts provide source information for traffic-engineering analyses and models, aimed at the calculation of effectiveness of measures. Implemented effective traffic-safety precautions will accordingly result not only in reduction and severity of traffic accidents but also considerable saving and efficient spending of financial resources.

Key Words
Negative externalities, losses caused by traffic, economic evaluation.

Introduction
For all of us, traffic is an everyday part of our life. Traffic has significant positive effects, but also causes a lot of negative externalities. There is traffic and health damage, environmental damage (noise, emission) and many other externalities.

The financial evaluation of negative externalities caused by traffic is an important part of the state economy. The externalities concern the loss of human life, financial and material damage, social losses funds which would be otherwise produced by this person. Traffic accidents impact not only upon persons involved in them and their families but also up the whole society and state budget. Incurred losses are directly related to particular governmental agencies and self-government bodies, such as the Ministry of the Interior, the Ministry of Labor and Social Affairs, individual municipalities and regions.
We live in the modern times when a lot of values are expressed by money. People produce goods and services through their own hard work, which makes up the total value of the society.

Under conditions of the Czech Republic, the methodical procedure of economic evaluations of negative externalities was used but it was not up-to-date and did not include important cost items, which are inserted into the calculation. Therefore mentioned values were out-of-date and underestimated. Missing was evaluations of subjective damages.

The calculation of losses caused by traffic make up one of the factors of road safety models for calculation of the effectiveness of road safety measures. The implementation of good and effective road safety measures would be important to effectively invest funds for the elimination of negative externalities caused by traffic and for the fulfilment of the goals of the National Strategy of Road Safety. The National Strategy of Road Safety is a document of the Ministry of Transport determining goals and basic principles leading to the reduction of accidents consequences on roads in the Czech Republic. The main goal is to reduce the number of fatalities by 60% and number of serious injuries by 40% between 2009 and 2020. The accident rate decrease is based also on White Paper “European transport policy for 2010: time to decide”.

For this reason, it is very important to pay attention to the economic calculation of negative externalities caused by traffic and prevent later inefficient use of funds.

**Objectives and methodology**

The main objective of the contribution is description of new approach to economic evaluation of negative externalities caused by traffic under conditions of the Czech Republic, which provides current survey and more exact data on costs of traffic accidents for government and society.

The new methodology is based on the method of “human capital”. The method of human capital is suitable for objective evaluations of individual damage and losses. The quantification of costs and losses is made by a direct detection of health care, administration (police, courts, insurance), social costs and material damage. Concerning the evaluation of production losses, GDP per capita is used.

The statistical data are completed with expert estimates in the areas of health care, insurance, social care, traffic police, etc. The types of data are very different, e.g. macro and micro economic, demographic, operational data. These data differ further in quality, reliability and accessibility.

Fundamental to this is the identification, quantification and subsequent evaluation of costs needed for calculation. These costs (both direct and indirect) are financial amounts determined to cover or eliminate consequences of traffic accidents.

Costs caused by traffic are divided between direct and indirect costs Fig. 1.
For greater detail and also in-depth details, the calculation of losses is defined by: costs and losses divided by their impact:

1: Accidents with fatal injuries – This research follows the international definition of “accidents with fatal injuries” which covers a period of 30 days following an accident. (In the Czech Republic an approach is currently used which only covers the first 24 hours following an accident.)

2: Accidents with serious injuries
The difference between serious and slight injuries is based (along expression of the Police presidium of the Czech Republic) on the assessment of an operating doctor on the place of accident or later in the hospital. The operation doctor probably makes decision on the basis of MAIS scale (>3).

3: Accidents with slight injuries

- Material damage only accidents - nobody is injured and only the damage of car(s) occurs. Total costs are a product of unit costs and the number of units.

Costs items are described and calculated in the results. In great detail are described calculation of subjective damages.
Results
In this chapter are described and calculated each cost items according to new methodology.

Direct costs
Direct costs are costs that are directly related to traffic accidents and are possible to be defined and calculated in a short time. Once an accident has been analyzed, it is possible to calculate these costs. Direct costs include health care, costs of fire rescue service, police, material damage, court, insurance and administrational cost.

Costs of health care
Costs of health care are calculated in the case when an accident with injuries occurs. These costs include:
- arrival of emergency medical services to the place of accident (including transport to hospital)
- hospital care – hospitalization and rehabilitation
- autopsy (in the case of death)

Total costs of health care are a sum of these costs. These costs include:
- personal costs,
- fuel and other costs associated with medical care (medical helicopter),
- medical material (medicine),
- overheads,
- other costs.

Costs of fire rescue service
This cost item was newly added to the loss calculation.

Costs of fire rescue service in the Czech Republic depend on a lot of factors. The intervention of the fire rescue service includes two parts: rescue service (medical care, treatment of injuries) and clean up works (clearing of the accident site, handling of cars, etc.)

The rescue service is funded by the budget of the fire rescue service and clearing works are funded by an insurance company. This difference is not relevant for the calculation.
Average costs for one accident are calculated from the costs of the fire rescue service in the Czech Republic where the average costs for one accident are based on the total budget of the fire rescue service divided by the number of all interventions in the year.

According to the severity of accidents, the % share of help (help on the place of accidents) of the fire rescue service is calculated. The following is a list of the costs breakdown of accidents for only the fire rescue service and the total number of accidents:

- Accidents with fatal injuries – 55 %
- Accidents with severe injuries – 90 %
- Accidents with slight injuries – 40 %
- Material damage only accidents – 8 %
Costs for each category are multiple average costs for one service and percentage share for accident of this category.

Costs of police
Police costs include all costs associated with an accident. These costs are calculated from the time spent per accident from each category (fatal injuries, severe and slight injuries and material damage only accidents).
The examination at the location of an accident is done by two people and in the case of a very serious accident by three people, (e.g. witnesses) one person for other work. Police costs include average costs for a car (CZK/km) and average distance to the traffic accident.

Material damage and costs of insurance
There is a material alteration in the calculation of these costs. The calculation of material damage is not possible to calculate only from the traffic police data (not all accidents are reported to the police – in the Czech Republic it is an obligation to report an accident with a financial amount higher than CZK 100 000).

It is very important to correct these data with the insurance figures on the total paid sum within a year. For the calculation of average material damage, the coefficient “k” is used to add the paid sum of material damage, which is much higher than material damage estimated by the police at the location of an accident:

\[
k = \frac{k1 + (C1 - C2 - C3)}{C4}
\]

\[
k = \frac{1.25 \times (727\,121\,156 - 155\,098\,358 - 27\,403\,805)}{178\,346\,050}
\]

\[
k = 3.82
\]

The used data concern the year of 2011 (in EUR).

k1 – a coefficient expressing % increase of material damage and administration costs of insurance and material damage uncovered by insurance (this coefficient is 1.25 for the year 2011)
C1 – paid insurance per year
C2 – costs of healthcare which are paid from liability insurance
C3 – costs of fire rescue service which are paid by a commercial insurance company
C4 – Police estimate of the total damage

The total amount of material damage attributable to an average of individual types of accidents according to their severity is then equal to the multiple of the conversion coefficient "k" and the average amount of material damage to one accident according to police estimates. Calculation for the 2011 year is provided in Tab I.
### I: Total material damage per 1 injury (1 accident) in EUR

<table>
<thead>
<tr>
<th></th>
<th>Material damage according to police</th>
<th>Total number of accidents</th>
<th>Material damage according to police for 1 accident</th>
<th>Total material damage per 1 injury (1 accident)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal injuries</td>
<td>5 600 898</td>
<td>650</td>
<td>8 617</td>
<td>32 969</td>
</tr>
<tr>
<td>Serious injuries</td>
<td>9 482 909</td>
<td>2 666</td>
<td>3 557</td>
<td>13 587</td>
</tr>
<tr>
<td>Slight injuries</td>
<td>48 851 017</td>
<td>17 170</td>
<td>2 845</td>
<td>10 868</td>
</tr>
<tr>
<td>Material damage only accidents</td>
<td>114 411 256</td>
<td>54 651</td>
<td>2 093</td>
<td>7 995</td>
</tr>
</tbody>
</table>

Source: oww calculation

Converted by the exchange rate of ČNB (the Czech National Bank) of 25 July 2013: 1 EUR = CZK 25.950

### Courts and administrative bodies

Courts handle severe accidents which are classified as offences (accidents with fatal injuries, accidents with severe injuries), administrative bodies are responsible for handling minor accidents. Administration costs include personal costs, testimony, expertise costs).

### Indirect costs

Indirect costs are not related to traffic accidents directly but they are revealed in the long term. These costs include production losses and social costs, which are describes in the following text.

### Production losses

Production losses are calculated for accidents with fatal injuries and accidents with severe injuries. Production losses are the highest item in the calculation of negative externalities caused by traffic. For this reason, it is very important to pay attention to the calculation of these costs.

We need to know the following items for the calculation:
- GDP (gross domestic product) for economically active population
- average number of productive years of an average person,
- number of fatal injuries, severe injuries.

Different people have different productivity. Average values (age, sex, health and income) are used for the data accessibility and simplification of the calculation. This value is determined as a share of total GDP and the number of inhabitants in productive age.

### Social costs

Social costs include:
- health insurance,
- widow’s pension and widower’s pension,
- orphan’s pension,
- disability pension.

Social costs are calculated for each category (fatal, serious, slight injury).
The old methodology didn’t include very important costs – subjective damages. Economic evaluations of subjective damages is very specific. So it was very important include evaluations of subjective damages to calculation of negative externalities caused by traffic.

**Subjective damages - compensation for damage established by the courts**

This cost item has been newly added to the loss calculation.

Amount of awarded compensations for damages of health influences very significantly the total economic loss caused by traffic accidents. Just an effort for integrated description of processes related to resolution of traffic accidents resulted that we addressed district courts in the Czech Republic. We can form from table determinations for decision on the amount of compensation for damage of health a general view at the structure of assessment and at its amount. However, we can acquire real summary of the way of decision-making and factors influencing this decision-making, only from concrete cases. We acquired approximately 250 dooms from most district courts in the Czech Republic for this purpose.

The following acts belong among basic variants of filing a claim for damages:
- entering a lawsuit for damages of health to an appropriate district court
- bringing an action to protection of personality to a competent regional court
- adding of a claim for compensation for damages of health to criminal proceedings.

In the first step, the most common procedure of victims of traffic accidents is usually a separate action for damages of health in the tort litigation. This step will result accordingly in the compensation of pain and aggravation of social position where the compensation amount is exactly calculated on the basis of tables.

After the analysis of judgments from criminal proceedings it was found that the criminal proceedings are relatively fast and most subjects do not manage to file their claim for compensation with all necessary documents before dismissal. The court, with respect to the need to ensure further evidences and expertises of officially appointed experts, refers then subjects to put in their claim by entry of the action for damages of health in civil proceedings. In cases of actions by virtue of the personality protection, the courts decide on the basis of allegations of fact, performed probation, expert's statements and in accordance with the existing practice of the courts. Amount of the compensation for nonfinancial damage will be established by the court with regard to seriousness of incurred harm and circumstances, in which there was a breach of law.

In addition to exercising of the compensation for nonfinancial damage by virtue of the personality protection, secondary victims have a possibility to seek lump-sum compensation by reason of death according to the section No. 444, Subsection No. 3 of the Civil Code. From the point of view of the present methodology of the loss calculation, the compensation for secondary victims of traffic accidents was not calculated into total losses. It was expected that it depends on the decision of secondary victims, if they will ask for compensation for damage. However, the contrary results from dooms of district courts. If a person had a fatal injury at the traffic accident, surviving relatives of the victim living with him in common household are automatically entitled to lump-sum compensation in the amount of CZK 240 000 (9 248 EUR). In case when a person, who was also a guilty of the traffic accident, had a fatal injury, the survivors will receive only CZK 120 000 (4 624 EUR).
Important information was acquired from the analysis of judgments and decision-making processes of courts for more unbiased and exact calculation of economic losses caused by traffic accidents. In terms of the total economic loss, in case of fatal injury of one person the difference in the calculation can be then CZK 1 000 000 (38 535 EUR).

Methodic procedure of calculation of compensation of the damage awarded by the courts

1. Drawing-up of the actual application for information according to the Act No. 106/1999 Coll; the application should include among others, which judgments are concerned, eventually from which year they are established.
2. Making an application in the registry of the appropriate court.
3. If a request for payment of the fee for search was received, to pay this amount.
4. The actual processing of judgments according to their content.

Losses caused by traffic accidents are not reflected only in the state economy but they have also social dimension. In one of many cases there was a serious injury of the motorcyclist, to which the injury compensation and aggravation of social position was awarded in the amount of approximately CZK 4 000 000 (154 142 EUR). In total, with all costs of judicial proceedings and treatment of an injured, the amount was CZK 5 000 000 (192 678 EUR). This value was intended for payment to a guilty party of the mentioned traffic accident. The guilty person in the traffic accident was propertiless and was not able to pay the amount. The admitted damages represented rather a formal satisfaction for an aggrieved traffic accident. Traffic accidents have accordingly a socio-economic impact not only on victims but also on their guilty persons.

II: Average amount of compensation at traffic accidents with death in EUR

<table>
<thead>
<tr>
<th>Fatal injury</th>
<th>Total</th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation amount in total</td>
<td>294 856</td>
<td>194 244</td>
<td>100 611</td>
</tr>
<tr>
<td>Number of surviving relatives (compensated)</td>
<td>43</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>Average amount of compensation</td>
<td>6 857</td>
<td>6 937</td>
<td>6 707</td>
</tr>
</tbody>
</table>

Source: oww calculation

Converted by the exchange rate of ČNB (the Czech National Bank) of 25 July 2013: 1 EUR = CZK 25.950

III: Average amount of compensation at traffic accidents with serious injury in EUR

<table>
<thead>
<tr>
<th>Seriously injured</th>
<th>Total</th>
<th>Man</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation amount in total</td>
<td>328 006</td>
<td>257 081</td>
<td>70 925</td>
</tr>
<tr>
<td>Number of compensated persons</td>
<td>16</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Average amount of compensation</td>
<td>20 500</td>
<td>21 423</td>
<td>17 731</td>
</tr>
<tr>
<td>Awarded compensation to insurance companies in total</td>
<td>46 963</td>
<td>11 122</td>
<td>35 841</td>
</tr>
<tr>
<td>Number of compensated cases</td>
<td>14</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Average amount of the awarded compensation to insurance companies</td>
<td>3 355</td>
<td>1 390</td>
<td>5 973</td>
</tr>
</tbody>
</table>

Source: oww calculation

Converted by the exchange rate of ČNB (the Czech National Bank) of 25 July 2013: 1 EUR = CZK 25.950
Average amount of compensation is significantly higher at persons with serious injury, namely by reason of subsequent medical care and health indisposition in further course of life, especially with respect to exercise of a profession. According to the present Civil Code No. 40/1964 Coll, the maximum limit is determined for fatal injury to EUR 9 249.

Sample example of calculation

The sample example is provided to calculate the losses caused by traffic for the accident, during which a fatal injury of one person occurred. The compensation for damage is calculated for six surviving relatives. The offence according to the Act No. 361/2000 Coll., on traffic on land roads, was concerned when the vehicle driver did not behave considerately and the vehicle did not meet technical conditions for traffic on land roads. The driver was also influenced by alcoholic drink, did not adjust the driving speed to condition of the vehicle and pavement, he was not belted up and his driving license was taken away before this accident.

Calculation of costs of 1 person who died due to a fatal injury, without awarded compensations of the court is provided in Tab IV, costs amounts to CZK 18.5 million

<table>
<thead>
<tr>
<th>IV: Amount of losses per 1 person who died due to fatal injury in EUR</th>
<th>EUR</th>
<th>Percentage share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct costs (EUR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of health care</td>
<td>7 060</td>
<td>0.92</td>
</tr>
<tr>
<td>Cost of fire rescue brigade</td>
<td>1 682</td>
<td>0.21</td>
</tr>
<tr>
<td>Cost of police</td>
<td>1 865</td>
<td>0.24</td>
</tr>
<tr>
<td>Material damages incl. costs of insurance companies</td>
<td>32 969</td>
<td>4.34</td>
</tr>
<tr>
<td>Courts and administrative bodies</td>
<td>370</td>
<td>0.05</td>
</tr>
<tr>
<td>Direct costs in total</td>
<td>43 945</td>
<td>5.8</td>
</tr>
<tr>
<td>Indirect costs (EUR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production losses</td>
<td>664 606</td>
<td>87.4</td>
</tr>
<tr>
<td>Social expenditures</td>
<td>7 144</td>
<td>0.94</td>
</tr>
<tr>
<td>Compensation for damage established by the courts</td>
<td>44 571</td>
<td>5.86</td>
</tr>
<tr>
<td>Indirect costs in total</td>
<td>716 322</td>
<td>94.2</td>
</tr>
<tr>
<td>Total loss in consequence of death of one person (EUR)</td>
<td>760 267</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: ovw calculation

Converted by the exchange rate of ČNB (the Czech National Bank) of 25 July 2013: 1 EUR = CZK 25.950

It is necessary to add to these costs also the compensation of the damage amount awarded by the courts. The amount established by the court for dead person is provided in Tab. V.

Total loss in consequence of death of one person is EUR 760 267. The highest cost item forms the production losses that amount approximately to 94 % of total costs.

It is also necessary to take into account, how serious offence is concerned. In the above mentioned case the driver caused a negligent homicide of other person, endangered other road traffic participants by use of addictive drugs and defeated an action of ruling. The
confinement for 60 months was imposed on a driver for these offences. He will not be gainfully employed for this period, wherewith will not develop the production for the benefit of economy respectively the government will spend further funds on stay of a guilty person of the traffic accident in the penal institution during 60 months.

V: Amount of compensation for damage awarded by the court in EUR

<table>
<thead>
<tr>
<th>Compensated subject</th>
<th>Compensation for damage established by the court</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 aggrieved person</td>
<td>12 535</td>
</tr>
<tr>
<td>2 aggrieved persons</td>
<td>9 249</td>
</tr>
<tr>
<td>3 aggrieved persons</td>
<td>9 249</td>
</tr>
<tr>
<td>4 aggrieved persons</td>
<td>6 744</td>
</tr>
<tr>
<td>5 aggrieved persons</td>
<td>6 744</td>
</tr>
<tr>
<td>Insurance company</td>
<td>52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44 571</strong></td>
</tr>
</tbody>
</table>

Source: oww calculation

Converted by the exchange rate of ČNB (the Czech National Bank) of 25 July 2013: 1 EUR = CZK 25.950

Discussion

Ing. Alena Vyskočilová is researcher in Transport research centre and author of the old methodology for calculation of losses caused by traffic. Transport research centre is the only organisation performing the calculation of losses from road traffic accidents in the Czech Republic. This calculation was made according to an incomplete and outdated methodology. This methodology did not include all cost items. For this reason was very important update the methodology.

It was added calculation of costs of fire rescue service, new calculation of healthcare and “unregistered accidents” and insurance costs. Very important was added calculation of subjective damages. Economic evaluation of subjective cost allows including of subjective item to calculation and also allows making international comparison with European countries.

Economic evaluation of negative externalities caused by traffic according to new methodology provides inputs to traffic-safety analyses. This data are updated and are used by Motorway and Highway director of the Czech Republic and Ministry of transport.

Conclusion

Calculation of negative externalities caused by traffic is important not only in terms of economic evaluation of traffic consequences but also from the point of view of safety, road, vehicle and human factor. There are considerable negative externalities, which impact upon the government and the society.

Just these economic losses represent 1.4 % GDP in the Czech Republic. One of the top priorities of the Czech Republic is to reduce this damage and decrease the number of accidents with fatal injuries (by the implementation of road safety measures).
The state budget has limited funds and it is very important to use these funds effectively. For this reason, it is essential to pay attention to economic evaluations of negative externalities caused by traffic. The implementation of effective road safety measures should help to reduce the number and impact of traffic accidents.

New updated methodology reflects current changes, whereby it provides more exact data to be involved in further economic and traffic-safety analyses. Special attention is paid to verification of input data in the total loss calculation, based on direct communication with particular administrative bodies, for example courts, which provide exact data on compensations for damages.

Considerable multiplicity of the amount of compensations for slight, serious and fatal injuries results from the analysis of judicial decisions, hence it is suitable to reckon the losses caused by traffic on a concrete sample of traffic accidents. Culpability of the traffic accident by an aggrieved person has then an essential influence on the amount of compensation for damage. Calculation of losses is most often represented at a traffic accident with death when this is thought to be the most costly. After the analysis of several tens of judgments, the group of serious injuries with permanent consequences on health proves to be the most costly. A person aggrieved in this way must then wrestle his health, economic and social handicap through his whole life.

References


Outputs of project HEATCO (Developing Harmonised European Approaches for Transport Costing and Project Assessment).

European Road Safety Observatory, http://erso.swov.nl/index.html

Civil Code, Decree No. 440/2001 Coll, Prague, 2001

Act No. 106/1999 Coll, Prague, 1999