

Airport Pricing and Concession Revenues

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Abstract

This paper considers a congested airport that provides aeronautical services to airlines and concessions to retailers or, respectively, car rental companies. It is shown that airport retailers exert downward pressure on the private aeronautical charge. On the other hand, the effect of car rentals on the private aeronautical charge is ambiguous. By contrast, the first-best airfare and aeronautical charge are independent of retail profits, while they are positively related to car rentals. Finally, the comparison of private and welfare-oriented airport behavior shows that private behavior can lead to the welfare-optimal outcome when commercial services exist.

JEL Classification: D42, D62, L12, L93, R41, R48.

Keywords: Airport pricing, concessions, retail services, car rentals, congestion.

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1 Introduction

A growing number of airports are fully or partially privatized, and airport privatization is almost always accompanied by some form of price regulation. This is because airports are assumed to possess monopolistic market power in the area of aeronautical services, which includes the supply of runway, terminal, and parking capacity for aircraft.¹ There are specific characteristics of airports that, potentially, reduce the benefits or regulation, however. First, many airports are scarce in runway and terminal capacity, which leads to congestion; in this situation, increased airport charges limit the demand for airport capacity and delays, which can be positive from the regulator's viewpoint. Second, airport business areas comprise aeronautical *and* commercial services, which include retailing, advertising, car rentals, car parking, and land rents. Commercial airport services are relevant because they may reduce the incentives to charge a high price for aeronautical services, since this would reduce concession revenues. Today, the share of revenues from commercial services among airports worldwide has reached an average level of roughly 50% (ACI, 2008).²

There is an important difference between the types of commercial airport services on which this paper concentrates. Consider retail services and car rentals as examples. The overall demand for retail services is largely independent of travel activities. For example, the decision to consume food and beverages or buy clothing is not likely to depend much on whether individuals fly or not fly. This is different in the case of car rentals because the decision to rent a car may only be relevant in the case of traveling. In light of this ob-

¹For example, Bel and Fageda (2010) empirically analyze European airports and find that private, unregulated airports charge relatively high prices compared to public or regulated airports.

²Graham (2009) discusses the importance of commercial revenues to today's airports.

servation, the key contribution of this paper is to propose two airport models that can be used to investigate the mentioned difference between retail services and car rentals (retail services and car rentals may also represent other commercial service areas such as car parking or advertising). The analysis may therefore provide a more complete picture of the relationship between aeronautical and commercial business areas in practice. The insights may also contribute to a better understanding of the conflicts of interest between private airports and regulators.

The first model concentrates on retail services and abstracts away from car rentals. In this model, retailers earn a given profit per passenger, which depends on the retailers' degree of localized market power. More importantly, the *overall* consumption of retail services is considered to be independent of traveling activities (i.e. passenger numbers), and passenger numbers are considered to be independent of airport retail services as well. The second model concentrates on car rentals and abstracts away from retailers. In this model, the overall number of car rentals depends on the airport car rental charge (which is part of the concession contracts and determined by the airport authority) and on passenger numbers. Moreover, passenger numbers depend on the airport car rental charge, which is in contrast to retail services.

Both models include a congested airport that provides aeronautical services to airlines and concessions to retailers or, respectively, car rental companies. Furthermore, the rents of concessionaires are completely captured by the airport via take-it-or-leave offers for concessions.³ Each model is then used to analyze two scenarios: (i) a private airport that chooses airport charges to maximize airport profit; (ii) a welfare-oriented airport that

³This assumption is not entirely realistic because concessionaires may earn some rents in practice; however, it simplifies the strategic relationship between the airport and concessionaires and should not effect the main insights obtained in this paper.

maximizes a social objective function that is composed of the weighted sum of consumer surplus and producer surplus. In these scenarios, airport and airline behavior is modeled as a two-stage game. In the first stage, the airport chooses airport charges. In the second stage, airlines are in Cournot competition.

The main insights are the following. The analysis of the private airport scenario shows that the private aeronautical charge is always reduced by retail profits when one abstracts away from car rentals. By contrast, the effect of car rentals on the private aeronautical charge can be positive or negative. This is because car rentals can shift passenger demand and exhibit downward pressure on the aeronautical charge at the same time. The total effect of car rentals on the private aeronautical charge is therefore ambiguous. Furthermore, in a full setting with airport retailers and car rentals, retailers can exert downward pressure on both the private aeronautical charge as well as the private car rental charge.

In the welfare-oriented airport scenario, the first-best aeronautical charge is independent of retail services and inversely related to airline market shares. Moreover, the first-best car rental charge is independent of retail services as well, while car rentals increase the first-best aeronautical charge and also the first-best airfare. Note that the first-best car rental charge always lies below the costs of car rentals, which implies financial losses. Therefore, the aeronautical charge is increased to reduce passenger demand, which reduces the demand for airport car rentals and cuts financial losses in the car rental area. Finally, the comparison of private and welfare-oriented airport behavior shows that private behavior can lead to the first-best outcome when commercial services exist. The results presented here are partly consistent with the results obtained by other economists, but there are also differences.

Starkie (2001 and 2008) provides a graphical analysis and demonstrates that commercial services can exert downward pressure on the aeronautical charge of a private airport. Zhang and Zhang (2003 and 2010), Oum, Zhang and Zhang (2004) find the same relationship but, in addition, they find that, to maximize total surplus, the aeronautical charge should not fully internalize marginal congestion costs to passengers. In their context, this is to increase the surplus generated by commercial services. This result is in contrast to the results presented in this paper, where the first-best aeronautical charge is unrelated to retailing but increased by car rentals. Furthermore, Zhang and Zhang (2003 and 2010) find that the private aeronautical charge is always greater than the total surplus-maximizing charge; this is another result that stands in contrast to the results presented here, where commercial services can imply the first-best outcome.

Note that the mentioned authors consider a single, monopolistic commercial airport service; hence, the differences between commercial business areas and their specific market environments were not considered, and this is the reason for the discrepancy between their results and the results provided in this paper. In particular, they did not take into account that (i) the demand for commercial services can be independent of traveling and (ii) commercial services can have an effect on passenger demand. On the other hand, Czerny (2006) considers a model of an uncongested airport that provides aeronautical and commercial services. He finds that commercial services increase the aeronautical charge in the case of a private airport, as is consistent with the results presented in this paper. However, he does not consider retail services and therefore underestimates the downward pressure of commercial services on the aeronautical charge.

The relationship between airline market shares and the internalization of marginal congestion costs has already been investigated by Daniel (1995), Brueckner (2002), Pels and Verhoef (2004), Basso and Zhang (2008) and Brueckner and van Dender (2008). However, all mentioned studies concentrate on total surplus as the social objective function. By contrast, in this paper a general social objective function is considered that is composed of the weighted sum of consumer surplus and profits. The results are therefore informative for regulators who concentrate on total surplus and for regulators who give a greater relative weight to consumers.

The paper is organized as follows. Section 2 presents the model of an airport that provides aeronautical services and concessions to retailers. Section 3 analyzes equilibrium airline behavior, private airport behavior, first-best airport behavior and the conflicts of interest between a private airport and a regulator in a context with retail services. Retail services are replaced by car rental services in Section 4. Section 5 provides concluding remarks and a discussion of the results.

2 The Model

The supply side is described first. There is an airport that provides aeronautical services to airlines and concessions and shopping areas to commercial service providers. In the area of aeronautical services, the airport is a monopoly provider and charges a price $\tau \in \mathbb{R}$ per passenger to airlines, while per passenger costs are $c_1 \geq 0$. Denoting the number of passengers by $q_1 \geq 0$, airport revenues arising from aeronautical services are τq_1 and costs are $c_1 q_1$, which gives profits $(\tau - c_1)q_1$.

In the area of commercial services, the airport is a monopoly provider of concessions and captures all rents via take-it-or-leave-it offers to concessionaires. Suppose that only retailers are provided with concessions (retailers will be replaced by car rental companies in Section 4). Airport retail services include the supply of food and beverages, cigarettes, alcohol, electrical appliances and clothing and footwear (Thompson, 2007).

It is assumed that every consumer always buys one unit of retail services. As a consequence, the overall retail demand is independent of traveling activities and independent of retail prices at the airport.⁴ However, whether passengers will actually buy retail services at the airport depends on whether the airport mark-up on the competitive price that exists outside the airport area stays below a critical level.⁵ Furthermore, this critical level depends on the degree of airport retailers' localized monopoly power. Then, given that mark-ups are set at the critical level dictated by the degree of localized monopoly power, every passenger buys one unit of airport retail services and the per passenger profit from retail services is simply given by $\kappa \geq 0$. Letting “ R ” indicate the scenario with retail services (and without car rentals), total airport profit is

$$\Pi^R = (\tau + \kappa - c_1) q_1. \quad (1)$$

Runway and terminal capacity is limited so that traveling leads to congestion, which raises costs of passengers and airlines. Denote average congestion costs by $\Gamma(q_1) \geq 0$ with $\Gamma' > 0$ and $\Gamma'' \geq 0$. The airline market is oligopolistic

⁴In reality, the overall consumption of retail services may not be totally independent of traveling activities. However, the effect of airport retailers on the overall demand for retail services may be of second order from the policy viewpoint. This paper therefore concentrates on the observation that a part of the surplus generated at airports would also be generated when individuals decide against traveling.

⁵Passengers benefit from duty free sales, however. For example, roughly 25% of retail income was based on duty free sales at UK airports in 2006 (Thompson, 2007).

with $n \geq 1$ homogenous airlines in Cournot competition, and airline passenger numbers are denoted by $q_{i1} \geq 0$ with $i = 1, \dots, n$ and $\sum_i q_{i1} = q_1$. Airline costs, besides the aeronautical charge τ and congestion costs, are normalized to zero. Let $p_1 \in \mathbb{R}$ denote the airfare and $\alpha \in [0, 1]$ the share of congestion costs borne by airlines.

Turning to the demand side, travel benefits are denoted by $B^R(q_1)$ with $(B^R)'' < 0$ (where “ R ” indicates the retail scenario), and average congestion costs borne by passengers are $(1 - \alpha)\Gamma$. Note that traveling is associated with a disbenefit because passengers pay the competitive price for retail services outside the airport when they decide against traveling, while airport retailers charge a mark up. However, assume that this disbenefit is small enough so that it does not affect the passenger demand for airline services.⁶ Then, in demand equilibrium $(B^R)' = p_1 + (1 - \alpha)\Gamma$, where the right-hand side (RHS) is the “full price” of flying. Rearranging gives the inverse airline-passenger demand $P_1^R(q_1) = (B^R)' - (1 - \alpha)\Gamma$, which is independent of κ . Then, airline profits are

$$\pi_i^R = (P_1^R - \tau - \Gamma) q_{i1} \quad (2)$$

for all $i = 1, \dots, n$. Observe that airline profits are independent of α and, thus, the Cournot outcome is independent of α as well. This shows that the effect of congestion on passengers and carriers only depends on the total level of congestion costs but is independent of the distribution between passengers and carriers. Without loss of generality, one can therefore assume that congestion costs are fully borne by airlines (i.e. $\alpha = 1$).

⁶It could also be argued that booking is independent of airport retail prices because booking activities and the purchase of airport retail services are separated in time (Zhang and Zhang, 2003). Again, this can be realistic for relatively small disbenefits.

Since the overall consumption of retail services is independent of traveling and the disbenefits of consuming retail services at the airport are negligible, the consumer surplus generated by traveling is given by

$$CS^R = \int_0^{q_1} P_1^R(y) dy - q_1 P_1^R, \quad (3)$$

and the social objective function is

$$W^R = CS^R + \beta \left(\Pi^R - \kappa q_1 + \sum_i \pi_i^R \right) \quad (4)$$

with $\beta \in (0, 1]$.⁷ If $\beta = 1$, total surplus (sum of consumer surplus, the airport profit minus retail profits and airline profits) is relevant from the social viewpoint, and if $\beta \rightarrow 0$, it is only consumer surplus in (3).

Airport and airline behavior is modeled as a two-stage game. In the first stage, the airport chooses τ to maximize Π^R (in the case of a private airport) or W^R (in the case of welfare maximization). In the second stage, airlines simultaneously choose q_{i1} to maximize π_i^R . The game is solved by backward induction.

3 Aeronautical and Retail Services

In the second stage, equilibrium airline behavior is determined by the first-order conditions

$$\frac{\partial \pi_i^R}{\partial q_{i1}} = P_1^R - \tau - \Gamma + q_{i1} (P_1^R)' - q_{i1} \Gamma' = 0. \quad (5)$$

⁷The objective function in (4) is similar to the one investigated by Baron and Myerson (1982), except that subsidies or taxes are not considered.

Simultaneously solving the first-order conditions leads to the equilibrium behavior depending on τ , $q_{i1}^R(\tau)$. To ensure that the second order conditions are satisfied, assume that $(P_1^R)' + q_{i1}(P_1^R)'' < 0$ for all $i = 1, \dots, n$. It follows that $\partial q_{i1}^R(\tau)/\partial\tau < 0$ and $\partial q_1^R(\tau)/\partial\tau < 0$, since $q_1^R = nq_{i1}^R$; thus, an increase of the airport charge reduces passenger numbers. More specifically, symmetry implies

$$\frac{\partial q_1^R}{\partial\tau} = \frac{n}{(P_1^R)' - \Gamma' + n [(P_1^R)' + q_{i1}^R (P_1^R)'' - \Gamma' - q_{i1}^R \Gamma'']} < 0, \quad (6)$$

since $(P_1^R)' + q_{i1}(P_1^R)'' < 0$ for all $i = 1, \dots, n$ by assumption. Thus:

Lemma 1 *In the scenario with a congested airport that provides aeronautical services to airlines and concessions to retailers, there is a negative relationship between passenger numbers and the aeronautical charge.*

Substituting nq_{i1}^R for q_1 in the airport profit in (1) gives the airport profit depending on τ . In the first stage, the behavior of a private airport (which is indicated by superscript “ R, M ”) is then determined by the first-order condition

$$\frac{\partial \Pi^R}{\partial\tau} = (\tau^{R,M} + \kappa - c_1) \frac{\partial q_1^R}{\partial\tau} + q_1^R = 0, \quad (7)$$

where $q_1^R = nq_{i1}^R$. To ensure that the second order condition is satisfied, assume that $\partial^2 \Pi^R / \partial\tau^2 < 0$, which implies $\partial\tau^{R,M} / \partial\kappa < 0$. Hence:

Proposition 1 *In the scenario with a private and congested airport that provides aeronautical services to airlines and concessions to retailers, concession revenues exert downward pressure on the aeronautical charge.*

This proposition reproduces the results on the relationship between the aeronautical charge and concession revenues obtained by Starkie (2001 and 2008), Zhang and Zhang (2003 and 2010), and Oum, Zhang and Zhang (2004).

Turning to the first-best airport behavior, the social objective function depending on τ can be obtained by substituting q_{i1}^R for q_{i1} and q_1^R for q_1 in the social objective function in (4). The first-best optimal airport behavior is then determined by the first-order condition

$$\frac{\partial W^R}{\partial \tau} = \frac{\partial W^R}{\partial q_1} \cdot \frac{\partial q_1^R}{\partial \tau} \quad (8)$$

$$= \left[-q_1^R (P_1^R)' + \beta \left(P_1^R - c_1 - \Gamma - q_1^R \Gamma' + q_1^R (P_1^R)' \right) \right] \frac{\partial q_1^R}{\partial \tau} = 0, \quad (9)$$

where it is assumed that $\partial^2 W^R / \partial q_1^2 < 0$ to ensure the existence of a solution. Since $\partial q_1^R / \partial \tau < 0$, $\partial W^R / \partial \tau = 0$ implies $\partial W^R / \partial q_1 = 0$. Thus, the optimal aeronautical charge implies the first-best number of passengers denoted by $q_1^{R,*}$. Furthermore, $\partial W^R / \partial q_1 = 0$ implies the first-best airfare

$$P_1^{R,*} = c_1 + \left(\Gamma + q_1^{R,*} \Gamma' \right) - \frac{(1 - \beta) P_1^{R,*}}{\beta \varepsilon_1^{R,*}}, \quad (10)$$

where $\varepsilon_1^R = -P_1^R / q_1^R / (P_1^R)'$ (i.e. ε_1^R denotes the endogenous (positive) elasticity of passenger demand for airline services with respect to the airfare). The first term shows the airport costs per passenger and the second term marginal congestion costs. The third term is related to carriers' market power and the social weight attached profits. This term implies an upper limit for the first-best aeronautical charge determined by the social marginal costs of traveling, which is reached if $\beta = 1$. Moreover, the extreme case with $\beta \rightarrow 0$ leads to $P_1^{R,*} \rightarrow -\infty$. Hence, passengers prefer situations with low airfares even if congestion becomes a severe problem.⁸

⁸In this paper, it is implicitly assumed that the passengers' values of time are identical. By contrast, with heterogeneous values of time, positive airfares can be optimal even if $\beta = 0$ (e.g. Niskanen, 1986).

Substituting the RHS of (10) for P_1 in (5) and solving for τ gives the first-best aeronautical charge in the context with retail services

$$\tau^{R,*} = c_1 + \left(1 - \frac{1}{n}\right) q_1^{R,*} \Gamma' - \frac{1}{n} \frac{P_1^{R,*}}{\varepsilon_1^{R,*}} - \frac{(1-\beta)}{\beta} \frac{P_1^R}{\varepsilon_{1,p_1}^R}. \quad (11)$$

Suppose that $\beta = 1$. In this situation $(1-\beta)/\beta$ vanishes and the aeronautical charge in (11) reproduces the results obtained by Zhang and Zhang (2006).⁹ In particular, $\tau^{R,*}$ includes a residual share of congestion cost that is not internalized by carriers and a negative term that is related to carriers' market power.¹⁰

Now, suppose that $\beta < 1$. In this situation, $(1-\beta)/\beta > 0$ and the first-best aeronautical charge decreases (i.e. $\partial\tau^{R,*}/\partial\beta > 0$) leading to increasing passenger numbers, since $\partial q_1^R/\partial\tau < 0$. In the extreme case with $\beta \rightarrow 0$, $\tau^{R,*} \rightarrow -\infty$, since travelers prefer situations with low airfares even if congestion becomes a severe problem, which provides an explanation for the fact that (true) airport congestion pricing cannot be observed in reality. Note that fixed cost recovery can occur even when $\tau^{R,*} < 0$ because profits, $\kappa q_1^{R,*}$, are generated by retailers.

To summarize:

Proposition 2 *In the scenario with a welfare maximizing and congested airport that provides aeronautical services to airlines and concessions to retail-*

⁹Daniel (1995), Brueckner (2002), Pels and Verhoef (2004), Basso and Zhang (2008) and Brueckner and van Dender (2008) obtained similar results as Zhang and Zhang (2006) with different model settings.

¹⁰The empirical results on the relationship between market shares and congestion provided by Brueckner (2002), Mayer and Sinai (2003), Daniel and Harback (2008), and Morrison and Whinston (2007) are controversial, however. Note that a lack of self-internalization could occur when a Stackelberg airline interacts with a competitive fringe (Daniel, 1995, and Brueckner and van Dender, 2008). Furthermore, variations in the passengers' values of time can also lead to an outcome that seems inconsistent with self-internalization (Czerny and Zhang, 2010).

ers: (i) the social marginal costs of passengers impose an upper limit for the first-best optimal airfare, which is reached when airport and airline profits are attached with a social weight of one; (ii) the first-best aeronautical charge leads to the first-best passenger number; (iii) the first-best airfare and the first-best aeronautical charge are independent of retail profits; (iv) there is a positive relationship between the first-best airfare as well as the first-best aeronautical charge and the social weight attached to airport and airline profits.

Zhang and Zhang (2003 and 2010) investigate a congested airport that is a monopoly provider of aeronautical services and commercial services. In their setting, traveling decisions are also considered as independent of commercial airport services. However, they assume that the overall consumption of commercial services depends on traveling activities, which is different from the context employed in this section of the paper. The implications are also different because Zhang and Zhang find that the first-best airfare should not fully internalize marginal congestion costs to passengers to increase the surplus generated by commercial services. This is in sharp contrast to Proposition 2.

A natural question is whether, in the presence of retail services, private behavior can imply the first-best outcome. To see this, solve the first-order condition that determines private aeronautical charges in (7) for κ . Then, solve the first-order condition that determines equilibrium airline behavior in (5) for τ . Assuming that the first-best outcome is reached and substituting τ yields

$$\kappa = c_1 - q_1^{R,*} \frac{\partial \tau}{\partial q_1^R} - \left[P_1^{R,*} - \Gamma - \frac{q_1^{R,*}}{n} \left(\Gamma' - \left(P_1^{R,*} \right)' \right) \right], \quad (12)$$

where the RHS of (12) determines the value of κ that would imply the first-best aeronautical charge in the private airport scenario. To increase transparency, $\partial q_1^R / \partial \tau$ is substituted by the RHS of (6); rearranging then leads to

$$\begin{aligned} \kappa = & c_1 + \left(\Gamma + q_1^{R,*} \Gamma' \right) - P_1^{R,*} - q_1^{R,*} \left(P_1^{R,*} \right)' - \frac{q_1^{R,*}}{n} \left[\left(P_1^{R,*} \right)' - \Gamma' \right] \\ & - q_1^{R,*} \left[\left(P_1^{R,*} \right)' + \frac{q_1^{R,*}}{n} \left(P_1^{R,*} \right)'' - \Gamma' - \frac{q_1^{R,*}}{n} \Gamma'' \right] > 0. \end{aligned} \quad (13)$$

Note that the first three terms on the RHS are positive, which follows from the first-best airfare in (10). The remaining terms on the RHS are all also positive, since $(P_1^R)' + q_{i1}(P_1^R)'' < 0$ for all $i = 1, \dots, n$ by assumption. This implies:

Proposition 3 *In the scenario with a congested airport that provides aeronautical services to airlines and concessions to retail service providers, retail profits must be strictly positive to reach the first-best outcome under private airport ownership.*

A direct consequence of this proposition is that the private aeronautical charge is always excessive from the social viewpoint when $\kappa = 0$, which is consistent with the results obtained by Zhang and Zhang (2003), who considered atomistic airlines, and reproduces the results obtained by Basso (2008), who considered differentiated (oligopolistic) airlines and specific functional forms. By contrast, if retail profits are relatively high, the private aeronautical charge can be too low from the social viewpoint and lead to excessive congestion.

4 Aeronautical Services and Car Rentals

4.1 The model with car rentals

In this section, car rental services are considered, while it is abstracted away from retail services.¹¹ Assume that the airport provides concessions to (homogeneous) car rental companies, and that, as part of the concessions, the airport determines the car rental charge denoted by $p_2 \geq 0$. Moreover, concessions are such that the airport captures all rents from car rentals, and marginal car rental costs are constant and denoted by $c_2 \geq 0$.

Car rentals are essential for certain passengers, especially for business passengers with a high value of time, to circumvent the use of public transport services and limit total travel time, and these passengers may wish to rent cars directly inside the airport area. Therefore, the extreme assumption that there is no competition between car rental companies in- and outside the airport area is imposed. An important difference between car rentals and retailing is that the overall demand for car rentals depends on traveling, while the overall retail demand is independent of traveling. This is because car rentals are normally not required when individuals decide against traveling.

In the current scenario with car rentals (which is indicated by superscript “ C ”), passenger benefits denoted by B^C depend on the number of travelers, q_1 , and the number of car rentals denoted by $q_2 \geq 0$. The inverse passenger demand then is $\partial B^C / \partial q_1$ and the inverse demand for car rentals is $\partial B^C / \partial q_2$. Then, solving $p_2 = \partial B^C / \partial q_2$ for q_2 yields the car rental demand depending on q_1 and p_2 denoted by D_2^C with $\partial D_2^C / \partial p_2 < 0$. Furthermore, substituting q_2 by D_2^C in the inverse passenger demand leads to the inverse passenger demand

¹¹The supply of car rentals may also represent car parkings, which are of great importance for many airports as well.

depending on the passenger number and the car rental charge denoted by $P_1^C(q_1, p_2)$ with $\partial P_1^C / \partial q_1 < 0$.

To model the complementarity between aeronautical and car rental businesses, further assumptions are imposed: (i) an increase in the number of passengers increases the car rental demand at a declining rate, i.e. $\partial D_2^C / \partial q_1 > 0$ and $\partial^2 D_2^C / \partial q_1^2 \leq 0$; (ii) a reduced price for car rentals increases the inverse passenger demand, i.e. $\partial P_1^C / \partial p_2 < 0$; (iii) only passengers demand car rental services inside the airport area (customers do not travel from the outside airport area to the airport to rent a car given that they do not intend to travel), i.e. $D_2^C(0, p_2) = 0$ for all $p_2 \in \mathbb{R}$.

The relationships in (i) seem natural. To illustrate the economic rationale behind the relationship in (ii), consider a business traveler who achieves profit $\phi > p_1$ by flying and renting a car. Without car rentals, the business traveler uses public transport services, which increases total travel costs by $\theta > \phi - p_1$. The business traveler flies if and only if p_2 is low enough in this situation. Finally, the simplifying assumption in (iii) is introduced to concentrate on the complementary relationship between the passenger demand and the demand for commercial airport services.

In this modified model context, airport profit becomes

$$\Pi^C(\tau, p_2) = (\tau - c_1) q_1 + (p_2 - c_2) D_2^C(q_1, p_2). \quad (14)$$

Furthermore, airline profits denoted by π_i^C are obtained by substituting P_1^R for P_1^C in (2), and consumer surplus becomes

$$CS^C = B^C - P_1^C q_1 - p_2 D_2^C \quad (15)$$

$$= \oint_{(0,p_2)}^{(q_1,\infty)} [P_1^C(x_1, x_2) dx_i + D_2^C(x_1, x_2) dx_j] - P_1^C q_1 \quad (16)$$

with $j \neq i$. Since income effects are zero, the integrability condition is satisfied (Crew and Kleindorfer, 1979); therefore, the solution of the line integral in (16) is independent of the particular path along which integration is taken. One way to calculate consumer surplus is

$$CS^C = \int_0^{q_1} P_1^C(x_1, p_2) dx_1 - P_1^C q_1, \quad (17)$$

since $D_2^C(0, p_2) = 0$ for all $p_2 \in \mathbb{R}$ by assumption. In this modified context, the social objective function is

$$W^C = CS^C + \beta \left(\Pi^C + \sum_i \pi_i^C \right) \\ = \int_0^{q_1} P_1^C(x_1, p_2) dx_1 - P_1^C q_1 + \beta [(P_1^C - c_1 - \Gamma) q_1 + (p_2 - c_2) D_2^C]. \quad (18)$$

Observe that commercial services are part of W^C , which is in contrast to W^R . This is because the overall car rental demand depends on traveling.

4.2 Airline behavior and private airport behavior

The equilibrium airline behavior in the second stage, $q_1^C(\tau, p_2)$, can be obtained in a similar way as in the scenario with retail services. To en-

sure that the second order conditions are satisfied, assume that $\partial P_1^C / \partial q_1 + q_{i1}^R \partial^2 P_1^C / \partial q_1^2 < 0$ for all $i = 1, \dots, n$. Moreover, assume that $\partial^2 P_1^C / (\partial q_{i1} \partial p_2) \leq 0$. These assumptions imply $\partial q_1^C / \partial \tau < 0$, which is similar to the relationship in (6), and

$$\frac{\partial q_1^C}{\partial p_2} = \frac{n \left(\frac{\partial P_1^C}{\partial p_2} + q_{i1}^C \frac{\partial^2 P_1^C}{\partial q_{i1} \partial p_2} \right)}{\frac{\partial P_1^C}{\partial q_1} - \Gamma' + n \left[\frac{\partial P_1^C}{\partial q_1} + q_{i1}^R \frac{\partial^2 P_1^C}{\partial q_1^2} - \Gamma' - q_{i1}^R \Gamma'' \right]} < 0. \quad (19)$$

Thus:

Lemma 2 *In the scenario with a congested airport that provides aeronautical services to airlines and concessions to car rental companies, there is a negative relationship between passenger numbers and the aeronautical charge and between passenger numbers and the car rental charge.*

Turning to stage one and substituting q_1^C for q_1 in Π^C gives the airport profit depending on τ and p_2 . To ensure that a solution exists in the first stage, assume that

$$\frac{\partial^2 \Pi^C}{\partial \tau^2} < 0, \frac{\partial^2 \Pi^C}{\partial p_2^2} < 0 \quad \text{and} \quad \frac{\partial^2 \Pi^C}{\partial \tau^2} \cdot \frac{\partial^2 \Pi^C}{\partial p_2^2} - \left(\frac{\partial^2 \Pi^C}{\partial \tau \partial p_2} \right)^2 > 0. \quad (20)$$

The behavior of a private airport (which is indicated by superscript “ C, M ”) is then determined by the first-order conditions

$$\frac{\partial \Pi^C}{\partial \tau} = q_1^C + (\tau^{C,M} - c_1) \frac{\partial q_1^C}{\partial \tau} + (p_2 - c_2) \frac{\partial q_2^C}{\partial \tau} = 0 \quad (21)$$

and

$$\frac{\partial \Pi^C}{\partial p_2} = (\tau - c_1) \frac{\partial q_1^C}{\partial p_2} + q_2^C + (p_2^{C,M} - c_2) \frac{\partial q_2^C}{\partial p_2} = 0. \quad (22)$$

Consider the effect of car rentals on the aeronautical charge first. A useful benchmark for the aeronautical charge in a context with car rentals is the aeronautical charge that would be chosen if car rentals would not be used (i.e. $p_2 \rightarrow \infty$, which implies $D_2 = 0$). In this situation, the third term on the RHS of (21) vanishes; hence, the private airport follows the standard rule where the mark-up on c_1 is inversely related to the price elasticity of airline demand for aeronautical services.

Now, suppose that the profit margin of car rentals is positive (i.e. $p_2 - c_2 \geq 0$) with $p_2 < \infty$. In this situation, there are two opposing effects and therefore, the relationship between the private aeronautical charge and car rentals is ambiguous. First, the private aeronautical charge should be increased because car rentals shift the airline demand for aeronautical services relative to a situation without car rentals. Second, the aeronautical charge should be reduced, to take advantage of the demand complementarity between the demands for aeronautical and car rental services. The overall effect of car rentals on the aeronautical charge can therefore be positive or negative. More specifically, letting τ^M denote the private aeronautical charge in the absence of concession revenues, $\tau^{C,M} \geq \tau^M$ when

$$p_2 \leq c_2 - \left(q_1^C + (\tau^M - c_1) \frac{\partial q_1^C}{\partial \tau} \right) \frac{\partial \tau}{\partial q_2^C}, \quad (23)$$

which follows from the first-order condition in (21) and $\partial^2 \Pi^C / \partial \tau^2 < 0$. Moreover, if the profit margin of car rentals is negative (i.e. $p_2 - c_2 < 0$), the effect of car rentals on the aeronautical charge is clear-cut and positive. This is because car rentals increase the airline demand for aeronautical services and further because a greater aeronautical charge is used to reduce losses in the car rental business area.

To illustrate the effect of aeronautical services on the car rental charge implied by the first-order condition in (22) and $\partial^2\Pi^C/\partial p_2^2 < 0$, $\tau = c_1$ is used as a benchmark. Then, if the profit margin of aeronautical services is positive(negative), aeronautical services exert downward(upward) pressure on the car rental charge due to the complementarity of demands. In the current context without retailing, a situation where the aeronautical charge and the car rental charge are below marginal costs (i.e. $\tau - c_1 < 0$ and $p_2 - c_2 < 0$) cannot be optimal for a private airport, however. To summarize:

Proposition 4 *In the scenario with a congested private airport that provides aeronautical services to airlines and concessions to car rental companies: (i) aeronautical services or car rental services may be offered below marginal costs, and (ii) the relationship between the aeronautical charge and the supply of car rentals is ambiguous (i.e. the car rentals can increase or reduce the aeronautical charge compared to a situation where car rentals are not used).*

These results are consistent with the results obtained by Tirole (1988), who considered a multi-product monopoly and found that in the case of complements, goods may be sold below marginal cost.¹² However, Proposition 4 stands in contrast to retail services and in contrast to the notion of economists who find a strict negative relationship between the aeronautical charge and commercial airport services (see Starkie, 2001 and 2008, and Zhang and Zhang, 2003 and 2010). On the other hand, Czerny (2006) considers an uncongested airport that provides aeronautical and commercial services, where the overall demand for commercial services depends on traveling activities. He finds that commercial airport services increase the aeronautical charge in the case of a private airport, as is consistent with Proposition 4.

¹²Goods are considered as complements when an increase in the supply of one good increases the demand for the other good or a reduction of one good's price increases the other good's demand.

4.3 First-best airport behavior

Substituting q_1^C for q_1 in (18) gives the social objective function depending on τ and p_2 . To ensure that a solution for the first-best optimal outcome exists, assume that

$$\frac{\partial^2 W^C}{\partial \tau^2} < 0, \frac{\partial^2 W^C}{\partial p_2^2} < 0 \quad \text{and} \quad \frac{\partial^2 W^C}{\partial \tau^2} \cdot \frac{\partial^2 W^C}{\partial p_2^2} - \left(\frac{\partial^2 W^C}{\partial \tau \partial p_2} \right)^2 > 0. \quad (24)$$

Then, the first-best airport behavior in a context with car rentals (which is indicated by superscript “C, *”) is determined by the first-order conditions

$$\begin{aligned} \frac{\partial W^C}{\partial q_1} \frac{\partial q_1^C}{\partial \tau} = \\ \left(-\frac{\partial P_1^C}{\partial q_1} q_1^C + \beta \left[P_1^C - c_1 - \Gamma - \Gamma' q_1^C - \frac{\partial P_1^C}{\partial q_1} q_1^C + (p_2 - c_2) \frac{\partial D_2^C}{\partial q_1} \right] \right) \frac{\partial q_1^C}{\partial \tau} = 0 \end{aligned} \quad (25)$$

and

$$\frac{\partial W^C}{\partial p_2} = \int_0^{q_1^C} \frac{\partial P_1^C}{\partial p_2} dx_1 - \frac{\partial P_1^C}{\partial p_2} q_1^C + \beta \left[\frac{\partial P_1^C}{\partial p_2} q_1^C + D_2^C + (p_2^{C,*} - c_2) \frac{\partial D_2^C}{\partial p_2} \right] = 0. \quad (26)$$

The first-best aeronautical charge implies, again, the first-best airfare and the first-best passenger number, since $\partial q_1^C / \partial \tau < 0$. Though this result also holds in a context with retail services, car rentals change the economic rationale of the first-best airfare and the first-best aeronautical charge relative to a context with retail services. Rearranging the first-order condition in (25) gives the first-best airfare

$$P_1^{C,*} = c_1 + \left(\Gamma + q_1^{C,*} \Gamma' \right) + \frac{(1 - \beta) P_1^{C,*}}{\beta \varepsilon_1^{C,*}} - (p_2 - c_2) \frac{\partial D_2^C}{\partial q_1}. \quad (27)$$

Furthermore, to obtain the first-best aeronautical charge, the same procedure as in the case of retail services is followed, which yields

$$\tau^{C,*} = c_1 + \left(1 - \frac{1}{n}\right) q_1^C \Gamma' - \frac{1}{n} \frac{P_1^C}{\varepsilon_{1,p_1}^C} - \frac{(1-\beta)}{\beta} \frac{P_1^C}{\varepsilon_{1,p_1}^C} - (p_2 - c_2) \frac{\partial D_2^C}{\partial q_1}. \quad (28)$$

Observe that the economic rationale behind $(P_1^{C,*}, \tau^{C,*})$ and $(P_1^{R,*}, \tau^{R,*})$ is exactly equal if $p_2 = c_2$. By contrast, if $p_2 - c_2 > 0$ ($p_2 - c_2 < 0$), car rentals reduce (increase) the first-best airfare and the first-best aeronautical charge relative to a situation where $p_2 = c_2$.

Moreover, substituting $-D_2^C$ for $\int_0^{q_1} \partial P_1^C / \partial p_2 dx_1$ and $-\partial D_2^C / \partial q_1^C$ for $\partial P_1^C / \partial p_2$ (recall that $\int_0^{q_1} P_1^C(x_1, p_2) dx_1 - P_1^C q_1 = B^C - P_1^C q_1 - p_2 D_2^C$; these two relationships therefore follow from the envelope theorem) in the first-order condition in (26), solving for p_2 and manipulating yields the first-best car rental charge

$$p_2^{C,*} = c_2 + \frac{(1-\beta)}{\beta} \frac{\partial p_2}{\partial D_2^C} \left(D_2^{C,*} - q_1^{C,*} \frac{\partial D_2^C}{\partial q_1} \right). \quad (29)$$

It directly follows that $p_2^{C,*} = c_2$ when $\beta = 1$. To see the relationship between $p_2^{C,*}$ and β , note that $\partial^2 D_2^C / \partial q_1^2 \leq 0$ implies $D_2^C - q_1^C \partial D_2^C / \partial q_1 > 0$. Therefore, (29) implies that the first-best car rental charge lies below costs when $\beta < 1$, i.e. $p_2^{C,*} < c_2$ for all $\beta < 1$. Note that an important implication of this result is that car rentals exhibit a positive effect on the first-best airfare and the first-best aeronautical charge, which is implied by the final terms in (27) and (28).¹³ Summarizing yields:

¹³Though $\beta < 1$ must be true so that $p_2^{C,*} < c_2$, one can show by numerical simulations that the relationships between β and the first-best car rental charge as well as the first-best airfare are not monotone.

Proposition 5 *In the scenario with a welfare maximizing and congested airport that provides aeronautical services to airlines and concessions to car rental companies: (i) the first-best car rental charge lies below marginal costs, and (ii) car rentals exhibit a positive effect on the first-best airfare and the first-best aeronautical charge.*

These results are in sharp contrast to retail services, which leave the first-best airfare and the first-best aeronautical charge unchanged. They are also in sharp contrast to the results obtained by Zhang and Zhang (2003 and 2010), who found that concession revenues create downward pressure on the first-best airfare and the first-best aeronautical charge at congested airports.

Similarly to the retailing scenario, in the current car rental scenario, the first-best aeronautical charge can be below passenger costs, c_1 , and even become negative for low values of β or n . In this situation and given that airport retailers do not exist, airport profit always becomes negative because the first-best car rental charge is below costs as well; therefore, private airport behavior would not lead to the first-best outcome in such constellations. More specifically, rearranging the first-order condition for private aeronautical charges in (21) evaluated at the first-best outcome yields

$$\tau^{C,*} = c_1 - \frac{\partial \tau}{\partial q_1^C} \left(q_1^{C,*} + \left(p_2^{C,*} - c_2 \right) \frac{\partial q_2^C}{\partial \tau} \right), \quad (30)$$

where the RHS is strictly positive by the relationships described in Lemma 2 and because $p_2^{C,*} - c_2 \leq 0$. It follows:

Proposition 6 *In the scenario with a congested airport that provides aeronautical services to airlines and concessions to car rental companies, the first-best outcome can occur if and only if the first-best aeronautical charge is greater than the airport's per passenger costs.*

Thus, private airport behavior can be fully consistent with first-best behavior. However, private ownership can also lead to severe deviations from first-best behavior in the case of oligopolistic airline markets or relatively low social weights attached to profits. This is because the first-best aeronautical charge can be below the airport's per passenger costs in these situations.

Recall that retail services do not affect the social objective function. For this reason, the joint investigation of aeronautical, car rental and retail services would not change the results on the first-best airport behavior compared to the current scenario that abstracts away from retail services. On the other hand, one can show that, in the case of a private airport, retail services can exert downward pressure on both the aeronautical charge and the car rental charge.¹⁴ In the full setting with aeronautical, retail and car rental services, market constellations may therefore occur where retail profits are so high that the private aeronautical charge and the private car rental charge are below costs. In principal, private airport behavior can therefore be fully consistent with the first-best airport behavior even when airline market power is substantial or the social weight attached to profits is relatively low.

5 Conclusions

In this paper, theoretical models of a congested airport that provides aeronautical services to airlines and concessions to commercial service providers are proposed. These models capture the observation that the overall retail demand is largely independent of traveling, while the overall car rental demand depends on traveling. Though this paper concentrates on car rental

¹⁴However, the relationship between retail profits and the private aeronautical charge as well as the relationship between retail profits and the private car rental charge are not clear-cut. This is because a reduction of prices in one business area lowers the incentives to reduce the charge in the other business area.

and retail services, these services may be representative for other commercial business areas such as car parkings or advertising.

The main insights are the following. If it is abstracted away from car rentals, retail services always exert downward pressure on the private aeronautical charge. By contrast, the effect of car rentals on the private aeronautical charge can be positive or negative. Furthermore, the first-best behavior is independent of retail services, while car rentals have a positive effect on the first-best airfare and the first-best aeronautical charge. Finally, market constellations can occur where private airport behavior is consistent with first-best behavior.

There are some aspects that are not covered in this paper and that should be analyzed in the future to obtain a more complete and realistic picture of the relationship between aeronautical and commercial business areas. This includes the consideration of price regulation regimes and capacity choice.

There is a discussion about whether airport price regulation should pursue a single-till or dual-till approach.¹⁵ The key difference between single-till and dual-till regulation is that with single-till, commercial revenues are used to cover fixed airport costs, which includes runway costs. In comparison, the dual-till approach attributes portions of fixed airport costs to aeronautical and commercial business areas so that cost recovery has to be achieved in both areas separately. In this paper, first-best behavior may lead to heavy losses in the aeronautical business area and the car rental business area. In this case, the implementation of the first-best outcome is possible under single-till regulation only (or with subsidies, which are usually not available for airports).

¹⁵For a detailed investigation of single-till and dual-till regulation, see Crew and Kleindorfer (2001), Starkie (2001 and 2008), Lu and Pagliari (2004), Oum, Zhang and Zhang (2004) and Czerny (2006).

Airport capacity can be expanded in reality. To obtain a more complete picture of the conflicts between a private airport and the regulator in a context where commercial revenues are relevant, it would therefore be useful to consider investments. Zhang and Zhang (2003) analyze lumpy airport investments in a growing airport market and find that private airports slow down expansion relative to the expansion path that should be taken under the conditions of total surplus maximization. This result can be different in the setting proposed in this paper, where the supply of retail services by airports does not contribute to consumer or total surplus but may increase private airport investments. In a recent paper, Zhang and Zhang (2010) find that private and public airports would over-invest in capacity when airline markets are oligopolistic, however.

Overall, the research provided in this paper is based on a differentiated look at commercial airport services. The results may therefore provide a better picture of the relationship between aeronautical and commercial airport services and the conflicts of interest between private airports and regulators.

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