Modelling the impact of product differentiation, commercial revenues and degree of regulation on competition and airport charges

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Abstract

The objective of our paper is to provide a formal framework for the analysis of the airport pricing policy under competition, taking into account the externalities existing between both the aeronautical and commercial activities of the airport. We use a theoretical modelling of the airport market, where the airline allocates its traffic between two competing airports, which are more are less differentiated and substitutable in the airline's network. Externalities between commercial and aeronautical activities exist, in the sense that an increase in the airport's commercial revenue benefits society *via* an increase in quantities and a decrease in airfare, and the airline *via* the achievement of a higher profit. Commercial revenues also have an effect on the airport's market share regarding aeronautical services. Finally, we discuss the effect of the degree of integration of commercial activities into the regulatory perimeter *i.e.,* the till structure, on airport competition. The private optimal degree of inclusion of commercial activities in the regulatory perimeter will depend on the degree of competition existing between airports.

1) Introduction

The move towards liberalization in the air transport industry started in the late 1970's, in the United States. At that time, airports were only public owned facilities, and airlines were constrained by national requirements in terms of pricing and network policy. Nowadays, airports can be considered as full-fledged businesses. Graham (2018) qualifies this shift as a "*move towards commercialization"* that the airport industry made in the 1980's. The way airports are seen has led to a dramatical change in the way they are managed. Kasarda (2006) lists how airports managers have made a shift towards extra aeronautical commercial development. New projects in Bangkok, Beijing, or Kuala Lumpur reflect as well what Kasada calls an "*Aerotropolis*". Finally, this tendency towards commercialization implied a change in the way airport revenues are balanced. Between 2008 and 2015, the share of the non-aeronautical revenues went from 54.6% to 61.9% for London Heathrow, from 55.7% to 59.5% for Paris Charles De Gaulle, and from 55.8% to 61.1% for Amsterdam Schipol (Battal and Bakir, 2017). As airports are becoming more profitable businesses, private companies tend to be interested in operating or owning airports. This is illustrated, for instance, by the aborted project of the privatization of Aéroports de Paris, under the *Loi Pacte,* the privatization of all the Portuguese airports in 2012, or the emergence of profit orientated global airport operators such as Vinci Airports, Fraport, or Groupe ADP.

Moreover, following the increase in global traffic, and the emergence of low-cost airlines, airports have started to compete in order to capture this increase in traffic. As airlines are becoming more and more footloose (Wiltshire, 2018; Thelle and Sonne, 2018) *i.e.,* they are able to open and close bases and routes at a reasonable cost. As a result, more pressure is put by airlines on airports in order to reduce their total turnaround cost[1] in order to attract traffic.

The modelling of airport and air transport markets have been widely studied in the literature. As summed up by Basso and Zhang (2008), airport pricing models can be classified in two categories. On the one hand, the airline market can be characterized as atomistic. Hence, the airport charges incurred by the airlines are directly passed onto the passengers. On the other hand, the airline-airport relationship can be modelled thanks to a vertical relationship where airports provide aeronautical services *e.g.,* the use of runways, taxiways, and terminal facilities, in the exchange of the payment of an airport charge. Flight tickets are then sold by the oligopoly airline to the passenger on a downstream market, where the airline has a certain market power.

More recently, with the growing importance of commercial activities offered by profit-oriented airport operators, those activities have been included in airport pricing models. Particularly, the two-sided market theory has been used in order to account for externalities existing between the provision of both aeronautical and commercial activities. This theory appeared jointly with the antitrust trials about the credit card market that occurred in the late 1990's (Caillaud and Trégouët, 2006) and has been theorized by Rochet and Tirole (2003) and Armstrong (2006) among others. A two-sided market is a market where two groups of consumers interact around a platform. This notion is highly linked with positive network externalities. For Rochet and Tirole (2003), the externalities created by the interaction of the two groups of consumers leads to the fact that those two groups of consumers have an interest in interacting (Rochet and Tirole, 2003). The utility of an agent is then positively correlated with the presence of another agent on the other side of the market such that the modification of the price on one side of the market has an effect on the demand on the other side of the market.

The application of the two-sided market theory to the air transport market has been widely used. The airport can indeed be seen as a platform that brings together passenger and airlines in the sense that the addition by airlines of more destinations and more frequencies will attract passengers to the airport. Conversely, airlines will be willing to increase their presence at an airport if it serves more passengers (Gillen, 2008). This application of the two-sided market theory to the airport market has been empirically proved by Ivaldi et al. (2015). There exist indeed externalities between commercial and aeronautical activities, even though the unidirectional or bidirectional character of those externalities is debated. Though, it has been shown that a market can be considered two-sided even if the externalities are only unidirectional (Hagiu and Wright, 2015).

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[1] This includes the airport charges, but as well the handling costs and the overall operational performance of the airport regarding taxi times, or baggage handling for instance.

The paper is organized as follows: in section 2 we present our model, its assumptions, and the main results following its resolution. In section 3, we analyze those results in order to discuss the presence of externalities between the two airport activities. Section 4 focuses on airport competition, and the way it manifests itself. Finally, in section 5, we introduce sector regulation and till structure design and its implication on airport competition.

2) Modelling airport competition and the airline planning process

We model the airport market as vertically integrated. Here, the airline is an oligopoly, and express a derived demand for aeronautical services. The passenger demand for air transportation is a downstream market. We identify three types of agents: the airports, the passengers, and the airline. There are three airports: a departure airport, exogenous to the model, where the airline and the passengers are based. And two arrival airports (A and B), on which the model is centered, and to which the airline will allocate its traffic. The airport has two activities: the provision of aeronautical services and infrastructures to the airlines in exchange of the payment of airport charges, which takes the form of a per passenger charge, and the provision of commercial services directly to the passengers, such as parking, catering, or duty-free shopping. We model a two-stage game where the two airports set the level of airport charges before the airline chooses its quantities at those two airports.

Despite the fact that the pricing of aeronautical services is more complex in the reality, we only choose to use a per passenger landing charge, as the number of seats sold by the airline to both destinations is continuous and does not depend on the number of flights operated.

Regarding the commercial side, there are a lot of ways for airports to earn revenues from commercial activities such as concession fees, direct revenues, or the creation of commercial subsidies (Graham, 2018). However, the main indicator of the commercial performance of profit orientated airports is commercial revenue per passenger. We will thus use this variable in our model. Even if there is a lot of ways for airports to actively increase the revenue per passenger, for instance by redesigning the passenger path, contracting with more premium brands or allocating more space to the shops within the terminal, we consider that the average commercial revenue that the airport gets from the passenger is fixed and exogenous. This will enable us to study the effect of the variation of the parameter on the model's outcomes.

We choose to model competition between two airports by using the Dixit model (1979), that accounts for product differentiation in a duopoly setting. Indeed, the price of one product is function of the quantity of that product that is offered, but also of the quantity of another product that is more or less differentiated. A similar model is used in the airport case by Basso (2008), although he uses it in a different way as he takes into account congestion and schedule delays, and Socorro *et al.* (2018) to study the feasibility and desirability of airport competition.

The two inverse demand for air transportation to airports A and B are given by:

$$p_A = \alpha - \beta q_A - \gamma q_B$$

$$p_B = \alpha - \beta q_B - \gamma q_A$$

$$\text{With } 0 < \gamma < \beta$$

With p_A and p_B the fares for a flight to A and B, and q_A and q_B the quantity of seats flown to each airport. β and γ are measure the degree of homogeneity between the two airports. If γ is close to β, they are substituable in the airline's network, if γ is close to zero, airports are in a near-monopoly position.

The airline sells tickets to the passengers, and pays a landing per passenger charge l to the airport, for the provision of aeronautical services.

The airline's profit writes as follows:

$$\pi_A^C = (p_A - l_A)q_A$$

$$\pi_B^C = (p_B - l_B)q_B$$

$$\pi^C = \pi_A^C + \pi_B^C$$

Where π_A^C is the airline's profit on the route to airport A.

Both airports receive from the airline a landing charge for each passenger. Moreover, the airport provides commercial services that take the form of a unit revenue per passenger equal to c. This commercial revenue is exogenous to the model. We also make the assumption that the airport's fixed and marginal costs are equal to zero[2].

The profit functions of airports A and B are then given by:

$$\pi^A = (l_A + c)q_A$$

$$\pi^B = (l_B + c)q_B$$

The airline planning process consists in the maximization of its profit by the setting of the quantity of the seats offered (and flown in our case) for each airport across its network, regarding the marginal cost of operating the flight, and the demand for air transportation

[2] In this paper, we are only interested by the simple modelling of competition between airports, and thus adding cost parameters would add useless complexity to the model.

services for each airport. In this simple model, the only cost born by the airline is the airport landing charge. Moreover, the airline does not operate the route if it is note individually profitable[3].

$$max_{q_A,\, q_B} \pi^c = (p_A - l_A)q_A + (p_B - l_B)q_B$$

$$s.t\, p_a = \alpha - \beta q_A - \gamma q_B$$
$$s.t\, p_b = \alpha - \beta q_B - \gamma q_B$$
$$s.t\, \pi_A^C \geq 0\; and\; \pi_B^C \geq 0$$

The optimal quantity for airport A is given by:

$$q_A^* = \frac{\alpha(\beta - \gamma) + \gamma l_B - \beta l_A}{2(\beta^2 - \gamma^2)}$$

Here, the quantity allocated to one airport depends on the level of charges of both airports, and of the degree of differentiation existing between the two airports. We can already see that the effect on the airline quantity decisions of a difference in the airport charge levels decided by airports A and B depends on the degree of differentiation of those airports.

Then, the airport maximizes its profit by setting the airport charges, while ensuring the airline's participation.

$$max_{l_A} \pi^A = (l_A + c)q_A$$
$$s.t\, q_A^* = \frac{\alpha(\beta - \gamma) + \gamma l_B - \beta l_A}{2(\beta^2 - \gamma^2)}$$
$$s.t\, \pi_A^C \geq 0$$

The profit maximizing value of the airport charge is given by:

$$l_A^* = \frac{\alpha(\beta - \gamma) - \beta c}{2\beta - \gamma}$$

The price paid by the passenger to the airline is given by[4]:

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[3] In reality, the airline's network strategy consists in the maximization of the whole network's profitability, such that not profitable routes can be operated as long as the marginal profitability of the network increases following the operation of this route (Belobaba *et al.*, 2015).

[4] Hence, the airline participation condition is validated: $l_A^* < p_A^* \iff \pi_A^C > 0$

$$p_A^* = \frac{\alpha\left(3\beta - 2\gamma\right) - \beta c}{2(2\beta - \gamma)}$$

The final quantity operated at airport A by the airline is given by:

$$q_A^* = \frac{\beta(\alpha + c)}{2\beta\gamma + 2(2\beta^2 - \gamma^2)}$$

As the two airports are symmetric, the final quantity of air transportation services in this market is given by:

$$q^* = \frac{\beta(\alpha + c)}{\beta\gamma + 2\beta^2 - \gamma^2}$$

Finally, the airport's profit equals:

$$\pi^{*A} = \frac{\beta(\alpha + c)^2(\beta - \gamma)}{(2\beta - \gamma)(4\beta^2 - 2\gamma^2 + 2\beta\gamma)}$$

And the airline's profit: $\pi^{*C} = \dfrac{\beta^2(\alpha + c)^2}{2(\beta + \gamma)(2\beta - \gamma)^2}$

This simple modelling of the airport market allows us to accurately replicate the airline network planning process, where, given the level of the airport charges published by airports, and the characteristics and elasticities of demand, the airline will allocate its fleet towards a network of competing airports.

3) The airport market as a two-sided market

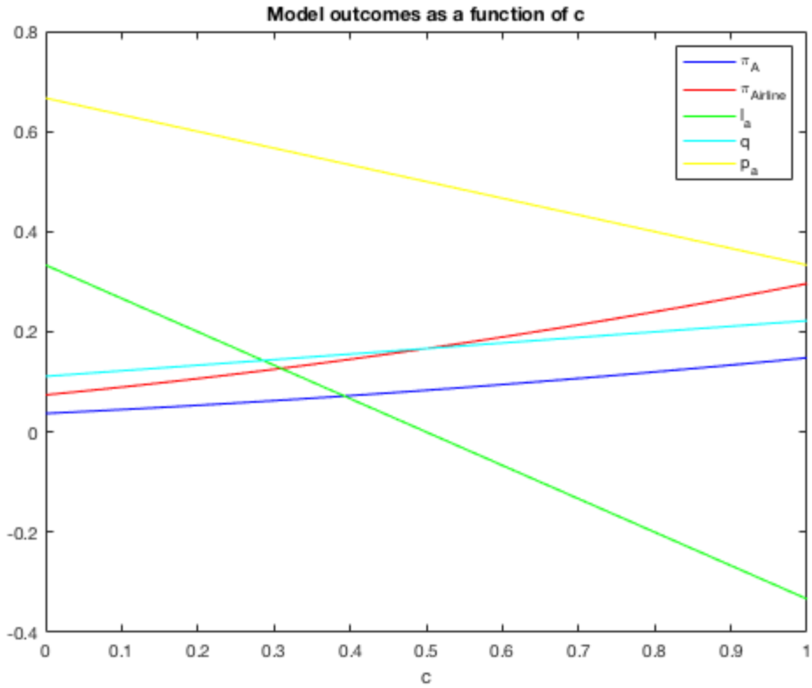
We find here that externalities between the aeronautical and commercial activities of the airport exist. Naturally, the allocation of a higher quantity of seats by the airline on the airport has a mechanical effect on its profit, all else being equal. However, by the mean of competition, the commercial activity also creates externalities on the aeronautical side of the market. When considering an exogenous rise in the commercial revenue per passenger, the model's outcomes are affected as follows:

The additional revenue on the commercial side modifies the airport's optimal pricing policy, allowing it to charge a lower airport fee.

$$\frac{\delta l_A^*}{\delta c} < 0$$

The airlines benefits from the airport's higher unit commercial revenue, and sets higher quantities and lower prices.

$$\frac{\delta\pi^{*C}}{\delta c} > 0,\ \frac{\delta p_A^*}{\delta c} < 0,\ \frac{\delta q^*}{\delta c} > 0$$



Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1$

Under competition, the airport's optimal pricing policy depends on the revenues generated by commercial activities, in the sense that a higher unit revenue will also benefit the airlines and the consumers. The aeronautical activity hence benefits from the externalities created by the commercial activity of the airport.

An important characteristic of two-sided markets is the possible presence of a so-called "loss leader" that subsidizes the activity of the other side of the platform (Rochet and Tirole, 2003). In our case we can observe that, at a certain level of homogeneity, it is rational for the airport to set the charge below the marginal cost in order to attract the airline, and thus its passengers who will bring commercial revenues. This phenomenon is indeed observed for small regional airports that heavily rely on the presence of one or several low-cost carriers (Carrard, 2013; Malavolti and Marty, 2017).

4) Modelling airport competition

Literature about airport competition tends to show that it can exist is several ways. According to Socorro *et al*. (2018), airports can compete in three ways: i) to attract local passengers when they serve the same area, ii) to attract inbound passengers even if the airports are not located close to each other. This is especially true for leisure-oriented airports, and iii) to attract connecting traffic.

In this paper, we focus on competition for inbound passengers, that will take the form of a competition between airports for attracting airlines. Airlines have indeed a certain buyer power on airports as they are footloose businesses. For Wiltshire (2018), their ability to make their routes and frequencies portfolio evolve efficiently put pressure on airports. Let us once again focus on the airline route planning process. Thelle and Sonne (2018) report that every year, 15% of all airlines route are suppressed whereas 20% of new routes are created. According to Copenhagen Economics (2012), 54% of the total of routes closures concern routes that have been open for two years or less. For Wiltshire (2018), two factors affect the ability of the airline to easily change their route portfolio. First of all, it has to be relatively costless for an airline to close or open a route. Nowadays, most of the manpower used by an airline at an airport is handled by specialized ground handling companies such as D-Nata or Swissport. The fixed investment required in manpower at each station is hence quite limited. As a major part of the tickets are sold on the internet, the airline does not need to open agencies in the city where they opened a route. It is hence easy for airlines, especially low-cost ones as they are considered as being more footloose (Wiltshire, 2018), to put pressure on airports in order to get charge reductions. According to Wiltshire (2018) the second reason that could explain that airlines become more and more footloose is the fact that airports could be considered as substitutable. A leisure-oriented airline will consider that their passengers, who are price sensitive, do not care to spend their vacations either in Mallorca or Heraklion, the price of the airline ticket will have a strong influence on their destination choice. On the contrary some destinations, leisure or business oriented, or with a large VFR traffic, are not substitutable for passengers. If you absolutely want to visit Paris because you want to contemplate the Joconde, a cheap airline ticket to Madrid will not convince you to change your plans.

In this section, we study how airport differentiation, and airport competition affects the structure of the market, by using the features of our model.

4.1) The effect of product differentiation on airport competition

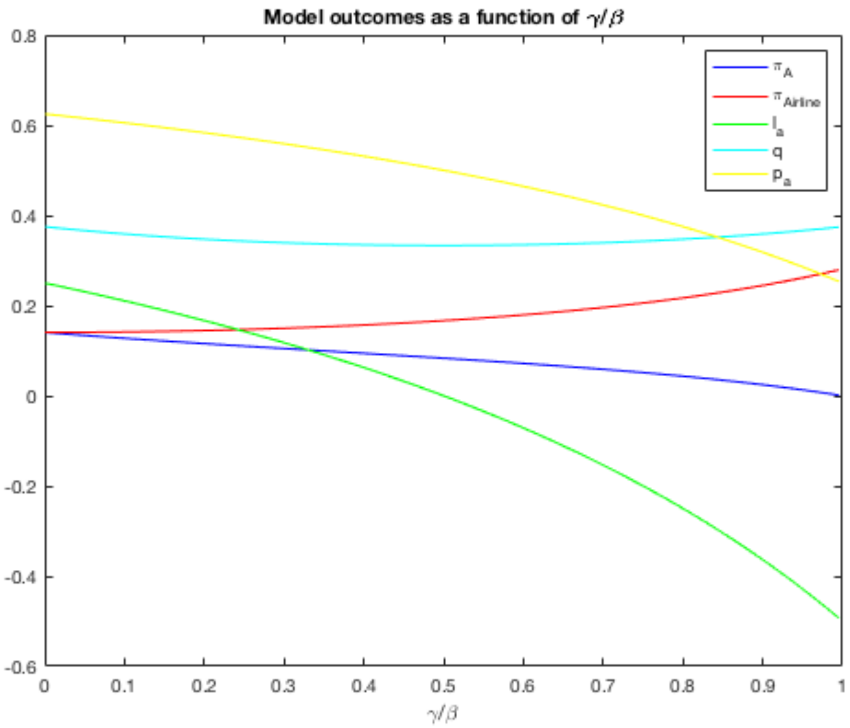
The use of the Dixit (1979) model allows us to study how the degree of competition, measured by the $\frac{\gamma}{\beta}$ ratio, affects the model outcomes.

In our model, the increase in competition takes the form of a less degree of differentiation between the airports with regard to the passengers' preferences. Airports that are perceived by passengers as substitutes will set a lower charge and see their profit decrease. This will have a positive effect on the airline's profit, and a negative effect on the airfare. Naturally, the airport's profit declines as it loses market power.

$$\frac{\delta l_A^*}{\delta \gamma} < 0, \frac{\delta p_A^*}{\delta \gamma} < 0, \frac{\delta \pi^{*A}}{\delta \gamma} < 0, \frac{\delta \pi^{*C}}{\delta \gamma} > 0$$

Regarding the quantities offered on the market, the effect of a higher degree of competition will depend on the relative value of β and γ.

$$\frac{\delta q^*}{\delta \gamma} < 0\, for\, \gamma\, \epsilon\, \left[0, \frac{\beta}{2}\right[and\, \frac{\delta q^*}{\delta \gamma} > 0\, for\, \gamma\, \epsilon\, \left]\frac{\beta}{2}, \beta\right[$$



Numerical simulation with $\alpha = 1, \beta = 2, c = 0.5$

4.2) The effect of commercial revenues on competition

Can the commercial revenue per passenger have an effect on the structure of the market?

In this new version of the model, airport A and B can earn a different commercial revenue c_A and c_B. The level of those revenues is still exogenous to the model.

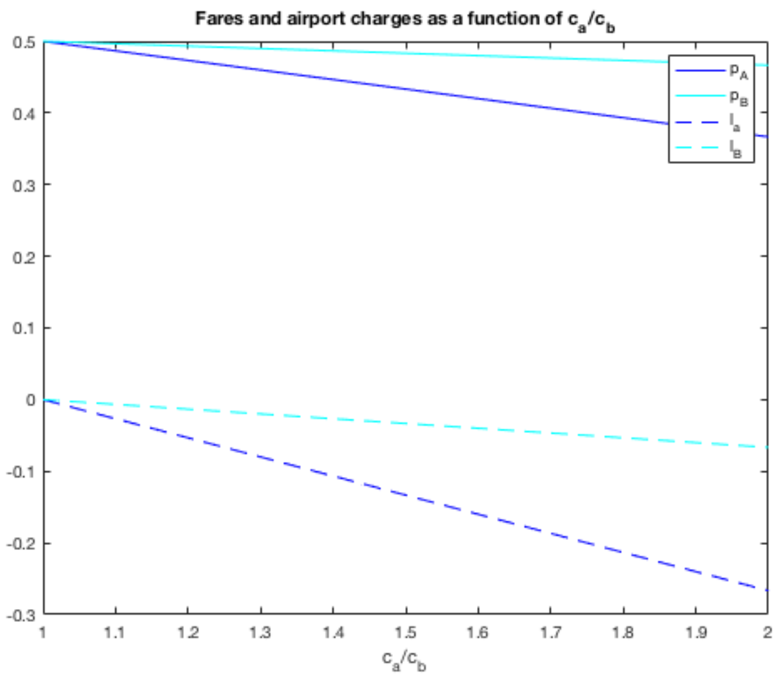
An increase in c_A all else being equal has a negative effect on the airport charges and airfares for both airports. The cross effect of an increase in c_A on the level of airport B's level of charges is more important as the two airports are less differentiated.

$$l_A^* = \frac{\alpha\left(2\beta^2 - \gamma^2 - \beta\gamma\right) - c_A 2\beta^2 - c_B\beta\gamma}{4\beta^2 - \gamma^2}$$

$$\frac{\delta l_A^*}{\delta c_A} < 0, \frac{\delta l_B^*}{\delta c_A} < 0$$

$$p_A^* = \frac{\alpha\left(6\beta^2 - 2\gamma^2 - \beta\gamma\right) - c_A 2\beta^2 - c_B\beta\gamma}{2(4\beta^2 - \gamma^2)}$$

$$\frac{\delta p_A^*}{\delta c_A} < 0, \frac{\delta p_B^*}{\delta c_A} < 0$$

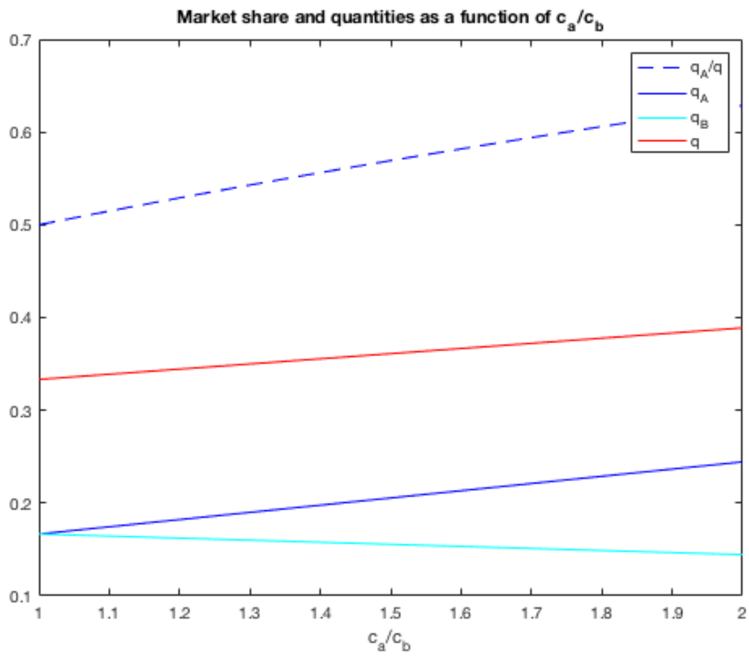


Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1, c_B = 0.5$

Increasing its commercial revenue with respect to the one of the competitor allows the airport to achieve a greater market share on the aeronautical side.

$$\frac{q_A^*}{q^*} = \frac{(-2\beta^2 + \gamma^2 - \beta\gamma)(2\alpha\beta^2 - \alpha\gamma^2 - \alpha\beta\gamma + c_A\left(2\beta^2 - \gamma^2\right) - c_B\beta\gamma)}{(2\alpha + c_A + c_B)(4\beta^4 + \gamma^4 - 5\beta^2\gamma^2)}$$

$$\frac{\delta \frac{q_A^*}{q^*}}{\delta c_A} > 0$$



Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1, c_B = 0.5$

With a unilateral and exogenous rise in c_A with respect to c_B, airport A will see an increase of its profit, and airport B a decrease. Because the additional commercial revenues lead airport A to decrease its charges, the airline will set a higher quantity, and achieve a greater profit.

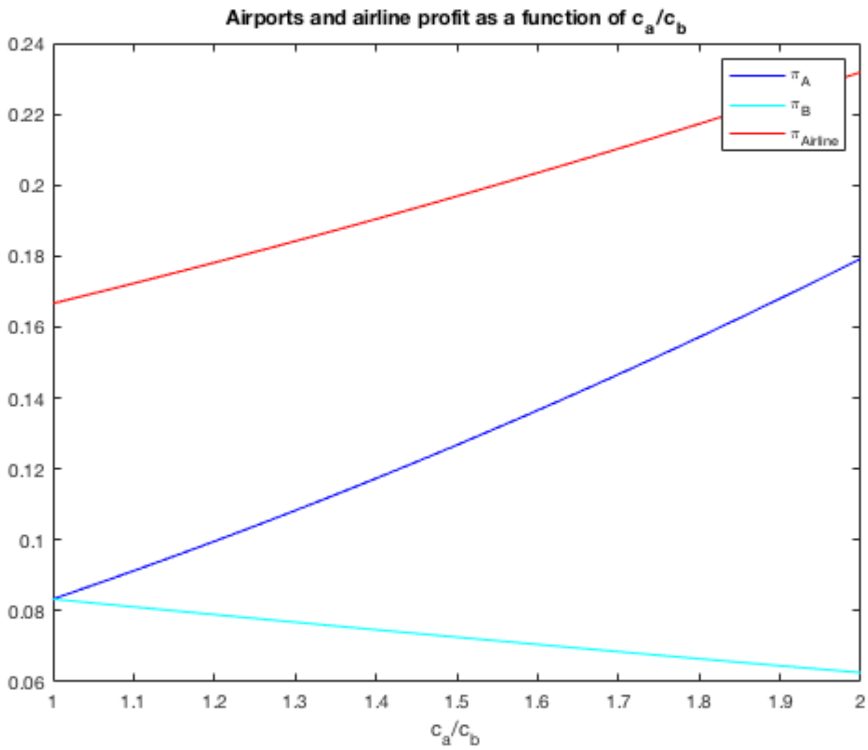
$$\pi^{*A} = \frac{\beta\left(\alpha\left(-2\beta^2 + \gamma^2 + \beta\gamma\right) - c_A(\gamma^2 - 2\beta^2\right) + c_B\beta\gamma)^2}{2(4\beta^2 - \gamma^2)(4\beta^4 - 5\beta^2\gamma^2 + \gamma^4)}$$

$$\pi^{*B} = \frac{\beta\left(\alpha\left(-2\beta^2 + \gamma^2 + \beta\gamma\right) - c_B(\gamma^2 - 2\beta^2\right) + c_A\beta\gamma)^2}{2(4\beta^2 - \gamma^2)(4\beta^4 - 5\beta^2\gamma^2 + \gamma^4)}$$

$$\frac{\delta\pi^{*A}}{\delta c_A} > 0, \frac{\delta\pi^{*B}}{\delta c_A} < 0$$

$$\pi^{*C} = \frac{\beta^2(\alpha^2\left(8\beta^3 - 6\beta\gamma^2 - 2\gamma^3\right) + c_A\left(8\alpha\beta^3 - 6\alpha\beta\gamma^2 - 2\alpha\gamma^3 + c_A\left(4\beta^3 - 3\beta\gamma^2\right)\right) + c_B\left(8\alpha\beta^3 - 6\alpha\beta\gamma^2 - 2\alpha\gamma^3 + c_B\left(4\beta^3 - 3\beta\gamma^2\right)\right) - c_A c_B 2\gamma^3}{4(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)^2}$$

$$\frac{\delta \pi^{*C}}{\delta c_A} > 0$$



Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1, c_B = 0.5$

The degree of competition between two airports is measured thanks to their perceived differentiation from the passengers. A higher perceived degree of homogeneity between the destinations served by the two airports results in a loss of market power, and thus on a lower profit for the airport, that will set lower charges and hence transfer a portion of its rent to the airline. As we have seen, airports also compete with each other via their commercial revenues that have an effect on their market share for the provision of aeronautical services.

5) The introduction of State regulation

Because of their market power, airports are often regulated businesses. Even though different regulation schemes exist, like price cap or rate-of-return, a common principle of airport regulation is that the price for aeronautical services should reflect the cost of the provision of those services (Mills, 2019). Without precisely modelling the regulator's action on the market, we can study the effect of competition under State regulation. In this section, our goal is not to discuss the socially optimal till system or regulatory scheme to put in place, but to study the effect of different existing schemes on airport competition.

5.1) Defining the regulatory perimeter

One of the existing debates concerning airport regulation is what should be the perimeter of the regulation *i.e.,* should the State only regulate the activity where the airport is in a monopoly position, leaving the non-aeronautical activity without any regulation, or should it regulate the entirety of the airport activity. Here, two forms of regulation are considered: the single till, and the dual till. In the case of the dual till, the revenues of the two activities of the airport (aeronautical and non-aeronautical) are separated. In the single till system, the profit made on the commercial side of the market can subsidize the aeronautical activity, as the total profit will be capped by the regulator, such that any increase in commercial profit will mechanically decrease the ceiling of authorized airport charges level. In certain cases, some of the commercial activity is included in the regulatory perimeter. This hybrid till system is for instance used in France, where the car park activities of Aéroports de Paris are included in the regulatory perimeter.

A large portion of the literature is dedicated to the study of the definition of the socially optimal till system. Some argue that a single till system is socially better in order to fully take into account the externalities existing between aeronautical and commercial activities (Malavolti, 2016), and to avoid the costs and asymmetries of information implied by the control of the complex allocation of assets and costs to the regulatory perimeter system (Malavolti, 2017). However, a dual till system is said by others to be preferable at congested airports in order to reduce congestion (Starkie, 2001), and to achieve a higher commercial revenue (ACI, 2017), and an overall better productivity (Oum *et al.,* 2004). Some authors hence claim that the single till structure is superior for uncongested airports, and the dual till for congested airports (Lu and Pagliari, 2004; Czerny, 2006; Czerny *et al.,* 2016).

We decide here to introduce a new parameter, ω, that accounts for the share of commercial activities that are included in the regulatory perimeter, where the regulator will set the airport charge level in order to achieve a targeted level of profit[5]. If $\omega = 0$, the dual till is used, and if $\omega = 1$, it is the single till, and a hybrid till for $0 < \omega < 1$.

Let us develop a new model to account for regulation in the airport sector. The State regulates the prices of the aeronautical activities by setting the variable charge to a level equaling the marginal cost of aeronautical activities minus a share ω of the marginal commercial revenue, so that the airport's profit on the regulatory perimeter equals zero.

$$\bar{l}_A = 0 - \omega c$$

The optimal quantity for A is hence given by:

$$q_A^* = \frac{\alpha + \omega c}{2(\beta + \gamma)}$$

[5] In our case zero, because we make the assumption that the airport does not incur any cost.

As the two airports are symmetric, the final quantity of air transportation services in this market is given by:

$$q^* = \frac{\alpha + \omega c}{\beta + \gamma}$$

The price paid by the passenger to the airline is given by:

$$p_A^* = \frac{\alpha - \omega c}{2}$$

The airline's profit is given by:

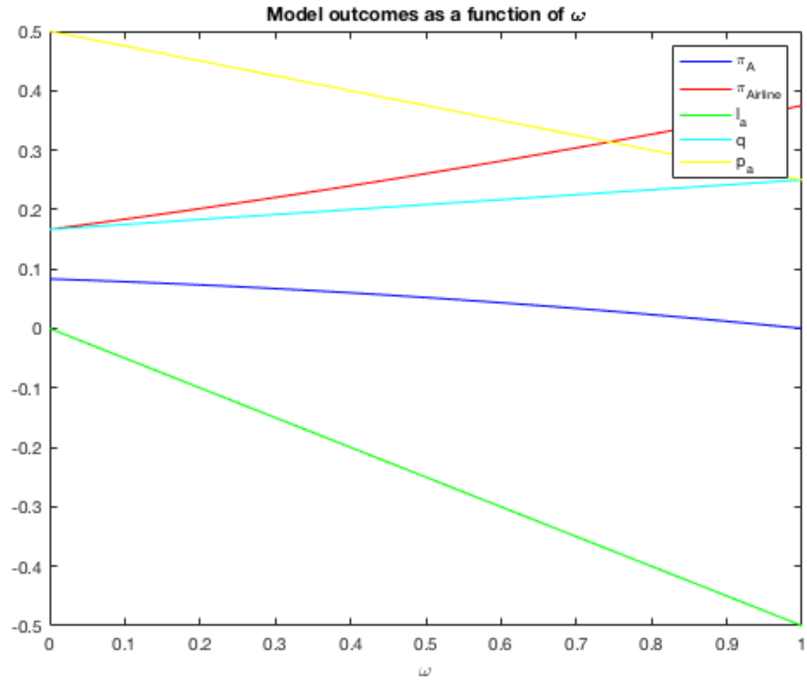
$$\pi^{*C} = \frac{(\alpha + \omega c)^2}{2(\beta + \gamma)}$$

And the airport's profit by: $\pi^{*A} = \dfrac{c(1-\omega)(\alpha + c)}{2(\beta + \gamma)}$

What is the effect of the degree of integration of commercial activities in the regulatory perimeter?

Including commercial revenues in the regulatory perimeter allows airlines to internalize the externalities they create by allocating traffic to the airport, *via* a decrease in the airport charge. This results in a higher quantity in the market and lower airfares. The airport's profit decreases following a further integration of commercial activities in the regulatory perimeter where the profit is capped by the regulator.

$$\frac{\delta \pi^{*A}}{\delta \omega} < 0, \frac{\delta \pi^{*C}}{\delta \omega} > 0, \frac{\delta \pi^{*C}}{\delta \omega} > 0, \frac{\delta p_A^*}{\delta \omega} < 0, \frac{\delta q^*}{\delta \omega} > 0$$



Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1, c = 0.5$

5.2) The effect of commercial revenues on competition in a regulatory framework

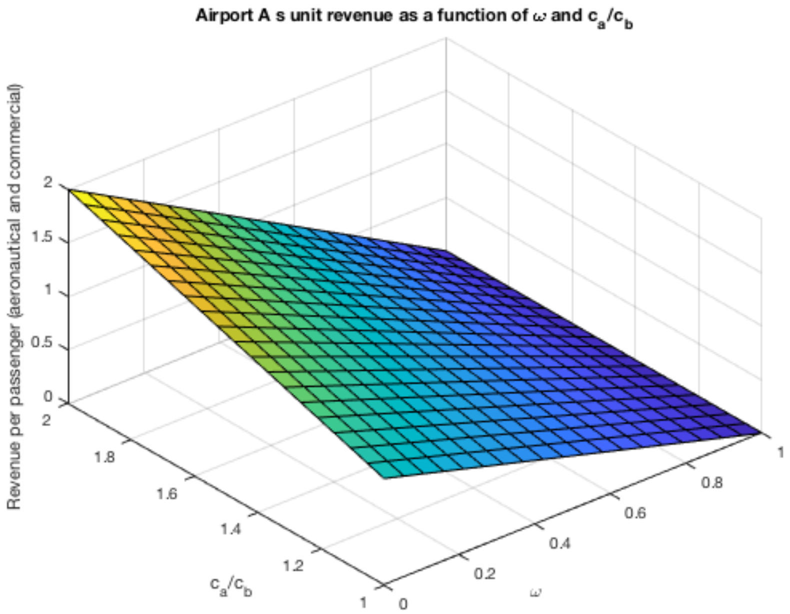
In this last section, we will consider two asymmetric airports where the exogenous commercial revenues can vary from an airport to another. We will be looking at how regulation affects competition in the case of the existence of different commercial revenues earned by the two airports.

In this new setting, airport A and B can earn a different commercial revenue from passengers, c_A and c_B. The regulator will then set the airport charges such that:

$$\bar{l}_A = 0 - \omega c_A$$

$$\bar{l}_B = 0 - \omega c_B$$

When a higher share of commercial revenue is included in the regulatory perimeter, airports see their unit revenue decrease. On the commercial side, more revenue is shared with the airlines and passengers, and on the aeronautical side, the airport also achieves a lower unit revenue because the airport charge has mechanically decreased following the till structure modification.



Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1, c_B = 0.5$

As the aeronautical charge set by the regulator can be lowered by the inclusion of some of the commercial activity in the regulatory perimeter, this will have an effect on competition and market share between the two airports. Indeed, the prices set by the regulator reflects the economic reality of an individual airport *i.e.,* its cost and revenue structure[6]. Two airports regulated by the same body, under the same jurisdiction can hence be assigned a different price cap by the authority. How will this affect the market structure when two airports are competing?

Under this setting, airport A's market share is given by:

$$\frac{q_A^*}{q^*} = \frac{(\beta + \gamma)(\alpha(\beta - \gamma) + \omega(\beta c_A - \gamma c_B))}{(\beta^2 - \gamma^2)(2\alpha + \omega(c_A + c_B)}$$

$$\frac{\delta \frac{q_A^*}{q^*}}{\delta c_A} > 0$$

Hence, the lower airport charge set by the regulator will allow the regulated airport to achieve a greater market share if its unit commercial revenue is superior to the competitor's one. Naturally, this volume effect is greater as a higher share ω of this commercial revenue is included in the regulatory perimeter.

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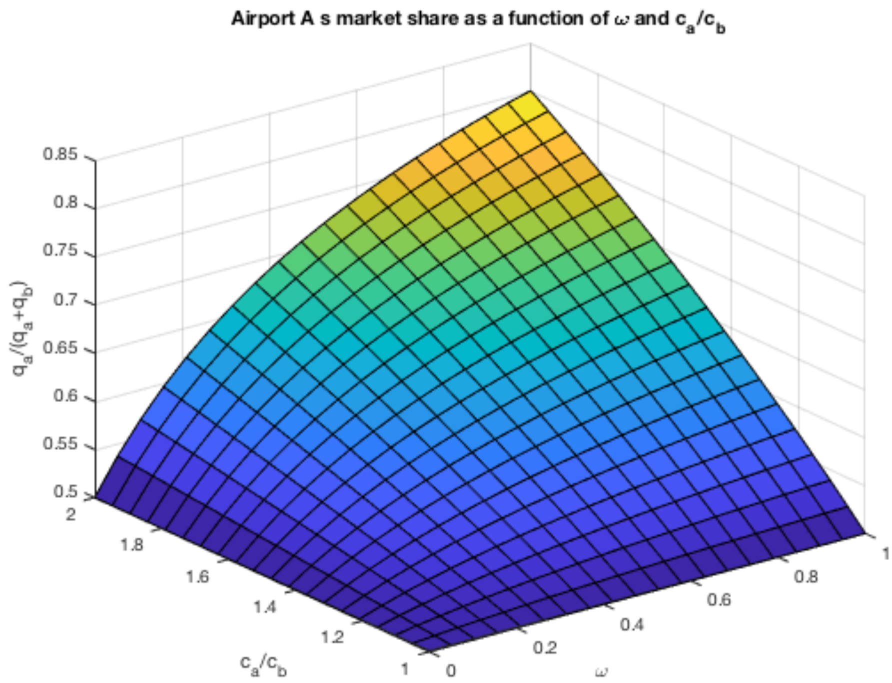
[6] Exceptions exist where common charging system can be put in place for airports serving the same area. It is for instance the case of Paris Charles-de-Gaulle and Paris-Orly, where the airport charge level is the same.



Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1, c_B = 0.5$

Here, the degree of inclusion of commercial activities in the regulatory perimeter has two effects on the airport profit: first of all, it reduces the marginal revenue (both aeronautical and commercial) per passenger, because a higher degree of commercial revenues is shared with the airline and the passenger, and that the authorized level of airport charges decreases. Second, in the case of a single or hybrid till, the commercial revenue subsidizes the aeronautical activity, leading to a lower level of airport charges, and hence a higher quantity for the airport with higher commercial revenues, provided that the two airports are substitutable enough. How do those revenue and volume effects combine?

Airport A's profit is then given by:

$$\pi^{*A} = \frac{c(1-\omega)(\alpha(\beta-\gamma)+\omega(\beta c_A - \gamma c_B))}{2(\beta^2-\gamma^2)}$$

$$\frac{\delta \pi^{*A}}{\delta \omega} = \frac{c_A(\alpha(\gamma-\beta)+c_A(\beta-2\beta\omega)+c_B(-\gamma+2\gamma\omega))}{2(\beta^2-\gamma^2)}$$

When commercial revenues are different, *i.e.*, $c_A \neq c_B$, there exists a level of inclusion of the commercial activities in the regulatory perimeter $\omega^*{}_A$, that maximizes airport A's profit[7].

[7] Again, our aim is not to discuss the socially optimal level of inclusion of aeronautical activities in the regulatory perimeter, but to study the effect of different till structures on airport competition.

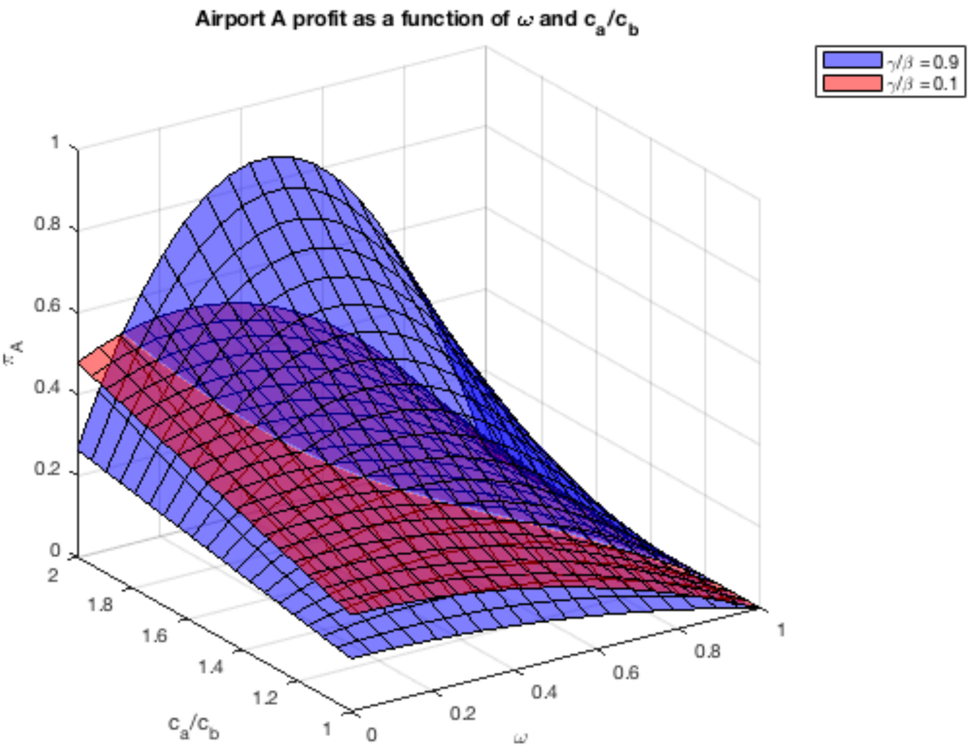
Indeed, when the airports are differentiated, and that the commercial revenue is greater than the competitor's one, any additional level of inclusion of this commercial revenue in the regulatory perimeter will lower the price cap set by the regulator, increase the airport's traffic, and thus aeronautical and commercial revenues, only if there is a sufficient level of differentiation between airports.

$$\frac{\delta \pi^{*A}}{\delta \omega} = 0 \iff \omega^{*}{}_{A} = \frac{\alpha(\gamma - \beta) + \beta c_A - \gamma c_B}{2(\beta c_A - \gamma c_B)}$$

$$\frac{\delta \pi^{*A}}{\delta \omega} > 0 \; for \; \omega \; \epsilon \left[0, \frac{\alpha(\gamma - \beta) + \beta c_A - \gamma c_B}{2(\beta c_A - \gamma c_B)}\right[\; and \; \frac{\delta \pi^{*A}}{\delta \omega} < 0 \; for \; \omega \; \epsilon \left]\frac{\alpha(\gamma - \beta) + \beta c_A - \gamma c_B}{2(\beta c_A - \gamma c_B)}, 1\right[$$

This optimal level of integration of commercial activities in the regulatory perimeter is closer to 0 *i.e.,* close to a dual till structure, when airports are close to monopolies, and close to 1 *i.e.,* close to a single-till structure when airport are almost in perfect competition.

$$\frac{\delta \omega^{*}}{\delta \gamma} > 0$$



Numerical simulation with $\alpha = 1, \beta = 2, \gamma = 1, c_B = 0.5$

6) Conclusion

In conclusion, we have proposed an original modelling of the airport business, taking into account the airports' substitutability in the airline's network, that is derived from the passenger's perceived differentiation of the area they serve, and the externalities existing between aeronautical and commercial activities. Moreover, our model accounts for the fact that when airlines modify their fleet allocation between a portfolio of airports, they balance the marginal cost (positive or negative) of reallocating quantities to another airport with the elasticity of demand for a service to the two airports. We have shown that the level of commercial revenues achieved by the two airports has an effect on the pricing structure of airports, with or without regulation, and hence on their market share and overall quantity offered on the market. It will be interesting to complexify this simple model by making the airport's commercial activities endogenous, in order to discuss airport strategy, such as the realization of investments in order to increase commercial revenues, according to the degree of competition they face.

More precisely, we studied the effect of the till structure on competition. When airport competition exists *i.e.,* when airports are not seen as perfectly heterogenous, a level of inclusion of the commercial activities into the regulatory perimeter that maximizes the airport's profit, and that is not 1 nor 0 exist. The objective of our paper did not include the study of the socially optimal till structure, but it would be interesting to study this matter in the future.

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