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Abstract

We study multiproduct pricing of core and side goods in the case of a (monopoly) airport city. The consumption of the side services is not conditional on the consumption of the core service, i.e., travellers as well as non-travellers may demand side goods but derive different benefits. We obtain several results in two different settings. The first one depicts the case in which individuals make decisions about buying core and side goods independently. In this case, non-traveller demand induces the facility to increase the core price with respect to the case in which only travellers may purchase side services. In the second one, individuals make decisions simultaneously, depending on their degree of foresight over the surplus that they anticipate to obtain from the consumption of side goods. In this case, the non-passenger demand might incentivizes the transport facility to charge lower core price, with respect to the case in which only travellers may purchase side services. Manipulating the side products mix in order to enrich the shopping experience of travellers (i.e., to increase the benefit that they derive from the joint consumption of core and side goods) may be welfare-enhancing. Traveller surplus would certainly increase, but such positive effects occur to the detriment of non-travellers, who find themselves to pay a higher price for side products, whatever is the level of consumer foresight.

Keywords: monopoly; multiproduct pricing; complementarity effect; demand effect; hierarchical demands; airport city.

Jel Classification: L1, L2, L93

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1. Introduction

The growing importance of concession revenues is acknowledged as one of the most striking and consistent trend in the airport sector over the last thirty years (Czerny and Zhang, 2015; Halpern and Graham, 2013). Aviation (core) activities are associated with runways, aircraft parking, and terminals, whereas the concession or non-aviation (side) activities include retailing, advertising, car rentals, car parking, and land rentals. In facts, airports worldwide derive as much revenue, on average, from concession activities as from aviation ones (ACI, 2008; Thompson, 2007), owing partly to prevailing regulations mechanisms which leave concession activities unregulated (Jones et al., 1993; Starkie, 2001), and partly to locational rents enjoyed in relations to passengers (Forsyth, 2004). Nowadays, for instance, at some medium to large sized United States and European Union airports concession business represents 75–80% of the total revenues (ATRS, 2014).

In some cases, airports have become real layover paradises— some of them quite spectacular — with an indoor rainforest in Kuala Lumpur, Malaysia; a wave pool in Munich, Germany; or a rooftop dog park in Queens, New York. Incheon International Airport in Seoul, South Korea, is home to free showers, medical services, a post office, dry cleaning service, salons, two movie theaters, golf course, ice rink, casino, culture museum, and 90 duty-free shops (TechInsider Innovation, 2015). The most innovative airports have been developing their concession business landside, before security screenings, and investing to include in the concession activities businesses lying outside the traditional boundary of goods and services that are complementary to the airside (Morrison, 2009). Such concession strategies are becoming prevalent due to airports actively pursuing initiatives for de-risking their aviation and, thus, their non-aviation (passenger-dependent) businesses (Pungias, 2009; Reiss, 2006). For instance, between 1998 and 2008 operating revenues derived from rent of land and non-passenger terminal facilities grew by 58% at large hubs, 54% at non-hubs, 24% at medium hubs, and 43% at small hubs in United States (Kramer, 2010). Actually, commercially run airports have been evolving into real *airport cities*, integrated real estate developments whose clustering functions expand in the landside property zone of the airport (Kasarda, 2001): as their terminals transform into shopping malls and artistic venues, airports are spawning clusters of hotels, convention, trade and exhibition facilities, corporate offices, and retail complexes along with culture, entertainment and recreation centers. Air gateways, in short, have become as much commercial destinations as places of departure: they are urban realms in their own right, driving and shaping the very fabric of the new cities they are creating (Kasarda, 2008). A huge debate has been ignited by the airport city phenomenon, as the substantial airport-centric commercial development is giving rise to a new urban form — the *aerotropolis* (The Economist, 2013;2015a; The New York Times, 2006; 2011a; The Wall Street Journal, 2011)[1].

In Europe, Schiphol provides an example of an airport which actively promotes the concept of an airport city, conceived as a *civic amenity* (Adey, 2006). The Schiphol airport shopping center (38 outlets with a total area of more than 5,300 square meters), containing an expansive mix of shopping, dining and entertainment arcades, doubles as a suburban mall that is accessible both to air travellers and the general public (Euromonitor International, 2006). The surrounding business district stretches for 15 miles including the regional headquarters of such firms as Unilever and, given the proximity and intermodal links to Amsterdam, it attracts city residents along with approximately 58,000 people who work in the airport business district (Morrison, 2009). Indeed, Schiphol group appears keen to export the concept of airport cities to locations such as Cairo International Airport, where (under Schiphol management) there are plans to include an international airport hospital that will compete in the regional market for medical treatments and operations (Morrison, 2009).

The new major project "The Circle" at the Zurich airport is another prominent example (Orth et al., 2015). It is 12 minutes from the city center and it is already Switzerland's second biggest shopping center by revenue, with the highest sales in terms of square meters. In 2013, the Circle attracted 68,000 air travellers and 55,000 non-travellers (20,000 commuters, 10,000 visitors, 25,000 employees on site) daily. With all the bustle of an international trading center, from 2018 it will become a focal point for business and lifestyle, covering 180,000 square meters of useable space. It will feature two Hyatt hotels and a convention center, top international brands and companies along its avenues and squares and a medical center. There will also be plethora of other attractions with direct access, from art and culture to food and entertainment, as well as knowledge related activities and opportunities for learning[2]. This new development is forecasted to result in an additional 3,000 jobs (Orth et al., 2015).

In a similar vein, other numerous airport city projects demonstrate the popularity of the airport city concept worldwide. For example, in Australia, the privatisation of airports has led to a considerable

[1] Similar in shape to the traditional metropolis, made up of a central city core and its commuter-linked suburbs, the aerotropolis consists of an airport city core and extensive outlying areas of aviation-oriented businesses and their associated mixed use residential developments - in most of the cases lying beyond airport's property. Reflecting the new economy's demands for connectivity, speed and agility, the aerotropolis is optimized by corridor and cluster development, wide lanes and fast movement (Appold and Kasarda, 2014).

[2] Further draws are a mini-airport playpark, various informative exhibits, a discovery trail and an observation walkway that allows aviation buffs to get closer to the aircraft than ever before. In its first month after opening, the observation deck already welcomed over 20,000 guests, confirming the tremendous drawing power of this new attraction. Managers anticipate over 300,000 visitors a year. The observation deck also has a modern well-equipped meeting room for family occasions, conferences and other events. Further information are available at http://info.thecircle.ch/home-en.html, where the proposed figures have been retrieved from.

expansion of non-aviation activities, some of which have a low or no complementarity to passenger volumes. Several airports have developed factory outlet retail stores on airport land, including Brisbane, Perth, Adelaide and Canberra (Freestone and Baker, 2010). These outlets are outside the terminal building and principally attract members of the non-travelling public (Morrison, 2009). McArthurGlen Vancouver Airport, an exciting luxury shopping destination about 20 minutes from Downtown Vancouver by Canada Line, has just opened for general shopper as well as passengers (The Province, 2015) and has been recently awarded as the best outlet centre at MAPIC, a major international retail property conference that attracted more than 8,000 delegates from the retail property industry (city and shopping centers, factory outlets, leisure areas and transit zones), 2,000 retailers, 470 brands, and 700 exhibiting companies from 74 countries (Business Vancouver, 2015). Athens has already completed many undertakings in its particular airport city: it has a large IKEA and Kotsovolos Megastore (Kasarda, 2008). Fraport is extensively developing and marketing attractive commercial space in direct proximity of the Frankfurt airport (such as Monchhof site or Gataway gardens). The airport of Munich has attracted more tourists than Ludwig's castle Neuschwanstein and is Bavaria's tourist attraction number one (Sulzmaier, 2001). In the middle of the sprawling structure, designed by Helmut Jahn, there is a yawning roofed atrium - the Munich Airport Center. Normally an ordinary plaza, the atrium transforms depending on the season. Passengers as well visitors can surf in the summer, drink beer in October, and Christmas shop in December. Munich Airport also offers a year-round cycle of events. The current attractions include weekend family buffets, art exhibitions, and a flight simulator. Beijing is developing an airport city with an area of 100 square kilometers, which is expected to generate 8 per cent of Beijing's gross domestic product by as early as 2015 (Poungias, 2009). Hong Kong International Airport has established both commercial and real estate divisions to boost its terminal retail and to develop SkyCity, a 10 million square feet retail, exhibition, business office, and hotel and entertainment complex near its passenger terminals.

The immediate consequence of the airport city phenomenon is that airports are extending their offerings to new target groups, in addition to the traditional captive audience – origin, destination and transit passengers (Doganis, 1992; Poungias, 2009). These include the employees of the airport authority, the airlines and the other air service providers, local residents all around the airport[3,4]

3 For instance, around 75,000 people work at Frankfurt Airport, making it one of Germany's largest regional places of work. More importantly, 60% of airport employees live within approximately 35 kilometers of the airport. An increasing number of airports employs more than 50,000 daily workers, which would make them metropolitan central cities by the U.S. census definition (Kasarda, 2008). See also Appold and Kasarda (2013), Brueckner (2003), Graham (2013) for evidences on airport agglomeration economies and urban economic development around airports.

4 In "Airports as malls: Everyday beauty brands enter travel retail", Euromonitor International highlights how the airport is developing into a hub for commerce. Similar to a traditional metropolis of a central city and its outlying suburbs, the

(Jarach, 2001) as well as meeter-and-greeters, strollers and half-day trippers, motivated to shop by the international flair, the exciting atmosphere and the variety of offerings that are sold at the airport (Sulzmaier, 2001). In other words, airports may face two types of customers in the non-aviation business: travellers and non-travellers. Travellers may reach the transport infrastructure since their primary intent is to fly and, once at the facility, they may purchase the side goods. On the other hand non-travellers reach the transport facility to buy side goods only. Some people, for instance, may reach the airport city to make use of side activities, simply because they know that there are stores there.

In this paper, we focus on the issue of multiproduct pricing of core and side services in the case of airport cities, when side goods, supplied within the terminal, before security screenings, or in the surrounding land parcels owned by the airport authority, are available to two groups of customers: travellers and non-travellers.

In fact, the airport as a tourism and leisure destination concept attracting additional influxes of demand even without direct correlation with a possession of an airline ticket in broader terms is not new phenomenon, neither to the marketing literature nor to the retail and distribution management debate (Levitt, 1980; Fernie, 1995; Jarach, 2005). In his classical work, *Downtown*, Fogelson (2005) writes that "the decentralization of the department store is one of the main reasons that the central business district, once the mecca for shoppers, does less than 5% of the retail trade of metropolitan areas everywhere but in New York, New Orleans, and San Francisco." As new forms of retail out-of-town development, the expansion of airport retail outside the terminals has been openly criticized for the impact that it may have on nearby shopping centers: airport retailing complexes cater more for some shoppers than conventional formats and are likely to pose as much of a threat to traditional high street retailing (Fernie, 1995). However, the air transport economics literature has always abstracted away from this issue and uses to rely on the assumption that only travellers can purchase concessions services at the airport (though they may abstain from consuming any of these services). Indeed, literature says, most people would not visit an airport just to consume side services, that is there is a hierarchical structure of demand in which consumers buy one good (concession goods) only if they buy another as well (the flight ticket).

Our paper introduces two novel contributions to the existing literature on air transport economics. On the one hand, for the first time, we remove the assumption of a hierarchical structure of demands.

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airport is becoming the focus of a sprawl of businesses. What this means for cosmetics and toiletries is that airport shops will no longer be solely for duty-free gifts and indulgences. Instead, industry players will have to diversify their travel retail product ranges to cater too to the workers and residents of the surrounding 'city' (Euromonitor International, 2006).

People who do not fly may purchase side goods. By doing so, this paper represents the first attempt to model the issue of complementarity between core and side goods in the new and evolving scenario that is the airport city. On the other hand, we make explicit an important difference between the two groups of customers: they derive different benefits from consuming side services. The are several reasons that may explain this setting. First, some side services (e.g., car parking, car rental) are strictly related to the travel and the willingness to pay for such services is lower, if not null, when the individual does not have to travel (Czerny, 2013). Second, travellers constitute a captive group with a high disposable income but little time to dispose of it in the high street (Davies, 1995). Third, travellers simply do not have an outside option: they are constrained at the facility, since their primary intent is to fly. Finally, evidence shows that airports are unique retailing environments, which can make travellers react in unusual ways and thus they are unlike general shoppers in a high street situation (Brown, 1992; Crawford and Malaware, 2003; Guenes et al. 2004; Huang and Kuai, 2006; Sulzmaier, 2001).

The implications of the model are relevant and can be explained as follows.

On the one hand, we investigate whether a private (uncongested) airport uses its market power to ask for relatively high landing fees, even though this may risk shrinking demand for side goods from one group of costumers (or both). By doing so, our paper contributes to the debate on airport market power and the need for regulators to allow pricing freedom to the airport, as well as on the issue of whether aviation and concession operations should be regulated (Czerny et al., 2015). As it will result clear from the literature review, we pursue this goal building on the two major frameworks that have shaped the entire debate around airport pricing when concessions activities matter. The first one assumes that travellers make air ticket and concession purchase decisions independently, that is when passenger demand for flights does not depend on the supply of airport concession services (*one-way or one-side complementarity*). The second one relates to travellers that might make decisions about buying the goods simultaneously rather than independently, in the sense that there may be a demand effect of the side good supply on core good demand (*two-way or two-side complementarity*).

On the other hand, we draw some lessons as to the most profitable airport strategies with regard to the extra-surplus gained by travellers from consuming core and side services together and we ought to inform policy makers about their implications for the society as a whole, as well as for specific groups of individuals.

While airports and their characteristics represent the motivation for the model, it is easy to think of other settings to which the model could be applied, with suitable adaptations. In general terms, in our basic model we study pricing when a supplier offers two goods or services and, importantly, two types of customers coexist: for one group, one service is primary and the other one is secondary. In order to purchase the secondary good, these consumers must have initially purchased the primary good (the flight). Moreover, they constitute a captive group with a disposable income but little time to dispose of it, since they cannot exit from their primary activity. The other group is only interested to one of the two goods (the secondary one); they are not trapped in their primary activity, thus they have an outside option. Other transport facilities, such as railways stations and cruise terminal are primary examples for our setting: people may go there to catch the train and end up buying some side goods. Some other may go there just to shop.[5] Other applications include cinema or theatre malls: people may go there for a primary activity (e.g., watch the movie or the performance) from which they cannot exit, but may end up also purchasing a secondary good (a meal, or some other type of shopping); at the same time, some people may reach the mall just to shop. While each setting would have its distinguishing features, our model provides a framework to study these environments too.

The paper is organized as follows. Section 2 presents the literature review. Section 3 describes the basic model and the extension to the case of two-side complementarity. Section 4 discusses the robustness of results while Section 5 presents the policy implications. Section 6 presents concluding remarks.

2. Literature review

Three major strands of literature relate to this paper.

The first one studies complementarity between aviation and non-aviation activities. The majority of this literature has focused on airport market power and the need for airport regulation (see Czerny and Zhang, 2015 for a survey), as well as on the role that non-aviation revenues may have in financing capacity investments (Zhang and Zhang, 2003; 2010). Since airports possess a significant amount of monopoly power, infrastructure charges of privatized airports are often subject to economic regulation. However it has been conjectured that there might be no need for economic regulation of

[5] For instance, the list of the European Shopping Centre Awards includes the Munich railway station. The city of Katowice will have a modern station that presents a surface of 136,000 square meters, of which 17,350 square meters for the actual railway station, 24,000 for shops and 19,000 for cultural activities (Luică, 2011). In Italy, with over 1,500,000 square meters of real estate and over 600 million visitors per year, no longer soulless places of passage, main stations are set to become services centers among the busiest in Europe: meeting places, shopping malls, venues for the arts and special and cultural events. In England, with significant investments, Network Rail is transforming its managed stations into retail destinations in their own right (e.g., the new retail space at Manchester Piccadilly, Birmingham New Street and London Victoria stations). The cruise *Ocean Terminal*, part of the Harbour City complex managed/operated by the private company Harbour City Estates Limited, is the largest shopping center in Hong Kong with more than 700 shops and over 50 restaurants. Mathews and Lui (2001) describe the *Ocean Terminal* as a "city in miniature", consisting in three concourses crammed with shops, large Chinese and Western restaurants, coffe bars, discotheque, overall as a place for people to rendezvous, hang out and shop.

airports: since side operations depend greatly on the passenger throughput, airports may curb their market power and restrain the aviation charge they impose to airlines in order to boost traffic and expand revenues from concessions. If this is true, the need for heavy-handed airport regulation is alleviated (Starkie, 2002).

Starkie's conjecture has been investigated under two distinct assumptions on the nature of the demand complementarity between aviation and non-aviation services of airports, that is whether the passenger quantity is independent or not of airport concession prices. On the one hand, some contributions assume that passenger demand for air ticket is independent of the price of concession services (*one-way or one-side complementarity)*. This may be the case because buying the air tickets and side services can be separated in time (D'Alfonso et al., 2013; Oum et al., 2004; Yang and Zhang, 2011; Zhang and Zhang, 1997; 2003; 2010). On the other hand, a second strand of literature assumes that consumers may make decisions about buying the goods simultaneously rather than independently (*two-way or two-side complementarity*). The argument behind this assumption is that the issue of the time-separation has been moderated over time by the e-commerce advancement and airports increasingly advertise their concession services on-line (Bracaglia et al., 2014). Furthermore, many passengers, in particular business travellers, are frequent flyers, which are unlikely totally unaware of the surplus associated with concession services, such as car rental or car parking (Czerny, 2013).

Literature on one-way complementarity found that the concession business unambiguously exerts downward pressure on the private aviation charge, confirming Starkie's conjecture. Zhang and Zhang (2003), in particular, show that when a private airport (which is not subject to regulation) has profitable concession operations, its airport charges are closer to the social optimum compared to the case in which there are no concession activities, or if aviation and concession activities are treated separately. However, in effect, a private airport would charge a higher price than the socially optimal level. Conversely, if an increase in the price for concession services reduces the amount of travelling, the two-sided nature of the airport business can induce a monopoly airport to increase the core price. Indeed, a reduction in the prices for concession services can be considered as an increase in airport "quality," which stimulates travel demand (Czerny and Lindsey, 2014). These contributions have questioned Starkie's (2002) conjecture (Bracaglia et al., 2015; Czerny, 2006; Czerny et al., 2015; Flores Fillol et al., 2015).[6]

The assumption of *two-way complementarity* has been firstly introduced by Czerny (2006). The paper assumes that individuals may consume core and side services together, if what they are willing to pay

[6] The two-sided platform nature of the airport business is often cited (see also D'Alfonso and Nastasi, 2014; Gillen, 2011; Gillen and Mantin, 2012; Ivaldi et al., 2012).

for the flight is lower than the ticket price, but the combined willingness to pay for flying and consuming services exceeds the ticket price plus the price of the concession service. In Bracaglia et al. (2015), whether travellers decide to travel accounting (also) for the surplus they would gain from concession consumption depends on e-commerce strategies of airports, since the interaction of purchasing decisions is induced by the observability of both prices at the time of the ticket purchase. Flores Fillol et al. (2015) assume that passengers may account for a certain portion of the surplus that they expect to obtain from the consumption of the retail good once at the airport, depending on their degree of foresight. Czerny et al. (2015) use a IV regression analysis to empirically show that a one-dollar increase in the daily car rental price reduces passenger demand at 199 US airports by more than 0.36 percent. Their results indicate that airports can abuse market power by an increase in the prices for concession goods and services when airport aviation charges are regulated.

Our paper moves a step further this strand of literature since we remove the assumption of a hierarchical structure of demand. In other word, in our model, the demand for the side products is not a subset of the demand for the primary product because non-travellers might demand concession services from the facility. Second, we make explicit the difference between the surpluses that these two groups of individuals gain from the consumption of side services and we make travellers and non-traveller demand for side services interdependent. In order to investigate the effect of non-passenger demand for side services, both in the case of *one-way* and *two-way complementarity*, we study two different settings. The first one depicts the case in which individuals make decisions about buying core and side goods independently. Thus, in order to purchase the side goods, these consumers must have initially purchased the core good (the flight): first, they reach the facility in order to travel, afterwards they decide whether to buy side goods or not. Then, we present an extension of the model in which individuals make decisions simultaneously. In doing so we assume that the demand for air travel depends on a portion of the surplus that the individuals anticipate to obtain from the consumption of side goods good according to their degree of foresight, following the approach of Flores Fillol et al. (2015).

The second branch of literature relates to the pricing strategies pursued by the airports for the side business. Unlike what has appeared for aviation charges, there are no specific studies focusing on this issue. The research has mainly focused on consumer typologies segmentation, what passengers may be looking to buy in the airport as well as shopping determinants (Castillo-Manzano, 2009; Geuens et al., 2004; Perng; et al, 2010; Lin and Chen, 2013). However, in the popular press, it emerges that consumers are unhappy about the price paid and feel that airports allow overcharging for the services the consumer purchases (The Indianapolis Business Journal, 2009; The Wall Street Journal, 2015).

Recently, Waguespack (2015) has focused on the issue of *street (or value) pricing* (see also Appold and Kasarda, 2006). The basic concept is that, in order to showcase the facility to the local community, airport concessions shall be priced at a level equivalent to what a consumer/passenger would find for the item within a location outside the airport, in a traditional retail 'street' location. While addressing the issues of how the *comparable location* shall be defined in order to enforce the street pricing concept, as well as of which are the allowed variations from the street price, she finds that larger United States airports have overwhelmingly adopted the concept of street pricing in the concession opportunities offered. Airports like Chicago O'Hare, Chicago Midway and Houston Bush Intercontinental implement value pricing, which requires concessionaires to charge the same price for a product or service at the airport as the price charged for the same product or service at a benchmark store in the noted city.

Our problem also relates to the literature on markets where primary and secondary goods (i.e., add-ons) are traded and shopping malls.

In the former case, the settings of Gehrig (1998) and Schulz and Stahl (1996) are of interest, with respect to specialized and infrequent purchases, when consumers are not well informed initially, and only buy one product at the end of the process. Verboven (1999), based on Mussa and Rosen (1978), finds that a lower mark-up for add-ons is set when there is full consumer information on prices, compared to the case in which the base product is advertised and premium product price information is available at the shop only. Ellison (2005) combines Hotelling horizontal differentiation with vertical differentiation. Mark-ups on products vary depending on marginal utility of income and full information on prices reduces profits. Again, in all these models, there is a hierarchical structure of demands for the two goods, which make this literature different from our paper.

As regards shopping malls, in particular, part of the literature is concerned with the instruments to internalize the externalities between the different outlets within a shopping mall, and between the shopping malls and the neighboring activities/properties. Gould et al. (2002) and Pashigian et al. (1998) demonstrate the empirical importance of externalities between product lines, and show that owners of malls are willing to reduce rent for stores that generate positive externalities for other traders at the mall. Therefore, to varying degrees, the success of each store depends upon the presence and effort of other stores, and the effort of the developer to attract customers to the mall. Smith and Hay (2005) model competition between shopping centers, comparing competitive outcomes in three alternative modes of retail organization. Here, fully informed consumers about the offerings at each center buy a range of products on a shopping trip, and care about vertical product characteristics. In particular, a transportation cost is used to model the fact that consumers may buy a product k since they want to reach the facility in order to purchase a specific product *l*. The behavior of consumers is assumed to be the same and the effect of one product's supply over the other products' demand is the same across all products (i.e, the effect that the supply of *k* has on the demand for *l* is equal to the effect that the supply of *l* has on the demand for *k*). All these papers remove the assumption of hierarchical demands. Indeed, in those works the demand for one good is not necessarily a subset of the demand for another good. However, there is a basic difference between these papers and our work. In our basic model (*one-way complementarity*), consumers make decision about buying core and side services independently. This implies that the offer of flights is able to stimulate the demand for retail, but the reverse is not true (i.e., the effect that the supply of side product has on the demand for flight is not equal to the effect that the supply of flight has on the demand for side products). When we look at the case in which individuals make decisions simultaneously (*two-way complementarity*), we model in the continuum the degree of foresight with respect to the surplus that the individuals anticipate to obtain - when buying the core product - from the consumption of side goods. In other words, even if the offer of side goods is able to stimulate the demand for flights, this stimulus is imperfect and can be weaker than the one that the offer of flights produces on the demand for retail goods. Thus, the effect that the supply of side goods has on the demand for flights may be weaker than the effect that the supply of flights has on the demand for side goods. Of course, this is a distinctive feature of transport facilities, since the primary intent of many people is to travel.

3. The model

3.1 The basic case

Consider an airport whose clustering functions expand beyond the terminal in the landside zone of the airport. The entire complex (including the terminal) is managed/operated by the airport authority which is assumed to be profit maximizing[7].

For the sake of convenience, we assume that the runway and the terminal are uncongested. The airport authority incurs constant marginal costs to operate core services, further normalized to 0. In fact, airport operating costs are typically very low (especially compared to airport infrastructure costs) (Czerny and Zhang, 2015). We assume that the number of airlines in competition is so large that ticket prices are determined by the airlines' operating costs per passenger and that these operating costs are

[7] Starting with the privatization of some UK airports in 1987, a growing number of airports around the world have been privatized, or partially privatized, especially in Europe, Australia, and New Zealand (Czerny and Zhang, 2015). However, we note that about half of US airports are still owned and operated by a municipality or county, with the other half run by a regional authority, and the land tenure situation is very different (Cidell, 2014). The land outside of airport property is generally owned by many fragmented interests who make decisions independently of one another and of the airport.

solely determined by the airport infrastructure charge, that is the core price[8]. Let $p_c \geq 0$ be the per passenger infrastructure charge levied by the airport to the air carrier for the provision of core services; previous assumptions imply that p_c equates the final prices to travellers departing from the airport, that is the air ticket price charged by airlines. Thus, in what follows, we will refer equivalently to core services as well as the flights. We shall discussion this assumption in Section 4. Let $p_s \geq 0$ be the per-passenger charge levied by the airport authority to concession services providers located within the terminal – before passport control – or in the surrounding land parcels owned by the airport authority. Similarly to the airline market, we assume that the concession services market is perfect competitively. Providers are price takers and have zero constant marginal operational costs and it follows that p_s equates the final price to individuals for side services supplied by the retailers in the airport landside area or in the surrounding land parcels.

We consider a unit mass of individuals, each of them characterized by a couple of parameters (v_c, v_s), where v_c represents the valuation for the travel, i.e., the gross utility she derives from flying, and v_s represents the valuation for the side services. The individuals are uniformly distributed with density $(v_c, v_s) \sim U([-k, 1] \times [-l, 1])$, where $k \geq 1$ and $l \geq 1$[9]. However, when the side service is consumed jointly to the core service, individuals' valuation for the side good is higher than the value they attach to the side service when it is consumed individually. In fact, we are assume that the gross utility which travellers derive from the consumption of side services is $v_{s,t} = v_s + a$, $0 \leq a \leq 1$. There are several reasons that may explain this modelling. First, some side services are strictly related to the travel activities and the willingness to pay for such services is lower when the individual does not have to travel. In other words, such side services generate an extra surplus, a, since they are elicited by travel-related motivations. Primary examples are car parking or car rental (Czerny, 2013). Second, travellers constitute a captive group with a high disposable income but little time to dispose of it in the high street (Davies, 1995). In other words, travellers simply do not have an outside option: they are constrained at the facility, since their primary intent is to fly. Thus, they may will to pay more for a good than in the street (The Economist, 2015b; The New York Times, 2011b). Some illustrations include forgotten items, that are those day-to-day items which one has forgotten to pack, or alternatively items gone missing with passengers' bags in transit (Crawford and Melaware, 2003). Finally, evidences show that airports are unique retailing environments, which can make travellers react in unusual ways and thus they are unlike general shoppers in a high street situation (Crawford

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[8] This assumption is coherent with the hypothesis of absence of runway congestion. Moreover, we are implicitly assuming the absence of economies of density. We will refer indistinctively to airport infrastructure charge as well as to the landing fee.

[9] We assume that the distribution is not 0-bounded from below in order to focus on the case in which neither the passenger market for travel nor the market for concession services are fully covered when the services are supplied for free.

and Malaware, 2003). Indeed, different authors have analysed airport shopping specificities and have identified different stimuli, which airports are able to activate through effective communication, that convert browsers into customers with a higher disposable income than normal. The motivations are almost inherent to travelling activities and can be considered to be present as one starts the trip (Geuens et al., 2004)[10].

We assume that each consumer is willing to purchase at most one unit of each product and she receives zero utility if she does not make any purchase. Furthermore, we assume that passenger demand for flights, D_c, does not depend on the supply of airport side services, that is we assume *one-way complementarity* between core and side services.

Analytically individuals buy the core service if they derive a positive utility from travelling. Thus, we may derive the demand for core services as:

$$D_c(p_c) = Prob(v_c \geq p_c) = A + B_1 + B_2 = \frac{1 - p_c}{1 + k} \quad (1)$$

where A, B_1 and B_2 are the areas depicted in Figure 1.

We now derive the demand function for side services. On the one hand, if an individual derives a positive net utility from buying the side services. i.e., $v_s \geq p_s$, then she is going to demand them, irrespectively of travelling or not. These individuals constitute the *non-induced demand* for side services:

$$D_{s,ni}(p_s) = Prob(v_s \geq p_s) = B_2 + C = \frac{1 - p_s}{1 + l} \quad (2)$$

where the areas B_2 and C are depicted in Figure 1. On the other hand, if a traveller derives a positive net utility from consuming side services jointly to the flight, $v_s + a - p_s > 0$, then she is going to

[10] Geuens et al. (2004) identify motivations related *to contrast day-to-day* and *to be out of place*. Crawford and Melaware (2003) identify the following stimuli, among others. *Holidays*: The 'I'm on my holidays syndrome', excitement is high and there is a higher disposable income than normal. Several authors agree that the shopping and purchasing habits of a tourist often vary considerably from their normal pattern at home (see also Brown, 1992; Huang and Kuai, 2006). *Reward*: Self-indulgence, 'Just do it!'. *Confusion*: information overload by the retailers can serve to reduce cognitive effects and stimulate purchasing behavior. *Exclusivity*: many products are developed exclusively for the travel retail channel of distribution, inducing purchases (see also Vlitos Rowe, 1999). *Disposal of foreign currency*. *Fear:* for some people, travelling causes fear or feelings of insecurity, leading them to search for comforting behaviors from shopping (see also Dube and Menon, 2000). *Waiting time:* waiting travelers shop because they are bored and seek entertainment in shopping (see also Geuens et al., 2004; The Economist, 2015b; The New York Times, 2011b). Finally, shopping around the airport can become a symbolic act, a ritual that gives expression to the consumers' self-presentation and self-fashioning: authenticity is not necessarily what they are looking for, hyperreality and hypersignification can become a more plausible version of reality, as the disneyfication of urban and suburban shopping malls and town centers shows (Sulzmaier, 2001).

consume them even though she would had not bought side services alone, $v_s - p_s < 0$. These individuals constitute the *induced demand* for side services:

$$D_{s,i}(p_c) = Prob(p_s - a \leq v_s \leq p_s \, , v_c \geq p_c) = B_1 = \frac{a(1 - p_c)}{(1 + l)(1 + k)} \tag{3}$$

Overall, we may write the demand functions for side services as:

$$D_s(p_c, p_s) = D_{s,ni}(p_s) + D_{s,i}(p_c) = B_1 + B_2 + C = \frac{(1 - p_s)(1 + k) + a(1 - p_c)}{(1 + l)(1 + k)} \tag{4}$$

We remark that, when $a \neq 0$, D_s is a function of p_c, while $\forall a$ D_c only reacts to changes in p_c. In other words, the offer of flights is able to stimulate the demand for side services, while the reverse is not true.

== *Insert Figure 1* ==

The demand structure can be described alternatively. It is easy to note that $Prob(p_s \leq v_s \wedge v_c < p_c)$ represents the non-traveller demand for side services, $D_{s,t}(p_c, p_s)$, which is constituted by those people who purchase side services at the airport but they are not willing to fly. As opposite, $Prob(p_s \leq v_s + a \, , v_c \geq p_c)$ represents the traveller demand for side services, $D_{s,nt}(p_c, p_s)$.

$$D_{s,t}(p_c, p_s) = Prob\big(v_c \geq p_c \, , v_{s,t} \geq p_s\big) = Prob(v_c \geq p_c \, , v_s + a \geq p_s) = B_1 + B_2 = \frac{\big(1 - (p_s - a)\big)(1 - p_c)}{(1 + l)(1 + k)} \tag{5}$$

$$D_{s,nt}(p_c, p_s) = Prob(v_c < p_c \, , v_s \geq p_s) = C = \frac{(1 - p_s)(p_c + k)}{(1 + l)(1 + k)} \tag{6}$$

As it results clear from relations (5)-(6), we can relabel the gross utility that non-travellers derive from the consumption of side services as $v_{s,nt} = v_{s,t} - a$. From this specification, it is easy to see how the parameter a can be also interpreted as the value of time that an individual who flies gain when purchasing a good at the airport for being already at the facility due to her primary intent to travel. If she does not fly, she has to reach the facility just to buy side services and a represents the opportunity cost of her time. Equivalently, as noted, since travellers are caught in their primary activity from which they cannot exit, the parameter a represents the surplus that non-travellers gain from the outside option compared to travellers.

In what follows, we refer to $I \triangleq \{(a,k,l): 0 \leq a \leq 1, k \geq 1, l \geq 1\}$ to indicate the set of parameters where the demand functions are defined[11].

3.1.1 Airport pricing

The airport maximizes its profits choosing simultaneously the charges for the two sides of its business. Analytically, the airport solves the following decision problem:

$$max_{p_c,p_s}\, \pi(p_c,p_s) = \; p_c D_c(p_c,p_s) + p_s D_s(p_c,p_s) \tag{7}$$

where $D_s(p_c,p_s) = D_{s,ni}(p_s) + D_{s,i}(p_c) = D_{s,nt}(p_c,p_s) + D_{s,t}(p_c,p_s)$.

First order necessary optimality conditions for unconstrained optimization can be expressed as follows:

$$\begin{aligned} \left.\frac{\partial \pi}{\partial p_c}\right|_{p_c=p_c^*,p_s=p_s^*} &= D_c(p_c^*) + p_c^* \left.\frac{\partial D_c(p_c)}{\partial p_c}\right|_{p_c=p_c^*} + p_s^* \left.\frac{\partial D_{s,i}(p_c)}{\partial p_c}\right|_{p_c=p_c^*} = 0 \\ \left.\frac{\partial \pi}{\partial p_s}\right|_{p_c=p_c^*,p_s=p_s^*} &= D_{s,ni}(p_s^*) + D_{s,i}(p_c^*) + p_s^* \left.\frac{\partial D_{s,ni}(p_s)}{\partial p_s}\right|_{p_s=p_s^*} = 0 \end{aligned} \tag{8}$$

where the superscript * is used to indicate the optimum. Relations (9) yield to the unique solution (p_c^*, p_s^*), with $p_j^* \in [0,1]$ for $j = c, s$, described as follows[12]:

$$\begin{pmatrix} p_c^* \\ p_s^* \end{pmatrix} = \begin{pmatrix} \dfrac{a^2 + a(1+k) - 2(1+l)(1+k)}{4(1+l)(1+k) - a^2} \\ \dfrac{(1+l)(2(1+k)+a)}{4(1+l)(1+k) - a^2} \end{pmatrix} \tag{9}$$

Observation 1 There is a complementarity effect between core and side services, i.e., $\partial D_s(p_c,p_s)/\partial p_c = \partial D_{s,t}(p_c,p_s)/\partial p_c + \partial D_{s,nt}(p_c,p_s)/\partial p_c \leq 0$. However, it results $\partial D_{s,t}(p_c,p_s)/\partial p_c \leq 0$, while $\partial D_{s,nt}(p_c,p_s)/\partial p_c \geq 0$.

[11] In the above expressions we have confined attention to the case $p_c \leq 1$ and $p_s \leq 1$, which will turn out to be the relevant case. Indeed, it can be demonstrated that the airport would be not be able to increase its profits setting $p_c \geq 1$ and/or $p_s \leq 1$.

[12] The eigenvalues of the Hessian of the objective function are negative, thus second order necessary optimality conditions for unconstrained optimization are always satisfied. We further remark that we solved the decision problem relaxing the constraint that prices must in be in the range [0,1]. However, it is easy to check that the optimal solution of this relaxed problem is such that $p_j^* \in [0,1]\ \forall x \in I$.

Indeed, it is easy to check that $D_s(p_c)/\partial p_c = -a/\big((1+l)(1+k)\big) \leq 0$, $\partial D_{s,t}(p_c, p_s)/\partial p_c = -\big((1-p_s)+a\big)/\big((1+l)(1+k)\big) \leq 0$, while $D_{s,nt}(p_c, p_s)/\partial p_c = (1-p_s)/\big((1+l)(1+k)\big) \geq 0$ since $p_s \in [0,1]$. According to previous studies (Starkie, 2002), Observation 1 implies that a reduction in the price for core services induce a higher demand for side services. However, adding to literature, the model shows that such increase in the demand for side services is driven by the increase in the demand from travellers, to the detriment of demand from non-travellers.

Lemma 1 The complementarity effect between core and side services, i.e., $\partial D_s(p_c, p_s)/\partial p_c = \partial D_{s,i}(p_c)/\partial p_c$ increases with a, the extra-surplus gained by travellers from consuming core and side services together, that is $\partial^2 D_s(p_c, p_s)/\partial p_c \partial a = \partial^2 D_{s,i}(p_c)/\partial p_c \partial a \leq 0$. Moreover $\partial^2 \pi/\partial p_c \partial p_s = \partial D_s(p_c, p_s)/\partial p_c = \partial D_{s,i}(p_c)/\partial p_c \ \leq 0$.

The proof of Lemma 1 follows immediately given that $D_s(p_c, p_s) = D_{s,i}(p_c) + D_{s,ni}(p_s)$.

When $a = 0$, that is when there is not induced demand for side services, a variation in the side price does not induce any change in the core price. However, as $a > 0$, two forces play a role. First, an increase in the price for side services induces a reduction in the price for core services. The reason is that an increase in the price for core services reduces the demand for flights and thus the pool of those individuals who do not derive any surplus from buying side services if they do not travel, but they do if they consume the two services together, i.e., $D_{s,i}(p_c) \subseteq D_{s,t}(p_c, p_s)$. Thus, when both travellers and non-travellers buy side services, the airport would find it more convenient to react to an increase in a raising the price for side services, to the detriment of non-travellers, and reducing the price for core services. The second effect can be explained looking at the elasticity of the demand for side services, i.e., $\varepsilon_s = -\partial D_s(p_c, p_s)/\partial p_s \cdot p_s/D_s(p_c, p_s)$. It is easy to note that $\partial \varepsilon_s/\partial a \leq 0$, that is an increase in the extra surplus a elicited by travel-related motivations causes a decrease in the price elasticity of the demand for side services. This is due to the fact that $\partial D_s(p_c, p_s)/\partial a = \partial D_{s,t}(p_c, p_s)/\partial a = \partial D_{s,i}(p_c)/\partial a \geq 0$, that is as a increases the demand for side services increases due to the increase in the induced demand from travellers. As opposite, $\partial \varepsilon_c/\partial a = 0$, where $\varepsilon_c = -\partial D_c(p_c)/\partial p_c \cdot p_c/D_c$ is the elasticity of the demand for core services.

These considerations lead to Proposition 1, which can be directly verified $\forall (a, k, l) \in I$.

Proposition 1 At the optimum, an increase in the extra-surplus gained from travellers when consuming core and side services together leads to an increase of the side price and to a reduction of the core price, i.e., $\boldsymbol{\partial p_s^*/\partial a \geq 0}$ and $\boldsymbol{\partial p_c^*/\partial a \leq 0}$.

It is easy to see that $\partial^2\pi/\partial p_c\partial a = p_s\partial^2 D_{s,i}(p_c)/\partial p_c\partial a \leq 0$, while $\partial^2\pi/\partial p_s\partial a = \partial D_{s,i}(p_c)/\partial a \geq 0$. In other words, as a increases ε_s reduces and the facility is incentivized to charge higher side price. Based on Lemma 1, a marginal increase in the side price produces an incentive to reduce the core price as to induce higher demand for side services from travellers. In Figure 2, we plot optimal charges as a function of a.

==Insert Figure 2 ==

3.2 Extension: two-side complementarity

In this section, we aim at extending the model to the case in which there may be a demand externality provided by the side good supply to the market for flight tickets, that is the case of *two-way complementarity* between core and side service. In fact, we assume that individuals might take into account the surplus they get from the consumption of the side services when purchasing the flight ticket. By doing so, we share the approach of Flores Fillol et al., (2015), where the demand for air travel depends on a portion (that represents the degree of foresight of the individual) of the surplus that the individuals anticipate to obtain from the consumption of the side good. In other words, consumers know the core price (the ticket flight) but may not fully informed about the surplus they obtain from side goods when making the decision of buying the flight ticket. This is consistent with the fact that, while there is evidence of impulsive purchasing brought about by effective responses to the airport context, some of the browsing and purchasing behavior in airports might be planned in advance of the airport visit and is seen as a component of the trip/holiday (Baron and Wass, 2006). Flores Fillol et al. (2015) note that according to a recent report by Mintel (2013), 16% of German leisure travellers anticipate airport shopping, while the percentage is 18% for British ones. Asian-pacific international travellers are also committed shoppers. On the extreme case, passengers may be fully informed about the surplus they can obtain from side goods. This can occur in the case of experienced travellers, e.g., business passengers, who may decide upon traveling based on the entire trip costs for both the tickets and (for example) car rentals or car parking (Czerny, 2006;2013). Similarly, when airports engage in e-commerce, customers can observe both prices at the time of ticket purchase and decide whether to buy the flight and side services, the travel ticket only or nothing, taking into account the net benefit they could get from concession services if they travel (Bracaglia et al., 2015).

In analogy to the previous section, we assume that each consumer is willing to purchase at most one unit of each product and she receives zero utility if she does not make any purchase. In this new setting, people will buy the ticket flight if the benefit $v_c + \delta\ max\{CS_{s,t}(p_s), 0\} - p_c$ is greater than 0. Here, $CS_{s,t}(p_s) = v_s - p_s + a$ is the surplus that travellers would gain from the consumption of side activities and δ, with $0 \le \delta \le 1$, is the degree of individual foresight. The parameter δ tells how much the individual takes into account the utility she would derive from the consumption of the retail good when making her flight purchase decision. If $\delta = 0$, the individual is perfectly myopic and the flight is bought based only on the utility the individual derives strictly from it; we are back to the basic model and, thus, to the hypothesis of *one-way complementarity*. When $\delta = 1$, the individual has perfect foresight, i.e., she is fully informed about the side offering and fully anticipates the surplus she obtains from purchasing side goods at the airport when buying the flight[13].

We can derive the demands for the two goods as follows.

Customer (v_c, v_s) will buy the flight alone if and only if the net benefit she gains from this choice is greater than the utility she expect to gain from buying the two products together or buying nothing. Analytically, this is the case in which $v_c - p_c \ge 0$ and $v_c - p_c \ge v_c - p_c + \delta(v_s + a - p_s)$, which corresponds to the area A in Figure 3 .

Analogously, customer (v_c, v_s) will buy the two products together if and only if the utility she expects to receive from this alternative is positive and greater than the utility she gains from the flight ticket or the side services alone, i.e. if $v_c - p_c + \delta(v_s + a - p_s) \ge 0$, and $v_c - p_c + \delta(v_s + a - p_s) \ge \delta(v_s - p_s)$ and $v_c - p_c + \delta(v_s + a - p_s) \ge v_c - p_c$, which is true for individuals located in the area $B_1 + B_2 + C_1 + C_2$ in Figure 3.

Finally, individual (v_c, v_s) will buy the side good only if this choice is expected to bring greater net benefit than buying the two products together or buying nothing, i.e., if $\delta(v_s - p_s) \ge 0$ and $\delta(v_s - p_s) \ge v_c - p_c + \delta(v_s + a - p_s)$, which is the case for individuals in the area D of Figure 3.

[13] To see how this setting is related to the basic one, note that implicitly we are assuming that the elements which contribute to a are now partially anticipated by the travelers. In other words, the individuals know that, to certain extent, consuming side services when traveling might generate an extra-surplus (with respect to the case in which they consume side services individually). If this does not apply to purely impulsive purchases, the assumption still holds in many cases. First, when side services are strictly related to the travel, e.g., car parking, car rental or hotel reservation. Second, the experienced traveler may know that travelling causes her fear or feelings of insecurity, leading her to search for comforting behaviors from shopping, or that she will have to wait and she will seek entertainment in shopping because she is bored (see footnote 10). As an example, all these factors play an important role when a traveler has to buy multiple stops flights. Even if, at the moment of the ticket purchase, she does not exactly know what she will need, she may end up with choosing – ticket price and waiting time being equal – the ticket that involves the stop in the more fashionable hub, such that she knows that all her feelings will be satiated.

Overall, we can write the demand function for the side goods as follows[14]:

$$D_s(p_c,p_s) = \underbrace{D}_{D_{s,nt}} + \underbrace{B_1 + B_2 + C_1 + C_2}_{D_{s,t}} \tag{10}$$

$$= \underbrace{\frac{(1-p_s)(p_c-\delta a+k)}{(1+l)(1+k)}}_{D_{s,nt}} + \underbrace{\frac{(2(1-p_c)+\delta a)(1-p_s)}{2(1+l)(1+k)}}_{D_{s,t}}$$

where we have implicitly acknowledged the distinction between travellers and non-travellers demand for side services. To see how this model relates to the one presented in the basic setting, note that $Prob(v_c \geq p_c)$ represents the non-induced demand for flights, $D_{c,ni}(p_c)$, which in the previous section constituted the whole demand for flights. In addition, $Prob(v_c < p_c, v_s < p_s, v_c + \delta(v_s + a - p_s) - p_c \geq 0)$ and $Prob(v_c < p_c, v_s \geq p_s, v_c + \delta a - p_c \geq 0) = Prob(p_c - \delta a \leq v_c \leq p_c, v_c + \delta(v_s + a - p_s) - p_c \geq 0)$ represent the induced demand for traveling, $D_{c,i}(p_s)$. Therefore, we may write the demand for core goods as:

$$D_c(p_c,p_s) = \underbrace{A + B_1 + B_2}_{D_{c,ni}} + \underbrace{C_1 + C_2}_{D_{c,i}} = \underbrace{\frac{1-p_c}{1+k}}_{D_{c,ni}} + \underbrace{\frac{\delta a^2 + 2\delta a(1-p_s)}{2(1+l)(1+k)}}_{D_{c,i}} \tag{11}$$

We may decompose the demand for side services similarly. The non-induced demand for side services, $D_{s,ni} = Prob(v_s \geq p_s)$, remains unchanged. However, the induced demand for side services includes the individuals that are willing to buy core and side services only jointly, $Prob(v_s < p_s, v_c < p_c, v_c + \delta(v_s + a - p_s) - p_c \geq 0)$ together with the individuals that are willing to purchase the core service alone but demand the side service only jointly to the flight, $Prob(v_s < p_s, v_c \geq p_c, v_s + a - p_s \geq 0\ )$. We obtain:

$$D_s(p_c,p_s) = \underbrace{B_2 + C_2 + D}_{D_{s,ni}(p_s)} + \underbrace{B_1 + C_1}_{D_{s,i}(p_c)} = \underbrace{\frac{1-p_s}{1+l}}_{D_{s,ni}(p_s)} + \underbrace{\frac{a(1-p_c)}{(1+l)(1+k)} + \frac{\delta a^2}{2(1+l)(1+k)}}_{D_{s,i}(p_c)} \tag{12}$$

== *Insert Figure 3* ==

[14] When information about the side offering is revealed, i.e., the day of departure, and actual purchases take place, the demand for side services includes those people who buy side goods when $v_s - p_s \geq 0$.

In what follows, we refer to $I_\delta \triangleq \{(a,\delta,k,l): 0 \le a \le 1, 0 \le \delta \le 1, k \ge 1, l \ge 1\}$, with $I_\delta \subseteq I$, to indicate the set of parameters where the demand functions are defined as in $(10)-(11)$[15].

In this new setting, the airport solves the following decision problem:

$$max_{p_c,p_s}\, \pi(p_c,p_s) = \; p_c D_c(p_c,p_s) + p_s D_s(p_c,p_s) \tag{13}$$

where $D_s(p_c,p_s) = D_{s,nt}(p_c,p_s) + D_{s,t}(p_c,p_s) = D_{s,ni}(p_s) + D_{s,i}(p_c)$ and $D_c(p_c,p_s) = D_{c,ni}(p_c) + D_{c,i}(p_s)$.

First order necessary optimality conditions for unconstrained optimization can be expressed as follows:

$$\begin{aligned} \left.\frac{\partial \pi}{\partial p_c}\right|_{p_c=p_c^*,p_s=p_s^*} &= D_{c,ni}(p_c^*) + D_{c,i}(p_s^*) + p_c^* \left.\frac{\partial D_{c,ni}(p_c)}{\partial p_c}\right|_{p_c=p_c^*} + p_s^* \left.\frac{\partial D_{s,i}(p_c)}{\partial p_c}\right|_{p_c=p_c^*} = 0 \\ \left.\frac{\partial \pi}{\partial p_s}\right|_{p_c=p_c^*,p_s=p_s^*} &= p_c^* \left.\frac{\partial D_{c,i}(p_s)}{\partial p_s}\right|_{p_s=p_s^*} + D_{s,ni}(p_s^*) + D_{s,i}(p_c^*) + p_s^* \left.\frac{\partial D_{s,ni}(p_s)}{\partial p_s}\right|_{p_s=p_s^*} = 0 \end{aligned} \tag{14}$$

where the superscript * is used to indicate the optimum. Relations (14) yield to the unique (interior) solution (p_c^*, p_s^*), with $p_j^* \in [0,1]$ for $j = c, s$, described as follows[16]:

$$\begin{pmatrix} p_c^* \\ p_s^* \end{pmatrix} = \begin{pmatrix} \dfrac{a^3\delta(1+\delta) + 2a(1-\delta)(1+k) - 4(1+l)(1+k) + 2a^2(1-\delta y)}{2\left(a^2(1+\delta)^2 - 4(1+l)(1+k)\right)} \\ \dfrac{a^3\delta(1+\delta) - 2a^2\delta(l-\delta) - 2a(1-\delta)(1+l) - 4(1+l)(1+y)}{2(a^2(1+\delta)^2 - 4(1+l)(1+y))} \end{pmatrix} \tag{15}$$

It is easy to note that an increase of the degree of individuals foresight, δ, reduces the price elasticity of the demand for both core and side services, $\partial\varepsilon_s/\partial\delta \le 0$ and $\partial\varepsilon_c/\partial\delta \le 0$, since it produces an increase in the demands for side goods and for flights. Obviously, when $a = 0$, δ does not affect neither the demand for core services nor for side goods: $\partial\varepsilon_s/\partial\delta = 0$ and $\partial\varepsilon_c/\partial\delta = 0$. Besides, an increase of the extra surplus a elicited by travellers – when buying core and side services together –

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[15] Similarly to what has been noted in the basic case we remark that in the above expressions we have confined attention to the case $p_c \le 1$ and $p_s \le 1$, which will turn out to be the relevant case. Indeed, it can be demonstrated that the airport would be not be able to increase its profits setting $p_c \ge 1$ and/or $p_s \le 1$.

[16] The eigenvalues of the Hessian of the objective function are negative, thus second order necessary optimality conditions for unconstrained optimization are always satisfied. We further note that we solved the decision problem relaxing the constraint that prices must in be in the range [0,1]. However, it is easy to check that the optimal solution of this relaxed problem is such that $p_j^* \in [0,1]\ \forall(a,\delta,k,l) \in I_\delta$. For the sake of notation, we here use again p_c^* and p_s^* to indicate the optimal prices. Indeed, we never compare optimal prices in the two settings since the optimal solution of problem (13) is continuous and (9) follows directly from (15) by substituting $\delta = 0$.

exacerbates the effect that δ does have on ε_c and ε_s, i.e. $\partial\varepsilon_j/\partial\delta \leq 0$ and $\partial^2\varepsilon_j/\partial\delta\partial a \leq 0$, $j = c, s$. This is due to the fact that an increase of the extra surplus a elicited by travellers causes a further increase in the induced demand for side and core services, i.e., $\partial D_{j,i}(p_{-j})/\partial a \geq 0$, $j = c, s$ $(-j = s, c)$. For same reasons, when individuals make decisions about buying core and side goods independently, i.e., $\delta = 0$ (basic setting), it results $\partial\varepsilon_c/\partial a = 0$, whereas when individuals may anticipate the surplus they obtain from the consumption of the retail good at the airport, the extra-surplus a unattainable elsewhere, starts to positively affect the demand for flights, i.e., $\partial D_c(p_c, p_s)/\partial a = \partial D_{c,i}(p_s)/\partial a \geq 0$, and $\partial\varepsilon_c/\partial a \leq 0$. Again, $\partial^2\varepsilon_c/\partial a\partial\delta \leq 0$.

Looking at the relationship with Lemma 1, it is easy to verify that $\partial^2\pi/\partial p_c\partial p_s = \partial D_{c,i}(p_s)/\partial p_s + \partial D_{s,i}(p_c)/\partial p_c \leq 0$, with $\partial D_{c,i}(p_s)/\partial p_s = 0$ when $\delta = 0$.

These considerations lead to the following Proposition, which can be directly verified $\forall(a, \delta, k, l) \in I_\delta$.

Proposition 2 At the optimum, an increase in the degree of traveller foresight leads to an increase of the core price and to a reduction of the side price, i.e., $\partial p_c^*/\partial\delta \geq 0$ and $\partial p_s^*/\partial\delta \leq 0$.

Again, the intuition follows from the structure of the decision problem. First, it results $\partial^2\pi/\partial p_c\partial p_s \leq 0$. Second, on the one hand, $\partial^2\pi/\partial p_c\partial\delta = \partial D_{c,i}(p_s)/\partial\delta \geq 0$, i.e., when δ increases, ε_c reduces due to the increase of the induced demand for core services, and the facility is incentivized to charge higher core prices. On the other hand, $\partial^2\pi/\partial p_s\partial\delta = p_c\partial^2 D_{c,i}(p_s)/\partial p_s\partial\delta + \partial D_{s,i}(p_s)/\partial\delta$, with $\partial^2 D_{c,i}(p_s)/\partial p_s\partial\delta \leq 0$ and $D_{s,i}(p_s)/\partial\delta \geq 0$. In other words, ε_s reduces due to the increase of the induced demand for side services and this incentivizes the facility to levy higher price for side services. However, the cross elasticity of the core demand with respect to the side price p_s, $\varepsilon_{c,s} = -\partial D_c(p_c, p_s)/\partial p_s \cdot p_s/D_c(p_c, p_s)$ increases and this incentivizes the facility to levy lower price for side services. In Figure 4, we plot optimal charges as a function of δ, when $a = 1$.

== *Insert Figure 4* ==

Consistently with literature on two-side complementarity between core and side services in airport pricing (Bracaglia et al., 2015; Czerny, 2006, 2013; Czerny and Lindsey, 2015, unpublished; Flores Fillol et al., 2015, unpublished), Proposition 2 shows that increasing traveller foresight pushes up (down) core (side) prices. In addition, Proposition 3, which is proved in the Appendix, illustrates how the degree of consumer foresight affects the behavior of optimal charges in a.

Proposition 3 At the optimum, an increase in the extra-surplus gained by travellers from consuming core and side services together leads to an increase in side prices, i.e., $\partial p_s^*/\partial a \geq 0$. Besides, the following statements hold:

(i) if $0 \leq \delta \leq 1/3$, $\partial p_c^*/\partial a < 0$

(ii) if $\delta = 1$, $\partial p_c^*/\partial a > 0$

(iii) $\forall (a,k,l) \in I_\delta$, $\exists \delta^*(a,k,l) \in (1/3,1)$ such that $\forall \delta \in (1/3, \delta^*(a,k,l))$, $\partial p_c^*/\partial a \leq 0$ and $\partial p_c^*/\partial a > 0$ otherwise.

Thus, if the degree of foresight is sufficiently low, the results described in the basic case still hold. Otherwise, it is not straightforward to appraise the effect of a on p_c^*. In order to illustrate Proposition 3, let consider, for instance, the case in which $l = 1$ (and $k > 1$, i.e., $k = 10$), as it is showed in Figure 5. The grey region represents the case in which $\partial p_c^*/\partial a > 0$. It is easy to see that $\partial^2\pi/\partial p_c \partial a = \partial D_{c,i}(p_s)/\partial a + p_s \partial^2 D_{s,i}(p_c)/\partial p_c \partial a$ with $\partial D_{c,i}(p_s)/\partial a \geq 0$ and $\partial^2 D_{s,i}(p_c)/\partial p_c \partial a \leq 0$. When δ increases, the two effects play a role in opposite directions. On the one hand, $D_{c,i}(p_s)$ increases, thus the elasticity of the demand for flights decreases and this will push up core price. On the other hand, a marginal reduction in the core price produces a higher increase of profits due to the increase of the induced demand for side services from travellers. As regards p_s, it results $\partial^2\pi/\partial p_s \partial a = p_c \partial^2 D_{c,i}(p_s)/\partial p_s \partial a + \partial D_{s,i}(p_c)/\partial a \geq 0$, where $\partial^2 D_{c,i}(p_s)/\partial p_s \partial a \leq 0$ and $\partial D_{s,i}(p_c)/\partial a \geq 0$. In particular, when δ increases, it results $\partial^2 \varepsilon_s/\partial a \partial \delta \leq 0$, and the second effect, $\partial D_{s,i}(p_c)/\partial a \geq 0$, always dominates the first one, $p_c \partial^2 D_{c,i}(p_s)/\partial p_s \partial a \leq 0$.

== *Insert Figure 5* ==

Let now consider the effect that l has on the demand for core services. As noted in Section 3.1, the distribution of v_c is not 0-bounded from below in order to avoid having the case in which the market for flights could be fully covered. In particular, as l increases, other things being equal, it is more likely that an individual (v_c, v_s) has $v_s < 0$. From previous considerations, it is intuitive to understand why the following Observation holds.

Observation 2 When individuals make decisions about buying core and side goods independently, i.e., $\delta = 0$, $\partial \varepsilon_c / \partial l = 0 \; \forall a, 0 \leq a \leq 1$. However, when individuals are forward looking, i.e., $\delta > 0$, $\partial \varepsilon_c / \partial l \geq 0$ if and only if $a > 0$.

Of course the reason is that if a traveller would have purchased side goods from airport's shops even if not traveling, the offer of such goods induces her to fly if and only if she gains extra-surplus, i.e., when $\delta > 0$, $D_{c,i}(p_s) > 0$ if and only if $a \neq 0$.

Proposition 4, which is proved in the Appendix, follows from the intuition behind Observation 2 and illustrates how optimal charges vary if the market for side good is elastic.

Proposition 4 Let consider a market in which individuals might have a (sufficiently) negative valuation for side services, i.e., $l \geq 1$. The following statements hold:

(i) if travellers do not enjoy extra-surplus when buying core and side services together, there is no effect of l on optimal prices for core and side goods, no matter whether travellers make decisions about buying core and side goods independently or simultaneously, i.e.,$\partial p_c^* / \partial l|_{a=0} = 0$ and $\partial p_s^* / \partial l|_{a=0} = 0$; otherwise:

(ii) if $0 \leq \delta \leq 1/2$, $\partial p_c^* / \partial l > 0$ and $\partial p_s^* / \partial l < 0$;

(iii) if $\delta = 1$, $\partial p_c^* / \partial l \leq 0$ and $\partial p_s^* / \partial l \geq 0$;

(iv) $\forall (a, k) \in I \; \exists \delta^*(a, k) \in (1/2, 1)$ such that $\forall \delta \in (1/2, \delta^*(a, k))$ $\partial p_c^* / \partial l \geq 0$ and $\partial p_s^* / \partial l \leq 0$ and $\partial p_c^* / \partial l \leq 0$ and $\partial p_s^* / \partial l \geq 0$ otherwise.

Figure 6 shows intuitively the joint effect of δ and a on $\partial p_c^* / \partial l$ and $\partial p_s^* / \partial l$ for fixed values of k (i.e., $k = 10$). The grey region represents the case in which $\partial p_c^* / \partial l < 0$ and $\partial p_s^* / \partial l > 0$. It is easy to see that, if the degree of traveller foresight is sufficiently low, whatever is the level of a, the facility finds always it convenient to increase core price and decrease side price when l increases. However, when the degree of foresight increases, the amount of extra surplus enjoyed by travellers when buying core and side services together starts playing a role. In particular, if travellers are sufficiently forward looking, $\partial p_c^* / \partial l \leq 0$ and $\partial p_s^* / \partial l \geq 0$ when a is high enough. On the extreme case, when $\delta = 1$, whatever is the level of a, the facility finds it always convenient to increase the side price and decrease the core price, as l increases, if passengers are fully forward looking.

== *Insert Figure 6* ==

4. Robustness of the results

Before proceeding to the policy implications of our work, the reader should note that we have so far focused on the relation between the landing fee and traveller *vs* non-traveller demand, in order to isolate some of the forces determining the fee. However, a thorough analysis would have to account for other forces that are peculiar of the air transport industry and it is difficult to include them in a tractable model. In this section, we discuss in brief two aspects that have been left out of our formal analysis.

First, it should be noted that profits from those retail services and goods that could be only purchased after the security checks should also be taken into account. This allows us to incorporate into the analysis an important feature of the airport business: side services supplied airside, i.e., after passport control are only available to travellers, while side services sold landside within the terminal or in the surrounding land parcels are available to both travellers and non-travellers. In particular, a preliminary attempt to take into account for this feature into our work can be performed by modeling a fixed add-on profit per passenger (Zhang and Zhang, 1997, 2003, 2010; Oum et al., 2004). In such scenario, the airport decision problem in (13) would become $\pi(p_c, p_s) = (p_c + \tau)D_c(p_c, p_s) + p_s D_s(p_c, p_s)$ and it can be proved that $\forall(a, k, l, \delta) \in I_\delta$ there exists a $\tau^*(a, k, l, \delta) > 0$ such that $\forall\tau \leq \tau^*$, the optimal charges in this benchmark scenario remain the one indicated in relation (13). In particular, as τ increases the incentive to increase profits through a reduction of the core charge increases, due to the additional profits linked to the growth of passenger demand, i.e., $\partial^2\pi/\partial p_c \partial\tau = \partial D_c(p_c)/\partial p_c \leq 0$. As a consequence, the price for side services would increase (see Lemma 1). In fact when τ is sufficiently large, i.e., $\forall\tau > \tau^*(a, k, l, \delta)$, the airport prices core charges at the marginal cost, i.e., $p_c^* = 0$.

Second, the paper does not go into the details of airline market power and airline market structure. However, we expect the result to be qualitatively true when the downstream market is not perfectly competitive. When airlines are not atomistic, the demand for aviation services depends on the mark-up in the downstream market: the higher the market power of airlines, the lower the number of passengers, for a given level of airport core charges. When travellers make decision about buying core and side goods independently, this makes it more profitable for the airport to stimulate non-passenger demand by a reduction of the side price. When travellers make decision about buying core and side goods simultaneously rather than independently, the airport tendency to reduce the side price and to increase the core charge would be less marked. Indeed, higher aviation charges are less able to compensate for a reduction in concession profits when the airlines′ mark-up makes the increase in aviation price result in a higher reduction of aviation demand than in our model.

The inclusion of elements such as market structure and market power of downstream transport services providers in our model, for instance, would be important if one wants to apply our framework to study pricing of core and side services in the case of railways stations, where the provider of rail transport services is generally a monopolist (e.g., in Europe).

5. Policy implications

In this section, we discuss the implications of our model from the point of view of policy makers. In particular, we will focus on the role of the extra-surplus gained by travellers with respect to non-travellers from consuming core and side services together. Such extra-surplus is assumed exogenous in our model. However we note that it could be affected by the airport, for instance through the choice of the type of retailers to whom award space in the terminal or in the surrounding land parcels (e.g., passenger-dependent activities might increase traveller extra-surplus), as well as creating a unique environment that proposes different stimuli which are able to convert browsers into customers[17].

In particular, we want to answer to the following questions: does a private (uncongested) airport use its market power to ask for relatively high landing fees, even though this may risk shrinking demand for side goods from one group of costumers (or both)? Which are the implications of airport pricing strategies for the society as a whole, as well as for specific groups of individuals?

5.1. Airport market power

In this section, we consider two benchmark cases. The first benchmark case depicts a situation in which only core services are available at the infrastructure. The second describes the case in which only travellers can purchase concession services at the airport (though they may abstain from consuming any of these services) and thus there is a hierarchical demand structure, in which consumers buy side goods only if they buy the flight ticket as well.

[17] Crawford and Melaware (2003), for instance, describe different strategies in order to increase the surplus that browsers may obtain from airport purchases such as: (i) *increase excitement* (Live fashion show – Abu Dhabi Duty Free; 'Win a million $' prize draw – Dubai Duty Free; first airport sex shop – Frankfurt Airport; Chocolate production demonstration by Lindt; Belgium Sky Shops); (ii) *reduce boredom* (the world's first airport casino, Amsterdam Duty Free); (iii) *"Happy hour" syndrome* (provision of personal shoppers – BAA, "Cigar Bar" for customers – Beirut Duty free. If we take into account impulse purchases (i.e., the basic settings), we might also consider impulse maximizer elements such as use of psychological tactics to improve store penetration, reinforcement of 'value' through visible price comparisons, stress the rationality of impulse buying in advertising efforts, stress the non-economic rewards of impulse buying, well-trained sales staff, straining customers' abilities to process information accurately. See also Davies (1995) for a spectrum of primary activities and their typical complementary retail opportunities, spanning from sport sports spectating, cinema or theatre.

One-side complementarity

Let consider a situation in which only core services are available at the infrastructure. In this case, the airport maximizes its profits choosing the core charge and, thus, it solves the following decision problem:

$$max_{p_c}\, \pi^S(p_c) = \; p_c D_c(p_c) \tag{16}$$

where $D_c(p_c)$ is defined in (3). We can easily obtain the solution of the problem, where the superscript S is used to indicate the optimal solution in the case of a single product facility.

$$\boldsymbol{p_c^S} = \frac{1}{2} \tag{17}$$

Observation 3, which can be easily proved, compares the optimal level of core charges in this scenario with the one of the basic case - described in (9).

Observation 3 When only core services are available at the infrastructure, the airport charges higher core price, compared to a case in which side services are also available to individuals, i.e., $p_c^* \leq p_c^S$.

Let consider now the case in which both core and side services are available at the airport, with the latter being available for purchase only to travellers. In this case, the airport maximizes its profits choosing simultaneously its charges on both sides of the business and solves the following decision problem:

$$max_{p_c,p_s}\, \pi^H(p_c, p_s) = \; p_c D_c(p_c) + p_s D_{s,t}(p_c, p_s) \tag{18}$$

where $D_c(p_c)$ and $D_{s,t}(p_c, p_s)$ are defined in (1) and (5) respectively. First order necessary optimality conditions for unconstrained optimization are described as follows:

$$\begin{aligned} \left.\frac{\partial \pi^H}{\partial p_c}\right|_{p_c=p_c^H, p_s=p_s^H} &= D_c(p_c^H) + p_c^H \left.\frac{\partial D_c(p_c)}{\partial p_c}\right|_{p_c=p_c^H} + p_c^H \left.\frac{\partial D_{s,t}(p_c, p_s)}{\partial p_c}\right|_{p_c=p_c^H, p_s=p_s^H} = 0 \\ \left.\frac{\partial \pi^H}{\partial p_c}\right|_{p_c=p_c^H, p_s=p_s^H} &= D_{s,t}(p_c^H, p_s^H) + p_s^H \left.\frac{\partial D_{s,t}(p_c, p_s)}{\partial p_s}\right|_{p_c=p_c^H, p_s=p_s^H} = 0 \end{aligned} \tag{19}$$

where the superscript H is used to indicate the optimal solution in the case of hierarchical demands. Relations (19) lead to a unique solution described as follows[18]:

$$\begin{pmatrix} p_c^H \\ p_s^H \end{pmatrix} = \begin{pmatrix} \dfrac{3-2a-a^2+4l}{8(1+l)} \\ \dfrac{(1+a)}{2} \end{pmatrix} \tag{20}$$

Proposition 5 compares the optimal level of core charges in this scenario with the one described in (9).

Proposition 5 When both travellers and non-travellers demand side services, the airport charges higher (lower) core (side) price, compared to a case in which only travellers demand side services, i.e., $p_c^* \geq p_c^H$ and $p_s^* \leq p_s^H$.

The reader may easy check that $p_c^* - p_c^{H,*} \geq 0$ and $p_s^* - p_s^{H,*} \leq 0$ for each $(a,k,l) \in I$. Besides, the intuition behind Proposition 5 can be explained as follows. When both travellers and non-travellers demand side services, the airport has incentive to reduce the side price in order to earn more profits from non-travellers. Furthermore, the marginal benefit from core price reduction decreases since $\partial D_{s,nt}(p_c,p_s)/p_s \leq 0$ and $\partial D_{s,nt}(p_c,p_s)/p_c \geq 0$. Analytically, from (7) it follows that:

$$\begin{aligned} \frac{\partial \pi}{\partial p_c} &= D_c(p_c) + p_c \frac{\partial D_c(p_c)}{\partial p_c} + p_s \left(\frac{\partial D_{s,t}(p_c,p_s)}{\partial p_c} + \frac{\partial D_{s,nt}(p_c,p_s)}{\partial p_c} \right) \\ \frac{\partial \pi}{\partial p_s} &= D_{s,t}(p_c,p_s) + D_{s,nt}(p_c,p_s) + p_s \left(\frac{\partial D_{s,t}(p_c,p_s)}{\partial p_c} + \frac{\partial D_{s,nt}(p_c,p_s)}{\partial p_c} \right) \end{aligned} \tag{21}$$

Evaluating relations (21) at $\boldsymbol{p^H} = (p_c^H, p_s^H)$, and substituting (19), we obtain

$$\begin{aligned} \left.\frac{\partial \pi}{\partial p_c}\right|_{p_c=p_c^H, p_s=p_s^H} &= p_s^H \left.\frac{\partial D_{s,nt}(p_c,p_s)}{\partial p_c}\right|_{p_c=p_c^H, p_s=p_s^H} \geq 0 \\ \left.\frac{\partial \pi}{\partial p_s}\right|_{p_c=p_c^H, p_s=p_s^H} &= \underbrace{D_{s,nt}(p_s^H)}_{\geq 0} + \underbrace{p_s^H \left.\frac{\partial D_{s,nt}(p_c,p_s)}{p_s}\right|_{p_c=p_c^H, p_s=p_s^H}}_{\leq 0} \leq 0 \end{aligned}$$

[18] Karush–Kuhn–Tucker conditions are verified for the decision problem (18) considering the constraint that prices must in be in the range [0,1]. In particular, it can be verified that the optimal solution is an interior one and that the airport would be not be able to increase its profits setting $p_c \geq 1$ and/or $p_s \leq 1$. All relevant parameters are then considered in the range in which $p_j^H \in [0,1]$ for $j = c, s$.

Now, it is easy to compare our results with previous literature. On the one hand, consistently with literature on one side-complementarity between core and side services, Observation 3 shows that airports have incentive to restrain the aviation charge in order to boost traffic and expand concessions revenues, since concession operations depend on the passenger throughput (D'Alfonso et al., 2013; Kratzsch and Sieg, 2011; Oum et al., 2004; Starkie, 2002; Yang and Zhang, 2011; Zhang and Zhang, 1997; 2003; 2010). On the other hand, Proposition 5 shows that, when non-travellers also demand side services and travellers do enjoy an extra surplus when buying core and side services together, airports may still abuse market power by an increase in the price for core services.

Moreover, our results appear to be consistent with the findings of Waguespack (2015) on the issue of street (or value) pricing, according to which airport concessions shall be reduced and tend to the level equivalent to what a consumer/passenger would find for the item within a location outside the airport, in a traditional retail 'street' location. Indeed, street pricing is, in some cases, explicitly accompanied by the evidence that airports are trying to help retailers by coming up with a plan which allows them to sell goods at kiosks in the publicly accessible civic amenities. The goal is to draw more non-travellers to the plaza – kicking around the idea of concerts and other activities, which could translate into more sales for concessionaires, as in the case of the Indianapolis International Airport (The Indianapolis Business Journal, 2009)

It is easy to check that Observation 4 holds $\forall(a,k,l) \in I$.

Observation 4 An increase in the extra-surplus gained by travellers from consuming core and side services together induces the airport to decrease (increase) less the core (side) charge compared to the case in which only travellers demand side, i.e., $\partial(p_c^* - p_c^H)/\partial a \geq 0$ and $\partial(p_s^H - p_s^*)/\partial a \geq 0$.

Observation 4 implies that as the extra-surplus gained by travellers from consuming core and side services together increases, airport's tendency to charge higher core price compared to a case in which only travellers demand side services is even reinforced. This results because an increase in a leads to an increase in travellers demand for side services, while non-travellers demand remains unchanged. Thus, the marginal benefit from core price reduction further decreases.

The policy implications of these results for private airport pricing are significant. If side activities are dependent of core prices because of the presence of non-travellers demand for concession services (and travellers do enjoy an extra surplus when buying core and side services together), the side business may not unambiguously exert downward pressure on the private aviation charge. Literature on one-side complementarity between core and side services used to abstract away from this mechanism, since demand for side services had been assumed to come from travellers only and, thus, to be a decreasing function of core prices. However, we proved that common results in one-side complementarity literature may not hold when non-travellers demand for side services exists and is an increasing function of core prices.

Two-side complementarity

We now turn to analyse the case in which travellers make decision about buying core and side goods simultaneously rather than independently. If only core services are available at the infrastructure, of course, the benchmark decision problem will be the same as described in (13). In this case, the immediate comparison between p_c^*, as described in (15), and (17) shows that if the degree of foresight is sufficiently high, the facility may charge the core good more than absent the side good business. Otherwise, the facility charges the core good less. Indeed, the benefit from the induced core (and thus side) demand offsets the loss in induced side profits due to higher core prices.

As opposite, in the case of hierarchical demands, the structure of the benchmark problem will change. In analogy to the previous section, when $\delta > 0$ and both services are available at the facility, people will buy the ticket flight if the benefit $v_c + \delta\, max\{CS_{s,t}(p_s), 0\} - p_c$ is greater than 0, where $CS_{s,t}(p_s) = v_s - p_s + a$. However, the purchase of the side good only is not an option now, i.e., only travellers may purchase side good. Thus, we can derive the demands for the two goods as follows. Customer (v_c, v_s) will buy the flight alone if and only if the net benefit she gains from this choice is greater than the utility she expect to gain from buying nothing or the two products together. Analytically, this is the case in which $v_c - p_c \geq 0$ and $v_c - p_c \geq v_c - p_c + \delta(v_s + a - p_s)$. Conversely, she will buy the two products together if and only if the utility she expects to receive from this alternative is positive and greater than the utility she gains from the flight ticket alone, i.e. if $v_c - p_c + \delta(v_s + a - p_s) \geq 0$ and $v_c - p_c + \delta(v_s + a - p_s) \geq v_c - p_c$. Thus, in this scenario, the benchmark decision problem of the airport is $max_{p_c, p_s}\, \pi^H(p_c, p_s) = p_c D_c^{H,\delta}(p_c, p_c) + p_s D_{s,t}^{H,\delta}(p_c, p_s)$ where $D_c^{H,\delta}(p_c, p_c)$ and $D_{s,t}^{H,\delta}(p_c, p_s)$ are respectively the demand for core and side services in this setting, as derived from previous assumptions[19].

In order to illustrate how results in Proposition 5 modify as δ increases, taking into account that the highly non-linear nature of the problem at hand prevents us from fully characterizing the optimal

[19] For the sake of space, we did not report here the full expression for demand functions in this benchmark scenario, but they are available upon request from the authors.

airport choices analytically, we resort to numerical methods. Table 1 shows the optimal airport choices, i.e., $p_c^{H,\delta}$ and $p_s^{H,\delta}$, for some fixed value of a in the range [0,1] (and $l = 1$).

== Insert Table 1 ==

Consistently with the findings of Flores Fillol et al. (2015), the core (side) charge $p_c^{H,\delta}$ ($p_s^{H,\delta}$) increases (decreases) as travellers become progressively forward-looking. Indeed, with perfectly myopic consumers, the airport attracts more passengers via low landing fees. However when consumers have some degree of foresight, the decision whether to fly is influenced by the fare charged by airlines (thus, by the core fee charged by the airport) as well as by the surplus that they expect to obtain from the consumption of the retail good. This is exploited by the airport charging higher landing fees[20].

Moreover, it is easy to note that if the degree of foresight is sufficiently high, the facility may charge lower core price (higher side price) with respect to the case in which the side good is consumed by passengers only. Otherwise, the facility may charges higher core price (lower side price).

Certainly, the incentive to increase (reduce) side (core) charges relies on the size of the demand for side services with respect to the size of the demand for core services. An increase in the side price induces a higher reduction of side demand when side services can be purchase by non-travellers compared to the case in which those services are only available to travellers. When non-travellers demand side services and the degree of traveller foresight is low, the relative size of the induced demand for core and side services is low and the facility would find it more convenient to boost profits via low (high) side (core) fees, compared to the case in which side services are only available to travellers. Indeed, lowering the side fees allows the facility to boost side revenues from non-travellers.

Conversely, as travellers become sufficiently forward looking, the airport would find it more convenient to charge a lower core price and higher side price compared to the case in which side

[20] Czerny and Linsdey (2014, unpublished), with the use of a microeconomic model, generalize such results. They show that if consumers have identical preferences for the side good, the monopolist prices the side good at marginal cost and extracts consumer's surplus through the core price: the monopolist profits indirectly from selling the side good because it boosts demand for the core good. Moreover, if demand for the side good rises the monopoly markup on the core good can increase, decrease, or remain unchanged depending on how the price elasticity of core-good demand changes as the demand curve shifts out. Finally, if consumers are heterogeneous the monopolist can price the side good above or below marginal cost depending on how preferences for the core good and side good are correlated.

services are only available to travellers. Indeed, in this case, the relative size of the induced demand for core and side services increases and, even if the rise of the side price would imply losing non-travelers demand, the airport would profits from an increasing demand for side services and travellers demand for side services[21].

5.2 Airport profits, social welfare and consumer surplus

In this section, we analyse the implications of airport pricing on social welfare and on consumer surplus. At this aim, we first focus on the relationship between a and the airport profits. We refer to the problem (13) since, as noted, optimal solution of problem (13) is continuous and (9) follows directly from (15) by substituting $\delta = 0$.

Airport profits

Let π^*, π_c^*, π_s^* be the airport's equilibrium profits from all, core and side activities respectively, i.e., $\pi^* = \pi_c^* + \pi_s^* = p_c^* D_c(p_c^*, p_s^*) + p_s^* D_s(p_c^*, p_s^*)$, where p_c^* and p_s^* are the optimal charges described in (1). Moreover, let $\pi_{s,t}^*$ and $\pi_{s,nt}^*$ be the airport's equilibrium side profits from travellers and non-travellers respectively, i.e., $\pi_{s,t}^* = p_s^* D_{s,t}(p_c^*, p_s^*)$, $\pi_{s,nt}^* = p_s^* D_{s,nt}(p_c^*, p_s^*)$. The effect of a on the airport's profits are presented in the following Proposition.

Proposition 6 When non-passengers demand side services, the following statement holds with respect to the optimal level of airport profits:

(i) $\forall \delta, 0 \leq \delta \leq 1, \partial \pi^* / \partial a \geq 0$;

(ii) $\forall \delta, 0 \leq \delta \leq 1 \; \partial \pi_s^* / \partial a \geq 0$. However, $\partial \pi_{s,t}^* / \partial a \geq 0$ while $\partial \pi_{s,nt}^* / \partial a \leq 0$.

(ii) if $\delta = 0, \; \partial \pi_c^* / \partial a \leq 0$.

if $= 1, \; \partial \pi_c^* / \partial a \geq 0$;

$\forall (a, k, l) \in I_\delta \; \exists \delta^*(a, k, l) \; \in (0, 1)$ such that $\forall \delta \; \in (0, \delta^*(a, k, l)) \; \partial \pi_c^* / \partial a \leq 0$; otherwise, $\partial \pi_c^* / \partial a \geq 0$.

---

[21] In fact, whether $p_s^{H,\delta}$ ($p_c^{H,\delta}$) is higher (lower) than p_s^* (p_c^*) depends on the relative size of non-travellers demand for side services compared to the size of travellers' induced demand for core and side services. As k increases, the relative importance of non-travellers demand for side services grows compared to that of travellers' induced demand for core and side services, e.g., when $\delta = 0.9$, $p_s^{H,\delta} - p_s^* < 0$ and $p_c^{H,\delta} - p_c^* > 0$ if $k \leq 22.606$, while $p_s^{H,\delta} - p_s^* > 0$ and $p_c^{H,\delta} - p_c^* < 0$ if $k > 22.606$. Conversely, as a increases – from panel (a) to (c) – the relative importance of non-travellers demand for side services diminishes compared to that of travellers' induced demand for core and side services, e.g., when $\delta = 0.7$, $p_s^{H,\delta} - p_s^* < 0$ and $p_c^{H,\delta} - p_c^* > 0$ if $a = 0.5$, while $p_s^{H,\delta} - p_s^* > 0$ and $p_c^{H,\delta} - p_c^* < 0$ if $a = 1$.

The proof of Proposition 6 can be found in the Appendix, while here we give the intuition behind the results.

At the optimum, an increase in a produces an increase in side profits, whatever is the level of δ. On the one hand, as a increases, side profits from travellers increase. Let us first focus on the case $\delta = 0$ (i.e., basic model). Three forces play a role. First, as a increases, p_s increases, which has a positive effect on side profits. However, such increase induces lower traveller demand for side services, $D_{s,t}(p_c, p_s)$, and this has a negative effect on side profits. Second, according to Lemma 1, as a increases, $D_{s,t}(p_c, p_s)$ increases thanks to the increase in the induced demand for side services, $D_{s,i}(p_c, p_s) \subseteq D_{s,t}(p_c, p_s)$, which is beneficial to side profit. Finally, $D_{s,t}(p_c, p_s)$ increases thanks to a reduction of p_c which is, again, beneficial to side profit. Analytically, when $\delta = 0$, it results:

$$\frac{\partial \pi_{s,t}^*}{\partial a} = \underbrace{\frac{\partial p_s^*}{\partial a} D_{s,t}(p_c^*, p_s^*)}_{\geq 0} + p_s^* \left(\underbrace{\frac{\partial D_{s,t}(p_c, p_s)}{\partial a}}_{\geq 0} + \underbrace{\left. \frac{\partial D_{s,t}(p_c, p_s)}{\partial p_c} \right|_{p_c = p_c^*} \frac{\partial p_c^*}{\partial a}}_{\geq 0} + \underbrace{\left. \frac{\partial D_{s,t}(p_c, p_s)}{\partial p_s} \right|_{p_s = p_s^*} \frac{\partial p_s^*}{\partial a}}_{\leq 0} \right)$$
$$\geq 0$$

Let us now focus on the case $\delta > 0$. When δ increases, p_s decreases, which implies a marginal reduction of unitary profits. Moreover, p_c increases, which has a negative effect on $D_{s,t}(p_c, p_s) \subseteq D_c(p_c, p_s)$ and it is also detrimental for profits. However, two beneficial effects offset the negative impacts described above. Indeed, $D_{s,t}(p_c, p_s)$ increases thanks to: (i) the decrease in p_s; (ii) the increase in the induced demand for side services, $D_{s,i}(p_c) \subseteq D_{s,t}(p_c, p_s)$, due to the effect of δ. The latter even reinforces the positive effect that an increase of a has on $D_{s,i}(p_c)$.

As opposite, side profits from non-travellers decrease. Again, let first focus on the case $\delta = 0$. As a increases, p_s increases, which has a positive impact on profits. However, $D_{s,nt}(p_c, p_s)$ decreases, due to the joint increase of p_s and decrease of p_c, which is detrimental for profits. Analytically,

$$\frac{\partial \pi_{s,nt}^*}{\partial a} = \underbrace{\frac{\partial p_s^*}{\partial a} D_{s,nt}(p_c^*, p_s^*)}_{\geq 0}$$
$$+ p_s^* \left(\underbrace{\frac{\partial D_{s,nt}(p_c, p_s)}{\partial a}}_{=0} + \underbrace{\left. \frac{\partial D_{s,nt}(p_c, p_s)}{\partial p_c} \right|_{p_c = p_c^*} \frac{\partial p_c^*}{\partial a}}_{\leq 0} + \underbrace{\left. \frac{\partial D_{s,nt}(p_c, p_s)}{\partial p_s} \right|_{p_s = p_s^*} \frac{\partial p_s^*}{\partial a}}_{\leq 0} \right) \leq 0$$

Again, when $\delta > 0$, an increase of δ produces a decrease of p_s, while p_c increases and these variations induce an increase in the non-travellers demand for side services, $D_{s,nt}(p_c, p_s)$. However, two detrimental effects offset these beneficial impacts (in addiction to the reduction of unitary profits due to the decrease of p_s). First, when $\delta > 0$, $\partial D_{s,nt}(p_c, p_s)/\partial a < 0$. In other words, when the degree of the extra-surplus gained by (forward looking) travellers from consuming core and side services together increases, non-travellers demand for side services starts to vary and, in particular, decreases. Second, the reduction is even stronger as δ increases since $\partial D_{s,nt}(p_c, p_s)/\partial \delta \leq 0$ and $\partial^2 D_{s,nt}(p_c, p_s)/\partial a \partial \delta \leq 0$.

Finally, we turn to core profits. When $\delta = 0$ and the degree of the extra-surplus gained by travellers with respect to non-travellers from consuming core and side services together increases, core profits decrease. Two forces play a role. On the one hand, as a increases, p_c decreases, which has a negative effect on profits. On the other hand, such a decrease induces higher demand for traveling activities, which is beneficial to core revenues. The contrasting effects balance out in favor of the first effect and analytically we have

$$\frac{\partial \pi_c^*}{\partial a} = \underbrace{\frac{\partial p_c^*}{\partial a} D_c(p_c^*)}_{\leq 0} + p_c^* \left(\underbrace{\frac{\partial D_{c,ni}(p_c)}{\partial a}}_{=0} + \underbrace{\left.\frac{\partial D_{c,ni}(p_c)}{\partial p_c}\right|_{p_c = p_c^*} \frac{\partial p_c^*}{\partial a}}_{\geq 0} \right) \leq 0$$

where $D_{c,ni}(p_c) = D_c(p_c)$ since $\delta = 0$. However, when $\delta > 0$, the demand for core services is dependent from side activities. Thus, we have

$$\frac{\partial \pi_c^*}{\partial a} = \frac{\partial p_c^*}{\partial a} D_c(p_c^*, p_s^*) + p_c^* \left(\frac{\partial D_{c,ni}(p_c)}{\partial a} + \left.\frac{\partial D_{c,ni}(p_c)}{\partial p_c}\right|_{p_c = p_c^*} \frac{\partial p_c^*}{\partial a} + \underbrace{\frac{\partial D_{c,i}(p_s)}{\partial a}}_{>0} + \underbrace{\left.\frac{\partial D_{c,i}(p_s)}{\partial p_s}\right|_{p_s = p_s^*} \frac{\partial p_s^*}{\partial a}}_{\leq 0} \right) \lesseqgtr 0$$

In other words, when $\delta > 0$, two more forces play a role. On the one hand, an increase in a induces an increase in the demand for flights due to the rise of the induced demand, $D_{c,i}(p_s)$. On the other hand, p_s increases: if this has a positive impact on revenues, on the other side it implies a reduction of $D_{c,i}(p_s)$. Again, the magnitude of these effects is even larger when δ increases. Let us now analyse the additional effects that a marginal increase of δ produces. The direct effect is that the higher δ the larger $D_{c,i}(p_s)$, while $D_{c,ni}(p_c)$ is not affected. The indirect effect, instead, can be described as follow.

For each level of a, the higher δ the lower p_s while the higher p_c. Besides the intuitive impact that these changes have on revenues, this produces an increase in $D_{c,i}(p_s)$ and a decrease on $D_{c,ni}(p_c)$.

All these forces play in opposite directions and whether core profits increase or decrease in a depends on the magnitude of δ, as illustrated in Figure 7.

== *Insert Figure 7* ==

The grey region represents the range in which core profits increase in a. Results show that if passengers are sufficiently forward looking, an increase in the extra-surplus gained by travellers when consuming core and side service together is always beneficial to profits. Otherwise, i.e., if travellers are forward looking but not enough, core profits increase if and only if a is sufficiently small. On the extreme, if travellers make decision about buying core and side goods independently, an increase of a is always detrimental for core profits. Finally, it is easy to verify that $\lim_{k\to\infty} \partial\pi_c^*/\partial a = \lim_{l\to\infty} \partial\pi_c^*/\partial a = 0$, that is if the market for travel or the market for side service is perfectly elastic, an increase of a is always beneficial to core profits[22].

Results in Proposition 6 allow us to draw some lessons about the side business strategy of the airport. Though we did not seek to characterize the optimal level of a, our findings certainly illustrate that strategies aimed at delivering higher benefit to passengers and activating, through effective communication, different stimuli which can make travellers react in unusual ways, bring more revenues to the airport. Nevertheless, two aspects need to be taken into the picture, given that the increase in side revenues is (also) driven by an increase in the side price set by the airport. First, this strategy might not be sustainable in presence of tough competition from outside retailers, which is not modeled in this paper and deserves further attention in future works. Second, the interplay between a and δ in enhancing airport side revenues is not straightforward. In particular, it may be checked that when a is sufficiently small (high enough), the benefit for side revenues from a further increase in the level of a increases (diminishes) with δ, i.e., $\partial^2\pi_s^*/\partial a\partial\delta \geq (\leq) 0$. Indeed, $\partial^2 p_s^*/\partial a\partial\delta$

[22] It can be demonstrated that, at the optimum, an increase in travelers' foresight induces higher aggregate profits, from both sides of the business, i.e., $\partial\pi_c^*/\partial\delta \geq 0$, $\partial\pi_s^*/\partial\delta \geq 0$. The proof is available from the authors, while the intuition can be easily derived from Propositions 2 and 3. We note that results are consistent with those of previous literature on platform pricing and travelers' degree of foresight toward the surplus gained from the consumption of side activities (Flores Fillol et al., 2015).

follows the same behaviour. In other words, the airport would be able to enhance the side revenues brought by the higher level of a further stimulating δ (for instance, advertising the concession products and services online at the time of ticket purchase, see Bracaglia et al., 2014) only when a is low. However, when a is quite high, the airport would deflate side revenues brought by the higher level of a further stimulating δ. Accordingly, for growing degrees of traveller foresight, airport side revenues increase less (more) with a when a is high (low), making concession activities relatively more (less) substantial in airport business.

Social welfare and consumer surplus

Social welfare is the sum of the surplus generated by core and side activities and can be evaluated as follows:

$$\begin{aligned} &\mathrm{W}(p_c, p_s) \\ &= \frac{1}{(1+l)(1+k)}\left(\int_{-l}^{1}\int_{p_c}^{1} v_c dv_c dv_s + \int_{p_s}^{1}\int_{p_c-\delta a}^{p_c} v_c dv_c dv_s + \int_{p_s-a}^{p_s}\int_{p_c-\delta(v_s+a-p_s)}^{p_c} v_c dv_c dv_s \right. \\ &\left. + \int_{p_c-\delta a}^{1}\int_{p_s}^{1}(v_s+a)dv_s dv_c + \int_{p_c-\delta(v_s+a-p_s)}^{1}\int_{p_s-a}^{p_s}(v_s+a)dv_s dv_c + \int_{-k}^{p_c-\delta a}\int_{p_s}^{1} v_s dv_s dv_c\right) \end{aligned} \tag{22}$$

Policy makers may be more concerned about consumer surplus rather than producer surplus when assessing social welfare. Moreover, in our scenario, two types of consumers may buy goods at the facility, that are travellers and non-travellers. For these reasons, we analyse consumer surplus, $\mathrm{CS}(p_c, p_s)$, distinguishing between the surplus that the passengers gain from the consumption of core and side services, $\mathrm{CS}_t(p_c, p_s)$, and the surplus that non-travellers gain from the consumption of side services, $\mathrm{CS}_{nt}(p_c, p_s)$:

$$\begin{aligned} \mathrm{CS}_t(p_c, p_s) = \frac{1}{(1+l)(1+k)}&\left(\int_{-l}^{1}\int_{p_c}^{1}(v_c-p_c)dv_c dv_s \right. \\ &+ \int_{p_s}^{1}\int_{p_c-\delta a}^{p_c}(v_c-p_c)dv_c dv_s + \int_{p_s-a}^{p_s}\int_{p_c-\delta(v_s+a-p_s)}^{p_c}(v_c-p_c)dv_c dv_s \\ &\left. + \int_{p_c-\delta a}^{1}\int_{p_s}^{1}(v_s+a-p_s)dv_s dv_c + \int_{p_c-\delta(v_s+a-p_s)}^{1}\int_{p_s-a}^{p_s}(v_s+a-p_s)dv_s dv_c\right) \end{aligned} \tag{23}$$

$$\mathrm{CS}_{nt}(p_c,p_s) = \frac{1}{(1+l)(1+k)}\left(\int_{-k}^{p_c-\delta a}\int_{p_s}^{1}(v_s - p_s dv_s dv_c\right) \tag{24}$$

where $\mathrm{CS}(p_c,p_s) = \mathrm{CS}_t(p_c,p_s) + \mathrm{CS}_{nt}(p_c,p_s)$.

Let W^* be the equilibrium social welfare obtained plugging in airport optimal charges described in (15) in equation (22), i.e., $W^* = W(p_c^*,p_s^*)$. Moreover, let CS_t^* and CS_{nt}^* be the equilibrium travellers and non-travellers surplus respectively, obtained plugging in airport optimal charges described in (19) in equations (23) and (24), i.e., $CS_t^* = CS_t(p_c^*,p_s^*)$ and $CS_{nt}^* = CS_{nt}(p_c^*,p_s^*)$. The following proposition illustrates how social welfare and consumer surplus vary when the extra-surplus gained by travellers when consuming core and side goods together varies.

Proposition 7 Let $W^*$and CS^* be the equilibrium social welfare and consumer surplus, respectively. Moreover, let CS_t^* and CS_{nt}^* be the equilibrium travellers and non-travellers surplus, respectively. Then:

(i) Social welfare: $\partial W^*/\partial a \geq 0$;

(ii) Consumer surplus: $\partial CS^*/\partial a \geq 0$. However, $\partial CS_t^*/\partial a \geq 0$ while $\partial CS_{nt}^*/\partial a \leq 0$.

The proof of the Proposition can be found in the Appendix.

When $\delta = 0$, (i.e., the basic model holds) results can be explained on the basis of Proposition 1 and Lemma 1. As a increases, p_s increases, which has a negative effect on social welfare and on non-travellers surplus, since it causes a reduction of the demand for side services. However, there is a direct positive effect on social welfare and on traveller surplus thanks to the increase in the induced demand from those individuals who would have not bought side services if not traveling. In addiction, the reduction of p_c positively contributes to social welfare and on traveller surplus, but reduces the demand for side services from non-travellers. Similarly, as δ increases results can be explained on the basis of Proposition 5[23].

[23] It can be demonstrated that at the optimum, an increase in travelers' foresight induces higher social welfare, i.e., $\partial W^*/\partial \delta \geq 0$. However, $\forall (a,k,l) \in I_\delta$ $\exists \delta^*(a,k,l)$ such that $\forall \delta, 0 \leq \delta \leq \delta^*(a,k)$ $\partial CS^*/\partial \delta \geq 0$, while $\partial CS^*/\partial \delta \leq 0$ $\forall \delta, \delta^*(a,k) < \delta \leq 1$. The proof is available from the authors, but the intuition can be easily derived from Propositions 2 and 3. While social welfare always increases when the degree of travelers foresight increases, consumers surplus may also decreases if travelers are sufficiently forward looking, depending on the extra-surplus enjoyed by travelers when consuming core and side services together.

Results in Proposition 7 allow us to draw some important policy implications. As noted in previous sections, the degree of extra-surplus gained by travellers from side services at the airport is assumed to be exogenous in our model but it could be affected by the airport, for instance with an appropriate mix choice of side products. In particular, we show that moving the side product mix towards a more travellers-oriented business (to increase a) may actually be very profitable (see Proposition 6). In this scenario, our model dictates that social welfare and travellers surplus would increase but such positive effects occur to the detriment of non-travellers, who find themselves to pay a higher price for side products. Thus, policy makers might be aware that, although airport strategies may be valuable for the society, a group of individuals might end up to be worst off.

6. Concluding remarks

In this paper, we focused on the issue of multiproduct pricing of core and side services in the case of airport cities, when side goods, supplied within the terminal, before security screenings, or in the surrounding land parcels owned by the airport authority, are available to two groups of customers: travellers and non-travellers. In fact, the air transport economics literature has always abstracted away from this issue and uses to rely on the assumption that only travellers can purchase concession services at the airport (though they may abstain from consuming any of these services). However, the spread of the airport city model throughout the world has demonstrated that this is no longer the case.

We find that, when side activities are dependent of core prices because of the presence of non-travellers demand for concession services (and travellers do enjoy an extra surplus when buying core and side services together), the side business may not unambiguously exert downward pressure on the private aviation charge. In particular, when individuals make decisions about buying core and side goods independently, the facility charges higher core price (lower side price) with respect to the case in which the side good is consumed by passengers only, which might be also observed when the degree of foresight is sufficiently low. Literature on one-side complementarity between core and side services used to abstract away from this mechanism, since demand for side services had been assumed to come from travellers only and, thus, to be a decreasing function of core prices. However, we proved that common results in one-side complementarity literature may not hold when non-travellers demand for side services exists and is an increasing function of core prices. Policy makers should be aware of such results when questioning Starkie's (2002) conjecture and deciding on the need for heavy-handed airport regulation. Morever, we find that welfare and traveller surplus would increase in our setting, whatever is the level of consumer foresight, but such positive effects occur to the detriment of non-travellers, who find themselves to pay a higher price for side products. Thus, policy makers might be aware that, although airport strategies may be valuable for the society, a group of individuals might end up being worst off.

As noted, a thorough analysis of the issue examined in this paper would have to account for other forces that are peculiar of airport infrastructures and it is difficult to include them in a tractable model. We have discussed the implications of airline market power and airline market structure, as well as a preliminary attempt to take into account the fact that side services sold airside, i.e., after passport control are only available to travellers, while side services sold landside within the terminal or in the surrounding land parcels are available to both travellers and non-travellers. Further developments of this paper should also cover some specific issues. First, concession services provider market structure has not been investigated. Whether the airport should allow for several concessions for similar services or should it award only very few concessions per type of service (thus enhancing the revenues that can be extracted from firms bidding for the concessions) may have endogenously an impact on the extra-surplus that travellers enjoy when consuming core and side services together. Second, we have not modeled competition from outside retailers. In our model, the surplus that non-travellers may gain from the outside option is exogenous. In fact, non-travellers decide whether to buy side services within the airport city or from other service providers, i.e., the surplus that non-travellers may gain from the outside option is endogenous and may depend on the market structure and offer of outside retailers. In particular, when a monopolist in a primary market (e.g., the airport) competes with a rival in a complementary market (e.g., an outside concession service provider) joint offers of core and side services may have implications on social welfare, in terms of competition and – if endogenous – quality investments[24]. Finally, we remark that as long as airports evolve into real airport cities, an increase in vehicle traffic and use of public transport to the infrastructure site, particularly over the first several weekends of operation, might be anticipated, as both passengers and regional shoppers visit the outlet centers[25]. Thus, negative externalities such as congestion should be taken into account in the model to figure out a comprehensive transportation plan that would address additional vehicle traffic, limit impacts to airport operations and maintain the safety of all visitors and employees, e.g., alternate routes, additional parking locations and the use of shuttles.

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[24] For a valid analysis of this issue in the case of bundling see Avenali et al. (2013) and references therein.
[25] See, for instance, http://www.yvr.ca/en/business-at-yvr/mcarthurglendesigneroutletvancouverairport.aspx

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References

ACI (2008), ACI Airport Economics Survey 2008, Montreal, QC: Airports Council International (ACI).

ATRS (2014). The ATRS (Air Transport Research Society) Airport Performance Benchmarking Report: Global Standards for Airport Excellence, 3-volume report, published by the Center for Transportation Studies, Sauder School of Business, University of British Columbia, Vancouver, BC.

Adey, P., 2006. Airports and air-mindedness: Spacing, timing and using the Liverpool Airport, 1929–1939, Social and Cultural Geography, 7, pp. 343–363

Appold, S.J., and Kasarda, J.D., 2006. The appropriate scale of US airport retail activities. Journal of Air Transport Management, 12, 277-287.

Appold, S. J., Kasarda, J. D., 2013. The Airport City phenomenon: Evidence from large US airports. Urban Studies, 50(6), 1239-1259.

Avenali, A., D’Annunzio, A., Reverberi, P., 2013. Bundling, competition and quality investment: a welfare analysis. Review of Industrial Organization, 43(3), 221-241.

Baron, S., Wass, K., 1996. Towards an understanding of airport shopping behaviour. International Review of Retail, Distribution and Consumer Research, 6(3), 301-322.

Brown, G., 1992. Tourism and symbolic consumption’, in P. Johnson and B. Thomas (eds), Choice and Demand in Tourism, Mansell, London, 51–71.

Bracaglia, V., D’Alfonso, T., Nastasi, A., 2014. Competition between multiproduct airports. Economics of Transportation, 3(4), 270-281.

Brueckner, J., 2003. Airline traffic and urban economic development. Urban Studies, 40: 1455–1469.

Business Vancouver, 2015. Richmond's McArthurGlen mall named world's best outlet centre. Available at: https://www.biv.com/article/2015/11/richmonds-mcarthurglen-mall-named-worlds-best-outl/

Castillo-Manzano, J. I., 2010. Determinants of commercial revenues at airports: Lessons learned from Spanish regional airports. Tourism Management, 31(6), 788-796.

Cidell, J., 2014. The role of major infrastructure in subregional economic development: an empirical study of airports and cities. Journal of Economic Geography, lbu029.

Crawford, G., Melewar, T. C., 2003. The importance of impulse purchasing behaviour in the international airport environment. Journal of Consumer Behaviour, 3(1), 85-98.

Czerny, A.I., 2006. Price-cap regulation of airports: single-till versus dual-till. Journal of Regulatory Economics, 30(1), 85-97.

Czerny, A.I., 2013. Public versus private airport behavior when concession revenues exist. Economics of Transportation 2, 38-46.

Czerny, A. I., Lindsey, R., 2014. Multiproduct Pricing with Core Goods and Side Goods. Mimeo, University of British Columbia.

Czerny, A. I., Zhang, A., 2015. Single-till versus dual-till regulation of airports (No. 15-049/VIII). Tinbergen Institute.

Czerny, A. I., Shi, Z., Zhang, A., 2015. Can market power be controlled by regulation of core prices alone?: An empirical analysis of airport demand and car rental price. Mimeo, VU Free University of Amsterdam.

Davies, G., 1995. Bringing stores to shoppers-not shoppers to stores. International Journal of Retail & Distribution Management, 23(1), 18-23.

D'Alfonso, T., Nastasi, A., 2014. Airport–Airline interaction: some food for thought. Transport Reviews, 34(6), 730-748.

D'Alfonso, T., Jiang, C., Wan, Y., 2013. Airport pricing, concession revenues and passenger types. Journal of Transport Economics and Policy 47(1), 71 – 89.

Doganis, R., 1992. The airport business. New York:Routledge.

Dube, L., Menon, K., 2000. Ensuring greater satisfaction by engineering salesperson response to customer emotions. Journal of Retailing, 76, 285–308

Ellison, G., 2005. A model of add-on pricing. Quartely Journal of Economics, 120 (2), 585–637.

Euromonitor International, 2006. Airports as malls: Everyday beauty brands enter travel retail. Available at: http://www.marketresearchworld.net/content/view/830/77/

Fernie,1995. The coming of the fourth wave: new forms of retail out of town development. International Journal of Retail & Distribution Management, 23 (1), 4 - 11.

Flores-Fillol, R., Iozzi, A., Valletti, T., 2015. Platform pricing and consumer myopia: The case of airports. Mimeo.

Fogelson, R.M., 2005. Downtown, Its Rise and Fall, 1880–1950. New Haven: Yale University Press

Freestone, R., Baker, D., 2010. Challenges in land use planning around Australian airports. Journal of Air Transport Management, 16(5), 264-271.

Gehrig, T., 1998. Competing Markets. European Economic Review, 42, 277–310

Geuens, M., Vantomme, D., Brengman, M., 2004. Developing a typology of airport shoppers. Tourism Management, 25(5), 615-622.

Gillen, D., 2011. The evolution of airport governance and ownership. Journal of Air Transport Management 17 (1), 3-13.

Gillen, D. and B. Mantin, 2012. Transportation infrastructure management: One and two sided market approaches. Journal of Transport Economics and Policy 47 (2), 207-227.

Gould, E. D., Pashigian, B. P., Prendergast, C. J., 2005. Contracts, externalities, and incentives in shopping malls. Review of Economics and Statistics, 87(3), 411-422.

Graham, A., 2013. Managing Airports 4th Edition: An International Perspective. New York:Routledge.

Halpern, N., Graham, A., 2013. Airport Marketing. New York: Routledge.

Henseler, M., 2013. Single–till versus dual–till regulation of railway stations. International Journal of Management and Network Economics, 3(1), 78-93.

Huang, W. H., Kuai, L., 2006. The in-flight shopper. Journal of air transport management, 12(4), 207-211.

Ivaldi, M., S. Sokullu, and T. Toru, 2012. Are airports two-sided platforms? A methodological approach. In J. Peoples (Ed.), Advances in airline economics: Pricing behavior and non-price characteristics in the airline industry. Bingley: Emerald Group Publishing.

Jarach, D., 2001. The evolution of airport management practices: towards a multi-point, multi-service, marketing-driven firm. Journal of air transport management, 7(2), 119-125.

Jarach, D., 2005. Airport Marketing. Burlington: Ashgate Publishing.

Jones, I., Vieho, I., Marks, P., 1993. The economics of airports slot. Fiscal Studies 14, 37-57.

Kasarda, J., 2001. From airport city to aerotropolis. Airport world.

Kasarda, J. D., 2008. Shopping in the airport city and aerotropolis. Research Review, 15(2), 50-56.

Kramer, L. S., 2010. Airport Revenue Diversification (Vol. 19). Transportation Research Board. Available at: http://onlinepubs.trb.org/onlinepubs/acrp/acrp_syn_019.pdf

Kasarda, J. D., Appold, S. J., 2014. Planning a Competitive Aerotropolis. Advances in Airline Economics, 4, 281-308.

Kratzsch, U., Sieg, G., 2011. Non-aviation revenues and their implications for airport regulation. Transportation Research Part E 47, 755-763.

Levitt, T., 1980. Marketing success through differentiation — of anything. Harvard Business Review 58, 83–91.

Lin, Y. H., Chen, C. F., 2013. Passengers' shopping motivations and commercial activities at airports–The moderating effects of time pressure and impulse buying tendency. Tourism Management, 36, 426-434.

Luică, P., 2011. Shopping trip at rail stations. Railway Pro, Vol. 4.12, No. 78, p.35. Available at: http://www.railwaypro.com/wp/?p=7474

Mathews, G., Lui, T. L., 2001. Consuming Hong Kong (Vol. 1). Hong Kong University Press.

Morrison, W. G., 2009. Real estate, factory outlets and bricks: A note on non-aviation activities at commercial airports. Journal of Air Transport Management, 15(3), 112-115.

Mussa M., Rosen S., 1978. Monopoly and Product Quality. Journal of Economic Theory 18, 301-307.

Orth, H., Frei, O., Weidmann, U., 2015. Effects of non-aviation activities at airports on the public transport access system: A case study of Zurich Airport. Journal of Air Transport Management, 42, 37-46.

Oum, T.H., Zhang, A., Zhang, Y., 2004. Alternative forms of economic regulation and their efficiency implications for airports. Journal of Transport Economics and Policy 38(2), 217-246.

Perng, S. W., Chow, C. C., and Liao, W. C., 2010. Analysis of shopping preference and satisfaction with airport retailing products. Journal of Air Transport Management, 16(5), 279-283.

Poungias, P., 2009. Airport city developments: An airport investor's perspective. Journal of Airport Management, 4(1), 14-22.

Reiss, B., 2007. Maximising non-aviation revenue for airports: Developing airport cities to optimise real estate and capitalise on land development opportunities. Journal of Airport Management, 1(3), 284-293.

Smith, H., Hay, D., 2005. Streets, malls, and supermarkets. Journal of Economics & Management Strategy, 14(1), 29-59.

Starkie, D., 2001. Reforming UK airport regulation. Journal of Transport Economics and Policy, 35, 119-135.

Starkie, D., 2002. Airport regulation and competition. Journal of Air Transport Management 8, 63-72.

Sulzmaier, S., 2001. Consumer Oriented Business Design: The Case of Airport Management; with 108 Tables. Springer.

TechInsider Innovation, 2015. The 10 most innovative airports in the world, December, 8, 2015.

The Economist, 2013. What is an aerotropolis?. December, 11, 2013.

The Economist, 2015a. Aerotropolitan ambitions. March, 14, 2015.

The Economist, 2015b. Flying High. Why Buying airports has taken off. June, 6, 2015.

The Indianapolis Business Journal, 2009. Airport retailers want relief from street pricing policy , November 21, 2009.

The Province, 2015. New Vancouver airport outlet mall announces list of 46 retailers, looking to hire 600. May 13, 2015.

The New York Times, 2010. The Aerotropolis. December 10, 2010.

The New York Times, 2011a. To fly or to walk. May 16, 2011.

The New York Times, 2011b. The airport experience now includes shopping for the family. August 1, 2011.

The Wall Street Journal, 2011. Cities of the Sky. February 26, 2011.

The Wall Street Journal, 2015. The price you pay for water at the airport. April 22, 2015.

Thompson, B., 2007. Airport retailing in the UK. Journal of Retail and Leisure Property 6, 203–211.

Waguespack, B., 2015. A Research Note on Street Pricing Requirements in Major US Airport Retail Concessions Requests for Proposals.

Wang, K. J., Hong, W. C., 2011. Competitive advantage analysis and strategy formulation of airport city development—The case of Taiwan. Transport Policy, 18(1), 276-288.

Verboven, F., 1999. Product line rivalry and market segmentation with an application to automobile industry. Journal of Industrial Economics 47(49), 399-425.

Vlitos Rowe, I. (ed.), 1999. The Future of Duty-free Retailing. Developments and Trends in Europe and the Middle East, Financial Times Retail and Consumer Publishing, London.

Yang, H., Zhang, A., 2011. Price-cap regulation of congestion airports. Journal of Regulatory Economics 39(3), 293-312.

Zhang, A., Czerny, A.I., 2012. Airports and airlines economics and policy: An interpretive review of recent research. Economics of Transportation 1(1-2), 15 – 34.

Zhang, A., Zhang, Y., 1997. Concession revenue and optimal airport pricing. Transportation Research Part E: Logistics and Transportation Review, 33(4), 287-296.

Zhang, A., Zhang, Y., 2003. Airport charges and capacity expansion: effects of concessions and privatization. Journal of Urban Economics 53(1), 54-75.

Zhang, A., Zhang, Y., 2010. Airport capacity and congestion pricing with both aviation and commercial operations. Transportation Research Part B 44(3), 404 – 413.

Appendix

To save notation we resort on $\hat{x}$ to indicate the elements $(a, \delta, k, l) \in I_\delta$.

Proof of Proposition 3

$\partial p_s^*/\partial a \geq 0$ when $\delta = 0$ and $\partial^2 p_s^*/\partial a \partial \delta \geq 0 \;\; \forall \hat{x} \in I_\delta \Rightarrow \; \partial p_s^*/\partial a \geq 0 \; \forall \delta$.

$\partial p_c^*/\partial a < 0 \;\; \forall 0 \leq \delta \leq 1/3, \; \partial p_c^*/\partial a > 0$ when $\delta = 1$ and $\partial^2 p_c^*/\partial a \partial \delta \geq 0 \;\; \forall \hat{x} \in I_\delta$. Statements from (i) to (iii) follow.

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Proof of Proposition 4

It is straightforward to check that ,$\partial p_c^*/\partial l|_{a=0} = 0$ and $\partial p_s^*/\partial l|_{a=0} = 0$.

Statements from (ii) to (iv) follow from:

$\partial p_c^*/\partial l > 0 \; \forall 0 \leq \delta \leq 1/2, \; \partial p_c^*/\partial l < 0$ when $\delta = 1$ and $\partial^2 p_c^*/\partial l \partial \delta \leq 0 \;\; \forall \hat{x} \in I_\delta$.

$\partial p_s^*/\partial l < 0 \; \forall 0 \leq \delta \leq 1/2, \; \partial p_c^*/\partial l > 0$ when $\delta = 1$ and $\partial^2 p_c^*/\partial l \partial \delta \geq 0 \;\; \forall \hat{x} \in I_\delta$.

$(\partial p_c^*/\partial l)(\partial p_s^*/\partial l) \leq 0$

∎

Proof of Proposition 6

The proof follows immediately given that:

(i) $\pi_a^* \geq 0$ when $k = 1$ and $\partial \pi_a^*/\partial k \geq 0 \; \forall \hat{x} \in I_\delta$;

(ii) $\pi_{s,a}^* \geq 0$ when $l = 1$. Moreover, it results $\partial \pi_{s,a}^*/\partial l \geq 0 \;\; \forall \hat{x} \in I_\delta$. Indeed, let $\pi_{s,a,l}^*$ denote $\partial \pi_{s,a}^*/\partial l$. It results: $\pi_{s,a,l}^* \geq 0$ when $l = 1$, $\partial \pi_{s,a,l}^*/\partial l\big|_{l=1} \geq 0$ and $\partial^2 \pi_{s,a,l}^*/\partial^2 l \geq 0 \;\; \forall \hat{x} \in I_\delta$; $\pi_{s,nt,a}^* \leq 0$ when $l = 1$, $\partial \pi_{s,nt,a}^*/\partial l\big|_{l=1} \leq 0$, $\partial^2 \pi_{s,nt,a}^*/\partial^2 l\big|_{l=1} \leq 0$, $\partial^3 \pi_{s,nt,a}^*/\partial^3 l\big|_{l=1} \leq 0$ and $\partial^4 \pi_{s,nt,a}^*/\partial^4 l \leq 0 \; \forall \hat{x} \in I_\delta$;

$\pi_{s,a}^* = \pi_{s,nt,a}^* + \pi_{s,t,a}^*$, which implies that $\pi_{s,t,a}^* = \pi_{s,a}^* - \pi_{s,nt,a}^* \geq 0 \; \forall \hat{x} \in I_\delta$;

(iii)-(iv) $\pi_{c,a}^* \leq 0$ when $\delta = 0$ and $\pi_{c,a}^* \geq 0$ when $\delta = 1 \; \forall \hat{x} \in I_\delta$;. Moreover, it results $\pi_{c,a}^*/\partial \delta \geq 0$ $\forall \hat{x} \in I_\delta$;. Let $\pi_{c,a,\delta}^*$ denote $\partial \pi_{c,a}^*/\partial \delta$. It results: $\pi_{c,a,\delta}^* \geq 0$ when $k = 1$, $\partial \pi_{c,a,\delta}^*/\partial k\big|_{k=1} \geq 0$ and $\partial^2 \pi_{c,a,\delta}^*/\partial^2 k \geq 0 \; \forall \hat{x} \in I_\delta$.

■

Proof of Proposition 7

The proof follows immediately given that:

(i) $W_a^* \geq 0$ when $k = 1$, $\partial W_a^*/\partial k|_{k=1} \geq 0$, $\partial^2 W_a^*/\partial^2 k|_{k=1} \geq 0$ and $\partial^3 W_a^*/\partial^3 k \geq 0$ $\forall \hat{x} \in I_\delta$;

(ii) $CS_a^* \geq 0$ when $k = 1$, $\partial CS_a^*/\partial k|_{k=1} \geq 0$, $\partial^2 CS_a^*/\partial^2 k|_{k=1} \geq 0$ and $\partial^3 CS_a^*/\partial^3 k \geq 0$ $\forall \hat{x} \in I_\delta$;

$CS_{nt,a}^* \leq 0$ when $k = 1$, $\partial CS_{nt,a}^*/\partial k\big|_{k=1} \leq 0$, $\partial^2 CS_{nt,a}^*/\partial^2 k\big|_{k=1} \leq 0$, $\partial^2 \partial^3 CS_{nt,a}^*/\partial^3 k\big|_{k=1} \leq 0$ and $\partial^4 CS_{nt,a}^*/\partial^4 k \geq 0$ $\forall \hat{x} \in I_\delta$;

(iv) $CS_a^* = CS_{nt,a}^* + CS_{t,a}^*$, which implies that $CS_{t,a}^* = CS_a^* - CS_{nt,a}^* \geq 0$ $\forall \hat{x} \in I_\delta$;

where $W_a^* = \partial W^*/\partial a$, $CS_a^* = \partial CS^*/\partial a$, $CS_{nt,a}^* = \partial CS_{nt}^*/\partial a$ and $CS_{t,a}^* = \partial CS_t^*/\partial a$.

■

List of figures

Figure 1

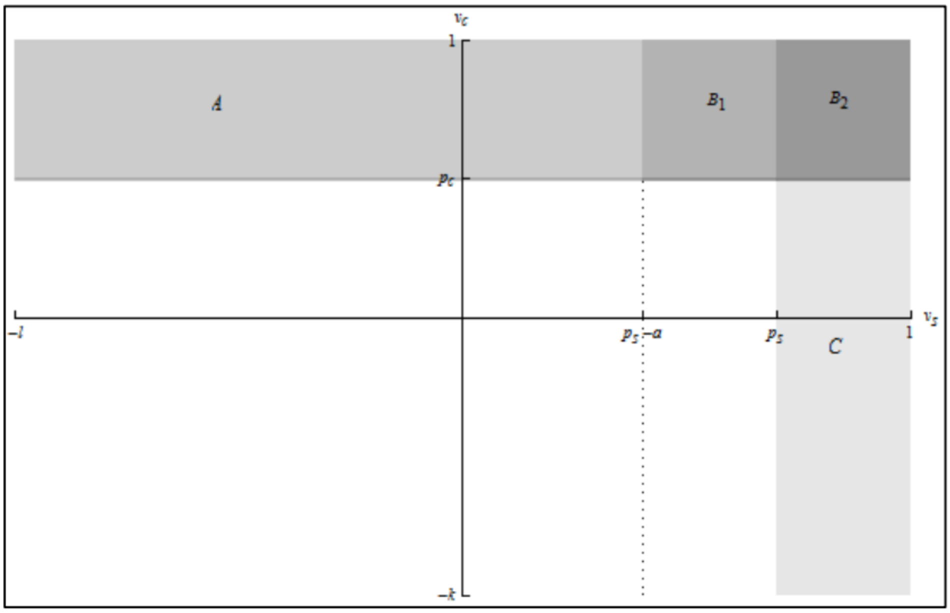

Fig. 1 One-side complementarity: the structure of the demand function.

Figure 2

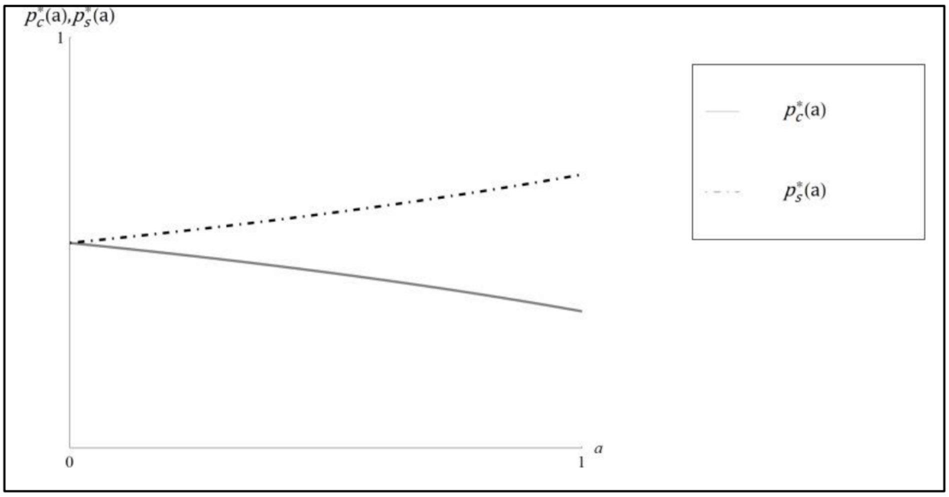

Fig. 2 The effect of a on optimal charges under the assumption of one-side complementarity (when $\boldsymbol{l = 1, k = 10}$*)*[26]

Figure 3

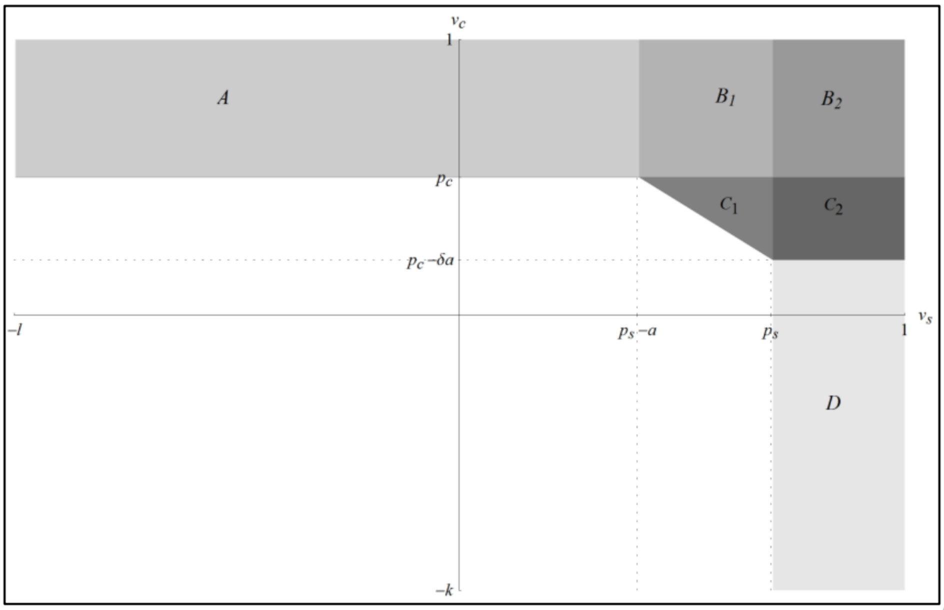

Fig. 3 Two-side complementarity: the structure of the demand function

[26] Figure 2 and the following plots have been realized setting $l = 1$ and $k \gg 1$ (i.e., $k = 10$). The reason is that it is assumed that the maximum negative valuation for side services is lower (in absolute value) than the maximum negative valuation for core services. This assumption seems quite plausible, since the primary intent is to travel.

Figure 4

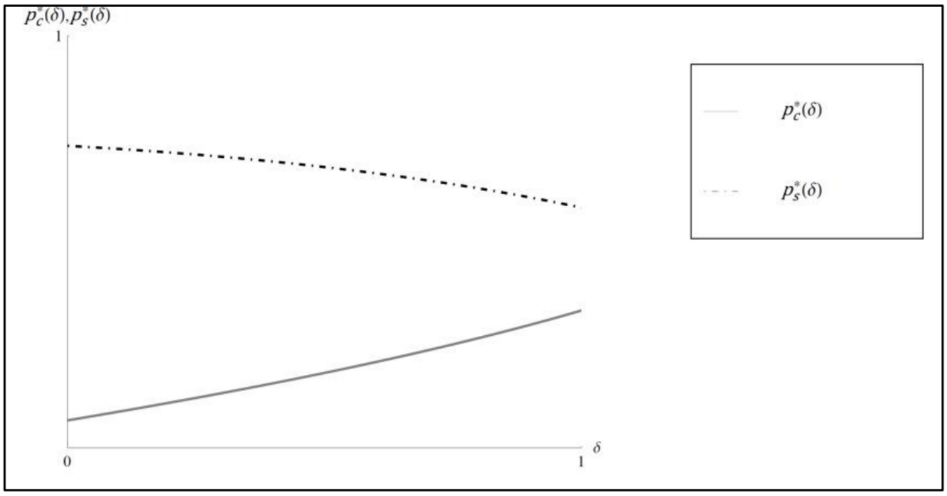

Fig. 4 The effect of $\boldsymbol{\delta}$ *on optimal charges under the assumption of two-side complementarity (when* $\boldsymbol{l = 1, k = 10}$)

Figure 5

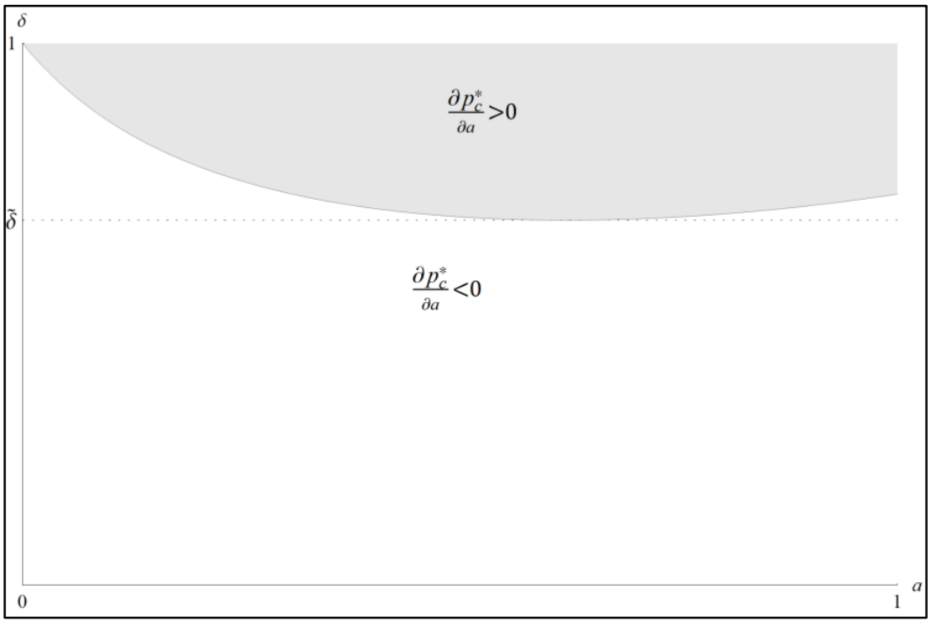

Fig. 5 The joint effect of $\boldsymbol{a}$ *and* $\boldsymbol{\delta}$ *on optimal charges under the assumption of two-side complementarity (when* $\boldsymbol{l = 1, k = 10}$)

Figure 6

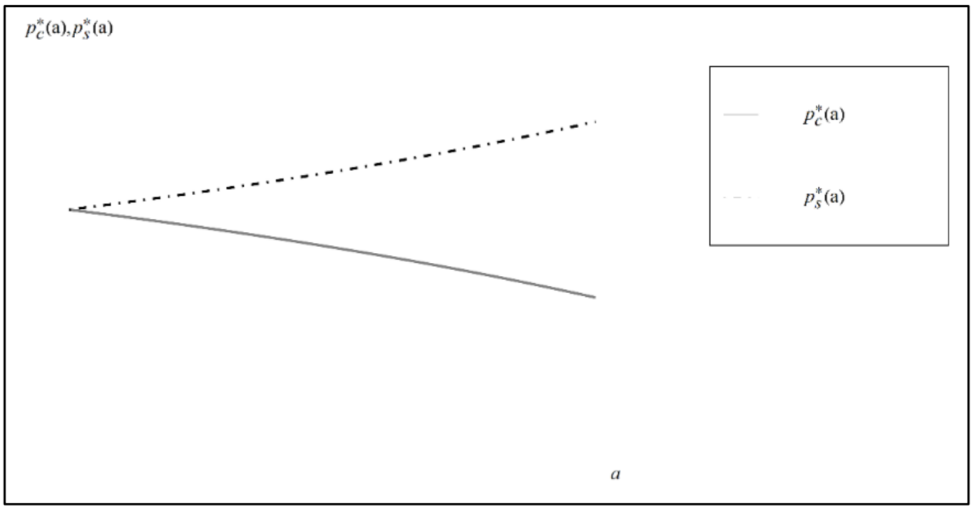

Fig. 6 The joint effect of $\boldsymbol{a}, \boldsymbol{l}$ *and* $\boldsymbol{\delta}$ *on optimal charges under the assumption of two-side complementarity (when* $\boldsymbol{k} = \mathbf{10}$)

List of tables

Table 1

Panel a ($a = 0$)

	$p_c^{H,\delta}$	$p_s^{H,\delta}$	$p_c^{H,\delta} - \mathrm{p}_\mathrm{c}^*$	$p_s^{H,\delta} - p_s^*$
$\delta = 0.00$	*0.438*	*0.500*	< 0	$= 0$
$\delta = 0.10$	*0.441*	*0.469*	< 0	< 0
$\delta = 0.20$	*0.446*	*0.439*	< 0	< 0
$\delta = 0.30$	*0.453*	*0.408*	< 0	< 0
$\delta = 0.40$	*0.461*	*0.378*	< 0	< 0
$\delta = 0.50$	*0.470*	*0.349*	< 0	< 0
$\delta = 0.60$	*0.480*	*0.319*	< 0	< 0
$\delta = 0.70$	*0.493*	*0.290*	< 0	< 0
$\delta = 0.80$	*0.506*	*0.262*	> 0	< 0
$\delta = 0.90$	*0.522*	*0.233*	> 0	< 0
$\delta = 1.00$	*0.544*	*0.203*	> 0	< 0

Panel b ($a = 1/2$)

	$p_c^{H,\delta}$	$p_s^{H,\delta}$	$p_c^{H,\delta} - \mathrm{p}_\mathrm{c}^*$	$p_s^{H,\delta} - p_s^*$
$\delta = 0.00$	*0.359*	*0.750*	< 0	> 0
$\delta = 0.10$	*0.368*	*0.707*	< 0	> 0
$\delta = 0.20$	*0.379*	*0.666*	< 0	> 0
$\delta = 0.30$	*0.392*	*0.625*	< 0	> 0
$\delta = 0.40$	*0.408*	*0.585*	< 0	> 0

$\delta = 0.50$	*0.427*	*0.544*	< 0	$> 0\ if\ k > 1.322$ $< 0\ if\ k \leq 1.322$
$\delta = 0.60$	*0.449*	*0.504*	< 0	$> 0\ if\ k > 24.786$ $< 0\ if\ k \leq 24.786$
$\delta = 0.70$	*0.475*	*0.462*	< 0	< 0
$\delta = 0.80$	*0.504*	*0.418*	> 0	< 0
$\delta = 0.90$	*0.539*	*0.370*	> 0	< 0
$\delta = 1.00$	*0.581*	*0.317*	> 0	< 0

Panel c ($a = 1$)

	$p_c^{H,\delta}$	$p_s^{H,\delta}$	$p_c^{H,\delta} - \mathrm{p}_\mathrm{c}^*$	$p_s^{H,\delta} - p_\mathrm{s}^*$
$\delta = 0.00$	*0.250*	*1.000*	< 0	> 0
$\delta = 0.10$	*0.264*	*0.951*	< 0	> 0
$\delta = 0.20$	*0.282*	*0.903*	< 0	> 0
$\delta = 0.30$	*0.304*	*0.855*	< 0	> 0
$\delta = 0.40$	*0.330*	*0.807*	< 0	> 0
$\delta = 0.50$	*0.361*	*0.758*	< 0	> 0
$\delta = 0.60$	*0.397*	*0.706*	< 0	> 0
$\delta = 0.70$	*0.440*	*0.650*	< 0	> 0
$\delta = 0.80$	*0.493*	*0.586*	< 0	$> 0\ if\ k > 1.537$ $< 0\ if\ k \leq 1.537$
$\delta = 0.90$	*0.562*	*0.507*	$< 0\ if\ k > 1.374$ $> 0\ if\ k \leq 1.374$	$> 0\ if\ k > 22.606$ $< 0\ if\ k \leq 22.606$
$\delta = 1.00$	*0.667*	*0.391*	> 0	< 0

Table 1 Comparison between optimal charges when $\boldsymbol{a = 0}$ *(Panel a),* $\boldsymbol{a = 1/2}$ *(Panel b) and* $\boldsymbol{a = 1}$ *(Panel c), with* $\boldsymbol{l = 1}$. $\boldsymbol{p_c^*}$ *and* $\boldsymbol{p_s^*}$ *are the optimal charges that the airport levies when the side good may also be purchased by non-travellers. Conversely,* $\boldsymbol{p_c^{H,\delta}}$ *and* $\boldsymbol{p_s^{H,\delta}}$ *are the optimal charges that the airport levies when the side good may only be purchased by travellers.*