Master of Science in Economics – Major in Finance

Master Thesis:

PUBLIC-PRIVATE PARTNERSHIPS IN PORTUGUESE HIGHWAYS

A REAL OPTIONS APPROACH TO THE SCUTS CASE

Abstract

The purpose of this paper is to propose an innovative model to evaluate the portfolio of "shadow toll" highways in Portugal, through the use of the Real Options model, at the time of the concession. During the valuation, some Monte Carlo simulations will be performed in order to analyze the impact of changes on the fundamentals to the value of the projects.

Amongst the major results, this article concludes that the valuation of the Net Present Value of the projects of the SCUTs with Discounted Cash-Flows model underestimates, systematically, the true value of the ventures by ignoring the price of the flexibility of the fundamentals. Under the model proposed, it became clear that the value of the elasticity of the exogenous risky variables (cost of debt and demand) is significant, increasing substantially the worth of the projects.

Catarina Correia da Silva | 152210004

Supervisors: Professor Ricardo Reis and Professor Joaquim Sarmento

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Symbols and acronyms

Δ	Variation.
$\Theta(\cdot)$	Function.
$\Theta(\cdot)'$	First derivative of the function $\Theta(\cdot)$.
μ_i	Instantaneous expected return on the project i.
σ_i	Squared root of the instantaneous variance of the return on the project i.
$\psi(\cdot)$	Function.
ΔWC_t^i	Investment in Working Capital of project i in period t.
$\sim \mathcal{N}(\mu, \sigma)$	Follows a Normal Distribution with mean μ and standard deviation σ.
c	Marginal cost.
$CAPEX_t^i$	Capital Expenditures of project i in period t.
CF_t	Cash-flow in period t.
$\mathrm{Cov}(\cdot)$	Covariance.
d_i	Parameter governing the size of the down movements in the value of the project i.
DCF	Discounted Cash-Flows model.
$E(\cdot)$	Expected value.
F_i	Fixed Costs of the SPV i.
$FCFF_t$	Free Cash-Flow to the Firm in period t.
i	Project.
I^i	Initial investment of project i.
km_i	Length of the highway i in kilometers.
NPV_t^i	Net Present Value of project i in period t.
$OPEX_t^i$	Operational Expenditures of project i in period t.
p	Portfolio.
p_i	Probability of the value of the project i increase.
Q_t	Demand for highways.
r_f	Risk-free rate.
r_i	Discount rate for project i.
RO	Real Options model.
t	Period of time.
T	Maturity.
T_t^i	Direct taxes of project i in period t.
u_i	Parameter governing the size of the up movements in the value of the project i.

V_t^i	Present Value of project i in period t under the RO model.
$\widetilde{V_t^i}$	Present Value of project i in period t under the DCF model.
$wacc_t^i$	Weighted Average Cost of Capital of project i in period t.

SECTION I - INTRODUCTION

I.I - BRIEF INTRODUCTION

The Public-Private Partnerships (PPPs) became a common practice in several countries as an easy method for the provision of specific services that, traditionally, are of the responsibility of the Government by a private company (Vajdic e Damnjanovic 2011). With significant potential efficiency gains, with cost reduction and risk shifting as examples, PPPs permits the allocation of limited public resources to worthy projects.

By definition, PPPs are agreements for the provision, by the private sector, of a public service through a contract that defers the cash flow payment for the public administration arising from the provision of a service (OCDE 2011). The choice between being the public or private sector to provide the access to the mentioned service is associated to which alternative is more efficient, that is, which sector can provide the respective service, with a specific quality target at a lower cost. If the private sector would be able to provide the service, respecting all the necessary quality constraints and covering all the capital costs, for a lower amount than the one the public sector would spent if it was provided by the Government (the so called Public Sector Comparator – PSC), then the best option from an efficiency point of view, is to engage in a Public-Private Partnership. Since the enterprises are executed by private companies (the sponsors), these partnerships allow the Government to be able to engage in necessary investments for the provision of public services, achieving efficient gains and shifting the risks inherent to those projects with the private sector (Takashima, Yagi e Takamori 2010). Those advantages of PPPs become even more evident when the Public Administration faces budget restrictions.

After the first wave of PPP roads in the 80s (toll pay concessions), in the end of the 90s, the Portuguese Government initiated a second round of concessions for the construction and exploitation of seven highways in order to expand the national grid of motorways[1]. Nationally known as SCUTs, the seven roads are on: *Beira Interior, Beira Litoral e Alta, Interior Norte, Norte Litoral, Costa de Prata, Algarve* and *Grande Porto*. Those concessions took the form of Design-Build-Finance-Operate (DBTO) PPPs. Distributed throughout the country, the new highways would have the particularity of being "free of charge" for the consumers. These are the so called Shadow Toll Motorways which are toll-free for an average of thirty years. With a unique type of business plan, under the agreement, the concessionary is obliged to build the highway, to manage it and to take care of its maintenance, vis-à-vis a payment schedule that the Government must comply with through disbursement to the concessionary during the stipulated period of the concession, as a compensation for the provision of the highway to the consumers.

Usually, the concession is granted to the best bid in a public tender, from an efficiency point of view. Since, in the Portuguese case, the concessionary does not have to provide any down payment to the Government, and in light of the Efficient Gains Principle for the use of PPPs, the winner bid for each highway would be the one that required the lowest present value of the total amount of payments made by the Government to cover all operational, capital and financial costs, from amongst all the viable projects within an economical and financial frame. For the estimation of the required payments that the Government must make to the concessionary, the private investors have to estimate the present market value of the project that is the object of the concession. As it will be presented below, the most used technique for the valuation of this type of projects is the Net Present Value (NPV) model. Although this approach is very easy to estimate, which is the main reason for its popularity, the NPV model is based on very strong assumptions, which lead to less precise valuations and, consequently, a less accurate risks analysis.

The purpose of this paper is to evaluate the portfolio of "shadow toll" highways in Portugal, through the use of the Real Options technique, at the time of the

[1] The first round was in 1972, with the creation of Brisa, a public company at the time, which was responsible for the construction, exploitation (under the form of a tool regime) and maintenance of 390 km of highways.

concession[2]. During the process, three questions will be addressed: *Which are the risks that influence the value of SCUTS?; How is Real Options applied in the valuation of PPPs?; and, How much is each of the projects of SCUTS worth under the proposed model?.* The particularity of being "free of charge" for the consumers, which makes the second round of PPPs in highways different from the first round and even from the later concessions that the Government had engaged in, makes the analysis of those partnerships extremely interesting from a financial and economical viewpoint. During the valuation process, some Monte Carlo simulations will be performed in order to estimate the required volatility of the generated cash-flows. Besides the volatility, the simulations' results will also be very important to analyze the financial viability of the projects, as well as the impact of changes to their fundamentals on the value of the projects.

As it will be seen below, there are few studies in the literature that apply the Real Options model to the valuation of PPP. Chean and Liu (2006) propose a model to value the Malaysia-Singapure Second Crossing, Alonso-Conde et al. (2007) apply RO to value some particularities of the Melbourne CityLink Project and Liu and Cheah (2009) use Real Options to analyze the negotiation process. Although these papers are very important and provide significant improvements to the valuation of PPPs under the Real Options model, there are majorly theoretical studies. By proposing a model and applying it to the valuation of a portfolio of seven SCUTs, this paper aims to fill the lack of applied studies in the valuation of PPPs through Real Options. With a quite general model and an appropriate and fully described framework, this dissertation aspire to be a starting point to further applications and valuations of concrete and real projects of PPPs.

The remainder of this paper is organized as follows. Section I focuses firstly on the Literature Review, which is followed by the presentation of the methodology that will be used in the study developed in the present essay. Section II presents the model for the valuation of the portfolio of the concessions' second round of highways which was made possible by Public-Private Partnerships, as well as its

[2]In fact, nowadays, those highways are no longer "free of charge" for the consumers. Even so, all the analysis in this paper would assume that the roads would always be "free" for consumers and that there is no risk of changing it.

risk analysis. Moreover, all the underlying assumptions pertaining to the model will be reviewed. Section III provides the application of the model proposed, starting with the discussion of the potential sources of uncertainty to the value of a highway project. Once the risks are identified, the value of the seven projects will be computed under both the base-case model and the one proposed in this article. Finally, in Section IV, the results from the simulations and valuations will be analyzed and the conclusions of the study will be presented.

I.II - Literature Review

Overview

The literature around PPPs is more focused on the public management point of view rather than on the economical and financial view[3]. With significant potential advantages to the Public Administration and the national economy as a whole, Public-Private Partnerships have become very popular, mainly in developed countries, a situation that has motivated the recent interest from researchers. Among several authors, Broadbent and Laughlin (2003) discussed the major issues behind the mentioned partnerships, such as the management policies associated with them, the major trends throughout the globe, its history and the social and economic context in which PPPs have emerged. Later on, the International Monetary Fund (IMF) published an empirical study focused on the analysis of the determinants, both cross-country and cross-industry, of the Public-Private Partnerships around the world (Hammami, Ruhashyankiko e Yehoue 2006). In this study, evidence about the importance of macroeconomic stability is presented, as well as a large aggregated demand for the success of said agreements. Moreover, it is also shown that institutional quality, with an efficient rule of law, and political stability are crucial factors which contribute to the Governments' engagement in PPPs. This recognition of those key macroeconomic and social factors that are essential for the emergence and good performance of the Public-Private Partnerships is very important for the identification of the potential sources of risk.

[3] It is important to highlight the fact that the partnerships between the Public Government and private investors for the provision of a service to the community (Public-Private Partnerships) acquired different names in different countries: Private Finance Initiative (UK), Privately Financed Projects (Australia), etc. (Grimsey e Lewis 2002)

TRADITIONAL RISK ANALYSIS AND VALUATION METHODS USED IN PPPS

Regarding the valuation of the PPPs and its analysis of the risks, the literature available is more focused on specific topics than on the general theory. With some applied studies covering specific projects in several countries, mainly in the United Kingdom and the United States, there are very few theoretical studies about the proper methods of evaluation and assessment of risks for investment projects under Public-Private Partnerships. As any other investment project, there are some methods that could be used to estimate the Market Value of the project. When the first PPPs emerged, the mostly used model for the decision making process of acceptance or rejection of a specific and project was the Net Present Value (NPV) technique. According to this approach, the Net Present Value of the venture p equals the sum of all the expected cash-flows that the project is expected to generate $[E(CF_t)]$, discounted at a proper risk-adjusted average cost of capital $[r_p]$, minus the value of the amount invested $[I_0]$.

$$NPV^p = -I + \sum_{t=0}^{T} \frac{E(CF_t)}{(1+r_p)^t}$$

1

In general terms, the NPV rule is simple: the project should not be accepted if its NPV is negative[4]. As it can be seen, a positive NPV means that the present value of the incomes that the project will generate is higher than the investment required, which, in another word, means that the project creates value to the firm. More than to decide if one project should be taken or not, the NPV model is very important in the process of choice between projects. Due to the simplicity of the mathematical computation, the NPV has become the most used tool for the valuation of large investments (Copeland e Antikarov 2001), a fact that is still true nowadays. The simplicity of the valuation is a result of the method's strong underlying assumptions. Amongst the NPV's underlying assumptions, through the use of a proper risk-adjusted average cost of capital, usually the weighted cost of capital (WACC), for discounting the expected cash flows generated by the project, this

[4]In fact, most frequently, the decision between accepting or rejecting one project is more complex, mainly when there are budget constraints or different alternatives (projects) for the provision of the same good or service.

method is implicitly based upon the assumptions mentioned above, such as the fixed cost of capital, both for equity and debt. Another important underlying assumption to the NPV technique is that, once the firm engages in a specific investment, the project's outcome will be unaffected until the end of the concession – the project will be undertaken within an uncertainty free environment.

As stated previously, the assumptions behind the NPV approach are very strong and hardly correspond to the reality. In the valuation of a project, as well as in any economic or financial model, there is a tradeoff between the simplicity of the method used and its accuracy. In fact, the majority of the projects that request external financing have a variable cost of debt, usually a spread over a reference interest rate, which typically varies over time. More than introducing a variable cost of capital, which violates the assumptions of the NPV model, this fact introduces uncertainty to the problem. Actually, each project faces several sources of risk that could affect its cash flows. Grimsey and Lewis (2002) have reflected and identified the nine major sources of threat for Public-Private Partnerships' cash flows for infrastructure projects. According to these authors, the most significant sources of risk for any investment in infrastructures can be classified as: technical, operational, demand, financial, *force majeure*, regulatory/political, environmental, project default and construction risks (Grimsey e Lewis 2002). The existence of such sources of uncertainty creates the need to choose a more sophisticated method for the assessment of the fair Market Value of the project. In order to attend to this requirement, some techniques were developed. One of the most widespread techniques is the sensitivity analysis approach, which consists of the determination of some possible scenarios for the evolution of the risk sources and the stipulation of the probability of occurrence of each scenario in order to compute the expected cash flows of the project. Even if a large number of scenarios are determined, it will be almost insufficient in comparison to the infinite possible performances that each variable can present. This fact is even clearer as the number of sources of risk one project can have increases. As a result, although this technique approaches the existence of uncertainty, it is not complex enough.

MOST RECENT AND INNOVATIVE TECHNIQUES IN PPP RISK VALUATION

In the end of the 70s, some authors began using the options' pricing model developed by Black and Scholes (1973) and by Merton (1973) and applied the model to the valuation of real assets. In fact, the generality of the projects have optionality inherent in the cash flows themselves or, in the absence of uncertainty on the cash-flows, the ability to delay the project confers optionality to it (Ross 1995). Due the existence of flexibility to adapt the course of the project, according to the performance of some exogenous variables, such as changes on interest rates or demand, one project can be seen as a right to take a specific action (for instance deferring the project, increasing/reducing capacity, etc.) at a predetermined cost and for a predetermined period of time. This way of looking at the project is called Real Option approach (Copeland e Antikarov 2001). Treating the project as an option, or a group of options, it is possible to estimate the fair market value of the project as a function of the cash flows generated by the enterprise, using complex but efficient methodologies derived from the Black and Scholes valuation model (continuous time approach) or the Binomial model (discrete time approach).

Ross (1995) discussed the issues underlying the NPV technique and its alternatives to the valuation of an investment project. Due to the uncertainty surrounding the fundaments of the value of any project, Ross argued that its value comes from three sources: (i) the NPV of the project – "it's in-the-money value"; (ii) the value of all embedded options built into the project itself; and (iii) the value of the option on the movement of capital costs and prices. As a result, comparatively with the traditional NPV model and Sensitivity Analysis, the Real Options approach supplements those valuation methods, in the sense that it contemplates the value of the existence of flexibility and decision making (Brandão e Dyer 2005) in the value of the project by including the value of all embedded options of the valuation process. Copeland and Antikarov (2001) reinforce this perspective arguing that, by ignoring this flexibility, the NPV technique systematically undervalues the project, which means that, systematically, those estimators generate (negative) biased outcomes. Nevertheless, the merits of the NPV approach are recognized by considering it the best unbiased estimator of the market value of the project without embedded options (Brandão e Dyer 2005). In other words, the NPV is seen as a particular case of the Real Options analysis, for the absence of uncertainty in the project. Consequently, in projects with embedded options, since almost every project faces different risks and an uncertain future, the Real Options approach turns out to be a more general estimator for the true value of a project, by contemplating the existence of flexibility in the valuation. However, the referred approach has some disadvantages, regarding the complexity of its mathematical computations and the difficulty in getting all the data necessary to the valuation.

VALUATING INVESTMENT PROJECTS AND PPPS USING REAL OPTIONS

Among several studies, some authors had proposed different techniques for the valuation of investment projects through Real Options. Savvides (1994) had proposed a framework for the risk analysis based on Monte Carlo simulations, starting from the forecast of the base case scenario, which could be applied to analyses and assessment of risk in the evaluation of investment projects. By proposing the estimation of the present Market Value through the NPV model, this technique focuses on the impact that shocks on fundamentals have over the value of the project through a kind of Sensitivity Analysis with the attribution of Probability Distributions to those variables. In turn, Copeland et al. (2001) proposed a four step procedure for the valuation of a project: computation of the base case present value using the NPV model; modeling of the uncertainty with event trees; identification and incorporation of the flexibilities creating a decision tree; and, conduction of Real Options Analysis. Later on, Brandão and Dyer (2005) proposed an extension to the work developed by Copeland and Antikarov (2001). By proposing a discrete time method to the Real Options valuation methodologies, the authors simplified the process and proposed a more intuitive method (Brandão e Dyer 2005).

With the increasing acceptance of the Real Options method for the valuation of Public-Private Partnerships, some authors focused on the analysis of specific issues on those ventures from the perspective of the referred technique. Cheah and Liu (2006) gave an important contribution by valuing the governmental support in infrastructure projects under Public-Private Partnerships, in the form of Build-Operate-Transfer, using Real Options with Monte Carlo simulations. Through the analysis of a real project, the Malaysia-Singapore second crossing, the authors argue that Governmental support to the project can be interpreted as an option, since the commitment is triggered when some specific conditions are met, which creates value to the project (Cheah e Liu 2006). One year later, Alonso-Conde et al. (2007) also suggested that the conditions imposed and the guarantees given by the Public Administration can be treated as real options and analyzed the impact of those conditions on the incentives to invest and on how much value the Government is transferring to the private investors on those conditions. In order to perform this analysis, the authors used the case of an Australian toll road project as example. Regarding the negotiation process between both the public and private entities, Liu and Cheah (2009) demonstrated how introducing the value of some guarantees from the Government to the private investors and risk shifting between the parties in the negotiation process can increase the achievable bargaining range for both agents. Using a Chinese wastewater treatment plant, the value of those options was computed by the Real Option technique.

SECTION II – METHODOLOGY AND DATA

A Real Option is defined as an option-pricing application that does not involve financial instruments (Schwartz e Trigeorgis 2001). Having as underlying asset a physical (real) asset, typically an investment project, the Real Option approach emerged from the application of the option-pricing principles to value investment projects in natural resources, more precisely in commodities.

As with financial options, the value of a Real Option depends on six crucial variables: (i) the value of the underlying asset, (ii) the exercise price, (iii) the risk-free rate, (iv) the time to maturity, (v) the dividends that will be distributed and (vi) the volatility of the value. Table 2 synthesizes the correspondent variables of the Black & Scholes model in the Real Options valuation.

Variables	Correspondent
Underlying asset	The highway project and its concession
Exercise Price	The amount invested
Risk-free rate	Portuguese sovereign 10 years bonds rate
Time to maturity	Duration of the partnership
Dividends	SPVs dividends

Volatility	Volatility of the market value of the project

Table 1 - Relevant variables for the Real Options Approach

Applying this theoretical model to the valuation of a highway projects, (i) the underlying asset is the value of the project itself, (ii) the exercise price is the present value of the initial investment required, (iii) the risk free rate becomes the sovereign ten years bonds rate, (iv) the time to maturity equals the duration period of the concession and (v) the dividends are the ones distributed by the SPV to its shareholders.

In what concerns the (vi) volatility of the value of the different highways projects, and once those investments are typically non-traded assets on the financial markets, there is no market data about the required volatility of the project. This lack of real data created the need to find alternative methods to estimate the required volatility. Copeland and Antikarov (2001) proposed three different methods to estimate the volatility: (i) using the volatility of the unlevered stock returns as a proxy (if the project is the only asset of a public firm); (ii) historical data of similar projects; (iii) or using the volatility of the major risk driver as a proxy of the project's volatility. Given that those partnerships usually involve the Government and one private firm created exclusively for the infrastructure built and exploitation of the concession, called a Special Purpose Vehicle (SPV), the first option is not valid. In the case of the historical data, even though this alternative could be used easily, the pioneer character of the majority of the related investments, at least in geographic terms, compromises the explanatory power of the historical data. As a result, amongst those options, in the case of the valuation of Public-Private Partnerships for the road sector, the better approach seems to be the third alternative: using the volatility of the major risk driver as a proxy of the project's volatility.

For reasons that will be explored below, the analysis will follow a discrete time approach. Consequently, the valuation will pursue the option-pricing Binomial Model, with the construction of binomial trees, in order to compute the value of each project.

II.I - METHODOLOGY

As advanced before, one of the major purposes of this paper is to value the portfolio of "shadow toll" highways in Portugal, through the use of the Real Options technique, at the time of the concession. The methodology that will be followed in this article is based on the frameworks proposed by Brandão & Dyer (2005) and Copeland & Antikarov (2001). The valuation of the portfolio of the referred Public-Private Partnerships will take the form of a four step procedure:

1. Qualitative analysis of the major sources of risk;
2. Estimation of the value of the portfolio without flexibility – the valuation of the base case scenario through the NPV approach;
3. Monte Carlo simulations for the assessment of the volatility of the value of the portfolio;
4. Valuation of the portfolio through the Binomial model.

For the sake of simplicity, the valuation of the PPPs will be performed in a discrete time approach, in line with the framework proposed by Brandão & Dyer (2005). As it will be seen below, it will be assumed that all transactions will occur at the end of each year, which implies that the value of the portfolio only changes annually. This annual character of the value of the portfolio allows the valuation to follow a discrete approach, in which the period of time that will be considered is two years[5].

As it is presented above, the first step consists in a qualitative analysis of the potential sources of risk for any large investment project for the construction and exploitation of a highway. Secondly, the value of each one of the seven projects in the Base Case scenario will be forecasted and, by aggregation, the value of the portfolio. In the third step, through Monte Carlo simulations, 1000 possible scenarios will be forecasted for the evolution of the two major potential sources of risk: the EURIBOR 6M and operation expenditures. The simulations will allow the estimation of the volatility of the value of each project. Finally, the fourth step introduces flexibility in the value of the project. With the estimated volatility, one

[5] Given the exponential growth of a binomial tree and the rows limitation of Microsoft Excel, the period of time could not be smaller.

can design a binomial tree for each project and, with it, forecast the value of each project through Real Options.

As it can be seen, the whole analysis will be performed project by project, since those enterprises have different fundamentals, and are aggregated only in the end in order to access the value of the portfolio.

II.II - General Assumptions

In the valuation process several assumptions will be presumed, in the belief that those assumptions would not lead to a loss of generality. First of all, for the estimation of the market value of the projects through Real Options it is essential to presume two crucial assumptions:

A. 1. Market Asset Disclaimer assumption – the present value of the risky asset without uncertainty can be used as if it were a marketed security (Copeland e Antikarov 2001)*;*

The first assumption allows the estimation of the present value of a project as if it was a marketed security, that is, it allows the valuation of the project by the same models as the traded assets (Copeland e Antikarov 2001).

A. 2. Properly anticipated prices fluctuate randomly (Samuelson 1965)*;*

Assumption A.2 implies that, whatever the pattern of the cash-flows of a project, its price (value) follows a random walk. As a result, one can estimate the present value of the projects through the Binomial Model as if it was a marketed security.

A. 3. No debt or Government payments renegotiation;

The inability of renegotiations implies that any necessary capital increase in any SPV would be entirely carried on by the shareholders. As it will be seen later, this assumption is compatible with the allocation of risk between the public and private sectors.

A. 4. All transactions are made (payments and receipts) in the end of each period (year);

A. 5. All variables except the annual growth of operational expenditures and the Euribor will perform as forecasted to the Base Case scenario;

A. 6. All the required liabilities are contracted in the beginning of the concession.

This assumption implies that, after the grace period, the debt ratio will decrease over the life of the concession until the SPV becomes 100% equity. As a result, and remembering the volatility of the cost of debt, in each period the SPV will face a different, and increasing, weighted average cost of capital.

A. 7. No dividends distribution (payout ratio equals 0%);

The payout ratio will be assumed to be zero, given the finite maturity of the concessions and the very nature of the PPPs makes the dividends policy irrelevant to the valuation of the project.

II.III – MODEL

THE BASE CASE SCENARIO

The value of the project of PPP i in period t without uncertainty [$\widetilde{V_{i,t}}$], later on called Base Case scenario, can be expressed by:

$$\widetilde{V_{i,t}} = \sum_{t=0}^{T} \frac{FCFF_{i,t}}{\prod_{s=0}^{t}\left(1 + wacc_{i,s}\right)}$$

1

in which $FCFF_{i,t}$ is the Free Cash-Flow to the Firm by the PPP i in period t and $wacc_{i,s}$ is the weighted average cost of capital for the PPP i in period t. In turn, the FCFF can be obtained by:

$$FCFF_{i,t} = Revenues_{i,t} - CAPEX_{i,t} - OPEX_{i,t} - T_{i,t} \mp \Delta WC_{i,t}$$

2

in which $CAPEX_{i,t}$ is the Capital Expenditures of the PPP i in period t, $OPEX_{i,t}$ is the Operational Expenditures of the PPP i in period t, $T_{i,t}$ are the income taxes that the PPP i has to pay on period t and $\Delta WC_{i,t}$ represents the investment/disinvestment on Working Capital. Under A.3, all the financial transactions are made on the end of each period (year), which allows us to assume that there is no need to invest in working capital.

A. 8. There is no investment in working capital requirements;

Taking equation 1, the net present value of the project i $\left[\widetilde{NPV_i}\right]$ in the base-case scenario is given by:

$$\widetilde{NPV_i} = \widetilde{V_{i,0}} - I_i$$

3

THE BINOMIAL LATTICE

Assuming a *frictionless market* and the value of project I, with the introduction of flexibility, the value of project (V_i) follows a *Geometric Brownian Motion* (GBM) stochastic process. Consequently, one can say that, for any period t, the value of the project is given by:

$$\frac{\Delta V_{i;t}}{V_{i;t}} = \mu_i \times \Delta t + \sigma_i \times \Delta z$$

4

where μ_i is the instantaneous expected return on the project, σ_i is the squared root of the instantaneous variance of the return and Δz is a standard Gauss-Wiener process (Merton 1973). Taking the discrete time Binomial approximation proposed by Cox, Ross & Rubinstein (1979), the value of the PPP i in period t and state a [$V_{i;t,a}$] can be obtained by:

$$V_{i;t,a} = \widetilde{V_{i,0}} \times u^a \times d^{t-a}$$

5

where $V_{i,0}$ is the present value of the PPP i, u is the parameter governing the size of the up movements and d represents the respective parameter for the down movements (Brandão e Dyer 2005). Lastly, a represents the number of periods that the value of the PPP had increased. With equation 5 one can forecast the evolution of the value of each project i during the concession period T, starting with the value of the project in the Base Case scenario as the present value $V_{i,0}$.[6]

Taking the forecasted evolution of the value of the underlying asset, one can estimate the value of each project i through Real Options as the average present value of the project in the next period, that is:

$$V_{i;t} = \frac{p_i}{1+r_f} \times V_{i,t+1}{}^{u} + \frac{1-p_i}{1+r_f} \times V_{i,t+1}{}^{d}$$

6

where p_1 is the probability of the value of the project increases, r_f denominates the risk-free rate, $V_{i,t+1}{}^{u}$ is the value of the project in the next period if it goes up and $V_{i,t+1}{}^{d}$ is the value of the project in the next period if it goes down.

Finally, and taking once again the equation 1, the net present value of the project i [NPV_i] under the Real Options model is given by:

$$NPV_i = V_{i,0} - I_i$$

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II.IV - DATA

As advanced before, the only data that is considered in this analysis is the one available at the time of the first concession of "shadow tolls" in 1999. Consequently, the valuation will be based on the Base Case Scenario proposed by the winner bid of each concession and that was agreed with the Government, which data was available on a report from the Portuguese Court of Auditors in 2003. Regarding the market data - interest rates time series (FIBOR 6-months and FIBOR 6-months) and Portuguese Gross Domestic Product (GDP) – it was obtained public market data base.

In what concerns the time series of the annual change of the Portuguese GDP in real terms, the data includes the 39 observations from 1960 to 1998[7]. Regarding

[6] With the pattern of evolution designed, it is necessary to calibrate the pattern by including all the managerial decisions that could be taken in the different scenarios of the development of the project. Once the underlying asset of this application is the initial projects, without possible future renegotiations, there would be no calibration to the pattern of evolution.

the annual variation of the historical series of the EURIBOR 6-months[8], there is no previous data that could have been used for the estimation of its path because the timing of the concessions coincided with the birth of Euro. Therefore, the time series of FIBOR 6-months was used (Frankfurt Interbank Offered Rate 6-months) as a proxy. Unfortunately, there are only 17 previous observations to the annual change of the referred rate, a small sample in statistical terms. The small length of the sample raises questions about the representativeness of the series. Although this could be a very important question, which could invalidate the results of the model, the inexistence of previous data constitutes a limitation to the model and the sample described well the performance of the population.

SECTION III – APPLYING THE MODEL

III.I - STEP I: RISKS IDENTIFICATION

In general terms, one highway investment project, as any other large infrastructure investment project, faces several different risks during the period of construction and exploration. Starting from the beginning, the large initial investment required introduces the need for external financial capital (debt), which, in turn, introduces the *financial risk* in the value of the project. If there is no proper hedging for this risk, the cash flows of the project will be affected by the volatility of its cost of capital. More related to the construction phase, the concession also faces the *construction*/*technical risks*, defined as the probability of faulty concession techniques and engineering/design failures, respectively (Grimsey e Lewis 2002). In the exploration phases, the major risks are related with the *demand risk*, related to the probability of deficits in the estimated traffic, which would face directly the cash flows of the enterprise. On the costs side, the likelihood of unexpected increases in the operational and maintenance costs introduces the *operational risk* in the value of the project. Finally, in a macro perspective, those investments also face the so called "*force majeure risk*" (the probability of exogenous shocks over the infrastructure); "*regulatory risk*" (the chance of changes in the legal regulation of the PPPs); "*political risk*" (which could

[7]See Exhibit II to a statistical description of the series.
[8]See Exhibit I to a statistical description of the series.

affect the behavior of the partnership); and "*environmental risk*" (due to the externalities of the infrastructures on the environment) (Grimsey e Lewis 2002).

THE SCUT'S CASE

In Portugal, the "shadow tolls" highways Public-Private Partnerships have a specific business model: the concessionary is responsible for getting the necessary financing, building the highway and all additional infrastructures, providing them to the consumers during the time of concession and taking care of its maintenance; in return, the Government pays a specific scheduled amount to the concessionary. This type of PPPs is called Design-Built-Finance-Operate (DBFO) projects. With this agreement, all the parties involved benefit from the partnership: the Public Administration benefits from having the highways available to the consumers with a relative low cost, the private investors get the required return from the investment, the creditors profit from the spread associated with the required cost of capital for the concessionary and, finally, the consumers benefit from having the highway available to use "without charge". In terms of the whole economy, the society benefits from the existence of efficiency gains in the provision of the service.

The scheduled Government's payments took the form of a three part tariff system – bands A, B and C – according to the volume of traffic. Band A works as an "availability fee", which covers a high percentage of the amount of the capital needs, while the bands B and C were an extra payment for higher than expected volume of traffic.

Risk	**Allocated sector**
Financial Risk	Private
Construction/Technical Risk	Private
Operational Risk	Private
Force Majeure Risk	Public
Regulatory Risk	Public
Political Risk	Public
Environmental Risk	Public
Demand Risk	Public

Table 2- Allocation of risks on Portuguese PPPs

In terms of allocation of risks, they were shared between the public and private sectors. Table 1 presents the summary of the allocation of each risk between the parties. As it can be seen, the private sector is exposed to the financial, construction/technical and operational risks. Consequently, the key variables that influence the value of the concession to the private investors are the cost of debt (financial risk), budgetary slippages or delays during the phase of construction (construction/technical risks) and the operation costs (operation risk). In what concerns the demand risk, since band A is almost always guaranteed[9] and remembering that the availability fee covers the major costs, it is fair to say that the Portuguese concessionaries do not face demand risk. In fact, the only potential risk related to the demand side is assumed by the Government: the risk of increases in the estimated payments to the concessionary that the Public Administration has to do due to a volume of traffic that exceeds the band A (the forecasted payments in the Base Case scenario). Regarding the other risks, as it would be expected, the "*force majeure*" risk (also referred as "Acts of God"), regulatory and political risks are taken on by the public sector.

The following procedures will only consider the operational (given by changes on OPEX) and financial (derived from the volatility of the annual change on EURIBOR 6M) risks on the value of the different "shadow tolls" Portuguese Public-Private Partnerships, both over the private sector responsibility. The construction/technical risks will be disregarded due to the relatively small period of time of the construction phase and due to the fact that the majority of shareholders are civil construction companies, which reduces the risk of delays on the building.

EURIBOR 6M

The cost of debt contracted by each SPV follows the traditional form of a constant spread over a reference interest rate (Silva 2011), in this case, the EURIBOR 6-Months. Under A.3, all the interest payments are made in the end of each year, which implies that the financial risk inherent is the annual change of the EURIBOR 6-Months.

[9] In this study the risk of the Portuguese Government default or financial distress will be disregarded.

Since EURIBOR was first published on 30th December 1998 (Media s.d.), at the time of the concession (1999), there were insufficient data available for the estimation of the mean, standard deviation and probability distribution of the series. Consequently, it will be necessary to use another variable as a proxy of the performance of EURIBOR. Given the particularities of the construction of Euro, the best candidate to be a proxy of Euribor is the Frankfurt Interbank Offered Rate 6-months (Fibor 6M), the correspondent rate of the Deutsche mark, before the introduction of the single currency.[10]

A. 9. The reference rate Euribor 6M will perform as the previous Fibor 6M.

Operational expenditures (OPEX)

The operational expenditures, in this model, will be described by a fixed part [F] and a variable part that is a function of the demand and the length of the road [$\psi(Q_t)$].

$$OPEX_{i,t} = \psi(Q_t, km_i)_{i,t} + F$$

8

For the sake of simplicity, it will be assumed that the variable costs are a linear function of the demand.

$$\psi(Q_t, km_i)_{i,t} = c \times Q_t \times km_i$$

9

As a result, the volatility of the operational costs is given by the volatility of the demand.

A. 10. The only economic variable that changes over time on OPEX is the demand for highways.

Once again, there are three possible methods to estimate the volatility of the demand on each road. Since the road is not traded on financial markets and there are no previous highways in the regions where each road is, there is no historical data that could be used as a proxy. Consequently, it is necessary to use, again, another variable that could be used as an estimator for the volatility of demand.

[10] See Exhibit I for more data about Fibor.

The variable that will be considered is the Portuguese Gross Domestic Product (GDP), in the belief that the demand for highways is procyclic and that the GDP growth is a good estimator for changes on demand.[11]

$$\sigma_Q = \Theta(\sigma_{GDP}) \ , \qquad \Theta(\sigma_{GDP})' > 0$$

10

Once again, for the sake of simplicity, it will be assumed that the degree of pro-cyclicality equals one.

$$\sigma_{\Delta Q} = \sigma_{\Delta GDP}$$

11

A. 11. The volatility of the demand on highways equals the volatility of the GDP.

For the sake of simplicity, it will also be assumed that the demand performs homogeneously in the seven highways.

A. 12. The volatility of demand will perform equally on all highways.

III.II - Step II: Base Case scenario

As it was said before, the valuation of the Base Case scenario was performed through the Discounted Cash-Flows model, with both debt ratio and weighted cost of capital varying over time. The net present value of the portfolio in the Base Case scenario was estimated with the financial data that make up the projects presented at the time of concessions (1999). In what concerns the potential sources of risk, the Euribor 6-months is assumed to be constant over time and the OPEX will only grow due to the inflation rate, which will also be fixed by construction.

The table below shows the major results from the valuation of the referred scenario. As it can be seen, the seven projects exhibit a positive net present value, that is, all the seven projects create value to the respective SPVs. Moreover, by analyzing the ratio NPV/I, a measure of the return of each project to its company, it

[11] See Exhibit I for more data about Portuguese GDP.

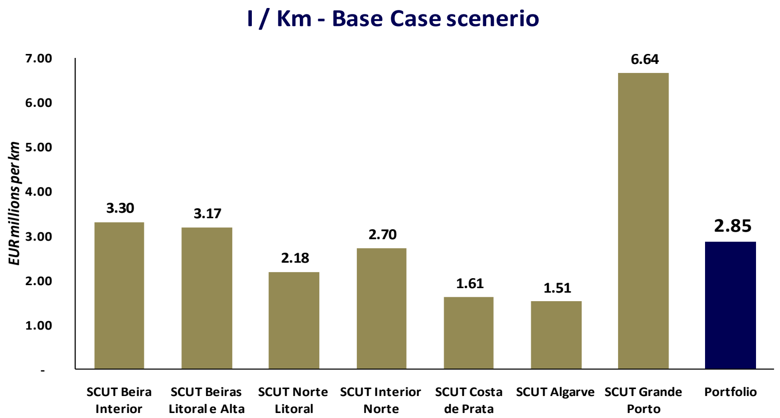
became clear that all of them generate high returns over the initial investment, with all of them generating a return above 74%, except the Grande Porto (16%).

(EUR million)	I	NPV/I	NPV	V	E
SCUT Beira Interior	586.68	0.85	496.77	1 083.45	229.31
SCUT Beiras Litoral e Alta	557.42	0.74	411.26	968.68	157.79
SCUT Norte Litoral	250.53	0.75	187.82	438.36	134.02
SCUT Interior Norte	418.10	1.40	586.85	1 004.94	194.45
SCUT Costa de Prata	168.69	1.75	295.59	464.27	225.96
SCUT Algarve	194.18	0.74	143.07	337.21	118.55
SCUT Grande Porto	478.06	0.16	77.05	555.11	104.62
Portfolio	2 653.65	0.83	2 198.38	4 852.03	1 164.69

Table 3 - The Base Case scenario financial data. Source: Made by the author.

Table 3 presents the initial investment (I), return (NPV/I), net present value (NPV), present value (V) and equity value (E) for all the seven concessions and portfolio. As one can verify, under the DCF model, the portfolio of Portuguese "shadow toll" highways, without flexibility, values EUR 2 198.38 million, which correspond to a return of 83% over the initial investment.

In what concerns the debt ratio, and as it was expected, all the seven SPVs exhibit a high debt ratio in book values, with every project having a proportion above 80%. However, in market values, the debt ratio falls in a range between 51% and 84%. Once again, the debt ratio is lower in market values than in book values for all the projects, with Grande Porto being the unique exception. The referred decreased in the debt ratio is related to the high Value Added (VA) that the projects generate to their shareholders, which increases substantially the net present value of the project and that is totally adsorbed to the sponsors of the projects.



2 - Investment per kilometer

Figure 2 present the required investment of each project per kilometer. As it can be seen, the second round of concessions involved an average investment of EUR 2.85 million per kilometer. Geographically, and as it would be expected, it is clear that the concessions in the north of Portugal require a higher investment per kilometer, with the expenditure of construction decreasing as we move to the south. This phenomenon is intrinsically associated with the higher incidence of rugged terrain in the north of the country, which involves higher construction costs.

III.III - Step III: Simulations

The simulations of 1 000 possible scenarios for the evolution of Euribor 6-months and OPEX was performed under the assumptions that the annual change of both variables follow the Normal Distribution and that its statistical moments equals the historical ones of its proxies.

A. 13. The annual returns on the Euribor6-months follows a random walk with mean 0 and standard deviation of 0.005[12];

$$\Delta r \sim \mathcal{N}(0; 0.262)$$

12

A. 14. The annual changes of OPEX follow the Normal distribution with mean 0.04 and standard deviation of 0.032;

$$\Delta OPEX \sim \mathcal{N}(0.04; 0.032)$$

13

Moreover, for the sake of simplicity, it was assumed that the two variables are uncorrelated.

A. 15. The annual returns on the Euribor6-months and the annual changes of OPEX are uncorrelated;

$$Cov(\Delta r; \Delta OPEX) = 0$$

14

[12] According to the Efficient Market Hypothesis (EMH), all the relevant information is public and the market incorporates instantaneously all the relevant information in the price of the financial asset. This assumption implies that, under a perfect market, the returns on any financial asset follow a random walk, with mean zero and a constant variance.

Based on the results from the simulations a series of possible values was computed for each project. Since the annual variations in risk sources are assumed to follow the Normal distribution, one can argue that the derived series for the value of each PPP is implicitly distributed accordingly.

III.IV - STEP IV: PORTFOLIO VALUATION BY THE BINOMIAL MODEL

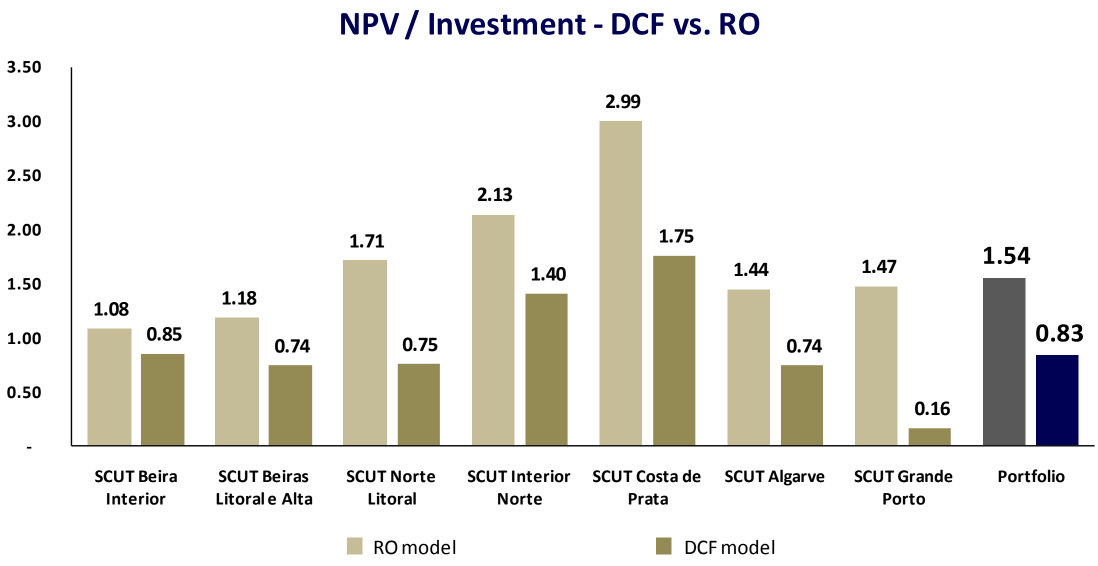
As it was advanced above, the final step of the valuation was the estimation of the net present value of the project through the Binomial Model. Due to some limitations of software, the binomial trees were constructed with biannual periods and the standard deviations estimated through the Monte Carlo simulations. The table below presents the results obtained.

(EUR million)	**Base Case NPV_i**	**Binomial Model NPV_i**
SCUT Beira Interior	496.77	632.45
SCUT Beiras Litoral e Alta	411.26	658.36
SCUT Norte Litoral	187.82	427.96
SCUT Interior Norte	586.85	891.85
SCUT Costa de Prata	295.59	505.18
SCUT Algarve	143.07	280.08
SCUT Grande Porto	77.05	703.48
Portfolio	2 198.38	4 099.35

Table 4 - Net present value through Real Options. Source: Made by the author.

Under the binomial model, the net present value of the portfolio of concessions equals EUR 4 099.35 million, 86.47% above the net present value computed on the base-case scenario. By analyzing the results per concession, one can also verify that the net present value computed by Real Options exceeds, in the seven projects, the net present value of the base-case. This result corroborates the evidence from literature, confirming that the net present value, computed through discounted cash-flows, systematically underestimated the value of the projects. As a result, one can argue that the introduction of flexibility, or uncertainty, in the valuation of the projects of SCUTs creates value.

The value of flexibility for a project can be divided in two different parts: the direct effect of the variations in the cash-flows and, in the case of existence of the financial risk, the indirect impact of the variation of the weighted cost of capital. From the base-case model it is possible to verify that both operational and financial costs are not relatively high when compared with the amount of annual receipts of the SPVs. Consequently, one can suspect that the direct effect of the variation of the cash-flows will be quite small. If this is true, then the significant increase in the net present value of the projects when we introduce flexibility in the valuation is majorly explained by the change in the weighted cost of capital through the variation of the cost of debt. This conclusion became stronger given the high debt ratio of the projects.



3 - Comparison of the results obtained in both models. Source: Court of Auditors; NPV computed by the author.

Figure 3 presents the comparison between the returns obtained with the DCF and RO models. Comparing the outcomes, there are some interesting results that are immediately clear. First of all, and as it was anticipated by the analyses of the net present value of each project by the Real Options model, one can verify that the valuation through Real Options generates higher returns than the DCF model, a consequence of the increase in the value of the projects comparing to the base-case valuation. Secondly, it is interesting to verify that the pattern of the returns is similar between the two models, with the same SCUTs generating the higher returns in both models. The exception is made by Grande Porto, which experiences a significant increase in value when the assumption of no flexibility is relaxed.

SECTION IV - CONCLUSION

IV.I - THE MAJOR RESULTS

In the analysis of the allocation of risks between the public and the private sector, on the concessions of SCUTs, it became clear that the sponsors of SCUTs are exposed to three different kinds of risks, among the nine potential sources of risk for a large infrastructure project: the financial risk, associated to the volatility of the reference interest rate; the operational risk, related to variations in the operational costs; and the construction/technical risk that can be disregarded given the fact that typically the company that built the highway is also a sponsor of that concession. Those risks are materialized by the volatility of Euribor 6-M, the reference interest rate, and the variations in the demand of the referred highways, which affect the operational costs directly.

Applying the traditional Discounted Cash-Flows model, the portfolio of the seven SCUTs in the base-case scenario is worth EUR 2 198.38 million in net terms, generating a return of 83%, which is significantly high. As discussed above, this result is referred to the value of portfolio without flexibility, that is, with fixed fundamentals. Relaxing the implicit assumption of no flexibility, and applying the proposed Real Options model to evaluate the portfolio, the value of the portfolio increases to EUR 4 099.35 million, generating a return of 154.77% over the initial investment.

Comparing the results obtained from both models it became clear that the DCF model underestimates the value of the SCUTs portfolio and that the flexibility of fundamentals creates value to the shareholders of the SPVs. If in some concessions the increase in value is quite moderate, like Beira Interior and Beiras Litoral e Alta, in other concessions the RO approach gives a valuation that is largely high, as in the case of Grande Porto. The significant increase in value under the proposed model compared shows that flexibility in the SCUTs projects is significantly valuable and that cannot be disregard during the valuation process. This result proves the advantage of the use of the RO approach in the valuation of SCUTs and, broadly, PPPs.

Additionally, given the relative low value of both operational and financial costs, when compared to the amount of the receipts of the SPVs, the large increase in the value of the portfolio seems to be majorly explained by the impact of the volatility of Euribor 6-M on the weighted cost of capital of the different SPVs. Since the fixed weighted cost of capital assumption of the DCF model is one of the most criticized hypothesis, its relaxation should lead to a more precise valuation of the projects. Therefore, the financial risk, measured by the variation of the interest rate, appears as the major source of uncertainty in the SCUTs case for the sponsors and, as a result, constitutes the major cause of the high value of the flexibility.

Comparing the increases in value on the different SCUTs, and comparing it with their fundamentals, there is no clear relationship between the relative spread between valuations $\left(V_0^i/\widetilde{V_0^i}\right)$ and any other variable (e.g. cost of equity, debt ratio or return under DCF). Even some patterns could be considered, as a positive relationship between dent ratio and the spread between valuations, that relationship is not clear for the entire portfolio. This lack of a defined relationship can be explained by the existence of a negotiation process before establishing each agreement, which has an important influence in the value of the different concessions and contaminate the comparison analysis. Another important aspect is the fact that the concessions were signed in different years. Although the partnerships were established in a short period of 4 years (1999-2002), the macroeconomic conjuncture and expectations in those years could be quite different and certainly had a significant influence in the value of the projects, since it coincided with the creation of the Euro zone and introduction of the single currency.

IV.II - Model's limitations and further work

One of the main limitations of the valuations presented above was the scarcity of historical data for a proper estimation of the statistical moments of each potential risk source variable. As it was said before, this limitation led to the use of proxy variables. In the forecast of the demand case, the proxy variable was GDP, due to the prociclicity of Private Consumption. Regarding the Euribor 6-M, since the concession of SCUTs coincided with the introduction of the single European currency, there were no previous data that could be used to forecast the moments. The solution was to use the Fibor 6-M, the previous German reference rate, as a proxy. However, there were few historical observations of that rate, which led to a statistically small sample and, as a result, raised the issue of the sample's representativeness problems. Even so, the series of Fibor 6-M was used as a proxy, in the belief that there were no representativeness problems with the sample.

Another important limitation of the model is the inexistence, for SCUTs, of a Public Comparable (PC) that could be used as a benchmark. Without a PC, it became difficult, and highly subjective, to analyze the value of the portfolio and its components under DCF and RO. One possible improvement to this dissertation is, therefore, the computation of the PC and its comparison to the results obtained from the model above.

Finally, the last constraint of the model is related with one of its own assumptions: cash-flows fluctuate randomly (A.2). Looking at the evolution of the free cash-flows to the firm of the seven SPVs, one can find two different groups of patterns: the ones that are increasing over time (Norte Litorial and Algarve) and the ones that start by increasing and, almost in the middle of the maturity of the concession, start decreasing until the end (Beira Interior, Beira Litoral e Alta, Interior Norte, Costa de Prata and Grande Porto). Clearly, in both cases, free cash-flows change annually in a specific pattern, which is not random. Consequently, A.2 is a very strong supposition, in the SCUTs case, that does not fit the reality. This assumption has an important impact in the RO valuation, because it is fundamental to the hypothesis of homogeneity of the standard deviation of the returns on the asset (the SCUTs) over time. Given the fact that there are large discrepancies between cash-flows during the maturity of the concessions, mainly in the second indentified pattern of free cash-flows, biannual returns will not follow a random walk, so a unique measure of the volatility of the returns will overvaluate the real volatility and will be less representative. This limitation leads to an interesting improvement to the model presented by using a more sophisticated model, based on more precise assumptions, to value the concessions under real options and compare the results obtained.

As additional further work, it would be very interesting to rerun the model proposed to evaluate the concessions after the different renegotiations that were agreed. This analysis would be particularly interesting to evaluate the impact of the introduction of real tools in those highways in 2010. As a final point, it would be very remarkable the adaptation of the model proposed to evaluate other PPPs in different activity sectors, like the PPPs in the health sector and security, both in Portugal and other countries.

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EXHIBITS

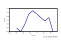
EXHIBIT I – FIBOR 6-M

The table below presents the summary statistics of the series of the Fibor 6-M annual growth rate. As it can be seen, the series is composed by 19 observations (from 1981 to 1999). Over the past 39 years, the Portuguese economy has grown -0.1% per year on average and has suffered a standard deviation of 26.22%. Given the small dimension of the sample and in order to approximate the valuation to the financial theory, it was assumed in the valuation that the Fibor 6-M rate changes annually at an average of 0.0%, contrarily to the statistics present.

variable	n	mean	std. dev.	min	max
Fibor_6-M_change	**19**	**-0.00935**	**0.26217**	**-0.41589**	**0.50685**

Table 5- GDP annual growth rate statistics. Source: Reuters EcoWin.

Graph 1 shows the histogram of the series. By analyzing the form of the histogram it is clear that the distribution does not exhibit the patterns of a Normal distribution, mainly in the tails. As it can be seen, there are inflection points near the tails, which turns the series away from the desired Gaussian distribution.



Graphic 1 - GDP growth rate histogram. Source: Reuters EcoWin.

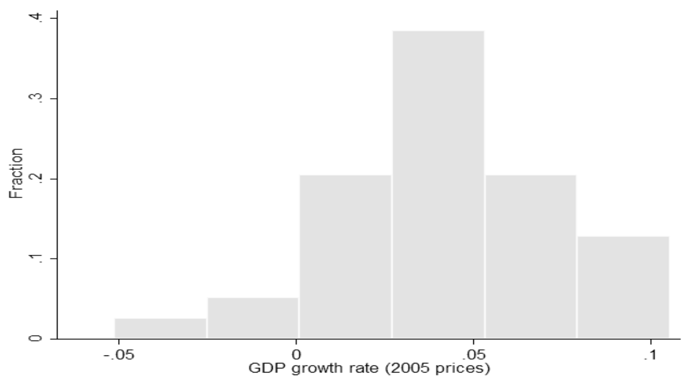
EXHIBIT II – PORTUGUESE GDP GROWTH RATE

The table below presents the summary statistics of the series of the Portuguese GDP annual growth rate. As it can be seen, the series is composed by 39 observations (from 1960 to 1998). Over the past 39 years, the Portuguese economy has grown on average 4.4% per year, in real terms, and a standard has experienced a deviation of 3.2%.

Variable	Obs	Mean	Std. Dev.	Min	Max
Growth	39	.0439856	.0324918	-.0509697	.1054325

Table 6 - GDP annual growth rate statistics. Source: Reuters EcoWin.

Graph 2 shows the histogram of the series. By analyzing the form of the histogram it is clear that the distribution exhibits a negative skewness, revealing a higher concentration of values on the right side of the mean, as more extreme values appear on the left side.



Graphic 2 - GDP growth rate histogram. Source: Reuters EcoWin.

In order to test the normality of the distribution the Skewness/Kurtosis tests were performed. As it can be seen in the table below, the joint test rejects the null hypothesis of the normality of the Growth series, with a significance level of 5%.

Skewness/Kurtosis tests for Normality

				joint	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
Growth	39	0.4927	0.1792	2.44	0.2959

Table 7 - Skewness/kurtosis tests for normality for the Growth's distributions. Source: Reuters EcoWin; STATA.

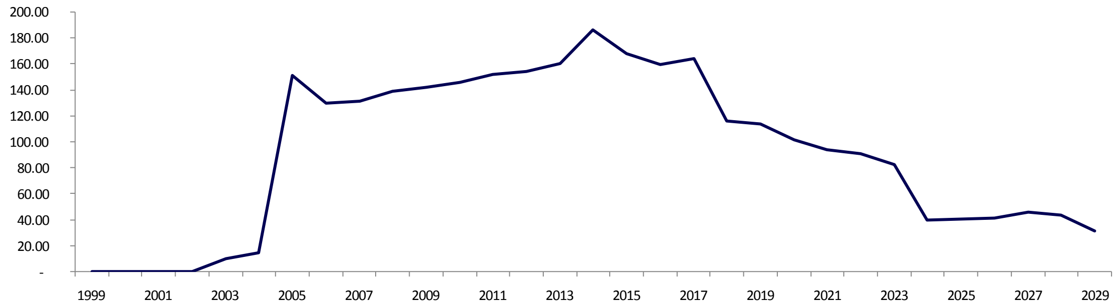
EXHIBIT III – PPPS TECHNICAL ANALYSIS

BEIRA INTERIOR

Characteristics

km	I	I / km	M	Adjudication date
178	EUR 586.68 million	EUR 3.30 million	27 years	13/09/1999

Receipts evolution

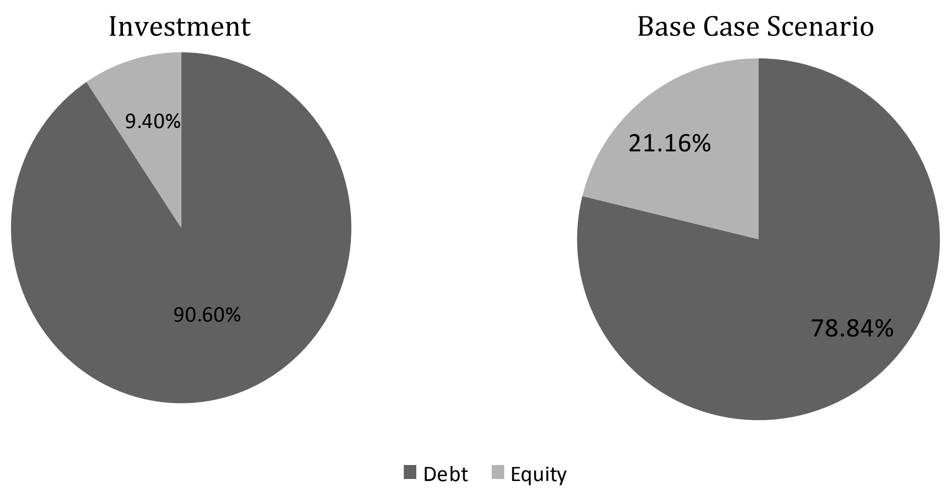


Graphic 3 - Beira Interior's receipts evolution. Source: Court of Auditors.

Valuation

			Net Present Value	
(EUR million)	**spread**	**Re**	**Base Case**	**Binomial Model**
	0.90%	13.03%	496.77	632.45

Implied capital structure

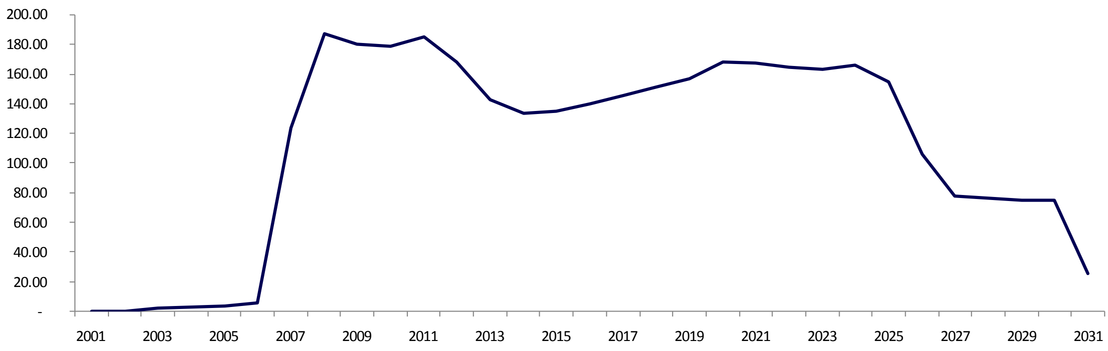


BEIRAS LITORAL E ALTA

Characteristics

km	I	I / km	M	Adjudication date
176	EUR 557.42 million	EUR 3.94 million	26 years	20/04/2001

Receipts evolution

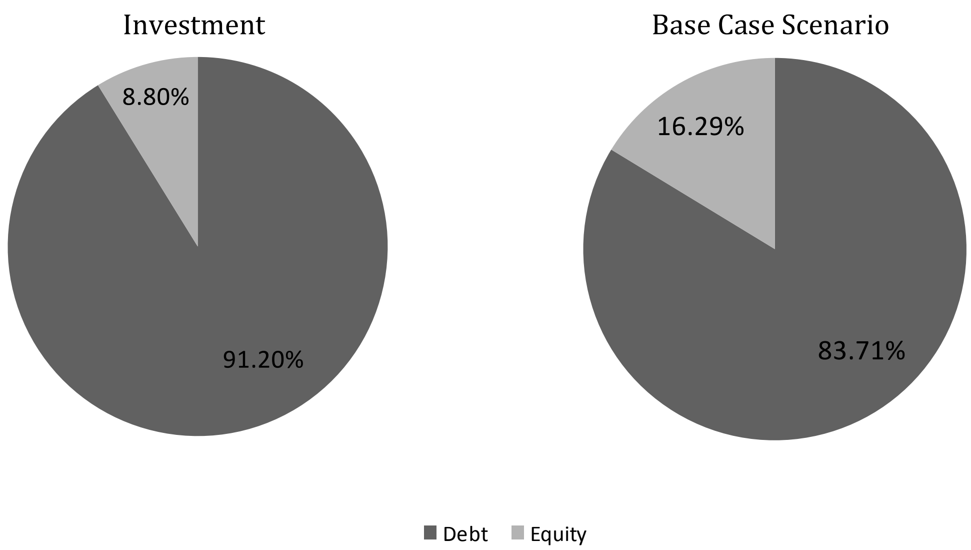


Graphic 4 - Beira Litoral e Alta's receipts evolution. Source: Court of Auditors.

Valuation

			Net Present Value	
(EUR million)	**spread**	**Re**	**Base Case**	**Binomial Model**
	1.20%	13.01%	411.26	658.36

Implied capital structure

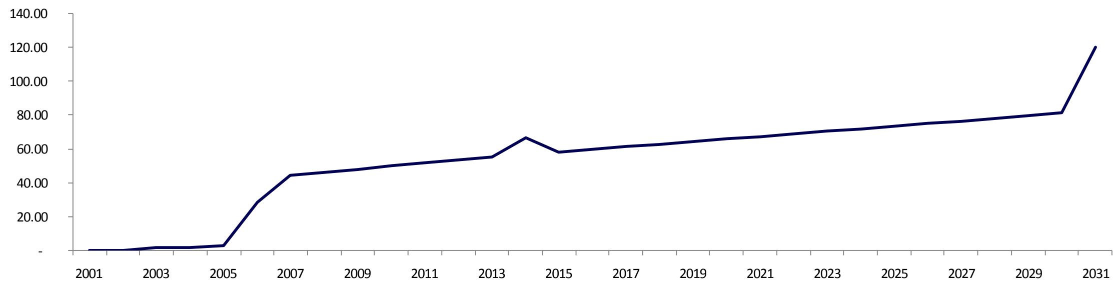


NORTE LITORAL

Characteristics

km	I	I / km	M	Adjudication date
115	EUR 250.53 million	EUR 2.66 million	27 years	17/09/2001

Receipts evolution

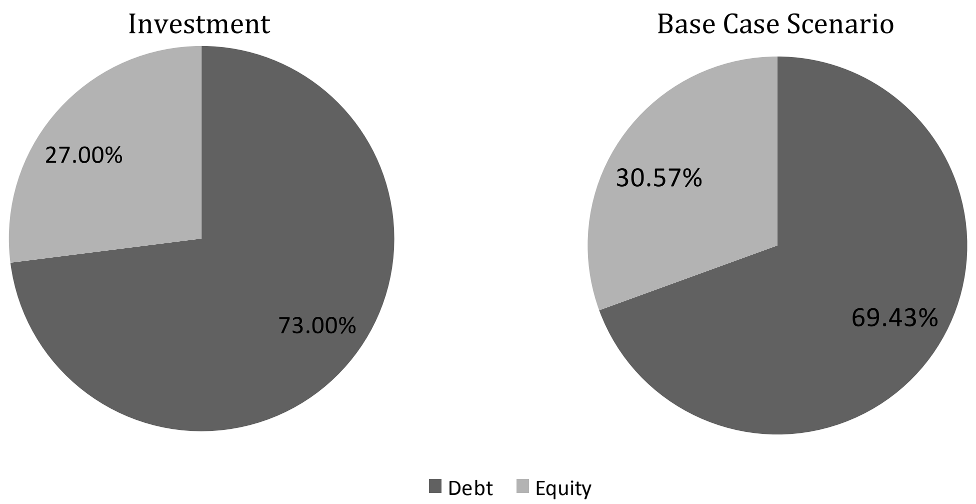


Graphic 5 - Norte Litoral's receipts evolution. Source: Court of Auditors.

Valuation

(EUR million)	spread	Re	Net Present Value: Base Case	Net Present Value: Binomial Model
	1.25%	6.41%	187.82	427.96

Implied capital structure

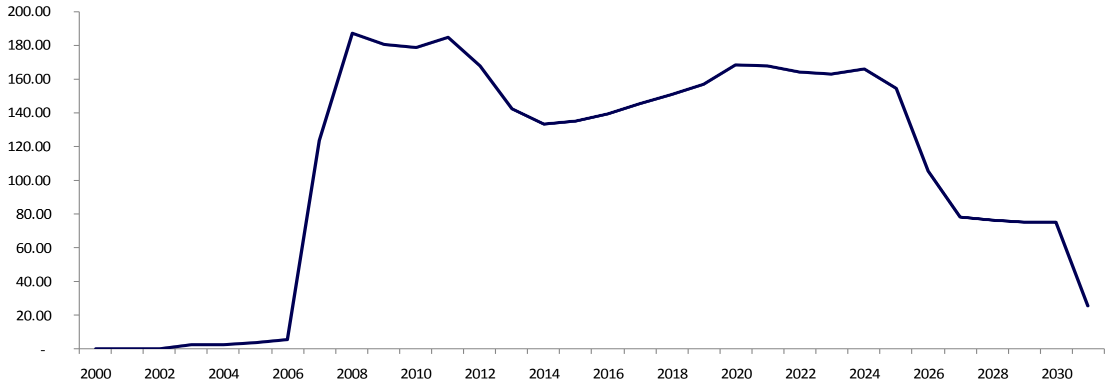


INTERIOR NORTE

Characteristics

km	I	I / km	M	Adjudication date
155	EUR 418.10 million	EUR 3.18 million	27 years	30/12/2000

Receipts evolution

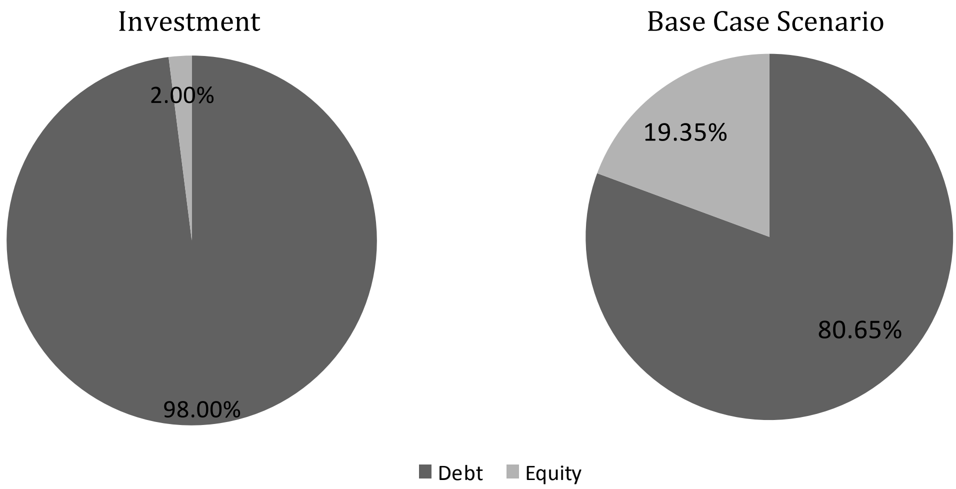


Graphic 6 - Interior Norte's receipts evolution. Source: Court of Auditors.

Valuation

(EUR million)	spread	Re	Net Present Value – Base Case	Net Present Value – Binomial Model
	1.30%	13.18%	586.85	891.85

Implied capital structure

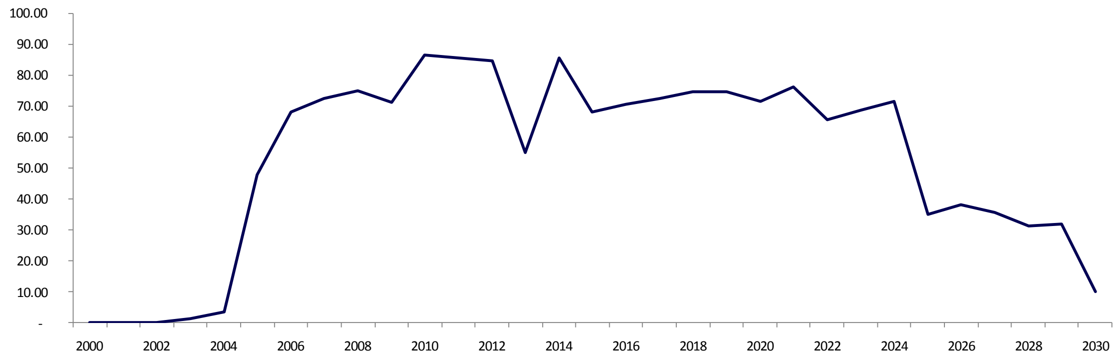


Costa Prata

Characteristics

km	I	I / km	M	Adjudication date
105	EUR 168.69 million	EUR 1.84 million	27 years	19/05/2000

Receipts evolution

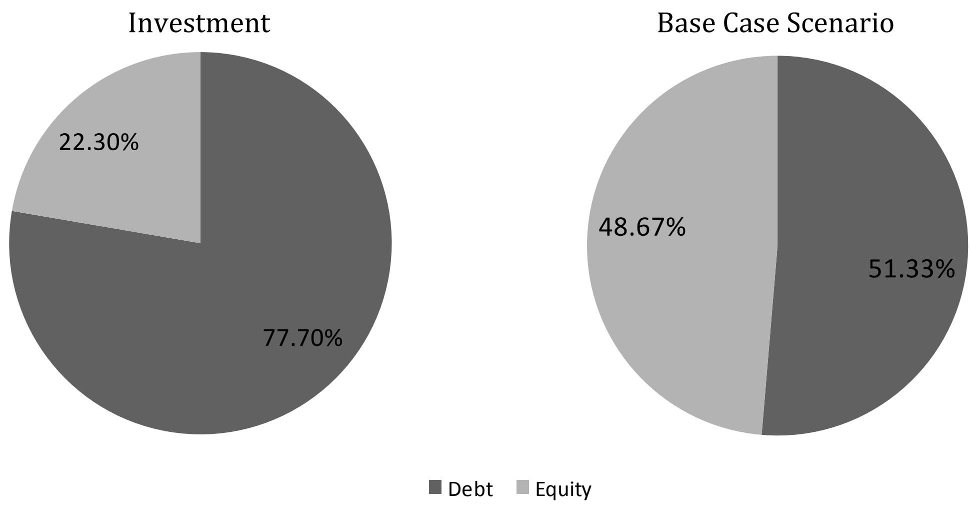


Graphic 7 - Costa Prata's receipts evolution. Source: Court of Auditors.

Valuation

			Net Present Value	
(EUR million)	**spread**	**Re**	**Base Case**	**Binomial Model**
	1.10%	11.89%	295.59	505.18

Implied capital structure

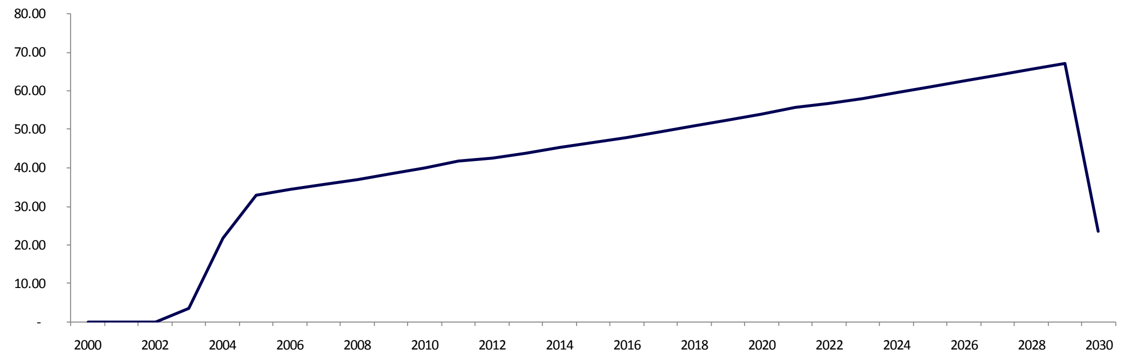


Algarve

Characteristics

km	I	I / km	M	Adjudication date
129	EUR 194.18 million	EUR 1.69 million	28 years	15/05/2000

Receipts evolution

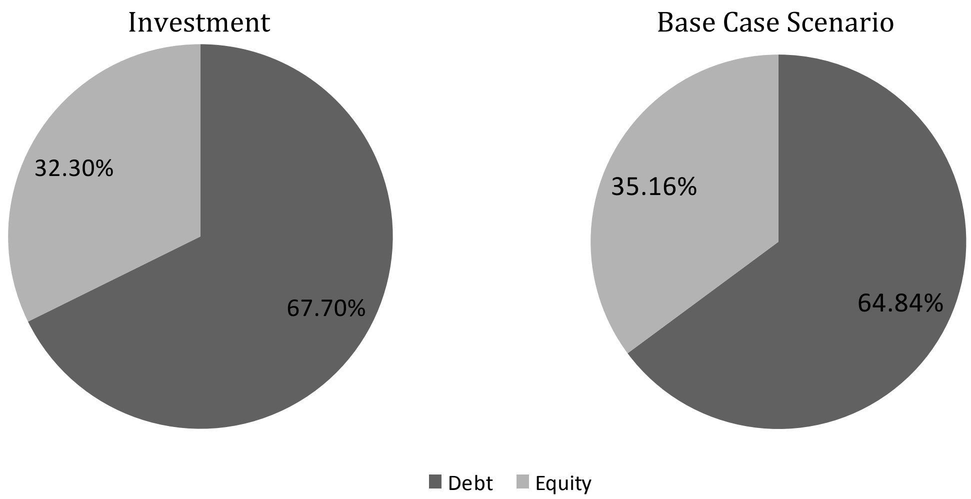


Graphic 8 - Algarve's receipts evolution. Source: Court of Auditors.

Valuation

			Net Present Value	
(EUR million)	**spread**	**Re**	**Base Case**	**Binomial Model**
	1.10%	7.72%	143.07	280.08

Implied capital structure

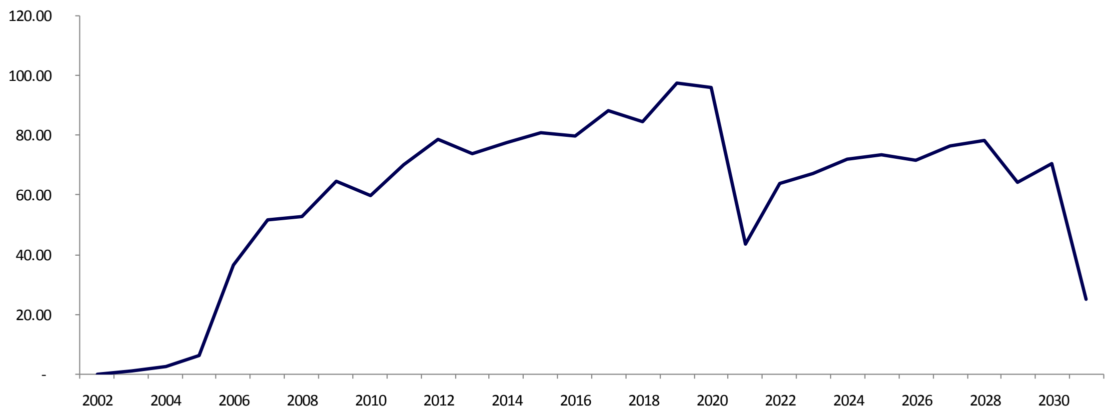


GRANDE PORTO

Characteristics

km	I	I / km	M	Adjudication date
72	EUR 478.06 million	EUR 6.64 million	26 years	28/08/2002

Receipts evolution



Graphic 9 - Grande Porto's receipts evolution. Source: Court of Auditors.

Valuation

			Net Present Value	
(EUR million)	**spread**	**Re**	**Base Case**	**Binomial Model**
	1.20%	12.02%	77.05	703.48

Implied capital structure