RISK MANAGEMENT IN PUBLIC-PRIVATE PARTNERSHIP ROAD PROJECTS USING THE REAL OPTIONS THEORY

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ABSTRACT

Application of public-private partnership (PPP) agreements as a method for implementation of transport infrastructure projects is a common practice in many countries. Although history of this type of agreements includes examples of failures and successes, in some cases outcomes were responsibility of one partner, while in others outcomes were either favorable or not, shared between partners. Considering long term obligations between contract parties, which are for highway projects usually 25 to 30 years, and complex nature of this type of projects with number of risks, there is a need for contractual flexibility which will provide a right for a change in investment decision depending on the project’s future performance. Application of real options theory in road PPP projects enables this kind of flexibility and share of associated risks. Overview of theory of real options and examples used in road PPP projects is part of this paper which objective is to develop a valuation model to determine the value of a buyback option in the case of unexpected outcome, i.e. in the case of excessive revenues. This option provides contractual flexibility for the public sector, that is the right to buyback the project from the private sector for the predetermined price.

Key words: real options, public private partnerships, toll roads

1. INTRODUCTION

Public private partnerships (PPP) are, in general, agreements between two parties, the public and the private sector, for delivery of services which were traditionally provided by the public sector. These partnerships serve as a model for overcoming budgetary shortfalls, i.e. for filling the gap between services required by the society and available funds for delivery of those services. Transport is one of major sectors in which the implementation of these types of agreements has become a common approach in resolving the infrastructure issues.

Revenue generating projects like toll roads were usually funded by the public sector, while the private sector was involved mainly in several phases of project’s life like construction of the highway section or scheduled maintenance work. However, PPP agreements enable the private sector to participate in the project delivery through several crucial phases like design, building, finance, and operation or build-operate-transfer (BOT) scheme which is one of common PPP models. For providing these services, the private sector is usually entitled to collect tolls from users, although the public sector may provide an annual payment directly to the private sector proportional to the highway traffic volumes.

Considering long term obligations between contract parties, which are for highway PPP projects, i.e. concessions, usually 25 to 30 years, and complex nature of this type of projects with number of associated risks, there is a need for contractual flexibility which will provide a right for a change in investment decision depending on the project’s future performance. Application of real options
theory in road PPP projects enables this kind of flexibility thus increasing the project value, and better share between parties of project’s risks.

Managerial or real options are analogous to financial options. Options are contracts between two parties which grant the right, but not the obligation to one party to exercise the contract if specified event occurs. Generally, there are two types of options, put and call options. Put option grants a right to sell the financial instrument or an asset if the instrument’s price drops below the predetermined level (exercised price) at some future agreed date (expiration date). In contrast, call option grants a right to buy the instrument if its price exceeds the exercised price at the expiration date. Also, depending on the time when the option can be exercised, two basic styles can be distinguished: American and European style. European options can be exercised only at the expiration date, while American options can be exercised any time before the expiration date.

In context of toll road projects, managerial options can be interpreted as a right to sell or buy the project for a specified price, if the option’s exercise conditions are met (project’s value or yearly revenue drops or exceeds some predetermined level). In such settings, two distinct situations can occur: revenue is higher than expected or revenue is below the expected level and cannot cover operational and debt servicing costs.

In these situations, real options do provide flexibility to prevent potential losses or increase the profit. For example, if the agreement specifies that the private investor has a flexibility to abandon the project for a salvage value, then, this agreement represents a real option provided by the public sector to the private sector. This managerial flexibility provides a value to the investor as it can prevent losses beyond salvage value, hence increase the project’s market value. In contrast, agreement can have a clause that provides an opportunity to the public sector to act if the revenue is higher than anticipated. In this case, public sector has the same managerial flexibility as it can return the project to its ownership and repay the settled price to the private sector.

In this paper, focus is on the option to buyback the project if the revenue exceeds some predetermined level. Objective is to develop a valuation model to determine the value of this option. This paper is organized as follows. A background with examples of real options used in BOT projects is covered in the next section. Proposed valuation method is presented in the following section. Concluding comments, limitations, and directions for the future research are presented in the last section.

2. BACKGROUND

The theory of the option pricing dates back to Merton (1973), who derived explicit formulas for pricing European call and put options, and the options with the boundary condition (down-and-out). Rubinstein and Reiner (1991) and Rich (1994) developed pricing formulas for four types of European boundary options: down-and-out (in) and up-and-out (in). Geman and Yor (1996) used a Laplace transform for a derivation of a pricing formula based on the fundamental properties of Brownian motion. All this methods are developed for a pricing of an option based on the price of an underlying asset, its volatility, and the exercised price as a function of the asset price. In this paper, the buyback option is considered as the European barrier call option. Here, the underlying process is revenue for which the boundary condition is set. Such condition differs from traditional barrier options to include average revenue over a specified time period.

The main risk component in infrastructure projects including toll roads is the revenue risk (Yescombe, 2002). Over the years, a number of studies were conducted to model this risk and investigate possible mitigation strategies. For example, many public agencies provide a minimum revenue guarantee. This guarantee includes a minimum level of revenue that is assured to the investor. If the real revenue falls below that level, the public sector (the government) has an obligation to pay the difference. In practice, this type of the guarantee is priced as a European put option. Wibowo (2004) discuss a financial impact of different guarantees to the public sector. Guarantees under the evaluation are: minimum revenue,
minimum traffic, tariff, debt, and maximum interest. These guarantees are priced as European put options and compared with the government’s direct subsidies concluding that some of these guarantees are more successful in risk reduction than government subsidies. Chiara and Garvin (2007) introduce two methods for evaluating the minimum revenue guarantee: the multi-least square Monte Carlo method and the multi-exercised boundary method. They developed the model with a dynamic option that provides the investor alternative to decide about having the option during the pre-concession phase.

Garvin and Cheah (2004) use a simple binomial discrete-time model to value an option to defer the infrastructure investment. This option provides flexibility to the public sector to postpone the investment in the project depending on the economic growth in the region and the changes in the associated traffic demand. Lara Galera and Solino (2010) develop a methodology for valuing the real options clauses in concession agreements. Some of real options used in highway concession agreements are exchange rate guarantee, public participation loans, minimum traffic guarantees, maximum traffic guarantees, extension of the concession, establishment of subsidies, etc. Authors use a minimum traffic guarantee for application of a proposed methodology where the option was priced as a European put option.

Huang and Chou (2006) use the real option theory to price the minimum revenue guarantee and the option to abandon the project in the pre-construction phase. Option to abandon the project provides the flexibility to the private sector to walk away from the project if the estimated future operating revenues are below estimated capital costs and operating costs. Once when the project’s construction phase starts, this option is no longer alive, i.e. it is expired. Both options are priced as European put options. Zhao et al. (2004) develop a multistage stochastic model for decision making accounting for three risks: traffic demand, land price and highway deterioration. Three real options are incorporated in the model: right-of-way contract, highway expansion and rehabilitation decisions. These options are American style options since they can be exercised at any time during the project’s service life. Thus, the focus is on the optimal exercise timing.

Vassallo and Solino (2006) discuss minimum income guarantee implemented in Chile as one of mechanisms for traffic risk mitigation in concession agreements. This guarantee is determined by the government as the present value of 70% of the estimated investment cost plus the estimated operation and maintenance costs. Guarantee is optional and if concessioner decides to request the guarantee, than it would have to accept the clause about the extra revenue sharing, i.e. share of revenues that exceed the predefined threshold level. The trigger for the revenue sharing mechanism could be either the rate of return threshold (max internal rate of return of 15%) or “mirror line”. Two approaches are in use in Chile as the traffic risk mitigation strategies also: least present value of the revenues and the revenue distribution mechanism (Vassallo, 2006).

Investigating the nature of public-private partnerships, Yang and Meng (2000) developed a mathematical framework for feasibility assessment of a new project as a function of optimal capacity and a toll rate. Chen et al. (2001) extended this framework and included a simulation of a traffic demand as a random variable. A bi-level optimization program was used to formulate the financial analysis model. Addressing the planning decision process, Waller et al. (2001) evaluated the network assignment problem under uncertain demand. Chow and Regan (2009) use, as the key concept in a real options analysis for managerial flexibility in network investments, a stochastic process such as geometric Brownian motion to model future demand. Irwin (2003) assumed that the revenue of the toll road project can be modeled as a stochastic process.

3. OPTION VALUATION

For the public sector, the option to buyback the project is a right to acquire the project back to its ownership if the profit from its operation exceeds some predetermined level. In this case, the owner has a right to buy-back the project for some value and to continue to operate the project and collect all future revenues. Nevertheless, if the value of the project is considered to be a function of its future cash flows, the uncertain revenue that evolves over time stochastically causes the determination of the project’s value complicated. In this paper, new approach for the calculation of the project’s value is
proposed based on the Geman and Yor (1993) work. Project’s value at any given time during the concession period can be derived as the expected sum of future uncertain revenues.

Condition under which the option can be exercised is defined as an upper boundary and the average revenue (AR) over some time horizon is compared with this boundary. This approach overcomes the problem of yearly traffic volatility, hence revenues volatility risk. For considered period, AR is calculated using Monte Carlo simulation as the sum of the discrete values for yearly revenue for each simulated path and divided by the length of a time horizon. Once the value of the AR is evaluated and set, the next step is to, for those simulation paths for which forecasted revenue is above AR, compare the expected project value with the exercised price.

Project’s revenue is modeled as the stochastic process, i.e. geometric Brownian motion (Brandao and Saraiva, 2004; Huang and Chou, 2006). In that case, the revenue can be defined as:

\[ dR = \mu R dt + \sigma R dW_i \]

where \( R \) is the project’s revenue, \( \mu \) is a drift rate (trend), \( \sigma^2 \) is the variance, and \( dW_i = \epsilon_i \sqrt{dt} \) is a Weiner process where \( dt \) is time increment and \( \epsilon_i \sim N(0,1) \). The future revenue can be modeled by knowing its starting value \( R_0 \), the expected growth rate \( \mu \) and the volatility \( \sigma \).

Consider a time for which the average revenue value \( AR \) is calculated as \([0, t_i]\) and an upper bound as \( UB \). Option to buyback the project is considered to be a European barrier option (up-and-in) and it can be exercised at time \( t_i \). For each simulated path, if the AR for \([0, t_i]\) is above UB, the value of option is calculated as the call option comparing the expected value of the project for the remaining period and the exercised price. As mentioned earlier, following the Geman and Yor (1993) work, the expected value of the project \( E[PV]\) determined in the time \( t_i \) for the remaining period is:

\[ E[PV(t_i)] = \frac{4R(t_i) \exp\left(2h(v+1)\right)-1}{2(v+1)} \]

where

\[ h = \frac{\sigma^2}{4}(T-t_i) \]
\[ v = \frac{2\alpha}{\sigma^2}-1 \]

where \( T \) is a project’s service life and \( \alpha \) is a risk-adjusted drift rate. However, determination of the risk factor of the project’s revenue is a challenging task which is not analyzed in detail in this paper (see Brandao and Saraiva, 2004; Lara Galera and Solino, 2010). The value of the buyback option is calculated as:

\[ C = \max\left(E[PV(t_i)] - K_e, 0\right) | AR(t_i) > UB \], \( i = 1, ..., n \) \]

where \( K_e \) is the exercised price for the buyback option, \( C \) is the value of the option and \( n \) is the number of simulated paths. The exercised price is considered to be the cost of the initial investment in the project and operation and maintenance costs that have occurred in the mean time (Garvin and Cheah, 2004).

The paths in which the buyback option is in the money (expected project’s value is higher than the exercised price), the public sector can exercise the option. In those cases, the public sector expects...
that the project will generate more profit than the required payment for this option or the exercised price. The option valuation model is presented on Figure 1.

Let’s observe one path of all simulated revenue paths, i.e. path 1 on the Figure 1. After time $\Delta t$, when the option can be exercised, value of the $\overline{AR^1(\Delta t)}$ is determined for the period $[0,t_1]$ as an average of all revenues within that period:

$$\overline{AR^1(\Delta t)} = \frac{\sum_{i=0}^{[t_1]} R^1_i}{\Delta t}$$  

(4)

This average revenue is compared with the UB which is set in advance. Since the $\overline{AR^1(\Delta t)} > UB$, the option becomes alive. It will be exercised if it has positive payoff. For the given path 1, expected value of the project is determined from the Equation 2 and compared with the exercised price $K_c$. If the expected project value is higher than the $K_c$, the option will be in the money. The same process is used for all simulated paths, and the value of the option is determined as the average of all positive payoffs and zeros.

4. CONCLUSION

Lot of research is devoted to the development of models and tools for the valuation of government guarantees which protect the private sector from unexpected losses. In this paper, the valuation method for pricing the buyback option is developed as a risk mitigation strategy which provides flexibility to the public sector to return the project in the public ownership in the case when the revenue is higher than expected. Option is priced as the European call option.
Proposed model is based on the approach that the underlying asset for option’s pricing is an expected value of the project. Here, the project’s value at any given time during the concession period can be derived as the expected sum of future uncertain revenues which are modeled as a stochastic process, i.e. geometric Brownian motion. The mathematical foundation of the proposed model is presented here.

This approach as the revenue risk mitigation strategy has its limitations. When the project is transferred back under the public operational regime, additional costs for the public sector will occur such as project’s future operation and maintenance costs and remaining project’s debt. Further research is needed on integrating these costs in the pricing model.

REFERENCES


