Determination of the optimal time to invest in the new Montijo Airport in Portugal using the real options analysis

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Abstract

Lisbon airport, the most important air transport infrastructure in Portugal, has reached its capacity due to an enormous boost in the tourism sector. A solution was designed in order to avoid economic constraints: build a new airport in Montijo in order to receive point-to-point flights. Using a real options approach, it was assessed if it is the optimal time to invest in new airport or if it is more valuable to wait until some of the demand uncertainty is resolved, since it was considered that demand was the main source of uncertainty. The results show that, althought investment opportunity value is slighlty superior than NPV, it is valuable to defer the investment until demands grows until demand threshold. This paper presents an important case study with major implications to the economy of Portugal.

Keywords: economic welfare; airport investment; defer option; stochastic processes; uncertainty.

EFM Classification Code: 430

1 Introduction

Lisbon, the capital of Portugal, is one of the most distinguish destinations in Europe today, being rewarded multiple times regarding to its features. The number of guests and overnights have been growing fast and, since 2014, it is the portuguese region with more guests in hotels and similar establishments.

Chambers (2007) mentions that the degree of success of a project in the transport sector is strongly associated with the demand for tourism and business, economic indicators such as GDP or per capita income, the price of gas and fuel, and general changes in consumer preferences. In other words, the trips are a means to an end, not a motivation in themselves.

Since Humberto Delgado airport (official name) is the main gateway for visitors to Lisbon, it is expected that activity at this airport will continue to increase in the coming years due to the expected increase in the number of tourists in this region and in Portugal in general, associated with a more competitive tourism industry and an economy that is recovering from the economic and finantial crisis. Moreover, it is a very important infraestructure to connect the portuguese population to other countries.

According to data from Statistics Portugal (INE), there have been significant volume increases in passenger traffic in Lisbon in the last decades, but the pronounced growths happened in the last years (above 10% in 2014, 2015 and 2016, and near 20% in 2017). In 2017, Lisbon airport was responsible for handling 50.6% of all passengers who embarked, disembarked, or were in transit in the portuguese airports.

The concession contract between the Portuguese State and ANA – Aeroportos de Portugal, S.A. (which is, since 2013, owned by VINCI, Airports International, S.A.) states that a process to construct a new airport in Lisboa should start when, among other capacity factors, the numbers of passagenrs exceeds 22 millions. This limit was reached, for the first time, in 2016 (near 22.5 million) and 2017 (more than 26.5 millions). There multiple reports that this airport exceeded its capacity, with long delays and waiting lines that can damage the destination image.

After multiple studies, it was concluded that a construction of a new airport in Lisbon was not viable at this time. So the alternative solution found was to adapt the Air Base of Montijo, a military facility that is installed near the Lisbon Airport.

Using the Real Options Analysis (ROA), we pretend to assess whether it is justifiable to implement this investment now or if this preferreble to wait, according to the actual demand for Montijo Airport. Contrary to most of the literature, we will determine the optimal time to invest in terms of economic welfare instead of return of investment to the investors. As stated by Pimentel et al. (2012), a decision to construct a large infraestructure needs to consider the interest of all taxpayers.

This paper contributes to the development of models that assesses large infrastructure investments considering important factors such as risk, flexibility, optimal time to invest and economic welfare.

Following this introduction, the literature review is focused on the advantages of the real options analysis and how it has been treated by the practitioners, especially on the air transport sector. Immediately after, the specific case of Lisbon airport expansion is described, presenting the methodology, data, results and discussion. This is followed by the listing of the main conclusions, outlining the contributions of this study and potential flaws that future research may overcome.

2 Literature Review

Traditional methods of investment valuation assume management passivity, since the projected scenario is the most likely given the strategy previously outlined for company operations. These methods may not consider market dynamics surrounded by change, uncertainty and competitive interactions, which may affect the cash flows initially estimated (Trigeorgis, 1995). Real options analysis is a method that fill in this gap, with an integrated solution that uses financial theory, economic analysis, management science, decision making process, statistics and econometrics to apply the options theory in the evaluation of real assets (Mun, 2006). In this way, according to Putten and MacMillan (2004), the real options analysis allows recapturing some of the value lost through more conservative evaluation methods, since different scenarios are designed for the operation and, according to Trigeorgis and Reuer (2017), management has an asymmetric decision to only execute the option if it is worth, maintaning the option alive otherwise. For Brach (2003), real options analysis assumes that managers can mitigate the risk over time, which means that volatility is seen as a positive factor that increases assets value.

The growth option allows the enterprise to expand their capacity to take advantage of future growth opportunities (Brach, 2003). For this kind of options, high levels of uncertainty and irreversibility reduces the incentives for firms to immediately invest but increases the incentives to wait, since they maintain their option to invest when future business conditions become more attractive (Vo & Le, 2017). The decision to deploy an investment ”kills” the option to postpone it until a better moment. In this way, it is important to consider not only the option value, but also the optimal time to invest (Pimentel et al., 2012)

Čulík (2016) identified several methods in financial theory to pricing options, from analytical equations (Black-Scholes model), network models (binomial, trinomial, multinomial), or simulation (Monte Carlo) of partial differential equations (finite difference method). Generally, any of these approaches can be used to price real options but, given their specific features, the network models are the most commonly used; they are easy to calculate and interpret, easily adaptable to most real options problems, and are useful for evaluating different types of options (call, put, etc.). Nonetherless, as deterministic models may underestimate the value of projects, since input data are constant or assumed to be known with certainty, stochastic models allow to optimize the outcomes as some of the model data are uncertain and described with probability distributions (Mun, 2006).

There are many authors that developed models using real options analysis to evaluate investment decisions. To cite a few, Pimentel et al. (2012) developed a model to determine the optimal time to invest in high-speed transport based on an analysis in continuous time with stochastic demand and stochastic investment spending. Kerr (2014) used the real options approach to assess forest investment by Brazilian cellulose industry companies and the optimal time to harvest, based on a method of fully implicit finite differences, considering that wood prices followed a stochastic process. Kostrova et al. (2016) developed a numerical method to evaluate American-type real options, which are the most difficult and complex to solve, as they may be exercised at any time. The method was based on Monte Carlo simulation and network models, upon a practical case of permanent energy crops on a farm.

For investment in transport infrastructure, particularly in airport infrastructure, Smit (2003) states that these investments can lead to economic growth in a region. In addition, they represent benefits to shareholders and opportunities for other economic players, which assigns added importance to the government, either because they establish the regulatory framework, or because they often have a key role in providing the infrastructure. Thus, the option value is not fully allocated to investors, but is shared by other players in the region where the investment is made.

There is high uncertainty associated with investments in transport infrastructure, particularly regarding the estimation of costs and traffic forecasts, which are essential for determining the viability and value of projects. Regarding the estimation of costs, Flyvbjerg, Holm and Buhl (2002) concluded that nine out of ten transport infrastructure projects cost more than originally planned, and this reality is global and insensitive to time. Additionally, he adds that, when carried out by the public sector, the projects show a greater disparity between the predicted values and real values, not only in terms of construction costs, but also in terms of time to build. On the other hand, poor traffic forecasting can be even more damaging, since it can lead to the construction of a more expensive infrastructure for a low utilization rate.

Regarding to investments in air transport infrastructure, Chambers (2007) identifies several sources of uncertainty, such as changes in the economy, which can have both positive and negative effects. Other sources include the number of trips for business and leisure; regulatory and technological changes that impact, for example, airport design; competition with other forms of transport, as alternatives such as high-speed transport; restructuring of airlines, with particular emphasis on the growth of low cost carriers; public support and drastic changes of opinion; and the growth of airport multi systems.

Smit (2003) apply the real option analysis the expansion of a European airport. The author explains that investments in infrastructure require more careful scrutiny and analysis than what is offered by traditional discounted cash flow methods. Consequently, he developed an evaluation framework that combines real options and game theory using a binomial model to capture not only a more effective assessment of a stand alone investment, but also the trade-off between the flexibility of management and competitive pressures to invest for different investment strategies. Pereira, Rodrigues, and Armada (2007) developed a model to assess the optimal time to invest in the construction of a new airport using two stochastic factors (number of passengers and net cash flow per passenger) and shocks (random events with positive or negative impacts on airport revenues). More recently, Xiao et al. (2017) modelled the choice of airport capacity *a priori* (i.e. to invest immediately) and the real option value for future expansion based on different objectives (maximization of profits or social welfare).

3 The airport expansion

3.1 Methodology

This study pretends to employ a real option model to determine the optimal time to invest in Montijo airport. As present in Figure 1, demand in Lisboa airport in the last decades shown a high volatility, with a tendency to growth, although there were periods when demand actually decrease.

[Insert Figure 1 here]

That being said, although the demand is expected to grow, the airport expansion entails high uncertainty. As referred by Chambers (2007), demand is exogenous and the high competition between tourist destinations worldwide may mean that demand growth may not be realized. With this scenario, real options analysis is the most suitable method to assess this type of decision, that involves large amounts of capital and irreversible investments, since it will capture the management flexibility value on adjust the decisions according to the evolution of demand.

In this study, we will employ the framework developed by Pimentel et al. (2012). In their study, they evaluate the implementation of a high-speed rail in Portugal using real option analysis and utility theory, since large infrastructures investments should be assessed in terms of economic welfare. The main source of uncertainty is derived from the level of future demand for the new airport. Any user of any mean of transport is a potential user of the new airport, and the competition between the different transport modes are incorporated in demand stochastic process parameters. Users will decide to flight to the new airport if, at least, utility remains.

We consider that demand for the new airport (x_t) follows a geometric Brownian motion process:

$$\mathrm{d}x_t = \mu_x x_t \mathrm{d}t + \sigma_x x_t \mathrm{d}w_t \quad (1)$$

In this equation, μ_x represents the growth rate and σ_x the standard deviation of demand, that will be constant in time. The Wiener process (w_t) has zero mean and a standard deviation of $\sigma_x\sqrt{\mathrm{d}t}$.

Each user faces a cost for travel between two destinations (ψ), that is a function of the total value of travel time for the user (η) and the airport taxes for passengers (p). According to an IATA Report (2008), short flights (that will be the main type of flights in the new airport), have a greater competition with other means of transport. In this way, it is reasonable to accept that both of these variables show a relationship to the air demand. It is important to clarify that we are not considering the ticket price, but just passenger taxes, since ticket prices are defined according to air company policies.

To illustrate the relationship between the total value of travel time and the demand for air transport, we assume the following functional form:

$$\eta(x_t) = \beta x_t^{\delta_\beta} \tag{2}$$

In this equation, δ_β represents the elasticity between the total value of travel time and the demand for the new airport and β is the scale parameter between demand for the new airport and the total value of travel time. A positive elasticity between the total value of travel time and the demand for the new airport means that increases in the value of travel time will be directly related to the demand for the new airport.

In the same way, the functional form that illustrates the relationship between demand for the new airport and airport taxes is:

$$p(x_t) = \alpha x_t^{\delta_\alpha} \tag{3}$$

δ_α represents the elasticity between the airport taxes and the demand for the new airport and α is the scale parameter between demand for the new airport and the airport taxes. A positive elasticity between the airport taxes and the demand for the new airport means that increases in airport taxes of other airports will be directly related to the demand for the new airport. It can be understood as the cross elasticity between travel fares of substitute services and the demand for the new airport.

The value that each user confers to an air flight is represent by the following value function (V), with m representing the individual disposable income by unit of time:

$$V(x_t) = m_t - \psi(x_t) \tag{4}$$

The new airport will allow to reduce the travel time, since the new airport will operate point-to-point flights. This means that, not only it will reduce the time that passengers are in waiting lines, but also the processes will be more agile. In this way, it is expected that the total value of travel time reduces from η_0 (before the investment) to η_2 (after the investment). η_1 represents the total value of travel time during the implementation of the investment that we assume that will be equal to η_0. The difference between β_0 and β_2 reflects the decrease in travel time.

Similarly, the cost of travelling before the investment is ready is ψ_0 and ψ_2 is the cost of travelling after the investments is ready. The equations that represents each of them are:

$$\psi_0(x_t) = \beta_0 x_t^{\delta_\beta} + \alpha_0 x_t^{\delta_\alpha} \tag{5}$$

$$\psi_2(x_t) = \beta_2 x_t^{\delta_\beta} \tag{6}$$

The cost function ψ_2 is not affected by airport taxes because this framework implicitly assumes that each user will support a part of the investment expenditures and the corresponding operating costs. So, a socially acceptable tax is already implicitly and it does not make sense to duplicate it, as supported by Pimentel et al. (2012).

Until the new airport starts to operate, the value function per user is given by:

$$V_0(x_{t+n}) = m_{t+n} - \beta_0 x_{t+n}^{\delta_\beta} + \alpha_0 x_{t+n}^{\delta_\alpha} \tag{7}$$

The value function per user is given after the investment is ready is given by:

$$V_2(x_{t+n}) = m_{t+n} - \beta_2 x_{t+n}^{\delta_\beta} - w - \frac{\varphi}{x_{t+n}} - \frac{\rho\gamma e^{\rho n}}{x_{t+n}} \tag{8}$$

Note that this equation continues to reflect a travel cost, the variable operating cost (w), the investment expenditures (γ) and fixed operating costs (φ). ρ is the discount rate. We are assuming that investment cashflows will last for an unlimited time horizon.

In this study, we pretend to calculate the optimal time to invest preserving utility function balance. So, it is necessary to find the new airport demand threshold (x^*), above which it will be optimal to invest. In their work, Pimentel et al. (2012) deduced equations that allow us to calculate a close form solution for this maximization problem. The demand threshold is calculated thought the following equation:

$$x^* = \exp[\frac{\ln\left(1 - r_1(C_{tc} + D)\right) / ((A_{tc} + B_{tc})(r_1 - \theta)}{\theta}] \tag{9}$$

With:

$$A_{tc} = \frac{2(\beta_0 - \beta_2)e^{\left(\mu_x\theta_\beta + (1/2)\theta_\beta(\theta_\beta - 1)\sigma_x^2 - \rho\right)n}}{2\rho - 2\mu_x\theta_\beta - \theta_\beta^2\sigma_x^2 + \theta_\beta\sigma_x^2} \tag{10}$$

$$B_{tc} = +\frac{2\alpha_0 e^{(\mu_x\theta_\alpha+(1/2)\theta_\alpha(\theta_\alpha-1)\sigma_x^2-\rho)n}}{2\rho - 2\mu_x\theta_\alpha - \theta_\alpha^2\sigma_x^2 + \theta_\alpha\sigma_x^2} \quad (11)$$

$$C_{tc} = -\frac{\varphi e^{-\rho n}}{\rho} \quad (12)$$

$$D = -\gamma \quad (13)$$

In these equations, A_{tc} reflects the present value of travel time savings, B_{tc} reflects the present value of airport taxes, C_{tc} reflects the present value of fixed operation costs and D represents the present value of investment expenditures. The subscript tc indicates the time-to-build effect. Moreover, r_1 is the positive root of the quadratic equation:

$$\frac{1}{2}\sigma_x^2 r(r-1) + \mu_x r - \rho = 0 \quad (14)$$

It can be calculated with the following equation:

$$r_1 = \frac{((1/2)\sigma_x^2 - \mu_x) + \sqrt{(\mu_x - (1/2)\sigma_x^2)^2 + 2\rho\sigma_x^2}}{\sigma_x^2} \quad (15)$$

It is important to refer that, according to Pimentel et al. (2012), in order to obtain demand threshold through equation (9), two assumptions need to be made: 1) the total value of travel time/demand elasticity and the airport taxes/demand cross elasticity are equal ($\theta_\beta = \theta_\alpha = \theta$); 2) the operational variable costs are negligence. In fact, considering the characteristics of an airport investment, all major operational costs tend to be fixed.

The investment opportunity value is given by the following terms:

$$v(x) = \begin{cases} \left(\frac{x}{x^*}\right)^{r_1}\left[\frac{\theta(C_{tc}+D}{\theta - r_1}\right], \text{for } x < x^* \\ (A_{tc}+B_{tc})x^\theta + C_{tc} + D, \text{for } x \geq x^* \end{cases} \quad (16)$$

The first term of the equation (16) gives the investment opportunity value until demand threshold is reached. The second term of the equation gives the Net Present Value (NPV) of the investment. Note that, when actual demand exceeds demand threshold, it is better to invest and receive NPV. Until there, there is inherent value of waiting for new information about the new airport demand. The defer option value is the difference between the first and second terms of equation (16).

3.2 Data and Results

Information about the new airport in Montijo is very scarce, since the memorandum of understanding between the Portuguese Government and ANA, Aeroportos de Portugal, S.A., the private company that holds the rights to explore Lisbon airport, was signed very recently. In this memorandum, the concession contract was revised, which will include ANA's right to explore the new Montijo airport and the investments terms in this and other projects. In this way, we gather all the information that was in public domain and other information from portuguese media. The basic parameters values are presented in Table 1.

[Insert Table 1 here]

Investment expenditures's present value is around 650 million euros, which include expenses to transform part of the air base in a civil airport and to minimize and correct environment impacts. The construction period is 3 years. According to the project, the new airport will start with a demand of 4.5 million passengers.

According to the Portuguese Civil Aviation Authority (ANAC), traffic passengers should rise, in the long run, around 2% per year in Lisbon. We will assume a standard deviation of 18%, which corresponds to the standard deviation of historical growth rates in Lisbon (1970-2017).

The new airport will allow to reduce passagenr's waiting time, whether on boarding or landing. Note that Lisbon airport has been experiencing its worst rates of punctuality, registering, at peak activity levels, waiting periods longer than 2 hours. With the new aiport, which will be dedicated to point-to-point flights, it is reasonable to accept that waiting times will be reduced by half, even considering that the new airport is around 15 minutes further to downtown. So, an average waiting time of 1 hour in Lisbon airport will be converted in an average waiting time of 30 minutes in Montijo airport (15 minutes in the airport plus 15 minutes by car or boat).

According to official from EU guide to appraise infraestructural investments, the estimated value of travel time per hour for air transports in the EU is 13.62 euros. The total value of travel time in each airport is given by the multiplication of the value of travel time per hour and the average time that passengers spend in each airport. Cross-price elasticity between rail and air travel is around 0.43 and 0.5 (Kopsch, 2012).

[Insert Table 2 here]

The results (Table 2) show that airport construction should only begin when the demand reaches 4,931 million passangers. It is interesting to note that the actual demand is near this value, which helps to justify the discussion about the need for a new airport in Lisbon in the short run.

The investment has a positive NPV. If a traditional capital budgeting analysis was used, the decision was to invest now. However, the demand uncertainty may force a delay in the investment, since call option is not deep in the money. This investment opportunity has a value of 1,192 million euros, with a defer option value of 9.8 million euros. The option value represents just 0,8% of the investment opportunity value. In this particular case, with a positive NPV and a defer option value almost 0, we can note that the call option is near the money. In this way, the decision maker, facing other non-economic factors that influences his decision to invest, can negligect the defer option value and implement the investment now, knowing that the value that will not be created is very small.

4 Final considerations

The main objective of this study was to valuate the investment in the new Montijo airport in Lisbon. The capacity of the actual airport is already exceeded and a solution was designed in order to avoid economic constraints in Portugal, speccialy in tourism sector. In an environment surrounded by uncertainty, a real options approach is recommend. Using a framework developed by Pimentel et al. (2012), it was assessed if it is the optimal time to invest in the new airport. Contrary to most models in literature to assess infraestructural investments, this framework valuates the investment in terms of economic welfare, considering factors as stochastic demand, users' utility and value of time travel savings. The net benefits were calculated in user's perspetive instead of shareholder's perspetive.

According to the results, the actual demand is getting near to demand thershold, which means that the optimal time to invest in the new airport may be in the near future. The value of the option to defer represents just 0.8% of the investment oportunity value.

During the investigation, some scope limitations were found: public information about the new airport is and studies about the characteristics of air demand are scarce yet.

For future research, framework should be extended in order to include more economic factors that influence demand behaviour in air transport sector.

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Table 1 – Parameters for the Montijo airport investment

Parameter	Value
x - Airport demand at the actual time	4.5 M
γ - Present value of the investment expenditures	650 M€
η_0 - Total value of travel time without investment	13.62 €
η_2 - Total value of travel time in Montijo Airport	6.81 €
p_0 - Airport taxes	19.53 €
φ - Fixed operating cost (in % of CAPEX)	3%
ρ - Discount rate	9%
μ_x - Demand expected growth rate	2%
σ_x - Demand standard deviation	18%
n - Time to build (years)	3
δ - Cross-price elasticity between rail and air travel	0.43

Note: M - Millions

Source: Own elaboration

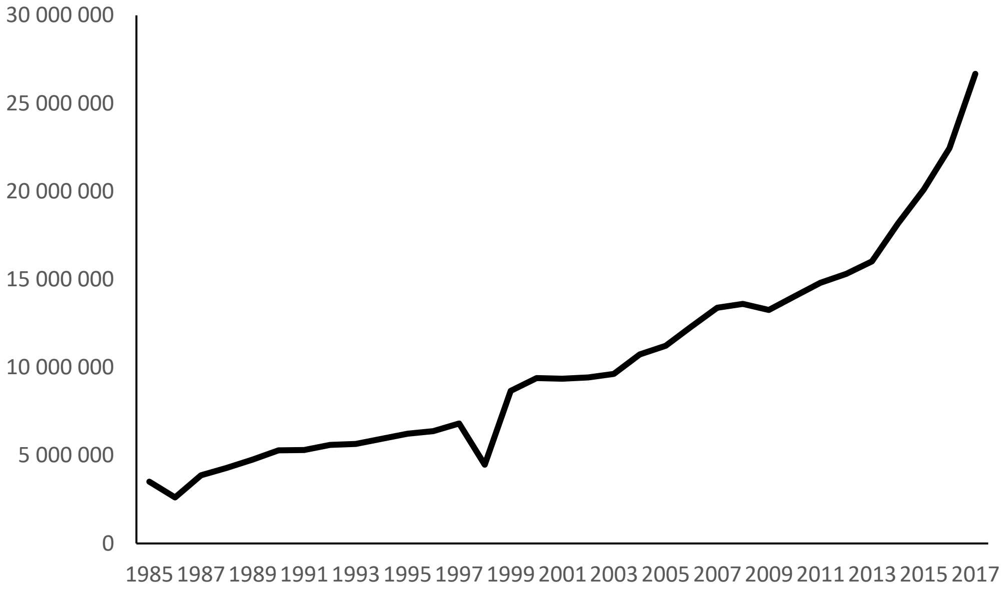
Table 2 – Montijo airport valuation results

Output	Value
x^* - Demand threshold	4.931 M
$v\ (x)$ - Investment opportunity value	1,191 M€
npv - Net present value	1,181 M€
vod - Value of the option to defer	9.841 M€

Note: M - Millions

Source: Own elaboration

Figure 1 - Movement of passengers at Lisbon airport (1970-2017)



Source: Statistics Portugal (INE)