Capacity Expansion with Term Extension in Government Concessions: A Real Options Model

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Abstract

Infrastructure projects have as characteristics a long maturation period and high capital investments, which generates significant risks. Government Grants or Concessions, as well as Public Private Partnerships (PPPs), are usually bound by a time term defined in the contract, during which the private party must get its payback and return on invested capital. Although the objectives of both sides (public and private) are oppositely different, they need not be antagonistic as they both get to profit from the other in the project involved. When well designed, the contract rules should guarantee the smooth development of the concession, bringing about a win-win partnership. Capacity expansion, especially in infrastructure concessions such as roads, ports, trains, airports, among others, should be driven by the demand and decided by the concessionaire, since it is an intensive capital decision and is subject to a time frame limit. We argue in this research that in order to optimize such a financial decision, which finally should be beneficial to both parties involved, an investment in capacity expansion should not only be decided by the concessionaire, evidently under previously designed contract rules, but also permit extension of the time grant in order to turn it financially viable for the investor, even if close to the end of the contract term. In this sense, the purpose of this article is to model, through the real options approach, different policies of capacity expansion option in governmental concession grants

Keywords: Capacity Expansion; Real Options; Term Extension; Concessions.

1. Introduction

Infrastructure projects have as characteristics a long maturation period and high capital investments, which generates significant risks. Given the limited capacity of public funding and the worldwide tendency to grant to private initiative projects that can provide an adequate return to investors, a process of granting this class of projects to the private sector in Brazil began in the 1990s. Government Grants or Concessions, as well as Public Private Partnerships (PPPs), are usually bound by a time term defined in the contract, during which the private party must get its payback and return on invested capital. In order to decide its capital investment in a grant venture, a private investor considers expected return and risk of the sector, government and project, as well as income, costs, fiscal conditions and uncertainties involved. While the Government or Agency granting the concession has other utilities or goals: qualities of services rendered, tariff or price modesty, level of investment as well as commitment to limit the participation of other players in an area frequently seen as a natural oligopoly.

Although the objectives of both sides (public and private) are oppositely different, they need not be antagonistic as they both get to profit from the other in the project involved: the government agency aims at the public benefit from the investment to be executed by the private party and this latter at the return it will obtain from the service rendered in a sector protected from competition by the government grant. Evidently the private party will search to maximize its profitability bounded by the limits of the grant contract, while the government agency must in some way control and verify the service rendered as well as investment done, with a limit to the tariff that can be charged by the private party. All these rules and boundaries must be fixed and clearly defined in the grant contract at the start of the concession.

When well designed, the contract rules should guarantee the smooth development of the concession, bringing about a win-win partnership. But even with clear rules and limits, concessions frequently run into problems which may occur due to events or variables that were not be forecasted at the time of the grant. Due to the risks involved, many of these projects are not attractive to private capital. In this sense, some mechanism of risk mitigation by the granting authority is required to make these investments viable. One of the traditional forms of risk mitigation in infrastructure projects is to establish a collar option (for example, Minimum Revenue Guarantees – MRG), that is, public authorities undertake to compensate the concessionaire if the demand falls below a pre-established level, in the same way that the concessionaire transfers to the government any extraordinary gain if there is excess demand. This form of risk mitigation has been used in several projects, such as Chile (Engel, Fischer, & Galetovic, 1999), Colombia (Irwin, 2003), Korea (Jinyoung & Jinsu, 2014) and Brazil (Brandão, Bastian-Pinto, Gomes, & Labes, 2012).

The collar option mechanisms are relevant to attracting private initiative and mitigate government spending. The advantage of this type of mechanism is that it is more efficient for risk mitigation than non-recourse assets or fixed counter-payments (Brandão et al., 2012). On the other hand, these guarantees have the potential to generate a contingent liability for the public agent, which can be extremely costly if not properly priced and modeled, as occurred in the 1990s when road concessions generated an unplanned cost of $ 8.9 billion to the Mexican government. More recently, several PPP projects in Korea, such as the YongIn EverLine Project, the Incheon International Airport Expressway, and others, have been criticized because of the cost of MRGs granted to those projects (Jinyoung & Jinsu, 2014; Kim, Kim, Shin, & Lee, 2011).

Also, since one of the major uncertainties that may affect a concession project is the demand and, consequently, has a probability of underestimating in the long term, it is understood that the concessionaire may have an interest in expanding the capacity of the project. However, the existence of collar options as a risk mitigation mechanism generates a disincentive for the concessionaire to expand the marginal cash flows would no longer be captured exclusively by the private investor to be shared with the government.

Capacity expansion, especially in infrastructure concessions such as roads, ports, trains, airports, among others, should be driven by the demand and decided by the concessionaire, since it is an intensive capital decision and is subject to a time frame limit. We argue in this research that in order to optimize such a financial decision, which finally should be beneficial to both parties involved, an investment in capacity expansion should not only be decided by the concessionaire, evidently under previously designed contract rules, but also permit extension of the time grant in order to turn it financially viable for the investor, even if close to the end of the contract term. In this sense, the purpose of this article is to model, through the real options approach, different policies of capacity expansion option in governmental concession grants.

This article is organized in as follows. After this introduction, we review of the related literature in the field. In section 3 we present the common problems related to concessions and we propose a model to evaluate different policies of capacity expansion option with term extension. In section 4 we present an application in a real case to verify the validity of the proposed model, and in section 5 we conclude.

2. Literature Review

In the evaluation of projects, the Discounted Cash Flow (DCF) method is often used. This traditional method, although very robust, does not consider the managerial flexibilities and evaluates the project only based on the information known at the initial moment, ignoring possible changes resulting from a dynamic environment in which companies are inserted.

The Real Options Approach (ROA) arose as a response to the limitations of the traditional DCF model. This new approach adapts the financial options pricing models developed by Black and Scholes (1973) and Merton (1973), allowing the treatment of investment under uncertainty and flexibility. Tourinho (1979) was the first to use this method to assess an oil reservoir project under price uncertainty. McDonald and Siegel (1985), Titman (1985), Majd and Pindyck (1987) and Triantis and Hodder (1990) further developed the field by provided solutions to particular applications. A few years later, Dixit and Pindyck (1994) and Trigeorgis (1996) synthesize the main concepts and the possible applications of this methodology.

ROA has found several applications in infrastructure projects, such as transportation, roads, airports and highways. Bowe and Lee (2004), for example, analyze the construction of the Taiwan High-Speed Rail project, considering the expansion, postponement, abandonment, and contraction options. Their results suggest that management flexibility in the face of unexpected market developments is important to determine the economic feasibility of the project and confirm the theoretical result that the multiple options values will be non-additive if exercised in the presence of one another.

The first to determine the value of government guarantees was Charoenpornpattana, Minato, and Nakahama (2003). The authors model a minimum traffic guarantee as a bundle of independent European options and conclude that government guarantees should be carefully priced given their importance for project implementation. After this, several studies focused on different kinds of government guarantees. Huang and Chou (2006), for example, complement the analysis performed by

Bowe and Lee (2004), considering the minimum revenue guarantee and the option to abandon during the project pre-construction phase.

Brandão et al. (2012) analyze the Line 4 concession of the São Paulo Subway System and compare the results of the project valuation under the traditional DCF method with the real options approach. The authors study the impact that the capacity limitation of the line has on the project risk value and propose a model that considers different guarantees levels for each traffic band in order to minimize the risk of not realizing the estimated revenues.

Chiara, Garvin, and Vecer (2007) study a hypothetical case of a 30-year BOT (Build – Operate – Transfer) concession project, considering three different classes of discrete real options. Another BOT project which had traffic guarantees involved the construction of a new bridge between Malaysia and Singapore, and was analyzed by Cheah and Liu (2006) using the ROA. In this article, a model to evaluate the government guarantees as real options is proposed. The authors suggest that the option values should be incorporate into the negotiation framework and conclude that the guarantee value could indeed be significant relative to the initial net present value.

Brandao and Saraiva (2008) propose a model to estimate the value of an MRG for traffic volume in highway projects when this variable follows a GBM (Geometric Brownian Motion) process. Unlike the previous literature, the authors use market data to determine stochastic project parameters to estimate the guarantee value. Feng, Zhang, and Gao (2015) develop a model to evaluate the minimum revenue guarantee, the minimum traffic guarantee, and the price compensation guarantee, and thereby determined the optimal toll price on highway projects. In addition, the authors verify the impact of government guarantees on toll collection, highway capacity and road quality.

Attarzadeh, Chua, Beer, and Abbott (2017) develop a different approach by proposing a model to evaluate a revenue guarantee on PPP projects of plants with equitable limits. For this, the authors use the fuzzy technique to deal with the uncertainties involved in estimating cash flow. On the other hand, instead of proposing a revenue guarantee put option, which has a limitation due to an upfront premium payment requirement, Shan, Garvin, and Kumar (2010) suggest a collar option to improve the effectiveness of risk management in a real toll project and to redistribute downside losses and upside profits to fulfil stakeholders' needs.

Buyukyoran and Gundes (2018) propose a model to value MRG in a BOT toll road project, considering that future traffic demand is perceived as the most critical risk factor that affects the financial viability of the project. In this sense, they combine an optimization approach with MCS to identify the optimum upper and lower boundaries of options with the difference that here they were modelled as European call and put options. Takashima, Yagi and Takamori (2010) present a real options model for analyzing the interaction between a private firm and a government over the timing of the decision to invest in a PPP project, considering the degree of sharing in the cost of the investment and the operation risk. The results show that when the government guarantee is large and/or the cost sharing rate for the private firm is low, then the private firm-maximizing policy exercises the investment option earlier than the project value-maximizing policy.

Carbonara and Pellegrino (2018) develop a model based on the ROA to calculate the optimal revenue floor and ceiling values in a way that creates a win-win condition for the concessionaire and the government, fairly sharing the risk between them. The authors apply this model to the Strait of Messina Bridge case and conclude that this mechanism can support the decision-making process of the government in assessing the values of public subsidies necessary to make the project attractive to private investors and assist public and private parties during the negotiation in pursuit of fair floor values and revenue ceiling.

Wang, Liu, Xiong and Zhu (2018) investigate how distinct types of government support can attract more private investment. To do this, the authors analyze 4,484 PPP projects across 130 developing countries and the results show that capital, revenue and in-kind subsidies attract more private capital, while indirect supports through government guarantee policies do not. Besides, statistical analyses indicate that increased institutional quality of a country can enhance the positive relationship between government supports and private investment, especially for government direct supports.

Aside from the importance and contributions of all these works, there is a standard feature in all of them: they analyze the guarantees mechanisms without considering its disadvantages, such as: the potential to generate a contingent liability for the public agent and the disincentive for the concessionaire to expand the marginal cash flows. Therefore, the main contributions of this article are: evidence not only the advantages of using collar options, but also the negative points of this type of mechanism; and evaluate the different capacity expansion policies.

3. Model

In concessions, one of the main uncertainties that can affect the private agent investment return in both directions is the demand (*D*). This variable usually follows a Geometric Brownian Motion (GBM), as shown in equation (1) and has the behavior shown in Figure 1:

$$dD_t = \mu D_t dt + \sigma D_t dz_t \tag{1}$$

where: dD_t is the incremental variation of demand in the time interval dt; μ represents the expected growth rate of demand; σ is the demand volatility; and, $dz_t = \varepsilon\sqrt{dt}$ represents the standard increment of Wiener, where $\varepsilon \approx N(0,1)$.

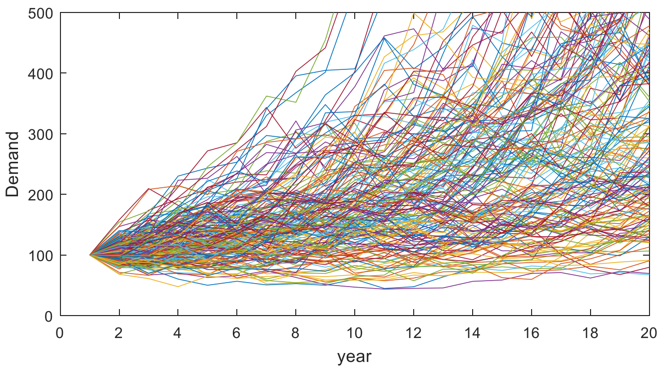

Figure 1 – Demand Simulation

In order to calculate the present value (*PV*) of concession projects that have the demand (*D*) as the main uncertainty, we use the following equation (2):

$$PV = \int_{t=1}^{n} E\left[f\left(D_t\right)\right] e^{-kt} dt \tag{2}$$

where PV is the present value of the concession project at time t = 0; $E[f(D_t)]$ is the expected value of the project's future cash flows, which are a demand function; k is the cost of capital (WACC); and, n is the concession term.

Since the demand (D) follows a GBM, we adopt the discrete binomial tree model proposed by Cox, Ross and Rubinstein (1979) (CRR). The model parameters are presented in equation (3):

$$u = e^{\sigma\sqrt{dt}}, \quad d = \frac{1}{u} \quad \text{e} \quad p = \frac{1 + r_f - d}{u - d} \tag{3}$$

where u and d are, respectively, the upside and downside factors; p is the risk neutral probability; σ is the demand volatility; and, r_f is the risk-free rate.

This option pricing model requires the use of the risk-neutral measure that can be determined by deducting the risk premium from the asset's rate of return and then discounting cash flows at the free rate of risk. Thus, the risk-neutral process of demand is defined by equation (4):

$$dD_t^R = (\mu - \zeta_D) D_t^R dt + \sigma D_t^R dz_t \tag{4}$$

where ζ_D represents the demand risk premium; μ is the rate of return of the demand; and, dD_t^R is the incremental variation of the risk-neutral demand in the time interval dt.

As discussed by Freitas and Brandão (2009), the market risk premium can be observed directly or can be determined through CAPM (Capital Asset Pricing Model), where $\mu = r_f + \zeta$ and $\zeta = \beta\left(E\left[R_M\right] - r_f\right)$. On the other hand, the risk premium of incomplete market assets, as is the case of this paper, can only be calculated through indirect methods.

To evaluate the demand risk premium, we consider that the expected value of gains in the risk-neutral valuation, regardless of possible options, should be strictly equal to the expected value of gains in the traditional static valuation, as shows the equation (5) :

$$\int_{t=1}^{n} f\left(D_t\right) e^{-\mu t} dt = \int_{t=1}^{n} f\left(D_t^R\right) e^{-(\mu - \zeta_D)t} dt \tag{5}$$

where $f(.)$ represents the cash flows.

In this sense, this model will consider the following risk neutral probability, defined in equation (6):

$$p = \frac{1 + \mu - \zeta_D - d}{u - d} \tag{6}$$

3.1. Base Case

Note, from Figure 1, that demand volatility can affect the private party investment return in both directions. If the demand reveals to be much less than expected, this will negatively affect the financial return of the subsidy, leading the private agent to abandon the concession, even with the financial consequences that may be imposed. On the other hand, if the demand reveals to be significantly above the expected trajectory will require capacity expansion from the concessionaire, with capital investments necessary in order to capture the upside and not cause demand bottleneck, which is an undesired effect for the agency grant.

We will model our theoretical framework considering a hypothetical road concession project with the following values listed in Table 1.

Table 1 – Concession data and values

Grant term	20 years
CAPEX	35 million $
Fixed cost	1 million $ (per year)
Variable cost	30% of revenue
Tax rate	34% (per year)
Depreciation	20 years
Tariff	5 $ (per vehicle)
Risk free rate	6.18%
Risk adjusted rate	8.33%
Road capacity	2,000 (thousand vehicles per day)

Since the demand (D) is our stochastic variable, we model this uncertainty as a GBM, using the values and parameters given in Table 2.

Table 2 – Stochastic Demand values and parameters

Initial value (in t = 0)	D_0	1,000 (thousand vehicles per day)
Demand drift	μ	6% (per year)
Demand Volatility	σ	15% (per year)
Lattice upside factor	u	1.1618
Lattice downside factor	d	0.8607
Demand risk premium	ζ_D	2.44%
Upside move probability	p	0.5809
Downside move probability	$(1-p)$	0.4191

Based on equation (2), we calculate that the present value of this concession project at time t = 0, without considering the road capacity limit, is PV = 37,076,000 $. We also estimate this value through a lattice, in which we first model the demand as a GBM. Then, we estimate a cash flow lattice, and finally, discounting this latter at the risk free rate and using the risk neutral adjusted probabilities, we estimate the project value lattice, which gives the same present value calculated above. The project value lattice is displayed in Figure 2.

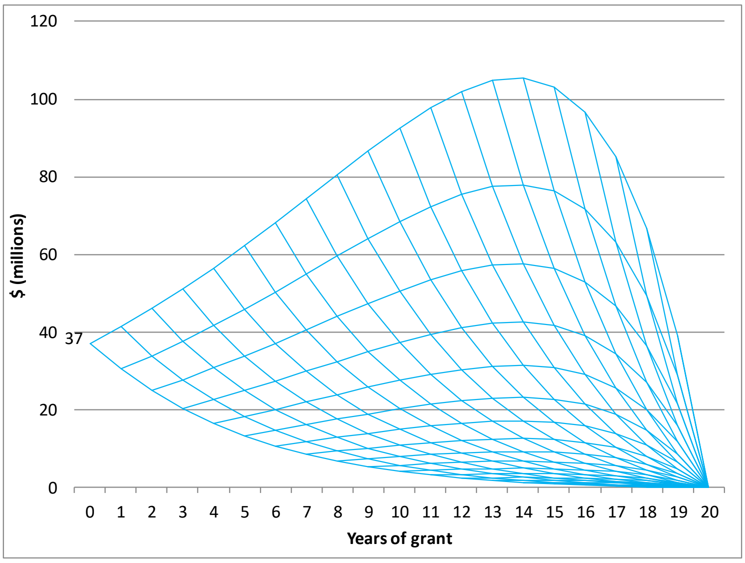

Figure 2 – Project value lattice without demand capacity limit

Note that this lattice is the discretization of a Brownian bridge, since the concession has a term limit after which there is no cash flow, it will forcefully end in zero value at the expiration of the term. Also, we can see that this lattice does not consider the road capacity limit as listed in Table 1.

Thus, when we take into account this cap on the road traffic, as an absorbing barrier, the lattice and the present value of this base case project change (PV = 33,264,400 \$), thus yielding a negative NPV. In Figure 3, we can see the lattice with and without capacity limit, as well as the present value in each case.

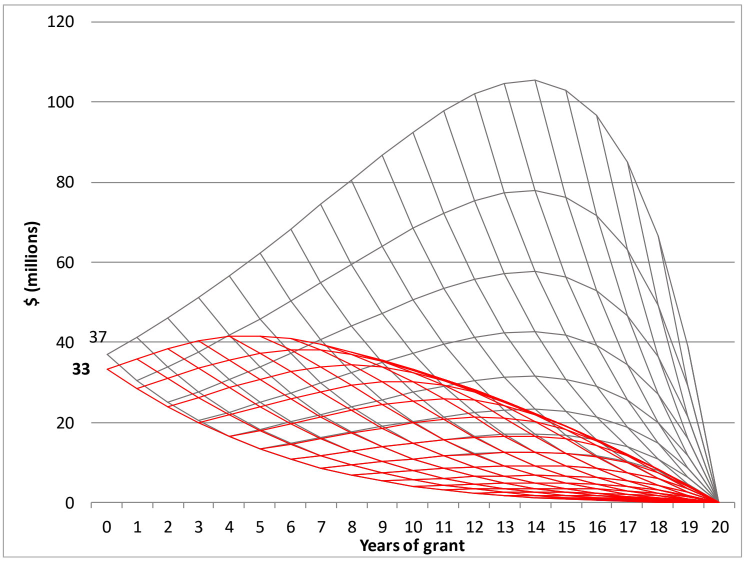

Figure 3 – Project value lattice (without demand capacity limit: -- | with demand capacity limit: --)

3.2. Capacity Expansion with Term Extension

Given that concessions generally expire after a time term specified in the grant contract, the closer the concession timing is to this term, the less time the investor will have to receive cash flows from any follow-up capacity expansion investments. Also, frequently, capacity expansions may be listed and included in the grant contract. But, it may prove useless to force an expansion either when there is no demand for such, or at a later time when the demand upside has already revealed itself in previous periods.

In order to verify the validity of this last statement, we analyze the case of a traditional capacity expansion option, that is, without the concession extension term. For this, we consider that the concessionaire has the option of investing $ 35 million (*Expansion CAPEX*) to have the right to increase the road capacity limit to 5,000 (thousand vehicles per day). As expected, we find that this option is not exercised at any time. Also, to make the analysis more robust, we vary the values adopted for the expansion option to verify their impact on the option exercise, but we find that the option will only be exercised at very low levels of *Expansion CAPEX* and road capacity limit, which is not realistic.

Therefore, the results show that this type of capacity expansion option is not optimal for both parties involved. In this sense, a possible solution for this is that the government, through the concession contract, allows the private agent to have the option of extending the concession term to encourage their investment in capacity expansion. The capacity expansion with term extension can be implemented through different policies.

3.2.1. Fixed Term Extension Simultaneous with Capacity Expansion Policy

The first policy proposed in this paper establishes that the term extension is fixed (equal to the grant term, that is, 20 years) and occurs at the time of the investment in capacity expansion. For model this policy, we use the CRR binomial model and calculate the perpetuity limited in *t* years through equation (7):

$$PV_\tau = \int_\tau^{\tau+n} E\left[f\left(D_t\right)\right] e^{-kt} dt \tag{7}$$

where PV_τ is the present value of the perpetuity limited in *n* years, which is the concession term.

Since we will use a discreet model, we will use the equation (8) to calculate the present value of the perpetuity limited in *n* years:

$$PV_t = \frac{E\left[f(D_{t+1})\right]}{k-\mu}\left(1-\left(\frac{1+\mu}{1+k}\right)^n\right) \tag{8}$$

where PV_t is the present value of the perpetuity limited in *n* years, which is the concession term; and, $E[f(D_{t+1})]$ is the expected value of cash flow at time $t+1$.

Figure 4 presents the results obtained with the implementation of this first capacity expansion policy.

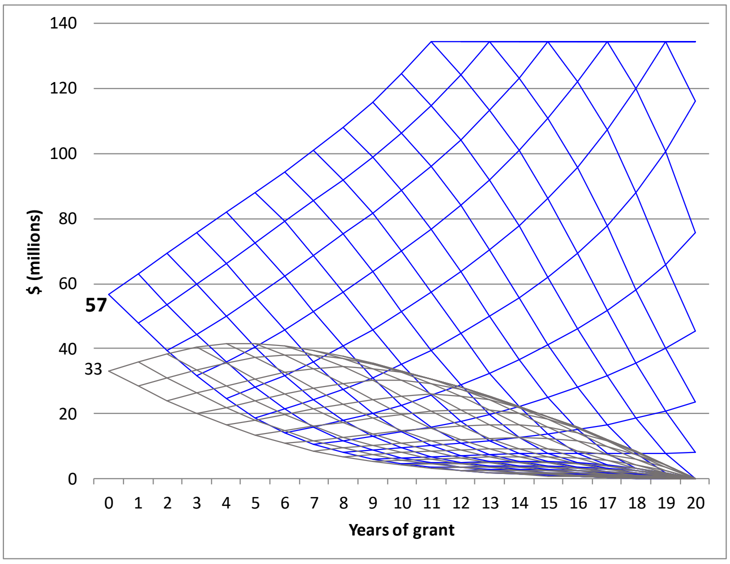

Figure 4 – Project value lattice (with fixed term extension at the time of capacity expansion: -- | with demand capacity limit: --)

Note that, by adopting this first policy, the present value of the concession becomes equal to *PV* = 56,722,000 \$. In this sense, the implementation of this first policy generates an increase of 70.52% in the *PV* of the concession project.

3.2.2. Fixed Term Extension Additional to Concession Term Policy

On the other hand, the second policy proposed in this article establishes that the term extension is fixed (equal to the grant term, that is, 20 years) and additional to the pre-established term of the concession. In this case, we also use the CRR binomial model and calculate the perpetuity limited in *n* years through equation (8). Figure 5 presents the results obtained with the implementation of this second capacity expansion policy.

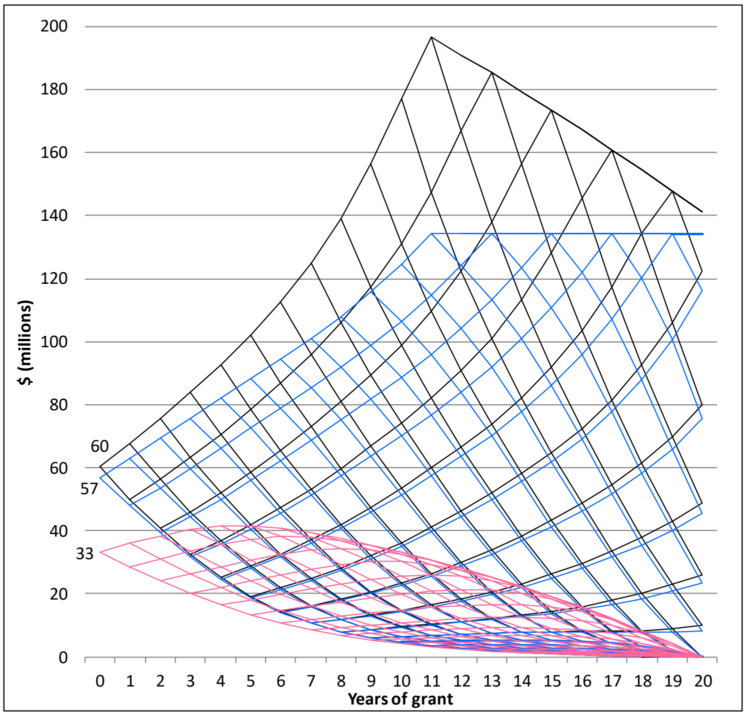

Figure 5 – Project value lattice (with fixed term extension additional to grant term: -- | with fixed term extension at the time of capacity expansion: -- | with demand capacity limit: --)

Observe that the present value of the concession becomes equal to *PV* = 60,290,000 $. Thus, the implementation of the second policy generates an increase of 81.24% in the *PV* of the concession project.

Comparing the two proposed policies, we can see that the latter beyond increasing the present value also works as an incentive to anticipation the exercise of the expansion capacity option since the concessionaire will try to maximize the number of periods of his grant with increased cash flow. Note that the variable that guides the expansion decision is the present value of the concession project, but the variable that guides the option exercise is the demand.

From the two proposed policies, we can conclude preliminarily that both are extreme policies developed to promote the expansion capacity option, besides we find that they add value to the concessionaire and to the government when compared to the traditional capacity expansion option, mentioned in the base case. Other policies can be proposed in this context and it is the authors' objective to continue developing this study.

4. Application in a Real Project

The next steps in this research are related to applying the proposed model in a real concession project. We will use the case of the first Brazilian project between the government and the private sector, the Line 4 of the São Paulo Subway System (or Yellow Line). This concession, which provided for investments in 12.8 km of the line for 30 years, was signed in November 2006 by the government of the São Paulo and a consortium led by Road Concession Company and has been the subject of real options studies (Brandão et al., 2012).

5. Conclusions

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