Airport privatization and international competition

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Abstract

We provide a simple theoretical model to explain the mechanism whereby the privatization of international airports can improve welfare. The model consists of a downstream (airline) duopoly with two inputs (landings at two airports) and two types of consumers. The airline companies compete internationally. We show that the outcome in which both airports are privatized is always an equilibrium, whereas that in which no airport is privatized is an equilibrium only if the degree of product differentiation is large. We also discuss airport congestion problems within the model framework.

JEL classification: L33, L13, R48

Key words: Airport, Privatization, International competition, Vertical relations, Congestion.

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1 Introduction

Following the example of the UK, many countries have moved—or are moving—towards the privatization of some public airports. For instance, in New Zealand, major national airports, including the Auckland and Wellington International Airports, are operated by “for-profit” private sector firms with various local governments as minority owners (Oum et al. (2006)).

There are many sound reasons behind the move towards the privatization of public airports. Typical reasons are efficiency improvement (Oum et al. (2006)), mitigation of financial constraints (Hooper, 2002), and a belief that a private airport would manage congestion better (Basso (2008)).

Much research on airport privatization has been conducted recently (Basso (2008), Basso and Zhang (2008), Zhang and Zhang (2003, 2006)). In their seminal paper on airport privatization, Zhang and Zhang (2003) raise the following question: Can we expect the profit-maximizing behavior of privatized, unregulated airports to maximize social welfare, or is there a conflict between maximizing social welfare and maximizing profits? They incorporate the problems of congestion, capacity investment, and market power over landing charges into a privatization policy framework and compare the price decisions of privatized, unregulated airports with those of public airports that maximize social welfare.

Although these studies of airport privatization provide interesting insights, they do not show situations in which privatization improves welfare; therefore, a welfare-maximizing government has no incentive to privatize airports. This paper provides a different rationale for privatization from those mentioned above, where in fact privatization is welfare-improving.

In this paper, we present a model in which local welfare-maximizing governments have

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1 New Zealand introduced no formal price regulation with regard to the privatized airports, whereas most major Australian airports were privatized utilizing price-cap regulation until June 2002 (Oum et al. (2006)).

2 Focusing on productive efficiency and operating profitability, Oum et al. (2006) show that airports owned and managed by a mixed enterprise with majority government ownership are significantly less efficient than 100% publicly owned and operated airports. Basso (2008) shows theoretically that there will be less congestion in a private airport.

3 Schmidt (1996a,b) investigates privatization problems using an incomplete contracts approach.
incentives to privatize airports, and we show why many countries have moved towards the privatization of public airports. We consider a simple downstream (airline) duopoly with two inputs (landings at two airports). The model setting is as follows.\(^4\) There are two airlines companies that supply final products to passengers. The consumer sizes in the two countries differ. We call the country with the larger number of consumers “the large country.” Each airline company procures two inputs for its final product. Each input is monopolistically supplied by an independent supplier. In the context of airline competition, the inputs are related to airports commonly used by the airline companies.

We consider the following three-stage game. First, each government independently decides whether to privatize its airport. The objective of a public airport is to maximize domestic welfare, whereas that of a private airport is to maximize its own profit.\(^5\) In the second stage, the airports independently set their airport charges. In the third stage, two airlines face price competition and set their prices simultaneously.

We show that each government privatizes its airport so as to maximize its domestic social surplus in equilibrium. We also find that the governments may face a prisoner’s dilemma; that is, commitments to nonprivatization policies may be mutually beneficial for the two countries. The results do not depend on the competition structure between the airline companies. Furthermore, if the difference between the consumer sizes is large and if the degree of product differentiation in the airline market is small, the large country prefers the privatization of both airports, whereas the small one prefers the nationalization of both airports. We also consider the case in which two airline companies face quantity competition and set their quantities simultaneously. The results in the two models are qualitatively the same.

The rationale behind the result is as follows. The strategic interaction between the airports is strategic substitution. That is, when an airport charge is high (low), the charge set by the other airport becomes low (high). This is because a higher airport charge diminishes the demand for each airline, which is closely correlated to the derived demand

\(^4\) In the basic model, we do not consider the problems of congestion and capacity at airports, although these are discussed in many of the papers mentioned above. We discuss the problems in Section 5.

\(^5\) This, in addition to the competition structure in the second and third stages, follows the model assumption in Zhang and Zhang (2003).
for the other airport. Given the strategic interactions, we now consider the relation between the airport charges and the objectives of the airports. A national airport sets a lower airport charge than a privatized one because the national airport considers not only its own profit but also that of the domestic airline company and consumer welfare. When the other airport is foreign, this lower charge set by the national airport constitutes a transfer from it to the other airport. This causes a welfare loss that can dominate both the welfare gain for consumers and the profit of the domestic airline company. The privatization of an airport involves a commitment not to lower its airport charge, which can thus improve its domestic social surplus.

The effect of airport privatization on the two countries is quite interesting when the difference between the consumer sizes is large and when the degree of product differentiation is small. In this situation, the large country prefers the privatization of both airports, whereas the small one prefers the nationalization of both airports. The rationale behind the result is as follows. When both airports are nationalized, the airport charge in the large country is smaller than that in the small one. The difference between the charges is significant when the above two conditions are satisfied. That is, the rent-shift from the large country to the small one is significant in this situation. When the degree of product differentiation is small (airline competition is severe), the profits of the airline companies are small. This implies that consumer welfare and airport profits are more important than the airline profits. Because consumer welfare is relatively important to the large country, its airport charge tends to be lower than that in the small country. When the difference between the sizes of consumers is large, the nationalized airport in the large country takes into account its large consumer size. Moreover, the strategic substitutability of the airport charges exacerbates the difference between airport charges. Therefore, when the above two conditions are satisfied, privatization of the two airports improves social welfare in the large country.

We further extend our model. We incorporate airport congestion problems into the basic model, and we consider a situation in which only one airport is privatized. This setting allows us to investigate which airport has more incentive to mitigate congestion problems. We show that the privatized airport has a stronger incentive to mitigate congestion problems. As explained earlier, the privatized airport sets a higher airport
charge, but the nationalized airport sets a lower airport charge. The change in the airport charges causes the rent-shift from the nationalized airport to the privatized one. Because the rent-shift increases the marginal gain of the privatized airport from the reduction of congestion problems, the privatized airport has a stronger incentive to engage in the reduction of congestion problems.

The mechanism behind the main result may evoke strategic government intervention in international trade (Brander (1995)). The properties underlying the results in the literature of strategic trade policy and those in our paper are quite different. The papers in the literature on strategic trade policy mainly show that a government encourages its downstream domestic firm through subsidies and that this encouragement deprives foreign downstream rivals of rent. Our paper shows that upstream firms (airports) indirectly compete via their airport charges and that the privatization of an airport induces it to adopt a higher pricing strategy that deprives the foreign airport of rent because of strategic substitution.

We have to mention that Mantin (2012) independently develops a model related to ours. He also shows a similar result in which privatization can appear in equilibrium. In his model, the sizes in the two countries are the same. That is, he does not discuss how the market-size heterogeneity affects the incentives of the airports to privatize and the welfare properties in the two countries. Moreover, he does not consider the congestion problems that are often discussed in the context of airport competition.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 provides the main result. Section 4 considers a competition structure that differs from that in the basic model. Section 5 discusses the effect of congestion (negative externalities). Finally, Section 6 concludes the paper.

2 The model

We consider an oligopoly model with international airline competition. Two countries, $A$ and $B$, exist. There are two downstream airline companies ($D_1$ and $D_2$), two airport operators for the airline companies ($U_A$ and $U_B$), and two consumer groups ($C_A$ and $C_B$).
The nationalities of $D_1$, $U_A$, and $C_A$ and those of $D_2$, $U_B$, and $C_B$ are the same, respectively, with the former group belonging to country $A$ and the latter to country $B$. We now describe the details of these players.

Two airline companies, $D_1$ and $D_2$, supply passenger services to consumers. Each maximizes its own profit. The passenger services are differentiated. Each airline company uses two airports ($A$ and $B$) for its passenger service. Airports $A$ and $B$ are supplied by monopolistic common airport operators, $U_j$ ($j = A, B$). To produce a unit of passenger service, each airline company $i$ ($i = 1, 2$) uses airport $A$ once and airport $B$ once. Airports incur no marginal cost for a unit of landing. Except for airport charges, the costs of the airline companies are zero. We assume that the airport operators $U_A$ and $U_B$ unilaterally set the airport charges, $w_A$ and $w_B$, respectively. We also assume that the airport operators do not price discriminate. In this setting, the per-unit cost of each airline company $i$ ($i = 1, 2$) is given as

$$c_i = w_A + w_B, \ (i = 1, 2).$$

There are two types of consumer groups, $C_A$ and $C_B$, which differ in size. The size of $C_A$ is $\lambda_A = 1$, and that of $C_B$ is $\lambda_B = \lambda (\leq 1)$. That is, $C_A$ is larger than or equal to $C_B$. Each consumer group (representative consumer) has a utility function, denoted by ($k = A, B$)

$$U_k = q_{1k} + q_{2k} - q_{1k}^2 + 2\gamma q_{1k}q_{2k} + q_{2k}^2,$$

where $q_{ik}$ is the number of airline company $i$’s flights and $\gamma$ is the degree of product differentiation ($\gamma \in (0, 1)$). The number of flights corresponds to the demand for airline services, which can be shown by assuming that the load factor is 100% and that aircraft size is 1. When $\gamma = 1$, the airline services are perfect substitutes; when $\gamma = 0$, they are independent. Given the utility function, each consumer $k$ has the inverse demand functions of the products, denoted by ($k = A, B$)

$$p_{ik} = 1 - q_{ik} - \gamma q_{-ik}, \ i, -i = 1, 2, \ (i \neq -i).$$
From the inverse demand functions, the demand functions are derived:  

\[ q_{ik} = \frac{1 - \gamma - p_{ik} + \gamma p_{-ik}}{1 - \gamma^2}, \quad i, -i = 1, 2, \quad (i \neq -i). \]

The total demand for airline company \(i\)'s service is given as \(q_{iA} + \lambda q_{iB} \quad (i = 1, 2)\). In the context of airline competition, the two airline companies compete on the same route between airports \(A\) and \(B\). Therefore, it is reasonable that the products are substitutes.  

The profit of airline company \(i\) \((i = 1, 2)\) is given as  

\[ \pi_{Di} = (p_{iA} - (w_A + w_B))q_{iA} + (p_{iB} - (w_A + w_B))\lambda q_{iB}, \quad i = 1, 2. \]

The net consumer surplus in country \(k\) \((k = A, B)\) is given as \((\lambda_A = 1 \text{ and } \lambda_B = \lambda)\)  

\[ CS_k = \lambda_k \left( q_{1k} + q_{2k} - \frac{q_{1k}^2 + 2\gamma q_{1k}q_{2k} + q_{2k}^2}{2} - p_{1k}q_{1k} - p_{2k}q_{2k} \right) \]

\[ = \lambda_k \left( \frac{2(1 - \gamma)(1 - p_{1k})(1 - p_{2k}) + (p_{1k} - p_{2k})^2}{2(1 - \gamma^2)} \right) = \lambda_k \left( \frac{q_{1k}^2 + 2\gamma q_{1k}q_{2k} + q_{2k}^2}{2} \right). \]

The profit of airport operator \(j\) \((j = A, B)\) is given as  

\[ \pi_{Uj} = w_j(q_{1A} + q_{2A} + \lambda(q_{1B} + q_{2B})), \quad j = A, B. \]

The market structure is summarized in Figure 1.

We consider two cases concerning the objective of each airport operator. The objective of an airport operator in one case is to maximize its own profit, and in the other to maximize its domestic social surplus. The former objective relates to a privatized airport and the latter to a nationalized airport. This specification is used in the literature on airport privatization (e.g., Zhang and Zhang (2003), Basso and Zhang (2008)). Because two airport operators exist, we must consider four cases concerning their objectives: (1) both airport operators are profit maximizers; (2) \(U_A\) is a profit maximizer and \(U_B\) is a profit maximizer; (3) \(U_A\) is a social maximizer and \(U_B\) is a profit maximizer; (4) both airport operators are social maximizers.

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7 Several papers related to airline competition use this functional form, for instance, Fu et al. (2006), Oum and Fu (2007) and Lin (2008).

8 Because they are not the main focus of this work, we do not explicitly deal with the choices of product quality, which is related to flight frequency in the context of airline competition (see, for instance, Kawasaki (2008)). We expect that incorporating the frequency problem into our model would not change the main result.
domestic welfare maximizer; (3) $U_B$ is a profit maximizer and $U_A$ is a domestic welfare maximizer; (4) both airport operators are domestic welfare maximizers. When $U_j$ is a profit maximizer, it maximizes $\pi_{Uj} \ (j = A, B)$. When $U_A \ (U_B)$ is a domestic welfare maximizer, it maximizes $SW_A = \pi_{UA} + CS_A + \pi_{D1}$ ($SW_B = \pi_{UB} + CS_B + \pi_{D2}$).

The game proceeds as follows. First, each government simultaneously decides whether to privatize its airport. Second, each common airport operator simultaneously sets $w_j$ to maximize its objective, which is determined in the first period ($j = A, B$). Third, given $w_A$ and $w_B$, the airline companies simultaneously set their prices at $p_i \ (i = 1, 2)$. We assume that the airline companies cannot price discriminate between consumer groups $A$ and $B$. That is, $p_{iA} = p_{iB} = p_i \ (i = 1, 2)$.

3 Results

We solve the game by backward induction.

3.1 The third stage

We first consider the third-stage game. The objective function of airline company $i \ (i = 1, 2)$ is

$$
\pi_{Di} \equiv (p_i - w_A - w_B)(q_iA + \lambda q_iB) \\
= \frac{(p_i - w_A - w_B)(1 + \lambda)(1 - \gamma - p_i + \gamma p_{-i})}{1 - \gamma^2}, \quad i = 1, 2, \ i \neq -i.
$$

The first-order conditions lead to

$$
p_i(w_A, w_B) = \frac{1 - \gamma + w_A + w_B}{2 - \gamma}, \quad q_i(w_A, w_B) = \frac{1 - w_A - w_B}{(2 - \gamma)(1 - \gamma)},
$$

$$
\pi_{Di}(w_A, w_B) = \frac{(1 + \lambda)(1 - \gamma)(1 - w_A - w_B)^2}{(2 - \gamma)^2(1 + \gamma)}, \quad i = 1, 2.
$$

The domestic social surplus in country $A \ (B)$ is the sum of the consumer surplus in country $A \ (B)$ and the total profits of $D_1$ and $U_A \ (D_2$ and $U_B)$. The social surplus in country $l \ (l \in \{A, B\})$ is given as

$$
SW_l(w_A, w_B) = \frac{\lambda_i(1 - w_A - w_B)^2}{(2 - \gamma)^2(1 + \gamma)} \cdot (1 - \gamma)(1 - w_A - w_B)^2 + \frac{2w_l(1 + \lambda)(1 - w_A - w_B)}{(2 - \gamma)(1 + \gamma)}, \quad (1)
$$

where $\lambda_A = 1$ and $\lambda_B = \lambda$. 

8
3.2 The second stage

There are four cases (subgames) that depend on the governments’ first-stage decisions: (1) both airport operators are profit maximizers; (2) $U_A$ is a profit maximizer and $U_B$ is a domestic welfare maximizer; (3) $U_B$ is a profit maximizer and $U_A$ is a domestic welfare maximizer; (4) both airport operators are domestic welfare maximizers.

**Privatization of the airports operators, $U_A$ and $U_B$.** We first consider the case in which the objectives of the airport operators are to maximize their own profits. In other words, we consider the situation after the privatization of the airport operators, $U_A$ and $U_B$.

The maximization problem of airport operator $j$ ($j = A, B$) is represented by

$$\max_{w_j} w_j (q_{1A} + q_{2A} + \lambda(q_{1B} + q_{2B})).$$

Let the superscript “PP” denote the equilibrium value when the airport operators are private firms. The maximization problems represented in (2) yield

$$w_j (w_{-j}) = \frac{1 - w_{-j}}{2} \quad (j = A, B, -j \neq j) \quad \rightarrow \quad w_{AP}^{PP} = w_{BP}^{PP} = \frac{1}{3}. \quad (3)$$

This result is summarized in the following lemma.

**Lemma 1** The strategic interaction between the airport operators is a strategic substitution. When the airport operators are profit maximizers, the equilibrium airport charges in the subgame are $w_{AP}^{PP} = w_{BP}^{PP} = 1/3$.

The reaction function in (3) means that the strategic interaction between the airport operators is a strategic substitution. When an airport operator sets its airport charge at a higher level, the total quantity demanded by the airline companies shrinks. Given the shrunken demand caused by the high airport charge, the other airport operator is forced to set a lower airport charge (Cournot (1838) and Sonnenschein (1968)). As we show below, this property holds irrespective of the airport operators’ objectives (profit or welfare maximization).

The profits of the airline companies and the airport operators are given as

$$\pi_{Di}^{PP} = \frac{(1 - \gamma)(1 + \lambda)}{9(2 - \gamma)^2(1 + \gamma)}, \quad \pi_{Uj}^{PP} = \frac{2(1 + \lambda)}{9(2 - \gamma)(1 + \gamma)}, \quad i = 1, 2; \quad j = A, B.$$
The prices of the airline companies and the quantities they supply are
\[ p_i^{PP} = \frac{5 - 3\gamma}{3(2 - \gamma)}, \quad q_i^{PP} = \frac{1}{3(2 - \gamma)(1 - \gamma)}, \quad i = 1, 2. \]

The domestic social surplus in each country is given as
\[ SW_A^{PP} = \frac{6 + 5\lambda - 3(1 + \lambda)\gamma}{9(2 - \gamma)^2(1 + \gamma)}, \quad SW_B^{PP} = \frac{5 + 6\lambda - 3(1 + \lambda)\gamma}{9(2 - \gamma)^2(1 + \gamma)}. \] (4)

**Only \( U_A \) is privatized** Second, we consider the case in which the objective of \( U_A \) (\( U_B \)) is to maximize its own profit (domestic social surplus). In other words, we consider the situation in which only \( U_A \) is privatized.

The maximization problem of airport operator \( j \) (\( j = A, B \)) is represented by
\[
\max_{w_A} w_A(q_1A + q_2A + \lambda(q_1B + q_2B)), \\
\max_{w_B} w_B(q_1A + q_2A + \lambda(q_1B + q_2B)) + (p_2 - w_A - w_B)(q_2A + \lambda q_2B) + \frac{\lambda(q_1B^2 + 2\gamma q_1B q_2B + q_2B^2)}{2}. \]

Let the superscript “PN” denote the equilibrium value when only \( U_A \) is a private firm.

The maximization problems represented in (5) yield
\[
\Rightarrow W_A^{PN} = \frac{(2 - \gamma)(1 + \lambda)}{5 + 4\lambda - 2(1 + \lambda)\gamma}, \quad W_B^{PN} = \frac{1}{5 + 4\lambda - 2(1 + \lambda)\gamma}. \]

We easily find that \( W_A^{PN} > W_B^{PN} \). This is summarized in the following lemma.

**Lemma 2** When only \( U_A \) is privatized, it sets a higher airport charge than \( U_B \). That is, \( W_A^{PN} > W_B^{PN} \).

The reason is as follows. The domestic welfare maximizer (\( U_B \)) takes into account the domestic consumer surplus and the domestic airline company’s profit as well as its own profit. Because a lower airport charge helps both consumers and the domestic airline company, the domestic welfare maximizer (\( U_B \)) sets a lower airport charge than the profit maximizer (\( U_A \)).
The profits of the airline companies and the airport operators are given as

\[ \pi_{D1}^{PN} = \pi_{D2}^{PN} = \frac{(1 - \gamma)(1 + \lambda)^3}{(1 + \gamma)(5 + 4\lambda - 2(1 + \lambda)\gamma)^2}, \]

\[ \pi_{UA}^{PN} = \frac{2(2 - \gamma)(1 + \lambda)^3}{(1 + \gamma)(5 + 4\lambda - 2(1 + \lambda)\gamma)^2}, \]

\[ \pi_{UB}^{PN} = \frac{2(1 + \lambda)^2}{(1 + \gamma)(5 + 4\lambda - 2(1 + \lambda)\gamma)^2}. \]

The prices of the airline companies and the quantities they supply are

\[ p_{i}^{PN} = \frac{4 + 3\lambda - 2(1 + \lambda)\gamma}{5 + 4\lambda - 2(1 + \lambda)\gamma}, \quad q_{i}^{PN} = \frac{1 + \lambda}{(1 - \gamma)(5 + 4\lambda - 2(1 + \lambda)\gamma)}, \quad i = 1, 2. \]

The domestic social surplus in each country is given by

\[ SW_{A}^{PN} = \frac{(6 + 5\lambda - 3(1 + \lambda)\gamma)(1 + \lambda)^2}{(1 + \gamma)(5 + 4\lambda - 2(1 + \lambda)\gamma)^2}, \quad SW_{B}^{PN} = \frac{(3 + 2\lambda - (1 + \lambda)\gamma)(1 + \lambda)^2}{(1 + \gamma)(5 + 4\lambda - 2(1 + \lambda)\gamma)^2}. \]  

**(Only U_B is privatized)** Third, we consider the case in which the objective of \( U_B \) (\( U_A \)) is to maximize its own profit (its domestic social surplus). In other words, we consider the situation in which only \( U_B \) is privatized.

The maximization problem of airport operator \( j \) \((j = A, B)\) is represented by

\[ \max_{w_A} w_A(q_{1A} + q_{2A} + \lambda(q_{1B} + q_{2B})) + (p_{1} - w_{A} - w_{B})(q_{1A} + \lambda q_{1B}) + \frac{q_{1A}^2 + 2\gamma q_{1A}q_{2A} + q_{2A}^2}{2}, \]

\[ \max_{w_B} w_B(q_{1A} + q_{2A} + \lambda(q_{1B} + q_{2B})). \]  

Let the superscript “NP” denote the equilibrium value when only \( U_B \) is a private firm.

The maximization problems represented in (7) yield

\[ w_{A}(w_{B}) = \frac{\lambda(1 - w_{B})}{3\lambda + 2 - (1 + \lambda)\gamma}, \quad w_{B}(w_{A}) = \frac{1 - w_{A}}{2}, \]

\[ w_{A}^{NP} = \frac{\lambda}{4 + 5\lambda - 2(1 + \lambda)\gamma}, \quad w_{B}^{NP} = \frac{(2 - \gamma)(1 + \lambda)}{4 + 5\lambda - 2(1 + \lambda)\gamma}. \]

We easily find that \( w_{A}^{NP} < w_{B}^{NP} \). This is summarized in the following lemma.

**Lemma 3** When only \( U_B \) is privatized, it sets a higher airport charge than \( U_A \). That is, \( w_{A}^{NP} < w_{B}^{NP} \).

The reason is similar to that in the previous case.
The profits of the airline companies and the airport operators are given as
\[ \pi_{NP}^{D1} = \pi_{NP}^{D2} = (1 - \gamma)(1 + \lambda)^3 \frac{(1 + \gamma)(4 + 5\lambda - 2(1 + \lambda)\gamma)^2}{(1 + \gamma)(4 + 5\lambda - 2(1 + \lambda)\gamma)^2}; \]
\[ \pi_{NP}^A = \frac{2\lambda(1 + \lambda)^2}{(1 + \gamma)(4 + 5\lambda - 2(1 + \lambda)\gamma)^2}, \quad \pi_{NP}^B = \frac{2(2 - \gamma)(1 + \lambda)^3}{(1 + \gamma)(4 + 5\lambda - 2(1 + \lambda)\gamma)^2}. \]

The prices of the airline companies and the quantities they supply are
\[ p_{NP}^i = \frac{3 + 4\lambda - 2(1 + \lambda)\gamma}{4 + 5\lambda - 2(1 + \lambda)\gamma}, \quad q_{NP}^i = \frac{1 + \lambda}{(1 - \gamma)(4 + 5\lambda - 2(1 + \lambda)\gamma)}, \quad i = 1, 2. \]

The domestic social surplus in each country is given by
\[ SW_{NP}^A = \frac{(2 + 3\lambda - (1 + \lambda)\gamma)(1 + \lambda)^2}{(1 + \gamma)(4 + 5\lambda - 2(1 + \lambda)\gamma)^2}, \quad SW_{NP}^B = \frac{(5 + 6\lambda - 3(1 + \lambda)\gamma)(1 + \lambda)^2}{(1 + \gamma)(4 + 5\lambda - 2(1 + \lambda)\gamma)^2}. \]

No supplier is privatized Finally, we consider the case in which the objectives of the airport operators are to maximize their own social surpluses. In other words, we consider the situation in which no airport operator is privatized.

The maximization problem of airport operator \( j \) \( (j = A, B) \) is represented by
\[ \max_{w_A} w_A(q_{1A} + q_{2A} + \lambda(q_{1B} + q_{2B})) + (p_1 - w_A - w_B)(q_{1A} + \lambda q_{1B}) + \frac{q_{1A}^2 + 2\gamma q_{1A} q_{2A} + q_{2A}^2}{2}; \]
\[ \max_{w_B} w_B(q_{1A} + q_{2A} + \lambda(q_{1B} + q_{2B})) + (p_2 - w_A - w_B)(q_{2A} + \lambda q_{2B}) + \frac{\lambda(q_{1B}^2 + 2\gamma q_{1B} q_{2B} + q_{2B}^2)}{2}. \]

Let the superscript “NN” denote the equilibrium value when no airport operator is privatized. The maximization problems represented in (9) and (10) yield
\[ w_{NN}^A = \frac{\lambda}{(3 - \gamma)(1 + \lambda)}, \quad w_{NN}^B = \frac{1}{(3 - \gamma)(1 + \lambda)}. \]

The result concerning the difference between \( w_{NN}^A \) and \( w_{NN}^B \) is summarized in the following lemma.

**Lemma 4** When the airport operators are domestic surplus maximizers, \( w_{NN}^A \leq w_{NN}^B \), and the equality holds only if \( \lambda = 1 \). That is, the airport charge in the country with a larger number of consumers is smaller than in the one with a smaller number of consumers.
The nationalized airport operator considers consumer welfare and the domestic airline company’s profit as well as its own profit. Because consumer welfare is more important in the country with a larger number of consumers (country $A$), $w_{NN}^A < w_{NN}^B$ in equilibrium.

The profits of the airline companies and the airport operators are given as

\[
\begin{align*}
\pi_{DN}^1 &= \pi_{DN}^2 = \frac{(1 - \gamma)(1 + \lambda)}{(3 - \gamma)^2(1 + \gamma)}, \\
\pi_{UA}^N &= \frac{2\lambda}{(3 - \gamma)^2(1 + \lambda)}, \\
\pi_{UB}^N &= \frac{2}{(3 - \gamma)^2(1 + \lambda)}.
\end{align*}
\]

The prices of the airline companies and the quantities they supply are

\[
\begin{align*}
p_i^N &= \frac{2 - \gamma}{3 - \gamma}, \\
q_i^N &= \frac{1}{(3 - \gamma)(1 - \gamma)}, \quad i = 1, 2.
\end{align*}
\]

The domestic social surplus in each country is given by

\[
\begin{align*}
SW_{NN}^A &= \frac{2 + 3\lambda - (1 + \lambda)(1 - \gamma)}{(3 - \gamma)^2(1 + \gamma)}, \\
SW_{NN}^B &= \frac{3 + 2\lambda - (1 + \lambda)(1 - \gamma)}{(3 - \gamma)^2(1 + \gamma)}.
\end{align*}
\]

**The comparison of the four cases**  We now compare the above four cases. A simple comparison leads to the following lemma.

**Lemma 5** For any $\lambda$ and $\gamma$, $p_i^N < p_i^{NP} < p_i^{PP}$, $w_A^N < w_A^{NP} < w_A^{PP}$, $w_B^N < w_B^{NP} < w_B^{PP}$, and $w_B^{PP}$ if and only if $\gamma < 3\lambda/(1 + \lambda)$ or $\lambda > \gamma/(3 - \gamma)$.

We find several properties. First, privatization of $U_j$ always increases $w_j$ and decreases $w_{-j}$ given the decision of government $-j$ ($j, -j = A, B, j \neq -j$). This is related to the explanation for Lemma 2. A higher airport charge set by a privatized airport operator induces the other airport operator to reduce its airport charge because of strategic substitution. Second, $w_A^N < w_A^{NP}$ for any $\lambda$ and $\gamma$, whereas $w_B^N$ can be larger than $w_B^{NP}$. This is related to the explanation of Lemma 4. Because consumer welfare is more important in the country with more consumers (country $A$), the nationalized airport operator $A$ sets a lower airport charge and the nationalized airport operator $B$ sets a higher airport charge because of strategic substitution. Finally, $p_i^{NP} < p_i^{PN}$. This is because privatization in the larger country increases the total airport charge $w_A + w_B$ to a greater extent; that is, $w_A^{NP} + w_B^{NP} > w_A^{PN} + w_B^{PN}.$
3.3 Privatization policy: The first stage

We now discuss decisions regarding privatization; that is, the first stage of the game is discussed. The first stage is represented by the following $2 \times 2$ matrix.

<table>
<thead>
<tr>
<th>A/B</th>
<th>$P$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P$</td>
<td>$SW_B^{PP}$ in (4)</td>
<td>$SW_B^{PN}$ in (6)</td>
</tr>
<tr>
<td>$N$</td>
<td>$SW_A^{NP}$ in (8)</td>
<td>$SW_A^{NN}$ in (12)</td>
</tr>
</tbody>
</table>

From the payoff matrix, we obtain the following proposition.

**Proposition 1** For any exogenous parameter, $(P, P)$ is an equilibrium outcome. If the following inequalities are satisfied, then $(N, N)$ is an equilibrium outcome:

$$\lambda \geq \frac{- (1 - 3\gamma + \gamma^2) + \sqrt{7 - 8\gamma + 2\gamma^2}}{(3 - \gamma)(1 - \gamma)} \quad \text{and} \quad \gamma \leq \frac{3 - \sqrt{6}}{2} \simeq 0.275. \quad (13)$$

Neither $(P, N)$ nor $(N, P)$ appears in equilibrium.

**Proof** See the Appendix.

The following figure indicates the area in which $(N, N)$ can be an equilibrium outcome.

[Figure 2 here]

Proposition 1 states that the outcome in which both governments privatize their own airport operators (henceforth, we call this the $PP$ equilibrium) is always an equilibrium, whereas that in which no government privatizes its own airport operator (henceforth, we call this the $NN$ equilibrium) can fail to be an equilibrium. Figure 2 indicates that the area of existence for the $NN$ equilibrium is small. Thus, we believe that the $PP$ equilibrium is more likely to occur than the $NN$ equilibrium.9

We now explain the rationale behind the proposition. As explained above, because the strategic interaction between the airport operators is a strategic substitution, lowering $w_j$ leads to higher $w_{-j}$ ($j, -j = A, B, j \neq -j$). Because airport operator $-j$ is a foreign

---

9 Even when both equilibria exist, we can show that the $PP$ equilibrium risk dominates that of the $NN$ equilibrium, so the former is more robust. For the concept of risk dominance, see Harsanyi and Selten (1988).
one, the shift of airport charge caused by a lower \( w_j \) is a transfer from the domestic to the foreign airport operator. This causes a welfare loss from the viewpoint of domestic welfare in country \( j \). In any case, this welfare loss is important to each country. Therefore, each government decides to privatize its own airport operator when it anticipates the privatization of the other.

In this setting, the degree of competitiveness (\( \gamma \)) also affects the welfare property concerning the objectives of the airport operators. When \( \gamma \) is large (competition between the airline companies is severe), the negative effect of double marginalization is small because airline companies cannot exert their market power. The strategic interaction between the airport operators is more important to each country. Moreover, the difference between the numbers of consumers in the countries is also important. The airport operator in the country with a larger number of consumers sets its airport charge at a lower level (Lemma 4), causing a transfer from this country to the foreign country. To reduce the amount of such a transfer, the airport operator in the country with a larger number of consumers tends to be privatized.

We now briefly discuss the relation between the levels of social welfare in two cases: (1) both airport operators are privatized, \((P, P)\); and (2) no airport operator is privatized, \((N, N)\). When both airport operators are privatized, the sum of airport charges \( w_A + w_B \) is higher than that in the case in which no airport operator is privatized; that is, \( w_A^{PP} + w_B^{PP} > w_A^{NN} + w_B^{NN} \). Although the higher airport charges in the privatized case reduce “global” welfare, this negative effect of privatization is not always applied to the social surplus in the large country (country \( A \)). After a simple calculation, we obtain the following proposition.

**Proposition 2** \( SW_B^{PP} < SW_B^{NN} \) for all \( \lambda \) and \( \gamma \). \( SW_A^{PP} > SW_A^{NN} \) if and only if

\[
\lambda < \frac{3(2 - \gamma)(-3 + 6\gamma - 2\gamma^2)}{(3 - \gamma)(21 - 22\gamma + 6\gamma^2)}.
\]

Figure 3 indicates the area in which the inequality in Proposition 2 is satisfied.

[Figure 3 here]

From the figure, we can see that the privatization of the two airport operators improves social welfare in the large country when airline competition is severe and the heterogeneity
of the consumer sizes is significant.

As shown in Lemma 4, $w_A^{NN} < w_B^{NN}$. $w_B^{NN}$ in (11) is increasing in $\gamma$ and decreasing in $\lambda$. That is, when $\gamma$ is large and $\lambda$ is small, the rent-shift from country $A$ to $B$ is significant. We now briefly explain the reason for this. When $\gamma$ is large (downstream competition is severe), the profits of the airline companies are small. This implies that consumer welfare and airport profits are more important than the airline profits. Therefore, each nationalized airport operator tends to set a higher airport charge, which harms the airline companies. A higher airport charge harms consumer welfare but increases its profit. Because the former negative effect is relatively important to the large country, $A$, $w_A$ tends to be lower than $w_B$. When $\lambda$ is small (the difference between the sizes of consumer group is large), the difference between $w_B^{NN}$ and $w_A^{NN}$ is large. This is because the nationalized airport operator in country $A$ takes into account its large consumer size when it sets $w_A$. Moreover, the strategic substitutability of the airport charges exacerbates the difference between airport charges. Therefore, when $\gamma$ is large and $\lambda$ is small, the privatization of the two airport operators improves social welfare in the large country; that is, $SW_A^{PP} > SW_A^{NN}$.

4 Quantity competition

To show the robustness of the main result in the previous sections, we discuss the case in which the airline companies compete in quantity.

The model structure is as follows. The players are the same as those described in Section 2. For simplicity, we assume that the demand sizes in the two markets are the same ($\lambda = 1$).

As mentioned in Section 2, each consumer $k$ has the inverse demand functions of the products, denoted by $(k = A, B)$

$$p_{ik} = 1 - q_{ik} - \gamma q_{-ik}, \quad (i, -i = 1, 2, \ i \neq -i).$$

By symmetry, when airline company $i$ sets its quantity at $q_i$, this quantity is symmetrically allocated to the two countries; that is, $q_{ik} = q_{i,-k} = q_i/2$.

The game proceeds as follows. First, each government simultaneously decides whether to privatize its airport operator. Second, each common airport operator simultaneously
sets \( w_j \) to maximize its objective, which is determined in the first period \( (j = A, B) \). Third, given the airport charges \( w_A \) and \( w_B \), the airline companies simultaneously set their quantities at \( q_i \) \( (i = 1, 2) \).

Applying the same procedure in the previous setting, we obtain the following propositions.

**Proposition 3** For any exogenous parameter, \((P, P)\) is an equilibrium outcome. If \( \gamma < (2\sqrt{6} - 3)/5 \), \((N, N)\) is an equilibrium outcome: Neither \((P, N)\) nor \((N, P)\) appears in equilibrium.

This is similar to Proposition 1. \((P, P)\) can always appear as an equilibrium outcome. If the competition between the airline companies is not severe, then \((N, N)\) may also appear as an equilibrium outcome. The logic behind this proposition is similar to that of Proposition 1. We also have the following proposition that is parallel to Proposition 2.

**Proposition 4** For all \( \gamma \), \( SW^{PP}_B < SW^{NN}_B \).

### 5 Congestion problems

We have not considered congestion problems, which are often discussed in the literature on airline competition (Brueckner (2002, 2009), Yuen et al. (2008), Zhang and Zhang (2006, 2010)). To address this problem, we assume that each representative consumer has a utility function, denoted by \((k = A, B)\)

\[
U_k = q_{1k} + q_{2k} - q_{1k}^2 + 2\gamma q_{1k}q_{2k} + q_{2k}^2 + (d_A + d_B)(q_{1k} + q_{1,-k} + q_{2k} + q_{2,-k})^2.
\]

where \( d_j \) is the degree of negative externalities caused by the number of total flights \((j = A, B)\). The negative externalities are related to the congestion at the two airports. Note that each passenger incurs the negative externalities at both airports because she/he uses both airports. Given the utility function, each consumer \( k \) has the inverse demand functions of the products, denoted by \((k = A, B)\)

\[
p_{ik} = 1 - q_{ik} - \gamma q_{-ik} - (d_A + d_B)(q_{1k} + q_{1,-k} + q_{2k} + q_{2,-k}), \quad i, -i = 1, 2, \quad (i \neq -i).
\]

By symmetry, when airline company \( i \) sets its quantity at \( q_i \), this quantity is symmetrically allocated in the two countries; that is, \( q_{ik} = q_{i,-k} = q_i/2 \).
Consider the case in which \( U_j \) has an opportunity to reduce the degree of negative externalities, \( d_j \) \((j = A, B)\). We suppose that only one airport operator is privatized. The assumption allows us to discuss which airport operator has more incentive to reduce the degree of negative externalities within a market.\(^{10}\) Under the asymmetric case, we consider the following three-stage game. First, each airport operator simultaneously reduces the degree of negative externalities, \( d_j \) \((j = A, B)\). Second, each airport operator simultaneously sets \( w_j \). Third, given the airport charges \( w_A \) and \( w_B \), the airline companies simultaneously set their quantities at \( q_i \) \((i = 1, 2)\). We now solve the game by backward induction.

The third stage: We first consider the third-stage game. The objective function of airline company \( i \) \((i = 1, 2, i \neq -i)\) is

\[
\pi_{Di} \equiv (p_iA - w_A - w_B)q_i/2 + (p_iB - w_A - w_B)q_i/2
= (1 - q_i/2 - \gamma q_{-i}/2 - (d_A + d_B)(q_i + q_{-i}) - w_A - w_B)q_i.
\]

The first-order condition is

\[
\frac{\partial \pi_{Di}}{\partial q_i} = 1 - (1 + 2(d_A + d_B))q_i - (\gamma/2 + d_A + d_B)q_{-i} - w_A - w_B = 0.
\]

These equations yield

\[
q_i(w_A, w_B) = \frac{2(1 - w_A - w_B)}{2 + \gamma + 6(d_A + d_B)},
\]

\[
\pi_{Di}(w_A, w_B) = \frac{2(1 + 2(d_A + d_B))(1 - w_A - w_B)^2}{(2 + \gamma + 6(d_A + d_B))^2}, \quad i = 1, 2.
\]

The domestic social surplus in country \( A \) \((B)\) is the sum of the consumer surplus in country \( A \) \((B)\) and the total profits of \( D_1 \) and \( U_A \) \((D_2 \) and \( U_B)\). The social surplus in country \( l \) \((l \in \{A, B\})\) is given as

\[
SW_l = \frac{(1 + \gamma)(1 - w_A - w_B)^2}{(2 + \gamma + 6(d_A + d_B))^2}
+ \frac{2(1 + 2(d_A + d_B))(1 - w_A - w_B)^2}{(2 + \gamma + 6(d_A + d_B))^2}
+ \frac{4w_l(1 - w_A - w_B)}{2 + \gamma + 6(d_A + d_B)}. \quad (14)
\]

\(^{10}\)We think that the analysis in this section is useful although this asymmetric case does not occur as an equilibrium outcome in the previous sections. This analysis allows us to understand how privatization changes the incentives of airport operators to reduce the congestion under the “transition” phase in which privatized and nationalized airports co-exist.
The second stage: We consider the case in which \( U_A \) is a profit maximizer and \( U_B \) is a domestic welfare maximizer. In other words, we consider the situation in which only \( U_A \) (or \( U_B \)) is privatized.

The maximization problem of supplier \( j \) \((j = A, B)\) is represented by

\[
\begin{align*}
\max_{w_A} & \quad w_A(q_1 + q_2), \\
\max_{w_B} & \quad w_B(q_1 + q_2) + \frac{q_1^2 + 2\gamma q_1 q_2 + q_2^2}{8} + (p_{2A} - w_A - w_B)q_2/2 + (p_{2B} - w_A - w_B)q_2/2.
\end{align*}
\] (15)

These are rewritten as (see \( SW_i \) in (14))

\[
\begin{align*}
\max_{w_A} & \quad \frac{4w_A(1 - w_A - w_B)}{(2 + \gamma + 6(d_A + d_B))}, \\
\max_{w_B} & \quad \frac{(1 + \gamma)(1 - w_A - w_B)^2}{(2 + \gamma + 6(d_A + d_B))^2} + \frac{2(1 + 2(d_A + d_B))(1 - w_A - w_B)^2}{(2 + \gamma + 6(d_A + d_B))^2} + \frac{4w_B(1 - w_A - w_B)}{2 + \gamma + 6(d_A + d_B)}. \\
\end{align*}
\]

Let the superscript “PN” denote the equilibrium value when only \( U_A \) is a private firm.

The maximization problems represented in (15) yield

\[
\begin{align*}
w_A(w_B) &= \frac{1 - w_B}{2}, \quad w_B(w_A) = \frac{(1 + \gamma + 8(d_A + d_B))(1 - w_A)}{5 + 3\gamma + 20(d_A + d_B)}, \\
\rightarrow w_{PN}^A &= \frac{2(2 + \gamma + 6(d_A + d_B))}{9 + 5\gamma + 32(d_A + d_B)}, \quad w_{PN}^B = \frac{(1 + \gamma + 8(d_A + d_B))}{9 + 5\gamma + 32(d_A + d_B)}. \\
\end{align*}
\] (16)

The profits of the firms are given as

\[
\begin{align*}
\pi_{D1}^{PN} &= \pi_{D2}^{PN} = \frac{8(1 + 2(d_A + d_B))}{(9 + 5\gamma + 32(d_A + d_B))^2}, \\
\pi_{UA}^{PN} &= \frac{16(2 + \gamma + 6(d_A + d_B))}{(9 + 5\gamma + 32(d_A + d_B))^2}, \quad \pi_{UB}^{PN} = \frac{8(1 + \gamma + 8(d_A + d_B))}{(9 + 5\gamma + 32(d_A + d_B))^2}.
\end{align*}
\]

The domestic social surplus in each country is given by

\[
\begin{align*}
SW_{A}^{PN} &= \frac{4(11 + 5\gamma + 28(d_A + d_B))}{(9 + 5\gamma + 32(d_A + d_B))^2}, \\
SW_{B}^{PN} &= \frac{4(5 + 3\gamma + 20(d_A + d_B))}{(9 + 5\gamma + 32(d_A + d_B))^2}. \\
\end{align*}
\] (17)

The first stage: We discuss the incentives of the airport operators to reduce the negative externalities, \( d_j \), \((j = A, B)\). Let \( d_j \equiv d - e_j \), where \( d \) is a positive constant and \( e_j \) is
the effort level of airport operator $j$. When only airport operator $A$ is privatized, the objectives of the airport operators are given as

$$\pi_{UA}^{PN} = \frac{16(2 + \gamma + 6(2d - e_A - e_B))}{(9 + 5\gamma + 32(2d - e_A - e_B))^2},$$

$$SW_{B}^{PN} = \frac{4(5 + 3\gamma + 20(2d - e_A - e_B))}{(9 + 5\gamma + 32(2d - e_A - e_B))^2}.$$

The partial derivatives of the objective functions are given as

$$\frac{\partial \pi_{UA}^{PN}}{\partial e_A} = \frac{32(37 + 17\gamma + 96(2d - e_A - e_B))}{(9 + 5\gamma + 32(2d - e_A - e_B))^3},$$

$$\frac{\partial SW_{B}^{PN}}{\partial e_B} = \frac{16(35 + 23\gamma + 160(2d - e_A - e_B))}{(9 + 5\gamma + 32(2d - e_A - e_B))^3}.$$

The difference between them is given as

$$\frac{\partial \pi_{UA}^{PN}}{\partial e_A} - \frac{\partial SW_{B}^{PN}}{\partial e_B} = \frac{16(39 + 11\gamma + 32(2d - e_A - e_B))}{(9 + 5\gamma + 32(2d - e_A - e_B))^3} > 0.$$

**Proposition 5** Suppose that one privatized airport and one nationalized airport exist. In the first stage, the marginal gain of the privatized airport from the marginal reduction in the degree of negative externalities is larger than that of the nationalized airport.

The privatized airport has a stronger incentive to reduce the negative externalities. As explained earlier, the privatization of $U_j$ increases $w_j$ but decreases $w_{-j}$ ($j, -j = A, B, j \neq -j$). The change in the airport charges causes the rent-shift from $U_{-j}$ to $U_j$. The rent-shift increases the marginal gain of $U_j$ from the reduction of $d_j$, but it decreases that of $U_{-j}$ from the reduction of $d_{-j}$. The reaction functions of the airports in the second stage, $w_A(w_B)$ and $w_B(w_A)$ in (16), reflect how the degree of negative externalities influences the airport charges. On the one hand, the privatized airport does not change its pricing schedule irrespective of the degree. On the other hand, the nationalized airport lowers its airport charge as the degree of negative externalities decreases because an airline-demand expansion via a lower airport charge does not so generate congestion costs when the degree of negative externalities is low. This implies that a decrease in $d$ enhances the rent-shift from the nationalized airport to the privatized airport. Therefore, the privatized airport has a stronger incentive to engage in the reduction of negative externalities.
6 Conclusion

Many countries have moved towards the privatization of public airports. In response to this trend, much research on airport privatization has been conducted recently (Basso (2008), Basso and Zhang (2008), Zhang and Zhang (2003, 2006)). Although these studies of airport privatization provide interesting insights, they do not show situations in which privatization improves welfare; therefore, a welfare-maximizing government has no incentive to privatize airports. This paper provides an explanation for privatization different from those mentioned above, whereby privatization is, in fact, welfare-improving.

We provide a simple theoretical model to explain the mechanism by which a government privatizes its international airport to maximize domestic welfare. The model consists of a simple downstream (airline) duopoly with two inputs (two airports). Using a simple international duopoly model, we show that the privatization of an airport can improve the domestic social surplus. A lower price set by one airport leads to higher airport charges set by the other. Because the other airport is foreign, this price shift is the transfer from the domestic airport to the foreign one. This causes a welfare loss from the viewpoint of domestic welfare. Even though privatization can lead to a welfare loss, we could not conclude that we need to restrict the privatization of international airports because privatization has several effects on not only airport charges but also the airport management including the facilities and the services. A considerable way to overcome this problem is to allow international airports to be partially privatized, which means that airport charges are regulated but the airport management is privatized.

Note that the result in our model would depend on the network structure under which only two international airports exist. We need to consider a hub-spoke network structure in which a few international hub airports connect with many local airports that have fewer connections to other airports. We guess that the governments holding those international hub airports would have stronger incentives to privatize their airports because the privatization of those hub airports influences the airport charges of many other airports. Based on the same logic, we also guess that many local airports would not be privatized because they do not so influence the prices of the other airports. Considering other network structures is a consideration for future research.
We also consider congestion problems, which are often discussed in the literature on airline competition (Basso (2008), Brueckner (2002, 2009), Yuen et al. (2008), Zhang and Zhang (2006, 2010)). We show that the privatized airport has a stronger incentive to mitigate congestion problems when only one airport is privatized.

We have not solved the privatization incentives under the model with congestion problems because the effect of privatization on efforts to reduce airport congestion is complex. As explained above, privatization of an airport increases the airport charge of this airport but decreases that of the rival. The change in the airport charge causes rent-shift from the other airport to this airport. Because the rent-shift increases its marginal gain from congestion reduction, the privatized supplier has a stronger incentive to reduce airport congestion. On the other hand, because a privatized airport does not consider the airline’s profit and consumer welfare, it has no strong incentive to reduce airport congestion. This is a consideration for future research.

Appendix

Proof of Proposition 1  $SW_{PP}^A - SW_{NP}^A$ and $SW_{PP}^B - SW_{PN}^B$ are given as

$$SW_{PP}^A - SW_{NP}^A = \frac{(2 - \gamma + (1 - \gamma)\lambda)(3(2 - \gamma)^2 + 2(2 - \gamma)(7 - 3\gamma)\lambda + (17 - 14\gamma + 3\gamma^2)\lambda^2)}{9(2 - \gamma)^2(1 + \gamma)(2(2 - \gamma) + (5 - 2\gamma)\lambda)^2} > 0,$$

$$SW_{PP}^B - SW_{PN}^B = \frac{(1 - \gamma + (2 - \gamma)\lambda)((17 - 14\gamma + 3\gamma^2) + 2(2 - \gamma)(7 - 3\gamma)\lambda + 3(2 - \gamma)^2\lambda^2)}{9(2 - \gamma)^2(1 + \gamma)(5 - 2\gamma + 2(2 - \gamma)\lambda)^2} > 0. $$

$(P, P)$ is an equilibrium outcome for all of the parameters, $\gamma \in (0, 1)$ and $\lambda \in (0, 1]$. These inequalities imply that neither $(N, P)$ nor $(P, N)$ is an equilibrium outcome. $SW_{AA}^{NN} - SW_{AP}^{PN}$ and $SW_{BN}^{NN} - SW_{BP}^{NP}$ are given as

$$SW_{AA}^{NN} - SW_{AP}^{PN} = \frac{(2 - \gamma + (1 - \gamma)\lambda)(-(2 + 2\gamma - \gamma^2) + 2(1 - 3\gamma + \gamma^2)\lambda + (3 - \gamma)(1 - \gamma)\lambda^2)}{(3 - \gamma)^2(1 + \gamma)(5 - 2\gamma) + 2(2 - \gamma)\lambda)^2},$$

$$SW_{BN}^{NN} - SW_{BP}^{NP} = \frac{(1 - \gamma + (2 - \gamma)\lambda)((3 - \gamma)(1 - \gamma) + 2(1 - 3\gamma + \gamma^2)\lambda - (2 + 2\gamma - \gamma^2)\lambda^2)}{(3 - \gamma)^2(1 + \gamma)(2(2 - \gamma) + (5 - 2\gamma)\lambda)^2}. $$

22
\[ SW^N_N - SW^P_N \geq 0 \quad (SW^N_B - SW^P_B \geq 0) \] if and only if
\[ SW^N_A - SW^P_A \geq 0 \iff \lambda \geq \frac{-(1 - 3\gamma + \gamma^2) + \sqrt{7 - 8\gamma + 2\gamma^2}}{(3 - \gamma)(1 - \gamma)}, \]
\[ SW^N_B - SW^P_B \geq 0 \iff \lambda \leq \frac{(1 - 3\gamma + \gamma^2) + \sqrt{7 - 8\gamma + 2\gamma^2}}{2 + 2\gamma - \gamma^2}. \]

After some calculations, we find that both inequalities are satisfied if and only if \( \gamma \leq (3 - \sqrt{6})/2 \). We also easily show that \((1 - 3\gamma + \gamma^2 + \sqrt{7 - 8\gamma + 2\gamma^2})/(2 + 2\gamma - \gamma^2)\) is larger than 1 if \( \gamma \leq (3 - \sqrt{6})/2 \). Therefore, the condition under which \((N, N)\) is an equilibrium outcome is given by
\[ \lambda \geq \frac{-(1 - 3\gamma + \gamma^2) + \sqrt{7 - 8\gamma + 2\gamma^2}}{(3 - \gamma)(1 - \gamma)} \quad \text{and} \quad \gamma \leq \frac{3 - \sqrt{6}}{2} \simeq 0.275. \]

These calculations yield Proposition 1.

Q.E.D.

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Market structure

Vertical structure in this market.

Figure 1: The market structure

Figure 2: The condition that \((N, N)\) is an equilibrium outcome.

Figure 3: The condition that \(SW_{PP}^A < SW_{NN}^A\) and \(SW_{PP}^A > SW_{NN}^A\).
Appendix (not for publication)

In the Appendix, we derive the result in Section 4. We solve the game by backward induction.

The third stage We first consider the third-stage game. The objective function of airline company \(i\) (\(i = 1, 2, i \neq -i\)) is

\[
\pi_{Di} \equiv (p_iA - w_A - w_B)q_i/2 + (p_iB - w_A - w_B)q_i/2 \\
= (1 - q_i/2 - \gamma q_{-i}/2 - w_A - w_B)q_i.
\]

The first-order conditions are

\[
\frac{\partial \pi_{Di}}{\partial q_i} = 1 - q_i - \gamma q_{-i}/2 - w_A - w_B = 0.
\]

These equations yield

\[
q_i(w_A, w_B) = \frac{2(1 - w_A - w_B)}{2 + \gamma}, \quad \pi_{Di}(w_A, w_B) = \frac{2(1 - w_A - w_B)^2}{(2 + \gamma)^2}, \quad i = 1, 2.
\]

The domestic social surplus in country \(A\) (\(B\)) is the sum of the consumer surplus in country \(A\) (\(B\)) and the total profits of \(D_1\) and \(U_A\) (\(D_2\) and \(U_B\)). The social surplus in country \(l\) (\(l \in \{A, B\}\)) is given as

\[
SW_l = \frac{(1 + \gamma)(1 - w_A - w_B)^2}{(2 + \gamma)^2} + \frac{2(1 - w_A - w_B)^2}{(2 + \gamma)^2} + \frac{4w_l(1 - w_A - w_B)}{2 + \gamma}. \quad (18)
\]

The second stage There are four cases (subgames) that depend on the first-stage decisions. We solve the four cases. By symmetry, we do not have to solve one of the two cases in which only one airport operator is privatized.

Only \(U_A\) is privatized: We consider the case in which the objective of \(U_A\) (\(U_B\)) is to maximize its own profit (domestic social surplus), that is, the situation in which only \(U_A\) is privatized.

The maximization problem of airport operator \(j\) (\(j = A, B\)) is represented by

\[
\begin{align*}
\max_{w_A} w_A(q_1 + q_2), \\
\max_{w_B} w_B(q_1 + q_2) + \frac{q_1^2 + 2\gamma q_1 q_2 + q_2^2}{8} \\
+ (p_{2A} - w_A - w_B)q_2/2 + (p_{2B} - w_A - w_B)q_2/2.
\end{align*}
\]
These are rewritten as (see $SW_l$ in (18))

$$
\max_{w_A} \frac{4w_A(1 - w_A - w_B)}{2 + \gamma},
\max_{w_B} \frac{(1 + \gamma)(1 - w_A - w_B)^2}{(2 + \gamma)^2} + 2(1 - w_A - w_B)^2 + \frac{4w_B(1 - w_A - w_B)}{2 + \gamma}.
$$

Let the superscript “PN” denote the equilibrium value when only $U_A$ is a private firm.

The maximization problems represented in (19) yield

$$
\begin{align*}
w_A(w_B) &= \frac{1 - w_B}{2}, \quad w_B(w_A) = \frac{(1 + \gamma)(1 - w_A)}{5 + 3\gamma}, \\
\rightarrow w_{PN}^A &= \frac{2(2 + \gamma)}{9 + 5\gamma}, \quad w_{PN}^B = \frac{(1 + \gamma)}{9 + 5\gamma}.
\end{align*}
$$

The reaction functions of the airport operators are downward sloping. This means that the strategic interaction between the suppliers is a strategic substitution irrespective of their organizational structures. This competition structure in quantity competition is similar to that in price competition discussed above. This similarity leads to similar results to those of price competition.

We easily find that $w_{PN}^A > w_{PN}^B = (3 + \gamma)/(9 + 5\gamma)$. This is summarized in the following lemma.

**Lemma 6** The strategic interaction between the suppliers is a strategic substitution.

When only $U_A$ is privatized, it sets a higher airport charge than $U_B$. That is, $w_{PN}^A > w_{PN}^B$.

This property is similar to that in Lemma 2. The reason is as follows. The domestic welfare maximizer ($U_B$) takes into account the domestic consumer surplus and the domestic airline company’s profit as well as its own profit. Because a lower airport charge helps both consumers and the domestic airline company, the domestic welfare maximizer ($U_B$) sets a lower airport charge than the profit maximizer ($U_A$).

The profits of the firms are given as

$$
\pi_{PN}^{D_1} = \pi_{PN}^{D_2} = \frac{8}{(9 + 5\gamma)^2}, \quad \pi_{PN}^{U_A} = \frac{16(2 + \gamma)}{(9 + 5\gamma)^2}, \quad \pi_{PN}^{U_B} = \frac{8(1 + \gamma)}{(9 + 5\gamma)^2}.
$$

The domestic social surplus in each country is given by

$$
SW_{PN}^A = \frac{4(11 + 5\gamma)}{(9 + 5\gamma)^2}, \quad SW_{PN}^B = \frac{4(5 + 3\gamma)}{(9 + 5\gamma)^2}.
$$

(20)
By symmetry, we obtain the domestic social surplus in each country when only $U_B$ is privatized:

$$SW_{A}^{NP} = \frac{4(5 + 3\gamma)}{(9 + 5\gamma)^2}, \quad SW_{B}^{NP} = \frac{4(11 + 5\gamma)}{(9 + 5\gamma)^2}. \quad (21)$$

**Privatization of the airport operators, $U_A$ and $U_B$:** We consider the case in which the objectives of the airport operators are to maximize their own profits. In other words, we consider the situation after privatization of the airport operators, $U_A$ and $U_B$.

The maximization problem of airport operator $j \ (j = A, B)$ is represented by

$$\max_{w_j} w_j(q_1 + q_2). \quad (22)$$

This is rewritten as

$$\max_{w_j} \frac{4w_j(1 - w_A - w_B)}{2 + \gamma}. \quad (22)$$

Let the superscript “PP” denote the equilibrium value when the airport operators are private firms. The maximization problems represented in (22) yield

$$w_j(w_{-j}) = \frac{1 - w_{-j}}{2} \ (j = A, B, -j \neq j) \rightarrow w_{A}^{PP} = w_{B}^{PP} = \frac{1}{3}. \quad (23)$$

This result is summarized in the following lemma.

**Lemma 7** When the airport operators are profit maximizers, the equilibrium airport charges in the subgame are $w_{A}^{PP} = w_{B}^{PP} = 1/3$.

The reaction function in (23) means that the strategic interaction between the suppliers is strategic substitution. This property is similar to that in the case of price competition.

The profits of the firms are given as $(i = 1, 2; \ j = A, B)$

$$\pi_{Di}^{PP} = \frac{2}{9(2 + \gamma)^2}, \quad \pi_{Uj}^{PP} = \frac{4}{9(2 + \gamma)}. \quad (23)$$

The domestic social surplus in each country is given as

$$SW_{A}^{PP} = SW_{B}^{PP} = \frac{(11 + 5\gamma)}{9(2 + \gamma)^2}. \quad (24)$$

**No airport operator is privatized:** Finally, we consider the case in which the objectives of the airport operators are to maximize their own social surplus. In other words, we consider the situation in which no airport operator is privatized.
The maximization problem of airport operator $j$ ($j = A, B$) is represented by

$$\max_{w_j} w_j (q_1 + q_2) \frac{q_1^2 + 2\gamma q_1 q_2 + q_2^2}{8}$$

$$+ (p_1 - w_A - w_B)q_1/2 + (p_1 - w_A - w_B)q_1/2,$$

$$\max_{w_B} w_B (q_1 + q_2) \frac{q_1^2 + 2\gamma q_1 q_2 + q_2^2}{8}$$

$$+ (p_2 - w_A - w_B)q_2/2 + (p_2 - w_A - w_B)q_2/2.$$ (25)

Let the superscript “NN” denote the equilibrium value when no airport operator is privatized. The maximization problems represented in (25) and (26) yield

$$w_{NN}^A = w_{NN}^B = 1 + \gamma \frac{2(3 + 2\gamma)}{(3 + 2\gamma)^2}. \quad (27)$$

The result concerning the difference between $w_{NN}^A$ and $w_{NN}^B$ is summarized in the following lemma.

**Lemma 8** When the airport operators are domestic surplus maximizers, $w_{NN}^A = w_{NN}^B = (1 + \gamma)/(2(3 + 2\gamma)).$

The profits of the firms are given by

$$\pi_{D1}^{NN} = \pi_{D2}^{NN} = \frac{2}{(3 + 2\gamma)^2}, \quad \pi_{UA}^{NN} = \pi_{UB}^{NN} = \frac{2(1 + \gamma)}{(3 + 2\gamma)^2}.$$ (28)

The domestic social surplus in each country is given by

$$SW_{NN}^A = SW_{NN}^B = \frac{5 + 3\gamma}{(3 + 2\gamma)^2}. \quad (28)$$

**Privatization policy: The first stage** We now discuss decisions regarding privatization; that is, the first stage of the game is discussed. The first stage is represented by the following $2 \times 2$ matrix.
Note that $SW_{AP}^{PP}$ in (24) is equal to $SW_{BP}^{PP}$ in (24) and that $SW_{AP}^{NP}$ in (21) is equal to $SW_{BP}^{PN}$ in (20). Therefore, if $SW_{AP}^{PP}$ in (24) is larger than $SW_{AP}^{NP}$ in (21), then $(P, P)$ appears in equilibrium. The difference between $SW_{AP}^{PP}$ in (24) and $SW_{AP}^{NP}$ in (21) is

$$SW_{AP}^{PP} - SW_{AP}^{NP} = \frac{11 + 5\gamma}{9(2 + \gamma)^2} - \frac{4(5 + 3\gamma)}{(9 + 5\gamma)^2} = \frac{(3 + \gamma)(57 + 62\gamma + 17\gamma^2)}{9(2 + \gamma)^2(9 + 5\gamma)^2} > 0.$$ 

For any $\gamma$, $(P, P)$ appears in equilibrium. The result also implies that neither $(P, N)$ nor $(N, P)$ appears in equilibrium.

Note also that $SW_{AP}^{NN}$ in (28) is equal to $SW_{BP}^{NN}$ in (28) and that $SW_{AP}^{PN}$ in (20) is equal to $SW_{BP}^{NP}$ in (21). Therefore, if $SW_{AP}^{NN}$ in (28) is larger than $SW_{AP}^{PN}$ in (20), then $(N, N)$ appears in equilibrium. The difference between $SW_{AP}^{NN}$ in (28) and $SW_{AP}^{PN}$ in (20) is

$$SW_{AP}^{NN} - SW_{AP}^{PN} = \frac{5 + 3\gamma}{(3 + 2\gamma)^2} - \frac{4(11 + 5\gamma)}{(9 + 5\gamma)^2} = \frac{(3 + \gamma)(3 - 6\gamma - 5\gamma^2)}{(3 + 2\gamma)^2(9 + 5\gamma)^2}.$$ 

This is positive if and only if $\gamma < (2\sqrt{6} - 3)/5$. From the discussion, we obtain Proposition 3.

Finally, we compare $SW_{AP}^{PP}$ in (24) with $SW_{AP}^{NN}$ in (28). The difference between $SW_{AP}^{PP}$ in (24) and $SW_{AP}^{NN}$ in (28) is

$$SW_{AP}^{PP} - SW_{AP}^{NN} = \frac{11 + 5\gamma}{9(2 + \gamma)^2} - \frac{5 + 3\gamma}{(3 + 2\gamma)^2} = \frac{-(3 + \gamma)(27 + 28\gamma + 7\gamma^2)}{9(3 + 2\gamma)^2(2 + \gamma)^2} < 0.$$ 

This is negative for all $\gamma$. From the discussion, we obtain Proposition 4.