LISBOA SCHOOL OF ECONOMICS & MANAGEMENT

U LISBOA | UNIVERSIDADE DE LISBOA

MASTER

FINANCE

MASTER´S FINAL WORK

DISSERTATION

AN ALTERNATIVE VALUATION MODEL FOR PORTUGUESE PUBLIC PRIVATE PARTNERSHIPS USING THE BLACK-SCHOLES MODEL: AN APPLICATION TO THE PORTUGUESE ROAD SECTOR

LUÍS DAVID PEDRA COSTA

SEPTEMBER - 2013

LISBOA SCHOOL OF ECONOMICS & MANAGEMENT

U LISBOA | UNIVERSIDADE DE LISBOA

MASTER

FINANCE

MASTER´S FINAL WORK

DISSERTATION

AN ALTERNATIVE VALUATION MODEL FOR PORTUGUESE PUBLIC PRIVATE PARTNERSHIPS USING THE BLACK-SCHOLES MODEL: AN APPLICATION TO THE PORTUGUESE ROAD SECTOR

LUÍS DAVID PEDRA COSTA

SUPERVISION:

JOAQUIM MIRANDA SARMENTO

SEPTEMBER - 2013

Abstract

Since the early nineties, PPP use has been increasing over the years across most of the developed countries in the world. Despite, or because of, its growing usage and importance in government financial sheets, its valuation has always been controversial, with the literature being less than unanimous.

In this article we will propose a different valuation method for this type of project based on the Black-Scholes Model and show how to take into account other non-explicit advantages that the use of option valuation can bring to the project being studied.

Resumo

Desde o início da década de 90, o uso de PPPs tem crescido em todo os países desenvolvidos do planeta. Apesar de, ou motivado por, a sua utilização e importância para os Governos ser cada vez maior, a sua avaliação sempre foi controversa, com a literatura disponível a não ser unanime.

Neste trabalho iremos propor um método de avaliação diferente para este tipo de projecto, baseado no modelo Black-Scholes e mostrar algumas vantagens não explícitas que o uso da avaliação através de opções pode ter quando estudada.

Table of Contents

ABSTRACT **1**

RESUMO **2**

TABLE OF CONTENTS **3**

TABLES AND GRAPHS **4**

GLOSSARY **5**

1 - INTRODUCTION **6**

2 - LITERATURE REVIEW **9**

2.1 WHAT ARE PPPS? 9
2.2 VFM AND RISK ALLOCATION 11
2.3 A LITERATURE SURVEY ON BSM 14
2.4 STUDIES ON PPP VALUATION 17
2.5 MAIN FINDINGS 19

3 - PORTUGUESE CASE **21**

4 - METHODOLOGY & DATA **23**

5 - RESULTS **31**

6 - CONCLUSION, LIMITATIONS AND FUTURE WORK **38**

REFERENCES **41**

Tables and graphs

TABLE I

RISK ANALYSIS ACCORDING TO ENTITY IN THE PROCESS 11

TABLE II

RISK-FREE VALUE ACCORDING TO THE YEAR IN QUESTION 24

TABLE III

VARIABLES RELEVANT TO THE FORECAST OF FCFE EXPLAINED 25

TABLE IV

EURIBOR 6M AVERAGE HISTORY AND FORECAST 27

TABLE V

PPP NPV VALUATION 31

TABLE VI

VALUE CHANGE FOR EACH PPP AND THE WEIGHTED AVERAGE CHANGE 31

TABLE VII

PAYBACK YEAR FOR EACH PPP 32

TABLE VIII

CALL OPTION VALUE FOR EACH OF THE PPPS 33

TABLE IX

CASH FLOWS FOR THE LITORAL OESTE SUBCONCESSION WITH/WITHOUT EXERCISING THE CALL OPTION .. 34

TABLE X

PUT OPTION VALUE FOR EACH OF THE PPPS 35

TABLE XI

BREAK-EVEN VALUES FOR THE PUT OPTIONS ON EACH PPP 36

Glossary

BSM – Black-Scholes Model.

CAPEX – Capital Expenditure

D&A – Depreciation and Amortization

EBT – Earnings before taxes

EBIT – Earnings before interest and taxes

EBITDA – Interest before interest, taxes, depreciation and amortization

FCFE – Free cash-flow to equity

GDP – Gross Domestic Product

IRR – Internal Rate of Revenue

NPV – Net Present Value

NWC – Net Working Capital

OECD – Organisation for economic co-operation and development. A think-tank of developed countries committed to democracy and market economy

O&M – Operating and maintenance

OPEX – Operational expenditures

PPP – Public-Private Partnerships

SPV – Special Purpose Vehicle

VfM – Value for Money

1 - Introduction

Public Private Partnerships (PPPs) have emerged, over the years, as one of the major approaches for delivering infrastructure projects, providing a number of benefits to the public sector, such as alleviating the financial burden on the public sector due to rising infrastructure costs and allowing some risks to be transferred to the private sector and providing more efficient and reliable services at a lower cost (Kwak et al, 2009).

This work focuses on infrastructure PPPs (more specifically on roads) as defined by Savas (2000) as an arrangement where government states its need for capital-intensive, long-lived infrastructure, and the desired facility is built using a complex combination of government and (mostly) private financing, after which it is operated by a private entity under a long-term franchise, contract or lease. The payments usually span over twenty to 99 years and cover construction, operation, maintenance and capital costs.

PPPs have different objectives for the different intervenients. The private party sees this as an investment opportunity capable of generating profits. Meanwhile the public sector sees this as an opportunity to generate value for money (maximum efficiency for public funds) through synergies and higher efficiency levels from the private party.

PPP valuation has always been a sensible subject given all its specifications and long-term commitment represented by both state and private investors. Given Portugal's current financial and budgetary situation and the public perception that the private investor has more favorable conditions when compared to the public sector, it is of paramount importance to find alternative valuation methods and compare not only the results but also the reasons for discrepancies.

The Black-Scholes Model (Black & Scholes, 1973), from now on referred to as BSM, was first devised as a mathematical model to evaluate derivative investment instruments. This model is often used, especially by option markets participants.

Applying the BSM to real options and investments has been presented in academic

papers (see Luehrman, 1998). Despite this fact, only the South Korean Government has applied this to their PPP project evaluations as explained by Jay-hyung, Jungwook, Sunghwan and Seung-yeon, (Jay-hyung et al, 2011).

This study will focus on four main research questions:

1. How to evaluate a PPP risk?
2. Is the Black Scholes an adequate method to evaluate PPP risk?
3. How to use the BS model on PPPs?
4. What valuation does this model yield to Portuguese PPPs?

This work will focus on using the BSM and some of its more common variations, suiting them to the Portuguese specifications and inputs. We will use the real inputs used for predictions made at the time of the original contractualisation and using those empirical resources, see whether there are significant discrepancies between our new evaluation and the initial one and study not only why these differences arose but also why they are significant. We will then compare the results from our model with what they would be by copying the South Korean Model.

The objective of this thesis is to ascertain whether the PPPs were originally licensed at a fair price and whether the model used was one of the reasons for the under or overpricing of the investment opportunities. This will be an innovative study, not only because it will adapt a seldom-used model in PPP valuation but also because it will be the only one to do so with the real Portuguese PPP values, using the original values as of the date the deal was made.

Having reached the final values for our valuations of the PPPs, we can address the main question of this study of whether the different valuation method results in differing valuations or not. This will provide valuable input in analysing the main PPP concerns about their equity and income distribution between participants.

This paper is organized as follows.

In section 2 we provide a literature review that gives the basis for our work and provides an historical overview on PPP history and which financial models are usually followed in an evaluation.

Section 3 provides the history on Portuguese PPPs with a special focus on road PPPs.

Section 4 expands our methodology and explains which data we are going to use in our model.

Section 5 will provide the results yielded by the model we created, based on the explanations from the previous sector.

Section 6 provides the conclusions, limitations of the work and possible relevant future work in this area.

2 - Literature Review

2.1 What are PPPs?

Over the last decades a new concept has emerged regarding public investment and services: Public Private Partnerships (from here on referred to as PPPs). OECD (2008) gives us some background information on these, stating that despite the fact private firms have been involved in public service delivery for a long time, PPPs as we know them today were only introduced in the early 1990s.

PPPs are defined as an agreement between the government and one or more private partners. According to which the private partners deliver the service in such a manner that the service delivery objectives of the government are aligned with the profit objectives of the private partners and where the effectiveness of the alignment depends on a sufficient transfer of risk to the private partners. Kwak, Chih and Ibbs (Kwak et al, 2009) do a fantastic work on explaining the importance of PPPs for any developed country's economy.

Because many governments experience the pressure of fiscal deficits and increasing public debt burdens, by the mid-1990s the perceived promise of private financing was alluring, especially for large infrastructure projects (such as roads).

The above-mentioned 2008 OECD document states that the introduction of PPPs also raised a series of political, economic and technical questions, such as whether there should be public or private provision of services traditionally provided by the public sector. The answer to this question involves economic and political choices that depend on the relative efficiency of public services in a given country, on the availability of capital and on the social consensus about acceptable ways of delivering certain services. The economic question in particular concerns issues such as contract management and risk sharing, which should be done with the purpose of maximizing value for money.

Lewis (2001) gives several relevant arguments why PPPs can be advantageous for the public sector. The first one is derived from tackling the popular argument that PPPs

allow investment to exist that would otherwise have not been possible due to financial restrictions from the public sector. This argument, however, may not hold true since PPPs still draw on public funds, the only difference being the time frame under which the public payments are made. These payments must, in turn, cover operating costs as well as giving return on capital.

This fact means that PPPs offer other attractive features to governments other than just value for money. Besides making it possible for a country which lacks infrastructure and faces an uncertain fiscal climate to invest in major infrastructure, it also has the great advantage of offering predictable costs and effective funding. PPPs ensure consideration on whole-of-life costs and budgeting necessities for both infrastructure and related services, providing predictability of financial needs for the public sector over the life of the project and reduce the risk of funds being diverted. This also ensures that government payments only start when specifications are achieved, thus removing any operational risk from the public sector, by bundling into private hands the tasks of design, finance, construction, operations and maintenance.

Current support for PPPs rely primarily on the claim that they are seen as providing better value for money than alternative models of procurement. Value for money is associated with economy, efficiency and effectiveness (Shaoul, 2005) and is based on the idea that PPPs can produce services at least equivalent to the quality that would be presented by the public sector but at lower cost.

Current literature claims that essentially, because of superior risk allocation and the benefits to be derived from cooperative partnership relationships, such as important benefits for risk allocation, since it implies a commitment to deal with unforeseen contingencies cooperatively instead of rigorous interpretation of contractual terms several synergies can be had and economic value added from the sharing of risks, despite having a drawback some inflexibility since parties cannot dispose of their interest without the consent of their fellow partners (Quiggin, 2006).

2.2 VfM and risk allocation

A popular view is that public sector financing is always cheaper than that obtained by private sector borrowers, thus meaning, so the argument goes, that PPPs are never value for money. Lewis (2001) draws on the CEDA (1999) and Giliber and Steinherr (1994) argument that proves this conclusion too simplistic. The first concern is that the lower government financing costs ignore the fact that public debt is not riskless in its entirety. In effect, governments enjoy lower risk as they can resort to general and "inflation" taxation to avoid bankruptcy. This focus on taxation needs to be built into social risk calculations, with conventional public financing and its discount rate needing to factor in the indirect costs that arise from higher public borrowing in the face of possible adverse macroeconomic outcomes and eventual externalities.

To study the effectiveness of PPPs, first we have to understand the risks present to each entity in the process. Grimsey and Lewis (2002) give us an accurate and succinct preview of this:

TABLE I

RISK ANALYSIS ACCORDING TO ENTITY IN THE PROCESS

Entity	Risk Perspective	Key Variables	Major Risks	Risk Analysis
Public Sector	Value-for-money / Contingent risks up to financial close.	Contract NPV	Bid Qualifications	Expected Cost. Sensitivity of Risks.
Sponsor	Impact on return.	Equity IRR / Contract NPV	Demand Factors. Mid-life CAPEX. OPEX. Performance.	Monte-Carlo Simulation.
Lender	Default / Delays in interest and principal.	Debt service. Cover Ratios.	Demand Factors. Mix-life CAPEX. OPEX. Performance. Construction.	Downside Sensitivity.

Lewis (2001) does a very complete analysis of the risks present in PPPs. There are several conclusions from his work that we should keep in mind, such as the fact that demand risk is not necessarily bundled into the contract agreement and may remain in the hands of the public sector. The study of the risks present in the project and whether these should be bundled into the private sector is one of the most important aspects in this area since unloading inappropriate forms of risk merely adds unnecessary costs to a PPP agreement. This means that only appropriate levels of risk should be transferred. Risk management - identification, assessment, allocation and its mitigation is central to the success of PPP delivery of value for money.

The allocation of risk is the central issue in contracting with the driving principle of negotiation, aiming to allocate the risk to whoever is able to manage it at the least cost, whilst always taking into account public interest (Quiginn, 2006). That is to say, risks should be allocated to whoever is the most efficient at dealing with them, bringing advantages to all parties involved in the project.

Lewis, like Quiginn, strongly focuses on risk allocation and finding out who is the most fit to manage them. The distribution of inappropriate risks to the private sector means adding more costs to a PPP than is necessary. This is especially relevant since the private sector does not bear risk cheaply. According to the value for money argument, the government may agree to assume some of the risks for which the other party would grossly overcharge if faced with the necessity of entirely assuming that risk.

The usual procedure is for the private party to take on risks that can be appropriately priced, managed and mitigated. This is usually done by transferring the risk to another party, by way of subcontracting or insurance. This is the main motivator behind SPVs being composed of a consortium of private companies such as debt financiers, equity investors, a design and/or construction contractor, along with government advisors. This means that when risks such as a design for a project possibly not being suitable for the designated purpose, having an experienced and insured designer greatly mitigates this risk. The private sector is then willing to accept a risk and earn a return for it (Lewis, 2001).

Optimal risk allocation aims to minimize the chances of project risk materializing, as well as their consequences if they do, as described by Lewis. This author also takes a special interest in the risks that are completely outside the control of both parties. In these cases, since none of the hosts has control, risk allocation assessment is more subjective and it should reflect how the private sector expects to be reimbursed for taking this risk and whether it is reasonable for the government to pay this price. This is done for taking into account what the probability of that risk materializing is, if the government has any ability to mitigate this risk and its cost to the government. Alternatively, the parties can also split the risk.

It is obvious that in the subject of managing the risks, nothing is free. While bidding for a project, the private party considers the project's risks and their potential impacts on revenues, fighting these by setting premiums to insulate itself from the financial results of materialized risks. This is a form of self-insurance as a way of weighing both the likelihood and the costs of adverse events happening. An explicit insurance can also be procured for certain risk, using insurance brokers, for example.

This also means that private providers are willing to accept most risks, provided that the premium is high enough. This means that it is in the hands of the government to analyze each risk and assess which decision brings more value for money (allocating a specific risk to the private sector or retaining it). According to Lewis (2001), typical risks the government might retain are, for example, risks of legislation or policy change affecting the project, risks of the government wanting to change service standards or some elements of pre-existing latent defects.

In any project of this size involving the public sector, there is a considerable amount of political pressure around it. Authors like Quiginn (2006) state that governments have found it politically advantageous to bundle all contractual relationships into a single contract, making it less transparent and increasing some risks faced by the government, such as those associated with renegotiation, while passing other risks to the financiers who put together the consortium required for this kind of bundling. The result of this is,

generally speaking, the transfer of too much risk, and opportunities to unbundle risks are foreited, thus losing on an amount of the value created by the project.

A clear example of this bundling of risks referred on the paragraph above is the transfer of demand risk. Demand for road projects are not severely dictated by the services offered by it (since there are none that are sufficiently relevant to the user) nor by its current state (as long as it does not pose a safety threat, it isn't of significant relevance to the driver). It is easy to see that the factors that actually influence traffic are fuel taxes, provisions of public transport and urban development policy, which are all out of arm's length of the private sector provider. As such, this is one of the risks that have no economical advantage to pass on to the private sector and would only be pursued for political or, arguably, moral reasons. In our assignment the demand risk is modeled as being held entirely by the public partner.

The need for contractual flexibility is another problem this type of investment faces. As stated by Vajdíc, Damnjanović (2011), the need for this arises from the nature and complexity of investments of this type, which present long term obligations between contract parties and a complex number of associated risks. This means that contractual flexibility, giving rise to a right to make changes in investment decisions according to the project's future performance, could be greatly beneficial to all parties involved. Applying real option theory to these projects emulates this kind of flexibility, increasing project value and a better sharing of project risks between the parties.

2.3 A literature survey on BSM

The Black Scholes model was first presented by Fischer Black and Myron Scholes in their 1973 paper *The Pricing of Options and Corporate Liabilities*, which stated that if options were correctly priced in the market, it should not be possible to make sure profits by creating portfolios of long and short positions in options and their underlying stocks and, from this principle, a theoretical valuation formula for options is derived.

This paper presents the BS Model which gives a simple solution to find the correct

pricing of financial options. This model assumes several "ideal conditions" for the derivations done:

1. The short-term interest rate is known and constant over time;
2. The stock price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus the distribution of possible stock prices at the end of any finite interval is log-normal. The variance rate of the return on the stock is constant;
3. The stock pays no dividends or other distributions;
4. The option is “European” that is, can only be exercised at maturity;
5. There are no transaction costs in buying or selling the stock or the option; it is possible to borrow at any fraction of the price of a security to buy it or hold it at the short-term interest rate;
6. There are no penalties to short selling. A seller who does not own a security will simply accept the price of the security from a buyer, and will agree to settle with the buyer on some future date by paying him an amount equal to the price of the security on that date.

The original BSM that presents these assumptions had a very significant impact on the finance world and has since been studied profusely. As a result, these assumptions have been studied over the years and the ones relevant to this paper can be relaxed or just removed and the original model adapted in ways that we will show as the opportunity arises. The ones that can not be relaxed will have to be assumed as a hindrance to our work and should be addressed in future work. Below we will show the treatment and our justification related to each of the original assumptions:

1. After the original paper was published and the BSM started being used profusely in valuing securities, this assumption was disregarded by investors and studies done in this specific case show that in reality a long-term approach can even reduce the bias present in the form of Kurtosis and Skewness (Black et al, 2004);
2. This is one of several possibilities of approaching the variance problem present in any valuation. However, the forecast of the variance proposes the same

problem for this model as it does for any other investment variance problem. We have chosen to follow the route suggested by Luerhman (1998) that says that one way to estimate volatility is to compute the implied volatility of the investment by using prices of securities traded in the market for which all parameters are known except the volatility. We have chosen several stocks publicly listed that have as a main business revenue source road PPPs;

3. Since in our case the BSM applies to a stand-alone project that has a conclusion date, we can ignore this assumption as long as we consider the cost of incurring the reinvestment fallacy as described by Kelleher & MacCormack (2005). However, since our reinvestment rate is the investor's cost of equity, the effect of this investment should be null since, as described by Myers and Majluf (1984), if the SPV decided to reinvest the equity holders' cash flows, they should have sufficient financial flack to do it;
4. This assumption has shown numerous times that it can be relaxed, but it is irrelevant to our study since we decided to issue our options as European Options anyway;
5. We will hold this assumption as is usual in academic papers. This is an assumption of our paper since these are not commonly traded options in the market. This topic will be touched upon again in the last chapter;
6. Irrelevant to our case since the BSM is applied to a specific investment with only one equity investor (the SPV, which in turn can have several investors);

This model has been through several adaptations through the years. One of the most relevant for our study was the one done by Luehrman (1998), which sees investment opportunities as Real Options, very similarly to the approach done by the South Korean Government as explained by Jay-hyung et al (2011). The South Korean method follows the Luehrman real option model, in which an investment opportunity is more adequately evaluated according to the Black Scholes Model.

Traditionally, detailed real investment valuations are based on discounted cash flows coupled with a NPV valuation. This, however, as pointed by authors referred to in the previous paragraph may hide some shadow advantages present in real investment

opportunities. Having a real option means that the potential investor has the possibility, for a limited amount of time, of either choosing for or against a final investment decision and its identification is, for this reason highly prized by corporate management (Carlsson & Fullér, 2003).

Since, at any given time, the benefits resulting from exercising the option are uncertain, the existence of a time to expiration is highly valued by potential investors, because it gives time for managers to collect more information on the investment and see how the factors affecting the investment change over time.

This represents the main difference between NPV valuation and a BSM valuation applied to real investment opportunities. In a real investment valuation utilizing the BSM and modeling it as a call option, the call value is, implicitly, a sum of both the project's intrinsic value (which yields the same result as a NPV valuation) and the time value of being able to defer the investment (in reality, the time lapse between realizing we have an investment opportunity and having to take it) and represents the real value that the investment opportunity represents to the option holder.

2.4 Studies on PPP valuation

With the explanation from the previous paragraphs we can see why we have chosen the South Korean approach as the most accurate model when valuating PPPs. The main reason why this happens is due to the complex negotiation rounds necessary in these types of investments and that give rise to time intervals between the first valuations and the final investment decision, while at the same time, many of these areas being discussed may hold little impact on the investment value as stated by the think-tank OCDE (2008). After the final negotiations, several rounds of approval must be made by public institutions (finance ministry, transport ministry and a final statement from the Portuguese court of accounts on whether the project is financially sound for the public sector) until the final public signing of the contract.

Naturally, until the final contractual signing, if the factors that affect the value of the

investment do not evolve favourably, the private would-be investor can bow out of the investment, having as a last resort option the possibility of writing-off the realized investment in the SPV (a subsidiary or a joint-venture with limited responsability for the investors). While in the process of deciding whether to write-off the realized investment or not, it should be important to see that these losses are sunken losses and should not influence future decisions.

The conditions described in the above paragraphs are why we are confident in saying that this situation gives rise to a real option where the decision is whether to continue and complete the rest of the necessary investment or bow out of the project. The exercise price is the remaining value of the investment and the time to maturity of the option is the amount of time after the initial offer and before the final agreement of terms and signing of the contract. In this situation the BSM is more adequate than the NPV model since it will take into account the value of the investment and the time deferral between recognizing the investment opportunity and having to make the final investment decision.

Applying the BSM to a real project can also help us create several other scenarios where issuing financial options on the project can help us on several scenarios, such as diminishing the amount of interest-bearing funds with collateral outside the actual investment to start the project. This is done in our project by having the SPV selling call options to foreign speculators. According to Bullock & Hayes (1992), options are the preferred instrument for speculation and this could be used to the advantage of the investment holders. It is feasible to issue financial options on the project since the assets, income streams and obligations of the private party are by nature tradable and there is a market for it, provided we find a buyer.

By selling a call with a future exercise date to a speculator, the SPV is earning cash flows today at the expense of a potential future upside in the market conditions. The incentive for the SPV to do this is that this way it would need to issue less equity or contract a lower amount of debt to finance the project. In the results chapter we will see what impact this has for the equity holders.

Another way in which issuing options under the BSM valuation can be helpful and present several advantage to the SPV investors is using them to hedge the risks surrounding the investment and deferring the final divestment decision until a further date when the investors have more information. This is specially useful, due to the main determinant of a road PPP success being the payments made by the state to the SPV and since we are in the middle of a financial crisis that has placed large financial and political pressure on the public entity to cut transfers to private partners. With this context of political uncertainty the holders of the investment and any parties potentially interested in the investment may be fearful of potential future cuts to their revenues.

Hedging by buying a put option would give the decision makers more time to appreciate the convoluted political positions and make sense of which rumors should be taken seriously and which should not. In a sense, by buying a put option, the decision-maker is buying time to assess the future developments to the factors that affect his investment. After buying the put option he can afford to wait before the final decision, since he knows he will always have a guaranteed value for the investment (the strike price) if he wishes to exercise the option.

As in any valuation, however, besides our main valuation model, several other tools can also be studied. Specially relevant to our case is one of the most commonly used tools in business valuation: Discounted Payback Period, defined by Berk and DeMarzo (2010) as the number of years that it takes for a project to break even from their initial investment, after having discounted all future cash flows to a moment zero. When coupled with the BSM model, we have can use our model for several purposes, namely to reduce the amount of capital at risk.

2.5 Main Findings

To endeavor to make a study of this kind, firstly we need to define exactly what we are studying and what our purpose is. Having taken as the definition for PPPs one accepted by OCDE, we could then follow on to find out what the motivations for engaging in

PPPs are for each party and what risks each of them is exposed to.

Having done that, we could then define more precisely the broad subject, which is Value-for-Money and how much of an important variable it is in the study of PPPs. This leads to us to study in more detail the risks inherent in road PPPs and see how the distribution of these (usually in bundles) among the participants affects the solidity of these projects.

This leads us to the importance of flexibility in the contracts and how options may help us achieve that. After defining the valuation model and why it can (and should) be applied in this case and under which assumptions we can then use it and reach a final valuation. Coordinating the presented model with the need for flexibility in order to generate more economic value we can see how options could be good for the investors.

This work has the particularity of being one of the first papers making the case that PPPs should be evaluated with the BSM similarly to the model used by the South Korean Government. In Portugal, this is still unexplored, as of yet.

3 - Portuguese Case

Given Portugal's current financial and political conditions, it is even more relevant to study a Portuguese case relating to PPPs. According to Sarmento, Reis (2013), PPPs in Portugal started in 1993 and involve transportation, health projects and to a lesser extent security facilities. The road sector is clearly the leading sector in PPPs, representing three-quarters of the total budget effort for PPPs.

In Portugal and the rest of the world the most common model for road PPPs is a build-operate-transfer (BOT) type of project. In this scheme the private party builds and finances the operation of the PPP for the duration of the concession before transferring the ownership of the investment back to the state. In return the private sector is entitled to collect tolls from users or receive payments from the public sector or any combination of both Vajdíc & Damnjanović (2011). These payments may also scale proportionally to traffic volumes but, in the case being modeled, the payments are fixed and independent of traffic.

According to the same paper, the total effort represented by private investment is a very big one for the country being studied, totaling EUR 30 billion (79% of which on roads), which led some to worry about whether these investments could be afforded or not. Future payments related to these contracts represent an annual effort of up to 1% of GDP from 2014 until 2020 and an effort higher than 0.5% of GDP until 2030.

These facts, coupled with the troika intervention and their interest in re-evaluating the PPPs underway and their value for money, make a more detailed analysis of the road PPPs specially relevant. This is another reason why in this study we try to find alternative valuations for them and see if the economic value by them is being explored to the fullest, either by identifying, managing and exercising several real options or by creating financial options with these real investments as the underlying asset.

This work establishes the necessary framework for further work to be done and leading to a more detailed study of the Portuguese road PPP scenario. It also makes it possible

to study whether taking into account the possibilities associated with options along the several phases of the investment can bring more value for money for all the parties involved in the project.

4 - Methodology & Data

We applied the BS Model to a real investment opportunity. This method of evaluation requires several steps similar to those required by a regular NPV valuation, such as computing the expected flows to the firm or to the equity.

Considering the literature presented in chapter 2, we can see that the inputs required for the BS Model when applied to a real investment opportunity are translated in the following way:

- S_0 – PV of a project's operating assets and future cash flows to be acquired;
- X - Expenditure required to acquire the project assets (usually designated by K in the standard BSM);
- t – Length of time the decision may be deferred;
- r – Time value of money;
- σ^2 – Riskiness of the project assets.

With these we can compute the inherent value to the holder of the right to follow through with the project using the BSM formulas:

$$c = S_0 N(d_1) - Xe^{-rt} N(d_2)$$

$$p = Xe^{-rt} N(-d_2) - S_0 N(-d_1)$$

$$\text{where} \quad d_1 = \frac{\ln \frac{S_0}{X} + (r + \sigma^2)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Where *c* and *p* are the values of European call and put options, correspondingly.

The next step was to discover what we consider as appropriate information to fill each variable. Since when the PPP reaches its maturity the asset ownership goes back to the

state, the S_0 is the present value of all future positive FCFEs. Since not all PPPs start turning positive FCFEs after a fixed amount of years (due to different scaling of payments) we assume that X is the sum of the discounted FCFEs until the first year of positive FCFE forecasts.

The BSM still required filling in the data for two other variables: Time value of money or risk-free rate (r) and the riskiness of the project (σ). We used as a proxy for the risk-free rate the 30-year German Bunds as quoted on the issue date of the option, and as the measure of investment volatility we will be using the historical volatility of quoted companies that operate in similar investments as this one.

Both the solutions referred in the previous chapter are common in the world of finance with Tobin (1997) referring that using the return on government bonds is normally perceived as a good proxy for the risk-free rate. Luerhman (1998) refers to our second assumption stating that we can get implied volatilities for shares for companies in industries similar to ours.

For our study of implied volatilities we searched for the publicly quoted companies with a business model as close as possible to the business underlying our PPPs. We used as proxies the following companies: Brisa, Abertis, Acciona, CCR.

TABLE II

RISK-FREE VALUE ACCORDING TO THE YEAR IN QUESTION

Year	1999	2008	2009	2012
r	4,418%	4,419%	2,554%	16,076%

In this work the focus was on the final equity investor in the SPV and that is the reason why we did the forecasts of the project's inherent value based on its FCFE. We managed to do this by forecasting its expected revenues and costs over the years of the project to its maturity. Any forecast has underlying its results several assumptions and ours is no exception. Our assumptions will be listed and explained below. The forecast of the FCFE will be as follows:

TABLE III

VARIABLES RELEVANT TO THE FORECAST OF FCFE EXPLAINED

Variable	Assumptions and Reasoning
Revenues	According to the payments agreed in the concession contract.
- O&M	First year O&M from the concession contract and increasing at the predicted inflation rate of 2% (ECB guidelines).
= EBITDA	Revenues - O&M
- D&A	D&A is computed through a constant quota equally distributed over the years in which the SPV explores the roads.
=EBIT	EBITDA - D&A
- Interest	Project Outstanding Debt * (6M Euribor + Project Spread)
=EBT	EBIT - Interest
- Taxes	(EBT - Eligible Net Loss Rollovers) * Tax Rate
= Net Income	EBT - Taxes
- CAPEX	The CAPEX is invested over a period of four years in the SCUTS cases and five years in the subconcessions (except the Pinhal Interior which was over six years).
- ΔNWC	Assumed as zero.
+ D&A	Same as above.
+ ΔDebt	Debt levels are quantified in the public contracts and it is now a question of modeling its gradual entrance into the SPV. We assume that debt levels increase in the construction years as a flat percentage of the CAPEX values and are repaid in constant terms over the years. The maturity of each debt is stated in the PPP contracts.
= FCFE	Unlevered Net Income - ΔNWC + D&A + ΔDebt

After forecasting the yearly FCFE all we needed to do was to compute them back to the starting year of each investment at the cost of equity rate. The reason why we wanted to compute the FCFE and not the more standard free cash flows to the firm is so we could showcase the importance that the interest and debt repayment amounts paid have, so it could be easily concluded that the main financial burden to the SPV is the service of

debt.

The equity rate used to compute the FCFEs in the SCUTS is taken from the public contracts of the SCUTS in which those values were reached and agreed on. Since we did not explicitly have these values for the subconcessions dated from 2009, we had to deduct these values. The cost of equity is commonly defined as the risk-free rate plus the market risk premium times the sensibility of the industry to its changes. Since we knew the risk-free rate at date 1999, we deducted it from the weighted average cost of equity from the SCUTS (weighted for total equity values) and got the industry's market risk premium. Since in 2009 the financial crisis was still not at its peak, there is no reason for this risk premium to change significantly and this is the most accurate proxy we can find for our subconcessions cost of equity.

It is the objective of the European Central Bank to set and actively pursue as an inflation target 2% per year and we will assume that in the years following the start of the investment the ECB will achieve its target. O&M is a clear example in which the prices present in the contracts generally arise from long-term commitments and are updated according to the general price increases in a certain economy, so we will assume that the only change over the years in the O&M prices is related to the inflation rates over the years.

Using the fact that we have a later evaluation period of the project, we can have a more accurate forecast of the interest costs of each project (since most of the financial burden comes from the Euribor rate), and we will be using the historical values for years 1999 to 2013 by averaging the values of each year. For the years 2014-2016 we will use the futures values (all values taken during May) and assume the futures value of the year 2016 since this is the most recent data available and will serve as a proxy rate for the following years.

TABLE IV

EURIBOR 6M AVERAGE HISTORY AND FORECAST

Year	Euribor 6M Average
1998	3,23%
1999	3,35%
2000	4,28%
2001	4,00%
2002	3,10%
2003	2,50%
2004	2,18%
2005	2,40%
2006	3,19%
2007	4,32%
2008	4,28%
2009	1,97%
2010	1,11%
2011	1,46%
2012	0,97%
2013F	0,32%
2014F	0,53%
2015F	0,74%
2016F - 2050F	1,15%

Traditionally in Corporate Finance, yearly changes in Net Working Capital has to be assumed when computing the FCFE, but in our case none of its major components are significant and we assume there would be no significant NWC investment or changes over the years in roads investments.

With all the information relayed in this chapter all we have to do is compute the yearly FCFE values at the cost of equity of each specific project as was described above.

The model we created tries, as any academic model, to produce a model that can be replicated for any investment with similar characteristics to the ones being originally studied. Due to the fact that roads are all necessarily in different places and have different lengths, it is impossible to find a sufficiently adequate generalization for revenues with origins other than state transfer (which generate most of the value of the investment). Examples of this type of alternative revenues are then spaces rented to

companies having petrol stations in the roads.

For similar reasons, and since it varies deeply from firm to firm that is proposing to build and operate the PPP, it is impossible to include in a reliable model the indirect costs that arise from these investments, such as financing, accounting and legal fees. Future users of this model should find it easy to correct for this, using real data for the investment they are studying. The way to apply these changes should be immediate since these are considered as accounting income or losses and can just be added or subtracted to the model under revenues or OPEX.

After adequately inputting the values in each variable, we reach the real option value of the investment opportunity, which takes into account not only the net present value of the investment but also the time value of the possibility of discarding the investment. In the computations we assumed a 1-year decision deferral period.

Having reached the final values for our valuations of the PPPs we can address the main question of whether these investment opportunities present advantages to the investors in the SPVs.

This MFW does, however, also aim to show that using options in real investment opportunities offers other advantages to the entities involved, such as minimizing risks or the amount of capital required at the beginning of the project. Options are well known as both hedging and financing tools, and we will aim to show that on any new or ongoing real investments options present several useful possibilities.

It is interesting to see the high level debt takes when compared to the total investment values. This means that the equity investors will have to provide comparatively low amounts of funds when compared to debt holders. However, by using options the equity investors can even lower the amount of funds required by selling a call option for a future date, making it possible to effectively reduce the amount of interest-bearing liabilities in their portfolio by sacrificing part of a possible future upside in the business value. In our example we have set as an exercise date for this option the first day of the

year in which the investment reaches its discounted payback period.

By setting the issue date of this option at the starting day of the investment (or just before) we can lower the amount of traditional equity funding required by the equity holders. This way the shareholder will receive an inflow at moment zero of the project, and at the payback year and exercise date of the options, he will either receive the exercise price, if conditions become more advantageous for whoever holds the investment, or the remainder of payments, if the call option owner chooses not to exercise. This is also why the option issuer is receiving the initial inflow at the expense of cashing in potential future upsides in the valuation, because if conditions become more advantageous for him he will probably lose ownership of the project, since the option owner would exercise its option and take control away from the original SPV owners.

Speculators could be very interested in buying options such as the ones described in this paper, since it would be an effective way of exploring potential upsides of changes on the several factors underlying the investment, such as interest rates. Another reason why it could be appealing would be if the buyers of the call option had not had access to the initial bidding and thought they could outperform the current SPV in operating or financing terms.

Another way in which options could be used would be to hedge against possible future risks. Hedging is when we take up a position on another investment (usually a financial security) that offsets some of the exposure risk on our main investment. With financial options we could, for example, buy a put option that would guarantee us a certain amount (the strike price) regardless of future events.

From our explanation of hedging, and taking into account the fact that we are in a climate of grave government financial uncertainty where the equity holders are afraid that their main source of income (government transfers) can be cut, it is of interest to search for ways in which to diminish risks without having to sacrifice a lot of cash flows. Devising an option such as the one described below that helps the equity holders

have a better and more informed decision at hand is an often effective way of hedging.

One of the hedging possibilities would be by buying a put option. In the Portuguese case for example, in the highly turbulent year of 2012, it might have been of interest to take some precautionary measures against the financial crisis and any measures the state might have taken in order to curtail transfers to the road PPP SPVs.

5 - Results

For comparison reasons it is interesting to see what results a traditional approach such as NPV valuation yields for the PPPs being studied:

TABLE V

PPP NPV VALUATION

	Beira Interior	Interior Norte	Algarve	Costa de Prata	Grande Porto	Beiras litoral e alta	Norte Litoral
PV(S)	240.229	167.856	153.988	141.689	94.595	228.676	238.850
PV(X)	-137.106	-109.564	-62.928	-72.856	-158.564	-203.963	-133.854
NPV	103.124	58.291	91.060	68.833	-63.969	24.713	104.996

	AE Transmontana	Baixo Alentejo	Baixo Tejo	Algarve Litoral	Douro Interior	Litoral Oeste	Pinhal Interior
PV(S)	146.145	168.944	254.913	193.053	360.212	332.433	640.023
PV(X)	-119.195	-109.484	-49.887	-61.282	-136.438	-91.188	-200.650
NPV	26.950	59.459	205.026	131.771	223.774	241.245	439.373

This initial and very standard valuation serves as a starting point for the valuation and as a comparison basis to see what effects the factoring in of the time value of being able to defer the final investment has on the project's valuation.

Following our explanation in the previous chapters we will now take into account the implicit time window to make a final investment decision and valuing it accordingly (by creating a call option) we can then reach the following Real Option Values:

TABLE VI

VALUE CHANGE FOR EACH PPP AND THE WEIGHTED AVERAGE CHANGE

	Beira Interior	Interior Norte	Algarve	Costa de Prata	Grande Porto	Beiras litoral e alta	Norte Litoral
NPV	103.124	58.291	91.060	68.833	-63.969	24.713	104.996
c0	109.696	64.358	93.795	72.131	1.189	46.971	111.330
% Change	6%	10%	3%	5%	N/A	90%	6%
WAvg %	**14%**						

	AE Transmontana	Baixo Alentejo	Baixo Tejo	Algarve Litoral	Douro Interior	Litoral Oeste	Pinhal Interior
NPV	26.950	59.459	205.026	131.771	223.774	241.245	439.373
c0	37.284	65.461	207.182	134.421	229.686	245.187	448.049
% Change	38%	10%	1%	2%	3%	2%	2%
Wavg %	**3%**						

We can see the effect that factoring in the time deferral we have at our disposal before taking the final decision: the real value of the investment increases significantly. In the Grande Porto SCUT case, a project with a negative NPV actually presents some value to the investor, since given the project's volatility over the course of one year the project

can come to present positive values. This is interesting because it shows that by having the option to invest, the equity holders can prefer to buy the option and speculate on a possible upside in the factors that determine the value of the project, such as interest rates or the cost of debt and equity.

The SCUT % increase in value when including the option to invest of one year (excluding Grande Porto and weighting the increases for call value) is 14% and 3% for the other subconcessions. This means that evaluating the PPPs using only the NPV calculations significantly underprices the investments by failing to take into account all the tools available to the investor and how these add value to the project.

We can now analyze how we can diminish our amount of invested cash flows at risk. We can model a call option issued today to be exercised on the first day of the year just after the discounted payback year. With the information gathered before, we reached the following years in which the discounted payback period was achieved for each SPV:

TABLE VII

PAYBACK YEAR FOR EACH PPP

SCUTS (1999)	Beira Interior	Interior Norte	Algarve	Costa de Prata	Grande Porto	Beiras litoral e alta	Norte Litoral
Payback Year	2011	2013	2013	2010	N/A	2020	2018

Subconcessions (2009)	AE Transmontana	Baixo Alentejo	Baixo Tejo	Algarve Litoral	Douro Interior	Litoral Oeste	Pinhal Interior
Payback Year	2035	2029	2015	2020	2019	2015	2020

Having seen in which year the payback period is achieved, we can model our option in the way described in the previous paragraph. We will be selling a call option as a way of limiting the necessary inflow of funds to complete the investment phase whilst only relinquishing some of the possible future upside.

TABLE VIII

CALL OPTION VALUE FOR EACH OF THE PPPS

	Beira Interior	Interior Norte	Algarve	Costa de Prata	Grande Porto	Beiras litoral e alta	Norte Litoral
Exercise Date	01-01-2012	01-01-2014	01-01-2014	01-01-2011	N/A	01-01-2022	01-01-2019
S	89.578,2	52.055,2	84.938,3	67.897,0	N/A	20.667,4	104.084,6
X	89.578,2	52.055,2	84.938,3	67.897,0	N/A	20.667,4	104.084,6
r	4,42%	4,42%	4,42%	4,42%	N/A	4,42%	4,42%
T	13	15	15	12	N/A	23	20
σ	32,09%	32,09%	32,09%	32,09%	N/A	32,09%	32,09%
c_0	53.358,1	33.120,0	54.041,7	38.929,8	N/A	15.672,8	74.824,0

	AE Transmontana	Baixo Alentejo	Baixo Tejo	Algarve Litoral	Douro Interior	Litoral Oeste	Pinhal Interior
Exercise Date	01-01-2032	01-01-2028	01-01-2016	01-01-2021	01-01-2020	01-01-2016	01-01-2021
S	21.683,3	57.622,4	189.060,0	124.240,3	205.405,0	237.974,8	408.938,4
X	21.683,3	57.622,4	189.060,0	124.240,3	205.405,0	237.974,8	408.938,4
r	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%	2,55%
T	33	29	17	22	21	17	22
σ	32,09%	32,09%	32,09%	32,09%	32,09%	32,09%	32,09%
c_0	16.864,6	42.859,4	113.343,5	83.122,0	134.826,1	142.668,4	273.597,1

The value of the call presented above refers to the value that the equity investor will receive at the beginning of the investment period and represents a commitment to sell in case the option holder would wish to exercise the option. Taking as an example the Litoral Oeste Subconcession, we can see how this affects cash flows over the concession period.

TABLE IX

CASH FLOWS FOR THE LITORAL OESTE SUBCONCESSION WITH/WITHOUT EXERCISING THE CALL OPTION

Non-Exercised Option Scenario						Exercised Option Scenario					
Year	Discounted Operational FCFE	Option CFs (Not exercised)	Total FCFE (Not exercised)	NPV (Not Exercised)	Cumulative Discounted FCFEs	Year	Discounted Operational FCFE	Option CFs (Exercised)	Total FCFE (Exercised)	NPV (Exercised)	Cumulative Discounted FCFEs
2009i	-11.325	142.668	131.343	383.914	131.343	2009i	-11.325	142.668	131.343	383.914	131.343
2009	-15.781		-15.781		115.563	2009	-15.781	0	-15.781		115.563
2010	-15.629		-15.629		99.934	2010	-15.629	0	-15.629		99.934
2011	-16.999		-16.999		82.935	2011	-16.999	0	-16.999		82.935
2012	-16.438		-16.438		66.496	2012	-16.438	0	-16.438		66.496
2013	-15.016		-15.016		51.480	2013	-15.016	0	-15.016		51.480
2014	46.097		46.097		97.577	2014	46.097	0	46.097		97.577
2015	48.362		48.362		145.939	2015	48.362	237.975	286.337		383.914
2016	44.482		44.482		190.420	2016	End of Operation				
2017	41.404		41.404		231.824	2017					
2018	38.547		38.547		270.372	2018					
2019	35.894		35.894		306.265	2019					
2020	33.435		33.435		339.700	2020					
2021	31.134		31.134		370.834	2021					
2022	28.994		28.994		399.828	2022					
2023	6.599		6.599		406.427	2023					
2024	1.567		1.567		407.994	2024					
2025	-2.733		-2.733		405.261	2025					
2026	-3.499		-3.499		401.762	2026					
2027	-3.035		-3.035		398.728	2027					
2028	-2.210		-2.210		396.517	2028					
2029	-1.168		-1.168		395.350	2029					
2030	-995		-995		394.354	2030					
2031	-1.342		-1.342		393.013	2031					
2032	-884		-884		392.129	2032					
2033	-926		-926		391.203	2033					
2034	-908		-908		390.295	2034					
2035	-755		-755		389.541	2035					
2036	-594		-594		388.946	2036					
2037	-463		-463		388.484	2037					
2038	61		61		388.544	2038					
2039	-1.491		-1.491		387.054	2039					
2040	-1.280		-1.280		385.774	2040					
2041	-1.148		-1.148		384.626	2041					
2042	-99		-99		384.527	2042					
2043	-93		-93		384.434	2043					
2044	-88		-88		384.346	2044					
2045	-83		-83		384.263	2045					
2046	-78		-78		384.185	2046					
2047	-74		-74		384.111	2047					
2048	-70		-70		384.041	2048					
2049	-66		-66		383.976	2049					
2050	-62		-62		383.914	2050					

So we can see that by selling an initial call on the payback date (2015 for the case discussed here), the equity holders can actually fulfil their contractual obligations by completing the investment requirements without having to generate any cash flows to invest any amounts in the project other than the ones generated from the project itself and the derivatives it can originate. This is made possible by a mixture of high debt levels and a clever use of financial options as a financing tool.

When considering the risk hedging aspect of the options, the equity holders can issue a put option in order to reach a fairer assessment of what the investment really is worth after dismissing or increasing the probability of having the project's revenues cut and delaying the final decision on whether the investment should be maintained or not. In our example we assume that the general consensus is that, due to the financial crisis, there is a 20% chance of a 30% cut to government payments to SPVs.

We assumed that the equity holders of the SCUTS would be willing to invest up to 2.5 million euros to have the right to defer their decision on whether to divest or not after 2 years and having more information on the effects of the financial crisis on the government payments. As for the equity holders of the subconcessions we assumed they would be willing to buy a put option for up to 5% value of the future cash flows. Additionally we assumed that the option would be issued on the first day of the year 2012 and would have a time to maturity of two years. Table X below shows what the exercise values would be, given a put value according to the description given in this paragraph.

These values may be freely changed by future users of the model according to their assessment of what each decision maker is willing to pay in order to hold such an option. It should be noted that the lower the willingness to pay for the option, the lower the exercise value (the price at which they can divest the PPP) will be.

TABLE X

PUT OPTION VALUE FOR EACH OF THE PPPS

	Beira Interior	Interior Norte	Algarve	Costa de Prata	Grande Porto	Beiras litoral e alta	Norte Litoral
S	58.839,5	48.931,9	79.842,0	40.457,6	43.238,2	69.561,0	145.392,8
X	55.771,7	48.380,8	70.771,1	41.844,7	44.014,3	63.527,2	113.990,6
r	16,08%	16,08%	16,08%	16,08%	16,08%	16,08%	16,08%
T	2	2	2	2	2	2	2
σ	32,09%	32,09%	32,09%	32,09%	32,09%	32,09%	32,09%
p0	2.500,0	2.500,0	2.500,0	2.500,0	2.500,0	2.500,0	2.500,0

	AE Transmontana	Baixo Alentejo	Baixo Tejo	Algarve Litoral	Douro Interior	Litoral Oeste	Pinhal Interior
S	137.376,0	158.807,0	239.617,8	181.470,0	338.598,9	312.487,3	572.569,2
X	135.149,2	156.233,1	235.733,8	178.528,5	333.110,3	307.422,3	563.288,4
r	16,08%	16,08%	16,08%	16,08%	16,08%	16,08%	16,08%
T	2	2	2	2	2	2	2
d2	0,51764414	0,517641221	0,517643957	0,517644196	0,517645712	0,517643243	0,517643555
p0	6.868,8	7.940,4	11.980,9	9.073,5	16.929,9	15.624,4	28.628,5

The put values are the values that the SPV holders would be willing to pay today to have the opportunity to defer the final decision and be able to gather more information before fully committing to a decision.

After structuring the put option we can easily find out under which conditions the put option holders would exercise the put according to their more informed perceptions of what the government cuts to subsidies would be.

We have made two simulations for each investment. In the first one it is given that the government has already notified the equity holders that they will cut transfers and the analysis is made on a basis of what % of transfer cuts is necessary for the equity holders to exercise the put. In the second situation, given a certain % of cuts, what would be the degree of certainty from the shareholders of that cut happening in order to exercise the put.

TABLE XI

BREAK-EVEN VALUES FOR THE PUT OPTIONS ON EACH PPP

	Beira Interior	Interior Norte	Algarve	Costa de Prata	Grande Porto	Beiras litoral e alta	Norte Litoral
Break-Even Point	55.771,7	48.380,8	70.771,1	41.844,7	44.014,3	63.527,2	113.990,6
Possible Outcome 1							
Planned Revenue	62.595,2	52.055,2	84.938,3	43.040,0	45.998,1	74.001,0	154.673,2
E(Revenue)	55.771,7	48.380,8	70.771,1	41.844,7	44.014,3	63.527,2	113.990,6
p	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
L	10,9%	7,1%	16,7%	2,8%	4,3%	14,2%	26,3%
Possible Outcome 2							
Planned Revenue	62.595,2	52.055,2	84.938,3	43.040,0	45.998,1	74.001,0	154.673,2
E(Revenue)	55.771,7	48.380,8	70.771,1	41.844,7	44.014,3	63.527,2	113.990,6
p	36,3%	23,5%	55,6%	9,3%	14,4%	47,2%	87,7%
L	30,0%	30,0%	30,0%	30,0%	30,0%	30,0%	30,0%

	AE Transmontana	Baixo Alentejo	Baixo Tejo	Algarve Litoral	Douro Interior	Litoral Oeste	Pinhal Interior
Break-Even Point	135.149,2	156.233,1	235.733,8	178.528,5	333.110,3	307.422,3	563.288,4
Possible Outcome 1							
Planned Revenue	146.144,6	168.943,7	254.912,6	193.053,1	360.211,6	332.433,3	609.116,1
E(Revenue)	135.149,2	156.233,1	235.733,8	178.528,5	333.110,3	307.422,3	563.288,4
p	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
L	7,5%	7,5%	7,5%	7,5%	7,5%	7,5%	7,5%
Possible Outcome 2							
Planned Revenue	146.144,6	168.943,7	254.912,6	193.053,1	360.211,6	332.433,3	609.116,1
E(Revenue)	135.144,6	156.233,1	235.733,8	178.528,5	333.110,3	307.422,3	563.288,4
p	25,1%	25,1%	25,1%	25,1%	25,1%	25,1%	25,1%
L	30,0%	30,0%	30,0%	30,0%	30,0%	30,0%	30,0%

Planned Revenue is the initial forecast payment scenarios, the ones we used in our starting valuation. E(Revenue) is the expected revenue we will receive taking into account our expectations of default at the date that we issue the options. p is the probability of having revenues cut and L is the amount of value subject to loss.

The percentages shown above give us some of the many possible combinations of perceived probability of losses and amounts of value at risk, above which it would be worth exercising the put option at the stipulated exercise values.

Table XI shows us that, regarding the SCUTS, if the Government would announce that there would be cuts made to government transfers into the SPVs, the equity holders of Beira Litoral e Alta SCUT would exercise the put option if the amount perceived to be cut was above 14,2% of government transfers. The lowest threshold for divesting is given by the Costa da Prata SCUT which says that if the amount to be cut was above 2,8% of revenues, the equity holders would divest through the put option.

As for the Subconcessions, we can see that if the government announced they were debating a 30% cut to transfers all investors (given the proposed put value) would divest if they attributed a chance of more that 25% of this cut happening.

6 - Conclusion, Limitations and Future Work

This paper set out to research the following questions:

1. How to evaluate a PPP risk?
2. Is the Black Scholes an adequate method to evaluate PPP risk?
3. How to use the BS model on PPPs?
4. What valuation does this model yield to Portuguese PPPs?

From the analysis done in this paper we can see that applying the Black-Scholes Model to the road PPP valuation yields different and interesting results when comparing with more traditional methods such as NPV. The time value of being able to make a final decision later than the opportunity presented itself is frequently ignored by decision-makers and can have a significant impact on the project's viability.

Another point this paper had set out to prove was that using techniques usually reserved for financial securities and applying them with the BSM to a real investment opportunity (particularly road PPPs) could yield several benefits for those involved in the process.

We set out to prove that the tactics usually reserved to financial securities using the BSM could also be applied to real investment opportunities such as the one we were analysing. This means setting out to prove not only what different valuation the BSM gives when compared to the NPV method but also whether we can use it as a speculation or hedging tool.

By studying the different applications of our model to the real investment opportunities we can significantly broaden the information available to the investors come decision making time.

We prove that some of these projects could be made without resorting to any outside financing for the initial investment by only having to sell a right to ownership at a future date and for a value that would make it indifferent for the shareholder to see that right

exercised or not.

This different approach to real investments also makes it possible to hedge future risks related to the operation without having to change anything operationally and having to pay the initial value for the right to sell at the future. This is specially relevant since in times of high uncertainty (such as the present financial crisis) the shareholders can defer any decision of divestment until a time when they have more information and can, in this way, more efficiently maximize their payoff whilst reducing risk.

Unfortunately it is impossible, in a work subject to the limitations presented to this one, to cover every possible topic of discussion. A specially relevant topic which has not been approached is whether the theoretical options described in the assignment would find no legal opposition and whether there would be buyers willing to engage in such a transaction without charging a large "liquidity discount" since these options would be traded over-the-counter and not in a listed exchange.

In this work we applied the real option theory to the projects being studied but solely from the perspective of the private party. This work lays the foundation to include real options on the contractual negotiations, namely of buy-back or abandonment options. This could be especially interesting since factoring real options into the agreement could bring advantages to both parties and help them explore possibilities presented to both as shown throughout this work. Future Work could devise which possible real options present themselves to the parties and which of them add more economic value to the project as a whole.

It would be especially relevant to see whether the existence of call-back or abandonment options would generate value-for-money by splitting the risks and creating, in a way, an upper and lower limit of earnings or responsibilities for both sides.

Related to the possible purposes of real options is also the fact that after the contract is formalized, the government loses any capacity to alter the terms and conditions stated in the contract to meet changing needs and circumstances. This could bring significant

economic advantages to some of the parties except insofar as these can be negotiated with the private partner. The private party, however, can capture most of the benefits that arise through subcontracting or selling the assets. This way, the public party has much of the costs of the partnership but few of the risk allocation benefits. Even though we touched on this topic and showed some ways in which real options could help divide the benefits through all parties, further work could be done in this area to study what consequences it would have in the value distribution and on the willingness of the private party to enter into such an agreement if it would mean a loss in the future upside potential.

Another point which we were unable to comment on due to space restrictions was which treatment to give to the risk-free rate when there is a large financial crisis in the country being studied. A point can be made that when there is this much financial distress, the risk-free rate cannot be based solely on what the rate of the Treasury Bond is. It is important, however, to stress that there is no absolute answer to this question and that it would present itself in a more classic approach such as the NPV valuation.

Regarding a more general concern related to PPPs, we would like to see how the incentives to invest vary from intervenient to intervenient, especially from the part of the banks and whether the high amounts of debt for the SPV create any sort of moral hazards and whether the high amount of risks that come with agreeing to finance 98% of an investment's initial capital outweigh the gains the project brings.

References

Kwak, Young Hoon, Chih, YingYi, Ibbs, C. William (2009). Towards a Comprehensive Understanding of Public Private Partnerships for Infrastructure Development. *California Management Review*, Vol. 51, n.º 2 (Winter 2009).

Savas, Emanual S. (2000). *Privatization and public-private partnerships*. Chatham House.

Black, F., Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *The Journal of Plitical Economy* Volume 81, Issue 3 (May-Jun, 1973), 637-654.

Luehrman, Timothy A. (1998). Investment Opportunities as Real Option: Getting Started on the Numbers. *Harvard Business Review*, Reprint 98404 (July-August 1998).

Jay-Hyung, Kim, Jungwook, Kim, Sunghwan,S hin, Seung-yeon, Lee (2011). *Public–Private Partnership Infrastructure Projects: Case Studies from the Republic of Korea, Volume 1: Institutional Arrangements and Performance*. Asian Development Bank.

OECD (2008). *Public-Private Partnerships: In Pursuit of Risk Sharing and Value for Money*.

Lewis, Mervyn K. (2001). *Risk Management in Public Private Partnerships*. CeGE Research Workshop at Georg-August-Universität Göttinggen

Shaoul, Jean (2005). A critical financial analysis of the Private Finance Initiative: selecting a financing method or allocating economic wealth? *Critical Perspectives on Accounting*.

Quiggin, J. (2006). Public Private Partnerships: Option for Improved Risk Allocation.

UNSW Law Journal Volume 29(3), 289-293.

CEDA (1999). Infrastructure and Economic Development. *CED information paper n.º 60, Melbourne: Committee for economic Development in Australia*.

Gilbert, P. L., Steinherr, A. (1994). Private Finance for Public Infrastructures. In Search of a New Framework. *EIB papers 23.* 77-90

Grimsey, Dararin, Lewis Mervyn K. (2002). Evaluating the Risk of Public Private Partnership for Infrastructure Projects. *International Journal of Project Management 20.* 107-118.

Vajdić, Nevena, Damnjanović, Ivan (2011). Risk Management Public-Private Partnership Road Projects Using the Real Options Theory. *International Symposium Engineering Management And Competitiveness 2011* (EMC2011) June 24-25, 2011, Zrenjanin, Serbia. 155-160

Kelleher, John C., MacCormack, Justin J. (2005). *Internal Rate of Return: A cautionary tale*. McKinsey & Company.

Myers, Stewart C., Majluf, Nicholas S. (1984). Corporate Financing and Investment Decisions when Firms have Information that Investors do not have. *Journal of Finance Economics 13 (1984),* North-Holland. 187-221.

Carlsson, Christer, Fullér, Robert (2003). A Fuzzy Approach to Real Option Valuation. *Fuzzy Sets and Systems,* 139(2003) 297-312.

Bullock, David W., Hayes Dermon J. (1992). Speculation and Hedging in Commodity Options: A Modification of Wolf's Portfolio Model. *Journal of Economics and Business*. 201-221.

Berks, Jonathan Berk, Peter DeMarzo (2010). Corporate Finance. 2nd Edition. Pearson

International.

Sarmento, Reis (2013). Do Public-Private Partnerships Create Value for Money for the Public Sector? The Portuguese Experience. *OECD Journal on Budgeting*, Volume 2010/1, 93-119.

Tobin, James (1997). Money, Credit and Capital. McGraw-Hill/Irwin; 1 edition