Open sky networks:

implications to the Asian aviation market*

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October 2007

Abstract

North America, Europe, and Asia are three largest regional blocks in the global aviation. EU has liberalized its aviation market within the region, following the north America. However, Asia is still left behind, and most of the markets in the region are still governed by bilateral air service agreements. This paper shows that, any pair of countries with an exclusive bilateral air-service agreement has no incentive to open their market to the third country; and yet that a comprehensive multilateral air service agreement within the entire region improves the welfare of all countries in the region.

Key words: air transport market, air-service agreements, social network analysis

* [**preliminary draft**] Research environment and financial support from International Transport Policy Research Unit (ITPU), Graduate School of Public Policy, The University of Tokyo are highly appreciated.

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1. Introduction

North America, Europe, and Asia are three largest regional blocks in the global aviation. EU has liberalized its aviation market within the region, following the north America. However, Asia is still left behind, and most of the markets in the region are still governed by bilateral air service agreements. It is an urgent agenda for the aviation in Asia to proceed the liberalization process. However, commercial traffic rights are not considered in WTO, and the air-service agreements are still governed through the ancient Chicago-treaty framework. According to Oum, "ICAO is not an effective organization to deal with liberalization of international air traffic because it is an UN organization and thus each country has one vote."

In fact, through a theoretical analysis this paper shows that any pair of countries with an exclusive bilateral air-service agreement has no incentive to open their market to the third country, when each country only cares about its own national interest. In turn, the paper shows that a cooperative multilateral air-service agreement improves the welfare of all countries in the agreement, and moreover that it is stable and self-fulfilling in the sense that once a subset of countries form a cooperative agreement, addition of countries to this coalition always improves both the incumbents and the newcomers with an appropriate transfer scheme. In other words, there is always a path for the coalition to grow larger without falling apart into pieces.

Network formation game is first analyzed by Jackson and Wolinsky (1996), which is recently adopted in the field of international trade by Furusawa and Konishi (2006). Furusawa and Konishi investigated an equilibrium and stability of various forms of free-trade networks. Here in this paper, we will focus on an air-transport market between two countries in a region, and analyze if those countries have an incentive to open their market to a third country. Our original idea is similar to that of Furusawa and Konishi, however, our approach of analysis shares its framework with Zhang and Zhang (2006). The model we employ is the two-stage game, with an airline's problem being the subgame. Airlines compete in Cournot fashion. These airlines are symmetric in costs and services they provide, whereas the countries can differ in the number of airlines that they have.

In the following section we set up the airline's profit maximization problem. Section 3 analyzes a non-cooperative game of countries, each maximizing national interest, and solves the entire game for a subgame-perfect equilibrium. Section 4 in turn shows that cooperative agreement is efficient and that it is also stable by showing that the cooperative agreement is a convex game. Section 5 concludes.

2. Airline's Problem

Let us consider an air transport market between countries i and j, labeled as market ij. The demand in this market is expressed as the following inverse demand function:

$$P^{ij} = P^{ij}\left(Q^{ij}\right).$$

Here Q^{ij} is the number of passengers in this market, and P^{ij} is the user cost of a flight between countries i and j, which is equal to the ticket price without the congestion considered in the model.

There are in total N^{ij} airline companies serving this market, of them n_i^{ij} is the number of airlines in country i. These airlines are assumed to compete in a Cournot fashion. We assume identical airlines and a symmetric equilibrium, while countries are asymmetric and differ in the number of airlines and hence in the market share. Airline's cost is consisted of airport charges in both countries i and j, and flight cost. Flight cost is assumed to be consisted of constant marginal cost only, with zero fixed cost. We denote this constant marginal flight cost by c^{ij}. Airlines' costs are measured in per-passenger unit. Country i levies an airport charge per passenger, denoted by μ_i^{ij}. An alternative view of μ_i^{ij} is that it also includes taxes charged by country i. We define the sum of airport charges in country i and j paid by an airline (and ultimately by a passenger) as μ^{ij}, i.e.,

$$\mu^{ij} \equiv \mu_i^{ij} + \mu_j^{ij}$$

Superscript ij will be suppressed for notational simplicity in what follows. Then the airline's profit maximization problem becomes

$$\max_q Pq - (\mu + c)\, q$$

where q is the demand for an airline.[1] The first-order condition is

$$P'q + P - (\mu + c) = 0. \tag{2.1}$$

The second-order condition is

$$P''q + 2P' < 0 \tag{2.2}$$

which is satisfied when P'' is negative or small if positive. We assume it is satisfied in such a way that $P''q < -P'$ in what follows. From above, profit for an airline π is obtained as

$$\pi = -P'q^2.$$

By symmetry of airlines equilibrium market quantity is N times output of each airline in

[1]Due to symmetry, it is not necessary that our notation identify airlines.

equilibrium, which we define as Q :

$$Q \equiv Nq^*$$

where $q^* \equiv \arg\max_q Pq - (\mu + c)\, q$. Then the airline's profit π can be rewritten as

$$\pi = -P' \frac{Q^2}{N^2}. \tag{2.3}$$

From (2.1) the equilibrium market demand Q is implicitly defined as a function of μ and N in the following equation:

$$P = \mu + c - P' \frac{Q}{N}. \tag{2.4}$$

Differentiating above gives

$$\frac{\partial Q}{\partial \mu} = \left[\frac{N+1}{N} P' + P'' \frac{Q}{N} \right]^{-1} \tag{2.5}$$

which is negative.[2]

3. Non-Cooperative Bilateral Air-Service Agreements

3.1. Formulation of National Interest

National interest of country i is consisted of consumer surplus of its residents, profits of airlines and the airport in country i. For simplicity we assume that for airports, marginal cost is constant and zero, and fixed cost is zero as well. We further assume that the share of consumer surplus in market ij attributable to the residents of country i is given by a constant s_i. Then the national interest v_i is formulated as

$$v_i \equiv s_i \left[\int_0^Q P\left(\tilde{Q}\right) d\tilde{Q} - PQ \right] + n_i \left[-P' \frac{Q^2}{N^2} \right] + \mu_i Q.$$

[2] This follows from our assumption that P'' smaller than $-P'/q$.

Country i maximizes its national interest v_i as

$$v_i^* \equiv \max_{\mu_i} v_i.$$

The first-order condition is

$$\begin{aligned} & s_i \left[-P'Q \frac{\partial Q}{\partial \mu} \right] + n_i \left[-P'' \frac{Q^2}{N^2} \frac{\partial Q}{\partial \mu} - 2P' \frac{Q}{N^2} \frac{\partial Q}{\partial \mu} \right] + Q + \mu_i \frac{\partial Q}{\partial \mu} \\ = & \ 0. \end{aligned} \quad (3.1)$$

Rearranging the above first-order condition gives

$$\mu_i = -Q \left[\frac{N+1}{N} P' + P'' \frac{Q}{N} \right] + s_i P'Q + n_i \left[2P' \frac{Q}{N^2} + P'' \frac{Q^2}{N^2} \right] \quad (3.2)$$

and for country j it is

$$\mu_j = -Q \left[\frac{N+1}{N} P' + P'' \frac{Q}{N} \right] + s_j P'Q + n_j \left[2P' \frac{Q}{N^2} + P'' \frac{Q^2}{N^2} \right] \quad (3.3)$$

Summing μ_i and μ_j given above gives the airport charges paid by an airline μ as follows.

Proposition 3.1. *When each country maximizes its national interest, the resulting airport charges paid by an airline μ is positive.*

Proof. From (3.2) and (3.3), we have

$$\begin{aligned} \mu &= \mu_i + \mu_j \\ &= -2Q \left[\frac{N+1}{N} P' + P'' \frac{Q}{N} \right] + (s_i + s_j) P'Q + (n_i + n_j) \left[2P' \frac{Q}{N^2} + P'' \frac{Q^2}{N^2} \right]. \end{aligned}$$

By using the fact that $s_i + s_j \leq 1$ and $n_i + n_j \leq N$ together with our assumption

$P''q < -P'$, we have that μ is positive:

$$\begin{aligned} \mu &= \left\{-2\frac{N+1}{N}P' - 2P''\frac{Q}{N} + (s_i + s_j)P' + \frac{(n_i+n_j)}{N}\left[2P'\frac{1}{N} + P''\frac{Q}{N}\right]\right\}Q \\ &\geq \left\{-2\frac{N+1}{N}P' - 2P''\frac{Q}{N} + P' + 2P'\frac{1}{N} + P''\frac{Q}{N}\right\}Q \\ &= -\left\{P' + P''\frac{Q}{N}\right\}Q \\ &> 0. \end{aligned}$$

■

The result above will be contrasted with the one in the cooperative case.

3.2. Stability of Bilateral Air-Service Agreements

In this section we investigate if a country has an incentive to open one of its markets, say market ij, to a country other than i and j. By opening the market, the number of airlines operating in the market will increase. We look at the first-order effects of an increase in N on the national interest v_i^* obtained above, conditional on the number of airlines of country i.[3]

Envelope theorem implies that

$$\begin{aligned} \frac{dv_i^*}{dN} &= s_i\left[-P'Q\frac{\partial Q}{\partial N}\right] \\ &\quad + n_i\left[-P''\frac{Q^2}{N^2}\frac{\partial Q}{\partial N} - 2P'\frac{Q}{N^2}\frac{\partial Q}{\partial N} + 2P'\frac{Q^2}{N^3}\right] \\ &\quad + \mu_i\frac{\partial Q}{\partial N}. \end{aligned}$$

By using (2.3), (2.5), and the first-order condition in (3.1), it simplifies as follows:

$$\frac{dv_i^*}{dN} = -Q\left[\frac{N+1}{N}P' + P''\frac{Q}{N}\right]\frac{\partial Q}{\partial N} - \frac{2n_i}{N}\pi. \tag{3.4}$$

[3] The analysis here can be interpreted as an impact of allowing a counterpart country j to increase the number of airlines in market ij.

Here note that differentiating (2.4) gives

$$\frac{\partial Q}{\partial N} = P' \frac{Q}{N^2} \left[\frac{N+1}{N} P' + P'' \frac{Q}{N} \right]^{-1}$$

which is positive. Plugging this into (3.4) and using (2.3) again finally yields

$$\frac{dv_i^*}{dN} = \left[1 - \frac{2n_i}{N} \right] \pi. \tag{3.5}$$

Equation (3.5) is negative when $n_i > N/2$. Summing up the discussion above, we have the following result.

Proposition 3.2. *If country i has the majority share of market ij in terms of the number of airlines, country i does not have an incentive to open the market ij to other airlines.*

Note that opening the market ij to airlines from a third country takes mutual agreements of both countries i and j. Therefore it is necessary to have both $dv_i^*/dN > 0$ and $dv_j^*/dN > 0$ for such an agreement to be signed. Clearly this is not feasible under a situation where a market ij is exclusively served by airlines from countries i and j, and thus an exclusive bilateral air-service agreement is stable.[4]

4. Cooperative Multilateral Air-Service Agreement

4.1. Efficiency of Cooperative Multilateral Air-Service Agreement

Let us now consider a region in which all countries signed a cooperative multilateral air-service agreement.[5] This is the situation where the decision makers of the region reach the conclusion

[4]Impact of increasing N discretely on the national interest v_i^* is ambiguous. This is because, though dv_i^*/dN becomes positive for $N > 2n_i$, π diminishes to zero due to competition as N becomes larger.

[5]The smallest number of countries of such regioin is two, in which case, the situation degenerates to that under a *cooperative* bilateral air-service agreement, and the following argumentn in this section still applies.

that they all cooperate to open the aviation market only to the member countries, and that a unanimous decision is made by a super-national entity so as to maximize the welfare in the entire region. Under this multilateral air-service agreement, all airlines from any countries in the region have access to any market in the region, while foreign airlines from countries outside of the region do not have any. The region we consider does not have to be the entire set of countries (i.e., the entire world) nor completely disjoint from other countries outside; however, it is a region such that the volume of foreign passengers from outside of the region is negligible.

The super-national entity maximizes welfare in the region, defined as the sum of consumer surplus, airlines' profits, and airports' revenues in the entire region. In market ij such entity maximizes the welfare by controlling the airport charges at both ends, μ_i and μ_j:

$$\max_{\mu_i,\mu_j} \left[\int_0^Q P\left(\tilde{Q}\right) d\tilde{Q} - PQ\right] + N\left[Pq - (\mu + c)\, q\right] + \mu Q$$

where $\mu = \mu_i + \mu_j$. By noting that $Q = Nq$ the above objective function can be simplified to

$$\max_{\mu_i,\mu_j} \int_0^Q P\left(\tilde{Q}\right) d\tilde{Q} - cQ \tag{4.1}$$

where Q is implicitly defined as a function of μ and N in (2.4). Then the first-order condition is

$$P\frac{\partial Q}{\partial \mu} - c\frac{\partial Q}{\partial \mu} = 0$$

or

$$P = c. \tag{4.2}$$

This implies that the cooperative agreement is efficient as marginal-cost pricing being achieved. Obviously, this is achieved with subsidies when the number of airlines is finite, i.e., if airlines have market power. The following proposition states this point.

Proposition 4.1. *Under the cooperative and bilateral agreement, the optimal airport charge becomes negative.*

Proof. Recall that first-order condition of an airline (2.1) together with (4.2) implies

$$\mu = P'q. \tag{4.3}$$

This means that μ is negative and thus each airline is subsidized according to its market power and share.■

From $\lim_{N\to\infty} q = 0$, it is obvious that subsidy per passenger goes to zero as $N \to \infty$. Profit of an airline in this situation is purely a transfer from the super-national entity, and is as follows:

$$\begin{aligned}\pi &= -P'q^2 \\ &= -\mu q.\end{aligned}$$

Therefore, airline's profit also goes to zero as $N \to \infty$, and hence amount of total subsidy decreases to zero as well.

Since the airlines' profits are purely transfer payments in the form of negative airport charges, the net gain is from the increase in gross consumer surplus minus the increase in flight operating cost.

Lemma 4.2. *Let Q_B be the equilibrium quantity in bilateral air-service agreement and Q_M be that under the multilateral agreement, then we have $Q_B < Q_M$.*

Proof. Recall that $\partial Q/\partial\mu < 0$ and $\partial Q/\partial N > 0$. Recall also that μ under bilateral air-service agreements, say μ_B, is positive while μ under multilateral air-service agreements, μ_M say, is negative. At the same time N is larger under the multilateral agreements, than under bilateral. Thus we have $Q_M > Q_B$.■

Proposition 4.3. *There always exist an international transfer scheme that is Pareto improving from the non-cooperative bilateral scheme.*[6]

Proof. The net gain from the regime change is

$$\int_{Q_B}^{Q_M} P\left(\tilde{Q}\right) d\tilde{Q} - c\left[Q_M - Q_B\right]$$

or

$$\int_{Q_B}^{Q_M} \left[P\left(\tilde{Q}\right) - c\right] d\tilde{Q}, \tag{4.4}$$

Since $P(Q) = c$ for $Q = Q_M$ and $P'(Q) < 0\ \forall Q$, $P - c > 0\ \forall Q < Q_M$. The fact that $Q_B < Q_M$ then implies

$$P - c > 0, \quad \forall Q \in [Q_B, Q_M],$$

which makes (4.4) positive.■

Such international transfer scheme depends on the market share of both airlines and passengers of each country in each market, as well as on the market power and size. Therefore, it is possible that in one particular market, some countries win and some lose; however, overall, all countries will be better off, in comparison to the non-cooperative bilateral scheme.[7]

[6] *This depends on the absence of foreign airlines. However, even with the existence of foreign airlines, if the market is sufficiently competitive, i.e., if N is large, then leakage to foreign airlines through subsidy will be negligible, and therefore multilateral scheme with airport subsidy will be Pareto efficient.*

[7] One way of mitigating such inequality in each market will be to adjust μ_i and μ_j while satisfying (4.3).

4.2. Stability of Cooperative Multilateral Air-Service Agreement

To show that the cooperative multilateral air-service agreement stated above is stable, let us formulate a cooperative game $C(T, v)$, where T stands for a player set and v a characteristic function. That is, T is a set of countries in agreement and v is the total welfare in this region with countries in set T.

Definition 4.4. *The set of allocation vector x, $C(T, v)$, is in the core if it satisfies the following.*

$$C(T, v) = \{x \in R^T | \sum_{i \in T} x_i = v(T) \ \ \textit{and} \ \ \sum_{i \in S} x_i \geq v(S) \ \forall \ S \subseteq T\}$$

Thus, the allocations in the core are not dominated by any other coalition rather than the grand coalition itself. Therefore, the core is one of the stable allocations of the payoff generated by the cooperation.

Proposition 4.5. *The core is nonempty in the game of the multilateral air-service agreement described above.*

Proof. We provide a heuristic proof here. Recall that there exists at least one allocation which is in the core if the coalition game $C(T, v)$ is a convex game.[8] $C(T, v)$ is said to be a convex game if and only if

$$v(S) - v(S - \{i\}) \leq v(T) - v(T - \{i\}), \quad \forall \ i \in S \subset T \tag{4.5}$$

is satisfied. Let $M(S)$ be the set of links between countries in S. Then the number of links denoted by $|M(S)|$ is such that

$$|M(S)| = \frac{|S|(|S| - 1)}{2} \tag{4.6}$$

[8] See, for example, the appendix of the chapter 18 in Mas-Colell, Whinston and Green(1995).

where $|S|$ denotes the number of countries in set S. If a country i leaves the agreement, the difference of the number of links from before the leave is

$$|M(S)| - |M(S - \{i\})| = |S| - 1. \tag{4.7}$$

Define $\triangle M(S)$ as the difference in the sets $M(S)$ and $M(S - \{i\})$, i.e.,

$$\triangle M(S) \equiv M(S) \cap \overline{M(S - \{i\})} \tag{4.8}$$

where the upper bar $(-)$ indicates the complement set. We have therefore, to confirm that

$$|\triangle M(S)| = |S| - 1. \tag{4.9}$$

Similarly, we define $\triangle M(T)$ as the set of links in $M(T)$ but not in $M(T - \{i\})$, yielding $|\triangle M(T)| = |T| - 1$, where $S \subset T$ as stated above. Then the latter is always larger because the latter possesses the extra links which used to be connected with the countries in T but not in S, that is,

$$|\triangle M(S)| < |\triangle M(T)| \tag{4.10}$$

and moreover,

$$\triangle M(S) \subset \triangle M(T). \tag{4.11}$$

On one hand, common links in $\triangle M(S)$ and $\triangle M(T)$ generate the same net gain by joining the cooperative agreement, since each link's payoff is maximized at the marginal-cost-pricing level regardless of the numbers of countries in the agreement (and hence of the number of airlines) as seen above. Therefore the common links in $\triangle M(S)$ and $\triangle M(T)$ can be canceled out when we calculate the welfare difference (4.5). On the other hand, there is at least one link that is in $\triangle M(T)$ and not in $\triangle M(S)$. As discussed above, the net gain of joining the cooperative agreement from this link is positive. Thus, this coalition game is a convex game for any $S \subset T$, and it means there exists at least one core for this game.■

5. Concluding Remarks

This paper showed that, any pair of countries with an exclusive bilateral air-service agreement has no incentive to open their market to the third country. This is particularly the case if either of the pair has the majority share of their market. This paper also showed that a cooperative multilateral air service agreement improves the welfare of all countries in the region. It has also shown that cooperative agreement is stable and self-fulfilling in the sense that once a subset of countries form a cooperative agreement, addition of countries to this coalition always improves both the incumbents and the newcomers with an appropriate transfer scheme, i.e., there is always a path for the coalition to grow larger, without falling apart.

Possible directions of future research include the following.

Non-cooperative multilateral agreement as a mixed regime: In this mixed regime, each country still maximizes its national interest, while it is allowed to operate in a link between third countries. Total welfare improves as a result of more competition, and incentive to open the market will increase as market shares decline.

Cost heterogeneity: The model provided in the previous section assumed symmetric airlines. However, in reality some airlines have strictly higher operating costs than others. With relatively higher operating costs for Japanese airlines, their profit diminishes even faster than that of their competitors as N increases. At the same time, Japanese airlines are still dominating majority shares in many markets to/from Japan. These two facts together further discourage Japanese government to liberalize its air transport markets.

Capacity constraints: Narita, the main international airport of Japan is capacity constrained. Though our model does not explicitly treat capacity of an airport, it is straightforward to conjecture that this constraint is acting as a physical barrier which reinforces a legal barrier of exclusive bilateral air-service agreements in limiting the number of airlines serving Japanese markets.

Monopolistic competition with differentiated air-transport services: When the air-transport services are differentiated, consumers appreciate variety. Therefore, introduction of new airline in the market can reduce the demand for incumbent greatly, given the overall demand for air-transport services. This can even narrow down the profit to an airline, and hence discouraging the country to open up its market even further.

Welfare analysis of global versus regional liberalization: While liberalization within the region progresses, that of inter-regional air-transport market is lagged behind. There is possibly a coordination failure between the regions, similar to that between countries in one region. Analysis will involve one-level deeper-modeling of a theoretical framework, which In our analysis we investigated a situation in which all the countries in the region are involved in the multilateral agreement. Alternative is that only subset of countries in the region first form a club of multilateral air-service agreements and leaves the others out of the club. Future research will investigate the efficiency and stability of such situation.

Existence of foreign airlines in the region: While the existence of foreign airlines will enhance the competition, it also drains out the welfare of the region to foreign countries in the forms of airlines' profits. This is true both under the bilateral air-service agreements and multilateral agreements with airports' subsidies, whenever airlines have some market power.

Comparison of the benefit of enhancing competition and cost of profit leakage is left for future work.

Incentive to give the fifth freedom to foreign airlines: Each country may have an incentive to give out the fifth freedom or co-terminalization to a foreign country in seeking for the benefit of establishing a regional hub within itself. However, allowing foreign airlines operating in the region worsens the regional welfare, and thus Pareto inefficient.

Inter-regional competition against US and EU: While the air carriers from the US operates within the Asian aviation markets, the US does not allow any Asian air carriers to operate in US aviation market due to cabotage. Taking into account the geographic and economic symmetry of US and asian markets, this asymmetric situation may well be socially unjustifiable.

Demand increase due to economic growth in east Asia: The payoff to the airlines and countries inside and outside of the Asian region is dynamically changing due to a rapid economic growth in east Asia. It is therefore necessary to modify our static model into a dynamic one.

General equilibrium effect of lowered air transport costs on national economy: Experience of Dubai indicates lowered air transport costs through liberalization bring new employment and new industry such as finance to emerge.

Welfare cost of substantial-ownership-and-effective-control regulation: With this regulation in effect, no airline is multinational. Allowing multinational (cross-national) ownership of airlines can induce a country to sign the multilateral air-service agreements.

Congestion and economy of density: User cost is not only consisted of ticket price, but also waiting time costs. Waiting time costs have two parts. One is waiting time due to airport congestion, and another is schedule delay. With increased airlines and flights, congestion situation worsens while increased frequency lowers the schedule delay costs.

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