Economic analysis of public service obligations on air transport using real option analysis

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Abstract

Public service obligations on air transport services are vital to ensure population mobility, as well as economic and social development. Nonetheless, they can lead to the low interest of investors or private companies, since they have high costs and are not optimal to maximize profit. Valuations with cash flows usually lead to negative net present values, which could result in decisions to not contract air carriers for services with public service obligations. Since they have a high value for multiple stakeholders, the valuation should also consider economic and social benefits and costs. Due to high uncertainty, real options analysis is the most suitable, but few frameworks allow to do an economic analysis. This study contributes to the development of theoretical and practical knowledge in the real options analysis field, especially regarding on economic analysis of relevant projects and contracts that contribute to economic and social development.

Keywords: real options analysis; economic analysis; public service obligations; concession

1 Introduction

To maintain appropriate scheduled air services on routes that are vital for the economic development of the region they serve, the Member States of the European Union may impose public service obligations. They should ensure the minimum provision of scheduled air services satisfying fixed standards of continuity, regularity, pricing, or minimum capacity, which air carriers would not assume if they were solely considering their commercial interest.

For investors, public service obligations may reduce the incentive to invest and explore, as these operations are not optimal to maximize profit (Pita, Antunes, Barnhart, and Menezes, 2013). Public service obligations can result in losses for the operator, and the Member States may compensate air carriers for these losses.

Being vital for the economic development of a region, these operations also present high economic value and contribution to the social welfare of a country or region. According to the European Commission and other authors, to evaluate this type of project, it should not be just from a purely financial point of view, but they may also include social and economic costs and benefits.

Traditional methods of evaluation, even for economic analysis, do not consider the value of management flexibility to make decisions that maximize value, since market dynamics, uncertainty, competitive interactions, and other factors, may change the initial projections and lead to different paths from the initial defined.

Real options analysis allows evaluating projects with uncertainty on one or more variables and different decisions that can be made in different periods. Nonetheless, being a recent area of interest, there is a lack of literature and models that evaluate projects from an economic and social welfare perspective using real options.

Using the case of a concession contract for public service obligations on air transport in the Autonomous Region of the Azores, a framework to evaluate relevant projects for regions using real options analysis is presented.

The Azores is an archipelago located in Portugal, constituted by nine heterogeneous islands. Public service obligations for air transport are defined to ensure population mobility between islands. Minimum flights and capacity for people and cargo per week, as well as maximum prices, are some of the obligations air carriers must comply with.

Azorean population travels between islands for health services, education, commerce, family, and business purposes. Due to the high costs of operation for air carriers to operate inter-island flights, there are no private players interested in carrying out this air transport service, even with financial compensation. This service is carried out by regional public air carriers, the only player that is presenting proposals to the international public tenders.

This paper intends to contribute to the literature by developing theoretical and practical knowledge on the real options analysis field, especially concerning to evaluation of projects with high relevance for the economy and social welfare.

The paper is traditionally structured. Following this introduction, the literature review is focused on real options analysis and economic and social analysis of relevant projects for a country or region. Then, the framework is presented, and, using the Azores case, the model is applied. Main conclusions follow, outlining the contributions of this study and limitations that future research may overcome.

2 Literature Review

The evaluation of projects, when carried out by public entities or funded by public money, should not be carried out just on a purely financial point of view, but on a social and economic perspective as well, since they have high benefits to different stakeholders, as explains Pimentel, Azevedo-Pereira and Couto (2012), European Commission (2014), and Couto, Pimentel, and Oliveira

(2021). These projects tend to present negative Financial Net Present Value (FNPV), demanding high financial efforts to implement and sustain the projects, but they could have high Economic Net Present Value (ENPV). According to (Pita, Antunes, Barnhart, and Menezes, 2013), Leandro, Andrade, and Kalakou (2021), among others, air transport services under public service obligations also contribute to social welfare, despite their financial costs and subsidy schemes to attract air carriers.

For economic analysis, cost-benefit analysis is widely used. Inclusive, it is imposed by European Commission to define co-funding rates for infrastructure investments. It is a traditional discounted cash-flow method, which adds up economic and social benefits and costs through monetization of non-monetary impacts, as presented European Commission (2014). In Portugal, cost-benefit analysis is also mandatory for all public tenders with a base price of over 5 million euros.

As sustained by European Commission (2014), air transport projects directly impact consumer surplus, supplier surplus, and externalities. All of these direct impacts should be appraised when valuation relevant projects for social welfare.

Using a traditional discounted cash flow method, the project is assessed as "now or never”, with no value coming from the flexibility to adapt the investment according to the evolution of the uncertain variables (Trigeorgis, 1995). These methods show limited applicability in contexts where there is high uncertainty since they focus on the selection of a discount rate suitable for the risk of the project but ignore the flexibility to make decisions along the way. For example, as explained by Vo and Le (2017), high levels of uncertainty and irreversibility reduce the incentives for firms to immediately invest but increase the incentives to wait, since they maintain their option to invest when future business conditions become more attractive. . In Covid-19 pandemic times, uncertainty related to megaprojects is even higher, as sustained by Pudney, Milss, and Mudunurim (2021).

To overcome the limitations of the traditional methods, real options analysis is being used in the literature to assess large infrastructure investments (for example, Marques, Brandão and Gomes (2019) and Balliauw and Onghena (2020)).

Real options analysis allows recapturing some of the value lost through conservative evaluation methods since different scenarios are drawn for the operation (Putten and MacMillan, 2014). As explained by Trigeorgis and Reuer (2017), management has an asymmetric decision to only execute the option if it is worth it. A real option is a right, but not an obligation, to perform a specific action, with a specific cost, related to real assets. Real options theory assumes that managers can mitigate the risk over time, which means that volatility is usually seen as a positive factor that increases asset value, but not in all situations (Brach, 2003).

Real options analysis is still presenting some limitations that are inducing some reluctance to managers and practitioners, as explained by Machiels, Compernolle, and Coppens (2020): the mathematical complexity of some models (especially when it is considered more than one uncertainty factor); the undefinition of what models are more suitable for the different types of projects and contexts; the difficulty or incapacity to incorporate other uncertainty sources than just market factors (like technological and political factors). The same authors refer that one of the major critics made to real options analysis is that it cannot capture the “big picture” of the project. Another critic, referred by Copeland and Tuland (2004), is that real options analysis is too optimistic and over evaluates the projects since it assumes that managers will have the opportunity to make decisions at the optimal time. To be considered a reliable model to managers and decision-makers, there is a need for more research on the real options analysis field, especially empirical research, and more concrete and suitable frameworks.

The known literature on real options analysis has mainly focused on the real assets’ evaluation, but some studies focus on the impact of the financing structure on the investor’s return. Pimentel, Couto, Tavares, and Oliveira (2020) studied the impacts of real options analysis on the EU co-funding policy since the literature shows that the investment project value is usually higher than the NPV. This study revealed that, if real options analysis were used instead of traditional discounted cash flow, the amount of EU’s aid to expand Ponta Delgada Port could be substantially lower. For that, port management would need to have the option to defer the investment until some uncertainty was cleared, which is not possible under the present legislation. Cheah and Liu (2006) implement real options analysis to value governmental support in an infrastructure project, using the case of Malaysia-Singapore Second Crossing. Boomsma, Meade, and Fleten (2012) studied renewable energy investments under different support schemes.

The impacts of real options analysis on public policies and political instruments and regulations are topics that lack more attention in the literature.

This research intends to give theoretical contributions to the literature regarding real options analysis on structural projects. As far as we know, there is not much research on real options frameworks that evaluate projects from an economic and social perspective, especially with public service obligations. It also may contribute to practitioners and decision-makers for the transition from passive planning to flexible or adaptive planning where decisions are made along the way to mitigate risks, according to available options (that were already predicted in the evaluation process). As stated by Rambaud and Pérez (2017), estimating options values facilitates the control of the uncertainty element implicit in the project.

3 Methodology

This study intends to present a real options model to assess contracts with public service obligations from an economic and social perspective. Due to the nature of contracts with public service obligations, binomial trees are suitable frameworks, since decisions are made in discrete-time. Moreover, complex models, even if more accurate, reduce the incentive to implement, as supported by Machiels, Compernolle, and Coppens (2020). Mun (2006) explains that binomial trees have similar results compared to complex models, but are easy to compute and manipulate according to available decisions.

An operator responsible to execute an air transport service contract with public service obligations will explore predetermined routes for a certain number of years (until year T).

As seen in the literature review, each contract or project with economic and social relevance will have multiple impacts on different stakeholders. To value the economic and social impact, it is necessary to monetize all non-monetary impacts, including externalities. The number of economic benefits and costs and the formula to monetize them depends on each project or contract. It is important to note that, as stood by European Comission (2014), only direct impacts should be considered. Indirect and induced impacts could result in an overvaluation since the same impact could be accounted for more than once.

On this model, it is assumed uncertain demand follows a binomial process, as also presented by Smit (2003), Oliveira, Couto, and Pimentel (2021), and others. The uncertainty comes mainly from a number of passengers moved on a given time t, which will result in a number of flights at that same time.

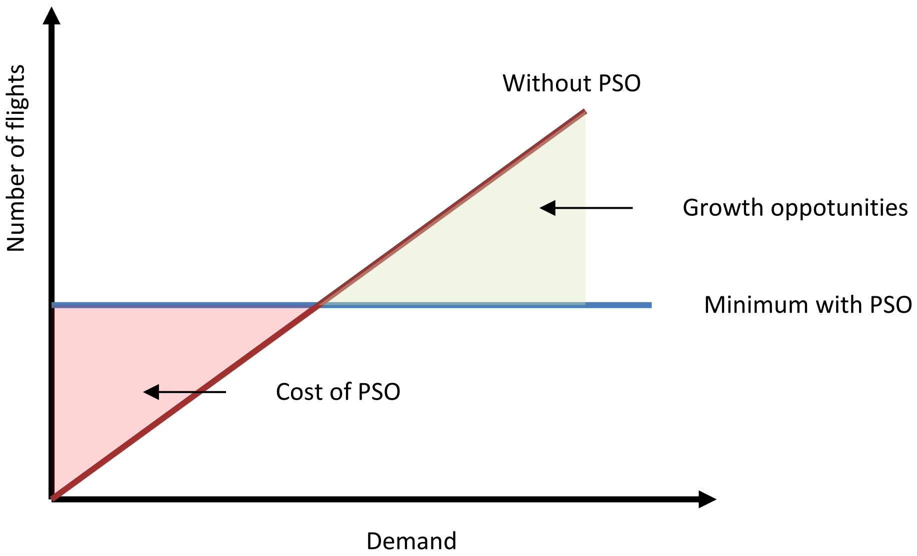
When exploring a contract with public service obligations, an operator (air carrier) has the option to, in each year, execute the minimum requirements of the contract (public service obligations) or to expand their transport capacity (doing more flights) according to demand evolution. Depending on the contract, this decision may also be made by the Member State to ensure a better quality of service and connectivity in that region or country. As presented in Figure 1 (green area), there are growing opportunities, which may result in more flights than required on public services obligations.

According to real options theory, at each time t, operators and Member States have a growth option, which is possible if the operator allocates more resources and assets. Otherwise, they do not grow on time t and wait for time t+1. The growth decision will depend on the value that can be captured and the costs to expand the activity.

Nonetheless, with public service obligations, at low demand levels, air carriers can not reduce activity below the minimum requirements. Generally, volatility and risk increase options value, since management can make decisions to not incur losses. With public service obligations, volatility can reduce options value, since management flexibility is reduced and potential losses can not be eliminated. For example, fixed costs can not be cut (fewer planes to operate fewer flights), as well as variable costs to operate each flight. At low demand levels, there is an incremental cost due to the obligation to not reduce the activity below minimum requirements (red area).

It is important to note that, at low demand levels, economic benefits may continue higher than economic costs, but it has a higher financial cost since it will have lower revenues for the same level of fixed costs. For operators, there is a risk of losses, even contracts have compensation since contracts usually fix a maximum value of compensation. Depending on the contract, these losses can also be supported by taxpayers.

Figure 1 - Cost and growth opportunities with public service obligations, according to demand evolution



Source: Own elaboration

The total contract value will be the sum of the net present value without the flexibility to grow with the value of the growth option.

The contract value without flexibility comes from the contract value on each node of the event tree with no growth. In each node, the operator will do the public service obligations, even if demand is very high or very low. If demand is higher than the operator's capacity, the value will be lost since some passengers wil not be transported.

In each time t, according to number of passengers and number of flights, a Total Economic Benefit (TEB_t) will be generated, which is the difference between the sum of all Economic Benefits (the contract will have m Economic Benefits - $EB_{m,t}$) and the sum of all Economic Costs (the contract will have n Economic Costs - $EC_{n,t}$), as follows on Equation (1).

$$\text{TEB}_{\text{t}} = \sum_{1}^{m} EB_{m,t} - \sum_{1}^{n} EC_{n,t} \tag{1}$$

In each time t, demand can growth for a positive scenario, generating TEB^{+}_{t+1}, or can decrease for a negative scenario, generating TEB^{-}_{t+1}. The risk-neutral probability to grow for positive scenario, p, according to Couto et al. (2013), is calculted using Equation (2).

$$p = \frac{e^{R_f \delta t} - d}{\mu - d} \tag{2}$$

The risk-neutral probability to growth for negative scenario is 1 - p.

According to Cox, Ross, and Rubinstein (1979), the up (μ) and down (d) movement factors needed to run the binomial process for the exogenous variable, as given by Equations (3) and (4):

$$\mu = e^{\sigma\sqrt{(\Delta t)}} \tag{3}$$

$$d = \frac{1}{\mu} = e^{-\sigma\sqrt{(\Delta t)}} \tag{4}$$

Volatility is a critical variable for accurate results since it will influence up and movement factors. Volatility will determine how much uncertain exogenous variable is and the growth opportunities values. But reliable volatility (σ) estimation is difficult to achieve, as discussed by Lewis and Spurlock (2004). The authors suggest that management perception and historical data could provide a good proxy to future volatility.

In the backward evaluation, the equivalent-certain values can be consistently discounted to the risk-free rate, to determine the contract value without flexibility.

In the end nodes (time T), contract value with no flexibility (V_T) is given by the sum of Total Economic Benefits at time T and the Residual Value of contract if the period of evaluation is lower than contract duration, as presented on Equation (5).

$$V_T = TEB_T + RV_T \tag{5}$$

When returning to the current state, the contract value is calculated using the risk-neutral probability, the present expected value in the up and down states, adding up to the Total Economic Benefits of that node (Equation (6)).

$$V_t = \frac{p \cdot V_{t+1}^{+} + (1-p) \cdot V_{t+1}^{-}}{e^{R_f \Delta t}} + TEB_t \tag{6}$$

The value at time 0, V_0, will be contract value without the flexibility to grow.

Considering the flexibility to make decisions according to the evolution of the exogenous demand, the operator has, in each period, the option to allocate more resources and assets if demand is high or defer this incremental allocation to next time t+1 if demand is low. These additional resources and assets will allow to do more flights on time t.

The value created comes from the present value of the incremental economic benefits of the additional flights. Compared to financial options, it is a call option on this additional economic benefit.

The additional resources and assets allocated will have a cost, I, to add additional flights. Compared to an investment project, where an investor invests capital to buy new assets that will generate benefits along the asset's lifetime, these contracts with public service obligations may have a small period of exploration. It will use assets already bought and used or, even if new assets are bought, their lifetime may be longer than the contract duration.

The capital the operator needs to invest on the contract to the amount that allows to cover all costs of additional operation that are not covered by additional revenues. It includes fixed costs (if necessary to allow more flights, as the example of planes) and variable costs (costs to run each additional flight).

In the end nodes (time T), the decision is either to invest more capital and receive the economic benefits generated, net of additional capital ($V_T - I$), or not to invest and receive zero, as follows on Equation (7).

$$C_T = \max\,[V_T - I; 0] \tag{7}$$

In the remaining nodes, payoffs are given by Equation (8). C_0 will be the growth option value.

$$C_t = \max\,[\Delta TEB_t - I + \frac{p \cdot C_{t+1}^{+} + (1-p) \cdot C_{t+1}^{-}}{e^{R_f \Delta t}}, \frac{p \cdot C_{t+1}^{+} + (1-p) \cdot C_{t+1}^{-}}{e^{R_f \Delta t}}] \tag{8}$$

Contrary to an investment project, where there is a defer option and it is "killed" when investment is made (it is not possible to postpone the investment after its implementation), contracts for air transport services with public obligations have multiple growth options. Even if investments are made for a specific contract, air carriers can diversify and allocate their resources and assets to other routes that are not on the contract on periods with low demand. An air carrier can exercise one growth option on time t, but not exercise the growth option on time t+1 if demand has a negative evolution, allocating their resources to other operations.

The total contract value is given by Equation (9).

$$Total\ value = V_0 + C_0 \tag{9}$$

The total contract value is composed of the contract value for an operation without any flexibility, implementing only the minimum requirements of public service obligations, and the flexibility value of future growth opportunities according to demand evolution.

4 Case study – The Azores

To illustrate the practical implications of real options analysis on an economic of air transport service contract with public service obligations, the case of the Azores is presented.

The Azores is an archipelago of Portugal composed of nine islands, located on the Atlantic Ocean between Europe and America, with its own regional government. There are three groups of islands (see Figure 2): Western Group, composed by Flores and Corvo islands, Central Group, composed by Terceira, São Jorge, Pico, Faial, and Graciosa islands, and Eastern Group, composed by Santa Maria and São Miguel islands.

Figure 2 – The Archipelago of the Azores

Source: www.vizitazores.com

To ensure the resident's mobility throughout all islands, for economic, health, education, business, and family purposes, regional governments contract an air carrier to operate multiple inter-island routes through international public tenders. These routes are operated in exclusivetyland, with no competitors. Due to the high cost of operation, private air carriers do not apply, even when the contract forecasts compensations for losses. The service has been carrying out by the regional public air carrier: SATA Air Açores.

The last international public tender was issued in 2021 for a five-year concession contract (November of 2021 to October of 2026), with a maximum compensation of 140 million euros. Each year, the compensation will be calculated according to the real operational loss, which adds up a return on capital. The return on capital is calculated with a rate of 2.5% plus average 12-month Euribor rates, applied to the total amount of operational costs.

Being a low-demand air transportation network (Pita, Antunes, Barnhart, and Menezes, 2013), public service obligations are imposed, including a minimum number of flights and seat capacity per week, maximum prices, and special tariffs. For this practical case, Table 1 shows only the minimum number of round trips (one round trip corresponds to two flights between these two islands) and seat capacity that air carriers must comply with.

Table 1 - Minimum number of flights and seat capacity per week imposed public service obligations

Route	Round trips			Seat capacity		
	IATA Winter	IATA Summer	June to September	IATA Winter	IATA Summer	June to September
São Miguel – Santa Maria	9	12	15	1,000	1,500	2,000
São Miguel – Terceira	30	31	38	2,600	2,900	3,800
São Miguel – Graciosa	0	1	1	0	70	140
São Miguel – São Jorge	0	0	5	0	0	400
São Miguel – Pico	2	6	10	300	900	1,700
São Miguel – Faial	8	11	13	800	1,300	1,900
São Miguel – Flores	2	2	8	100	300	1,000
São Miguel – Corvo	0	0	1	0	0	40
Terceira – Graciosa	9	9	12	1,000	1,000	1,000
Terceira – São Jorge	9	9	9	1,000	1,000	1,000
Terceira – Pico	7	7	11	800	800	900
Terceira – Horta	10	10	12	900	900	1,000
Terceira – Flores	2	4	4	100	200	200
Horta – Flores	8	8	10	700	800	900
Terceira – Corvo	3	4	5	80	100	150

Source: Public tender specifications for air transport services

In one year, the air carrier must operate around 12,649 flights and offer 639,179 seats.

To do the economic valuation using real options analysis, it is necessary to identify the main economic and social benefits and costs of this contract.

4.1 Economic Benefits

The economic benefit of air transport service for the Azorean population is travel time savings. Each user chooses the type of transport according to the difference between willingness-to-pay and the overall cost of transportation. The overall cost of transportation is the sum of the ticket fare and the value of travel time. Travel time has an economic and social cost since users can not do other activities (leisure or work) while on travel. There is a cost of opportunity.

In the Azores, the only travel alternative is a boat, which has a much higher travel time than a plane, even considering that waiting times to embark on ports are lower than on airports. Choosing airplanes has the economic benefit of saving travel time, that can be used for work or leisure. It is designated as Value of Travel Time Savings

Table 2 shows travel time savings in minutes for each route.

Table 2 - Travel times by boat and by plane, in minutes

Route	Travel time by plane	Waiting time at the airport	Travel time by boat	Waiting time on port	Difference
São Miguel – Santa Maria	30	90	225	60	165
São Miguel – Terceira	40	90	360	60	290
São Miguel – Graciosa	45	90	615	60	540
São Miguel – São Jorge	50	90	810	60	730
São Miguel – Pico	50	90	885	60	805
São Miguel – Faial	50	90	810	60	730
São Miguel – Flores	90	90	1,575	60	1,455
São Miguel – Corvo	95	90	1,615	60	1,490
Terceira – Graciosa	30	90	210	60	150
Terceira – São Jorge	30	90	405	15	300
Terceira – Pico	35	90	480	15	370
Terceira – Horta	35	90	585	15	475
Terceira – Flores	60	90	1,170	15	1,035
Horta – Flores	45	90	540	60	465
Terceira – Corvo	45	90	610	60	535

Source: Air carrier and maritime carrier schedules

Since the Value of Travel Time Savings is a non-monetary benefit (there is not a direct cash flow), this economic benefit should be monetized (converted on monetary value). HEATCO (2002) presents the Value of Travel Time Savings for multiple countries, including Portugal. It is recommended that values are updated each year according to the evolution of GDP per capita of each country, for better representation of economic and social development in each year. They were also updated according to inflation rates since the analysis will be carried out on constant prices of 2021. It was estimated a value of 41.8 euros per hour for work trips and 9.7 € per hour for other trips in 2021. Since it is a multiannual contract, Values of Travel Time Savings were also estimated according to the projection of GDP growth for the next years.

Additionally to direct economic benefits for users, there is also a direct social benefit related to externalities. Despite the negative externalities of air transport, which will be valued in the next subchapter, the air transport sector allows to relieve the pressure on maritime transport, which is also an activity that has negative externalities. With no air transport service in the Azores, users of this service would need to use maritime transport service, which would increment this activity and its impacts.

According to Ricardo-AEA (2014), the main externality related to maritime transport service is pollution. To monetize these impacts, following Ricardo-AEA (2014), it is considered that each passenger-kilometer on maritime transport has an impact of 3.7 euro cents. The savings on pollution by not increment maritime activity is a direct economic benefit of air transport service in the Azores.

4.2 Economic Costs

If, on one hand, air trips have lower travel time, which reduces the overall cost of transportation for users, on the other hand, they usually have higher fares than boats, which raises the overall cost of transportation.

In the Azores, both fares for air and maritime transports have maximum values due to public service obligations. For this valuation, the economic cost for users is estimated as the difference between maximum fares on both services, despite special tariffs that are also public service obligations and lower fares operators may apply. In all routes, tariffs are higher on planes than on boats, as shown in Table 3.

Table 3 - Maximum fares for air and maritime transports per user (€)

Route	Maximum fares by plane	Maximum fares by boat
São Miguel – Santa Maria	54	30
São Miguel – Terceira	72	50
São Miguel – Graciosa	72	51
São Miguel – São Jorge	72	51
São Miguel – Pico	72	51
São Miguel – Faial	72	51
São Miguel – Flores	72	52
São Miguel – Corvo	72	62
Terceira – Graciosa	54	27.5
Terceira – São Jorge	54	32
Terceira – Pico	72	32
Terceira – Horta	72	32
Terceira – Flores	72	40
Horta – Flores	54	40
Terceira – Corvo	54	50

Source: Public tenders specifications for air and maritime transport services

Beyond direct economic costs for users, there are also social costs related to externalities that air transport services impose, that should be monetized. According to Ricardo-AEA (2014), there are four main externalities related to air transport services: air pollution, noise, climate changes, and up-and-down processes. To monetize these impacts, the following data from Ricardo-AEA (2014), updated with inflation rates until 2021, was considered:

- For air pollution, each landing and take-off has an economic cost of 86.6 euros and each passenger-kilometer has an economic cost of 0.3 euro cents;
- For noise, each passenger-kilometer has an economic cost of 9.7 euros;
- For climate changes, each landing and take-off has an economic cost of 537 euros and each passenger-kilometer has an economic cost of 2.6 euro cents; and,
- For up-and-down processes, each landing and take-off has an economic cost of 222.9 euros and each passenger-kilometer has an economic cost of 1.1 euro cents.

For last, in this case, there is also the financial operating loss of this service. The air transport service under public service obligations generates operating losses since direct revenues do not cover all operating costs. The contract has compensation for operators for these losses. This operating cost is also an economic cost since the contract consumes monetary resources that are paid by all taxpayers.

Operating losses for this contract were estimated based on financial statements of the regional public company that has been executing this service over the years.

It is estimated that fixed costs are about 22.4 million euros per year to operate the minimum requirements of the contract. It is estimated that each passenger generates 35.4 euros in revenues, according to historical data. Using historical data on operating costs, variable costs were estimated for each flight.

To expand capacity, it was estimated that each new plane added to the operation will cost about 3 million euros per year, allowing to carry more 136,967 passengers.

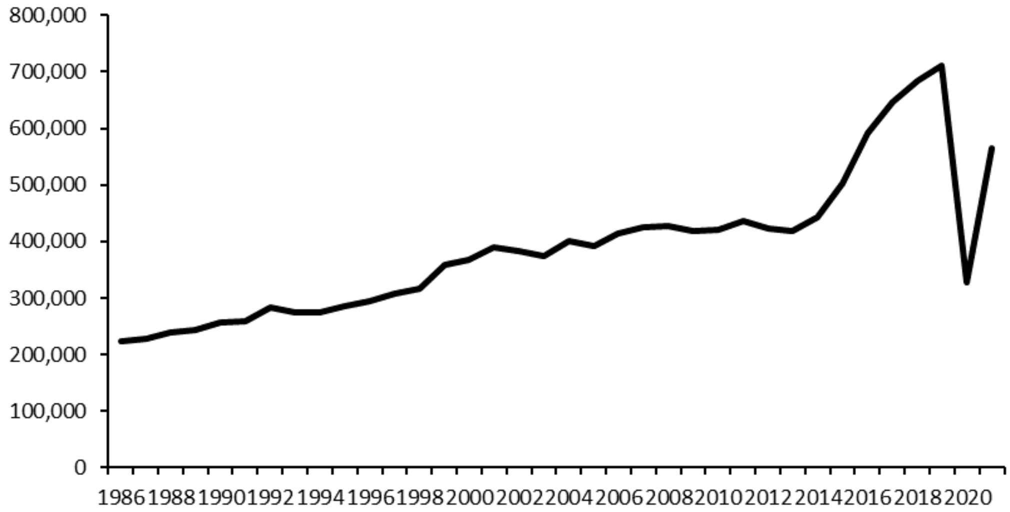
It is important to note that the return on capital that is paid to the operator is not an economic cost, according to European Comission (2014). It is a transfer between contractor and operator. The economic analysis should rule out all transfers between contractor and operator since the valuation should focus only on direct impacts on social welfare. For valuation purposes, contractor and operator are the same entity. It can be argued that this return is also paid by taxpayers and, therefore, it is also an economic cost. Nonetheless, being the operator of a regional public company, it is reasonable to accept that this return is not an economic cost.

4.3 Real Options Analysis

The real options analysis starts by calculating the up and down movements factors to forecast demand on each node of the event tree, using Equations (3) and (4). For that, it is necessary to estimate volatility (σ).

Historical volatility has been high, as Figure 3 shows. There is a growing tendency since 1986 (first year with available data), but with periods with decreases. From 2015 to 2019, high increases were registered due to changes in the air transport model in the Azores, which lowered the cost of transportation for residents and tourists. Due to the Covid-19 pandemic, the air transport sector had a shock and 2021 had a recovery, but not to levels registered in 2019.

Figure 3 - Passengers disembarked on Azorean airports from inter-islands flights



Source: Regional Service of Azores Statistics

For the valuation, volatility was computed at 16.1%, which corresponds to historical volatility between 2014 and 2019, a period that had a new dynamic for the inter-island air transport sector. 2020 and 2021 were excluded for being outliers due to the Covid-19 pandemic.

Using Equations (3) and (4), µ=1.17 and d=0,85.

With up and down movements, it is possible to compute the demand for different scenarios. At time 0 (the year before contract), 586,479 passengers were moved on inter-islands flights under public service obligations. For time 1 (first year of operation), demand can have positive evolution or negative evolution. For next years, the same pattern follows. At time 5 (last year of contract), there are six different scenarios for demand. It is assumed that for all routes, up and down factors are the same. The proportion of total passengers on each route will remain equal. Nonetheless, the different up and down movements could be estimated for each route according to the specific volatility of each route. Results are presented in Figure 4.

Figure 4 - Demand on each node of the binomial tree without capacity restrictions (passengers)

					1,311,351
				1,116,415	
			950,457		950,457
		809,169		809,169	
	688,883		688,883		688,883
586,479		586,479		586,479	
	499,297		499,297		499,297
		425,075		425,075	
			361,887		361,887
				308,091	
					262,293
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

Nonetheless, without activity expansion, there is a limit for passenger transportation. The operator is only obligated to offer about 639,179 seats per year. With capacity restrictions, on some nodes, there will be a demand that will not be served. Figure 5 shows the number of passengers to transport in each scenario with no activity expansion. This binomial tree will be used to evaluate the contract value with capacity limited to the minimum required.

Figure 5 - Demand on each node of the binomial tree with capacity restrictions (passengers)

					639,179
				639,179	
			639,179		639,179
		639,179		639,179	
	639,179		639,179		639,179
586,479		586,479		586,479	
	499,297		499,297		499,297
		425,075		425,075	
			361,887		361,887
				308,091	
					262,293
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

The total economic benefit value for each scenario was calculated according to data related to economic benefits and costs, as presented in Figure 6.

Figure 6 – Total economic benefit on each node of the binomial tree with capacity restrictions (euros)

					82,480,951
				79,101,272	
			75,800,804		82,480,951
		72,577,690		79,101,272	
	69,430,119		75,800,804		82,480,951
0		61,655,375		67,641,094	
	41,127,672		46,104,162		51,322,389
		28,203,451		32,541,853	
			16,932,056		20,714,186
				7,102,203	
					-1,470,397
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

For backward valuation, risk-neutral probability needs to be estimated.

The risk-free rate is the average risk-free rate applied in Germany (Euro-AAA rated countries) over the years of 2020 and 2021 (KPMG AG, 2021), as suggested by Damodaran (2008), which was 0.2%.

Risk-neutral probability, using formula (2), is 0.47.

Using Equations (5) and (6), contract value (with capacity restrictions) is calculated on each node. Results are shown in Figure 7. Contract value on time 0 is the net present value.

Figure 7 - Contract value on each node of the binomial tree with capacity restrictions (euros)

					82,480,951
				161,417,426	
			236,895,718		82,480,951
		301,030,739		161,417,426	
	338,220,238		221,940,676		82,480,951
274,757,137		241,657,652		133,353,249	
	220,395,428		144,072,493		51,322,389
		125,484,736		67,450,979	
			56,805,717		20,714,186
				15,953,121	
					-1,470,397
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

To value the growth options, a binomial tree with potential demand is computed (Figure 8). It is the difference between demand with no capacity restrictions and demand with capacity restrictions.

Figure 8 - Incremental demand on each node of the binomial tree (passengers)

					672,172
				477,236	
			311,278		311,278
		169,990		169,990	
	49,705		49,705		49,705
0		0		0	
	0		0		0
		0		0	
			0		0
				0	
					0
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

With this data, a decision tree is computed (Figure 9). The operator will expand activity if incremental economic benefits (net of economic costs) are higher than financial costs. Otherwise, it does not expand and waits for time t+1.

Figure 9 - Decisions on each node of the binomial tree

					Grow
				Grow	
			Grow		Grow
		Grow		Grow	
	Grow		Grow		Grow
		Not grow		Not grow	
	Not grow		Not grow		Not grow
		Not grow		Not grow	
			Not grow		Not grow
				Not grow	
					Not grow
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

Then, an incremental economic benefit on each node of the binomial tree is calculated (Figure 10).

Figure 10 - Incremental economic benefit on each node of the binomial tree (euros)

					95,132,291
				63,669,536	
			38,748,252		42,001,465
		19,218,298		20,953,250	
	4,129,032		4,624,440		5,143,913
0		0		0	
	0		0		0
		0		0	
			0		0
				0	
					0
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

Using Equations (7) and (8), options values are calculated with backward valuation (Figure 11). At time 5 (last year of contract), the operator does not have any more future growth options. On nodes where it expands, the economic benefit calculated on the prior tree will be captured. Otherwise, no economic benefit is generated. In years 1 to 4, the operator can expand activity, generating economic benefit, or not expand, not generating economic benefit (nor economic cost). Either way, it also maintains the options alive for next year (if positive).

Figure 11 - Growth options values (euros)

					95,132,291
				130,299,014	
			122,388,897		42,001,465
		90,001,571		43,229,877	
	52,751,832		26,006,233		5,143,913
27,827,616		12,688,875		2,392,510	
	6,177,593		1,112,792		0
		517,576		0	
			0		0
				0	
					0
0	**1**	**2**	**3**	**4**	**5**

Source: Own elaboration

Growth options value on time 0 is the options present value that increments contract value in terms of economic and social welfare.

4.4 Discussion of Results

Results presented in Table 4 show the economic and social benefit of air transport service in the Azores for a five year period.

Table 4 - Real options analysis results (million euros)

Contract with only public service obligations (NPV)	Growth options (Option value)	Total contract value (Expanded NPV)
274.8	27.9	302.6

Source: Own elaboration

If the operator and State Member decide to execute only minimum requirements of public service obligations, total contribution for the social welfare of the Azorean population is around 275 million euros. This value is similar to a traditional valuation, as stated by Smit (2003). Benefits refer mainly to users' travel time savings by using a plane instead of a boat. Travel time by boat is much higher than a plane. Economic costs were also accounted for, including operating losses that will be paid by taxpayers and externalities.

The results show that, even with operating losses, air transport services with public service obligations have high economic and social benefits for remote and ultrapherical regions. With lower travel times, mobility is induced, which results in saving times to expand on leisure, work, commerce, educations, and others.

Furthermore, considering uncertainty on demand, there are growth opportunities. On certain nodes, operators and State Member can decide on expanding air transport services, allocating more resources and assets. More flights could be done to accommodate more passengers. Each year, there are growth options with positive values. Using real options analysis, with a binomial tree model, growth options' present value is around 28 million euros. In total, air transport services in the Azores for 5 years have a total economic value of 303 million euros.

Public service obligations reduce management flexibility to optimize costs for low demand levels. It may impose high operating losses on certain scenarios, which could be eliminated if public service obligations did not exist. In the most negative scenario of year five, economic costs are higher than economic benefits. With no public service obligations, the operators could reduce flights and optimize schedules. If so, economic benefits could also reduce, since flights availability would reduce and waiting times to travel for another island would increase for existent demand.

It is important to note that, following European Comission (2014), only direct impacts were considered. It was assumed an alternative means of transport (boat) that is available all the time for users. Nonetheless, on some periods, there is not a regular maritime transport service that ensures mobility between all islands. Without air transport service, it is possible that maritime transport would be reinforced, but sea conditions impose more restrictions. High negative impacts could exist, including the difficulty to transport ill persons for islands with hospitals. The benefit of air transport services in the Azores could be underestimated.

5 Final Considerations

Public service obligations can be imposed by State Members for services with economic and importance for economic development and social welfare of a region or country. According to European Commission (2014), these relevant projects should not consider only cash flows, but also nonmonetary benefits and costs. These projects should be implemented if it has a positive contribution to social welfare.

Traditional valuation methods do not consider flexibility management to adjust decisions according to different scenarios. On contrary, real options analysis values options that management could have.

This study intends to present a model to evaluate the contribution to social welfare of air transport services with public service obligations. It considers direct economic and social benefits and costs, and also the flexibility to expand activity on scenarios where demand is higher than capacity defined on public service obligations.

Public service obligations could impose minimum requirements for number of flights and capacity. In scenarios with low demand levels, the operator can not eliminate most of the costs, since it may obey minimum requirements. It imposes a high risk of operating losses on these scenarios. Depending on the contract, these losses can be supported by taxpayers, operators, or both.

To illustrate model implementation, the case of the Azores is presented. There are public service obligations for fifteen inter-island routes. Even if the operator does not expand activity, there is a positive impact on social welfare, as expected. Considering the flexibility to expand activity on scenarios with higher demand, there is an incremental value for social welfare.

For future research, the framework can be extended to embrace greater randomness and uncertainty surrounding one or more exogenous variables, including macroeconomic indicators which may influence non-monetary impacts.

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