EVALUATION OF FLEXIBLE CONCESSION CONTRACTS

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Abstract

Several infrastructure concession contracts have shown flexibility in their clauses, whether through demand guarantees, capacity expansion options, or even through options to expand capacity linked to a term extension. In this sense, this article evaluates and analyzes a Brazilian concession contract that has these three flexible clauses under the real options approach. The idea is to verify if all of these clauses are beneficial to the government and the private investor. Our results show that when we consider only the demand guarantees and the natural capacity limit of the concession (cap), the project has a negative net present value. When we consider the option to expand capacity in addition to the demand guarantee clause, we find an insignificant improvement in the project's value. However, when we consider the option to expand capacity coupled with a conditional term extension besides the demand guarantee clause, we find a flexible concession contract format that appeals to both parties involved, as it generates a significant increase in the project's value.

Keywords: Concession contracts; Demand guarantees; Real options; Capacity expansion; Term extension.

1. Introduction

Infrastructure projects are characterized by a long maturity period and high capital investments, which creates significant risks. Given the limited financing capacity of the government and the worldwide tendency to grant infrastructure projects to private initiative, aiming to provide an adequate return to investors, a process of granting this class of projects to private sector began in the 1990s in Brazil.

However, 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 the Minimum Revenue Guarantee (MRG), where public authorities undertake to compensate the concessionaire if the revenue falls below a pre-established level. Also, it is common in these cases to establish a revenue ceiling, above which the concessionaire passes on to the public agent any extraordinary gains if there is an excess of revenue. This form of risk mitigation has been used in several concession contracts in Brazil, such as in the contracts of some lines of the São Paulo Subway and Monorail Systems and the Salvador Monorail System (Brandão, Bastian-Pinto, Gomes, & Labes, 2012; Sinergia, 2019; SEDUR, 2019).

Besides, in countries where transportation infrastructure is lacking or underdeveloped, newly built facilities tend to attract and increase demand. This can lead to cases where future demand levels exceed the capacity limit of the concession, which may require further investments in capacity expansion. This possible need for expansion has also been included in several concession agreements in Brazil, either through mandatory clauses such as in the contracts of the Rio de Janeiro International Airport and of some highways; either through flexible clauses, as in the contract of the Salvador Monorail System (Marques, Brandão, & Gomes, 2019; SEDUR, 2019; ANTT, 2019).

Since the guarantees mechanism and the managerial flexibility to expand capacity have the characteristics of options for the investor, their values cannot be determined through traditional methods of project evaluation, it becomes necessary to use options pricing tools, such as the Real Options Approach (ROA). In this perspective, the purpose of this article is to evaluate and analyze a Brazilian concession contract that has guarantees and expansion options in its clauses. The idea is to verify whether they are beneficial policies for the government and the private investor.

This article is organized as follows. After this introduction, we present a review of the related literature in the field and in section 3 we present a typical concession contract practiced in Brazil. In section 4 we develop a model to evaluate and analyze the clauses present in this type of contract and an additional clause suggested in this study. In section 5 we present a numerical application and discuss the results. Finally, we conclude.

2. Literature Review

The realm of infrastructure investment analysis has been an active field of research in the last decades. The Discounted Cash Flow (DCF) is the most common method to evaluate an infrastructure project. However, thanks to the seminal work developed by Black and

Scholes (1973) and Merton (1973) for the pricing of financial options, new methods that applied these concepts to the valuation of real assets under uncertainty and flexibility were developed, such as the Real Options Approach (ROA).

Over the past two decades, ROA has found many applications in infrastructure projects. Alonso-Conde, Brown and Rojo-Suarez (2007), for example, used this valuation tool to calculate government guarantees set in the Melbourne CityLink project and to analyze whether these guarantees affect investment incentives and whether the public sector may be transferring considerable value to the private sector. Brandão and Saraiva (2008) also evaluated government guarantees in a PPP project. For this, the authors considered market data from the BR-163 highway project and proposed a MRG model in order to assess the impact of government guarantees on project risk and the expected value of the resulting government liability.

Huang and Chou (2006) complemented the analysis of the Taiwan High-Speed Rail project performed by Bowe and Lee (2004), considering the MRG risk mitigating mechanism and the option to abandon during the project pre-construction phase. Their results showed that when the MRG level increases, the value of the abandon option decreases, and that at a certain MRG level, the option to abandon will be rendered worthless. Chiara, Garvin, and Vecer (2007) analyzed a BOT (Build-Operate-Transfer) project, but considering that the government guarantee is a Bermudan or a simple multiple-exercise real option, depending on the number of exercise opportunities offered. They used the multi-least-squares Monte Carlo technique and found interesting results to improve risk mitigation and facilitate contractual and financial negotiations of BOT projects.

Attarzadeh, Chua, Beer, and Abbott (2017) were also concerned with the issue of effectively mitigating the impact of revenue uncertainty on BOT projects. In this sense, they proposed a model for calculating equitable limits for guaranteed revenue for the private agent. The authors applied their model to a freeway PPP project and a power plant PPP project in Iran. Their findings showed that the proposed systematic negotiating mechanism provides benefits to both the public and private sectors. Brandão et al. (2012) evaluated another kind of government guarantee: the Minimum Demand Guarantee (MDG). The authors studied the Line 4 of the São Paulo Metropolitan Subway System and determined how different guarantee levels for each demand bands impact the risk and value of the project.

Buyukyoran and Gundes (2018) proposed a model to evaluate the MRG in a BOT toll road project, considering that future demand is the most critical risk factor that affects the financial viability of the project. In this sense, they combined an optimization approach with MCS (Monte Carlo Simulation) to identify the optimum upper and lower boundaries of guarantees. In a similar way, Carbonara and Pellegrino (2018) developed a model to calculate the optimal revenue floor and ceiling values in a way that creates a win-win condition for the concessionaire and the government. The authors applied this model to the Strait of Messina Bridge case and concluded 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.

Ashuri, Lu, and Kashani (2011) used ROA to evaluate investments in toll road projects delivered under the two-phase development plan. The authors applied the risk-neutral binomial lattice model to analyze the demand uncertainty and to find the optimal time for the toll road expansion. Their results showed that a flexible two-phase development plan can improve the investor's financial risk profile in the toll road project. Marques et al. (2019) used the case of the Rio de Janeiro International Airport concession to also analyze expansion options. The authors chose this project as this airport had significant potential for future expansion, which could justify it presenting the highest auction bid premium of the Brazilian government's airport privatization program. Their results showed that even considering the value of expansion options they are not sufficient to justify the bid premium offered.

Another study that evaluated expansion options was that of Zhao and Tseng (2003). In this study, the authors proposed a model of the foundations versus flexibility trade-off that enables the competing options to be optimized by balancing the expected profits that may arise from future expansion. They applied their model to the construction of a public parking garage and, through stochastic dynamic programming, they determined the optimal expansion process and found that this flexibility adds a significant value to the project. Bastian-Pinto, Marques, Brandão, and Igrejas (2019) proposed and evaluated different public policies involving capacity expansion option considering contract term extension and showed that a contract with a flexible expansion clause coupled with a conditional term extension has some advantages over current policies. In this sense, they concluded that flexible infrastructure contracts can overcome the difficulty of accurately forecast how market conditions and demand will evolve over the concession term.

3. A Typical Brazilian Concession Contract

A Brazilian concession contract typically has a 20-year term and allows the concessionaire to remunerate itself through tariff revenues, public consideration and non-tariff revenues from the commercial operation of stores, kiosks, cafeterias, convenience machines, restrooms; and, commercial exploitation of advertising and communication space. Besides, Brazilian concession contracts, generally, include several flexibilities.

One of these flexibilities is the risk mitigation mechanism, known as demand guarantee. Most Brazilian concession contracts provide for the sharing of the risk of variation in projected demand between the public and private agents since the beginning of the complete operation of the concession. Generally, these contracts have clauses that state that the concessionaire will receive a compensation whenever the actual demand $\left(D_\tau^A\right)$ fell below a certain percentage of the projected demand for the period $\left(D_\tau^P\right)$. Likewise, if D_τ^A is above a certain percentage of D_τ^P, the concessionaire will have to hand over part of this gain to the government.

Another common flexibility is the option to expand capacity. Typically, Brazilian concession contracts are based on a two-phase development plan, where the first phase is mandatory and the second is optional. The exercise of the latter will depend on the results found in the feasibility studies carried out by the concessionaire. In addition, Brazilian concession contracts also have term extension clauses linked to capacity expansion. Generally, these clauses allow for a 10-year term extension, which can result in a 30-year term contract.

Next, we will propose a model under the real options approach to evaluate these three contractual clauses.

4. Model

We propose a model for the investment decision in concessions that establish in their contracts different managerial flexibilities, such as demand guarantee and expansion option. We consider that the main source of uncertainty that affects the private agent investment returns and investment decision is the demand. In this sense, we can calculate the cash flow in each year through equation (1):

$$F_t = \left[R_t\left(1-\gamma_t\right)-\delta-\Gamma\right]\left(1-\pi\right)+\delta \tag{1}$$

where γ_t represents variable costs; π is the income tax; δ is the depreciation and Γ represents fixed costs. To simplify the cash flow equation, we consider that $F_t = f\left(D_t\right)$. Thus, to calculate the present value of concession projects that have the demand D as the main uncertainty, we use equation (2):

$$V_0 = \int_{t=1}^{n} f\left(D_t\right)e^{-kt}dt \tag{2}$$

where V is the present value of the concession project at time t = 0; $f(D_t)$ 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.

As is standard in the literature (Iyer & Sagheer, 2011; Li & Cai, 2017), we assume that the demand follows a Geometric Brownian Motion (GBM), as shown in equation (3):

$$dD_t = \mu D_t dt + \sigma_D D_t dz_t \tag{3}$$

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

To calculate this uncertainty, we use the discrete binomial tree model of Cox, Ross, and Rubinstein (1979) (CRR). The model parameters for this model are presented in equation (5):

$$u = e^{\sigma_D\sqrt{\Delta t}}, \quad d = \frac{1}{u} \quad \text{and} \quad p = \frac{\left(1+r_f\right)^{\Delta t} - d}{u-d} \tag{4}$$

where u and d are, respectively, the upside and downside multiplying factors; p is the risk-neutral probability; σ_D is the demand volatility; r_f is the risk-free rate; and Δt the discrete-time increment.

Additionally, 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 risk rate. Thus, the risk-neutral process of demand is defined by equation (5):

$$dD_t^R = (\mu - \zeta_D) D_t^R dt + \sigma_D D_t^R dz_t \tag{5}$$

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

According to Freitas and Brandão (2010), the value of ζ_D must be estimated numerically. In this sense, 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 (6):

$$\int_{t=1}^{n} f\left(\tilde{D}_t\right) e^{-\mu t} dt = \int_{t=1}^{n} f\left(\tilde{D}_t^R\right) e^{-(\mu - \zeta_D)t} dt \tag{6}$$

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

Thus, this model will consider the following risk neutral probability *p**, defined in equation (7).

$$p^* = \frac{\left(1 + \mu - \zeta_D\right)^{\Delta t} - d}{u - d} \tag{7}$$

Considering this risk neutral probability, we initially model the demand lattice and the equivalent cash flow lattice. Then, we determine the lattice that represents the project value $\left(V^R\right)$ over time through the discounted future cash flows of the cash flow lattice. Thus, under the discrete model, if the concession term is *n*, then the project value at time *n-1* can be determined by equation (8):

$$V_{n-1}^R = \left[F_n^+ p^* + F_n^- \left(1 - p^*\right)\right] / (1 + rf) \tag{8}$$

Generalizing this process for $t < n - 1$, we arrive at equation (9). Note that the value lattice ends at time *n* with no continuation value, because it will converge to zero in the end in the case of a fixed time term grant, representing a Brownian Bridge.

$$V_{t-1}^R = \left[\left(F_t^+ + V_t^+\right) p^* + \left(F_t^- + V_t^-\right)\left(1 - p^*\right)\right] / (1 + rf) \tag{9}$$

After presenting how we model the base case scenario, that is, the case that considers the demand uncertainty, but no flexibility, we will show how the flexible contractual clauses should be evaluated.

4.1. Guarantee Clause

The guarantee clause should be analyzed as a bundle of European options with maturities between 1 and 20 years. The minimum demand guarantee is modeled as a series of Put options, while concessionaire obligations to turn over excess demand are modeled as Call options in favor of the government. The valuation process assumes that at each time $t = \tau$ the optimal decision will be made considering the demand guarantee compensation levels shown in Table 1:

Table 1 – Demand guarantee compensation levels

Actual Demand $\left(D_\tau^A\right)$	Demand Compensation $\left(D_\tau^A\right)$
$75\%\ D_\tau^P \le D_\tau^A \le 125\%\ D_\tau^P$	$D_\tau^M = D_\tau^A$
$D_\tau^A < 75\% D_\tau^P$	$D_\tau^M = 0.3\left(0.75 \times D_\tau^P - D_\tau^A\right)$
$D_\tau^A > 125\%\ D_\tau^P$	$D_\tau^M = 0.3\left(D_\tau^A - 1.25 \times D_\tau^P\right)$

4.2 Flexible Capacity Expansion Clause

The flexible capacity expansion clause should be evaluated as an American call option. For this, we consider a fixed-term concession with a demand capacity limit $D_{\max 1}$, where the concessionaire has the option to expand capacity at any time during that period. In this sense, there will be a demand absorbing barrier or cap ($D_{\max 1}$), which is represented by a percentage (ψ) of the initial demand (D_0). As the cash flows generated by the project are a direct function of $\tilde{D}$, these will also be limited to an upper level: $F_{\max 1} = f\left(D_{\max 1}\right)$. So, if $F_t > F_{\max 1}$, then $F_t = F_{\max 1}$.

Denoting the time t project value with an expansion option at by $V_{t_{\exp}}$, the value of this option is conditioned to the optimal exercise of the expansion. In this sense, the expansion option value is expressed by equation (10):

$$V_{t_{exp}} = \max\left[V_t^R ; V_t^* - I_t\right] \tag{10}$$

where V_t^R represents the risk-neutral present value of the project at t without considering any options; V_t^* is the present value of the project cash flows after expansion in time t, and I_t represents the expansion *CAPEX*.

The project cash flows, after expansion, are no longer limited to the original cap ($D_{\max 1}$), but to a new higher capacity limit ($D_{\max 2}$), which is represented by a percentage (ς) of $D_{\max 1}$. This also implies a new limit for expanded cash flows (F_t^*): $F_{\max 1} < F_t^* \leq F_{\max 2}$. As well as the demand cap, we also reallocate the demand guarantee compensation levels by multiplying the capped original levels by ς, which we call the second capacity clearance factor.

In addition, we consider that there is a time to build for the expansion of one period, during which the project will receive the maximum level of cash flow prior to expansion $(F_{\max 1})$. Therefore, under the discrete model, we use equation (11) to determine the present value of the expanded cash flows at time t. Note that these will grow at μ, for n-(t+1) years and are discounted at k up to time t:

$$V_t^* = \frac{F_t^*}{(k-\mu)(1+k)}\left[1-\left(\frac{1+\mu}{1+k}\right)^{n-(t+1)}\right] + F_{\max 1} \tag{11}$$

4.3 Capacity Expansion with Term Extension Clause

Next, we extend this last framework to a clause that allows flexible capacity expansion conditioned to an extension of the concession term. We consider a fixed term extension equal to half the initial grant term of n years in addition to the original term of the concession is earned if the expansion occurs within the original term. Therefore, if the concessionaire decides to expand at any time $t \leq n$, it will have a total term of $n + n/2$ number of year of concession.

In this sense, the present value of the expanded cash flows at time t is now changed to equation (12):

$$V_t^* = \frac{F_t^*}{(k-\mu)(1+k)}\left[1-\left(\frac{1+\mu}{1+k}\right)^{n-(t+10-1)}\right]+F_{\max 1} \tag{12}$$

5. Numerical Application

In order to evaluate our model, we use a 20-year concession project as a numerical application, considering the parameters listed in Table 2:

Table 2 – Concession parameter and data

Grant term (n)	20 years
CAPEX	USD 375 million
Expansion CAPEX	USD 47 million
Fixed cost (Γ)	USD 25 million per year
Variable cost (γ)	11% of revenues
Tax rate (π)	34%
Depreciation (δ)	20 years
Tariff	USD 3.00
Risk-free rate (r_f)	4.08% per year
Risk-adjusted rate (k)	5.55% per year
First Yearly Maximum Demand Capacity ($D_{\max 1}$)	25,232,000
Second Yearly Maximum Demand Capacity ($D_{\max 2}$)	37,848,000
First Capacity Clearance Factor (ψ)	125%
Second Capacity Clearance Factor (ς)	150%

Since demand for infrastructure capacity tends to be correlated to GDP growth in developing economies, we model this uncertainty as a GBM as shown in Figure 1, using the values and parameters in Table 3.

Table 3 – Stochastic Demand values and parameters

Initial Annual demand	D_0	20,186,000
Demand drift (growth)	μ	1.78% (per year)
Demand Volatility	σ_D	8.00% (per year)
Demand risk premium	ζ_D	1.07% (per year)

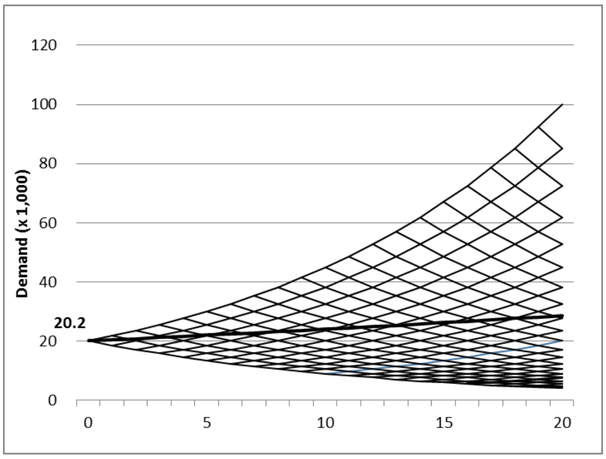

Figure 1 – Annual stochastic demand projection showing expected demand starting at 20.2 million.

Using equation (2), we determine under the DCF method that the value of this concession project at time $t = 0$ is $375.0 million, which yields a Net Present Value (NPV) equal to zero. We also estimate this value with a CRR lattice by stochastically modeling the demand as a GBM. The project value lattice is shown in Figure 2. As expected, this provides the same project value as the DCF method as this model presents no flexibility. Note that this type of project value lattice is the discretization of a Brownian Bridge, as the concession has a term limit after which there are no more cash flows.

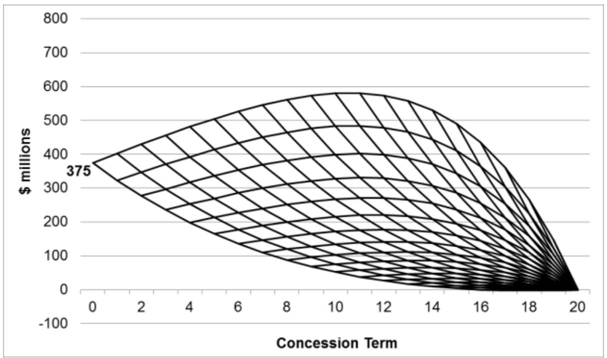

Figure 2 – Project value lattice

After this, we incorporate the first flexibility: the demand guarantee clause. We follow the compensation scheme shown in Table 1 and the results show that the adoption of this mechanism mitigates the risk of both the concessionaire and the government, as it eliminates part of the effect of demand volatility, as shown in Figure 3. In this sense, when we consider this clause, the value and the NPV of the base case scenario is increased to $399.2 million and $24.2 million, respectively.

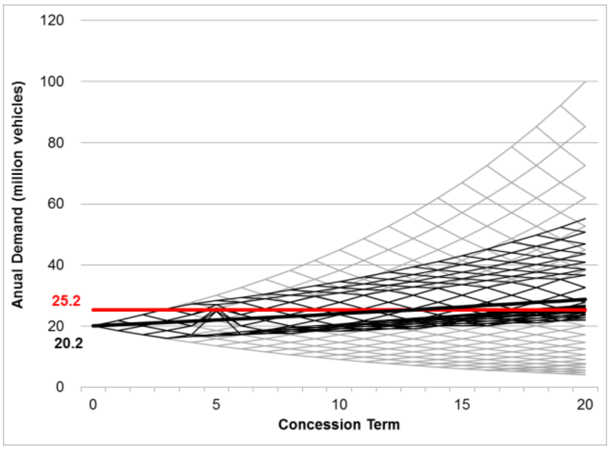

Figure 3 – Annual stochastic demand projection showing expected demand starting at 20.2 million and the capacity limit of 25.2 million (125% of initial demand) with demand guarantee compensation scheme (black) and without it, that is, the base case scenario (gray).

Given that actual demand is limited to the demand capacity as shown by a red line in Figure 3, total yearly demand is actually limited to 25.2 million per year. Thus, when we consider this absorbing barrier, the project value is reduced to $371.2 million, which makes its NPV negative and equal to -$3.8 million. The evolution of the project value lattice considering this cap is shown on the right of Figure 4. We can note that the difference in value when the demand absorbing barrier is taken into account is approximately $28.0 million.

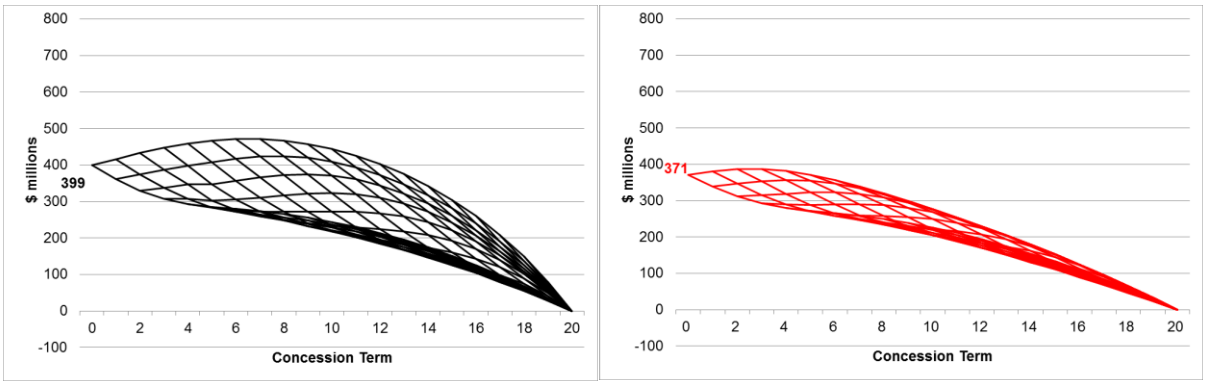

Figure 4 – Project value lattice without demand capacity limit (left) and project value lattice with demand capacity limit (right), illustrating how the absorbing barrier of the capacity limit reduces the actual value of the concession.

We now analyze the second flexibility: the capacity expansion clause, where the concessionaire´s investment decision will be based simply on whether the expansion will create value to the firm. Figure 5 shows that the option to expand increases the project value from $371.2 to $371.4 million, which indicates that the probability that the expansion option will be exercised is low.

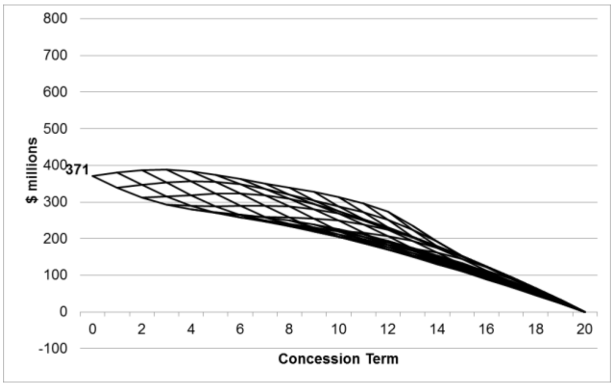

Figure 5 – Project value lattice for capacity expansion option during the original concession term.

These results show that this scenario does not guarantee that the expansion will take place within the concession contract term. Therefore, additional benefits must be provided to the concessionaire in order for this investment to take place.

Finally, we analyze the third clause, which allows the conditional extension of the contract term in order to encourage the investment in capacity expansion. Thus, the contract will no longer be bound to the original term time limit, the project value lattice will continue beyond that point, which implies the crossing of the Brownian Bridge.

This clause provides the concessionaire a fixed 10-year extension of the contract term, if the concessionaire invests in the expansion at any time during the first 20 years. Figure 6 indicates that the value of the concession is equal to $465.1 million, which represents an increase of 25.3% over the scenario that considers the guarantee and cap of demand.

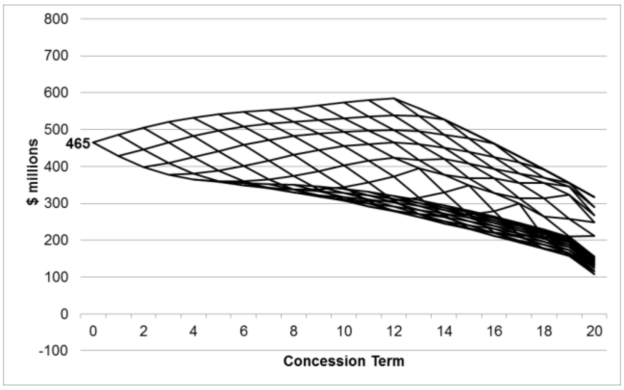

Figure 6 – Project value lattice with a 20-year fixed term extension conditional on the 10-year term extension, totaling 30 years.

6. Conclusion

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