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Valuation of the option of early reversion in road concessions

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In recent years there has been an increase in the interest in contractual flexibility in infrastructure investments, especially in Public-Private Partnership agreements, characterized by the uncertainty derived from the long duration of contracts. This has led to the extension of the theory of real options to the field of infrastructures, as an appropriate methodology for analyzing flexibility in contracts. Within this line of research, this paper focuses on the analysis of the option of early reversion of road concessions, as a right held by the Public Administration and whose value depends on the evolution of a random variable, the volume of traffic. The real option approach is applied to the case study of a road concession in Spain, consequently obtaining significant values for the probability of exercising the option. More generally, this paper contributes to characterizing the early reversion option as a practical tool that can be used by the Administration for the implementation of the infrastructure policy.

Keywords: *concession reversion; public procurement; real options; road concession.*

1. Introduction

The growing demand for road infrastructure in many countries, both for new projects and for the modernization of existing infrastructures, is increasing the use of concession contracts by Public Administrations to channel private participation in projects. In this type of contracts, the private partner is responsible for the construction of the infrastructure, and then for the operation during a certain period. In general, the Public Administration retains the legal ownership of the property that is returned to the Administration at the end of the concession period.

Road concession contracts regulate a complex and temporally long relationship, generally of more than 20 years, between the Public Administration and the private partner. Typically, the concession period includes the design of the infrastructure, the construction phase, the operation phase and, finally, the return of the assets to the Administration. During such a long period, there are numerous possible events not initially foreseen by the contracting parties. For this reason, the concession contracts establish, among other aspects, the distribution of risks between the Administration and the concessionaire throughout each of these phases. In particular, one of the

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most important risks in the case of road infrastructures is traffic risk (Flyvbjerg et al., 2005; Bain, 2009), taking into account that the concessionaire's remuneration is often based on the use of the infrastructure.

Although in concession contracts traffic risk is normally attributed to the concessionaire, it is also usual to include clauses in concession contracts to mitigate such risk, by redistributing it between the Administration and the concessionaire (Chung et al., 2010). Among the risk-sharing mechanisms that are common in concession contracts are the establishment of guaranteed minimum traffic, traffic caps above which the concessionaire does not receive additional revenues, a subsidy from the Administration linked to traffic, public participation loans whose remuneration is also linked to traffic, early reversion of the concession, early withdrawal by the concessionaire or the extension of the concession period (Lara Galera and Sánchez Soliño, 2010).

The development of a rigorous procedure to carry out the assessment of this kind of mechanism will achieve greater transparency in concession contracts, given the current situation in which many contract clauses are applied by the parties to the contract, but only with a limited, and sometimes only qualitative, knowledge of the contract consequences. However, calculating the value of risk-sharing mechanisms is a complex problem, since that value will depend fundamentally on a random variable, the traffic volume, which will need to be addressed. In this case, the greatest difficulty of traditional valuation methods, based on the discounting of cash flows, is the choice of the appropriate discount rate, since this is affected in turn by the presence of the risk-sharing mechanism itself. For this reason, the application of the real options approach to the valuation of infrastructure concessions was extended in recent years. The real options method was developed under the assumption of risk neutrality, which avoids the problem of having to choose the discount rate (Lara Galera and Sánchez Soliño, 2010; Ashuri et al., 2012; Pellegrino et al., 2013).

The real options approach is an extension of the theory of financial options to real assets. The theory of financial options has led to the development of methods of valuation of derivative assets based on the evolution of the value of an underlying asset, for example, the price of a share. The appropriate combination of the underlying asset and the derivative asset enables a portfolio to replicate the results of a risk-free asset (Black and Scholes, 1973; Merton, 1973). Thus, from the stochastic process estimated for the value of the underlying asset it is possible to calculate the value of any derivative asset in an environment of risk neutrality.

By applying this methodology to real assets, it is possible to calculate the value of certain options that are often present in investment projects: for example, the options to postpone the investment, extend it or abandon the project, among others (Dixit and Pindyck, 1994). The condition for this is that the terms of exercise of the option are included, explicitly or implicitly, in the corresponding contract. In this way, the real options approach allows for flexible operational management to be included in the valuation of investment projects, in situations frequently characterized by a high uncertainty (Mun, 2002).

As stated above, the application of the theory of real options has been significantly extended in recent years in the field of infrastructures. A good starting point to approach the literature in this field can be found in Martins et al. (2015). For these authors, real options in infrastructure projects consist of possibilities of change that one develops in the planning and design stage, allowing the infrastructure (and service) to cope with future uncertainty. In this sense, De Neufville and Scholtes, S. (2011) describe the paradigm shift in engineering design: the difficulty of predicting the future should lead to a design based on adaptability to change.

More specifically, the application of the real options approach is especially appropriate in Public-Private Partnerships (PPP) projects, including in the latter the concession contracts that regulate the relationship between a Public Administration and a private contractor for the construction and operation of an infrastructure for a prolonged period of time. Oliveira Cruz and Cunha Marques (2013) focus their analysis on improving the contractual performance of PPP projects, incorporating the concept of flexible contracts and the modeling of uncertainty to achieve greater robustness in the decision-making process. In airport PPP projects, the application of the real options approach in the works of Martins et al. (2014) and Xiao et al. (2017) can be highlighted. In the field of maritime transport, Martins et al. (2017) apply this same approach to the planning and development of a container terminal. These authors propose a flexible expansion of the terminal's capacity, through investment options that can be exercised at any time throughout the operation. The results obtained show a robust increase in the net present value of the project when incorporating this flexibility.

However, it is in the field of road PPP projects where the application of the theory of real options has been developed with greater intensity. For example, Zhao et al. (2004) use the real options approach for the analysis of the decision-making process in the development of a road network. Both Chiara et al. (2007) and Brandao and Saraiva (2008) use the real option framework to carry out the valuation of a guarantee of minimum revenues granted by the Administration to road concession. Shan et al. (2010) propose a system of options that allow to adequately manage the demand risk in road concessions. Kokkaew and Chiara (2013) also propose a government guarantee model based on multi-early exercise options with the objective of obtaining a better allocation of demand risk between the Administration and the concessionaire. Godinho and Dias (2012) use the option of postponing a certain investment to analyze the optimal timing in the development of road infrastructure.

The main objective of this paper is to develop a methodology based on the theory of real options to address specifically the problem of the valuation of the right of early reversion in road infrastructure concessions, as a particular case within the broader area of flexibility in contract design. This problem parallels the valuation of the withdrawal option in road concessions, studied by Cabero Colín et al. (2017). However, this latter work refers to the right of the concessionaire to obtain a compensation from the Public Administration in the event of bankruptcy of the concession when traffic is significantly lower than expected. In that case, the activation of the mechanism of compensation does not depend on the will of the concessionaire, but on an external event (the bankruptcy). On the contrary, in the case of early reversion of the concession, the holder of the option is the Public Administration, and its exercise depends entirely on the will of the latter. For the valuation of this option, a specific algorithm is developed in this paper that simulates the decision-making process of the Administration. To the best of our knowledge, this is the first attempt to quantify the value to the Public Administration of the early reversion in concession contracts, taking traffic volume as a stochastic variable.

In most jurisdictions, the Administration maintains the right to an early reversion of the concession under certain conditions, which normally include a pre-defined payment to the concessionaire. For example, according to the Federal Highway Administration (2014), it is normally considered a matter of best practice and common for concession agreements to include provisions that allow the government to terminate the contract at its convenience.

Assuming that the concessionaire's revenues over the life of the concession depend on the traffic in the concession, the value to the Administration of this early reversion right will also depend, fundamentally, on the evolution of traffic volume. The early reversion of the concession means a guarantee for the Public Administration, or the users, against excessive concessionaire revenues (independent of the efforts developed by the latter in the management of the project), in case the traffic is considerably larger than expected. Therefore, this option will not normally be exercised when actual traffic falls below expectations.

The option of early reversion of a concession can be considered as a call option granted by the concessionaire to the Administration. Logically, the latter will be interested in exercising the option if the traffic on the road is high, since this increases the value of the project and makes it attractive for the Administration that the concession finishes before the period initially established. The conditions for the exercise of the option may be stipulated in the concession contract, or derived from the general legislation on concessions: basically, the time at which such exercise can be performed and the price paid to the concessionaire by the Administration for exercising the early reversion option.

With this approach, section 2 is an examination of the methodology for calculating the early reversion option. Section 3 is an application of this methodology to a real concession case in Spain. Finally, section 4 is a summary of the main conclusions of the paper.

2. Methodology for the calculation of the early reversion option in road concessions

In general, the value of real options evolves according to the value of the project that defines the right of exercise they grant in contracts, and which coincides with the current value of a stream of future cash flows. In turn, the real options literature recommends finding the state variable on which the value of the cash flow stream depends on, characterizing the stochastic process followed by that variable. In the case of road concessions, this risk-inducing variable of the project will generally be the traffic on the corresponding road.

Given a concession of a road with an expected duration of N years, it is assumed that the free cash flow generated during a certain period t is determined by the traffic θ_t in that period. That is, $y_t = f(\theta_t)$, where y_t is the free cash flow of the project in period t. In addition, it can be considered that the traffic on the road evolves over time following a Geometric Brownian Motion (GBM). In this paper, an empirical study by Sánchez Soliño and Lara Galera (2012) has been considered. These authors performed a test for the GBM hypothesis for the evolution of traffic volume in toll motorways in Spain. The data set covered the Annual Average Daily Traffic (AADT) for eleven motorway stretches, most of them for the period 1976-2007 or longer. This empirical study was based on the Dickey-Fuller approach, which is the most widely used methodology for testing if time series follow a random walk (Dickey and Fuller, 1979). The results showed that it was not possible to reject the GBM hypothesis for traffic volume in any of the motorways analyzed. This study was extended in Cabero Colín et al. (2013), taking the period of analysis 1976-2010, and the results were the same than in the previous study.

The GBM has parameters a and σ, where a is the drift of the process and σ the volatility of the latter. So:

$$\frac{d\theta_t}{\theta_t} = \alpha dt + \sigma dW \tag{1}$$

Where dW represents a Wiener process.

By analogy with financial assets, it is possible to define an expected rate of return μ of the asset "traffic", that will satisfy the following equation, according to the Capital Asset Pricing Model (CAPM) (Sharpe, 1964):

$$\mu = r + \beta[r_m - r] \tag{2}$$

Where:

r: risk-free interest rate.

r_m: market return rate.

β: beta of the asset in relation with the whole market.

On the other hand, any asset will always satisfy the following (Dixit and Pindyck, 1994):

$$\mu = \alpha + \delta \tag{3}$$

Where:

a: rate of growth or revaluation of the asset.

δ: dividend paid by the asset.

By equating the two previous expressions, the following traffic growth rate, adjusted for risk, is defined:

$$\alpha^{adjusted} = r - \delta = \alpha - \beta[r_m - r] \tag{4}$$

Therefore, associated to θ_t there is another adjusted stochastic process $\theta_t{}^{adjusted}$ (Hull, 2006):

$$\frac{d\theta_t^{adjusted}}{\theta_t^{adjusted}} = (r-\delta)dt + \sigma dW \tag{5}$$

Where:

$\theta_t{}^{adjusted}$: Traffic variable, risk adjusted.

r-δ: Growth rate of traffic, risk adjusted.

The consideration of this adjusted process can determine the certain equivalent of any future value of those assets whose volatility is induced by the state variable, i.e., the traffic volume, within a universe of risk neutrality. Although traffic is a non-financial variable, this procedure treats it as if it were, which is a necessary requirement to apply the option valuation consistently.

The coefficient β can be related to the price of the traffic risk λ, similarly to a financial asset, using the expression (Dixit and Pindyck, 1994):

$$\lambda = \frac{\mu - r}{\sigma} = \frac{\alpha + \delta - r}{\sigma} = \frac{\mu_{project} - r}{\sigma_{project}} \tag{6}$$

With $\mu_{project}$ and $\sigma_{project}$ the return rate and volatility, respectively, of the project, that can be calculated by simulation. Note that the price of the traffic risk must be the same as that of the concession project, as traffic is the source of uncertainty of the latter. By replacing and operating:

$$\beta = \frac{\sigma}{\sigma_{project}} \beta_{project} \tag{7}$$

For the estimation of $\sigma_{project}$ and $\beta_{project}$, Lara Galera and Sánchez Soliño (2010) used as a proxy the parameters obtained for the series of the return of the shares of quoted road concessionaire firms in the Spanish stock market. The estimation of the volatility of traffic (σ) was obtained from traffic data on Spanish motorways. Based on these estimations, these authors obtained a characteristic value of β for traffic equal to 0.15.

The stochastic differential equation (5) has a solution of the type:

$$\theta_t^{adjusted} = \theta_0^{adjusted} \exp[(r - \delta - \frac{1}{2}\sigma^2)t + \sigma\xi\sqrt{t}] \tag{8}$$

Where ξ represents a normal random variable $N(0,1)$, and $\theta_0{}^{adjusted} = \theta_0$, the initial traffic volume.

Based on this process followed by the traffic volume in the concession, it is possible to calculate the value of the early reversion option in favor of the Administration, considered as a call option for the latter. It is assumed that such option can be exercised at a determined moment T, in accordance with the concession contract, and through a certain payment (the exercise price of the option) also explicitly established in the contract. In this way, the early reversion option would be characterized as a European call option, i.e., an option that can be exercised on a given date (Hull, 2006).

The value of the concession project V_T in year "T" will be given by:

$$V_T = \sum_{i=T}^{N} y_i(\theta_i^{adjusted}) \exp[-r(i-T)] \tag{9}$$

At the outset, the condition for the Administration to decide to revert the concession is that this V_T value of the project is greater than the strike price, called R_T, to be paid by the Administration to the concessionaire. The value of the option for the Administration will be given by the difference between both magnitudes. The reversion option represents a right for the Administration, and in no case an obligation, so that its value will be equal to *0* in case the Administration is not interested in the exercise of this option. Therefore, the value of the reversion option on the exercise date will be given by:

$$P_T = \begin{cases} 0 & \text{if } V_T \le R_T \\ V_T - R_T & \text{if } V_T > R_T \end{cases} \tag{10}$$

And at any time t:

$$P_t = \exp[-r(T-t)]E(P_T) \tag{11}$$

where E is the expected value operator.

It should be clarified that the exercise price may also include the transaction costs to be incurred by the Administration during the reversion process and, where appropriate, the transaction costs of the sale of the concession to a third party. In this case, if the total transaction costs expected by the Administration in the exercise of the option are TC, the option will be exercised only if it is satisfied that $V_T > R_T + TC$. Operationally, the value of the early reversion option can be calculated using the Monte Carlo simulation method. For this purpose, a large number of random trajectories of traffic are generated, following the process (8) from the start of the concession. At the exercise date, the value of the option for each trajectory of the traffic, according to expression (10), is calculated, to obtain the mean value of all trajectories analyzed. This procedure has the additional advantage of easily obtaining the probability of exercising the reversion option. In the following section this methodology is applied to the case of a real concession.

3. Application to the case of an early reversion option in a real concession

The concession of a road in Spain, currently in operation, was considered as a case study for the present paper. The project consisted in the extension and modernization of a previously existing road, carried out under a concession contract with a shadow toll scheme. The concessionaire's revenues basically depended on the traffic on the road.

The allocation of risks in the concession was defined in the terms of reference for the tender. In accordance with Spanish legislation on concessions, the Administration is responsible for the risks arising from regulatory changes and situations of force majeure. Likewise, the rates paid by the Administration are updated in accordance with the Consumer Price Index (CPI), so that the inflation risk is borne by the public sector. On the contrary, the concessionaire bears the risks of design, construction risk, financing risk, demand risk and asset maintenance risk. Regarding the demand risk, the concessionaire receives from the Administration a contractually fixed rate for each vehicle-kilometer on the road (distinguishing light and heavy vehicles). The concessionaire bears all the demand risk, since a minimum traffic level was not established. Conversely, the concessionaire's revenues are implicitly limited by the early reversion mechanism that is described next.

The total investment for the expansion and modernization of the road was 130 million Euros, for a road length of 42 km. The concession period was initially established in 37 years, with 3 years planned for the construction phase and 34 years for the operation phase. However, the terms of reference for the concession provided for the possibility of early reversion at the end of year 18 (and only in this moment) of the concession, i.e., after 15 years of operation. To obtain this the Administration would have to pay the concessionaire a price equivalent to 225 million Euros in year 18 (equivalent to 99 million Euros discounted at the risk-free interest rate at the beginning of the concession). This reversion price was established in the terms of reference for the concession. However, bidders could offer a lower price during the tender procedure, as will be seen below.

The expected initial traffic was 20,300 vehicles (Average Annual Daily Traffic), with a proportion of 90% of light vehicles and 10% of heavy vehicles. Taking into account the previous existence of a consolidated traffic, it was considered that the forecast of the initial traffic in the first year of the operation phase of the concession was reliable. However, an initial period of three years with strong traffic growth of 13% per year was considered, given the expected effect of the improvement of the road. From the third year of operation until year 18, an average traffic growth of 3% per year was forecasted, that was reduced to 1.5% per year from year 18 until the end of the concession. The same growth was estimated for light and heavy vehicles, so the proportion of each type of traffic was kept constant in the forecast. The expected volatility of traffic was 8% (annual volatility), which is the average for Spanish roads. However, a higher volatility of 20%, during the first three years of operation, i.e. during the ramp-up period, was considered. It was assumed that during this initial period, with higher expected growth in traffic, the uncertainty about the growth rate was also greater (Lara Galera and Sánchez Soliño, 2010).

Regarding interest rates, a risk-free interest rate of $r = 4.63\%$ was calculated from the average interest rates of 15 year maturity Spanish government bonds over the last 10 years. For the market return, the average annual growth of the main Spanish stock market index, the IBEX-35 (with a value $r_m = 10.45\%$), was taken. This index is considered as a good proxy for the market return, and some global infrastructure developers (such as Abertis, ACS or Ferrovial) are represented in it.

With this starting data, and applying the Monte Carlo simulation method (as explained in section 2), the value of the early reversion option was then estimated for year 18 of the concession, and also the discounted value at time $t = 0$, i.e., at the start of the concession. The early reversion option was treated as a European call option, granted by the concessionaire to the Public Administration, since the exercise of the option was established only at a specific time. In the simulation, different reversion prices were considered, taking into account that bidders could offer a lower price than the one fixed in the terms of reference of the concession. The results were the following (figure 1):

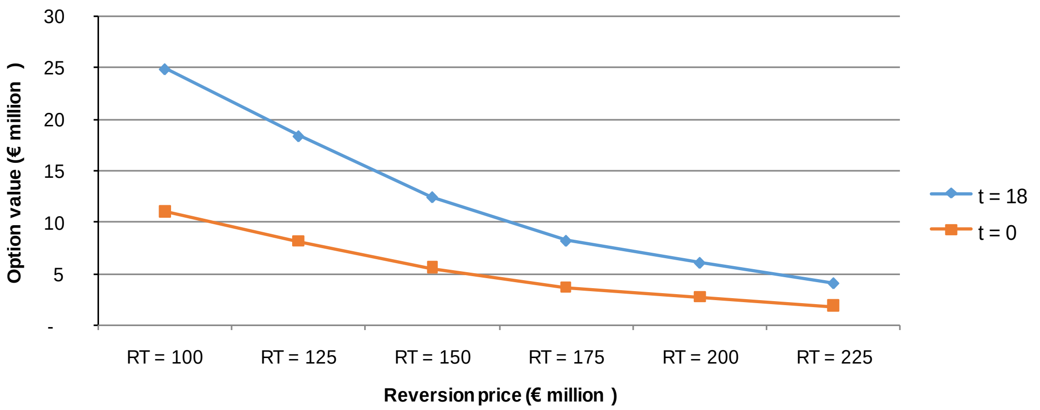

Figure 1. Value of the early reversion option for different reversion prices, at the time of reversion (t = 18) and discounted at the beginning of the concession (t = 0)

Additionally, figure 2 below shows the probability of exercising the option under the different assumptions about the reversion price.

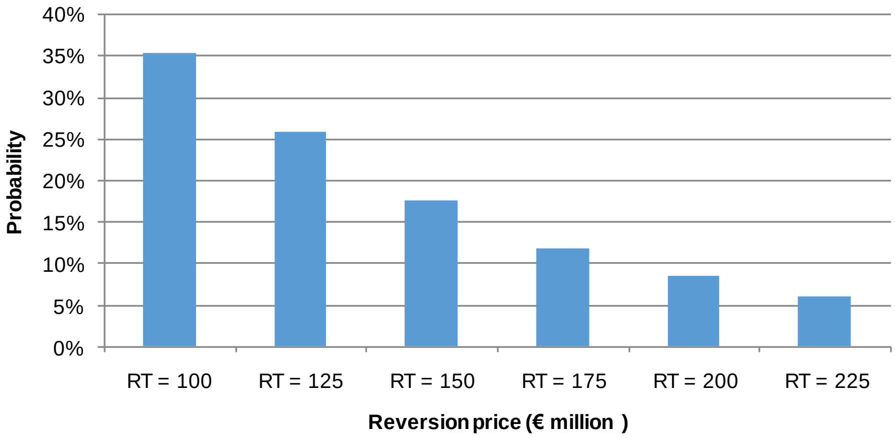

Figure 2. *Probability of exercising the early reversion option*

The value of the option is relatively small, 1.8 million Euros (discounted at $t=0$), for the reversion price of 225 million Euros established in the terms of reference. However, the value of the option increased significantly as the reversion price decreased, as might be expected. A lower reversion price makes it more attractive for the Administration to exercise the option and, therefore, increases the value of the option.

In the real case study, the reversion price resulting from the bidding process was 151.4 million Euros in year 18 (67 million discounted at the risk-free interest rate), considerably lower than that established in the terms of reference. For this reversion price, the resulting value of the option was 5.3 million Euros (discounted). This amount represented the value for the Administration, at the beginning of the concession, to have the possibility of terminating the concession contract in year 18. And by exercising this reversion option the Administration did not have to pay the shadow toll to the concessionaire for the remainder of the concession period. For the concessionaire, the value of the option is a negative value, which should be taken into account in the overall valuation of the concession.

Regarding the probability of exercising the option, again this is relatively small for the reversion price established in the terms of reference. However, it increases considerably by lowering the price of the reversion. For the reversion price resulting from the bidding process, the probability of exercising the option was 17%, which is not a negligible probability in any way.

Logically, both the value of the option and the probability of its exercise will vary throughout the concession period depending on the actual traffic flow. An evolution of traffic above the initial estimates will imply a greater attractiveness to the Administration of the possibility of terminating the contract in advance, and therefore, a greater value of the option and a greater probability of its exercise. On the other hand, less than expected traffic will reduce the value of the option and the probability of its exercise. The model developed in the present paper can include the actual traffic data during a given period and perform new simulations with this new information.

4. Conclusions

Road concessions represent a high risk business due to the randomness of traffic volume. For this reason, concession contracts usually include certain risk-sharing agreements between the Administration and the concessionaire. These agreements protect both contracting parties from a very different evolution of actual traffic to the estimated traffic. A traffic volume lower than the estimated would have a negative consequence on the results of the concession, while a high traffic volume would cause the Administration to make high payments.

This work focused on the analysis of contractual agreements for an early reversion of the concession. These types of agreements can be conceived as an option in favor of the Administration, which are exercised in the event that the real traffic during the life of the concession is higher than initially estimated. In this way, the Administration (or users in pay tolls) would stop paying excessively high amounts in tolls.

The valuation of a contractual agreement of this type create significant problems for the traditional methods based on the discounting of cash flows, given the difficulty of establishing the appropriate discount rate. For this reason, a valuation method was developed in a risk neutral environment, based on the real option approach. The method basically consisted in defining an algorithm that simulates the decision mechanism on the exercise of the option and its application to different trajectories of traffic generated in a random way. This method was applied to data of a road concession in Spain, where the terms of reference for the tender established an option for early reversion in favor of the Administration.

The results obtained show that both the value of the option and the probability of its exercise depend to a large extent on the price of reversion, that is, the amount that the Administration has to pay the concessionaire in case of early reversion. In the case study, the probability of exercise was very moderate with the reversion price set in the terms of reference. This result was reasonable, since the early reversion option was only intended to protect the Administration from the obligation of excessive payments to the concessionaire if the traffic was much higher than initially estimated. However, in the case study, the reversion price was a tendered variable, and the resulting price, established in the concession contract, was much lower (approximately 33% less) than that established in the terms of reference. In this way, the probability of exercising the option increased up to 17%, which is a considerable value. Given this result, it is doubtful whether the concessionaire, at the time of the tender, relied on the appropriate methodological tools to prepare their offer and measure the consequences of the clauses of the concession contract.

The option of early reversion is a tool that is still not very widespread. As it was seen in this paper, this option protects the Administration against excessive payments, and also allows a flexible planning in the design of the infrastructure policy. Thus, for example, the Administration, after exercising an early reversion option, may choose to return to direct road management or maintain the project as a PPP. If the Administration so desired they could call for new tenders that would in principle result in a concession with lower tolls.

The case study analyzed in this paper can easily be extended to other countries or fields of application. The option of early reversion has, in general, legal viability in other jurisdictions. Logically, the methodological tool for evaluating the option should be calibrated in each case, adopting the appropriate values of the different parameters, such as traffic volatility.

From a broader perspective, this paper is part of a field of research that has gained considerable development in recent years, such as contractual flexibility in infrastructure projects in the face of future uncertainty. From this perspective, a flexible design of contracts can contribute to an efficient allocation of risks and a reduction of costly renegotiation processes. This field of research opens the door to greater use of options in contracts (and in particular in PPPs), and to the development of appropriate methodological tools for the valuation of investment projects.

The analysis performed in the present study shows the ability of the real options approach to provide such methodological tools. A widespread use of this methodology would considerably improve the knowledge of both the Administration and the concessionaire in the implications of contracts.

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