Airport privatization competition including domestic airline networks*

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Abstract

This paper addresses the problem of hub airport privatization, similar to the studies by Matsumura and Matsushiam (2012) and Mantin (2012). However, differentiating from their papers, this paper introduces a domestic airline network. That is, each country has one major hub airport and some local airports.

The main result obtained in this paper is as follows. When at least one country has a small domestic airline network, the same result as that by Matsumura and Matsushima (2012) and Mantin (2012) is obtained. However, when both countries have a large domestic airline network, the public airport may be an equilibrium outcome. Furthermore, depending on the size of the airline network and the degree of airline competition, asymmetric equilibrium can also appear.

Keywords: Airport privatization, Airline network, Price competition with product differentiation

JEL: L33, L13, R48

*The author gratefully acknowledges that this study is financially supported by the Tokyo Center for Economic Research.

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1 Introduction

Recently, the discussion on privatization of airports in Japan has progressed, and many researchers have argued that airport privatization is efficient. For example, Oum et al. (2006) argue that an airport's efficiency improves when the airport transitions from being government owned to being privately owned[1]. In this discussion, one frequent argument exists: because many foreign airports are privatized, Japanese airports should also be privatized. While we agree that some foreign airports succeed in privatization, Japanese airports do not always do so. One reason is that the number of domestic airline networks differs between Japanese airports and foreign ones. For example, Changi International Airport in Singapore, which is a major hub airport in Asia, has no domestic airline network. By contrast, Narita International Airport, which is a hub airport in Japan, has a small domestic airline network. Furthermore, another crucial airport in Japan, Haneda Airport, has a very large domestic airline network.

Similarly, the current situation of each country or airport differs among countries, and, thus, an optimal airport strategy should differ among countries. Furthermore, even within the same country, each airport has different characteristics, for example, Narita and Haneda Airports. Thus, determining which airports should be privatized, whether each country should privatize its airports, and whether airport privatization is an optimal strategy for each country are considered in this paper.

Regarding the airport privatization problem, two types of studies exist. One study investigates the influence of airport privatization on the airport fee and investment. Another study considers whether airport privatization occurs.

Some papers address the former problem. Zhang and Zhang (2003) analyze the problem of airport fees and of timing capacity expansion. They conclude the following results: Public airport charges are lower than privatized airport charges. Furthermore, assuming a constrained public airport, the capacity decision of a privatized airport is socially preferable to that of the constrained public one. Zhang and Zhang (2006) investigate airport congestion pricing and the capacity expansion problem. They show similar results to Zhang and Zhang (2003) with regard to airport pricing. In addition, with regard to the capacity expansion problem, both private and budget-constrained airports tend to overinvest in capacity

[1] Among others, Hooper and Hensher (1997) and Abbott and Wu (2002) also arrive at similar results.

when carriers have market power. Basso (2008) constructs a model of vertical relations between congested airports and oligopolistic airlines and analyzes the congestion airport charge and airport capacity. The results indicate that the privatized airport overcharges for congestion and underinvests in airport capacity. Basso and Zhang (2008) examine the airport peak-load pricing using a vertical relationship between airport and airlines. They conclude that the privatized airport charges higher peak and off-peak airport fees than a public airport does.

Despite these papers' findings that a restricted public airport is not preferable to a privatized one, comparisons between non-restricted public airports and privatized airports have not been sufficiently considered[2]. Thus, three papers explain the progress of airport privatization in the actual world.

Vasigh and Haririan (1996) indicate three advantages of airport privatization: (1) Airport congestion decreases because sensible pricing is set; (2) the privatization enhances the incentive of investing in expanding the airport capacity; (3) privatization generates adequate cash to pay off items such as debts and taxes. Mantin (2012) and Matsumura and Matsushima (2012) consider international airport competition. They assume the complementarity of airports and a vertical relationship between airports and airlines, and they demonstrate that each country has an incentive to privatize airports to maintain domestic rents (or airport revenues).

This paper follows that by Mantin (2012) and Matsumura and Matsushima (2012). In their paper, there is no airline network, that is, only two hub airports exist in their model. However, in an actual airline network, each major hub airport also connects to local airports. Then, we seek to determine whether each airport is privatized if a complex airline network is considered. Mantin (2012) and Matsumura and Matsushima (2012) do not succeed in the explanation of a complex airline network. In addition, Mantin (2012) considers only the symmetric situation; however, this is rare in the actual airline market.

Kawasaki (2013) considers the international airline network and analyzes the airport privatization problem. However, his main shortcoming is that he does not consider the domestic airline network. Therefore, the result seems to be insufficient for forming an airport policy.

Considering these shortcomings, this paper addresses an extended situation where each country has

[2] Lin (2013) analyzes the problem of congested hub airport privatization.

some local airline networks. Simultaneously, there is a major hub airport in each country. This paper assumes that two major hub airports are complementary. There are passengers in each country's city. Passengers travel from a major city to another major city or from/to a major city to/from local cities. There is one air carrier in each country, which flies between major hub cities and to local cities connecting each major hub city. The air carriers compete with each other between major hub cities. In this paper, we use a price competition model with product differentiation. Considering this situation, we analyze whether each country privatizes its hub airport.

In this paper, we perform a simulation analysis because the calculation is complex. Using a simulation analysis, we demonstrate the following results. Suppose that the airline competition is heavy. When at least one country has a sufficiently small domestic airline network, both countries privatize their respective airports. When both countries have a large domestic airline network, neither privatizes its airport. When one country has a small (but not sufficiently small) domestic airline network and the other country has a large one, the former country privatizes its airport, but the latter country does not. When both countries have a middle-sized airline network, multiple equilibrium exists, that is, both airports are either privatized or public.

As the airline competition becomes moderate, the equilibrium whereby one airport is privatized and the other is public disappears. Ultimately, the unique equilibrium whereby both airports are privatized also disappears.

In Matsumura and Matsushima (2012) and Mantin (2012), there is no equilibrium where both airports are public. In addition, they cannot also show the equilibrium where one airport is privatized and the other airport is public. A major contribution of the current study is that it explains why the public airport is sustained.

The remainder of this paper is organized as follows. The following section sets up the model. In Section 3, we analyze the model and derive the Nash equilibrium of the airport privatization game. Section 4 examines whether the Nash equilibrium obtained in Section 3 is Pareto optimal. Section 5 concludes by presenting the results of this paper and future research.

2 The Model

In the economy, two countries exist, that is, Countries 1 and 2. Each country has one major city and some local cities. This paper expresses the number of local cities in Country $i(=1,2)$ as n_i. Following Matsumura and Matsushima (2012), we consider an oligopoly model with international airline competition. There is one airport in each city. Here, we assume that each major city has an international hub airport connecting to another international hub airport. Hereafter, we term the international hub airport located in Country i's major city "Airport i". In addition, we assume that each country has local airports connecting to its hub airport, and we express each country's local airports as k_i $(i = 1, 2)$.

There are passengers in Country 1 and in Country 2. We assume that passengers do not travel between local cities. This is because the number of passengers who visit local cities from other local cities seems to be very small. Alternatively, one passenger travels between the local city and the major city, and one passenger travels between the major cities. Consequently, the following types of passengers exist in this economy:

Type A: A passenger traveling from/to the major city in Country i to/from the major city in Country j.

Type B: A passenger traveling from/to the major city in Country i to/from the local city in Country j.

Type C: A passenger traveling from/to the major city in Country i to/from the local city in Country i.

Each country has one major carrier. We express the carrier in Country i as Airline i. Each carrier flies between the international hub airports in the major cities. In addition, each carrier flies from/to the airport in the major city in Country i to/from its local airport. Therefore, a Type A passenger can select which airline to use. In addition, this paper assumes that Airline 1 and Airline 2 perform code-sharing. Therefore, a Type B passenger can also select which airline to use[3]. By contrast, following Kawasaki and Lin (2012), we assume that the passenger does not change airlines at the major hub airport. Finally, the Type C passenger always uses Airline i. This paper assumes that these two airlines (Airline 1 and Airline 2) perform a price competition with product differentiation.

[3] If this assumption is relaxed, an equilibrium of privatized airports hardly exists.

Each airline supplies airline services with zero marginal cost except for an airport fee. The airfare of the passenger travelling between major cities is expressed as p^i_{12}, and the airfare for the passenger travelling between the major city in Country i and the local city in Country j is expressed as $p^i_{ik_j}$. The passenger gains utility when using the airline. Following Dixit (1979), the utility function of the passenger traveling between major countries is assumed to depend on the type mentioned previously, as follows. Here, we express Type $\ell(= A, B, C)$'s utility function as U_ℓ.

$$U_A = (q^1_{12} + q^2_{12}) - \frac{1}{2}((q^1_{12})^2 + 2bq^1_{12}q^2_{12} + (q^2_{12})^2) + M_A \tag{1}$$

$$U_B = (q^1_{ik_j} + q^2_{ik_j}) - \frac{1}{2}((q^1_{ik_j})^2 + 2bq^1_{ik_j}q^2_{12} + (q^2_{ik_j})^2) + M_B \tag{2}$$

$$U_C = q^i_{ik_i} - \frac{1}{2}(q^i_{ik_i})^2 + M_C \tag{3}$$

Here, the budget constraint of the passenger of each type is

$$p^1_{12}q^1_{12} + p^2_{12}q^2_{12} + M_A = I \tag{4}$$

$$p^1_{ik_j}q^1_{ik_j} + p^2_{ik_j}q^2_{ik_j} + M_B = I \tag{5}$$

$$p^i_{ik_i}q^i_{ik_i} + M_C = I \tag{6}$$

Here, M_ℓ expresses the numeraire goods. Each passenger sets its demand to maximize utility given the budget constraint.

Major airports charge airport fees when airlines use them. By contrast, for simplicity, this paper assumes that local airports do not charge airport fees[4]. This paper assumes that the aircraft used by the airline can only carry one passenger. Therefore, the demand equals airport usage. Here, we assume a code-sharing service between airlines. That is, when passengers ride on Airline i using a ticket of Airline j, Airline j must pay the airport fee and Airline i need not pay it[5].

Hereafter, the airport fee charged in Airport i is expressed as w_i. When the airlines transport a passenger of Type B, the airlines must pay the airport fee twice at the hub, Airport j[6]. In addition, two

[4]Even if this assumption is relaxed, the main results obtained in this paper may not change.

[5]Strictly speaking, although Airline i actually pays the airport fee, it charges the airport fee to Airline j.

[6]In other words, passengers must use the major hub airport twice (that is, on landing from the original city and on

passengers travel between each city-pairs. Therefore, all demand must double, and, thus, the profit of each airline becomes as follows:

$$\pi_1 = 2(p^1_{12} - (w_1 + w_2))q^1_{12} + 2\sum_{k_2=1}^{n_2}(p^1_{1k_2} - (w_1 + 2w_2))q^1_{1k_2} + 2\sum_{k_1=1}^{n_1}(p^1_{2k_1} - (2w_1 + w_2))q^1_{2k_1} \quad (7)$$

$$+ 2\sum_{k_1=1}^{n_1}(p^1_{1k_1} - w_1)q^1_{1k_1} \quad (8)$$

$$\pi_2 = 2(p^2_{12} - (w_1 + w_2))q^2_{12} + 2\sum_{k_2=1}^{n_2}(p^2_{1k_2} - (w_1 + 2w_2))q^2_{1k_2} + 2\sum_{k_1=1}^{n_1}(p^2_{2k_1} - (2w_1 + w_2))q^2_{2k_1} \quad (9)$$

$$+ 2\sum_{k_2=1}^{n_2}(p^2_{2k_2} - w_2)q^2_{1k_1}. \quad (10)$$

Because airport costs are assumed to be zero, the profit of each airport is

$$\Pi_1 = w_1(2q^1_{12} + 2q^2_{12} + 2\sum_{k_2=1}^{n_2} q^1_{1_{k_2}} + 2\sum_{k_2=1}^{n_2} q^2_{1_{k_2}} + 4\sum_{k_1=1}^{n_1} q^1_{2_{k_1}} + 4\sum_{k_1=1}^{n_1} q^2_{2_{k_1}}) + 2\sum_{k_1=1}^{n_1} q^1_{1k_1}), \quad (11)$$

$$\Pi_2 = w_2(2q^1_{12} + 2q^2_{12} + 4\sum_{k_2=1}^{n_2} q^1_{1_{k_2}} + 4\sum_{k_2=1}^{n_2} q^2_{1_{k_2}} + 2\sum_{k_1=1}^{n_1} q^1_{2_{k_1}} + 2\sum_{k_1=1}^{n_1} q^2_{2_{k_1}}) + 2\sum_{k_2=1}^{n_2} q^2_{2k_2}). \quad (12)$$

Finally, we define the welfare of each country. The welfare is defined as the sum of total consumer surplus and the airline's and airport's profit. Here, one passenger travels between major cities (Type A) and one passenger travels between the major city and the local city (Type B and Type C). In addition, the consumer surplus of the Type C passenger must double. Consequently, the welfare of Country i can be expressed as follows.

$$SW_i = U_{12} + \sum_{k_j=1}^{n_j} U_{ik_j} + \sum_{k_i=1}^{n_i} U_{ik_j} + 2\sum_{k_i=1}^{n_i} U_{ik_i} + \pi_i + \Pi_i \quad (13)$$

This paper analyzes the airport privatization problem. Therefore, following Matsumura (1998), we define the objective function as follows.

$$O_i = s_i\Pi_i + (1 - s_i)SW_i \quad (14)$$

where, $s_i = \{0, 1\}$. That is, if $s_i = 0$, the airport is managed by the government; if $s_i = 1$, the airport is

departure to the destination).

privatized. The airport fee is set to maximize this objective function.

3 Analysis

3.1 Airline strategy

First, we derive the demand function. Solving the utility maximization problem, we obtain the following demand functions.

$$q_{12}^i = \frac{1 - b - p_{12}^i + bp_{12}^j}{1 - b^2} \tag{15}$$

$$q_{ik_j}^i = \frac{1 - b - p_{ik_j}^i + bp_{ik_j}^j}{1 - b^2} \tag{16}$$

$$q_{ik_i}^i = 1 - p_{ik_i}^i \tag{17}$$

The airline sets airfare to maximize its profit. Solving the profit maximization problem, we obtain the following airfare.

$$p_{12}^i = \frac{1 - b + w_1 + w_2}{2 - b} \tag{18}$$

$$p_{ik_j} = \frac{1 - b + w_i + 2w_j}{2 - b} \tag{19}$$

$$p_{jk_i} = \frac{1 - b + 2w_i + w_j}{2 - b} \tag{20}$$

$$p_{ik_i} = \frac{1 + w_i}{2} \tag{21}$$

From these airfares, we find that the airfare increases with the airport fee, because the airport fee is the cost for each airline.

3.2 Best response of each airport

First, we derive the airport fee by solving each objective function maximization problem. However, because the calculation is too complex to show, we omit the detailed values here. The optimal airport fee can be expressed as follows.

$$w_i^* = w_i(n_i, n_j; b, s_i, s_j) \tag{22}$$

Substituting these airport fees into the welfare function, we obtain the social welfare of each country. Because each welfare depends on the manner of airport management (private or public), we express the welfare as follows.

$$SW_i(s_1, s_2) \equiv SW_i^*(n_1, n_2; b, s_1, s_2) \tag{23}$$

If $s_1 = s_2 = 0$, both airports are public; if $s_1 = s_2 = 1$, both airports are privatized. If $s_i = 1$ and $s_j = 0$, Airport i is public and Airport j is privatized. Depending on s_i and s_j, we create the matrix in Table 1.

Table 1 here.

Using this matrix, we derive the Nash equilibrium. Here, because of heavily calculations, we perform a simulation analysis. First, we derive the optimal reaction by comparing the welfare with each case. First, we compare $SW_1(0,0)$ and $SW_1(1,0)$. Figure 1 expresses the comparison result. Lemma 1 shows its result. Here, although this subsection analyzes only the best response of Country 1, the same discussion holds for the best response of Country 2. Therefore, we omit the detail of Country 2's best response.

Lemma 1 *If b is small, $SW_1(0,0)$ is always higher than $SW_1(1,0)$. If b is large, when n_1 is small (large), $SW_1(1,0)$ is higher (smaller) $SW_1(0,0)$*

Figure 1 here.

Given that Airport 2 is public, if Airport 1 becomes privatized, Airport 1 can gain more profits, increasing the social welfare of Country 1. By contrast, the consumer surplus of passengers in Country 1 is reduced because of the high airport fee. When b is small, the influence of double marginalization on the passenger is large. That is, the airfare increases because of the larger carrier's market power. In order to avoid this situation, the public airport is always socially preferable for Country 1.

As b increases, the airline competition becomes heavy and the influence of double marginalization becomes small. Then, if n_1 is small, the consumer surplus of the domestic passenger is less important.

Alternatively, the profits of the airport are important for increasing the social welfare of Country 1. Therefore, Country 1 privatizes Airport 1 and tries to increase the airport profits. Conversely, if n_1 is large, the consumer surplus of the domestic passengers is more important. Therefore, to lower the airport fee, Airport 1 becomes public.

Next, we compare $SW_1(0,1)$ and $SW_2(1,1)$. Figure 2 shows the result, from which we obtain Lemma 2.

Lemma 2 *When either n_1 or n_2 is small, $SW_1(1,1)$ is larger than $SW_1(0,1)$ for any b. Otherwise, $SW_1(0,1)$ is larger than $SW_1(1,1)$.*

Figure 2 here.

Given that Airport 1 is privatized, when both n_1 and n_2 are large, the consumer surplus of the domestic passengers is critical for increasing the social welfare. Therefore, although some domestic rent (that is, the airport profits) is lost, Country 1 selects a public airport to lower the airport fee. Conversely, when either n_1 or n_2 is small, the consumer surplus of the domestic passenger is less important than the loss of the domestic rent. Therefore, to keep the domestic rent by setting a higher airport fee, Country 1 privatizes Airport 1.

3.3 Is each airport privatized?

Finally, based on this subsection's results, we derive the Nash equilibrium. Here, the outcome depends on b. Therefore, we show three simulation results, depending on b. First, we show the results of $b = 0.99$.

Figure 3 here.

Figure 3 presents nine ranges. Hereafter, we derive the Nash equilibrium in each range. Table 2 summarizes the results.

Table 2 here.

From Figure 3 and Table 2, we obtain Proposition 1.

Proposition 1 *Given that the airline competition is heavy,*

(i) when each country has a large domestic airline network, both airports are public.

(ii) when each country has a medium-size airline network, multiple equilibrium exists, that is, both airports are either public or private.

(iii) when at least one country has a very small domestic airline network, or when both countries have a small one, both airports are private.

(iv) when one country has a small (not very) airline network and the other country has a large one, the former country chooses to privatize its airport and the latter country chooses to keep its airport public.

In ranges (1), (2), and (9), each airport becomes privatized. In these ranges, because the airline network of at least one country is very small, the consumer surplus of passengers who travel between the major and local cities is very small. Therefore, similar to Mantin (2012) and Matsumura and Matsushima (2012), each country privatizes the airport in order to keep the airport fee high and to gain high airport profits.

Here, we pay attention to the ranges (2) and (9). In these two ranges, although one country has a very small domestic airline network, the other country has a large one. Even in these ranges, airport privatization exists, which is an interesting result. If the rival country's airline network is small, the consumer surplus of passengers traveling from one country's major city to the rival country's local city is very small. Therefore, even if the airport is public, because its consumer surplus hardly increases, the social welfare also hardly increases. Rather, because of the loss of airport profits, the social welfare is reduced. Consequently, in these two ranges, each country privatizes its airport.

In ranges (5), (6), and (7), both airports are public, which is a result that does not appear in Mantin (2012) or in Matsumura and Matsushima (2012)[7]. In these ranges, the airline networks of both countries are large.

Essentially, the public airport is socially preferable for each country. However, according to this discussion, each country does not want to lose the domestic rent, that is, the airport profit. Therefore, one country (e.g., Country i) is compelled to privatize its airport if the rival country (e.g., Country j)

[7] In their analysis, the multiple equilibrium where both airports are privatized or public appears.

does so. However, Country j actually does not privatize the airport in ranges (5) and (7). Expecting this strategy by Country j, Country i makes its airport public. By contrast, in range (6), because the airline network is very large in both countries, the consumer surplus of passengers traveling between the major and local cities becomes important. Consequently, the loss of airport profits is not critical in each country. As a result, both countries have no incentive to privatize their airports.

In range (4), the optimal strategy for each country depends on the rival country's strategy. As mentioned previously, although each country wants to make its airport public, it would consequently lose the domestic rent. Therefore, if Country j chooses to privatize its airport, Country i also chooses to do so. However, if Country j chooses to make its airport public, Country i also chooses to do so because its airport does not lose the domestic rent. Consequently, a multiple equilibrium exists.

In ranges (3) and (8), the asymmetric equilibrium exists, which is also an interesting result. Hereafter, we term the country with a large domestic airline network Country ℓ, and the other country as Country m. Because Country m does not want to lose its domestic rent (because of the very small airline network), Country m wants to privatize its airport. That is, airport privatization is a dominant strategy for Country m. By contrast, because Country ℓ has a large airline network, the domestic rent is less important than the consumer surplus of passengers traveling between the major and local cities. Therefore, for Country ℓ, being a public airport is the dominant strategy. As a result, Country ℓ and Country m choose to make their airports public and private, respectively.

Next, to examine the influence of b, we show two simulation results. The following two figures ($b = 1/4$ in the left figure, and $b = 2/3$ in the right figure) express the results.

Figure 4 here.

From Figures 3 and 4, we obtain Proposition 2.

Proposition 2 *When the airline competition becomes moderate, airport privatization is difficult to realize.*

Comparing Figure 3 with Figure 4 shows that the range of airport privatization becomes narrower as b is reduced, and, finally, airport privatization in equilibrium disappears (except for the multiple equilibrium). The reduction of b means that the airline competition becomes moderate and the market power of each airline increases, and, thus, the airfare increases. Higher airfare reduces consumer surplus. Each country wants to avoid this situation, and as a result, each country has a weaker incentive to privatize its airport.

When $n_1 = n_2 = 0$, the result obtained in this paper is the same as those by Mantin (2012) and Matsumura and Matsushima (2012). However, different outcomes appear on introducing the airline network, which is a major contribution of this paper. The main reason is to introduce a consumer surplus of passengers who travel to/from local cities. When the airport problem is considered, we should examine the influence of the airline network. If the airline network is ignored, the wrong conclusion may be obtained. For example, with regard to the hub location problem, we realized that the hub city is selected to minimize the potential number of connecting passengers. In these studies, the influence of the network has been ignored. By contrast, Kawasaki (2012), who introduces the influence of airline networks, argues that the hub city is not always located to minimize the potential number of connecting passengers. In other words, introducing the influence of airline networks takes different results from previous studies.

4 Does the Pareto-optimal outcome exist?

In this section, we discuss whether the Nash equilibrium derived using Section 3 is the Pareto-efficient outcome. First, comparing $SW_i(0,0)$ and $SW_i(1,1)$, we find that $SW_i(0,0)$ is always larger than $SW_i(1,1)$. Figure 5 shows this result.

Figure 5 here.

In ranges (1), (2), and (9) in Figure 3, the Nash equilibrium is that both airports are privatized. However, according to the analysis in this section, this equilibrium is not Pareto-efficient. The main reason for the non-optimal result is due to the risk that the domestic rent is reduced. By contrast, in ranges (5), (6), and (7), the equilibrium is a public airport, which is Pareto-efficient. Finally, in ranges

(3) and (8), there is no Pareto-efficient outcome.

Originally, the public airport is socially preferable for both countries. In other words, the privatized airport charges higher airport fees than the public airport does. Therefore, from the viewpoint of social welfare, the privatized airport is not socially preferable. However, because of the risk of losing the domestic rent, each country has an incentive to privatize their airport when at least one country has a small domestic airline network. Consequently, the socially inefficient equilibrium exists.

According to the analysis in this paper, even when one country expands its domestic airline network, if the other country has a small domestic airline network, airport privatization exists, which is not socially preferable; that is, the prisoner's dilemma occurs. This paper demonstrates that airport policy between countries or the adjustment of the airport policy between countries may be required to avoid this prisoner's dilemma.

5 Concluding Remarks

This paper examined whether airport privatization exists in equilibrium, similar to the results found by studies such as Matsumura and Matsushima (2012) and Mantin (2012), when the domestic airline network is introduced into the complementary airport privatization problem. Thus, given that airline competition is heavy, if at least one country has a very small domestic airline network, this is true. By contrast, if both countries have a large domestic airline network, the results obtained in Matsumura and Matsushima (2012) and Mantin (2012) do not hold because the consumer surplus of passengers traveling to/from local cities is more important than the loss of the domestic rent from the viewpoint of social welfare of each country. Furthermore, when one country has a small domestic airline network and the other country has a large airline network, an asymmetric equilibrium appears. That is, the former country privatizes its airport and the latter country does not.

These results have some important implications for airport policies in Japan and worldwide. In Japan, Haneda Airport has a very large domestic airline network. Therefore, even if the rent of this airport is reduced because of foreign countries, it should remain public in order to increase the consumer surplus of the traveler. In contrast, Narita Airport has a somewhat small domestic airline network and a very large international airline network. Therefore, in order to maintain the domestic rent, Narita Airport should be privatized. In regards to global airports, for example, Changi International Airport in Singapore should be privatized because it has no domestic airline network. Similar to the results of this study, first, when considering the airport privatization problem, each country must consider how many domestic airline networks the airport has. Then, each country must consider the number of domestic airline networks of the rival country.

Now, we discuss the shortcomings remaining in this paper. First, we ignore the existence of passengers traveling between local cities. However, we estimate that even if this factor is introduced, the main results obtained in this paper almost hold. This is because, by introducing this factor, two existing influences (i.e., first, the consumer surplus of the domestic passengers, and second, the loss of domestic rent) simply strengthen. These two influences are offset by each other, and, therefore, the results remain almost unchanged.

Second, we omit the airport privatization problem of the local airport. By introducing this factor, the calculation is very complex. Therefore, this paper omits this problem. However, even if we introduce this factor, we expect that our results hold. The reason is similar to the one previously indicated. That is, two influences that are offset by each other simply appear in this model.

Finally, this paper does not address the airport congestion problem, which is significant in hub airports. Some papers discuss how airport privatization influences airport congestion. Consequently, we must include the airport congestion problem into this type of airline network analysis. In particular, the previous studies do not introduce the factor of airline networks into airport congestion analysis[8]. Consequently, this is an interesting problem.

In future research, we hope to consider a variety of other problems such as this and discuss the airport privatization policy further.

[8] As far as we are aware, only Brueckner (2005) introduces the factor of airline networks into the congestion problem. However, he does not discuss airport privatization in his paper.

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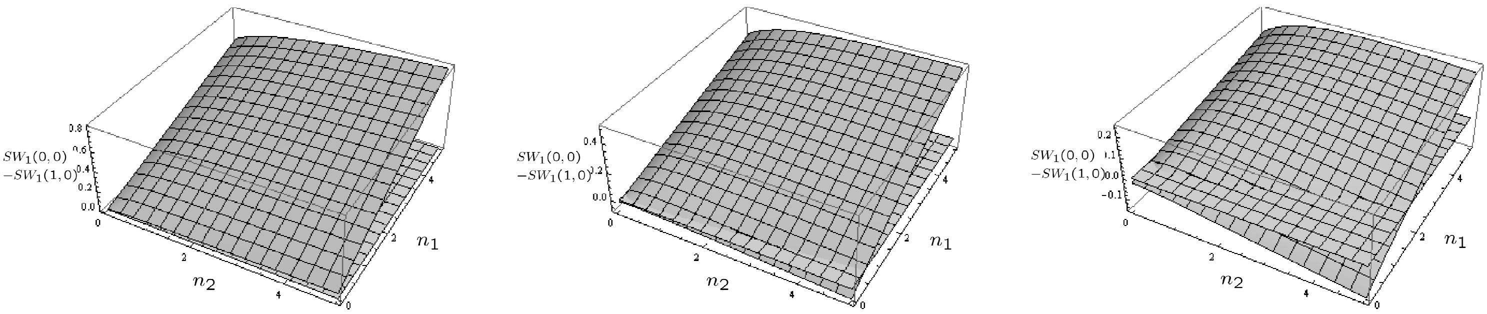
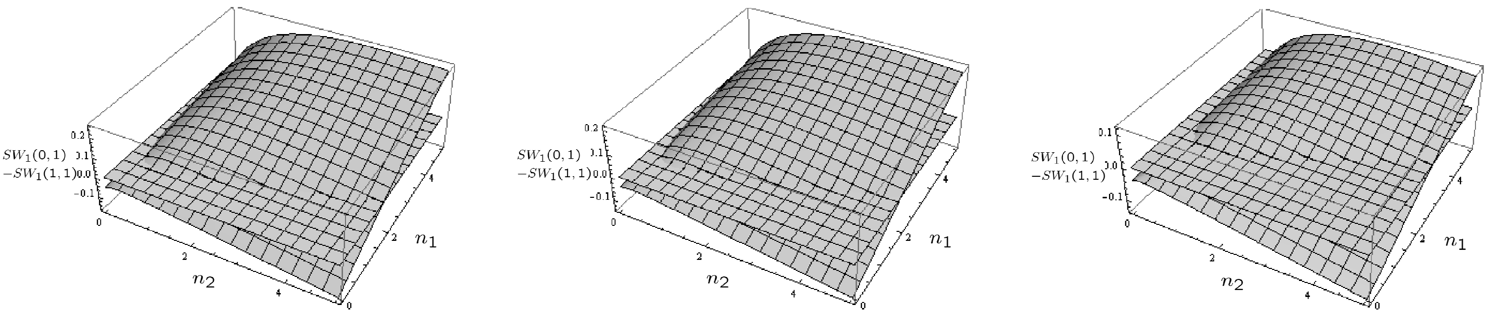


a. $b = 1/4$ b. $b = 2/3$ c. $b = 0.99$

Figure 1: Comparison of $SW_2(0,0)$ with $SW_2(0,1)$



a. $b = 1/4$ b. $b = 2/3$ c. $b = 0.99$

Figure 2: Comparison of $SW_2(1,1)$ with $SW_2(1,0)$

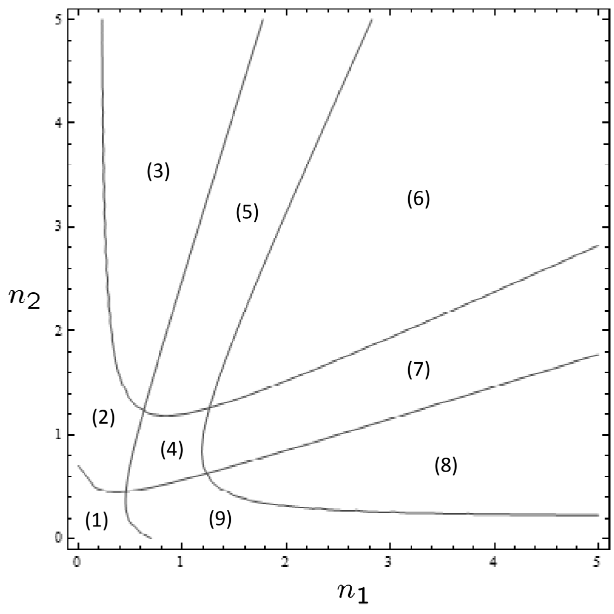
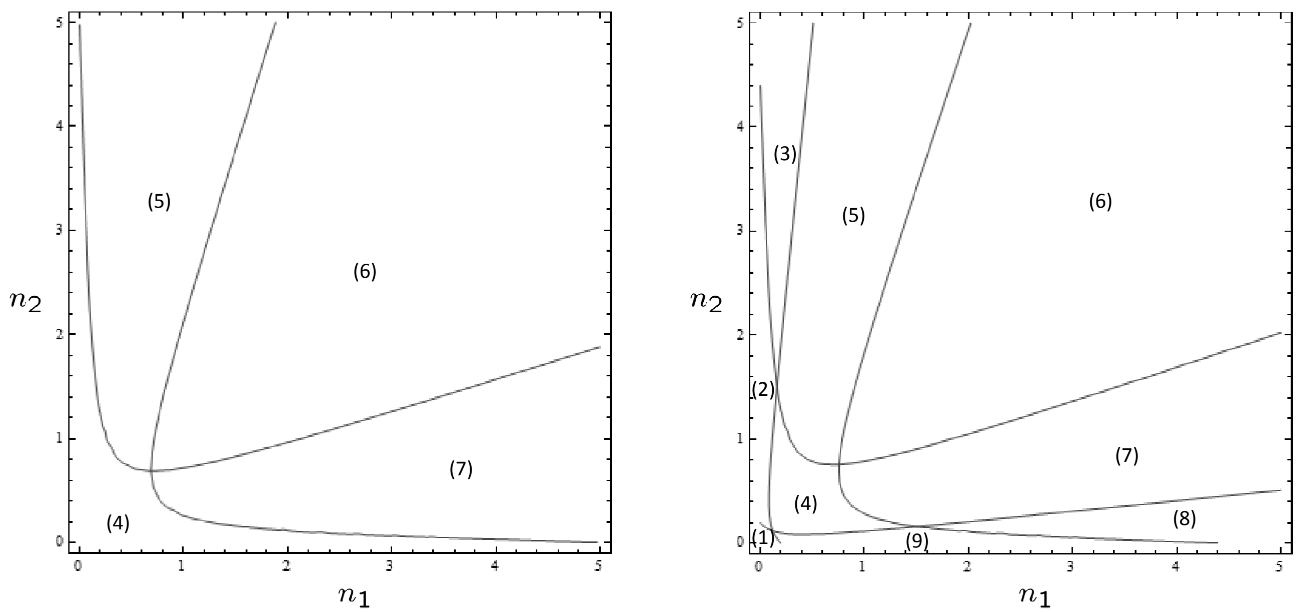
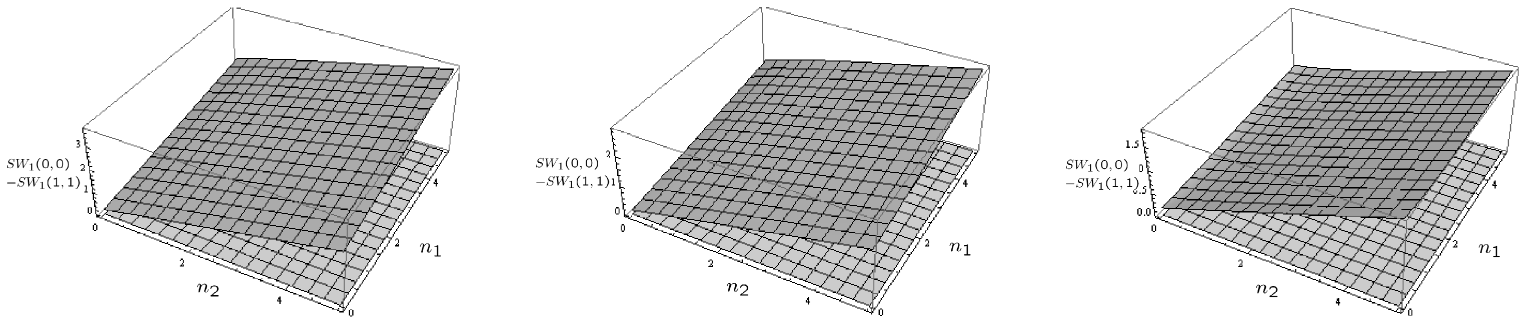


Figure 3: The range of Nash-Equilibrium ($b = 0.99$)



a. $b = 1/4$ b. $b = 2/3$

Figure 4: The range of the Nash equilibrium



a. b=1/4 b. b=2/3 c. b=0.99

Figure 5: Comparison of $SW_1(0,0)$ with $SW_1(1,1)$

Table 1: Payoff Matrix

	$s_2 = 0$	$s_2 = 1$
$s_1 = 0$	$SW_1(0,0),\ SW_2(0,0)$	$SW_1(0,1),\ SW_2(0,1)$
$s_1 = 1$	$SW_1(1,0),\ SW_2(1,0)$	$SW_1(1,1),\ SW_2(1,1)$

Table 2: The meaning of each range

range	comparison result	NE
(1)	$SW_1(0,0) < SW_1(1,0)$, $SW_1(0,1) < SW_1(1,1)$ $SW_2(0,0) < SW_2(0,1)$, $SW_2(1,0) < SW_2(1,1)$	$s_1 = 1, s_2 = 1$
(2)	$SW_1(0,0) > SW_1(1,0)$, $SW_1(0,1) < SW_1(1,1)$ $SW_2(0,0) < SW_2(0,1)$, $SW_2(1,0) < SW_2(1,1)$	$s_1 = 1, s_2 = 1$
(3)	$SW_1(0,0) > SW_1(1,0)$, $SW_1(0,1) > SW_1(1,1)$ $SW_2(0,0) >< SW_2(0,1)$, $SW_2(1,0) > SW_2(1,1)$	$s_1 = 0, s_2 = 1$
(4)	$SW_1(0,0) > SW_1(1,0)$, $SW_1(0,1) < SW_1(1,1)$ $SW_2(0,0) > SW_2(0,1)$, $SW_2(1,0) < SW_2(1,1)$	$s_1 = 1, s_2 = 1$ $s_1 = 0, s_2 = 0$
(5)	$SW_1(0,0) > SW_1(1,0)$, $SW_1(0,1) > SW_1(1,1)$ $SW_2(0,0) > SW_2(0,1)$, $SW_2(1,0) < SW_2(1,1)$	$s_1 = 0, s_2 = 0$
(6)	$SW_1(0,0) > SW_1(1,0)$, $SW_1(0,1) > SW_1(1,1)$ $SW_2(0,0) > SW_2(0,1)$, $SW_2(1,0) > SW_2(1,1)$	$s_1 = 0, s_2 = 0$
(7)	$SW_1(0,0) > SW_1(1,0)$, $SW_1(0,1) < SW_1(1,1)$ $SW_2(0,0) > SW_2(0,1)$, $SW_2(1,0) > SW_2(1,1)$	$s_1 = 0, s_2 = 0$
(8)	$SW_1(0,0) < SW_1(1,0)$, $SW_1(0,1) < SW_1(1,1)$ $SW_2(0,0) > SW_2(0,1)$, $SW_2(1,0) > SW_2(1,1)$	$s_1 = 1, s_2 = 0$
(9)	$SW_1(0,0) < SW_1(1,0)$, $SW_1(0,1) < SW_1(1,1)$ $SW_2(0,0) > SW_2(0,1)$, $SW_2(1,0) < SW_2(1,1)$	$s_1 = 1, s_2 = 1$