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Estimating minimum toll rates in Public Private Partnerships

Nevena Vajdic[a*], Goran Mladenovic[a], Cesar Queiroz[a]

[a]*University of Belgrade, Faculty of Civil Engineering, Bul. kralja Aleksandra 73, 11000 Belgrade, Serbia*

Abstract

Public private partnership (PPP) is a project delivery method which is used in many countries. The main advantage of this method compared with traditional methods is in the allocation of private funds which are used for providing public services and delivery of projects such as hospitals, schools, roads, and bridges. Under road PPP projects, a commonly used mechanism for the repayment of the private investment is the user charge system, i.e., charging tolls to the facility users. Although the toll rate may be set by the government, there are certain constraints which the minimum toll rate has to meet. These constraints are mainly related to financial parameters such as project's financial internal rate of return (IRR) and debt service coverage ratio (DSCR) which private investors evaluate during the decision making process. In other words, there is a minimum toll rate required to attract private investments. In addition to the financial constraints, other project's parameters such as construction cost, concession life, or level of government subsidies also have an impact on toll rates. The objective of this paper is to investigate the relationship between the level of toll rates and several project technical and financial parameters. A financial model included in the Toolkit for PPP in Roads and Highways, developed by the World Bank and the Public-Private Infrastructure Advisory Facility (PPIAF), is used as a tool to calculate toll rates for various sets of input values. The approach which was chosen to test sensitivity of selected parameters to potential changes in input values (e.g., technical and financial parameters) is by estimation of elasticities.

Keywords: Public Private Partnerships; toll rates; elasticities.

* Corresponding author. Tel.: +381 63 573 714.
E-mail address: nevena.vajdic@gmail.com.

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1. Introduction

Facing the deficiency in available funds, highway agencies are seeking best solutions for maintaining existing infrastructure and delivery of new projects. Beside this problem with lack of funds, there is also an increasing pressure on governments and public agencies to reduce traffic congestions and associated impact on environment. These facts have significantly contributed to the private sector involvement in delivery of public infrastructure.

Private sector participation in project's delivery is not limited to the traditional services like facility construction, but rather participation in almost all phases of project's life: design, construction, operation and maintenance. In return for providing these services, the private sector is usually entitled a right to collect tolls either directly from road users or to receive some sort of compensation from the public sector. This form of project's delivery method is known as the Public Private Partnership (PPP).

While the decision about the method of project delivery as a PPP contract or as a standard procurement process is made by the public sector, there are certain prerequisites which project has to fulfill in order to be considered as PPP like expected traffic volumes. If the project is chosen to be delivered as PPP contract, there are number of feasibility analyses and due diligence procedures which project has to meet in order to rich financial closure.

Risk assessment and risk management is considered as one of the crucial parts of the contract. Project's risk burden is measured against the project's ability to generate the revenue. Traffic and revenue risks are considered to be main risks in PPP contracts. The price of these risks is reflected in the cost of borrowing, i.e., in the level of interest rates. Beside forecasted traffic volumes, in the revenue risk assessment the public and the private sector rely heavily on the level of toll rates as means of generating the revenues.

In some cases, the toll rate is set by the government which requests from the private sector time frame as an offer for the concession, i.e., duration of operation phase which the private sector is willing to accept given the level of toll rates. However, in some cases toll rate is not set by the government and it is a subject of negotiation. The public sector is looking at the minimum toll rate which is socially acceptable and which will encourage users to use the facility. On the other side, the private sector is estimating toll rates based on the traffic forecasts, estimated construction cost and concession duration which will satisfy financial aspect of the project.

The objective of this paper is to investigate the relationship between toll rates and other key financial and technical parameters that define a toll road concession. To this aim, a mathematical model was developed which estimates the minimum toll rate required to attract private investors taking into account financial constraints for the given set of input data. The approach which was chosen to test sensitivity of selected parameters to potential changes in input values, i.e., project's technical parameters, is by estimation of elasticities.

2. Background

Swan and Belzer (2008) conducted an empirical study on diversion of trucks from tolled highways on non-tolled roads due to significant rise in toll rates. Results suggested that truck diversion is likely to take place if there is an increase in toll rates which consequently leads to safety issues and increased cost of freight transportation. Also, increased maintenance cost of non-tolled roads due to increased number of trucks places additional pressure on the budget available for pavement management on state level.

Analyzing price elasticities of travel demand, Hirschman et.al. (1995) provided an empirical study on sensitivity of traffic volumes with respect to the level of toll rates. They applied multiple linear regression analysis to a time series of traffic volumes on bridges and tunnels in New York City.Tthe authors included, in addition to toll rates, four independent variables: employment, motor vehicle registration, subway fare and gasoline price. The analysis showed very low toll elasticities. This means that, for the data analyzed, an increase in toll rates do not have a substantial impact on traffic volumes, which seems to be typical of commuter traffic, as is mostly the case of New York tunnels and bridges.

Other studies show different toll elasticities. For example, Matas and Raymond (2003) found a wide range of toll elasticities across motorway sections in Spain, varying from -0.21 to -0.83. They concluded that this range of variation can be explained by variables such as those related to the quality of the alternative roads, the length of the motorway section, and the location of the motorway (e.g., a tourist area). The more congested the alternative roads are, the higher the time benefits of using the tolled motorway will be, with demand consequently being more inelastic.

Similarly, Noland (2001) conducted an empirical study to statistically test if the increase in highway capacity induces additional traffic growth. Analysis included data on lane mileage and vehicle-miles traveled (VMT) in the US. The multiple linear regression model also included data about population, per capita income and cost of fuel as independent variables. Estimation of elasticities provided results which clearly indicate that increase in highway capacity have impact on VMT thus increasing traffic on the highway. Recognizing the issue of potential capacity changes in the PPP project, this paper addresses the importance of analyzing scenarios with various total construction costs and its impact on toll rates.

3. Data and methods

Data for the model were calculated using the Toolkit for PPP in Roads and Highways, developed by the World Bank and the Public-Private Infrastructure Advisory Facility (PPIAF) (World Bank, 2009). The Toolkit has the main objective of providing a tool to policy makers from transition and developing economies with some guidance and resources to design and implement PPP projects in the road subsector. The Toolkit includes a financial simulation model presented in two forms, Graphical and Numerical. The Graphical model is used as a diagnostic tool for preliminary assessments, while the Numerical model is more detailed and can serve for the first project analysis at the pre-feasibility level.

The Graphical model was used to calculate the minimum toll rates as a function of assumed input values characterizing potential PPP projects. There are four different groups of input values in the Graphical model with 18 input values in total, which are related to:

a) technical parameters of the project, including concession life, construction cost, construction period, distribution of works during the construction period, operation cost, initial daily traffic, traffic growth, and toll rate;
b) the financial structure of the project with two input values: percent of government subsidies and percent of equity;
c) the debt structure with four input values: debt maturity, interest rate, type of repayment, and grace period; and
d) country specific economic parameters: inflation rate, corporate tax rate, state discount rate, and VAT rate.

The Graphical model calculates key project financial parameters for the given set of input values. These financial parameters are: project financial internal rate of return (FIRR), equity internal rate of return (return on equity, ROE), annual debt service cover ratio (ADSCR), and loan life cover ratio (LLCR). The project's net present value of taxes and subsidies is also computed by the model. On a trial and error basis, one can determine the minimum toll rate which will satisfy predefined financial constraints. In other words, for the chosen set of input values, one can find the toll rate so that the FIRR, ROE, ADSCR and LLCR are above the minimum required values.

Using the background formulas in the Graphical model, a new deterministic model has been developed in this study which calculates the minimum toll rate for the given set of project parameters and for the minimum required values of the financial constraints. A modified version of the model was also developed to calculate the maximum construction cost that can be accommodated to keep toll rates within a predetermined level, or the level that meets users' willingness and ability to pay. In other words, if the levels of toll rates are set in advance, the model calculates the maximum construction cost which is allowed in order to keep the project financially viable.

Sensitivity of toll rates and construction costs to changes in some of project's technical parameters is assessed through the estimation of elasticities. The elasticity $\varepsilon_{x,y}$ of parameter x to a change in the parameter y can be expressed as follows:

$$\varepsilon_{x,y} = \frac{\frac{\Delta x}{x_0}}{\frac{\Delta y}{y_0}}$$

where Δx is a change in the parameter x, x_0 is its initial value; Δy is a change in the parameter y, and y_0 its initial value. Thus, the calculated elasticities represent the percent change in the toll rate or construction cost due to a percent change of some technical or financial parameter, e.g., initial daily traffic. As the elasticity of toll rates to level of traffic volume can vary from inelastic to elastic, it is difficult to estimate at the project development phase what type of elasticity would be once the road section is in the operation. Thus, it is assumed in this paper that the elasticity of toll rates to traffic volumes is inelastic, i.e., changes in toll rates do not have a substantial impact on traffic volumes. Such an assumption is more applicable, for example, to commuter traffic or where the non-tolled alternative roads are very congested. The results of the analysis are presented in the following section.

4. Analyses

For the assessment of the relationship between toll rates and project technical parameters several analyses were performed. Firstly, toll rates were reviewed as a function of construction cost and initial daily traffic. This analysis serves as the basis for a better understanding of toll rate sensitivity with respect to variations of construction costs and initial daily traffic. The initial daily traffic is expressed as Annual Average Daily Traffic (AADT) at the toll road opening year, while toll rates are expressed as the weighted average toll rate (WATR) in US dollar per vehicle. Assuming that traffic on the observed road section can be represented as a mix of cars, trucks and buses, the WATR per vehicle can be expressed as follows:

$$WATR = \left(\%C * TR_c + \%T * TR_t + \%B * TR_b\right) / 100$$

where %C is the percentage of cars, %T percentage of trucks, %B percentage of buses; TR_c, TR_t and TR_b are toll rates for cars, trucks and buses, respectively. Table 1 summarizes the input parameters and constraints which were used in this analysis.

Figure 1 represents the result of this analysis. The horizontal axis represents estimates of construction cost needed to build the road and to put the project into operation; the vertical axis represents toll rates, in terms of WATR. The results are as expected: as construction cost increases, the minimum toll rate required to attract private investors also increases. And for lower values of initial AADT, toll rates increase at a higher rate. Analysis of elasticities provides more information about sensitivity of toll rates with respect to changes in input parameters.

Table 1. Project input parameters

A. Project Parameters
Concession term = 20 years
Construction period = 2 years
Operation costs = \$100,000 per km per year (no variable costs)
Distribution of works during the construction period = 1st year 50%, 2nd year 50%
Equity = 40% of the construction cost
Government subsidies to the capital costs = 40% of the construction cost
Traffic growth = 4% per year
Inflation = 4% per year
Value added tax (VAT) =18%
Corporate tax = 10%
State discount rate (real terms) = 4%
B. Loan Terms
Nominal Interest rate=15% per year
Type of repayment = level-annuity basis (principal + interest = constant)
Grace period= 2 years; Repayment period=14 years
C. Financial Constraints
Financial internal rate of return of the project (FIRR) ≥12%
Return on equity (ROE) ≥16%
Loan life coverage ratio (LLCR) ≥1.2
Annual debt service coverage ratio (ADSCR) ≥1.2

Elasticity $\varepsilon_{TR,CC}$ of the toll rate TR (short form of WATR) to a change in construction cost CC is defined as:

$$\varepsilon_{TR,CC} = \frac{\frac{\Delta TR}{TR_0}}{\frac{\Delta CC}{CC_0}}$$

where ΔTR is the change in toll rate, $TR_0$is the toll rate at the initial point; ΔCC is the change in construction cost and CC_0 is the initial construction cost. The calculated elasticity depends on the selection of the initial point and this type of elasticity is called point elasticity.

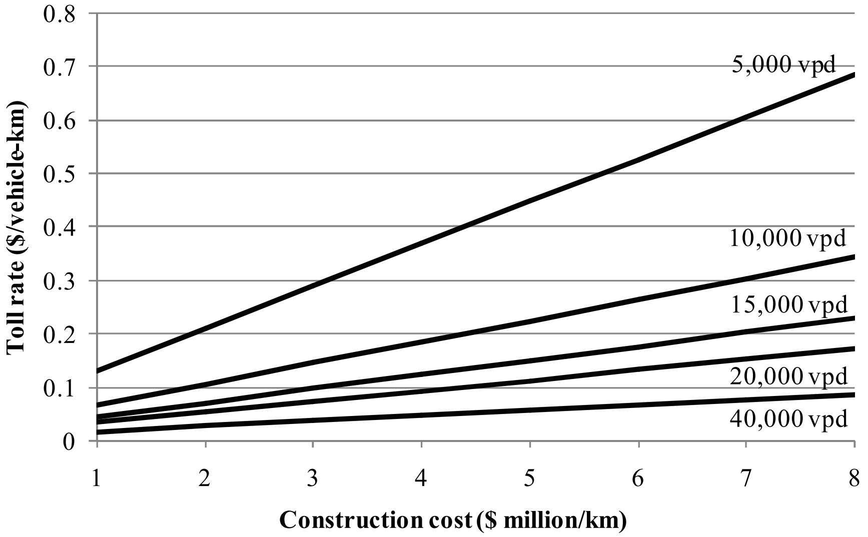

Fig. 1. Toll rate (WATR) estimated as a function of construction cost and AADT

For example, if the initial construction cost is $5 million/km, then the elasticity of the toll rate with respect to this value of construction cost is 0.89. In other words, if the initial construction cost is $5 million/km, a 1% change in the construction cost will change the toll rate by 0.89%. Similarly, the elasticity of the toll rate with respect to the construction cost of $4 million/km is 0.85, and with respect to the construction cost of $7 million/km is 0.91.

In this first analysis, the operation cost is assumed to be constant for all scenarios regardless of the initial investment. As a more realistic approach, in a second analysis it is assumed that the operation cost (OC) is a function of the construction cost, expressed as OC=0.1*CC. Similarly to the first analysis, the toll rate (WATR) was reviewed as a function of the AADT, construction cost, and operational cost. Figure 2 summarizes the results of this analysis.

Similarly to the first analysis, the results are as expected: the minimum toll rate to attract private investors increases with construction costs and decrease with AADT. A lower AADT leads to a higher toll rate to generate the amount of revenue needed to keep the project financially viable.

Further, a comparison of Figures 1 and 2 shows that toll rates are higher in the second analysis. For example, if AADT is 20,000 vehicles per day and the construction cost is $5 million/km, in the first analysis the calculated toll rate is $0.1 per vehicle per km, while in the second analysis it is $0.15. Since the only difference in these analyses is in the approach used for the forecast of operational cost (in the first analysis it was constant and in the second it was function of construction cost), it can be concluded that the model used for the forecast of operational cost have a substantial impact on the level of toll rates.

Elasticities are also calculated for this analysis for all cases of the construction cost, i.e. all values of construction cost used in the analysis were observed as starting points and the calculated elasticities are equal to 1. This case is called unit elasticity, or, in other words, if the construction cost is changed by 1%, the toll rate will also change by 1%.

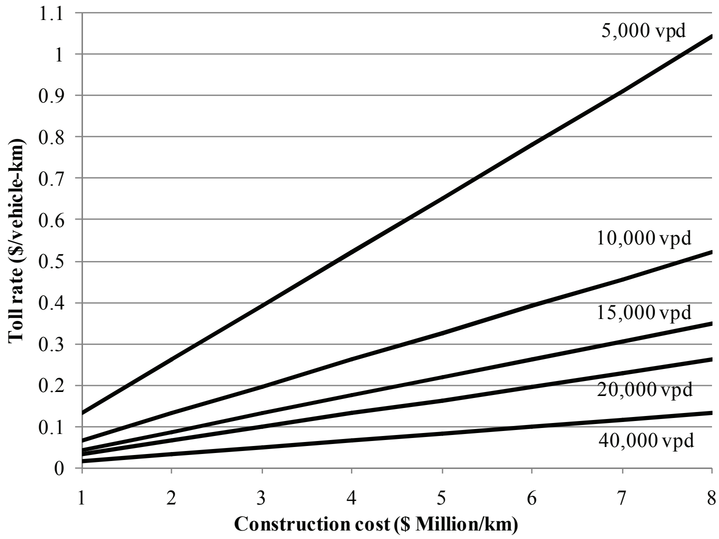

Fig. 2. Toll rate estimated as a function of construction cost and AADT, assuming annual operational costs equal to 10 percent of construction cost

A third analysis was conducted for the assessment of the relationship between the construction cost and some other project's technical parameters. The reasoning behind this approach was to seek for an answer to the question of finding a maximum value of construction cost for the estimated initial traffic (AADT) and given toll rate which will provide a financially viable project.

Figure 3 presents the results of this analysis. The horizontal axis represents the initial daily traffic expressed as AADT, and vertical axis represents the maximum construction cost per kilometer. Input parameters are as specified in Table 1.

The results are as expected: when the toll rate is set in advance, as AADT increases, the maximum construction cost increases as well. The application of this analysis is useful in the decision making process as it provides an insight into the maximum amount of the initial investment as the basis for the decision about potential phases of the projects. If the maximum construction cost is sufficient for single carriageway instead of an initially planned dual carriageway, the project might be considered to be built in phases (i.e., stage construction). The elasticities determined in this case are equal to 1, i.e., unit elasticity. In other words, if the AADT changes by 1%, the maximum construction cost will change by 1% also.

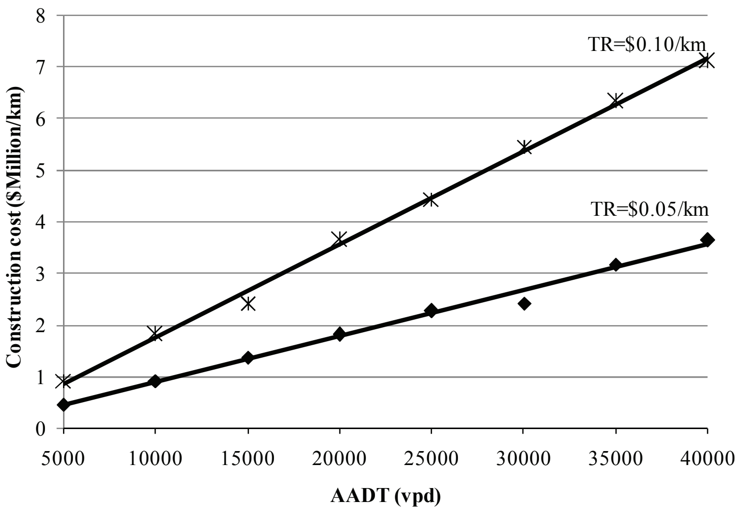

Fig. 3. Maximum construction cost, toll rates and initial traffic volumes

5. Conclusions

The actual toll rates charged usually are the result of balancing the affordability and sustainability of projects with the project's attractiveness to the private sector. Road planners can estimate the minimum toll rate that, while affordable to prospective road users, will be capable of providing the concessionaires with enough revenues to yield acceptable returns on their investments. All other things being equal, this rate depends largely on the construction cost, operating cost, and traffic volumes.

The objective of this paper was to investigate the relationships between toll rates and project's technical parameters. Empirical studies and analyses of toll rate elasticities found in the literature mainly include project's "external" variables like cost of fuel and employment rates, i.e., risks which are outside concessionaire control. In this study, focus is on variables which can be controlled and managed at the project level like construction and operational cost, i.e., project's "internal" parameters.

The results indicate that the toll rate is sensitive to changes in project's construction and operational costs. An analysis was also carried out to quantify the relationship between construction cost, annual average daily traffic (AADT), and the required toll rates which will provide a financially viable project.

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