Study on the cost structure of the highway projects in the Czech Republic

Renata Schneiderova Heralova
Czech Technical University in Prague, Faculty of Civil Engineering, Thakurova 7, 166 29 Prague, Czech Republic

Eduard Hromada *
Czech Technical University in Prague, Faculty of Civil Engineering, Thakurova 7, 166 29 Prague, Czech Republic

Hal Johnston
California Polytechnic State University, San Luis Obispo, California, USA

Abstract

Despite the general price decrease of construction projects the price of highway projects has tended to rise. Research has shown that building highways in the Czech Republic costs about 30% more than comparable projects abroad, for example in Germany and Austria. This paper will identify possible causes within the process of construction of highways. The paper will also identify the possibilities of cost optimisation for the construction process.

The total cost of highways consist of the construction cost (hard cost), the development cost (e.g. design fees, management fees), and the site cost (e.g. purchase of the land). This paper will present an analysis of the total costs of selected sections of the highways recently built in the Czech Republic. The elements that influence the total costs are design parameters of the road (category) and the topography. The output of this analysis is the average cost per one kilometre of a highway divided by the category of the road and the topography characteristics (urban/rural area, flat, hilly or mountainous area). The paper also analyses the additional costs associated with the overall project, especially the cost of the development of the project documents and the purchase of the land. These additional costs can significantly increase the total cost of a traffic project.

The authors summarize the causes of the high costs and at the same time proposes methods to reduce these costs. The public sector may use the results to identify ineffectiveness of construction processes in the area of traffic projects in the Czech Republic. The proposed optimisation procedures should lead to cost reductions.

Keywords: construction costs, cost optimization, cost reduction, motorways, traffic project.

1. Introduction

The issue of cost of highway projects has many studies, especially at the national level (e.g. Berechman, 2011, Link, 2014, Lambropoulos, 2013). There are also several studies in the Czech Republic (e.g. Stepanek, 2012, Nyvlt, 2011, Horak, 2007) that relate specifically with the efficiency of the construction and maintenance of the highway project within the life cycle.

Many departments of transportation have recently started to utilize innovative contracting methods that provide new incentives for improving construction quality. These emerging contracts place an increasing pressure on decision makers in the construction industry to search for an optimal resource utilization plan that minimizes construction cost and time while maximizing its quality (Rayes, Kandil, 2005).

The professional and lay public have been recently ever more often asking questions regarding the quality of construction of the transport infrastructure, its planning, and the total costs related to construction of highway infrastructure in the Czech Republic. Stories are often published in media about building Czech highways is much more expensive than constructing comparable roads abroad. The findings from many conducted studies is that the state administration does not spend taxpayer money economically. These studies have also found that the state projects are uneconomically and ineffectively designed. Thus the end result, the public does not get the added value from the state and must use poor and unsafe transport infrastructure. Lately it has been impossible to find some completed highway section in the Czech Republic where the cost had not been increased in the course of construction. The influence of various lobbying groups can be felt during preparation and realization of highways. Often suspicion of corruption is there. Effective quality and cost control is missing, and public contracts are not sufficiently transparent. Because of these results, the public considers the transport
infrastructure as a black hole in the state budget. This paper will identify possible causes of inefficiency within
the process of construction of highways and identifying the possibilities of cost reduction.

Few highway agencies use performance measures for cost estimating. The study (Harper 2014) synthesizes,
categorizes, and validates existing performance measures for cost estimating of highway projects to assist with
improving estimating accuracy.

2. Cost structure of highway projects

Highway construction costs include a wide range of items. These costs are project design, engineering support
services and surveying, costs of transport infrastructure, secondary costs related to siting of the project, running
costs of preliminaries and construction, and similar other costs. The highest share from the total budget of a
highway naturally is construction, i.e. the cost of each element of the infrastructure (roads, bridges, flyovers,
town bypasses, etc.). Also purchasing of the land is another large portion of the total budget of the transport
infrastructure in the Czech Republic.

The primary elements in a highway project is cost estimate can be broken down into the following groups:

- Preliminary engineering (PE).
- Right-of-way and utilities (ROW).
- Construction costs (C).

Preliminary engineering is the development of a project beginning will planning to designing of the complete
project. The right of way is defined as the purchase of land from a landowner. This land provides the available
space row needed to build and construct a road project. Construction costs are the expenses incurred during the
construction process from project bidding to purchasing materials and completing the construction work on the
project. These expenses are functions of project and roadway design (width, number of lanes, location).

Analysis of the total costs of selected sections of highways recently built in the Czech Republic has been
completed. Seventy-four projects were analysed with total costs of 7.8 billion euro. A more detail analysis was
conducted on 29 projects with total costs of 3.0 billion euro. The average total cost of 1 km of a multiple lane
highway was EUR 15.1 million; the average total cost of 1 km of a single lane motorway is EUR 13.7 million.
The study also analysed additional costs associated with the project, in particular the cost of the development of
project documents and the purchase of the land. These additional costs can significantly increase the total cost of
a highway project.

The structure of total costs is presented in Fig. 1. The left picture shows the structure of multiple lane
highway costs, the right one refers to single lane roads.

![Figure 1. Cost structure of multiple lane highways (D) and single lane roads (R)](image)

<table>
<thead>
<tr>
<th>Highway category</th>
<th>Group of costs (mil. EUR/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>preliminary engineering</td>
</tr>
<tr>
<td>D 26.5 - 27.5 m</td>
<td>0.38</td>
</tr>
<tr>
<td>R 22.5 - 27.5 m</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Table 1. Cost structure of highways (average).
The element that influences the total costs is the most the design parameters of the road (category), and the topography. The result of the analysis is the average cost per one kilometre of a motorway and expressway divided by the category of the road and the topography characteristics (urban/rural area, flat, hilly or mountainous area).

Table 2. Unit price of construction objects, flat area.

<table>
<thead>
<tr>
<th>Highway category</th>
<th>Unit price of construction objects - average (mil. EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 33.5</td>
<td>7.13</td>
</tr>
<tr>
<td>D 27.5</td>
<td>5.12</td>
</tr>
<tr>
<td>D 26.5</td>
<td>6.33</td>
</tr>
<tr>
<td>R 27.5</td>
<td>5.03</td>
</tr>
<tr>
<td>R 25.5</td>
<td>3.91</td>
</tr>
<tr>
<td>R 24.5</td>
<td>3.90</td>
</tr>
<tr>
<td>R 22.5</td>
<td>3.94</td>
</tr>
</tbody>
</table>

The assumed construction costs increased by 68% during the planning decision procedures and by 37% during the building decision procedures. The reason for this increase is the designing of unjustified infrastructure, ineffective technical solutions, and accepting requirements involved in planning and building decision procedures (often unreasonable requirements on environmental protection).

3. Causes of high costs

3.1. Insufficient planning of purchase of land and construction

We have been witnessing the two responsible bodies (first of all the Road and Motorway Directorate of the Czech Republic/RSD and the Ministry of Transport of the Czech Republic) for this work having no long-term concept of planning preliminaries and construction of the highway infrastructure. There does not exist priority road projects which have been authorized for construction as soon as possible. A clear linkage between planning the road infrastructure and real public funds is missing. The present criterion for approving construction of individual traffic projects is the status of the design and possibility of financing from EU funds. This approach cannot lead to reaching a high effectiveness of the construction of traffic projects in the Czech Republic. Integral sections of continuous transport routes cannot be completed using this approach and the number of incomplete sections of roads has been increasing disproportionately.

Planning and constructing of the transport infrastructure in the Czech Republic does not currently build on an approved conceptual and strategic document (master plan) that would contain specific information on proposed dates and costs of each particular project. One document, the General Plan of Development of Transport infrastructure (GEPARDI) does contained this necessary strategic information. This strategic document does show a change in attitude of the public sector in the field of preliminaries and construction of the transport infrastructure. It was hoped that this document will help and effectively cover and manage the development of transport infrastructure in the Czech Republic.

The GEPARDI document defined specific priorities of traffic projects with their assumed date of completion 2020. Unfortunately, the Czech government did not approve this strategic development document in the end. The consequence of this decision has created this current poor state of the transport infrastructure. When the Road and Motorway Directorate of the Czech Republic/RSD and the Ministry of Transport of the Czech Republic have available work with only general strategic documents focusing on the basic targets and the visions, they are destined to produce unexpected result. When there are described problems preventing effective and economic planning and construction of the transport infrastructure, poor results will happen.

The path forward for effective and professional management of public funds in the field of transport infrastructure is defined by creating and using a medium- and long-term strategic plan. This plan should contain specific information on the planned priority transport infrastructure projects, and the sequence of priority projects in terms of the importance of their completion. Also each project needs to describe its importance on a national, regional and international level. It will specify the maintenance and renovation plan for the existing transport infrastructure in terms both financing and organisation. The plan should define clear rules for allocation of funds flowing into the transport sector and it should specify real and stable sources for financing for transport infrastructure. It could compare various alternatives of technical and economical solution of individual traffic projects including their assessment in terms of environmental impacts and other issues. In general, transparent
and stable criteria for decision making and assessing should be established. The state administration should use this plan as a mandatory base for its day to day and future work.

3.2. Methods of financing

Larger highway projects are financed through the State Fund of Transport Infrastructure in the Czech Republic. This is a legal entity subordinate to the Ministry of Transport of the Czech Republic that uses the income for the benefit of construction, modernisation and maintenance of larger transport projects (roads, motorways, railways, and inland waterways). The Fund was established in 2000 in order to stabilize sources of financing to be spent on the transport infrastructure. Financial resources spent on the transport infrastructure must annually begin often maintain a stable level because preparation for traffic projects before construction take several years. The period beginning with developing a concept for a traffic project until its commissioning usually takes 12 years in the Czech Republic. Unfortunately, due to the personal and organizational turbulences we have recently been witnessing within the relevant state administration bodies, we may expect further extending of this unacceptable long time. The structure of the income of the State Fund of Transport Infrastructure is shown on following Table 3.

Table 3. Income of the State Fund of Transport Infrastructure (SFDI) (in CZK Mio).

<table>
<thead>
<tr>
<th>Income type</th>
<th>2014</th>
<th>Budget outlook 2015</th>
<th>Budget outlook 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Tax yields</td>
<td>5 200</td>
<td>5 300</td>
<td>5 300</td>
</tr>
<tr>
<td>Consumer Tax yields</td>
<td>7 500</td>
<td>7 200</td>
<td>7 200</td>
</tr>
<tr>
<td>Highway and motorway road fees</td>
<td>3 900</td>
<td>3 900</td>
<td>3 900</td>
</tr>
<tr>
<td>Toll yields</td>
<td>8 000</td>
<td>8 300</td>
<td>8 300</td>
</tr>
<tr>
<td>State Subsidies</td>
<td>18 400</td>
<td>12 300</td>
<td>12 300</td>
</tr>
<tr>
<td><strong>SFDI Total Income</strong></td>
<td>43 000</td>
<td>37 000</td>
<td>37 000</td>
</tr>
</tbody>
</table>

Source of data: The budget of the State Fund of Transport Infrastructure for 2014.

4. Methods of optimisation

4.1. Use of CBA at planning of preliminaries and construction

One of the tools that may effectively help the public sector at assessing traffic projects in terms of their meaningfulness, effectiveness, and selection of the most appropriate alternative of both technical and economical solution is the Cost-Benefit Analysis (CBA) (see Figure 1). This method allows us to answer the basic managerial question: “What, who, where will the gains and losses be on a built investment project?” The method allows the user to transfer the benefits and effects of an investment to specific cash flows (income and spending) based on the effectiveness of the investment. The effectiveness of the investment may be calculated by means of financial and decision making indexes (Net Present Value - NPV, Economic Rate of Return - ERR, Internal Rate of Return - IRR, Payback Period - PP, and similar indexes.). By evaluating the planned investment by the CBA method or using another managerial decision making tool, it may be shown that a traffic project that has approval may have a rate of return for three or more generations. Also these tools can project running future costs may be required for future frequent renovation and maintenance of structural elements. Not having this knowledge early can create burden to public budgets that will restrict the further local development of the transport infrastructure (Godinho, Dias, 2012).
The CBA method helps the owner decide whether an investment is acceptable and effective. If the financial and decision-making indicators for some traffic project come out positive, the basic condition for the CBA method is met. There is an assumption that the planned investment is more beneficial than detrimental to the owner. The owner must nevertheless also review whether the owner can finance the project and maintain it fully financially sustainable in a long-term perspective. Results of the CBA method are not sufficiently informative value. For instance, a project may be built that is highly valuable for the public but may generate substantial negative cash flows. To assess whether the planned financial burden is still acceptable for the owner further economic and managerial studies have to be performed. These studies are case studies, a feasibility studies, and a business plans. These studies provide further important data on the planned project helping to make the decision whether the project should be built or not.

Recommendations:

- Provision must be made for priority projects of the international, national and supra-regional significance when planning the traffic infrastructure development strategy. This strategy can be defined on the basis of the results of elaborated managerial-decision making studies (CBA, Feasibility study and similar). Change in the future demand of users which can be affected by fuel and toll prices must be also taken into consideration.
- Provisions must also be made for balancing the financial allocation to individual transport sectors (road transport, railway transport, water and air transport) and mutual connection of projects from different transport sectors.
- The need of investment in new traffic projects must be assessed in terms of the system as a whole with considerations for maintenance and renovation of the existing transport infrastructure that may need funding.
- All prepared investment projects must be mutually compared in order to determine the exact sequence of traffic projects in terms of their effectiveness, desirability and impact on the state budget and the environment. Alternative technical and economic solutions of these traffic projects (road vs. railway transport, various alternatives of directional, altitudinal and lateral design of roads, PPP projects, and others) must also be assessed.
- The public must be involved in each phase of the preparation of any traffic project. The public must have a chance to participate in the development of the concept of any traffic project. This approach will allow developing alternatives and other solutions from which the most appropriate ones can be selected. This approach will create the least negatively rising from the operation of a traffic project. Accepting this form of communication with the public will also allow positive approach for citizens to participate in preparation and construction of any particular traffic project. This allows the public to participate in the decision making processes.
- The process adopted for the development strategy of the transport infrastructure must be binding for all participating state bodies. These bodies must follow this strategy systematically and without an exemption. Only such projects that complying with this strategy should be approved for construction. It is not good policies to allow short-term political criteria to recommendations resulting from managerial-decision making studies.
4.2. Financing of traffic projects

Recommendations:
• Preparation of the budget for the State Fund of Transport Infrastructure for each following year must be open and transparent. The whole process of the state fund’s budget preparation and approving should be available to the public on the Internet. This way the public can comment on the preparation of the state fund’s budget.
• The development of the budget for the State Fund of Transport Infrastructure must be clearly linked to the approved and binding development strategy of the transport infrastructure in the Czech Republic.
• The State Fund of Transport Infrastructure must subject all planned traffic projects to an external professional due diligence, assessing them in terms of economy, desirability, the structure of financial resources, preparedness for construction, and environmental impact.
• Each prepared project must contain a realistic and detail budget which will include all negative externalities and investments. The project budget must contain all cost items reduced to the minimum.
• Mechanisms must be developed that allow feedback in the field of costs. The planned costs must be continuously compared with the real cost and in the case any deviation occurs, the sources that caused the change should be clearly identified. The mechanism must be capable of continuous updating of the internal construction price database.

5. Conclusion

According to the conceptual plans developed by the Ministry of Transport in the late 1990’s, the highway and motorway network would be completed today. Yet according to the current development it will take at least 32 more years and the money spent to achieve this goal will be over 19 billion EUR. The potential of possible savings in the process of construction of highways and motorways may be estimated in the range of 12 – 20 per cent of the total construction costs of these projects. To verify this estimate we compared the comparable construction costs for construction of one kilometre of a highway in the Czech Republic and Germany. This price was 13.0 Mio in the Czech Republic and 10.4 Mio in Germany; the difference being 25 % lower.

The paper summarizes the causes of the high costs and at the same time proposes methods to reduce the costs. The public sector should use the presented results to identify ineffectiveness of construction processes in the field of traffic projects in the Czech Republic. Implementing the proposed cost reduction procedures will lead to the cost reductions of these types of construction project in the future.

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References


