Revenue Sharing with Multiple Airlines and Airports

Anming Zhang,[a,c] Xiaowen Fu[b] and Hangjun (Gavin) Yang[a]

Revised: December 2009

Abstract: This paper investigates the effects of concession revenue sharing between an airport and its airlines. It is found that the degree of revenue sharing will be affected by how airlines' services are related to each other (complements, independent, or substitutes). In particular, when carriers provide strongly substitutable services to each other, the airport has incentive to charge airlines, rather than to pay airlines, a share of concession revenue. In these situations, while revenue sharing improves profit, it reduces social welfare. It is further found that airport competition results in a higher degree of revenue sharing than would be had in the case of single airports. The airport-airline chains may nevertheless derive lower profits through the revenue-sharing rivalry, and the situation is similar to a Prisoners' Dilemma. As the chains move further away from their joint profit maximum, welfare rises beyond the level achievable by single airports. The (equilibrium) revenue-sharing proportion at an airport is also shown to decrease in the number of its carriers, and to increase in the number of carriers at competing airports. Finally, the effects of a 'pure' sharing contract are compared to those of the two-part sharing contract. It is found that whether an airport is subject to competition is critical to the welfare consequences of alternative revenue sharing arrangements.

Keywords: Concession revenues; Revenue sharing; Airport competition; Airport-airline vertical cooperation; Non-atomistic carriers

Acknowledgement: We are very grateful to two anonymous referees for their helpful comments. We also thank Mikio Takebayashi and seminar participants at Kyoto University, Technical University of Berlin and Chinese University of Hong Kong for helpful comments. Financial support from the Social Science and Humanities Research Council of Canada (SSHRC), Hong Kong RGC Grant (RGC-PolyU5412/07H), HKPOLYU CRG Grant G-YG09 and the Li and Fung Institute for Supply Chain Management and Logistics at Chinese University of Hong Kong are gratefully acknowledged.

[a] Sauder School of Business, University of British Columbia, 2053 Main Mall, Vancouver, BC, Canada V6T 1Z2
anming.zhang@sauder.ubc.ca; gavin.yang@sauder.ubc.ca
[b] Faculty of Business, Hong Kong Polytechnic University, Hong Kong
lgtxfu@polyu.edu.hk
[c] Corresponding author

1. Introduction

An airport derives revenue from two facets of its business: the traditional aeronautical operations and the commercial (concession) operations. The former refer to aviation activities associated with runways, aircraft parking and terminals, whereas the latter refer to non-aeronautical activities occurring within terminals and on airport land, including terminal concessions (duty-free shops, restaurants, etc.), car rental and car parking. For the last two decades, commercial revenues have grown faster than aeronautical revenues and, as a result, have become the main income source of many airports. At medium to large US airports, for instance, commercial business represents 75-80% of the total airport revenue (Doganis, 1992). ATRS (2008) studied 142 airports worldwide and found a majority of these airports derived 40-75% of their revenues from non-aviation services, a major part of which is revenue from concession services (with large hub airports relying, on average, even more on concession income). Further, commercial operations tend to be more profitable than aeronautical operations (e.g. Jones et al., 1993; Starkie, 2001; Francis et al., 2004), owing in part to prevailing regulations and charging mechanisms (e.g. Starkie, 2001).

Paralleling the growth of concession revenues, revenue sharing between airports and airlines is getting popular in practice. As documented in Fu and Zhang (2009), there are cases, such as Tampa International Airport in the US and Ryanair in Europe, where airports and airlines share concession revenues.[1] In many other cases, revenue sharing is in effect when airports allow airlines to hold shares or control airport facilities. For example, Terminal 2 of Munich airport was jointly invested by the airport operating company FMG (60%) and the airport's dominant carrier, Lufthansa (40%) (Kuchinke and Sickmann, 2005). Commercial profits generated from this terminal are thus shared between FMG and Lufthansa. Fu and Zhang (2009) found that concession revenue sharing has important competitive and welfare implications: it allows the airport and airlines to internalize a multi-output complementarity between the passenger flights and

[1] Tampa has been sharing revenue with its carriers for several years. In 2004, it shared $7 million out of a total budget of $30 million (see the *2004 Annual Report of Tampa International Airport*). On the other hand, Ryanair has identified airport car parking as one of its business opportunities and cooperated with the leading airport parking company BCP. In its negotiations with some airports, Ryanair asked for parking revenue sharing as a condition to serve the airports.

the concession consumption brought about by the flights, which may improve social welfare. Essentially, passengers traveling through the airport also create a demand for concession consumption. As an airport depends on airlines to bring in passengers, concession revenue sharing will encourage the carriers to expand output, which may in turn improve profit for the whole airport-airlines chain (as well as improve welfare). However, revenue sharing can cause a negative effect on airline competition as an airport may strategically share revenue with its dominant carriers, further strengthening these airlines' market power. The US Federal Aviation Administration (FAA) has expressed concerns over airports' practice of offering particular airlines favorable terms, on the ground that such a special treatment may harm competition in the airline market downstream (FAA, 1999).[2] Since 1995, the EU's competition authorities have ruled against several major airports in Belgium, Finland and Portugal concerning their practices of charging lower prices to home carriers (Barbot, 2006, 2009a).

For the last several years, the effects of vertical relationships between airports and airlines have received growing attention from researchers. In addition to Fu and Zhang (2009), Auerbach and Koch (2007) and Barbot (2009a, 2009b) found that cooperation between an airport and its airlines can bring benefits to the alliance members in terms of increased traffic volume and operation efficiency. In this paper we extend this literature on airport-airline vertical cooperation, focusing on the effects of concession revenue sharing. More specifically, we consider that carriers may provide complementary, independent or substitutable services to each other, and that the proportions of revenue sharing may be outside of the [0, 1] range. The latter allows us to compare alternative sharing arrangements. Further, unlike the previous studies, our analysis is mostly conducted under general demand and cost functional forms. Moreover, as elaborated below, our work also extends the existing literature to the general case of multiple competing airports with each having an arbitrary number of carriers.

---

[2] Previous studies (e.g. FAA, 1999; GAO, 1997; Dresner et al., 2002; see also Hartmann, 2006, for a useful review on the topic) suggest that airline entry may be deterred if the dominant airline controls key airport facilities. Apparently, such a strategy by the dominant carrier would require at least implicit consent/cooperation from the airport. In the US, large and medium airports that meet a certain threshold of airline concentration are now required to submit competition plans as mandated by the 'Wendell H. Ford Aviation Investment and Reform Act for the 21st Century' legislated in 2000.

We find that the degree of revenue sharing will be affected by how airlines' services are related to each other. In particular, when carriers provide substitutable services to each other, they might need to pay to the airport a share of concession revenue (so-called the 'negative sharing') if substitutability is sufficiently strong and the fixed (transfer) payments between the airport and carriers are feasible (referred to as the 'two-part revenue sharing'). The negative sharing allows the airport to penalize the over-competing carriers so as to support airfares downstream and improve profit. In these situations, while revenue sharing improves total airport-airlines channel profit, it reduces social welfare. If the fixed payments are not feasible, under the resulting 'pure revenue sharing' the airport will, for the cases of independent or complementary services, share less concession revenue with its carriers than would be under the two-part revenue sharing. For the substitutes case, however, the sharing-proportions comparison between the two types is in general ambiguous. In the special case of negative sharing, the pure revenue sharing will, for sufficiently symmetric carriers, result in not only a higher sharing proportion, but also a higher welfare level, than the two-part revenue sharing.

Our second objective in this paper is to extend the airport literature by investigating revenue sharing for multiple, competing airports. Very few papers have examined competing airports analytically. For example, Fu and Zhang (2009) examined revenue sharing only for a monopoly airport. The few exceptions include Gillen and Morrison (2003), who examined two competing airports in the context of a full-service carrier and a low-cost carrier. More recently, Basso and Zhang (2007) provided a more general examination of airport competition with congestion and non-atomistic airlines at each airport, and Barbot (2009a) examined airport-airline interactions (collusion, in particular) using a spatial model similar to that of Basso and Zhang. The issues of concession revenues and revenue sharing were not considered in these papers, however.

This lack of analytical studies on airport competition is understandable given the local monopoly nature of an airport. The situation is changing, however. The world has experienced a rapid growth in air transport demand since the 1970s, and many airports have been built or expanded as a result. This has led to a number of multi-airport regions such as greater London in the UK and several metropolitan areas in the US (e.g. San Francisco, Chicago, New York, Washington, Dallas, Detroit, Huston, and Los Angeles) within which airports may compete with each other. At the same time, the dramatic growth of low-cost carriers (e.g. Southwest in the US and Ryanair in Europe) has enabled some smaller and peripheral airports to cut into the catchment areas of large airports. Starkie (2008) conducted an overview of UK airports from the perspective of a business enterprise. He concluded that effective competition across airports is possible and a competitive airport industry can be financially viable. Taken together, these observations suggest that it is important to investigate the effects of revenue sharing in the context of multiple, competing airports.

We find that airport competition will result in a higher degree of revenue sharing than would be had in the case of single airports. Nevertheless, the airport-airline chains may derive lower profits through this revenue-sharing rivalry. As the airport-airline chains move further away from their joint profit maximum, social welfare rises beyond the level achievable by single airports. Our analysis also shows that the airline market structure can have a bearing on revenue sharing arrangements not only at the airport in question, but also at its competing airports. Specifically, the (equilibrium) revenue-sharing proportion at an airport decreases in the number of its carriers, but increases in the number of carriers at the competing airport. In terms of the welfare consequences of alternative revenue sharing arrangements, whether an airport is subject to competition is critical: for competing airports, 'no sharing' is worse than 'pure sharing' which is in turn worse than the two-part sharing. For single airports however, both no-sharing and pure-sharing might be better than the two-part sharing when airlines provide substitutable services to each other.

The paper is organized as follows. Section 2 sets out the basic model and examines the revenue-sharing equilibrium for a single airport with multiple airlines. Section 3 examines revenue sharing for the general case of competing airports with each having an arbitrary number of carriers. Section 4 investigates the pure revenue sharing and compares its effects with those of the two-part revenue sharing. Section 5 contains concluding remarks.

2. Single Airport with Multiple Airlines

2.1 Basic model

Consider, in this section, that a single airport provides aeronautical service to airlines, for which it imposes a charge. In our modeling this charge is represented by a per-passenger fee w (>0), and is regulated and cannot be changed unilaterally by either the airport or airlines.[3] We have two carriers, labeled as $i = 1,2$, operating from the airport, although the analysis and results extend immediately to the *n*-carrier case (see, e.g., Section 3.2). They face inverse demands $p^i(q_1, q_2)$, which satisfy the usual properties of $p_i^i < 0$ and $p_1^1 p_2^2 - p_2^1 p_1^2 > 0$ with subscripts denoting partial derivatives.[4] The airlines' revenue from providing aviation service is then given by $R^i(q_1, q_2) = p^i(q_1, q_2)q_i$.

The revenue functions can be used to define how one airline's output is related to the other's. There are three possible cases:

(i) Complements: two carriers offer complementary services in the sense that

$$R_j^i(q_1, q_2) = p_j^i(q_1, q_2)q_i > 0, \qquad R_{ij}^i(q_1, q_2) > 0. \tag{1}$$

That is, increasing carrier j's output increases both the total and marginal revenues of carrier i (here, and below, if the indices i and j appear in the same expression, then it is to be understood that $i \neq j$).[5] In the present context, services provided by a trunk airline

---

[3] Since price discrimination (on aeronautical charges) by an airport is prohibited by the International Air Transport Association (IATA) rules, all airlines serving the airport face the same *w*.

[4] While $p_i^i < 0$ indicates the usual property of downward-sloping demands, $p_1^1 p_2^2 - p_2^1 p_1^2 > 0$ refers to the property of 'own effects' dominating 'cross effects' in demand functions. As noted by Dixit (1986, p. 108), the dominance of own-effects over cross-effects is a standard assumption in models of oligopoly.

[5] The first inequality in (1) shows (gross) complements between the airline services, whereas the second inequality implies 'strategic complements' (Bulow et al., 1985). That the former implies the latter holds for most (but not all) plausible demand structures; it certainly holds when demand functions are linear. In other words, the fact that services are complements is conducive to their strategic complementarity. Restricting attention to strategic complementarity is a standard practice in oligopoly models (Dixit, 1986; Tirole, 1988).

and a feeder airline – with their passengers connecting at the airport – may be considered as complements. Another example would be that two airlines engage in some form of strategic alliances or code-sharing arrangements (e.g. Brueckner, 2001; Brueckner and Whalen, 2000).

(ii) Independent services: two carriers' services are unrelated in demand as

$$R_j^i(q_1, q_2) = p_j^i(q_1, q_2)q_i = 0. \tag{2}$$

Note, in this case, that $R_j^i = 0$ implies $R_{ij}^i = 0$.

(iii) Substitutes: raising a carrier's output reduces the other's total and marginal revenues,

$$R_j^i(q_1, q_2) = p_j^i(q_1, q_2)q_i < 0, \qquad R_{ij}^i(q_1, q_2) < 0, \tag{3}$$

For instance, two competing trunk carriers likely provide substitutes at an airport, and so do two competing feeder carriers.

We consider that for each passenger going through the airport, a concession revenue h (>0) is derived. Assuming further (for simplicity) zero costs for providing concession services by the airport, then h represents a net surplus per passenger.[6] How total concession revenue hq_i is shared between the airport and airlines is modeled as a two-stage game. In the first stage, the airport offers carrier i to share proportion r_i of revenue hq_i in exchange for a fixed fee f_i, subject to the carrier's participation constraint. No restriction is imposed on r_i, and so r_i can be less than zero or greater than one. In the second stage, airlines choose quantities to maximize individual profits.[7] The subgame perfect equilibrium of this two-stage game is referred to as the 'revenue sharing equilibrium.'

Similar observations on 'substitutes' and 'strategic substitutes' hold for the substitutes case discussed next. We shall, as is common in the literature, refer to these two cases simply as 'complements' and 'substitutes.'

[6] This formulation of concession surplus has been used in, e.g., Zhang and Zhang (1997, 2003), Oum et al. (2004) and Fu and Zhang (2009). It is, nevertheless, a simple representation where concession surplus is strictly complementary to passenger volume. For an alternative and perhaps more realistic formulation, see Czerny (2006).

[7] This implies carriers interact with each other in Cournot fashion. Recent studies on airport pricing and capacity investment that have incorporated imperfect competition of air carriers at an airport (e.g. Brueckner, 2002; Pels and Verhoef, 2004; Zhang and Zhang, 2006; Basso, 2008) have assumed Cournot behavior. Brander and Zhang (1990, 1993), for example, find some empirical evidence that rivalry between duopoly airlines is consistent with Cournot behavior.

Prior to examination of the revenue-sharing equilibrium, two things about the sharing contract (r_i, f_i), $i = 1,2$, are worth noting. First, assuming that airline i gets a share of revenue hq_i means that the airport is able to know who is flying in which airline. This can happen after boarding, as passengers may present their boarding card, but not necessarily before boarding. Second, the contract being a pair (r_i, f_i) suggests a 'two part' revenue-sharing scheme under which fixed payments are possible. Such a model can be used to examine the incentive for vertical airport-airline cooperation – i.e. taking account of the profit for the airport-airline channel as a whole – and may also be consistent with situations in which airports and airlines can commit to medium-/long-term cooperation. Nonetheless, such fixed payments between airports and airlines might not be feasible in certain situations, owing to the difficulty in their agreeing to the right amount of payments, or to the preference for simpler revenue-sharing arrangements that do not involve any medium-/long-term commitment. In Section 4, we will examine a 'pure' sharing contract that restricts fixed payments f_i to zero.

2.2 Revenue-sharing equilibrium

The revenue-sharing equilibrium is solved in the standard backward induction.

<u>Stage two</u>: Given sharing contract (r_i, f_i), each carrier's profit is:

$$\pi^i(q_1, q_2) = R^i(q_1, q_2) - C_i(q_i) - wq_i + r_i hq_i - f_i, \tag{4}$$

where $C_i(q_i)$ denotes carrier i's production cost. Thus for carrier i, the total operating cost net of fixed payment f_i equals $C_i(q_i) + wq_i$. The Cournot-Nash equilibrium is characterized by the first-order conditions,

$$\pi^i_i(q_1, q_2) = R^i_i(q_1, q_2) - C_i'(q_i) - w + r_i h = 0, \tag{5}$$

and the second-order conditions $\pi^i_{ii}(q_1, q_2) = R^i_{ii}(q_1, q_2) - C_i''(q_i) < 0$. Both the second-order conditions and the stability condition, $J \equiv \pi^1_{11}\pi^2_{22} - \pi^1_{12}\pi^2_{21} > 0$, are assumed to hold over the entire region of interest.[8]

[8] This assumption implies that the Cournot equilibrium exists and is unique (e.g. Friedman, 1977). Note that if carriers face linear demands, then all these conditions will be satisfied.

The solution to (5) yields the second-stage equilibrium quantities, which are functions of the first-stage variables (r_1, r_2). Since fixed payments f_1 and f_2 enter the airlines' profit functions (4) as constants, they will not affect the equilibrium quantities. Denoting the equilibrium quantities as $q_i^*(r_1, r_2)$, substituting them into (5) and totally differentiating the resulting identity with respect to r_i, we obtain

$$\partial q_i^* / \partial r_i = -h\pi_{jj}^j / J, \qquad \partial q_j^* / \partial r_i = h\pi_{ji}^j / J. \tag{6}$$

It follows immediately that $\partial q_i^* / \partial r_i > 0$, while $\partial q_j^* / \partial r_i$ having the same sign as $\pi_{ji}^j = R_{ji}^j$, which by (1), (2) and (3) leads to:

Lemma 1. *(i)* $\partial q_i^* / \partial r_i > 0$*; and (ii)* $\partial q_j^* / \partial r_i > 0$, $= 0$*, and* < 0 *for carriers' producing complements, independent services, and substitutes, respectively.*

Thus an increase in the share of concession revenue to carrier *i* increases *i*'s output. The reason is that an increase in r_i will improve carrier *i*'s marginal profitability, owing to the multi-output complementarity between passenger flights and concession consumption. Furthermore, an increase in r_i increases, not affects, and decreases carrier *j*'s output if the carriers offer complementary, independent, and substitutable services, respectively. For the case of substitutes, since that $\pi_{ji}^j = R_{ji}^j < 0$ ensures a downward-sloping 'best reply function' for each carrier (defined by (5) in the output space), an increase in r_i will, by increasing carrier *i*'s marginal profit, shift its best-reply function outward. This will move the equilibrium quantities downward along *j*'s best-reply function, thereby increasing q_i^* and decreasing q_j^*. For complements, on the other hand, that $\pi_{ji}^j = R_{ji}^j > 0$ ensures an upward-sloping best-reply function for each carrier. An increase in r_i will again shift *i*'s best-reply function outward, moving the equilibrium quantities upward along *j*'s best-reply function, thereby increasing both q_i^* and q_j^*. Finally, if the services are independent, then an increase in r_i does not affect q_j^*, as expected.

<u>Stage one</u>: Revenue-sharing structures therefore influence subsequent airline quantities, which in turn will affect the airport's profit. Assume, for simplicity, that the airport's fixed cost is zero and its marginal cost is constant and normalized to zero. The airport's profit is then given by:

$$\Pi = w \cdot (q_1^* + q_2^*) + [(1-r_1)hq_1^* + (1-r_2)hq_2^*] + f_1 + f_2, \tag{7}$$

where the second-stage equilibrium outputs are taken into account. (Throughout the paper, we use capital letter Π to denote airport profit, while lower case π denoting airline profit.) There are three components in Π: (i) the aeronautical revenue (profit) given by $w \cdot (q_1 + q_2)$; (ii) the residual concession revenue given by the bracketed term in (7); and (iii) the fixed payment collected from carriers, $f_1 + f_2$.

The airport chooses (r_i, f_i), $i = 1,2$, to maximize Π. While f_i will not, as indicated above, affect the second-stage equilibrium outputs, $\partial\Pi / \partial f_i = 1$ by (7). Consequently, the airport should, given its Stackelberg leader's role, charge the airlines a fee as high as possible subject to their participation constraints $\pi^i \geq \pi_0^i$, with π_0^i being carrier *i*'s reservation profit. Assume, without loss of generality, that each carrier receives its reservation profit.[9] This participation constraint implies, using (4), that

$$f_i = R^i(q_1^*, q_2^*) - C_i(q_i^*) - wq_i^* + r_i hq_i^* - \pi_0^i, \qquad i = 1,2, \tag{8}$$

where equilibrium outputs q_i^* are functions of r_1 and r_2. With (8), airport profit (7) becomes:

$$\Pi(r_1, r_2) = \sum_i [R^i(q_1^*, q_2^*) - C_i(q_i^*) + hq_i^* - \pi_0^i] \equiv v(q_1^*(r_1, r_2), q_2^*(r_1, r_2)). \tag{9}$$

Thus, the revenue-sharing equilibrium is characterized by the first-order conditions,

---

[9] The assumption that the airport chooses the fees as high as possible subject to carriers' participation constraints implies that all the benefits from improvements in performance go to the airport. This is due to our airport-airlines relationship with the airport being a Stackelberg leader. Such a 'vertical structure' has been a standard set-up in the recent literature on airport pricing and capacity investment that incorporates imperfect competition of airlines at an airport (see, e.g., Basso and Zhang, 2008, for a survey). As pointed out by an anonymous referee, Bowley (1928) has this idea (not the expression) for a two firms' game in a vertical context (with one buyer and one seller, when the seller has more market power). In the present context, maybe a single airport ('monopolist') fits the set-up better than multiple airports: since the airport has more market power than airlines, its first mover advantage in choosing the fees may be due to its monopolist position. We discuss the issue further in the concluding remarks.

$$\partial \Pi / \partial r_i = v_i \cdot (\partial q_i^* / \partial r_i) + v_j \cdot (\partial q_j^* / \partial r_i) = 0, \qquad i = 1,2, \tag{10}$$

where $v_i (\equiv \partial v / \partial q_i) = R_i^i (q_1^*, q_2^*) - C_i^{'} (q_i^*) + h + R_i^j (q_1^*, q_2^*)$. By (5), v_i can be rewritten as:

$$v_i = w + (1 - r_i) h + R_i^j (q_1^*, q_2^*). \tag{11}$$

Consider first the case where carriers' services are independent. It can be easily seen from (10), (11), (2) and Lemma 1 that the equilibrium sharing proportions are given by (superscript *I* for 'independent services'):

$$r_i^I = 1 + (w / h), \qquad i = 1,2, \tag{12}$$

which are strictly positive. Revenue sharing therefore improves the airport's profit – here, the profit gain is due to the internalization of a demand complementarity between the flights and concession consumption. Further, even when $r_i = 1$, the profit will rise with r_i going beyond the 'full' share. Basically, the two-part revenue sharing resolves the well-known 'double marginalization' problem in a vertical structure (e.g. Tirole, 1988).

The independent-services case turns out to be a useful benchmark for the cases of substitutes and complements. By first-order conditions (10) it follows:

$$v_1 \cdot (\partial q_1^* / \partial r_1) + v_2 \cdot (\partial q_2^* / \partial r_1) = 0, \tag{13.1}$$

$$v_1 \cdot (\partial q_1^* / \partial r_2) + v_2 \cdot (\partial q_2^* / \partial r_2) = 0, \tag{13.2}$$

which give rise to $v_2 \cdot [(\partial q_1^* / \partial r_2)(\partial q_2^* / \partial r_1) - (\partial q_1^* / \partial r_1)(\partial q_2^* / \partial r_2)] = 0$. This equation, by (6), reduces further to $v_2 h^2 (\pi_{12}^1 \pi_{21}^2 - \pi_{11}^1 \pi_{22}^2) / J = 0 \Rightarrow -v_2 h^2 = 0 \Rightarrow v_2 = 0$. Plugging $v_2 = 0$ into (13.1) we immediately have $v_1 = 0$. It follows from (11) that

$$r_i = [1 + (w / h)] + (R_i^j / h), \qquad i = 1,2. \tag{14}$$

If airline services are complements, then $R_i^j > 0$; consequently (superscript *C* for 'complements'),

$$r_i^C > 1 + (w / h) = r_i^I, \qquad i = 1,2. \tag{15}$$

If airline services are substitutes, then $R_i^j < 0$ and so equation (14) yields (superscript *S* for 'substitutes')

$$r_i^S < 1 + (w/h) = r_i^I, \qquad i = 1,2, \qquad (16)$$

leading, therefore, to:

Proposition 1. *At the revenue-sharing equilibrium with a single airport, the sharing proportions are* $r_i^I = 1 + (w/h)$ *when airlines' services are independent,* $i = 1,2$. *The sharing proportions are greater (smaller, respectively) than* r_i^I *when airlines provide complementary (substitutable, respectively) services to each other.*

The explanations for the deviations from the independent-services benchmark are as follows. When services are complementary to each other, both carriers are interested in increasing passengers' numbers but are unable to internalize such complementarity by themselves. The airport, as a first mover, can achieve this by manipulating revenue-sharing proportions – here, by increasing the sharing proportions beyond r_i^I – and this in turn will increase the airport's profit. Conversely, substitutability between airlines' services will lead to a failure of coordination between competing airlines, resulting in their providing too much service with respect to what would be best for them as a whole. Anticipating this, the airport uses revenue sharing as a device to coordinate airline competition downstream. In particular, a smaller sharing proportion than the independent-services benchmark will, by Lemma 1, reduce industry output, thus lessening 'excessive' services by carriers.[10]

It is important to point out that for the substitutes case, the sharing proportions might become negative (i.e. $r_i^S < 0$). This is because airline-service substitutability works in an opposite direction of the flights-concessions demand complementarity discussed above, in terms of the amount of airline services the airport would like to induce. The optimal level of revenue sharing, r_i^S, is set to balance these two effects. Thus, r_i^S depends on the degree of substitutability between carriers' services. Numerical examples are constructed at the end of this section, in which airline-service substitutability is so

[10] An alternative explanation for the substitutes case is that substitutability increases one carrier's passengers at the expense of another carrier's passengers. The airport must balance this trade-off and will not allow for a very high r_i.

strong that r_i^S becomes negative. Such a 'negative revenue sharing' allows the airport to penalize the over-competing airlines so as to support prices in the output market and improve the profit of ('coordinate') the whole airport-airlines chain.

2.3 Comparison with the no-sharing regime

Our concern now is to compare the revenue-sharing equilibrium with the situation where airport-airline revenue sharing is not allowed, characterized by $r_i = f_i = 0$. First, for the cases of complements and independent services, it is clear from Lemma 1, Proposition 1, (10) and (11) that revenue sharing will increase airline output and improve airport profit. Define social welfare as the sum of the airport-airline profit and consumer (passenger) surplus:

$$W(r_1, r_2) = U(q_1^*, q_2^*) - C_1(q_1^*) - C_2(q_2^*) + hq_1^* + hq_2^* \equiv \varphi(q_1^*, q_2^*), \qquad (17)$$

where $U(q_1, q_2)$ is the consumer utility function in the usual industry (partial equilibrium) analysis, with $\partial U / \partial q_i = p^i$. Although passengers may derive surplus also from their concession consumption, such surplus per passenger is assumed constant and further normalized to zero, thus giving rise to formulation (17). Differentiating W with respect to r_i yields:

$$\partial W / \partial r_i = (p^i - C_i^{'} + h)(\partial q_i^* / \partial r_i) + (p^j - C_j^{'} + h)(\partial q_j^* / \partial r_i). \qquad (18)$$

Since $p^i - C_i^{'} > 0$ (positive markups in oligopoly), the output expansion identified above leads immediately to $\partial W / \partial r_i > 0$ and thus, revenue sharing improves welfare.

As for prices, it can be easily seen (from below) that they will fall if carriers' services are independent. For the complements case, the effect is not as straightforward. Differentiating $p^i(q_1^*, q_2^*)$ with respect to r_i and r_j yields

$$\partial p^i / \partial r_i = p_i^i \cdot (\partial q_i^* / \partial r_i) + p_j^i \cdot (\partial q_j^* / \partial r_i), \qquad (19.1)$$

$$\partial p^i / \partial r_j = p_i^i \cdot (\partial q_i^* / \partial r_j) + p_j^i \cdot (\partial q_j^* / \partial r_j), \qquad (19.2)$$

respectively. With carriers' services being complementary, the first term on the right-hand side (RHS) of (19.1) is negative (recall $p_i^i < 0$ and Lemma 1) whilst the second term is positive. Similarly, the first term on the RHS of (19.2) is negative whilst the second term is positive. Under 'symmetry' however, the overall effects will be negative for both (19.1) and (19.2), as is shown below (Proposition 2). By 'symmetry' we mean (i) carriers have identical cost functions and face symmetric demands, and (ii) at the equilibrium, carriers have the same sharing contract (i.e. $r_1 = r_2$, $f_1 = f_2$). The symmetry condition will also be used in the comparison for the substitutes case (see Proposition 2).

Proposition 2. *At the revenue-sharing equilibrium with a single airport,*

1. when airlines provide independent or complementary services to each other, (i) outputs and welfare are greater and (ii) under symmetry, prices are lower, than in the absence of revenue sharing;

2. when airlines provide substitutable services to each other and are symmetric, (i) outputs and welfare are greater (smaller, respectively) and (ii) prices are lower (higher, respectively), than in the absence of revenue sharing if $r_i^S > 0$ *(*$r_i^S < 0$*, respectively).*

Proof: 1. We only need to show the price effect for the complements case (the other parts have been shown in the text). Use Δ to denote any difference of variables between the revenue-sharing regime and no-sharing regime. Applying the mean value theorem (MVT) to the function $p^i(q_1^*, q_2^*)$ yields:

$$\Delta p^i = p_i^i \cdot \Delta q_i^* + p_j^i \cdot \Delta q_j^*,$$

where p_i^i and p_j^i are evaluated at some point between (q_1^O, q_2^O) and (q_1^C, q_2^C), with superscript *O* denoting variables associated with the no-sharing regime. Under symmetry, $\Delta q_i^* = \Delta q_j^* > 0$ from part (i). Consequently, $\Delta p^i = (p_i^i + p_j^i)\Delta q_i^* < 0$ with the inequality following from the condition $p_1^1 p_2^2 - p_2^1 p_1^2 > 0$ and symmetry: noting that symmetry implies $(p_i^i + p_j^i)(p_i^i - p_j^i) > 0$. Since $p_i^i - p_j^i < 0$ for complements and independent services, it follows that $p_i^i + p_j^i < 0$.

2. (i) Applying MVT to $q_i^*(r_1, r_2)$ yields $\Delta q_i^* = (\partial q_i^* / \partial r_i)\Delta r_i + (\partial q_i^* / \partial r_j)\Delta r_j$, with $\partial q_i^* / \partial r_i$ and $\partial q_i^* / \partial r_j$ evaluated at some point between (r_1^O, r_2^O) and (r_1^S, r_2^S). Under symmetry, $\Delta r_i = \Delta r_j$ and $\partial q_i^* / \partial r_j = \partial q_j^* / \partial r_i$; consequently,

$$\Delta q_i^* = [\partial(q_i^* + q_j^*) / \partial r_i]\Delta r_i = [h \cdot (\pi_{ji}^j - \pi_{jj}^j) / J]\Delta r_i$$

Since $\pi_{ji}^j - \pi_{jj}^j > 0$ and $J > 0$ under the second-order and substitutes conditions and the stability condition respectively, Δq_i^* must have the same sign as $\Delta r_i \equiv r_i^S - r_i^O = r_i^S$ (recall $r_i^O = 0$).

For the welfare comparison, applying MVT to $\varphi(q_1^*, q_2^*)$ in (17) yields $\Delta\varphi = \varphi_i \Delta q_i^* + \varphi_j \Delta q_j^*$, where φ_i and φ_j are evaluated at some point between (q_1^O, q_2^O) and (q_1^S, q_2^S). Under symmetry, $\Delta q_i^* = \Delta q_j^*$. Consequently, $\Delta\varphi = (\varphi_i + \varphi_j)\Delta q_i^*$ has the same sign as Δq_i^*, because $\varphi_i = p^i - C_i' + h > 0$. The welfare result then follows from the above quantity comparison.

(ii) Applying MVT to $p^i(q_1^*, q_2^*)$ yields $\Delta p^i = p_i^i \Delta q_i^* + p_j^i \Delta q_j^*$, where p_i^i and p_j^i are evaluated at some point between (q_1^O, q_2^O) and (q_1^S, q_2^S). With $\Delta q_i^* = \Delta q_j^*$ under symmetry, $\Delta p^i = (p_i^i + p_j^i)\Delta q_i^*$ has the opposite sign as Δq_i^*, because $p_i^i < 0$ and, by (3), $p_j^i < 0$. The result then follows from the above quantity comparison. *Q.E.D.*

Three comments about Proposition 2 are worth making. First, although the proposition does not say anything about airport-airlines profits, the joint profits of the airport and airlines are always higher at the revenue sharing equilibrium when carriers' services are independent, as expected. When carriers provide substitutable and complementary services, the joint profits are higher at the revenue sharing equilibrium for linear demand and cost functions, but we are unable to prove the result for general demand and cost functions.[11] Second, although some of the comparisons in Proposition 2 are carried out under 'perfect' symmetry between airlines, a closer look at the above proof indicates that small asymmetries will not undermine the results. Third, Proposition

[11] A similar comment about the profit comparison applies to Proposition 6 below.

2 shows that when carriers offer complementary and unrelated services to each other, revenue sharing between an airport and its airlines improves welfare. The welfare improvement arises because prices exceed marginal costs in the oligopolistic airline market and revenue sharing reduces prices (or equivalently, expands outputs).

When carriers provide substitutable services to each other, revenue sharing may or may not improve welfare, depending on the sign of equilibrium sharing proportions r_i^S. As indicated above, the sign of r_i^S will in turn depend on the degree of substitutability between carriers' services. To capture such an impact, we need to impose more structure on the model.[12] Specifically, a linear (inverse) demand is specified:

$$p^i = 1 - bq_i - kq_j ,$$

with $b > 0$ and $k \in (-b, b)$, which ensure downward-sloping demands and the property of 'own-price effects' dominating 'cross-price effects.' It is clear that carriers' services are complements, independent and substitutes when $k < 0$, $= 0$ and > 0 , respectively. Carriers' marginal costs c_1 and c_2 are constant and $c_1 = c_2$. In the simulation, parameters are chosen to ensure positive outputs and marginal revenues.

Figure 1 reports the effects of airline-service substitutability, where we define $k = m \cdot b$ with $m \in$ (-0.1, 1). Thus, negative *m* indicates complementarity between airlines' services, whilst for positive *m*, larger *m*'s mean increasingly substitutable services. As expected, for complementary services (*m* < 0), the airport shares a high percentage of concession revenue with airlines ($r_i > 1$) so as to internalize airline-service complementarity. On the other hand, the (equilibrium) sharing proportions r_i^S fall when airline services become increasingly substitutable. When airline-service substitutability becomes sufficiently strong, r_i^S turns into a negative value, implying carriers pay a

[12] Examining how equilibrium results change with substitutability (i.e. when airline services become more substitutable to each other) is also important, since there are situations in which airports or policy makers can 'moderate' such substitutability. For example, only a few Asian cities are served by multiple airports and as a result, low-cost carriers (LCCs) are often forced to use the same airport as competing full-service airlines (FSAs). Recently, airports in, e.g. Kuala Lumpur and Singapore, chose to build separate LCC terminals which offer lower quality of airport service with less charge (Zhang et al., 2009). Such a measure would make LCCs' services less substitutable to the services provided by FSAs.

higher price (than airport charge *w*) per unit of output. The figure shows that the fixed fees become negative in this case, indicating carriers are compensated for with fixed payments from the airport.[13] In such a case, the output and welfare (not shown in Figure 1) with revenue sharing (the solid line in the figure) are less than those in the no-sharing case (the dotted line), as predicted by Proposition 2. Here, while revenue sharing improves the total channel profit (see the figure), it might reduce social welfare.

**** Figure 1 About Here ****

3. Competing Airports

3.1 Strategic revenue sharing

We now consider two airports, represented by $i = 1,2$, beginning with a situation of one carrier at each airport. (The case of multiple airlines will be considered in Section 3.2.) To save notation we continue to use $p^i(q_1, q_2)$ for the inverse demands faced by carriers, with *i* denoting the *i*th airport's carrier (and q_i its output). The two airports compete with each other in the sense that their airlines' services are substitutes in the eyes of passenger: thus airlines compete with each other even if they operate at different airports. More specifically, airline revenue functions $R^i(q_1, q_2)$ $(= p^i(q_1, q_2)q_i)$ satisfy the substitutes condition (3).

[13] The combination of 'negative sharing' and airports' transfer payments to airlines may also be observed in practice. There are cases, for instance, where airports may make one-shot investments (for carriers) to offset high airport charges. For example, Federal Express (FedEx) had been planning to move its Asia Pacific operating center from Subic Bay in the Philippines to Guangzhou in China since 2003. However, FedEx was concerned about the high operating costs in Guangzhou airport due to its high charges for fuel, airport and ATC (air traffic control) services which are regulated by the central government. To offset these high service charges and attract FedEx, the airport agreed to invest US$300 million on infrastructures including exclusive aircraft parking space and taxi runways for the usage of FedEx. FedEx opened its Asia Pacific operating center in Guangzhou in February 2009, and within half a year it operates 136 flights per week at the airport. Notice, here, a negative relationship between airport charge *w* and revenue sharing proportion r_i. For instance, the value of r_i, for independent airline services, is equal to 1+(*h*/*w*); consequently, $dw/dr_i < 0$: i.e. the higher *w* is, the smaller will r_i be. A smaller or negative sharing would then be compensated with higher fixed payments which, in the present example, are represented by the investments that the airport made to attract carriers (i.e. airport quality is in a sense interpreted as negative fees offered to airlines). Our results also suggest that when the downstream airline market is extremely competitive, the airport may prefer similar 'negative sharing' strategy to the choice of encouraging additional outputs via positive revenue sharing, in order to coordinate the airport – airlines chain. We discuss the issue further in the concluding remarks.

Airport-airline behavior is modeled again as a two-stage game: In the first stage, each airport offers its carrier to share proportion r_i of concession revenue hq_i in exchange for fixed fee f_i, subject to the carrier's participation constraint. In the second stage, airlines compete in Cournot fashion with their profits given by (4). This airport-airline vertical structure has also been assumed in other analytical studies on competing airports mentioned in the introduction. Given this set-up, the second-stage equilibrium is characterized by (5), the same condition as in the single-airport case. Further, the equilibrium quantities – denoted again as $q_i^*(r_1, r_2)$ – have the comparative-static properties of Lemma 1: i.e. an increase in the sharing proportion by airport *i* will increase its carrier's output while reducing output of the competing airport's carrier.

Taking the second-stage equilibrium outputs into account, each airport's profit in stage 1 are expressed,

$$\Pi^i = wq_i^* + (1 - r_i)hq_i^* + f_i, \qquad i = 1,2. \tag{20}$$

The subgame perfect equilibrium then arises when each airport chooses its sharing contract (r_i, f_i) to maximize Π^i, taking its rival's sharing contract at the equilibrium values. This revenue-sharing equilibrium with airport competition will be referred to as the 'rivalry (revenue sharing) equilibrium,' where 'rivalry' refers to 'airport rivalry.' Without loss of generality the carriers are again assumed to receive their reservation profits π_0^i, $i = 1,2$; consequently, each airport's profit can be rewritten as:

$$\Pi^i(r_1, r_2) = R^i(q_1^*, q_2^*) - C_i(q_i^*) + hq_i^* - \pi_0^i \equiv v^i(q_1^*(r_1, r_2), q_2^*(r_1, r_2)). \tag{21}$$

The rivalry equilibrium is characterized by the first-order conditions,

$$\Pi_i^i = v_i^i \cdot (\partial q_i^* / \partial r_i) + v_j^i \cdot (\partial q_j^* / \partial r_i) = 0, \qquad i = 1,2, \tag{22}$$

where subscripts again denote partial derivatives (e.g., $\Pi_i^i \equiv \partial \Pi^i / \partial r_i$, $v_i^i \equiv \partial v^i / \partial q_i$ and $v_j^i \equiv \partial v^i / \partial q_j$). From (21), $v_i^i = R_i^i(q_1^*, q_2^*) - C_i'(q_i^*) + h$ which can by (5) be rewritten as:

$$v_i^i = w + (1 - r_i)h. \tag{23}$$

For the rivalry equilibrium, since $v_j^i = R_j^i < 0$, $\partial q_i^* / \partial r_i > 0$ and $\partial q_j^* / \partial r_i < 0$, it follows by (22) that $v_i^i < 0$. Thus by (23), the equilibrium sharing proportions satisfy (superscript *R* for 'rivalry equilibrium'),

$$r_i^R > 1 + (w/h), \qquad i = 1,2. \tag{24}$$

It is interesting to compare this rivalry equilibrium with the 'non-rivalry (revenue sharing) solution,' which is obtained when the two airports were perceived as independent in the sense that $p_j^i(q_1, q_2) = 0$. It can be easily seen from (22)-(23) that the non-rivalry sharing proportions are given by (superscript *N* for 'non-rivalry solution'):

$$r_i^N = 1 + (w/h), \qquad i = 1,2. \tag{25}$$

Comparing (25) with (24) leads to:

Proposition 3. *The revenue-sharing proportions are greater at the rivalry revenue-sharing equilibrium than under the non-rivalry revenue-sharing solution, i.e.* $r_i^R > r_i^N$ *for* $i = 1,2$.

The non-rivalry regime is, from (25) and (12), similar to the case of a single (monopoly) airport examined in Section 2, as expected: Like a monopoly airport, each airport in the non-rivalry regime shares positive proportion $r_i^N = 1 + (w/h)$ of concession revenue with its carrier. While r_i^N internalizes the flights-concessions demand complementarity, the rivalry revenue sharing involves an additional term δ_i – i.e. $r_i^R = r_i^N + \delta_i$ – which is unique to the case of competing airports. Since this additional effect works by indirectly influencing the behavior of the rival airport-airline pair – which in turn will improve profit of the airport-airline pair in question – the rivalry revenue sharing may be referred to as the 'strategic revenue sharing.' Proposition 3 therefore shows that airport competition will, owing to this strategic effect, result in a higher degree of revenue sharing than would be had in the case of single airports.

Next, the rivalry equilibrium is compared to the non-rivalry solution in terms of output, price, profit and social welfare. Here, welfare is the sum of passenger surplus and profits of the two airport-airline pairs; hence, it takes the same form as (17). The comparison results are stated as follows:

Proposition 4. *Under symmetry, at the rivalry revenue-sharing equilibrium, (i) outputs are greater, (ii) prices are lower, (iii) airport profits are lower, and (iv) social welfare is higher, than at the non-rivalry revenue-sharing solution.*

Proof: Use Δ to denote any difference of variables between the rivalry equilibrium and the non-rivalry solution. Here, we just show parts (i) and (iii); the proofs for parts (ii) and (iv) are similar to those of Proposition 2.

(i) Applying the mean value theorem (MVT) to $q_i^*(r_1, r_2)$ yields $\Delta q_i^* = (\partial q_i^* / \partial r_i)\Delta r_i + (\partial q_i^* / \partial r_j)\Delta r_j$, with $\partial q_i^* / \partial r_i$ and $\partial q_i^* / \partial r_j$ evaluated at some point between (r_1^N, r_2^N) and (r_1^R, r_2^R). Under symmetry, $\Delta r_i = \Delta r_j$ and $\partial q_i^* / \partial r_j = \partial q_j^* / \partial r_i$; consequently,

$$\Delta q_i^* = [\partial(q_i^* + q_j^*) / \partial r_i]\Delta r_i = [h \cdot (\pi_{ji}^j - \pi_{jj}^j) / J]\Delta r_i$$

Since $\pi_{ji}^j - \pi_{jj}^j > 0$ and $J > 0$ under the second-order and substitutes conditions and the stability condition respectively, $\Delta q_i^* \equiv q_i^R - q_i^N$ must have the same sign as $\Delta r_i \equiv r_i^R - r_i^N$. By Proposition 3, $r_i^R > r_i^N$ and hence $q_i^R > q_i^N$.

(iii) Applying MVT to $\Pi^i(r_1, r_2)$, given by (21), yields $\Delta\Pi^i = \overline{\Pi}_i^i \Delta r_i + \overline{\Pi}_j^i \Delta r_j$, where $\overline{\Pi}_i^i$ and $\overline{\Pi}_j^i$ are evaluated at $(\bar{r}_1, \bar{r}_2)$ with $r_i^N < \bar{r}_i < r_i^R$ (using Proposition 3). Since $\Delta r_i = \Delta r_j$ under symmetry and $\Delta r_i \equiv r_i^R - r_i^N > 0$, it follows that $\Delta\Pi^i = (\overline{\Pi}_i^i + \overline{\Pi}_j^i)(r_i^R - r_i^N)$ and hence $\Delta\Pi^i < 0$ if (and only if) $\overline{\Pi}_i^i + \overline{\Pi}_j^i < 0$. By (21) and symmetry, it follows that

$$\overline{\Pi}_i^i + \overline{\Pi}_j^i = (\bar{v}_i^i + \bar{v}_j^i)[\partial(q_1^* + q_2^*) / \partial r_i],$$

where $\bar{v}_i^i$ and $\bar{v}_j^i$ are evaluated at $\bar{q}_i = q_i^*(\bar{r}_1, \bar{r}_2)$. By (23), $\bar{v}_i^i = w + (1 - \bar{r}_i)h$ which is negative given that $\bar{r}_i > r_i^N = 1 + (w/h)$. Furthermore, since $\bar{v}_j^i = \overline{R}_j^i < 0$ (substitutable airports) and $\partial(q_i^* + q_j^*)/\partial r_i = h \cdot (\pi_{ji}^j - \pi_{jj}^j)/J > 0$, it follows that $\overline{\Pi}_i^i + \overline{\Pi}_j^i < 0$. Therefore, $\Delta\Pi^i \equiv \Pi^{iR} - \Pi^{iN} < 0$. *Q.E.D.*

Perhaps the most surprising result from Proposition 4 (especially as compared to the single-airport case) is related to profit comparison: both airport-airline pairs will derive *lower* profits through this revenue-sharing rivalry. In effect, the airport-airline pairs are trapped by the incentive structure of the environment. If one airport-airline pair ignores the possibility of strategic use of revenue-sharing contracts while the other pair shares revenue strategically, the first pair loses while the second pair gains relative to the non-strategic sharing arrangement. Here the situation is similar to a classic Prisoners' Dilemma. As the pairs move further away from their joint profit maximum through such a revenue-sharing rivalry, social welfare nevertheless rises beyond the level achievable by single airports.

3.2. Multiple airlines

Section 3.1 studies the case of one carrier per airport. We now extend the analysis to a situation where there may be multiple competing airlines at each airport. Our second objective in this section is to show that the general demand structure used in Section 3.1 can be generated through explicit considerations of passenger behavior.

More specifically, our demand derivation follows Basso and Zhang (2007) by considering an infinite linear city, where potential consumers are distributed uniformly with a density of one consumer per unit of length. Two competing airports are located at 0 (airport 1) and 1 (airport 2) and there are n_i carriers at airport *i*, $i = 1,2$ (see Figure 2). At each airport, carriers provide homogeneous output, with total output $Q_i = \sum_{k=1}^{n_i} q_{ik}$ and market price p^i.

**** Figure 2 About Here ****

The ‘full price’ faced by a consumer located at $0 \le z \le 1$ and who goes to airport 1 is given by $p^1 + (4t) \cdot z$, where $4t$ (>0) represents the consumer’s transportation cost from z to location 0. By choosing airport 1 or airport 2 (but not both) the consumer derives the following respective net utilities:

$$U_1 = V - p^1 - (4t) \cdot z, \qquad U_2 = V - p^2 - (4t) \cdot (1 - z), \tag{26}$$

where V denotes (gross) benefit from air travel.[14] Assuming everyone in the [0, 1] interval consumes, then the indifferent passenger $\tilde{z} \in (0,1)$ is determined by setting $U_1 = U_2$, or

$$\tilde{z} = (1/2) + (p^2 - p^1)/8t. \tag{27}$$

Given that airport 1 also captures consumers at its immediate left side, define z^l as the last passenger on the left side of the city who goes to airport 1. Similarly, define z^r as the last passenger on the right side of the city who goes to airport 2. With the uniformity and unit density of consumers, z^l and z^r are computed as:

$$z^l = -(V - p^1)/4t \qquad z^r = 1 + (V - p^2)/4t \tag{28}$$

The airports’ catchment areas are shown in Figure 2, and their demands are computed as:

$$Q_1 = \tilde{z} + \left|z^l\right| = \frac{1}{2} + \frac{p^2 - p^1}{8t} + \frac{V - p^1}{4t}, \tag{29.1}$$

$$Q_2 = (1 - \tilde{z}) + (z^r - 1) = \frac{1}{2} - \frac{p^2 - p^1}{8t} + \frac{V - p^2}{4t}. \tag{29.2}$$

From (29) the inverse demands are given by

$$p^i(Q_1, Q_2) = (2t + V) - 3tQ_i - tQ_j, \qquad i, j = 1,2. \tag{30}$$

which take the linear functional forms. This demand system has the properties of $p_i^i = -3t < 0$, $p_1^1 p_2^2 - p_2^1 p_1^2 = 8t^2 > 0$, and substitutes condition (3).

[14] This is an ‘address model’ with positive linear transportation costs, and the differentiation of the two airports is captured by consumer transportation cost. Within a multi-airport region, passengers may not necessarily choose an airport with cheaper airfare, but may go to a nearer airport – see the empirical studies by, e.g., Pels et al. (2001), Fournier et al. (2007) and Ishii et al. (2009). In addition to distance, other aspects of airport differentiation may be captured by extending the present formulation. For instance, Pels et al. (2000, 2001, 2003) have shown, using a hypothetical example and later the San Francisco Bay Area case study, that ground accessibility of an airport is the most important factor in affecting airport choices in a multi-airport market. Such differential ground access costs could be addressed by introducing a new parameter to the net-benefit functions (26).

To solve the two-stage airport competition game, we begin with an analysis of the second stage when airlines engage in intra- and inter-airport competition. Suppose for simplicity that carriers have linear costs $C(q) = F + cq$. Consider first that the two airports have the same number of carriers, i.e. $n_1 = n_2 \equiv n$. Then airline profits can be written as:

$$\pi^{ik}(Q_1, Q_2, q_{ik}) = p^i(Q_1, Q_2) \cdot q_{ik} - F - cq_{ik} - wq_{ik} + r_i h q_{ik} - f_i . \tag{31}$$

The Cournot-Nash equilibrium is characterized by first-order conditions,

$$\partial\pi^{ik}(Q_1, Q_2, q_{ik}) / \partial q_{ik} = p^i - 3tq_{ik} - c - w + r_i h = 0 , \quad k = 1,...,n , \quad i = 1,2 , \tag{32}$$

(and the corresponding second-order conditions, which hold as $\partial^2\pi^{ik} / \partial q_{ik}^2 = -6t < 0$). Given the underlying symmetry of this set-up, the equilibrium quantities are easily obtained:

$$q_{ik}^*(r_1, r_2) = \frac{[3(n+1)r_i - nr_j]h}{(2n+3)(4n+3)t} + \frac{2t + V - c - w}{(4n+3)t} , \qquad k = 1,...,n , \quad i = 1,2 . \tag{33}$$

Back to the first stage of the game, each airport's profit is:

$$\Pi^i = wQ_i^* + (1 - r_i)hQ_i^* + nf_i , \qquad i = 1,2 . \tag{34}$$

With the airline participation constraints, these profits can be rewritten as,

$$\Pi^i(r_1, r_2) = [p^i(Q_1^*, Q_2^*) - c + h]Q_i^* - n \cdot (F + \pi_0^i) . \tag{35}$$

Hence the rivalry equilibrium is characterized by first-order conditions,

$$\Pi_i^i = [w + (1 - r_i)h - 3t(Q_i^* - q_{ik}^*)] \cdot (\partial Q_i^* / \partial r_i) - tQ_i^* \cdot (\partial Q_j^* / \partial r_i) = 0 , \quad i = 1,2 . \tag{36}$$

From (36) the equilibrium sharing proportions are obtained as,

$$r_i^R(n) = 1 + (w/h) - (8n^2 - 9)(2t + V + h - c) / n(20n + 21)h , \quad i = 1,2 . \tag{37}$$

Notice from (37) that if $n = 1$ (each airport has one carrier) then $r_i^R > 1 + (w/h) = r_i^N$, a result obtained in Section 3.1 (see Proposition 3).[15] Further, it follows from (37) that $dr_i^R / dn < 0$, $i = 1,2$: i.e. the sharing proportions decrease in the number of carriers serving the airports.

[15] This result can also be shown using demand functions (30) and the property of their associated revenue functions $R_j^i = p_j^i q_i = -tq_i < 0$.

For the general case where airports 1 and 2 have n_1 and n_2 carriers respectively, the inverse demands are given by (30), where $Q_i = \sum_{k=1}^{n_i} q_{ik}$ is the aggregate demand at airport *i*. Solving the two-stage game yields:

$$r_i^R = 1 + \frac{w}{h} - \frac{[(8n_j + 9)n_i - 9n_j - 9](14n_i + 15)(2t + V + h - c)}{n_i(280n_i n_j + 297n_i + 297n_j + 315)h}, \quad i = 1,2. \quad (38)$$

Note that when $n_1 = n_2 = n$, the above expression reduces to expression (37). From (38) it is straightforward to show that $dr_i^R / dn_i < 0$ and $dr_i^R / dn_j > 0$, leading to:

Proposition 5. *At the rivalry equilibrium with n_1 and n_2 carriers at airports 1 and 2 respectively, $dr_i^R / dn_i < 0$ and $dr_i^R / dn_j > 0$: i.e. the revenue-sharing proportion of an airport-airlines chain decreases in the number of carriers at its airport, and increases in the number of carriers at the competing airport. If $n_1 = n_2 = n$, then $dr_i^R / dn < 0$.*

The intuition behind $dr_i^R / dn_i < 0$ is similar to that of Proposition 1 (the substitutes case): As n_i rises (while holding n_j constant) and airline competition intensifies, total output becomes increasingly 'excessive' (relative to profit maximization) for the *i*th airport-airlines chain. Anticipating this, airport *i* will have a greater incentive to discourage such competition, which can be achieved by a smaller sharing proportion.[16] While this result is largely expected, the other result, $dr_i^R / dn_j > 0$, is not obvious. Here, the explanation is related to the 'number of competitors' effect: An increase in the number of airlines serving at airport *j*, while holding n_i unchanged, would increase airport *j*'s output share in the two-airport market.[17] To counter the effect, airport *i* strategically raises the sharing proportion so as to induce its carriers to commit to greater output. This would credibly deter airport *j*'s carriers from providing more service, which

[16] While the two results have similar intuitions, the present result is nevertheless obtained in an environment of competing airports.

[17] This 'number of competitors' effect is related to a well-known result found by Salant et al. (1983): in a Cournot market, a merger of two firms into one entity reduces the merger partners' profit (unless the merger leads to a monopoly). By internalizing part of the effect that a firm's quantity decision has on the rivals' profit, the merged entity sets its quantity too low, thereby yielding market share to the non-participating firms.

in turn improves profit of the i^{th} airport-airline chain.[18] Finally, $dr_i^R / dn < 0$ for $n_1 = n_2 \equiv n$, indicating that as n rises, the (negative) excessive-output effect dominates the number-of-competitors effect.

Like Section 3.1 (which considers one carrier at each airport) we can compare the rivalry equilibrium with the non-rivalry solution – in the present case however, each airport has multiple carriers. It can be easily calculated that the non-rivalry sharing proportions are equal to:

$$r_i^N = 1 + (w/h) - (n_i - 1)(2t + V + h - c)/2n_i h, \qquad i = 1,2. \tag{39}$$

Note, first, that if $n_i = 1$, (39) reduces to (25) and so it extends formula (25) to the case of multiple airlines. Second, using (39) we obtain:

$$dr_i^N / dn_i < 0, \qquad i = 1,2, \qquad . \tag{40}$$

that is, as the number of airlines at a single airport increases and hence (uncoordinated) output gets increasingly excessive for the carriers' joint-profit maximization, the airport then has a greater incentive to curb output by using a smaller sharing proportion.[19] This result is a clear extension of Proposition 1 which considers the effect of moving from one carrier to two carriers. Finally, comparing (39) with (38) yields that $r_i^R > r_i^N$ for any n_i and n_j (n_i and n_j can take different values, $i, j = 1,2$): i.e. the revenue-sharing proportions are greater at the rivalry revenue-sharing equilibrium than under the non-rivalry revenue-sharing solution. This extends Proposition 3 of Section 3.1 to the general case of multiple airports with each having an arbitrary number of carriers.[20]

---

[18] As noted by an anonymous referee, Proposition 5 is rather interesting in that it recalls the case of some LCCs (for instance, Ryanair) at some secondary airports an LCC dominates. While competing with main airports with many airlines, the LCC will ask for a higher r_i and the airport will be interested in this.

[19] An alternative explanation for the intuition behind this result, suggested by an anonymous referee, is the following: As the number of airlines in an airport increases, the airport has more market power and may raise its share $1 - r_i$. Moreover, the competition effect (or the increase of the output, recalling that *w* is fixed, so that *wq* increases with *q*) is done in the downstream market by a more intense competition amongst airlines. Then the airport may increase $1 - r_i$ without decreasing much the output.

[20] Similarly, Proposition 4 (including the Prisoners' Dilemma result) can be extended to the *n*-carrier case. The derivation is available upon request.

4. Pure Revenue-Sharing Contract

So far our approach to revenue sharing has focused on a 'two part' scheme under which an airport chooses both a sharing proportion and a lump-sum fee on its carriers for the right to share concession revenue. In this section we consider a 'pure' sharing contract under which the fixed fee is constrained to zero, while keeping the rest of the model unchanged. Using 'hat' to denote the pure revenue-sharing equilibrium – i.e. $(\hat{r}_1, \hat{r}_2)$ – these sharing proportions are constrained by the carriers' participation constraints. Unlike the two-part sharing scheme, therefore, 'negative sharing' is not possible since these carriers cannot be compensated for with any fixed payments by the airport, indicating $\hat{r}_i \geq 0$. Given these observations, the effects of the pure revenue-sharing contract will be compared to those of the two-part scheme as well as the no-sharing regime.

4.1 Single airport

Consider first a single airport served by two carriers, which provide complementary, independent or substitutable services to each other. The airport offers carrier *i* a pure sharing contract with sharing proportion r_i, and the carriers compete by choosing quantities q_i. We can show (see the Appendix):

Proposition 6. *At the pure revenue-sharing equilibrium with a single airport,*

1. when carriers provide independent and complementary services (assuming symmetric carriers in the case of complements) to each other, both the sharing proportions and social welfare are smaller than at the revenue-sharing equilibrium;

2. when carriers provide substitutable services to each other, both the sharing proportions and social welfare may be higher or smaller than at the revenue-sharing equilibrium.

For the cases of independent or complementary services, the airport, being unable to charge the fixed fee under the pure revenue sharing, shares less concession revenue with its carriers than would be under the two-part revenue sharing. This result follows directly from comparing (A4)-(A5) with the sharing proportions (12) and (15). This reduction in sharing will, by similar arguments used in the proof of Proposition 2, reduce welfare. For the substitutes case however, although the equilibrium sharing proportions are, by (A4) and (16), less than $1+(w/h)$ for both types of revenue sharing, the sharing-proportions comparison between the two types is in general ambiguous. In particular, while negative sharing is ruled out under the pure revenue sharing, it is possible under the two-part revenue sharing. In such situations, it can be shown that the pure revenue sharing results in not only a higher sharing proportion, but also a *higher* welfare level if carriers are sufficiently symmetric, than the two-part revenue sharing.[21]

Finally, the pure revenue sharing can also be compared to the no-sharing regime. It can be shown that at the pure revenue-sharing equilibrium, prices are lower, and both outputs and welfare are greater, than in the absence of revenue sharing. These results hold irrespective of the carriers' offering complementary, unrelated or substitutable services. The proofs are analogous to the proofs of Proposition 2, with some of the results requiring that carriers be reasonably symmetric.

4.2 Competing airports

Next consider two competing airports, each served by one carrier. The stage-2 equilibrium quantities are again characterized by (5) and are given by $q_i^*(r_1, r_2)$, which have comparative-static property $\partial q_i^* / \partial r_i > 0$, $i = 1,2$. Then each airport's profit in stage 1 is $\Pi^i(r_1, r_2) = wq_i^*(r_1, r_2) + (1 - r_i)hq_i^*(r_1, r_2)$, and the pure revenue-sharing equilibrium is characterized by first-order conditions,

$$\Pi_i^i = [w + (1 - r_i)h] \cdot (\partial q_i^* / \partial r_i) - hq_i^* = 0, \qquad i = 1,2. \tag{41}$$

From (41) and $\partial q_i^* / \partial r_i > 0$, it follows that $w + (1 - r_i)h > 0$ and so

$$0 \le \hat{r}_i < 1 + (w/h) = r_i^N < r_i^R, \qquad i = 1,2. \tag{42}$$

The following results are then obtained (part 2's proof is analogous to Proposition 2's):

Proposition 7. *At the pure revenue-sharing equilibrium with competing airports,*

[21] When competing carriers are asymmetric, however, there is an interesting twist introduced in the sharing-proportions and welfare comparison between the pure and two-part sharing arrangements. Numerical simulations can be constructed (available upon request) to show that an airport with the two-part revenue sharing tends to share more revenue with a more efficient carrier, whilst an airport under the pure revenue sharing may share less with a carrier as it becomes more efficient. As a result, carrier asymmetry tends to favor the two-part revenue sharing, in terms of enhancing welfare, over the pure revenue sharing.

1. the sharing proportions are smaller (greater, respectively); and

2. under symmetry, (i) outputs and welfare are smaller (greater, respectively) and (ii) prices are higher (lower, respectively)

than at the revenue-sharing equilibrium (the no-sharing equilibrium, respectively).

Proposition 7 indicates that under airport competition, the pure revenue sharing improves welfare relative to the no-sharing regime, albeit less effective than the two-part revenue sharing. In general, in terms of airfare, traffic volume and social welfare, the pure revenue sharing with competing airports lies in between the no-sharing and two-part revenue sharing regimes. It is also worth noting that unlike the ambiguous result for the single airport, the two-part revenue sharing unambiguously entails a higher sharing proportion than the pure revenue sharing. The reason that competition between airports plays a decisive role in pushing up the sharing proportions under the two-part sharing is related to the result $dr_i^R / dn_j > 0$ of Proposition 5: an airport need to raise its two-part sharing proportions in the presence of a competing airport.

5. Concluding Remarks

This paper has investigated the implications of concession revenue sharing between an airport and its airlines. Earlier studies show that such sharing allows an airport to internalize the demand complementarity between flights and concessions, and may improve both profits and welfare. We found that the degree of sharing will be further affected by how carriers' services are related (complements, independent, or substitutes). In particular, when carriers provide substitutable services to each other, the sharing proportions might become negative if substitutability between airlines' services is sufficiently strong and the fixed (transfer) payments between the airport and carriers are feasible (the two-part revenue sharing). The negative sharing allows the airport to penalize the over-competing airlines so as to support airfares. In these situations, while revenue sharing improves the total airport-airlines channel profit, it reduces social welfare. If the fixed payments are not feasible, under the resulting pure revenue sharing the airport will, for the cases of independent or complementary services, share less concession revenue with its carriers than would be under the two-part revenue sharing.

For the substitutes case however, the sharing-proportions comparison between the two types is in general ambiguous. In the special case of negative sharing, the pure revenue sharing results in not only a higher sharing proportion, but also a higher welfare level if carriers are sufficiently symmetric, than the two-part revenue sharing.

Our second objective in writing this paper is to extend the existing literature on airport-airline vertical cooperation to the general case of multiple competing airports with each having an arbitrary number of carriers. We found that airport competition will result in a higher degree of vertical cooperation between an airport and its home carriers, in forms such as the revenue sharing modeled in our paper, than would be had in the case of single airports. Nevertheless, the airport-airline chains may derive lower profits through this revenue-sharing rivalry: in effect, the airports are trapped by the incentive structure of the environment, and the situation is similar to a classic Prisoners' Dilemma. As the airport-airline chains move further away from their joint profit maximum, social welfare rises beyond the level achievable by single airports. Our analysis also showed that the (equilibrium) revenue-sharing proportion at an airport decreases in the number of its carriers, and increases in the number of carriers at the competing airport. Airline market structure will therefore influence revenue sharing arrangements not only at the airport in question, but also at the competing airports.

Overall, our results indicate that when airport-airline vertical cooperation is allowed, an airport has a strategic interest in influencing competition in the downstream airline market. Airport competition further induces airports to strengthen their cooperation with airlines, although such cooperation might actually reduce joint profits. In terms of the welfare consequences of alternative revenue sharing arrangements, whether an airport is subject to competition is critical: for competing airports, 'no sharing' is worse than 'pure sharing' which is in turn worse than the two-part sharing. For single airports, on the other hand, while no-sharing is worse than pure-sharing, both no-sharing and pure-sharing might be better than the two-part sharing when airlines provide substitutable services to each other.

The paper has also raised several other issues and avenues for future research. First, we assumed that the airport chooses the fees as high as possible subject to carriers' participation constraints. An alternative, and perhaps more realistic, structure is to have the airport and airlines bargain over the fees, which may be modeled as the result of a Nash-bargaining process, with the division capturing the degree of bargaining power of the airport with respect to the airlines involved. Second, we assumed that the aeronautical fare, *w*, is regulated and cannot be changed. This assumption does not allow for analyzing the effects of changes in revenue-sharing systems on price *w*. It would be interesting to further study the implications of allowing *w* to vary, perhaps along with the contract variables examined in the present paper. For instance, the value of r_i is, for independent services, equal to $1+(h/w)$; consequently, $dw/dr_i < 0$: i.e. the higher *w* is, the smaller will r_i be. Airport deregulation or a loosened cap on the aeronautical price may mean a rise in *w* and hence a fall in r_i. Also, the game in Section 3.1 would become a three-stage game if airports would also compete in *w*. We see these analyses as natural extensions of the analysis presented here, although beyond the scope of the present article.

- The horizontal axis corresponds to substitutability parameter *m*, with $k = m \cdot b$, $m \in (-0.1, 1)$
- — Solid Line: Results with share revenue
- ⋯ Dotted Line: Results without revenue sharing.

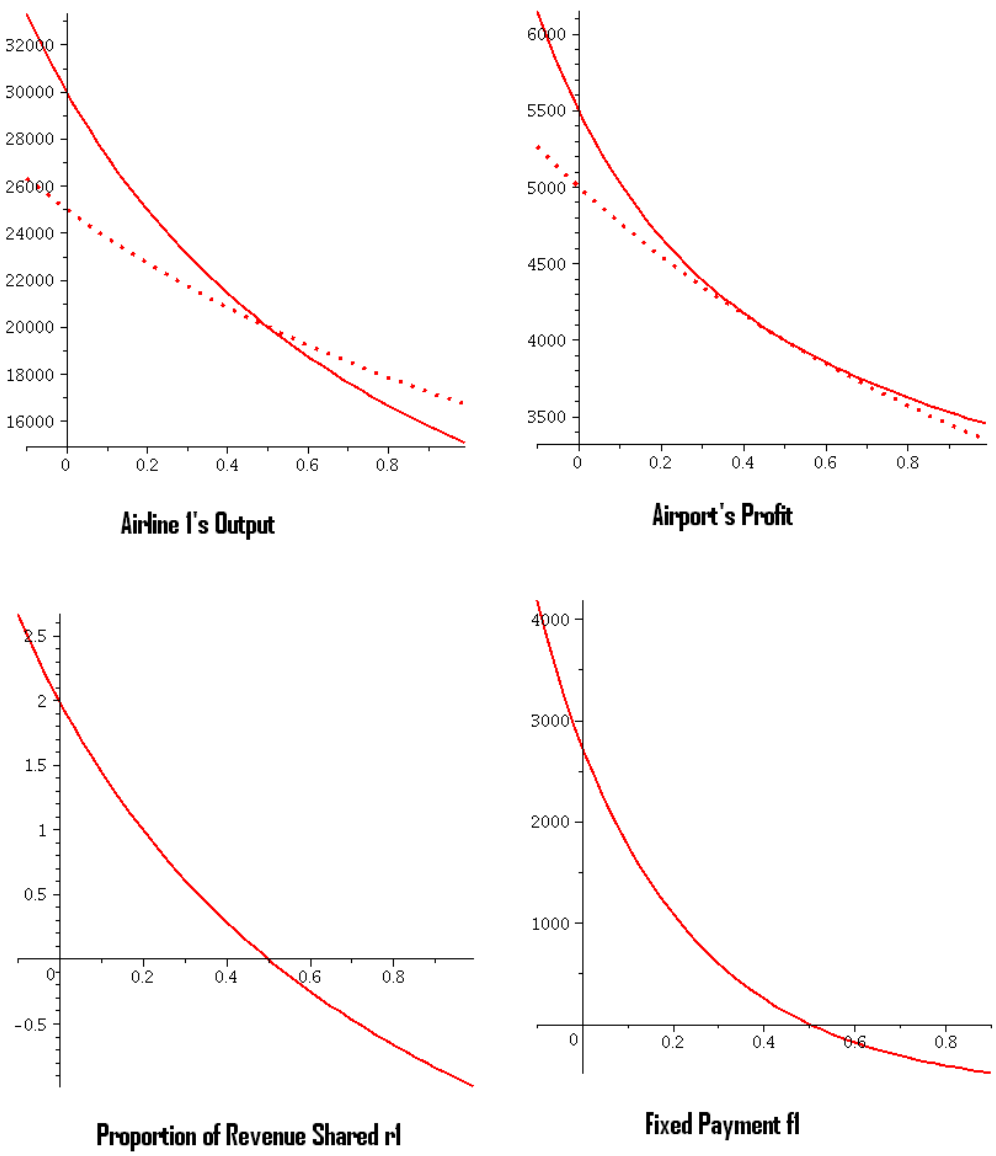

Figure 1. Revenue sharing vs. no sharing: Single airport with two carriers

(Parameter values: b = 0.00001, $c_1 = c_2 = 0.45$, w = 0.05, h = 0.05)

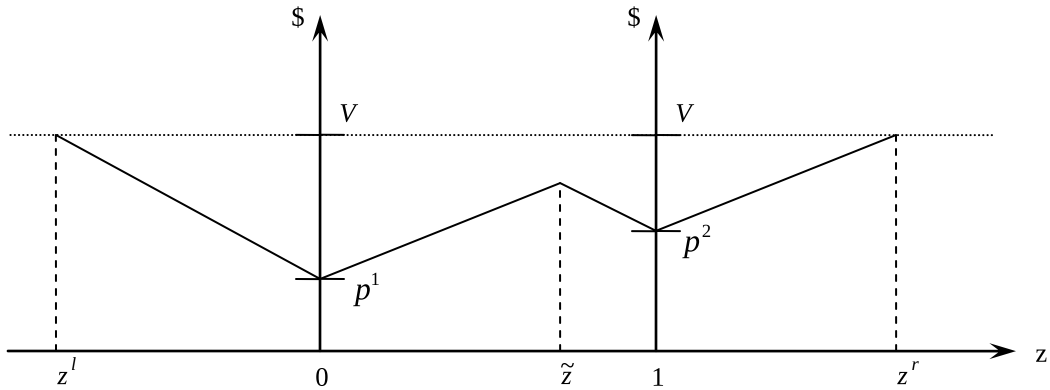

Figure 2. Consumer distribution and airports' catchment areas (adapted from Basso and Zhang, 2007)

Appendix

Proof of Proposition 6: Each carrier's profit is given by

$$\pi^i(q_1,q_2) = R^i(q_1,q_2) - C_i(q_i) - wq_i + r_i h q_i, \qquad i = 1,2. \tag{A1}$$

The stage-2 equilibrium quantities are characterized by (5), and are expressed as $q_i^*(r_1,r_2)$ with $\partial q_i^* / \partial r_i$ and $\partial q_j^* / \partial r_i$ given by (6). Then, the airport's profit in stage 1 is

$$\Pi(r_1,r_2) = w\cdot(q_1^* + q_2^*) + (1-r_1)hq_1^* + (1-r_2)hq_2^*. \tag{A2}$$

The pure revenue-sharing equilibrium is determined, implicitly, by first-order conditions,

$$\partial\Pi / \partial r_1 = [w+(1-r_1)h]\cdot(\partial q_1^* / \partial r_1) + [w+(1-r_2)h]\cdot(\partial q_2^* / \partial r_1) - hq_1^* = 0, \tag{A3.1}$$

$$\partial\Pi / \partial r_2 = [w+(1-r_2)h]\cdot(\partial q_2^* / \partial r_2) + [w+(1-r_1)h]\cdot(\partial q_1^* / \partial r_2) - hq_2^* = 0. \tag{A3.2}$$

Multiplying (A3.1) by $\partial q_1^* / \partial r_2$ and then subtracting $(A3.2)\times\partial q_1^* / \partial r_1$ yields:

$$[w+(1-r_2)h][(\partial q_1^* / \partial r_2)(\partial q_2^* / \partial r_1) - (\partial q_1^* / \partial r_1)(\partial q_2^* / \partial r_2)] = h[q_1^*(\partial q_1^* / \partial r_2) - q_2^*(\partial q_1^* / \partial r_1)].$$

Further, by (6) we have

$$[w+(1-r_2)h][h^2(\pi_{12}^1\pi_{21}^2 - \pi_{11}^1\pi_{22}^2) / J] = h[q_1^*(\partial q_1^* / \partial r_2) - q_2^*(\partial q_1^* / \partial r_1)].$$

Since $\pi_{12}^1\pi_{21}^2 - \pi_{11}^1\pi_{22}^2 = -J$, it follows that $[w+(1-r_2)h]h = -[q_1^*(\partial q_1^* / \partial r_2) - q_2^*(\partial q_1^* / \partial r_1)]$. By Lemma 1, $\partial q_1^* / \partial r_1 > 0$ and $\partial q_1^* / \partial r_2 = 0$ and < 0 for independent and substitutable services respectively, we must have $w+(1-r_2)h > 0$. Similarly, it can be shown that $w+(1-r_1)h > 0$ for independent and substitutable services. Therefore,

$$\hat{r}_i^I < 1 + (w/h) \quad \text{and} \quad \hat{r}_i^S < 1 + (w/h), \qquad i = 1,2. \tag{A4}$$

For complements however, we need to assume the symmetry condition. Under symmetry, we have $w+(1-r_1)h = w+(1-r_2)h$ in (A3.1), which reduces to:

$$[w+(1-r_1)h]\cdot(\partial q_1^* / \partial r_1 + \partial q_2^* / \partial r_1) = hq_1^*.$$

Because $\partial q_1^* / \partial r_1 > 0$, and $\partial q_2^* / \partial r_1 > 0$ for complementary services, we must have $w+(1-r_1)h > 0$, and so

$$\hat{r}_i^C < 1 + (w/h), \qquad i = 1,2. \tag{A5}$$

The rest of the proof is relatively straightforward and is available upon request from the authors. *Q.E.D.*

References

ATRS (Air Transport Research Society), 2008. *The ATRS Airport Performance Benchmarking Report: Global Standards for Airport Excellence*, 3-volume report, published by the Centre for Transportation Studies, University of British Columbia, Vancouver, BC. www.atrsworld.org

Auerbach, S. and Koch, B., 2007. Cooperative approaches to managing air traffic efficiently – the airline perspective. Journal of Air Transport Management, 13, 37-44.

Barbot, C., 2006. Low-cost airlines, secondary airports, and state aid: An economic assessment of the Ryanair–Charleroi airport agreement. Journal of Air Transport Management, 12, 197-203.

Barbot, C., 2009a. Airport and airline competition: Incentives for vertical collusion. Transportation Research Part B (Methodological), 43, 952-965.

Barbot, C., 2009b. Vertical contracts between airports and airlines: Is there a trade-off between welfare and competitiveness? Manuscript, CETE, Faculty of Economics of Porto, Porto, Portugal.

Basso, L.J., 2008. Airport deregulation: Effects on pricing and capacity. International Journal of Industrial Organization, 26, 1015-1031.

Basso, L.J. and Zhang, A., 2007. Congestible facility rivalry in vertical structures. Journal of Urban Economics, 61, 218-237.

Basso, L.J. and Zhang, A., 2008. On the relationship between airport pricing models. Transportation Research Part B (Methodological), 42, 725-735.

Bowley, A.L., 1928. Bilateral monopoly. The Economic Journal, 38, 651-659.

Brander, J.A. and Zhang, A., 1990. Market conduct in the airline industry: An empirical investigation. Rand Journal of Economics, 21, 567-583.

Brander, J.A. and Zhang, A., 1993. Dynamic behaviour in the airline industry. International Journal of Industrial Organization, 11, 407-435.

Brueckner, J.K., 2001. The economics of international codesharing: An analysis of airline alliances. International Journal of Industrial Organization, 19, 1475-1498.

Brueckner, J.K., 2002. Airport congestion when carriers have market power. American Economic Review, 92, 1357-1375.

Brueckner, J.K. and Whalen, W.T., 2000. The price effects of international airline alliances. Journal of Law and Economics, 43, 503-545.

Bulow, J.I., Geanakoplos, J.D. and Klemperer, P.D., 1985. Multimarket oligopoly: Strategic substitutes and complements. Journal of Political Economy, 93, 488-511.

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

Dixit, A.K., 1986. Comparative statics in oligopoly. International Economic Review, 27 (1), 107-122.

Doganis, R., 1992. The Airport Business. Routledge, London.

Dresner, M., Windle, R. and Yao, Y., 2002. Airport barriers to entry in the US. Journal of Transport Economics and Policy, 36, 389-405.

FAA (US Federal Aviation Administration), 1999. Airport business practices and their impact on airline competition. FAA/OST Taskforce Study.

Fournier, G.M., Hartmann, M.E. and Zuehlke, T., 2007. Airport substitution by travelers: Why do we have to drive to fly? in: D. Lee (Ed.), Advances in Airline Economics, Vol. 2, pp. 209-233, Elsevier.

Francis, G., Humphreys, I. and Ison, S., 2004. Airports' perspectives on the growth of low-cost airlines and the remodeling of the airport–airline relationship. Tourism Management, 25, 507–514.

Friedman, J.W., 1977. Oligopoly and the Theory of Games, North Holland, Amsterdam.

Fu, X. and Zhang, A., 2009. Effects of airport concession revenue sharing on competition and social welfare. Journal of Transport Economics and Policy, forthcoming.

GAO (US General Accounting Office), 1997. Domestic Aviation: Barriers Continue to Limit Competition, GAO/T-RCED-98-32.

Gillen, D.W. and Morrison, W.G., 2003. Bundling, integration and the delivered price of air travel: Are low cost carriers full service competitors? Journal of Air transport Management, 9, 15-23.

Hartmann, M.E., 2006. Access to airport facilities: Its impact on market competition. in: D. Lee (Ed.), Advances in Airline Economics, Vol. 1, pp. 369-384, Elsevier.

Ishii, J., Jun, S. and Van Dender, K., 2009. Air travel choices in multi-airport markets. Journal of Urban Economics, 65, 216-227.

Jones, I., Viehoff, I. and Marks, P., 1993. The economics of airport slots. Fiscal Studies, 14, 37–57.

Kuchinke, A.B. and Sickmann, J., 2005. The joint venture terminal 2 at Munich airport and the consequences: A competition economic analysis. Paper presented at the 4th Conference on Applied Infrastructure Research, Berlin, 8 October 2005.

Oum, T.H., Zhang, A. and Zhang, Y., 2004. Alternative forms of economic regulation and their efficiency implications for airports. Journal of Transport Economics and Policy, 28, 217-246.

Pels, E., Nijkamp, P. and Rietveld, P., 2000. Airport and airline competition for passengers departing from a large metropolitan area. Journal of Urban Economics, 48, 29-45.

Pels, E., Nijkamp, P. and Rietveld, P., 2001. Airport and airline choice in a multiple airport region: An empirical analysis for the San Francisco Bay area. Regional Studies, 35, 1-9.

Pels, E., Nijkamp, P. and Rietveld, P., 2003. Access to a competition between airports: A case study for the San Francisco Bay Area. Transportation Research Part A, 37, 71-83.

Pels, E. and Verhoef, E.T., 2004. The economics of airport congestion pricing. Journal of Urban Economics, 55, 257-277.

Salant, S., Switzer, S. and Reynolds, R., 1983. Losses from horizontal mergers: The effects of an exogenous change in industry structure on Cournot-Nash equilibrium. Quarterly Journal of Economics, 48, 185-199.

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

Starkie, D., 2008. The airport industry in a competitive environment: A United Kingdom perspective. OECD-ITF Discussion Paper No. 2008-15, July 2008.

Tirole, J., 1988. The Theory of Industrial Organization, MIT Press, Cambridge, Massachusetts.

Zhang, A. and Zhang, Y., 1997. Concession revenue and optimal airport pricing. Transportation Research Part E, 33, 287-296.

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

Zhang, A. and Zhang, Y., 2006. Airport capacity and congestion when carriers have market power. Journal of Urban Economics, 60, 229-247.

Zhang, A., Hanaoka, S., Inamura, H. and Ishikura, T., 2009. Low cost carriers in Asia: Deregulation, regional liberalization and secondary airports. Research in Transport Economics, 24, 36-50.