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**Multiproduct airport competition and
e-commerce strategies**

Valentina Bracaglia
Tiziana D'Alfonso
Alberto Nastasi

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Multiproduct airport competition and e-commerce strategies

Valentina Bracaglia^{a,*}, Tiziana D'Alfonso^a and Alberto Nastasi^a

^a Department of Computer, Control and Management Engineering, Sapienza Università di Roma,
Via Ariosto 25, Roma

Abstract

We study airport competition when vertically differentiated products may be strategically offered at the time of ticket purchase through the Internet: a base product – the flight – and a composite one – the flight plus some *premium commercials (PCs)*, as car parking, car rental or hotel reservation. We model a two stages game: first airports decide whether to offer PCs online, thus making the purchasing decisions interact through observability of aviation and commercial prices. Then, they engage in Bertrand competition deciding on both prices. We find that airports set lower aviation charge than they would have levied absent concessions, when they are both competing on online offers. Nevertheless, when only one airport pursues the online offer, that facility sets a higher aviation charge than it would have levied absent concessions, as long as profits from retail earned at the facility on the travel day are not high enough. This suggests that the combined effect between airports competition on side business and demand complementarity does moderate airports market power in the core business. The Nash equilibrium of the game is such that both airports offer PCs on line, making travelers account for the surplus they would gain from both the sides of the business when they buy air tickets. This is welfare enhancing. Nevertheless, when profits from retail earned at the airports on the travel day are sufficiently high, the facilities are caught in a Prisoner's Dilemma.

Keywords: Airports competition; e-commerce; concessions; vertical differentiation.

*Corresponding author:

Tel: +39 06 77274 085

fax: +39 06 77274 074

E-mail address: bracaglia@dis.uniroma.it (V. Bracaglia)

1. Introduction

Commercial revenues have been growing faster than aeronautical revenues during the years of privatization and commercialization of airports (Graham, 2009; Morrison, 2009): at some medium to large US-EU airports, for instance, commercial business represents 75–80% of the total revenue (ATRS, 2012)¹. One consequence of this profit disparity is that the profits made from commercial activities may be used to cross-subsidize aeronautical operations, thereby eliminating the need for government aid. Indeed, travel retail has been turning to be an important tool to ensure the capability to finance the significant capital expenditure needed. Accordingly, commercial strategies have been structured to meet new influencing factors, changes in consumer behavior, the power of digital media and the increasing levels of complexity in commercial operations (Belardini, 2013)

In particular, e-commerce has been recognized as a new strategic source of revenues and airports increasingly use their websites or mobile apps for *business-to-consumers* (B2C) activities. Through these platforms, airports sell some commercial services directly to customers – e.g. booking of car parking, hotels, car hire and, sometimes, foreign currency, shopping or executive lounge access – or support the distribution of such services offered by their partners (Halpern and Regmi, 2013; Halpern and Graham, 2013). In fact, airports try to react to the threat of Internet shopping, that is a major competitor both in terms of product variety and easy of purchase (Graham, 2009): through discount programs, for instance, they try to raise buyers' switching costs and address the lack of customer loyalty due to the fact that competitors are just a click away. SITA (2013a) mentions that 45% of airports surveyed² plans to offer the ability to pay for ancillary services, such as parking, through their mobile apps during the next three years, taking the total to 63% by the end of 2016. Similarly, on the demand side, SITA (2013b) shows that purchasing additional travel services via smartphone is considered more important than ticket purchasing to the majority of travelers surveyed: 39% of the passengers interviewed would definitely buy ancillary services using a mobile.

Empirical evidence shows that this is a growing trend in airport management. Schiphol Airport attributes the 15.5% and 5% increase in 2011 in long and short stay parking, respectively, to the growing number of reservations via web (Schiphol Airport Group, 2011). Similarly, Aeroports de Paris points out the success of

¹ One of the main reasons is that commercial operations tend to be more profitable than aeronautical operations (Jones et al., 1993), owing partly to the locational rents enjoyed by airports and partly to prevailing regulations and charging mechanisms (Czerny, 2006; Starkie, 2002; Yang and Zhang, 2011; Zhang and Zhang, 2010).

² The survey is based on responses from 122 respondents representing views of over 255 airports worldwide. 59% came from airports within the Top 100 in terms of revenue, representing 75% of revenue within the Top 100. 44% of replies came from airports within the Top 100 in terms of passenger numbers, representing 74% of traffic amongst the Top 100.

The airports participating in the research represent 54% of global traffic. For further details: www.flightglobal.com/ITzone; www.sita.aero/surveys; www.sita.aero/ittrendshub.

online car-parking offer: starting from 2010 car parking booking at Paris Orly can be made online up to six months in advance and 50,000 customers used this service in 2010 (Aéroports de Paris, 2010). Copenhagen Airports offers car parking and hotel reservation through its direct links to the websites of the operators. It fosters online purchases through a loyalty program that allows earning bonus points resulting in special offers. Even airlines, whose websites are among the main platforms through which travelers reserve their flight, have been starting to boost commercial sales through online platforms. Ryanair provides an example: it has identified airport car parking as a strategic source of revenues and it offers the opportunity to reserve car parking at the airport through its own website at the time of ticket purchase. Ryanair cooperates with the leading airport parking company Better Choice for Parking (BCP) and, in its negotiations with some airports, it asked for parking revenue sharing as a condition to serve them³.

The immediate effect of airport e-commerce strategies is the reduction of the time lag between the purchase of the air ticket and the purchase of some commercial services. Indeed, many airport websites, as opposite to the online platforms of car rental or car parking operators, allow the purchase of the flight ticket and those services through the same web main screen. In this way, each customer can observe both prices when buying the ticket. This observability makes the two purchasing decisions interact and passengers decide whether to buy the flight and some concessions, the travel ticket only or nothing. In other words, e-commerce enables customers to decide whether to travel accounting for the surplus they would gain from commercial consumption. Take the example of a traveler that is interested in car reservation, while planning a fly-and-drive trip (or needs to reach the final destination when landing in a secondary airport). If she finds out that the air ticket price is higher than what she is willing to pay, she may still decide to travel if she is offered a very convenient car rental rate at the time of ticket purchase. On the contrary, she might not buy the ticket if she would have to wait until the day of departure (or the arrival at the destination airport) to be informed about the car rental rate. The same might happen if she would have to incur high searching costs to get this information. A similar logic can be applied taking the example of car parking, which is needed when a traveler prefers to reach the airport by its own car due, for instance, to uncomfortable flight schedule.

The objective of this paper is to provide a simple framework for the analysis of airport demand – aeronautical and commercial – and airport pricing behavior, when e-commerce plays a role and it competes with another airport. In fact, observability of the full range of prices at the time of the ticket purchase makes airports compete for passengers through both aviation and non-aviation services. On the contrary, airports would have been monopolists in concessions and competitors in the aviation side only, if passengers are able to find out the price of commercial goods and product mix only at the airport – once locked in the facility by

³ Airports and airlines now use various agreements – such as the commercial revenue sharing – to internalize the positive demand externality between aviation and concession services (Zhang et al., 2010). Airlines benefit from concession sales at airports; otherwise, they would ignore such a demand externality in making their decisions. On the other hand, the airport is able to internalize the positive externality of online concession sales by airline websites.

the air ticket already purchased. Literature used to abstract away from the effects of airports competition on both sides of the business, since, for most passengers, purchases of air tickets and of concessions were well separated in time. In view of these changes, it would be useful to have an analytical framework that addresses such issue rigorously.

The contribution of the paper is threefold. First, we look at airports competition with vertically differentiated products, as induced by the interaction between passengers' purchasing decisions. Thus, we study airport demand and the effect of commercial charges on the demand for aeronautical services, rather than the effect of the aeronautical charge on the demand for commercial services only. We also examine whether the two-sided nature of the airport business does curb market power on the aviation side. Second, we study airports entry strategy, which is whether airports have incentive to offer some commercial services online at the time of the ticket purchase. Third, we examine implications of e-commerce strategy on social welfare.

Three branches of literature are related to the subject of this paper.

First, there is the effect of complementarity between aviation and non-aviation services on the pricing behavior of airports. The debate has been focusing on the monopoly case. Since commercial operations depend greatly on the passenger throughput of an airport, the aviation charge may be reduced to induce a higher volume of passengers and increase the demand for concessions (Starkie, 2002). Oum et al. (2004), Yang and Zhang (2011), Zhang and Zhang (1997; 2003; 2010) confirm analytically that commercial revenues may exert a downward pressure on the aviation charge of a monopolistic airport. Czerny (2006) is the only paper that also takes into account the effects of commercial charges on the demand for aeronautical services. He finds that, due to the specific complementarity of demands for aeronautical and commercial services, a monopolistic airport would reduce the commercial charge and raise the aeronautical one. Nevertheless, less attention has been deserved to the effects of complementarity between aviation and non-aviation services on the pricing behavior of airports when they compete on both sides of the business⁴.

A second branch studies welfare neutrality of commercial services. D'Alfonso et al. (2013) and Zhang and Czerny (2012) include a proportion of the surplus from concession services in the social welfare function. This reconciles two approaches in literature: if the proportion is equal to 1, all the surplus from concession activities is counted into social welfare (Yang and Zhang, 2011; Zhang and Zhang, 2003, 2010); if the

⁴ In a parallel but independent work, Czerny (2013b, unpublished) develops a spatial model in order to consider duopoly competition for the supply of core and side services. He shows that side services can exert a positive demand effect and a negative complementarity effect on core prices. The main difference with respect to our work is the following. In Czerny (2013b), side businesses increase the demand for core services simply because individuals may consume core and side services together while they would not consume core services alone. On the contrary, in our model the interaction of purchasing decisions is induced by the observability of both prices at the time of the ticket purchase. Thus, in our model, costumers decide whether to travel accounting also for the surplus they would gain from commercial consumption depending on e-commerce strategies of airports.

proportion is equal to 0, surplus from concession activities is excluded (Czerny, 2011; 2013a; Kratzsch and Sieg, 2011).

A third branch of literature explores multiproduct price competition and product line rivalry. Some contributions study duopoly Bertrand competition when a base product and its add-ons are produced. Verboven (1999), based on Mussa and Rosen (1978), examines the case in which there is full consumer information about prices, compared to the case in which the base product is advertised and premium product price information is available at the shop only (customers have to incur a sunk cost to learn it). A higher mark up for add-ons is found to be set. Ellison (2005), building on Verboven (1999), combines Hotelling horizontal differentiation with vertical differentiation assuming that passengers differ in their marginal utility of income. Mark ups on products vary depending on marginal utility of customers and full costumer information about prices reduces profits. Thisse and Vives (1988) study spatial price discrimination. They show that it is a dominant strategy for two competing firms, but profits are lower than profits under uniform pricing, which puts the firms into a Prisoner's Dilemma⁵.

In this paper, analysis will be based on a standard Hotelling model of demand with two uncongested airports. While assuming that fliers can consume commercial services while non-fliers cannot, we argue that consumer locations and reservation prices for commercial services are independently and randomly distributed on a unit square. We will make some accompanying simplifying assumptions (like uniform distribution of consumers or the absence of market power by airlines). Although this has some drawbacks in terms of generality, it has the advantage of making decisions of individuals and airports very explicit, and it allows for interpretable solutions and expressions. In our model, when some commercial services may be strategically offered through the Internet at the time of the ticket purchase, facilities compete for vertically and horizontally differentiated products. The first one is the base product and contains the aviation good only, i.e. the flight. The second one is a composite product and contains the aviation and some commercial goods, i.e. the flight plus some ancillary services for whom the traveler is willing to pay a certain random amount of money. Moreover, we recognize that a difference may exist between the types of concession services at the airport. For example, some concessions are bought only once at the airport, like food and beverages. On the other hand, some other services can be bought before the departure, like car rental or car parking. We assume that only this second type of service is offered at the time of the ticket purchase through the Internet, while the airport can earn from the first type of services once that the passengers are at the facility. Moreover, the overall demand for services like food and beverages may not depend much on whether individuals fly or not fly. Thus, we consider that the surplus from the first type of services may or may not be included in the social welfare function.

⁵ Extensions of their work have shown that equilibria also exist when firms adopt different spatial pricing policies (De Fraja and Norman, 1993). Some results for nonspatial models of differentiated product markets can be found in Corts (1998), Laffont, Rey and Tirole (1998) and Winter (1997).

The rest of the work is organized as follows. Section 2 sets up the model. Bertrand competition on aviation and commercial prices is modelled as a two stages game. In the first stage, airports decide whether to offer some commercial services online; in the second stage, airports compete on prices of aviation services and of those commercials included in their online offer. Section 3 describes airport pricing. We find that airports set lower aviation charges than they would have levied absent concessions, when they are both competing on online offers. Nevertheless, when only one airport pursues the online offer, that facility sets a higher aviation charge than it would have levied absent concessions, as long as profits from retail earned at the facility on the travel day are not high enough. Section 4 examines airports' entry strategies. The Nash equilibrium of the game is such that both airports offer some commercials on line. Section 5 analyses social welfare while Section 6 contains some concluding remarks and avenues for future research.

2. The model

Consider two profit maximizing airports, A and B , and a unit mass of individuals x uniformly distributed along a unit length segment, i.e., $x \in [0,1]$. The facilities are located at the opposite ends of the segment, that is $l_A = 0$ and $l_B = 1$, where l_i indicates the location of facility $i = A, B$. For the sake of convenience, we assume that the airports are uncongested and incur constant marginal operational costs, further normalized to 0. Moreover, in order to focus on the effects of airport competition on both sides of the business, we assume that airlines serving both facilities are homogeneous. They are price takers and have zero constant marginal operational costs⁶. Let p_a^i be the per passenger aviation charge levied by airport i . From previous assumptions, it follows that p_a^i equates the final prices to costumers of airport i , that is the air ticket price charged by airlines serving that airport.

Travelers are also offered commercial services. We distinguish between two types of concessions. The first type is constituted by commercial services that passengers are usually willing to buy before departure, e.g., car rental, car parking or hotel reservation. In order to simplify the exposition, in what follows we shall refer to them as *premium commercials (PCs)* or simply commercials. The second type is constituted by those services that travelers usually buy only once at the airport, e.g., retail services that include clothes and footwear, food and beverages, cigarettes, alcohol, cosmetics or electrical appliances (Thompson, 2007). Most of these purchases are related to instant needs, e.g. the need to eat and drink, or psychological issues linked with the travel process, as feelings of anxiety, stress or excitement, which make passengers react in unusual ways, or impulsively. For the sake of simplicity, in the rest of the paper we shall refer to this type of services as *retail services*.

⁶ This assumption is coherent with the hypothesis of absence of airport congestion. Moreover, we are implicitly assuming the absence of economies of density. For these reasons, we consider that the aviation market is made by O-D flights at non-hub airports. Again, this is consistent with the intent to focus on the effects of airport competition on vertically differentiated markets rather than on airports-airlines vertical structure.

We assume that both services can be purchased once at the facility but only *premium commercials* can be offered online by airport webstores at the time of the ticket purchase. The reason is threefold. First, the second group of services is unlikely to be bought before departure by definition. Pre-ordering foreign currency or duty-free items are useful in that they save the time one might spend browsing at duty free shops. However, passengers like to browse and others may do so because they have nothing better to do at an airport (Gillen and Lall, 2002). Second, empirical evidence suggests that few airports include services from the second group in their online product mix⁷. Third, this paper aims at analyzing the effects of airports competition on both sides of the business as a consequence of the interaction between traveler purchasing decisions: this is induced by the observability of both ticket and commercial prices at the time of the ticket purchase. Nevertheless, as we mentioned, *retail services* are unlikely to stimulate aviation demand.

Let p_c^i be the per-passenger charge of *PCs* sold online – before departure – and once at the airport i . We assume that commercial providers serving both facilities are price takers and have zero constant marginal operational costs. It follows that p_c^i equates the final price to travelers buying *PCs* online from airport i 's webstore or once at the facility i . Moreover, let τ_i be the per passenger profit⁸ from *retail services* that can be only purchased once at the facility i , with $\tau_A = \tau_B = \tau$. In this way, we incorporate into the model also the profits that the airports would earn from passengers who only decide to buy commercial services at the airports. We assume that only travelers can buy side services, i.e., the commercial demand is a subset of the passenger throughput of the airport. This assumption is common in literature (e.g. Czerny, 2006; Oum et al. 2004; Yang and Zhang, 2011; Zhang and Zhang, 1997, 2003; 2010)⁹. With these specifications, profit of airport i can be written as $\pi^i(\mathbf{p}) = (p_a^i + \tau) \cdot D_a^i(\mathbf{p}) + p_c^i \cdot D_c^i(\mathbf{p})$, with $D_c^i(\mathbf{p}) \subseteq D_a^i(\mathbf{p})$, where D_a^i is the demand for aviation services, D_c^i is the demand for commercial services at facility i and \mathbf{p} is the full vector of prices.

We now turn to the demand side. As introduced, there is a unit mass of individuals x uniformly distributed along a unit length segment, i.e., $x \in [0,1]$. They have unit demand for aviation and commercial services.

⁷ For instance, Manchester airport operates a Travel Extras Store, offering customers convenient travel-related and duty-free products on its official website (Manchester Airport Group, 2011). Similarly, Società Esercizi Aeroportuali (SEA) group, when defining its e-commerce strategy in 2010, has been developing a platform powered by *ViaMilano* directly accessible from SEA official website that allows the purchase of the flight ticket as well as Internet and mobile sale of products offered by the brick and mortar firms located at the airport (SEA, 2011).

⁸ Zhang and Zhang (1997; 2003; 2010) and Oum et al. (2004) model commercial profit as a fixed add on profit per passenger.

⁹ Graham (2009) suggests three reasons. First, more than 50% of retail space is in the departures airside area. Second, most passengers prefer to shop after check-in and security screening, when they are more relaxed. Third, duty and tax free purchases can be only made airside.

We assume that the gross benefit that they obtain from travelling, v , is such that each of them buys at least the aviation service from one of the airports¹⁰. Transportation costs are linear and equal to 1.

We suppose that the passenger valuation for PCs sold online by the airport webstores, v_c , is a random variable uniformly distributed on the interval $[0,1]$, where 1 is the highest valuation for concession goods, PCs . If PCs are offered online at the time of ticket purchase, each individual can observe their price and, when deciding whether to buy the transportation service, she may account for the surplus she would get from consuming commercial services. Therefore, an individual located in x is willing to buy aviation services from airport i in two cases. First, when the gross benefit she derives from traveling from airport i is higher than the sum of the ticket price and the transportation cost. Second, when the commercial surplus she would get buying PCs online would be able to compensate for the excess of the air ticket over the aviation benefit net of transportation cost.¹¹

In this setting, at the time of ticket purchase, passengers are offered two vertically differentiated products that are substitutes: a base product, i.e., the flight only, and a composite good, i.e., the flight plus PCs . A traveler located in x with willingness to pay v_c for *premium commercial* services – (x, v_c) – is willing to pay $v - |l_i - x|$, for the base product, and $v + v_c - |l_i - x|$, for the composite good, respectively. Analytically, let $-i$ denote the airport other than i , q_a^i and q_{a+c}^i the quantity sold by airport i to the passenger (x, v_c) with respect to the base and the composite product, respectively¹². She buys the one that maximizes her utility:

$$u(q_a^A, q_a^B, q_{a+c}^A, q_{a+c}^B; x, v_c) = \begin{cases} v + v_c - |l_i - x| - p_a^i - p_c^i & \text{if } q_a^i = 0, q_a^{-i} = 0, q_{a+c}^i = 1, q_{a+c}^{-i} = 0 \\ v - |l_i - x| - p_a^i & \text{if } q_a^i = 1, q_a^{-i} = 0, q_{a+c}^i = 0, q_{a+c}^{-i} = 0 \end{cases} \quad (1)$$

Let a stand for the base product and $a + c$ for the composite product. Customer (x, v_c) buys product $k \in \{a, a + c\}$ from airport i if and only if she prefers it (i) over product $-k$ from the same airport, with $-k = a$ if $k = a + c$, or $-k = a + c$ if $k = a$; (ii) over product k from airport $-i$, with $-i = A$ if $i = B$ or $-i = B$ if $i = A$; (iii) over product $-k$ from airport $-i$:

¹⁰ This assumption seems reasonable when there are two airports, since passengers are offered two horizontally differentiated services in the aviation market. See Barbot (2009) for application under a similar assumption. Moreover, it allows us to focus on the effects of airports competition on both sides of the business and on the way in which they strategically choose the online commercial strategy. For the same reason, and for analytical tractability, we assume that there are no customers beyond airports.

¹¹ This form of interaction between customer purchasing decisions is consistent with Czerny (2006).

¹² $q_a^i, q_{a+c}^i \in \{0,1\}$ and $\sum_{\substack{i \in \{A,B\} \\ k \in \{a,a+c\}}} q_k^i = 1$ since we assume that demand is unitary and everyone buys.

$$q_k^i(x, v_c) = 1 \Leftrightarrow$$

$$u(q_k^i = 1, q_{-k}^i = 0, q_k^{-i} = 0, q_{-k}^{-i} = 0; x, v_c) > \max \left\{ \begin{aligned} &u(q_k^i = 0, q_k^{-i} = 0, q_{-k}^i = 1, q_{-k}^{-i} = 0; x, v_c), \\ &u(q_k^i = 0, q_k^{-i} = 1, q_{-k}^i = 0, q_{-k}^{-i} = 0; x, v_c), \\ &u(q_k^i = 0, q_k^{-i} = 0, q_{-k}^i = 0, q_{-k}^{-i} = 1; x, v_c) \end{aligned} \right\} \quad (2)$$

First, we identify those passengers that are indifferent between two purchasing decisions, i.e. those (x, v_c) for whom $|\arg\max_{\mathbf{q}} u(\mathbf{q}; x, v_c)| > 1$, where $\mathbf{q} = (q_a^A, q_a^B, q_{a+c}^A, q_{a+c}^B)$.

Consumer (x, v_c) is indifferent between aviation services offered by the two airports if and only if:

$$\begin{aligned} u(q_a^A = 1, q_a^B = 0, q_{a+c}^A = 0, q_{a+c}^B = 0; x, v_c) &= u(q_a^A = 0, q_a^B = 1, q_{a+c}^A = 0, q_{a+c}^B = 0; x, v_c) \\ \Leftrightarrow x &= \frac{1}{2}(1 + p_a^B - p_a^A) := \bar{x} \end{aligned} \quad (3)$$

Consumer (x, v_c) is indifferent between buying aviation and *PCs* from airport *A* or from airport *B* if and only if:

$$\begin{aligned} u(q_a^A = 0, q_a^B = 0, q_{a+c}^A = 1, q_{a+c}^B = 0; x, v_c) &= u(q_a^A = 0, q_a^B = 0, q_{a+c}^A = 0, q_{a+c}^B = 1; x, v_c) \\ \Leftrightarrow x &= \frac{1}{2}(1 + p_a^B + p_c^B - p_a^A - p_c^A) := \bar{\bar{x}} \end{aligned} \quad (4)$$

Consumer (x, v_c) is indifferent between buying aviation services from airport *A* or aviation and *PCs* from airport *B* if and only if:

$$\begin{aligned} u(q_a^A = 1, q_a^B = 0, q_{a+c}^A = 0, q_{a+c}^B = 0; x, v_c) &= u(q_a^A = 0, q_a^B = 0, q_{a+c}^A = 0, q_{a+c}^B = 1; x, v_c) \\ \Leftrightarrow x &= \frac{1}{2}(1 - v_c + p_a^B + p_c^B - p_a^A) := \hat{x}(v_c) \end{aligned} \quad (5)$$

Finally, consumer (x, v_c) is indifferent between buying aviation and commercial services from airport *A* or aviation services from airport *B* if and only if:

$$\begin{aligned} u(q_a^A = 0, q_a^B = 0, q_{a+c}^A = 1, q_{a+c}^B = 0; x, v_c) &= u(q_a^A = 0, q_a^B = 1, q_{a+c}^A = 0, q_{a+c}^B = 0; x, v_c) \\ \Leftrightarrow x &= \frac{1}{2}(1 + v_c + p_a^B - p_a^A - p_c^A) := \hat{\hat{x}}(v_c) \end{aligned} \quad (6)$$

Figure 1 shows consumer distribution and the location of two representative customers: \bar{x} , $\bar{\bar{x}}$.

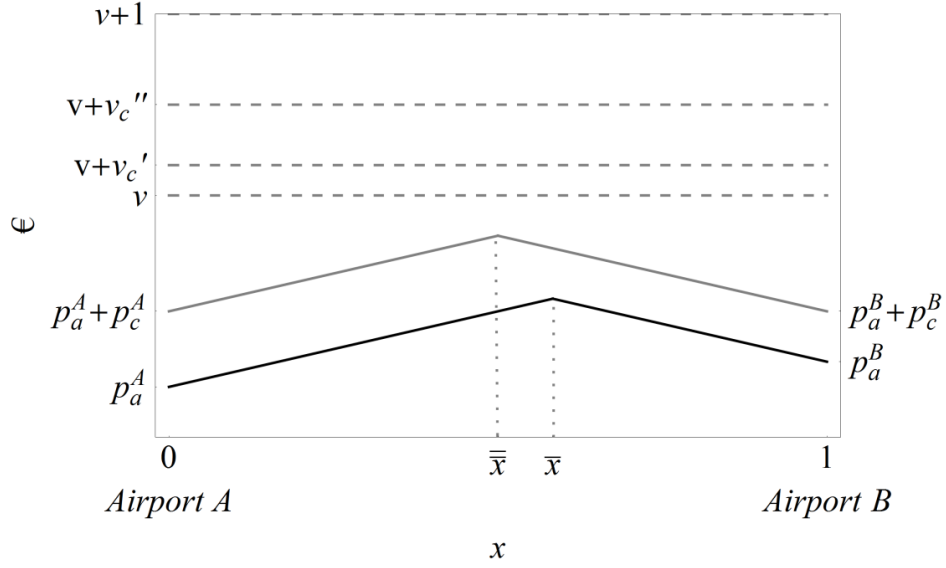


Figure 1. Consumer distribution, airports location, full price paid for aviation service and aviation plus PCs and indifferent customers.

Airports competition is modelled as a two stages game. In the first stage, airports decide whether to offer some *premium commercials* online. In this way, airports decide whether to reveal full information to travelers on the flight ticket and the price of PCs at the time of the ticket purchase, stimulating aviation demand through vertical differentiation¹³. In the second stage, airports compete *à la Bertrand* deciding on the level of aviation and commercial charges, p_a^i and p_c^i .

The game is solved by backward induction. First, we identify the second stage subgame Nash equilibrium charges. Then, we investigate airport entry strategies in the first stage, that is whether airports engage in the opening of online webstores where selling some *premium commercials*.

3. Airport pricing

We analyse three different Scenarios. In the first one, both airports offer PCs online at the time of ticket purchase. We denote this situation as Scenario 2, meaning that 2 airports are offering online. With the same logic, Scenario 1 depicts the case in which only one airport offers PCs online at the time of ticket purchase, while Scenario 0 the one in which none of the airports offer PCs when customers are buying tickets.

¹³ Online webstores don't usually require the airport to invest in brick and mortar assets. Nevertheless, it takes time to the airport to define contracts with concession services providers and to set up the online webstore, in order to start the online commercial business. As a result, the strategy toward e-commerce, once decided upon, cannot easily be changed and it seems reasonable to assume that the facility decides on its e-strategy before the pricing stage.

3.1 Both airports offer *premium commercial* services at the time of ticket purchase

When both airports offer *PCs* online, passengers have full information regarding their price and they account for the potential surplus from both the sides of airport business in order to decide whether to travel or not.

We first derive the demand for aviation and *premium commercial* services for airport i , $D_a^{i,(2)}$ and $D_c^{i,(2)}$ respectively, where the superscript (2) stands for Scenario 2¹⁴. A traveler located in (x, v_c) buys only aviation services from airport A if and only if $x \leq \min\{\bar{x}, \hat{x}(v_c)\} \wedge p_c^A \geq v_c$. On the other hand, (x, v_c) buys aviation and commercial services from the facility if and only if $x \leq \min\{\bar{x}, \hat{x}(v_c)\} \wedge p_c^A < v_c$, where all parameters have been defined in equations from (3) to (6). Graphically, this corresponds to:

$$\begin{aligned} D_a^{A,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) &= C^{(2)} + D^{(2)} \\ D_c^{A,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) &= C^{(2)} \end{aligned} \tag{7}$$

where $C^{(2)}$ and $D^{(2)}$ are the areas depicted in Figure 2.

Meanwhile, a traveler located in (x, v_c) buys only aviation services from airport B if and only if $x \geq \max\{\bar{x}, \hat{x}(v_c)\} \wedge p_c^B \geq v_c$, while (x, v_c) buys from both the sides of its business if $x > \max\{\bar{x}, \hat{x}(v_c)\} \wedge p_c^B < v_c$. We obtain that:

$$\begin{aligned} D_a^{B,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) &= A^{(2)} + B^{(2)} \\ D_c^{B,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) &= B^{(2)} \end{aligned} \tag{8}$$

where, again, $A^{(2)}$ and $B^{(2)}$ are the areas in Figure 2.

¹⁴ We shall follow the same notation on equilibrium values for charges, profits, welfare and surplus.

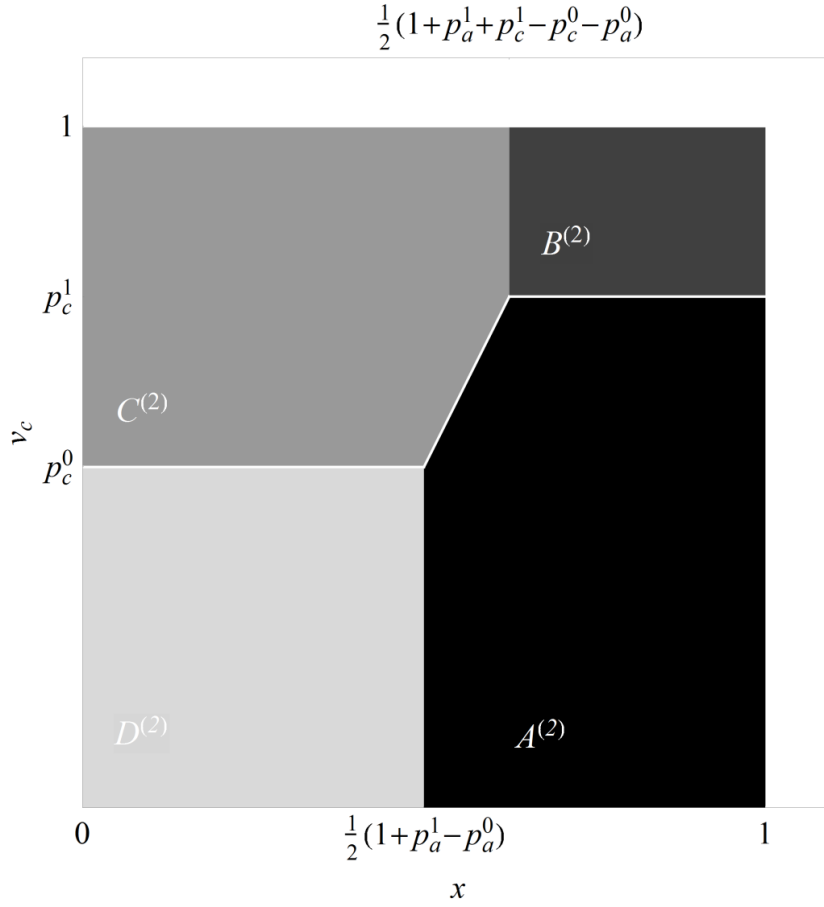


Figure 2. Demand functions for aviation and premium commercial services in Scenario 2, when $p_c^A < p_c^B$.

Demands are graphically represented in Figure 1¹⁵, while closed form expressions can be found in the Appendix. From (7) and (8) it can be easily seen that the aviation demand faced by each facility depends on its own charges on both sides of the business, p_a^i and p_c^i , and on the aviation charge levied by the other facility, p_a^{-i} , as usual because of competition on the core business. Moreover, it depends on the commercial charge levied by the competitor, p_c^{-i} , as opposite to literature on airport pricing with concessions, where demand for aviation is assumed to be independent from that one for commercial services (e.g., Oum et al. 2004; Zhang and Yang, 2010; Zhang and Zhang, 1997, 2003, 2010). This happens because selling online PCs and advertising them at the time of ticket purchase enable passenger purchasing decisions to interact. Therefore, this affects the passenger base of the airport on the aviation side, that is those who want to travel from that airport.

¹⁵ Without loss of generality, here we represent the case in which $p_c^A < p_c^B$ and thus $\bar{x} < \bar{\bar{x}}$. We shall refer to the same case in Figure 2.

Airports compete choosing simultaneously their charges on both sides of the business. Thus, they solve the following decision problem:

$$\max_{p_a^i \geq 0, p_c^i \geq 0} \pi^{i,(2)}(\mathbf{p}) = (p_a^i + \tau) \cdot D_a^{i,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) + p_c^i \cdot D_c^{i,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) \quad (9)$$

First order necessary optimality conditions for constrained optimization yield to the equilibrium charges, $\mathbf{p}^{(2)} = (p_a^{A,(2)}, p_a^{B,(2)}, p_c^{A,(2)}, p_c^{B,(2)})$, depicted in Figure 3.

We plot equilibrium charges as a function of τ , the per passenger profit from retail services collected at the airport. Details on the solving procedure and on closed forms solutions are available from the corresponding author upon request¹⁶.

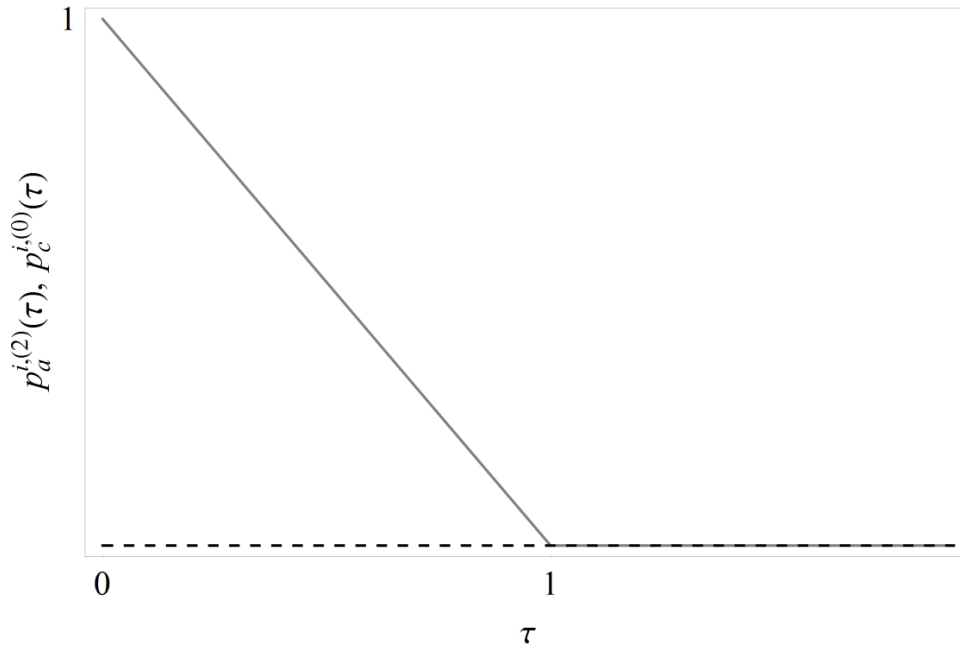


Figure 3. Equilibrium charges when both airports offer PCs online: $p_c^{i,(2)}(\tau)$ dashed line; $p_a^{i,(2)}(\tau)$ solid line.

Observation 1. When passengers are perfectly informed about the price of *premium commercials* sold through the Internet at the time of the ticket purchase, both facilities price PCs at the marginal cost.

The intuition for this result is in the complementary nature of demand for the two goods. When passengers are perfectly informed, their purchasing decisions interact and the price of PCs is able to affect aviation demand. Thus, other things being equal, each facility is able to increase aviation demand lowering either p_a^i

¹⁶ For the same reasons, the reader is referred to the corresponding author for details on closed form solutions and solving procedures with respect to equilibrium results in Scenario 1 and 0.

or p_c^i . Analytically, $dD_a^{i,(2)}/dp_c^i \leq 0$ and $dD_a^{i,(2)}/dp_a^i \leq 0$. Nevertheless, since only passengers can buy commercial services, the demand for the latter is a subset of the demand for flights: $D_a^{i,(2)} \supset D_c^{i,(2)}$ if $p_c^i > 0$ and $D_a^{i,(2)} = D_c^{i,(2)}$ if $p_c^i = 0$. Hence, lowering p_c^i increases revenues by a larger amount than lowering p_a^i . Therefore, both facilities have incentive to decrease PCs at the marginal cost, leaving infra-marginal aviation revenues unchanged. This result finds empirical support. Indeed, many airports moving towards e-commerce tend to offer discounts on premium services sold online. For instance Munich airport offers travelers special parking rates online, with discounts as high as 48% if compared with the prices travelers pay at the airport (Munich Airport Group, 2010).

Furthermore, one checks from Figure 3 that, when the per passenger profits earned from retail services directly at the facility, τ , are sufficiently high, the airport i prices aviation services at marginal cost. The intuition is that as τ increases, other things being equal, the airport may find more profitable to reduce the aviation charge so as to induce a higher volume of passengers and increase the demand for concessions (Oum et al., 2004; Yang and Zhang, 2011; Zhang and Zhang, 1997, 2003, 2010). In particular, when $\tau \geq 1$, $p_c^{i,(2)}(\tau) = 0$, i.e., this incentive is at the maximum level.

Finally, we analyze the impact of airport competition on both sides of the business induced by the observability of both prices at the time of the ticket purchase. We refer to the benchmark case of two airports competing on the core business only. Specifically, we compare the aviation charges levied by multiproduct facilities against those that standalone runway facilities would set in the same market for aviation services. Airports A and B offer aviation services only and engage in Bertrand competition deciding on aviation charges, p_a^i , with $i = A, B$ ¹⁷. A passenger located in x is indifferent between travelling from the airport A or airport B if $v - |0 - x| - p_a^A = v - |1 - x| - p_a^B$. We derive $x = (1 + p_a^B - p_a^A)/2 := x^*$. Thus, demand for aviation services faced by airport i is $D_a^i(p_a^A, p_a^B) = (1 + p_a^{-i} - p_a^i)/2$. The facilities simultaneously solve the following decision problem $\max_{p_a^i \geq 0} \pi^i(\mathbf{p}) = p_a^i \cdot D_a^i(p_a^A, p_a^B)$ and equilibrium charges are $p_a^{A,*} = p_a^{B,*} = 1$.

Proposition 1. When passengers are perfectly informed about the price of *premium commercials* sold through the Internet at the time of the ticket purchase, facilities levy lower aviation charges than those they would have levied absent concessions, if they earn from retail services sold only once at the facility, i.e. if $\tau > 0$.

¹⁷ To be coherent with our specifications, we maintain all our assumptions. Passengers are uniformly distributed over the segment and the transportation cost is equal to 1. Moreover, the gross aviation benefit is such that each individual decide to travel. Similarly, assumption on the costs and on the airline downstream market are maintained.

The proof follows immediately given that that we have $p_a^{i,(2)}(0) = p_a^{A,*} = p_a^{B,*} = 1 \wedge p_a^{i,(2)}(\tau) < p_a^{A,*} = p_a^{B,*} = 1 \forall \tau > 0, i = A, B$ ¹⁸ (see Figure 2). When $\tau > 0$, our result agrees with the thesis, proposed in literature by Starkie (2002), that the two sided nature of airport business would have dissuaded airports from exploiting market power in the aviation business. On the other side, our result disagrees with Czerny (2006), who found that, when passenger aviation and commercial purchasing decisions interact, a monopolistic airport levies a higher aviation charge than that it would have levied absent concessions. This suggests that it is the combined effect of competition between airports on both sides of the business and demand complementarity between aviation and concessions that does moderate airport market power in the core business.

Empirical evidence may support this intuition. For instance, the reader may refer to the case of competition between Bratislava Airport “Milan Rastislav Štefánik” and Vienna Airport “Schwechat”¹⁹. The main air carrier serving the airport is Ryanair, that provides passengers with the opportunity to buy online car parking and hotel reservation at the time of ticket purchase. In such a framework, Bratislava airport concluded with the carrier an agreement – valid from 2006 through 2016 – deciding on a reduction of the airport charge for new scheduled and existing destinations. Sky Europe claimed that such a favorable agreement constituted a state aid. Conversely, the Slovak Competition Authority pointed out that the strategy encourages the carrier to transport more passengers to the airport: this generates higher revenues from commercial activities, that do not relate to air transport but make the airport more attractive. The European Commission confirmed the reduction of aviation charge obeys to a profit maximizing logic (European Commission, 2010). Ryanair claims that the same logic applies for favorable agreements – under State aid investigation – on the reduction of the aviation charge concluded with Alghero, Pau, Lubeck, Frankfurt Hahn, Berlin Schonefeld, Aarhus and Tampere airport (Ryanair, 2010).

3.2 Only one airport offers *premium commercial* services at the time of ticket purchase

Without loss of generality, we assume that only airport *A* offers *premium commercial* services online. In this Scenario, at the time of ticket purchase, passengers are not able to observe neither the product mix nor the

¹⁸ $dp_a^{i,(2)}(\tau)/d\tau \Big|_{\tau=0} < 0 \wedge dp_a^{i,(2)}(\tau)/d\tau \leq 0 \wedge dp_a^*/d\tau = 0 \forall \tau \geq 0$

¹⁹ The Slovak Competition Authority prevented Vienna airport from acquiring Bratislava airport in order to avoid high concentration in the market (Forsyth et al., 2010). Furthermore Bratislava airport’s portfolio includes car rental, car parking as well as food and beverages outlets, duty-free shops and other retail services: non aviation revenues account for 20% of aviation revenues in 2006 and their relevance has been growing up to 36% of core business revenues in 2011 (Bratislava Airport Group, 2009;2011).

price of commercials of airport B . Therefore, they don't account for the benefit they would gain from commercial services when they decide whether to travel from that airport²⁰.

Passengers are offered two horizontally differentiated transportation services, i.e. flying from A or B , and a vertically differentiated composite good from airport A , i.e. the flight plus some *premium commercials*. A traveler located in (x, v_c) buys product k from airport A , if she prefers it (i) over product $-k$ from the same airport; (ii) over product a from airport B . Otherwise, she buys the transportation service from airport B and later, when she arrives at the airport and gets the information regarding the commercial price, she buys the commercial service if and only if she is willing to pay that price, i.e., if and only if $v_c \geq p_c$. From expressions (3) to (6) we can identify the demand functions as follows. A traveler located in (x, v_c) buys only aviation services from airport A if and only if $x \leq \bar{x} \wedge p_c^A \geq v_c$, while (x, v_c) buys aviation and commercial services from airport A if and only if $x \leq \hat{x}(v_c) \wedge p_c^A < v_c$. Therefore, we have:

$$\begin{aligned} D_a^{A,(1)}(p_a^A, p_a^B, p_c^A) &= C^{(1)} + D^{(1)} \\ D_c^{A,(1)}(p_a^A, p_a^B, p_c^A) &= C^{(1)} \end{aligned} \tag{10}$$

where $C^{(1)}$ and $D^{(1)}$ are the areas depicted in Figure 3 and the superscript (1) stands for Scenario 1. On the other hand, (x, v_c) buys only aviation services from airport B if and only if $x \geq \max\{\bar{x}, \hat{x}(v_c)\} \wedge p_c^B \geq v_c$, while she buys aviation and commercial services from that airport if and only if $x \geq \max\{\bar{x}, \hat{x}(v_c)\} \wedge p_c^B < v_c$. It follows that:

$$\begin{aligned} D_a^{B,(1)}(p_a^A, p_a^B, p_c^A) &= A^{(1)} + B^{(1)} \\ D_c^{B,(1)}(p_a^A, p_a^B, p_c^A, p_c^B) &= B^{(1)} \end{aligned} \tag{11}$$

Again, $A^{(1)}$ and $B^{(1)}$ are the areas depicted in Figure 4 which represents graphically all demands, while closed form expressions can be found in the Appendix.

²⁰ Customers would incur a searching cost in order to get the information regarding the price and the mix of commercial services. We assume that this searching cost is high enough that the two purchasing decisions do not interact or potential passengers do not form expectation on the price and the mix of commercial services such that the two purchasing decisions interact.

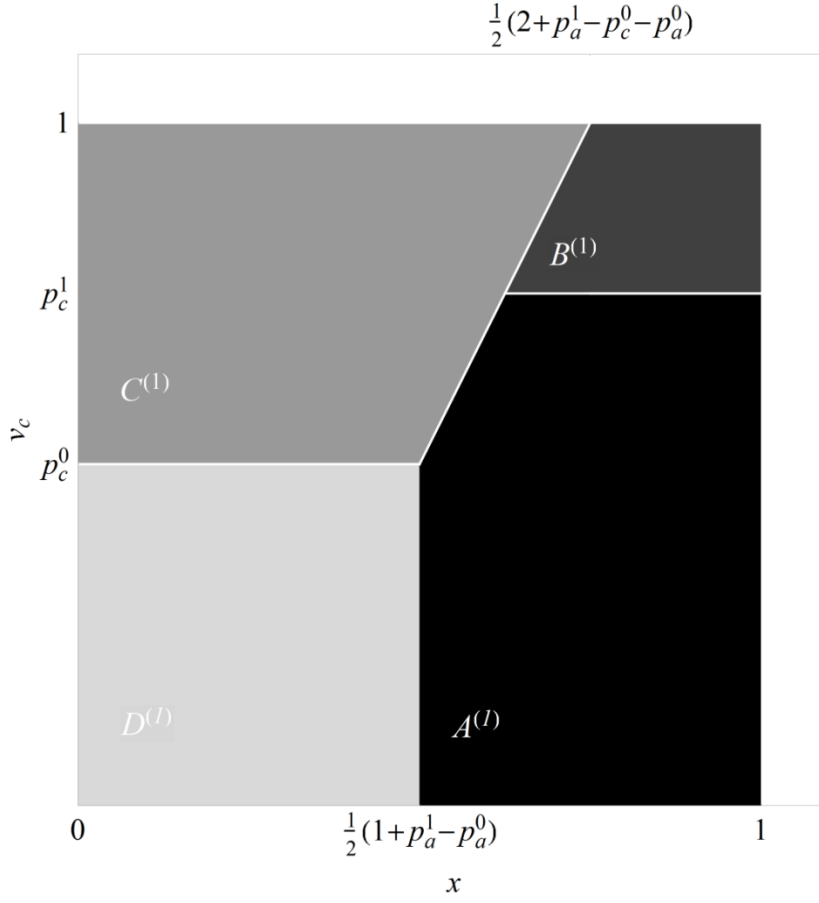


Figure 4. Demand functions for aviation and premium commercial services in Scenario 1, when $p_c^A < p_c^B$.

From (11) one checks that p_c^B does not affect the demand for aviation services. This happens since airport B does not advertise PCs at the time of the ticket purchase: passenger purchasing decisions do not interact and they buy commercials only once at the facility. Thus, the airport is a monopolist on the concession side of the business.

Airports simultaneously solve the following decision problems:

$$\max_{p_a^A \geq 0, p_c^A \geq 0} \pi^{A,(1)}(\mathbf{p}) = (p_a^A + \tau) \cdot D_a^{A,(1)}(p_a^A, p_a^B, p_c^A) + p_c^A \cdot D_c^{A,(1)}(p_a^A, p_a^B, p_c^A) \quad (12)$$

$$\max_{p_a^B \geq 0, p_c^B \geq 0} \pi^{B,(1)}(\mathbf{p}) = (p_a^B + \tau) \cdot D_a^{B,(1)}(p_a^A, p_a^B, p_c^A) + p_c^B \cdot D_c^{B,(1)}(p_a^A, p_a^B, p_c^A, p_c^B) \quad (13)$$

The optimal solution of the problem, $\mathbf{p}^{(1)} = (p_a^{A,(1)}, p_a^{B,(1)}, p_c^{A,(1)}, p_c^{B,(1)})$, is plotted in Figure 5 as a function of τ .

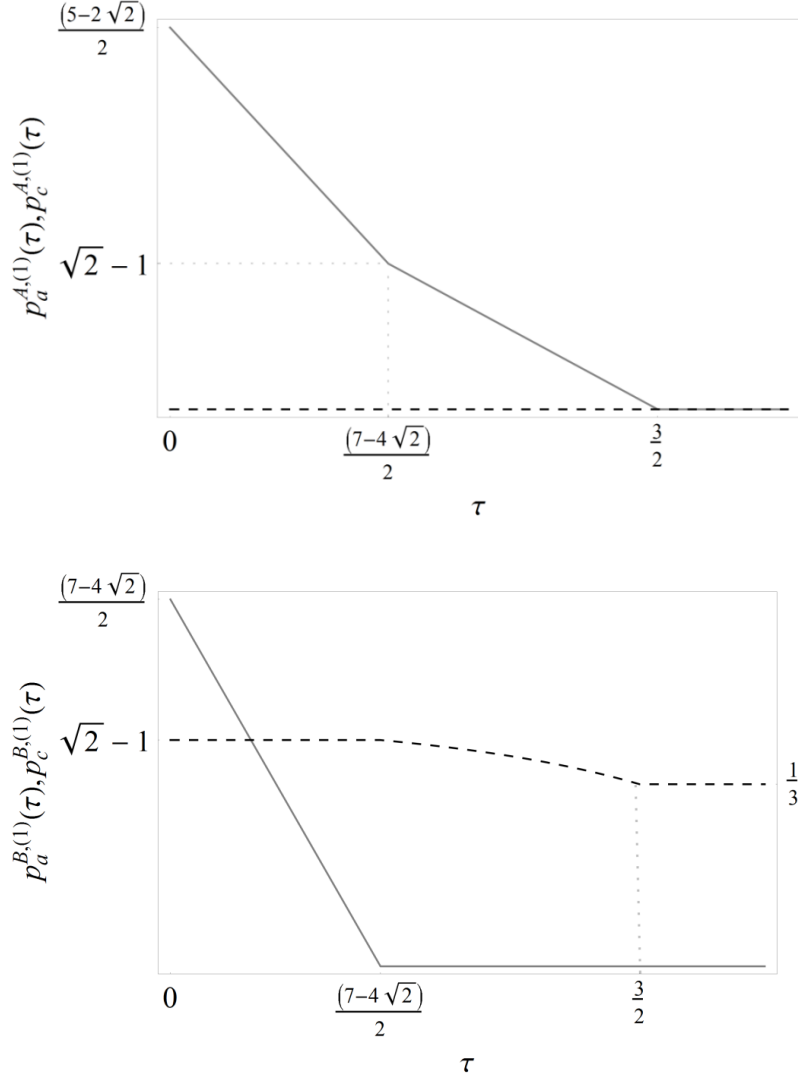


Figure 5. Equilibrium charges when only one airport offer PCs online: $p_c^{i,(1)}(\tau)$ dashed lines; $p_a^{i,(1)}(\tau)$ solid lines.

Observation 2. When passengers are perfectly informed about the price of *premium commercials* sold through the Internet by only one of the two airports at the time of the ticket purchase, the facility that had not committed to advanced online offer never prices PCs at marginal cost.

The intuition is as follows. Since airport B does not advertise PCs online, passengers do not observe their price at the time of the ticket purchase and purchasing decisions do not interact: the price of PCs by airport B is not able to affect aviation demand and the facility is a monopolistic supplier toward its traveler base on the concession side of the business. Other things being equal, this lowers the marginal benefit of reducing p_c^B in order to increase the aviation demand.

Observation 3. Compared to the case in which both airports offer *premium commercials* through the Internet at the time of the ticket purchase, the facility that had committed to advanced online offer charges aviation services equal or more, while the facility that had not, charges them equal or less.

It is easy to check that $p_a^{B,(1)}(0) = (7 - 4\sqrt{2})/2 < p_a^{B,(2)}(0) = 1 = p_a^{A,(2)}(0) < (5 - 2\sqrt{2})/2 = p_a^{A,(1)}(0)$ and $\left| dp_a^{A,(1)}(\tau)/d\tau \right| \leq \left| dp_a^{A,(2)}(\tau)/d\tau \right| \forall \tau > 0 \wedge dp_a^{B,(1)}(\tau)/d\tau = dp_a^{B,(2)}(\tau)/d\tau \forall \tau \leq (7 - 4\sqrt{2})/2 \wedge p_a^{B,(1)}(\tau) = 0 \forall \tau > (7 - 4\sqrt{2})/2$. This happens because *PCs* advanced offer provides a competitive advantage to airport *A* toward the competitor. This allows the facility to establish a higher aviation charge. On the other hand, airport *B* has to lower the aviation charge in order secure its market share, since the commercial price is not able to affect passenger volume. As τ increases, $p_a^{B,(1)}(\tau)$ equals the marginal cost, with a speed that is higher than that of $p_a^{A,(1)}(\tau)$ ²¹.

Proposition 2. When passengers are perfectly informed about the price of *premium commercials* sold through the Internet by only one of the two airports at the time of the ticket purchase, the facility that had committed to advanced online offer levies higher aviation charge than that absent concessions, if per passenger revenues from retails sold only at the facility are not sufficiently high, i.e. $\tau < (3 - 2\sqrt{2})/2$. The facility that had not, always levies lower aviation charge.

The proof follows immediately given that we have $p_a^{A,(1)}(0) = (7 - 4\sqrt{2})/2 < 1 = p_a^{A,*}$ and $dp_a^{A,(1)}(\tau)/d\tau \leq 0 \wedge dp_a^{A,*}/d\tau = 0 \forall \tau > 0$. Analogously $p_a^{B,*} = 1 < (5 - 2\sqrt{2})/2 = p_a^{B,(1)}(0) \wedge p_a^{B,*} = 1 = p_a^{B,(1)}(3/2 - \sqrt{2})$ and $dp_a^{B,(1)}(\tau)/d\tau \Big|_{\tau=3/2-\sqrt{2}} < 0 \wedge dp_a^{B,(1)}(\tau)/d\tau \leq 0 \wedge dp_a^{B,*}/d\tau = 0 \forall \tau > 0$ (see also Figure 5 for graphical evidence).

Proposition 2 suggests that it is not straightforward to assert that the two sided nature of airport business curbs aviation market power when it is associated with competition on prices. Indeed, asymmetries between airports on online entry strategies may provide them a competitive advantage and let them increase their aviation charges.

3.3 None of the airports offers *premium commercial* services at the time of ticket purchase

If none of the airports offers *PCs* online, passengers do not have information regarding the price of *premium commercials* and the product mix at the time of ticket purchase. Thus, they decide whether to fly from airport *A* or from airport *B* without taking into account commercial offers.

²¹ Indeed, it results $\min\{\tau: p_a^{B,(1)}(\tau) = 0\} = (7 - 4\sqrt{2})/2 < 3/2 = \min\{\tau: p_a^{A,(1)}(\tau) = 0\}$.

Individual (x, v_c) buys aviation services from airport i if and only if she prefers them over those of airport $-i$. Once the passenger has chosen the preferred airport, she buys *premium commercial* services and once at the facility if she is willing to pay their price.

From (3) to (6) we derive the demand functions faced by the airports. Individual located in (x, v_c) buys aviation services from airport A if and only if $x \leq \bar{x} \wedge p_c^A \geq v_c$, while she buys aviation and commercial services from that airport if and only if $x \leq \bar{x} \wedge p_c^A < v_c$. It follows that:

$$D_a^{A,(0)}(p_a^A, p_a^B) = C^{(0)} + D^{(0)} \quad (14)$$

$$D_c^{A,(0)}(p_a^A, p_a^B, p_c^A) = C^{(0)}$$

where $C^{(0)}$ and $D^{(0)}$ are the areas depicted in Figure 6 and the superscript (0) stands for Scenario 0. On the other hand, an individual located in (x, v_c) buys aviation services from airport B if and only if $x > \bar{x} \wedge p_c^B \geq v_c$, while she buys aviation and commercial services from that airport if and only if $x > \bar{x} \wedge p_c^B < v_c$. Therefore we have that:

$$D_a^{B,(0)}(p_a^A, p_a^B) = A^{(0)} + B^{(0)} \quad (15)$$

$$D_c^{B,(0)}(p_a^A, p_a^B, p_c^B) = B^{(0)}$$

where, again, $A^{(0)}$ and $B^{(0)}$ are the areas depicted in Figure 6.

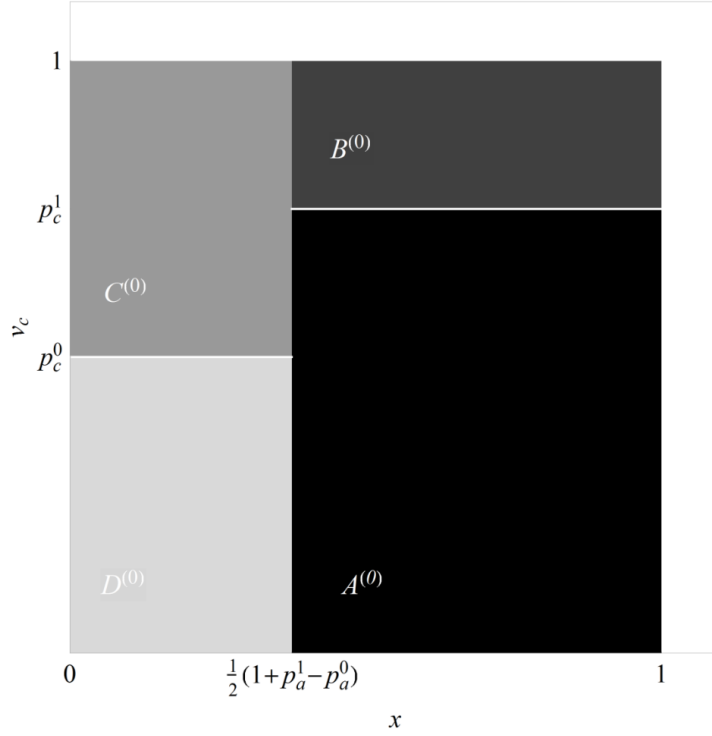


Figure 6. Demand functions for aviation and premium commercial services in Scenario 0, when $p_c^A < p_c^B$.

We observe that p_c^i levied by airport i affects only the commercial demand of that airport, while it does not affect the aviation demand. We reconcile, in this way, to a frequently used modeling assumption in the area of airports and airport concessions (for example, Zhang and Zhang 1997, 2003, 2010; Starkie 2001, Zhang et al. 2010, Yang and Zhang 2011, Zhang and Czerny 2012, Czerny 2013a, D’Alfonso et al. 2013).

Turning to airport pricing behavior, the two facilities simultaneously solve the following decision problem:

$$\max_{p_a^i \geq 0, p_c^i \geq 0} \pi^{i,(0)}(\mathbf{p}) = (p_a^i + \tau) \cdot D_a^{i,(0)}(p_a^A, p_a^B) + p_c^i \cdot D_c^{i,(0)}(p_a^A, p_a^B, p_c^i) \quad (16)$$

The optimal solution, $\mathbf{p}^{(0)} = (p_a^{A,(0)}, p_a^{B,(0)}, p_c^{A,(0)}, p_c^{B,(0)})$, is plotted in Figure 7 as a function of τ .

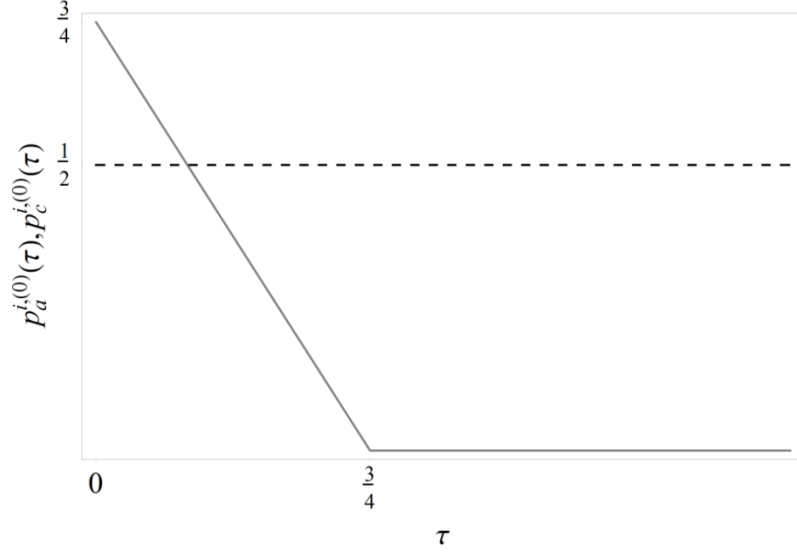


Figure 7. Equilibrium charges when none of the airports offer PCs online: $p_c^{i(1)}(\tau)$ dashed line; $p_a^{i(1)}(\tau)$ solid line.

Observation 4. When passengers are not informed about the price of *premium commercials* sold through the Internet by any of the airports at the time of the ticket purchase, the facilities levy lower aviation charges compared to the case in which they both offer *premium commercials* online.

Indeed, the price of *premium commercials* levied by both airports is not able to affect the aviation demand, since travelers cannot observe them at the time of the ticket purchase. Thus, the aviation charge is the only strategic tool on which the facilities compete for passengers. Moreover, absent any competitive advantage of any of the airports at the time of ticket purchase, we have that $p_a^{B,(1)} < p_a^{i,(0)} < p_a^{A,(1)}$. We further remark that this inelasticity of aviation demand to PCs price and airports monopolistic power on the concession side of the business entail that p_c^i is no longer set at the marginal cost level.

Proposition 3. When passengers are not informed about the price of *premium commercials* sold through the Internet by any of the airports at the time of the ticket purchase, the facilities levy lower aviation charge than that they would have levied absent concessions.

The proof follows immediately given that when $\tau = 0$ we have $p_a^{i,(0)}(0) = 3/4 < 1 = p_a^{A,*} = p_a^{B,*}$ and $dp_a^{i,(0)}(\tau)/\tau \leq 0 \wedge dp_a^*/d\tau = 0 \forall \tau > 0$, with $i = A, B$ (see also Figure 7 for graphical evidence).

Proposition 3 suggests that when the commercial and retail side provides further profits to the facilities without affecting their competitive behavior, the two sided nature of airport business always curbs their aviation market power.

4. Airport entry strategies

In this section, we investigate airport entry strategies in the first stage, that is whether airports engage in the opening of online webstores where selling some *premium commercials*. The matrix of the game is a 2 by 2 matrix as displayed in Figure 8, where $\pi^{i,(j)}(\mathbf{p}^{(j)})$, with $j \in \{0,1,2\}$, and $i = A, B$ are obtained plugging in second stage equilibrium charges, $\mathbf{p}^{(j)}$, into the profit functions of the airports and displayed in Figure 9.

A \ B	B	
	Offers PCs online	Does not Offer PCs online
Offers PCs online	$\pi^{A,(2)}(\mathbf{p}^{(2)}), \pi^{B,(2)}(\mathbf{p}^{(2)})$	$\pi^{A,(1)}(\mathbf{p}^{(1)}), \pi^{B,(1)}(\mathbf{p}^{(1)})$
Does not Offer PCs online	$\pi^{B,(1)}(\mathbf{p}^{(1)}), \pi^{A,(1)}(\mathbf{p}^{(1)})$	$\pi^{A,(0)}(\mathbf{p}^{(0)}), \pi^{B,(0)}(\mathbf{p}^{(0)})$

Figure 8. Payoff matrix of the first stage of the game: airports decide whether to offer online PCs at the time of the ticket purchase.

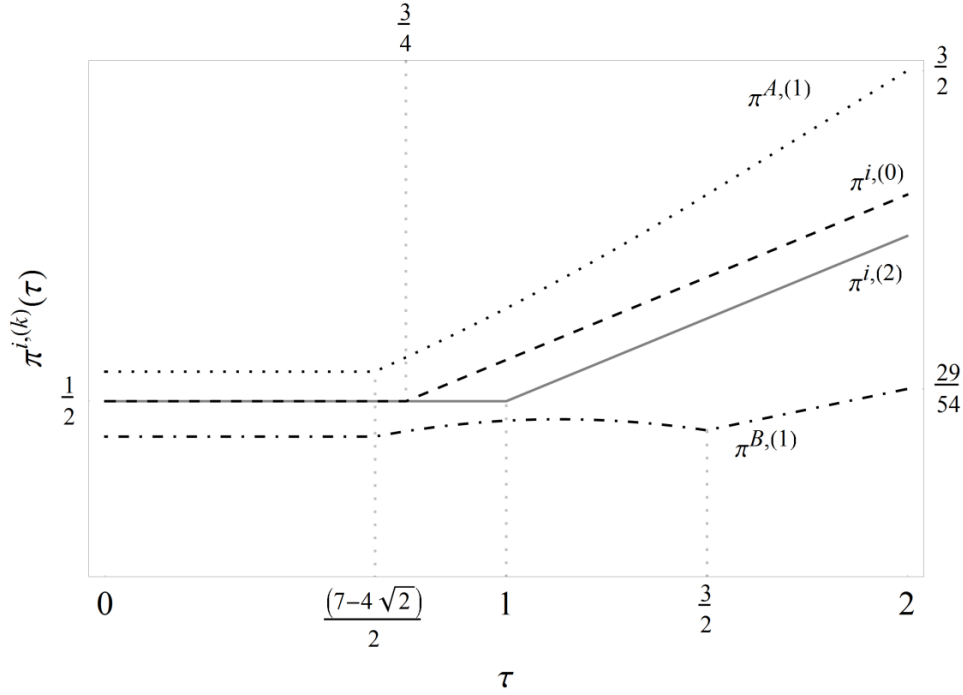


Figure 9. Equilibrium profits $\pi^{i,(j)}(\mathbf{p}^{(j)})$ with $j \in \{0,1,2\}$.

Proposition 4. At the equilibrium of the game:

- (i) both airports offer *premium commercial* services online at the time of ticket purchase
- (ii) if per passenger revenues from retails sold at the facility only are sufficiently high, i.e. $\tau > 3/4$, this is a Prisoner Dilemma.

Proof. Plugging in second stage equilibrium charges, $\mathbf{p}^{(j)}$, into the profit functions of the airports, it is straightforward to prove that:

$$\begin{aligned}
\pi^{i,(2)}(\mathbf{p}^{(2)}) &> \pi^{B,(1)}(\mathbf{p}^{(1)}) \\
\pi^{A,(1)}(\mathbf{p}^{(1)}) &> \pi^{i,(0)}(\mathbf{p}^{(0)})
\end{aligned} \tag{17}$$

It follows that at the equilibrium of the game both airports open their online commercial webstore. Furthermore, simple numerical calculations reveal that:

$$\begin{aligned}
\pi^{i,(0)}(\mathbf{p}^{(0)}) &= \pi^{i,(2)}(\mathbf{p}^{(2)}) \quad \forall \tau \leq \frac{3}{4} \\
\pi^{i,(0)}(\mathbf{p}^{(0)}) &> \pi^{i,(2)}(\mathbf{p}^{(2)}) \quad \forall \tau > \frac{3}{4}
\end{aligned} \tag{18}$$

Relations (18) implies that if $\tau \leq 3/4$ the equilibrium of the game is Pareto optimal, whereas if $\tau > 3/4$ the airports would be better off not offering *premium commercial* services online.

Thus, if per passenger revenues from retails sold only at the facility are sufficiently high, the airports may derive lower profits through online offer rivalry: in effect, the airports are trapped by the incentive structure of the environment, and the situation is similar to a classic Prisoner Dilemma.

The intuition is as follows. As pointed out in previous sections, when airports compete with each other with vertically differentiated products, they give up the opportunity to be monopolistic suppliers of commercial services for their own passenger base. On the other hand, they manage to stimulate aviation demand with *premium commercials* and to set higher aviation charges. For low values of τ the increase in the aviation profits resulting from this strategy compensates for the loss in profits earned from PCs. As the level of τ grows, the marginal benefit on the aviation side of reducing the aeronautical charge raises: the gain in aviation profits from e-commerce strategy reduces. As a result, when τ is sufficiently high, the airport would be better off being a monopolistic supplier on the concession side of the business without inducing the interaction of purchasing decisions.

5. Social Welfare Analysis

Our results show that airport pricing varies broadly depending on the e-commerce strategy that is adopted by the duopolists. In this section, we analyse the implications of airport strategies on social welfare and on consumer surplus. Social welfare can be evaluated as follows:

$$\begin{aligned}
W^{(j)}(p_a^A, p_c^A, p_a^B, p_c^B) &= \iint_{D^{(j)} \cup C^{(j)}} (v - x) dx dv_c + \iint_{A^{(j)} \cup B^{(j)}} (v - (1 - x)) dx dv_c + \\
&+ \iint_{B^{(j)} \cup C^{(j)}} v_c dx dv_c + \iint_{[0,1] \times [0,1]} T dx dv_c
\end{aligned} \tag{19}$$

where $T = \tau + cs_r$, with cs_r being the surplus that each passenger gains from retail services sold only at the facility²². In our formulation, modelling consumer surplus from retail purchases as a fixed add-on quantity per passenger makes our analysis robust toward the hypothesis that these services are welfare-enhancing or not. Indeed if $T = 0$, retail services do not generate extra surplus (Czerny, 2011; 2013a; Kratzsch and Sieg, 2011), i.e., they are welfare neutral. If $T > 0$, retail services generate extra surplus (i.e., surplus unattainable elsewhere), which is commonly assumed in the literature (Yang and Zhang, 2011; Zhang and Zhang 2003, 2010)²³.

Let $W(\mathbf{p}^{(j)})$ be the level of social welfare obtained under Scenario j plugging in second stage equilibrium charges, $\mathbf{p}^{(j)}$, into (19) (see Figure 10 for graphical evidence as a function of τ)²⁴.

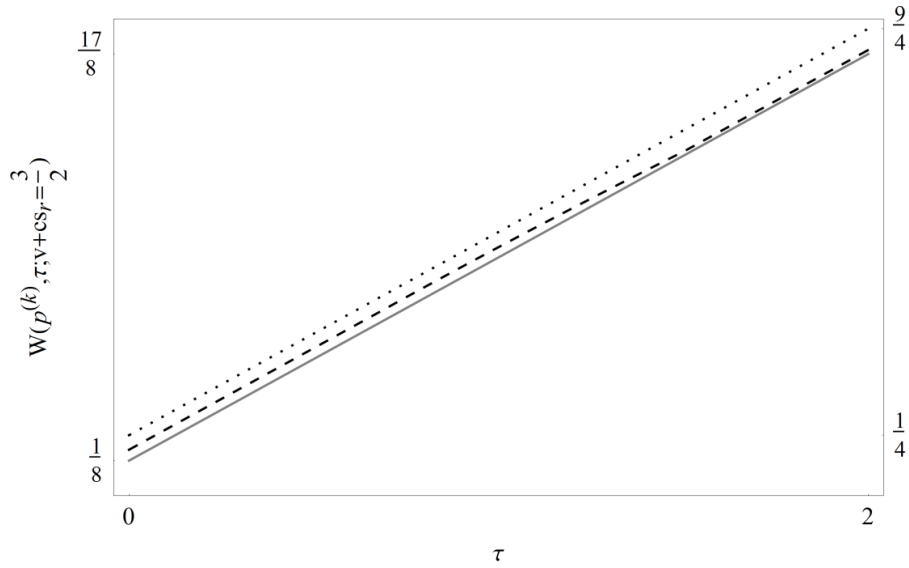


Figure 10. Equilibrium value of social welfare $W(\mathbf{p}^{(j)}, \tau)$ with $j \in \{0, 1, 2\}$. The solid line refers to Scenario 0, the dashed line refers to Scenario 1 and the dotted one to Scenario 2.

²² This modelling of social welfare generated by commercial purchases at airports has been proposed following Zhang and Zhang (2010).

²³ When $T > 0$ only a portion of surplus from *retails* may be counted into the social welfare function. The reason is that only under certain occasions concession services generate extra surplus. In other words, a difference may exist between the types of concession services at the airport. For example, the overall demand for food and beverages may not depend much on whether individuals fly or not fly. On the other hand, there are some other types of concession services which may be elicited by travel-related motivations. Geuens et al. (2004) find that there are specificities for airport shopping, such as motivation “to contrast day-to-day” and “to be out of place”. Several authors agree that the shopping and purchasing habits of a tourist often vary considerably from her normal pattern at home (Brown, 1992; Crawford and Melewar, 2003; Huang and Kuai, 2006). Another motivation is that travelers leaving a certain country shop in order to spend their remaining foreign currencies. Furthermore, the habit of buying souvenirs and presents motivates travelers to shop (Sulzmaier, 2001). Large international brands design new product lines exclusively for duty-free shops in order to seduce travelers to buy a unique souvenir (Vlitos Rowe, 1999). Moreover, for some people traveling causes fear or feelings of insecurity, leading them to search for comforting and reassuring behaviors from shopping (Dube and Menon, 2000).

²⁴ Welfare depends on three parameters, that are τ , v and cs_r . In Figure 10 we fix the parameters v and cs_r such that $v + cs_r = 3/2$, that corresponds to the smallest value of v such that everyone buys whatever the value of τ is. We shall follow the same logic in Figure 11.

Proposition 5. At the equilibrium, social welfare is maximum when both airports offer *premium commercials* through the Internet at the time of the ticket purchase. Furthermore, having only one airport that offers *PCs* online leads to higher social welfare than having none, i.e.,

$$W^{(2)}(\mathbf{p}^{(2)}) > W^{(1)}(\mathbf{p}^{(1)}) > W^{(0)}(\mathbf{p}^{(0)})$$

The intuition behind Proposition 5 is the following. The impact of airport e-commerce strategies on social welfare is the result of the interaction between two effects: the *demand effect* and the *product substitution effect*.

On one side, when airports offer commercial services online, commercial and aviation demand are non longer independent and this increases commercial output. This is the *demand effect*, which beneficial to the economy. On the other side, when there is only one airport selling commercial services in advance, an asymmetric equilibrium arises, thus there are customers buying services from the more distant airport and this is detrimental to social welfare (*product substitution effect*, see Matsumura and Shimizu, 2005).

Under Scenario 2, social welfare rises beyond the level achievable under other Scenarios because, when both airports make *premium commercial* services available online, the *product substitution effect* does not operate and the *demand effect* is maximum, $D_c^{A,(2)}(\mathbf{p}_k^{(2)}) + D_c^{B,(2)}(\mathbf{p}_k^{(2)}) > D_c^{A,(1)}(\mathbf{p}_k^{(1)}) + D_c^{B,(1)}(\mathbf{p}_k^{(1)}) > D_c^{A,(0)}(\mathbf{p}_k^{(0)}) + D_c^{B,(0)}(\mathbf{p}_k^{(0)})$. On the other hand, having only one airport that offers *premium commercial* services in advance leads to a higher welfare than having none, because the *demand effect* that arises, $D_c^{A,(1)}(\mathbf{p}^{(1)}) + D_c^{B,(1)}(\mathbf{p}^{(1)}) > D_c^{A,(0)}(\mathbf{p}^{(0)}) + D_c^{B,(0)}(\mathbf{p}^{(0)})$, compensates the *product substitution effect* due to equilibrium asymmetry.

Proposition 5 describes the effect of e-commerce strategies of airports on the whole economy. Nevertheless, policy makers may be more concerned about consumer surplus rather than producer surplus when assessing social welfare. The next proposition assesses the effect of advanced offer of *premium commercial* services on consumer surplus.

Consumer surplus is given by the sum of the surplus that the passengers gain from the consumption of aviation and concession services, *PCs* and retail.

$$\begin{aligned} CS^{(j)}(p_a^A, p_c^A, p_a^B, p_c^B) &= \\ &= \iint_{D^{(j)} \cup C^{(j)}} (v - x - p_a^A) dx dv_c + \iint_{A^{(j)} \cup B^{(j)}} (v - (1 - x) - p_a^A) dx dv_c \\ &\quad \iint_{C^{(j)}} (v_c - p_c^A) dx dv_c + \iint_{B^{(j)}} (v_c - p_c^B) dx dv_c + \iint_{[0,1] \times [0,1]} cs_r dx dv_c \end{aligned} \quad (20)$$

Let $CS^{(j)}(\mathbf{p}^{(j)})$ be the level of consumer surplus obtained under Scenario j , plugging in second stage equilibrium charges, $\mathbf{p}^{(j)}$, into (20) (see Figure 11 for graphical evidence as a function of τ).

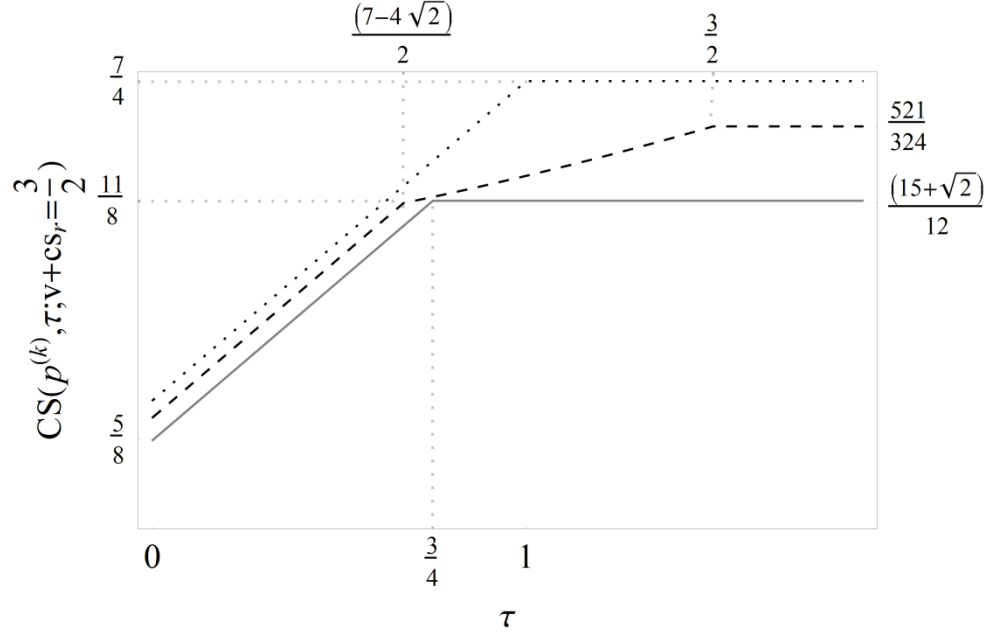


Figure 11. Equilibrium values of consumer surplus $CS(\mathbf{p}^{(j)}, \tau)$ with $j \in \{0, 1, 2\}$. Comparison between Scenarios. The solid line refers to Scenario 0, the dashed line refers to Scenario 1 and the dotted one to Scenario 2.

Proposition 6. At the equilibrium, consumer surplus is maximum when both airports offer *premium commercials* through the Internet at the time of the ticket purchase. Furthermore, having only one airport that offers PCs online leads to higher consumer surplus than having none, i.e.

$$CS^{(2)}(\mathbf{p}^{(2)}) > CS^{(1)}(\mathbf{p}^{(1)}) > CS^{(0)}(\mathbf{p}^{(0)})$$

When only one airport pursues the e-commerce strategy, three factors reduce consumer surplus with respect to the Scenario in which both facilities offer PCs online. First, $p_c^{i,(2)} = p_c^{A,(1)} < p_c^{B,(1)}$. Second, the *product substitution effect* plays a role. Finally, $p_a^{A,(2)} < p_a^{A,(1)}$. These factors offset the simultaneous increase in consumer surplus produced by $p_a^{B,(1)} < p_a^{B,(2)}$. Now we consider the second inequality of the chain. In this case, two forces reduce consumer surplus. The first is $p_a^{B,(1)} < p_a^{B,(0)}$ and the other is $p_c^{i,(0)} > p_c^{B,(1)} > p_c^{A,(1)} = p_c^{i,(2)}$. Those forces, lowering consumer surplus, offset the simultaneous increase due to the absence of product substitution effect in Scenario 0 and the lower level of aviation charge at airport A, $p_a^{A,(0)} < p_a^{A,(1)}$.

6. Concluding Remarks

This paper studies airport competition on core and side services, when vertically differentiated products may be strategically offered at the time of ticket purchase through the Internet: a base product – the flight – and a composite one – the flight plus some *premium commercials (PCs)*, as car parking, car rental or hotel reservation. The paper contributes to literature on airport rivalry, since few attention has been paid to competition on both sides of the business. It also contributes to literature on complementarity between aviation and non-aviation services, since we study airport demand and the effect of commercial charges on the demand for aeronautical services, rather than the effect of the aeronautical charge on the demand for commercial services only.

Results show some interesting implications. We examine whether the two-sided nature of the airport business does curb market power on the aviation side and we find that airports set lower aviation charge than they would have levied absent concessions, when they are both competing on online offers. Nevertheless, when only one airport pursues e-commerce, that facility sets a higher aviation charge than it would have levied absent concessions, as long as profits from retail earned at the facility are not high enough. This suggests that the combined effect between airport competition on side business and demand complementarity does moderate airport market power in the core business. The Nash equilibrium of the game is such that both airports offer *premium commercial* services online, making travelers to account for the surplus they would gain from both the sides of the business when they buy air tickets. This is welfare enhancing. Nevertheless, when the per-passenger revenue from retail earned only at the facility are sufficiently high, the airports may derive lower profits through this online offer: in effect, the airports are trapped by the incentive structure of the environment, and the situation is similar to a classic Prisoner Dilemma.

From a managerial perspective, the paper shows a basic mechanism playing a role in airport rivalry. When airports compete with each other through vertically differentiated products, they give up the opportunity to be monopolistic suppliers of commercial services for their own passenger base. On the other hand, they manage to stimulate aviation demand with *premium commercials* offer: they set lower commercial prices and this allow them to set higher aviation charges since they can capture part of the passenger surplus from concessions. Comparative statics show the profitability of e-commerce strategy, when airports compete on vertically differentiated products, seems to depend on the level of revenues that they can earn directly at the facility, once travelers are locked in.

These considerations raise a primary issue for further research. An empirical test of the results presented here would be interesting. This would allow to verify the analytical conclusions, and to quantify the actual impact of competition on both sides of the business. A sample of European airports would be appropriate, where the

privatization process has been almost completed²⁵ and competition is relatively high (OECD, 2009; ICCSAI, 2013).

A second, but not less important, development of the research presented here would be the analysis of the effects of e-commerce strategy on the pricing behavior of a monopolistic airport. While the main focus of this paper has been to study airport competition on both sides of the business, a minor intent has been to examine whether the two-sided nature of the airport business does curb market power on the aviation side. Our results suggest that the combined effect between airport competition on side business and demand complementarity does moderate airport market power in the core business. Nevertheless, policy makers would be interested to see if a monopolistic airport does have incentive to limit his market power when differentiated products are sold to consumers. This is something quite important to be explicitly taken into account: when examining the implications of complementarity between aviation and non-aviation services on the pricing behavior of a monopolist, the effect of the commercial price on the demand for aeronautical services needs to be studied besides the effect of the aeronautical charge on the demand for commercial services.

Finally, the analysis of the robustness of results to some outside options would be interesting. In this paper, we abstract away from these options but the Internet make easy to get the information regarding the price and the mix of commercial services even from the platforms powered by other operators, such as car parking or rental firm websites. Relaxing this hypothesis should undoubtedly raise attention from a managerial perspective.

Appendix A

Demand functions Scenario 2:

$$D_a^{i,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) = \frac{1}{4} \left(2 - 2p_a^i + 2p_a^{-i} + p_c^i(p_c^i - 2) - p_c^{-i}(p_c^{-i} - 2) \right)$$

$$D_c^{i,(2)}(p_a^A, p_a^B, p_c^A, p_c^B) = \begin{cases} \frac{1}{2} (p_c^i - 1)(-1 + p_a^i - p_a^{-i} + p_c^i - p_c^{-i}) & \text{if } p_c^i \geq p_c^{-i} \\ \frac{1}{4} \left(2 - p_c^i(p_c^i - 2) + p_c^{-i}(p_c^{-i} - 4) + 2(p_a^{-i} - p_a^i)(p_c^{-i} - 1) \right) & \text{if } p_c^i < p_c^{-i} \end{cases}$$

Demand functions Scenario 1:

²⁵ It started in Europe in 1987 with the privatization of the seven major British airports - including London Heathrow, Gatwick, and Stansted - sold to the British Airports Authority plc. (BAA). Following this example, the majority stakes of Copenhagen Kastrup International Airport, Vienna International Airport, Rome's Leonardo Da Vinci Airport, and 49 per cent of Schiphol Airport, have been sold to private owners (Oum et al. 2004). In fact, more than 20 countries have completed the sale or lease of airport facilities so far. Some of them are: Argentina, Australia, Austria, Bahamas, Bolivia, Cambodia, Canada, Chile, China, Colombia, Denmark, Dominican Republic, Germany, Hungary, Italy, Japan, Malaysia, Mexico, New Zealand, Singapore, South Africa and Switzerland (Forsyth et al. 2010).

$$\begin{aligned}
D_a^{i,(1)}(p_a^A, p_a^B, p_c^A) &= D_a^{i,(2)}(p_a^A, p_a^B, p_c^A, 1) \\
D_c^{A,(1)}(p_a^A, p_a^B, p_c^A) &= D_c^{A,(2)}(p_a^A, p_a^B, p_c^A, 1) \\
D_c^{B,(1)}(p_a^A, p_a^B, p_c^A, p_c^B) &= \begin{cases} \frac{1}{4}(p_c^B - 1)(1 + 2p_a^A - 2p_a^B + 2p_c^A - p_c^B) & \text{if } p_c^i \geq p_c^{-i} \\ \frac{1}{4}(2 - 2p_c^i - p_c^{-i}(p_c^{-i} - 2) + 2(p_a^i - p_a^{-i})(p_c^i - 1)) & \text{if } p_c^i < p_c^{-i} \end{cases}
\end{aligned}$$

Demand functions Scenario 0:

$$\begin{aligned}
D_a^{i,(0)}(p_a^A, p_c^A) &= D_a^{i,(2)}(p_a^A, p_a^B, 1, 1) \\
D_c^{i,(0)}(p_a^A, p_c^A, p_c^i) &= \frac{1}{2}(p_c^i - 1)(p_a^i - p_a^{-i} - 1)
\end{aligned}$$

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