REVISITING THE LPVR: A REAL OPTIONS APPROACH TO FLEXIBLE-TERM CONCESSION CONTRACTS

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Abstract

LPVR type of Auctions have been regarded as the best solution to demand risk sharing between concessionaire and regulators in infrastructure concessions. Yet implementation has been infrequent, mostly because of the strong opposition by concessionaires who do not see an equitable compensation for demand risk asymmetry. We review and analyze of all the aspects of LPVR auctions and other similar approaches of Flexible Term Concession (FTC), and propose a Real Options model that considers LPVR principles but treats uncertainties and flexibilities in a more informative and applicable way.

Keywords: concessions; real options; flexible-term contracts; infrastructure; auctions.

1. Introduction

The framework of Least Present Value of Revenue (LPVR) auctions (Engel, Fischer & Galetovic, 2001) proposes that instead of a reverse biding on tariff value or payment to the government, private firms should compete on the total present value of revenues the concessionaire will earn. The LPVR then states that as soon as this amount is reached, the concession term ends and the assets return to the government.

The stated intent of this proposal is to deliver the best solution for both parties involved (regulator and concessionaire) in infrastructure and highways concession auctions. In order to verify this, we should first investigate what both parties aim to achieve. Although may appear to be straightforward, we will see that it is in fact not, especially when we consider the regulator perspective. Once these interests are clearly defined, it is a good practice to verify whether LPVR truly optimizes both sides' interests in finding an optimized model for franchising auctions, and therefore allowing for a win-win partnership.

The concessionaire´s objective in participating in government infrastructure auctions is straightforward: it seeks to get return on its invested capital, while considering issues such as time frame of investment, and especially financial risk. This last issue, risk, may have several facets such as regulatory environment, demand uncertainty, political stability, etc. These generally translate into a risk adjusted discount rate, used to take investment decision with internal rate of return (IRR) or net present value (NPV). Other aspects that can influence this objectives, are generally related to option like flexibilities, such as government guaranties, entry and exit options, or strategic investment issues.

On the other hand, we have the government or its mandated branch (we will refer to it as the regulator). Its objective or utility is much subtler: it should aim specifically at public welfare. Yet, frequently, it uses a financial grant from the concessionaire as the decision bid yielding the concession to the higher value offered. Other auction forms are reverse toll level competitions where it seeks to determine the concessionaire candidate that will accept the lower income level for its investment. Others still consider a pre-defined toll but with the concessionary competing for the shortest term of concession, or for the highest payment to the government. In all these cases, the concession is granted to the candidate that accepts to receive the lower value of return, contrary to their own interest. When lowering this expected return in order to compete for the grant, companies may even enter a negative payback. Sometimes concessionaires ask that governments pledge guaranties against demand or commercial risks in order to participate in the auction.

LPVR proposal points out that these auction forms don´t allocate risk correctly between both parties and frequently contracts are renegotiated when, for instance, demand is lower than expected, affecting return for the concessionaire. The authors argue that LPVR guarantees the return for the concessionaire and at the same time maximizes the regulator utility: as soon as the concessionaire return is attained through the PVR, the grant goes back to the regulator and Bob´s your uncle. Some of the LPVR assumptions are reviewed in Nombela & Russ (2004), but the basic principles remain the same and their model also is hampered in its practical implementation. Also Vassalo (2010a) shows that LPVR scheme brings an asymmetry in risk profile since the upper positive tail of the return distribution is limited or caped while the lower tail is not. Therefore, the potential gains for the concessionaire are substantially limited while losses are not.

Thus, in this article, we discuss these assumptions and point out that several of the premises on which the LPVR is grounded are rather thorny to put together. We also propose a model that considers aspects of LPVR principles but treats uncertainties and flexibilities in a more practical and informative form that allows the model and exercise of real options, which do indeed bring an equilibrium model of risk allocation for both parties involved, fixing the asymmetry pointed out by Vassalo (2010a).

This paper is organized as follows: after this introduction we present a literature review covering applications and references of the model. In the following chapter, we comment and discuss on the principles and aspects of the LPVR model showing its advantages as well as implementation flaws. After this, we suggest a new approach that uses several aspects of the model but proposes diverse forms of modeling which can much more easily be put together and implemented. Finally, we discuss the approach and conclude.

2. Literature Review

Engel et al. (2001) are the first to show that fixed-term concession contracts do not allocate demand risk optimally. In this study, they propose the Least Present Value of Revenue (LPVR) auction, which optimally hedges the revenue uncertainty faced by the concessionaire by means of a flexible contract term. If demand is low, the term of the concession is extended, and if it is higher than expected the term is reduced. Nombela and de Rus (2004) extend the LPVR auction model and propose a new mechanism based on a flexible term contract and two-dimensional bids for total net revenue and maintenance costs, called Least Present Value of Net Revenue (LPVNR). Their results show that this mechanism allows to eliminate the risk of traffic and promote the selection of efficient concessionaires.

Vassalo (2010b) evaluates the effect that the LPVR discount rate, which is established by the government in the contract, has on the calculation of the traffic risk that is allocated to the concessionaire. Using a mathematical model, the author finds an inverse relation between these two variables and concludes that, although LPVR seems to be a very interesting approach, its practical implementation has been infrequent, mostly because of the strong opposition to LPVR by concessionaires. Rouhani, Geddes, Do, Gao, and Beheshtian (2018) review major revenue risk-sharing mechanisms developed world-wide. Regarding the LPVR approach, the authors state that this auction model allows to reduce the likelihood of renegotiations, but that it may not be as interesting when private operators are responsible for road quality or safety, since they are more willing to bear revenue risks in order to influence the level of road usage.

A research developed by Vassalo (2010a) shows that the main reason for the scarce implementation of flexible-term contracts lies in the strong opposition from the private sector to accept a mechanism whose risk profile is asymmetric, where the potential gains for the concessionaire are substantially limited while potential losses are not limited to almost the same degree. For example, among the 26 road projects that were granted in Chile until 2006, only four were tendered, and only two were successfully awarded under this approach (Vassalo, 2006). According to this author, the resistance to implement this mechanism occurs because, for the concessionaire, the LPVR does not improve the project's capacity to fulfill its commitments to the lenders; makes the concession operation difficult to organize; and, limits the positive profitability of the concessionaire.

Albalate and Bel (2009) compare the benefits of allowing for flexible-term contracts rather than fixing a rigid term in concession projects by using real data from the oldest Spanish toll motorways. Their results show that if there is an unexpected increase in traffic, the concession period will be shorter, which will drastically reduce the benefits of the private agent. Xiong, Zhang, and Chen (2015) address the issue of compensation to the concessionaire in an early-terminated concession through a compensation estimation framework and a corresponding mathematical model. The results show that this model can improve the accuracy of measuring uncertainties present in an infrastructure project and provide a fair compensation system to safeguard the benefits of both private and public agents.

Carbonara, Costantino, and Pellegrino (2014) argue that the determination of the concession period need to be managed in order to provide a beneficial condition for both parties involved in a concession. As a solution, they propose a model based on Monte Carlo simulation to determine the optimal concession period. Their results show that the concession period is able to guarantee a minimum profit and a fair risk allocation. Jin, Liu, Liu, and Udawatta (2019) also develop a model that uses Monte Carlo simulation to achieve this same objective. Their findings show that the optimal duration of a concession period should be long enough to control private investors' profit within a reasonable range while achieving a fair allocation of financial risk between governments and private investors.

In a work that specifically analyzes contract term extensions, Contreras and Angulo (2018) use real options approach (ROA) to determine the opportunity cost to the government of concession term extensions and conclude that these costs may be high in some cases. Besides contract term extensions, Xiong and Zhang (2014) also analyze two other compensation measures: toll adjustment and annual subsidy or unitary payment adjustment. The authors develop a quantitative compensation model to evaluate whether contract renegotiations are viable in concessions, considering that future traffic demand and operation and maintenance costs are stochastic variables. They conclude that the proposed model allows governments to compare different compensation measures and to select the most suitable for each concession project.

Jin, Liu, Sun, and Liu (2019) address the problem of optimizing the level of minimum revenue guarantees (MRG) and the length of the concession period to meet the interest of public and private parties in concession contracts. They propose an imperfect information trading model based on ROA and show that the length of the concession period is inversely proportional to the MRG level, and this correlation is influenced by the likelihood of reaching the equilibrium return rate of the investment. Lv, Ye, Liu, Shen, and Wang (2014) also develop a method that considers real options and game theory to determine the optimal concession period for BOT (build-operate-transfer) concession projects with government subsidies. Using a Chinese project as a numerical example, they find that this method allows to define the optimal concession period, especially when government subsidies are required to make the project financially viable.

Marques, Bastian-Pinto, and Brandão (2021) argue that flexible infrastructure contracts can overcome the difficulty of accurately forecast how market conditions and demand will evolve over the concession term. In this sense, they propose a model that combines capacity expansion decisions with conditional term extensions and model this flexibility under the ROA and the project value uncertainty as a Brownian Bridge. Their results show that these policies can be useful in attracting private investment in public infrastructure projects. Cruz and Marques (2013) also propose a real options model to evaluate the benefits of developing a flexible contract. They analyze the case of a hospital concession and verify that it is possible to find a contractual structure that maximizes the value for money when the uncertainties and flexibilities are taken into account in the project valuation.

3. LPVR model discussion

The authors of the LPVR proposal consider that, due to scarcity of resources, the government, or regulator, needs private investments for infrastructure construction, which are compensated by a tariff on the use of the concession once operational and for a defined time. They also assume that it has often been overlooked that medium and long-term traffic forecasts are very imprecise which leads to considerable demand uncertainty, most of it beyond the control of the concessionaire. Nevertheless, the model is built on a static level of demand throughout the term of the grant. They argue that the principles hold even if the demand is affected, and this premise is based on the principle of congestion tool. According to Engel et al. (2001):

> *"The congestion toll is the toll that induces drivers to internalize congestion optimally in the absence of a self-financing constraint."*

By this principle, the highway will always be used at its full capacity load, and this is achieved by setting the tariff at a level that will attract drivers to near congestion use. Being P^* the congestion toll and $Q(P)$ the corresponding demand, then the present value of revenues (PVR) can be defined by equation (1):

$$PVR = \int_0^T P^* Q(P) e^{-kt} dt \qquad (1)$$

This also assumes that the auction for the concession is competitive and the winner will have to accept the lower possible value of PVR and that this value is the amount expected to be invested in the concession, I. Therefore: $PVR - I = 0$.

The model considers that the highway will be built before demand Q reveals itself. But as the equilibrium above is to be kept ($PVR - I = 0$) then when bidding for the LPVR the candidate for the concession assumes the risk of over or under estimating the level of demand, and therefore the highway capacity to be built. That is, the value of I. The only contribution of the regulator at this level is that in the auction regulations, it sets the discount rate at which the revenues will be discounted as well as the levels of congestion tariff for different states of the demand.

Needless to say that the first flaw in this structure is that is ignores true cash flow structure of valuation, since Engel et al. (2001) assume that revenues are net for the concessionaire:

> *"Large fraction of the costs of the franchise are sunk when the road is built and before demand becomes known; operating and maintenance costs are comparatively small and are therefore ignored."*

Although this issue is partially corrected by Nombela and Rus (2004), these authors assume only fixed costs structure in their reviewed model called Least Present Value of Net Revenue (LPVNR), and propose that the above issue is corrected, transferring to the firms all the demand risk. They claim that:

> *"One of the most remarkable characteristics of the LPVNR auction is that firms do not need to rely on any traffic estimate to compute their bids. This eliminates the bias towards the selection of optimistic candidates detected in the traditional auctions for road concessions."*

Again, we find this unrealistic as on top of fixed costs, any infrastructure operation incurs in significant variable costs, income taxes, depreciation and maintenance investments which are necessary to the overcome depreciation as well as quality of the service rendered. We will show that only by considering fixed costs, the LPVR proposition of no risk for the concessionaire in the case of lower demand, and therefore longer term, is not true as this may yield a negative NPV while the biding proposition assumed at least a zero value NPV.

The principle of congestion tariff is also of difficult implementation as it implies in the following effect: if demand rises as an effect of greater welfare, the solution would be to rise toll, implying that the regulator proposes to squeeze augmented demand by increasing prices so as to keep congestion within the original road capacity. True welfare proposition would be, in this case, to expand road capacity while keeping tariff at and affordable level. On the other side of the demand spectrum, if demand reveals itself insufficient to cover the investment return, the concession will last forever. Again, this is not in the public interest and also not feasible for the private firm: in such a case, contrary to the LPVR calculation (remember it only considers Revenue) cash flows will probably be negative, or at least in present value, bellow the investment done. Therefore, no rational concessionaire will keep such a venture going on and will probably enter renegotiations.

4. A Real Options Approach to Flexible-Term Concession Contracts

We propose to develop a model that considers some of the positive aspects of LPVR or LPVNR but adjusted to more realistic implementation aspects.

Although demand Q is an important variable of any infrastructure investment, it is largely ignored ex-ante investment in the LPVR proposal. This is not only unrealistic but unpractical since projected road capacity is a direct result of Capital Investment and therefore will be the main driver of bid in any auction. We plan to use a stochastic model which can simulate possible paths of future realization. On a second level, the model will consider flexibilities as Real Options with which the concessionaire will react to demand, or market uncertainties, maximizing not only the concessionaire value but the regulator utility as well, as its main goal should be of providing infrastructure at the most adequate value or tariff. The main consequence of incorporating Real Options in a LPVR scheme of Auctions is to correct the asymmetry of demand risk pointed out by Vassalo (2010a) that appears to be the main reason for the strong opposition from the private sector to accept such a scheme.

5. Application

6. Conclusions

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