A STUDY ON THE AVIATION MARKET CONSIDERING ALLIANCE EFFECTS

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Abstract: It is considered that airline alliance is the most effective strategy to survive competition in the aviation market. Since the structure of the aviation network would rely on alliances, the necessity of quantitative analysis on alliance impacts has been increasing. At first, behaviors not only of the air passenger but also of the airline are formulated based on utility maximization and profit maximization, respectively. Then, the impacts of alliance are investigated by market equilibrium analysis considering some alliance effects such as code-sharing, cost sharing and network complementation. Influences of these effects are measured by changes of airline profit, user benefit and social welfare and some implications for air transport policies are derived.

1. INTRODUCTION

In the international aviation industry, the level of service such as the number of firms, frequencies and cities which could be served are arranged by bilateral agreement, therefore it is said that this industry is strongly regulated. The U.S. has intended to promote the "open sky policies" which is almost same, in terms of liberalization for the industry, as the deregulation in the U.S. domestic aviation industry. It is thought that the new bilateral agreement between Japan and the U.S. concluded in 1998 improve the level of service significantly in Japan. With this agreement, the market has taken a step toward liberalization of market.

The recent trend of the aviation industry is to build worldwide alliance. Figure 1 shows the current status of airline alliance. The size of circle indicates the number of passengers carried by the corresponding airline, and the patterns of circle indicate the alliance groups. Most major airlines in the world are included in any of the alliance groups. That is, alliance is one of the most important strategies to survive in this industry.

It is thought that alliance increases not only airline profit but also user benefit. However, as the results of competition among allied groups, some regions would suffer from decreasing the level of service. That is, alliance is one of the factors to change the market structure. Therefore, the effect of alliance is examined and the influence of alliance on market is also investigated through market equilibrium analysis.

2. REVIEW OF RELATED PAPERS

The papers related to merger and alliance in aviation market should be reviewed in terms of the factors which might cause the change in aviation market structure. After the deregulation of domestic aviation market in the U.S., the number of firms had increased and the condition of domestic aviation market

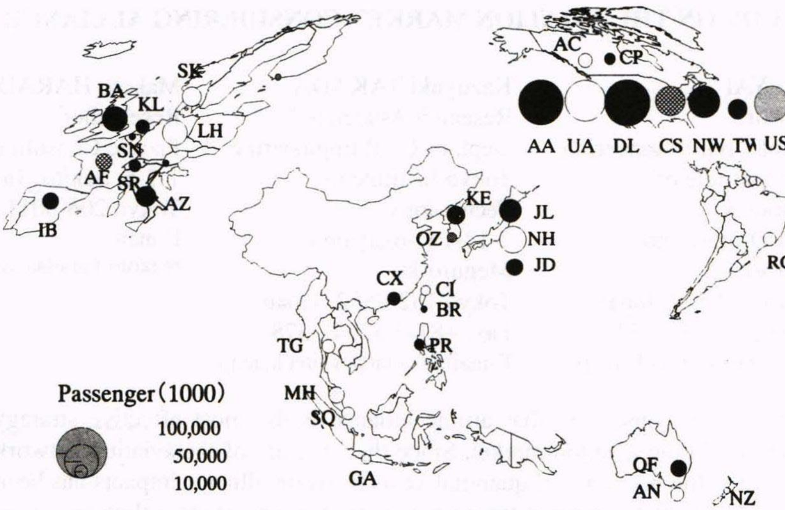


Figure 1. Current Status of Airline Alliance

looks like competitive. After the mid-80s, large airline developed new market strategies such as CRS, FFP and Hub and spoke network system. Therefore, they could prevent new entrant and form a merger with many small airlines. Then, many studies analyzed the relation between airport dominance and the degree of market competition. It was cleared that market concentration brings high yields. However, Morrison, S. et al.(1996) pointed out that the term of analysis in the previous studies was not enough long to conclude general view and they also showed a decrease of fare level with long term observation.

Moreover Glougherty, J.A.(1996) analyzed the influence of merger among domestic airlines on the international aviation market, and it was indicated that the increase of market concentration in the domestic market contributed to increase market share in the international market.

After 1990, the influence of new entrants such as southwest airlines to a niche markets, which remained in hub and spoke networks of mage airlines. And it was founded that an entrant of low cost airline contributes to increase of user benefit owing to decrease of market fare level.

Meanwhile, Youssef, W.(1992) started a research on the airline alliance. The influence of alliance, in terms of changes in level of service, between SR and SAS was investigated. And Youssef, W. et al.(1994) indicated that alliances cause the network restructuring and that the effect of alliance is explained with density of network, degree of vertical integration and scale of allied firms. GRA(1994) demonstrated the effect of code share flights of NW and KL, and US-Air and BA. It was shown that NW and KL increased the traffic and revenue and that US-Air and BA increased traffic with transit by 60%. Moreover, Hannegan, T.F. et al.(1995), Bissessur, A. et al.(1998) analyzed the influence of international airline alliance qualitatively, and Bayhoff, S. (1995) and Oum, T.H. at al.(1997) explained the effects of alliance.

In recent years, the influence of alliance is examined quantitatively. Oum, T.H. et al.(1996) examined the output level of the allied airlines, and it was shown that alliance without market leader makes market leader more competitive. Park, J.H. et al.(1997) verified the influence of four major alliance in the north Atlantic market by change in quality of service and change of traffic volume. Moreover, Park, J.H. et al.(1998) defined two types of alliance as parallel alliance and complementary alliance by network structure of allied airlines. And economic models for these two forms of alliance are formulated. Thorough the equilibrium analysis, it was shown that airline profit and user benefit differ by what network is formed after alliance occurs.

The user's preference for service is not considered sufficiently in these papers reviewed above. In this paper, service choice models which were estimated in our former research (Yai,T. et al.(1997)) is applied to the behavior passenger. That is, the influence of alliance on market will examined considering user's preference for air service.

In chapter 3, the behaviors of airline and passenger are formulized. And the effects of airline alliance are examined through equilibrium analysis in chapter 4. Finally, under the more realistic market condition, the influence of alliance is examined with considering the heterogeneity of airlines and passengers in chapter 5.

3. FORMULA OF AVIATION MARKET

3.1 Behavior of Air Passenger

In this paper, the amount of demand on every market is exdogenously given. According to the utility maximization theory, passengers choose a specific flight service among other alternate services to maximize their utility. The utility function is written in equation (1).
Finally, the utility of air route choice behavior is explained in detail, because endogenous variables in market model affect this function directly. If one route is operated by airline(i), then the utility of the route r is given as:

$$U_{nr}^{OD} = V_{nr}^{OD} + \varepsilon_{nr}^{OD} \tag{1}$$

U_{nr}^{OD} : Utility of air route r served by airline(n) in origin (O) - Destination (D) market;

V_{nr}^{OD} : Systematic component of utility specific to route r served by airline(n) in O-D market;

ε_{nr}^{OD} : Random utility component specific to route r served by airline(n) in O-D market;

It is assumed that ε_{nr}^{OD} is distributed in Gumbel distribution. Then, probability that passenger, who depart from O for D, choose route r served by airline(n) is written in equation (2),

$$Pr_{nr}^{OD} = \frac{exp(V_{nr}^{OD})}{\sum_{n}^{N} \sum_{r'}^{R(n)^{OD}} exp(V_{nr'}^{OD})} \tag{2}$$

N : number of airlines;

$R(n)^{OD}$: number of available routes served by airline(n) in O-D market;

Then,

$$T_{nr}^{OD} = T^{OD} \cdot Pr_{nr}^{OD} \tag{3}$$

$$T_{nl(b-e)} = \sum^{OD} \sum_{r}^{R(n)^{OD}} \delta_{nr}^{l(b-e)} \cdot T_{nr}^{OD} \qquad \text{for } n \in N \tag{4}$$

$$\delta_{nr}^{l(b-e)} \begin{cases} 1 & \textit{if route r of airline(n) pass through the link between region(b) and region(e),} \\ 0 & \textit{otherwise} \end{cases}$$

where,

T^{OD} : Passenger demand in O-D market;

T_{nr}^{OD} : Number of passengers who depart from O for D and choose route r of airline(n);

$T_{nl(b-e)}$: Number of passengers who use the flight of airline(n) between region(b) and region(e);

$$V_{nr}^{OD} = \beta_1^O \cdot fare_{nr}^{OD} + \beta_2^O \cdot \ln(freq_{nr}^{OD}) + \beta_3^O \cdot time_{nr}^{OD} + \beta_4^O \cdot dummy_{nr}^{OD} \quad (5)$$

$fare_{nr}^{OD}$: Fare on route r of airline(n) in the O-D market,

$freq_{nr}^{OD}$: Weekly flight frequency on route *r* of airline(n),

$time_{nr}^{OD}$: Travel time on route r of airline(n),

$dummy_{nr}^{OD}$: Dummy variables for airline characteristics

$$\begin{cases} 1 & \textit{if the airline(n) is a flag carrier of region(O)} \\ 0 & \textit{otherwise} \end{cases}$$

$\beta_1^O, \beta_2^O, \beta_3^O, \beta_4^O$: Parameters of utility function for the passenger who reside region(o)

3.2 Behavior of Airline

It is assumed that all airlines adjust the level of service such as fare and frequency to maximize their profits. Profit is obtained by the difference between revenue and cost, and profit of airline(n) is given as (6). Because the analysis system does not include the whole network of airlines, revenue from passenger is obtained only in the analysis system. Details of the cost function are explained in later section.

$$\begin{aligned} \pi_n &= Rev_n - Cost_n \\ &= \sum^{OD} \sum_r^{R(n)^{OD}} fare_{nr}^{OD} \cdot T_{nr}^{OD} - \frac{Y_n^{in}}{Y_n^{in} + Y_n^{out}} \cdot TC_n \end{aligned} \quad (6)$$

π_n : Profit of airline(n),

Rev_n : Revenue of airline(n),

$Cost_n$: Cost of airline(n),

Y_n^{in} : Output (passenger-kilometers) of airline(n) within objective network,

Y_n^{out} : Output (passenger-kilometers) of airline(n) outside objective network,

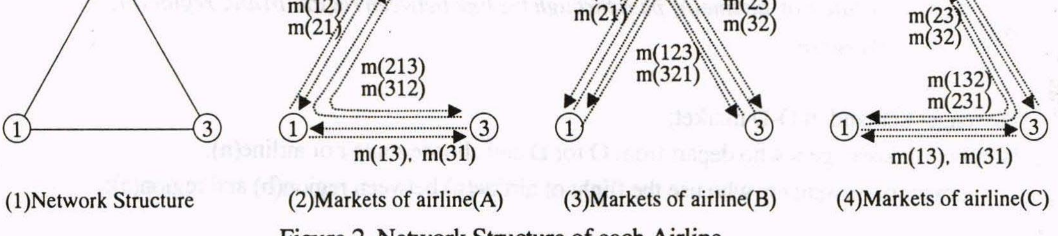
TC_i : Total cost of airline(n).

3.3 Assumption of Market Structure

Network structure examined in this paper and the markets of each airline are shown in Figure 2. The assumptions of market condition are described below. In the figure, m(od) means the market origin region o and destination region d. And m(ovd) also means the market of origin region o and destination region d with transit at region v.

(1) Market condition: competition among airlines is under nash-equilibrium. This indicates that nash-equiribrium solution are obtained by market equilibrium analysis, which is shown in Ohashi, T. et al.(1999).

(2) Network structure: the routes operated by each airline are determined exogenously. That is, airline(A)



(1)Network Structure (2)Markets of airline(A) (3)Markets of airline(B) (4)Markets of airline(C)

Figure 2. Network Structure of each Airline

operates flights on link(1-2) and link(1-3); the numbers in parentheses mean origin and destination regions of the link; airline(B) operates flights on link(2-1) and link(2-3). Airline(C) also operates flights on link(3-1) and link(3-2).

(3) Supply-Demand constraint: the relation between traffic transported by each airline and the number of available seats supplied by each airline is given in equation (10).

$$T_{nl(b-e)} \leq seat_{nl(b-e)} \cdot freq_{nl(b-e)} \tag{7}$$

$seat_{nl(b-e)}$: number of seats per flight on link(b-e) of airline(i),

$freq_{nl(b-e)}$: frequency on link(b-e) of airline(i),

3.4 Equilibrium Analysis

The solution of aviation market model is derived using equilibrium analysis. This problem is translated to a constrained maximization problem and the formula is given in equation (11).

$$\max_{fare_{nr}^{OD},\ freq_{nl(b-e)}} \quad \pi_n = \sum^{OD} \sum_{r}^{R(n)} fare_{nr}^{OD}\, T_{nr}^{OD} - \frac{Y_n^{in}}{Y_n^{in} + Y_n^{out}} \cdot TC_n \tag{8}$$

$$s.t. \quad (10)$$

In order to state the first-order condition for this problem, Lagrangian (Φ_i) it is useful to solve it and the formula is given in equation (9),

$$\Phi_n = \pi_n + \sum_{l(b-e)\in L(n)} \mu_{nl(b-e)} (seat_{nl(b-e)} \cdot freq_{nl} - T_{nl(b-e)}) \tag{9}$$

$\mu_{nl(b-e)}$: Kuhn-Tucker multipliers.

$L(n)$: a set of link on which airline(n) operates flight,

If $fare_{nr}^{OD} > 0$, $freq_{nl} > 0$ and the Kuhn-Tucker Theorem is employed, the first-order conditions are described in equation (10), (11) and (12).

The related fare on route r:

$$fare_{nr}^{OD} \frac{\partial \Phi_n}{\partial fare_{nr}^{OD}} = 0, \quad \frac{\partial \Phi_n}{\partial fare_{nr}^{OD}} \leq 0, \quad fare_{nr}^{OD} \geq 0 \quad for \quad n\in N, r\in R(n) \tag{10}$$

The related frequency on link l:

$$freq_{nl} \frac{\partial \Phi_n}{\partial freq_{nl}} = 0, \quad \frac{\partial \Phi_n}{\partial freq_{nl}} \leq 0, \quad freq_{nl} \geq 0 \quad for \quad n\in N, l\in L(n) \tag{11}$$

The related capacity constraints on link l:

$$\mu_{nl} \frac{\partial \Phi_n}{\partial \mu_{nl}} = 0, \quad \frac{\partial \Phi_n}{\partial \mu_{nl}} \geq 0, \quad \mu_{nl} \geq 0 \quad for \quad n\in N, l\in L(n) \tag{12}$$

4. INFLUENCE OF AIRLINE ALLIANCE ON AVIATION MARKET

The incentive to align with other airlines is to increase profit. The effects of alliance are examined with market equilibrium analysis. Alliance effect is divided into two aspects. One is direct effect and another is indirect effect. Cost reduction led by joint expense, and revenue gain led by code-share operation and network complement are considered as direct alliance effects. Meanwhile, reduction of average cost through economy of scale for output is considered as indirect alliance effect inn this paper.

4.1 Evaluation Indices of Influence of Airline Alliance

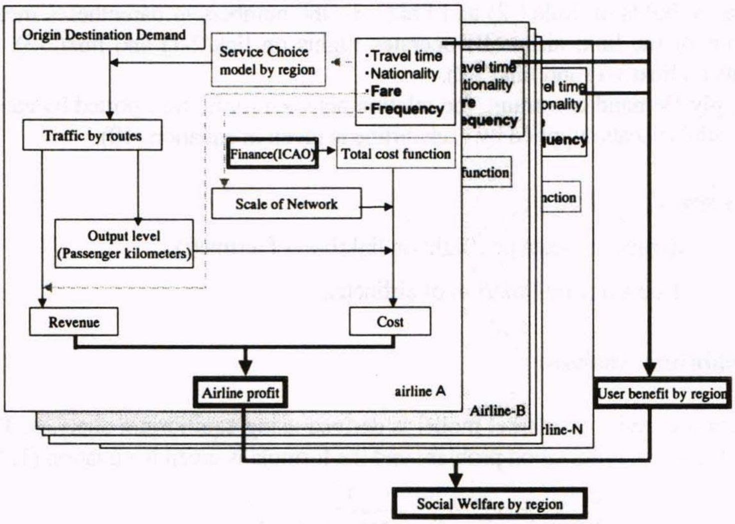


Figure-3 System of equilibrium analysis

The influence of airline alliance is measured in terms of change of profit by airline, change of user benefit by region and change of social welfare by region. Figure-3 shows the system of equilibrium analysis. Definition of indices is described below.

(1)Airline Profit

This index was already described in sec. 3.2.

(2)User Benefit

User benefit is measured by the compensating variation. This is determined by the difference of utility levels between before and after service changes. Before service changes, the expectation of maximum utility of air service choice is written in equation (13). Meanwhile, after service changes, that is written in (14). Since the total user benefit on a specific market is obtained by multiplying user benefit per passenger by passenger demand in this market. Therefore, total user benefit by region(TUB^O) is obtained by summing up all benefits generated in every market.

$$UL^{OD(b)} = ln \sum_{n}^{N} \sum_{r}^{R(n)^{OD}} expV_{nr}^{OD(b)} \quad (13)$$

$$UL^{OD(a)} = ln \sum_{n}^{N} \sum_{r}^{R(n)^{OD}} expV_{nr}^{OD(a)} \quad (14)$$

$$UB^{OD} = -\frac{UL^{OD(a)} - UL^{OD(b)}}{\beta_1^O} \quad (15)$$

$$TUB^O = \sum^{OD} T^{OD} \cdot UB^{OD} \quad (16)$$

$UL^{OD(b)}$: Expected value of maximum utility of air service choice for a passenger who travels from region(O) to region(D) before service changes.

$UL^{OD(a)}$: Expected value of maximum utility of air service choice for a passenger who travels from region(O) to region(D) before service changes.

UB^{OD} : User benefit for a passenger who travels from region(O) to region(D).

TUB^O : Total user benefit at region(O).

(3) Social Welfare
Social welfare is defined as a summation of the change of airline profit and that of user benefit at each region, and it is shown in equation (17).

$$SW^O = \sum_n^N \delta_n(\pi_n^a - \pi_n^b) + TUB^O \tag{17}$$

SW^O : Social welfare at region(O)
π_n^b : Profit of airline(n) before service changes.
π_n^a : Profit of airline(n) after service changes.
δ_n : $\begin{cases} 1 & \text{if base airport of airline(n) is located at region(O)} \\ 0 & \text{otherwise} \end{cases}$

4.2 Cost Reduction

One of the main effects of alliance is to reduce the cost. In this paper, it is assumed that allied airlines can make their cost structure lower and consequently they can reduce their cost. First of all, cost function should be estimated to examine cost reduction effect (CRE). It is pointed out that a limit of linear cost function and Cobb-Douglas cost function has a difficulty to express elasticity of input substitution. Therefore, as shown in Caves, D.W. et al.(1984) and Oum, T.H. et al.(1991), trans-log cost function is usually employed. However, the focus of this paper is not to estimate a precise cost function but to analyze the influence of airline alliance through the market equilibrium analysis, Cobb-Douglas form is adopted to a cost function, which is shown in equation (18).

$$\ln TC = \alpha_0 + \alpha_Y(\ln Y) + \alpha_N(\ln N) + \sum_{i=1}^{2}\alpha_i(\ln P_i) + \sum_k \delta_k d_k \tag{18}$$

$s.t.\quad \alpha_1 + \alpha_2 = 1$
TC : Total cost
Y : Output (total passenger kilometer)
N : Variable of network characteristics(the number of served cities)
P_1 : Unit price of variable cost
P_2 : Unit price of fixed cost
d_k : Dummy variable for airline attributes
(k=1 is applied to U.S. airlines and k=2 is applied to Japanese airlines)
$\alpha_0, \alpha_Y, \alpha_N, \alpha_i, \delta_k$: Parameter

Cost for flight operation, cost for maintenance, cost for user charges and station expenses, and cost for passenger services compose variable cost. And the unit price of variable cost is defined as the variable cost per output (available seat kilometers). Meanwhile, cost for depreciation, cost for ticketing, sales and promotion and general and administrative cost compose a fixed cost. And then, the unit price of fixed cost is defined as the fixed cost per employee. The data used in parameter estimation are referred to ICAO's statistics (1981,1987,1993) and OAG timetables (1981,1987,1993). Figure-4 shows the relation between total cost and output with data that are used to estimate the cost function. In this figure, three types of airline classified by their attributes are respectively shown using different symbols. It indicates that there is log-linear relation between total cost and output in all type of airlines.

Three stage least square method is employed to estimate parameters and the results is shown in table-1. Reliability of estimates for output, unit price of variable cost and unit price of fixed cost is statistically significant. What the parameter of output is less than one indicates the existence of scale economy related to output level. Therefore, it is thought that there is an incentive to enlarge output level for decreasing average cost.

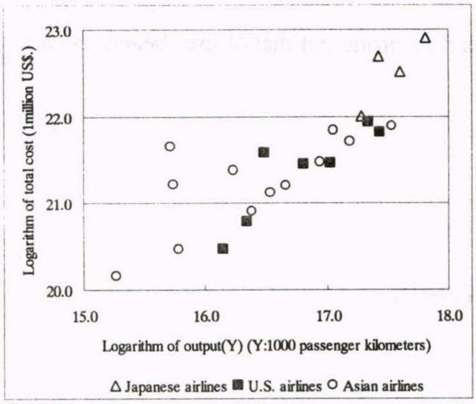


Figure-4 relation between total cost and output level

Table-1 Parameters of total cost function

Variable		Value	t-value
Output(1000 passenger kilometer)	α_Y	0.776	14.32
The number of cities served	α_N	0.105	1.31
Unit price of variable cost	α_1	0.809	20.38
Unit price of fixed cost	α_2	0.191	4.81
Constant	α_0	2.770	4.47
Dummy variable for U.S. carrier	d_1	0.085	1.20
Dummy variable for Japanese carrier	d_2	0.141	2.09
Number of samples		23	
Coefficient of determination		0.996	

Table-2 Value of exogenous variables

Variable		value	Notes
Demand between Origin and Destination	T^{OD}	250000	Constant at all market
Number of Seat per aircraft	S_i^l	300 seats	Constant for all aircraft
Distance between airport	L_i^l	2000 km	Constant for all link
Travel time	t_i^r	3.39 hour	Direct flight service
		7.71 hour	Transit route
Service choice model for U.S. passenger	β_{n1}	-0.345	Fare (n=1~3)
	β_{n2}	0.208	Frequency (n=1~3)
	β_{n3}	-0.240	Travel time (n=1~3)
	β_{n4}	0	Dummy variable (n=1~3)

Comparing dummy variables for airline attributes, there are positive sign in U.S. and Japanese airlines. It indicates that cost structures of these two types are higher than that of Asian airlines. Because dummy variables of Asian airlines is set 0 as standard point. It is also shown that cost structure of Japanese airline is higher than that of U.S. airlines.

One of the factors that cause cost reduction is joint expanse for fuel, aircraft and promotion. Moreover, joint flight operation also decreases operation cost. And joint utilization of terminal facilities decreases service cost. There is an indirect effect of cost reduction through the effect of economies of scale. The average cost is decreased in accordance with increase of output level. If the number of traffic of allied airline increase, allied airline can operate flights with low average cost.

Here, CRE of allied airlines is examined. It is assumed that airline(A) and airline(B) in Figure-2 align and that unit price of variable cost for the allied airlines decreases at same rate. A rate of decrease of variable cost is set α, and strength of CRE is examined by setting different value of α. And another condition is added that allied airlines pursue to maximize their own profit. That is, allied airlines cooperate to improve level of flight service and they continue competition after they allied. This assumption remains in the all analysis in this paper.

The value for exogenous variables in equilibrium analysis is shown in Table-2. Since the purpose of this

Table-3 Market equilibrium condition without alliance

Market	Airline(A) Frequency	Airline(A) Fare	Airline(B) Frequency	Airline(B) Fare	Airline(C) Frequency	Airline(C) Fare
1-2	17.7	6.7	17.7	6.7		7.9
2-1		6.7		6.7		7.9
1-3	17.7	6.7		7.9	17.7	6.7
3-1		6.7		7.9		6.7
2-3		7.9	17.7	6.7	17.7	6.7
3-2		7.9		6.7		6.7

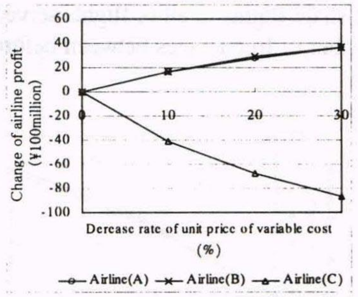


Figure-5 cost reduction effect on airline profit

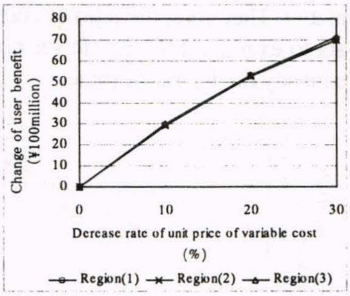


Figure-6 cost reduction effect on user benefit

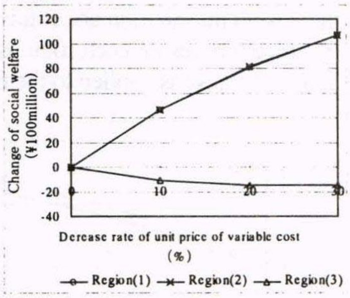


Figure-7 cost reduction effect on social welfare

section is to examine the CRE, all airlines assume to be homogeneous in terms of cost structure and their output level, and passengers also to be homogeneous in terms of their preference for airline service. Moreover, the demands in every market assume to be same amount.

Table-3 shows the market equilibrium states before alliance appears. Moreover, figure-6,7, and 8 respectively shows the change of airline profit, user benefit and social welfare with the change of decreasing rate (α) of unit price of variable cost.

Figure-5 shows that airline profit of allied airline increase in accordance with high value in α, it show that achievement to be low coat structure takes additional profit. The other hand, airline(C) that could not align with other airline decrease its profit. This is caused by the fact that allied airline can offer much lower fare, therefore competitive condition surrounding airline(C) becomes severer. Meanwhile, user benefit at every region increase in accordance with high value in α. This is because that influence of CRE spreads to a region in which there is no allied airline (Figure-6). Moreover, Figure-7 shows the decrease of social welfare at region(3), because profit loss of airline(C) excesses the increase of user benefit at this region.

To summarize, decrease of cost structure makes market condition more competitive and user benefit increase owing to lower fare. However, it should be mentioned that these results are obtained by the experiments under simple network structure in which all airlines operate flights at all regions.

4.3 Revenue Gain

Revenue increases with higher fare and more traffic. However, there is an opposite relation between higher fare and large traffic. Therefore, high fare does not always produce large revenue. Moreover, between frequency and fare, travel time and fare are also opposite relations. These relations are considered by airlines in market equilibrium analysis. Among many alliance effects such as joint FFP program, seamless service, and etc., only the effect of increase of frequency and effect of network complement are examined as factors in increase of airline profit.

(1) Frequency Increase Effect

Frequency Increase Effect (FIE) is led by code-share operations, because code-share flights are attached 2 flight numbers. One is a flight number of own company and another is that of alliance partner. Therefore, alliance partner can show passengers the increased number of frequency. For example, if allied airline(A) and airline(B) operate respectively 7 and 5 flights in a week on one route before they allied, both airlines could operate 12 flights in a week on the route after they started code-share operation.

It is unreasonable that every flight of both allied airlines is operated with code-share flight. However, there is no information about this matter. Therefore, the ratio of code-share flights to all of flights served by allied airlines on each route is set to examine FIE. The fewer number of frequencies between before and after transit is applied to the frequency on the transit route.

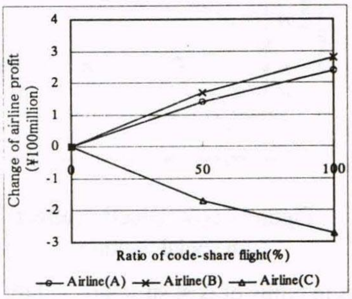


Figure-8 Code-share effect on airline profit

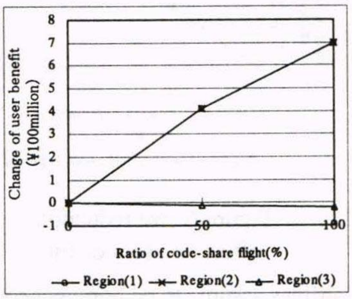


Figure-9 Code-share effect on user benefit

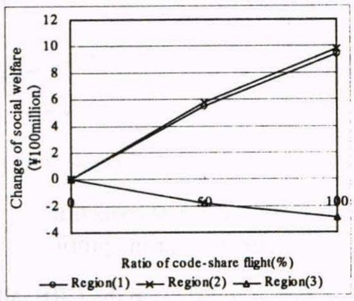


Figure-10 Code-share effect on social welfare

Figure-8, 9 and 10 shows respectively the change of airline profit, that of user benefit and that of social welfare. Figure-8 indicated that profit of allied airline increase in accordance with high ratio of code-share flight. Figure-9 shows that user benefit at region(1) and region(2) in which allied airline set their base, increase mainly because of increase in frequency. Similarly, figure-10 shows that social welfare at only region(1) and region(2) increase.

(2)Network Complementary Effect

Code-sharing operation usually makes network size of allied airline expand. Then, the utility of the route becomes higher because it provides passengers greater number of destinations. Therefore, it is thought that probability that passenger chose this route increases and that airline profit also increases. This effect which cause profit gain through the increase of number of destination is defined as network complementary effect (NEC).

Here, it is assumed that airline(n) operate no flights at region(k) before aligning with other airline. If passenger can select the code share-flight to region(k) after airline(n) aligned with other airline, NCE increases the utility of the route r of airline(n) by V_{nr}^{k}. Here, k denotes a region where airline(n) newly serves, which is a utility of destination k. Expected value of maximum utility in V^k which is shown in (19).

$$nw_{nr}^{OD} = \gamma \, ln \sum_{k}^{K} exp V^k \tag{19}$$

nw_{nr}^{OD} : Expectation of maximum utility led by increase in number of destination

γ : Parameter(coefficient of network complement)

If the utility of added destination (V_{nr}^{k}) is same as $\bar{V}$, (19) is rewritten to (20).

$$nw_{nr}^{OD} = \gamma \ ln(K + \bar{V}) \quad (20)$$

It indicates that increase in number of destinations become utility of route higher. Then, the utility of route r is obtained by adding utility shown in (20) to utility of route r shown in eq. (5).

$$V_{nr}^{OD} = \beta_1^O \cdot fare_{nr}^{OD} + \beta_2^O \cdot ln(\ freq_{nr}^{OD}\ ) + \beta_3^O \cdot time_{nr}^{OD} + \beta_4^O \cdot dummy_{nr}^{OD} + nw_{nr}^{OD} \quad (21)$$

Here, the different value of γ is set to examine NCE on market. Network complement among allied airline(A) and airline(B) is effective on the market between region(1) and region(2), and between region(2) and region(3) for airline(A), and also effective on market between region(1) and region(2), and between region(1) and region(3) for airline(B).

It is assumed that both allied airlines increase 20 destinations by alliance. Figure-11, 12 and 13 shows respectively the change of airline profit, that of user benefit and that of social welfare with different value of γ.

Profit of airline(A) and airline(B) increase because they can obtained additional traffic by NCE, and profit of airline(C) decreases. Meanwhile, user benefit at region(3) increases greater than that of region(1) and region(2), because the passenger at region(3) receive benefit of NCE in terms of increasing number of destinations. Figure-12 shows that the increase of user benefit diminishes with strength of NCE. Figure-13 shows that the social welfare at all regions increase in accordance with strength of NCE.

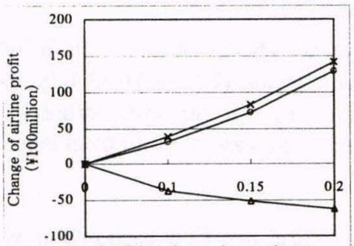


Figure-11 Network complementary effect on airline profit

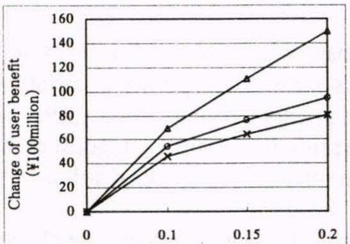


Figure-12 Network complementary effect on user benefit

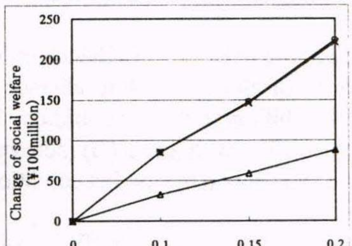


Figure-13 Network complementary effect on social welfare

5. Application

In this section, the applicability that market model and equilibrium analysis can evaluates the influence of airline alliance, is shown with considering heterogeneity of airline and passenger. Heterogeneity of airline is dealt with different cost structure and different scale of output. Meanwhile, heterogeneity of passenger is also dealt with different preference for air service.

U.S airline, Japanese airline and Korean airline are respectively applied to airline(A), (B) and (C), and values in table-4 are adopted as components of total cost. Similarly, utility functions of U.S. passenger and Korean passenger estimated in our former research are applied to the utility function of passenger at region(2) and region(3). Function of U.S. passenger is also applied to the function of Japanese passenger at region(1). Conditions of the demand volume on each market, aircraft size, network structure of each airline are same as pervious section in this paper.

Three kinds of alliance effect described former section are considered. And then, decrease rate of unit price of variable cost is set 10%. With regard to NCE, in case of alliance between airline(A) and airline(B), it is assumed that both allied airlines increase 10 destinations, and in case of another alliance, Table-4 Variable of the elements for cost function of airline(A),(B) and (C)

	Airline(A)	Airline(B)	Airline(C)
Available Seat Kilometer(10 billion)	592.2	1403.5	381.3
Number of Served Cities	53	37	49
Unit Price of variable cot per Available Seat Kilometers(US$)	0.0645	0.0275	0.0310
Unit Price of Fixed Cost per Employee(US$)	192392	89976	90797

it is also assumed that allied airlines increase 20 destinations.

Table-5 shows the equilibrium condition in the market in which there is no alliance. It shows that airline(A) can not set low level fare as compared with other two airlines, because of its high cost structure and weak competitive power. Therefore, the traffic of airline(A) is also below that of other airlines largely.

Next, the impact of alliance on market is examined by the difference in combination of alliance partners. Table-6, -7 and -8 respectively show the change of market condition by the different alliance form. The value in these tables indicates the difference between before and after alliance formed. That is, the sign of minus of fare indicates the decrease in fare, and the sign of minus of frequency indicates the decrease in frequency. It is found that allied airline increase frequency and non-allied airline decrease frequency. It is also shown that allied airline can set lower fare owing to CRE, and it makes market more competitive and that non-allied airline should set lower fare than before.

Then, the influence of alliance on market is examined. Figure-14 shows the change of airline profit by forms of alliance. Before alliance is formed, the profits of airline(A), (B) and (C) are ¥6.83 billion, ¥38.65billion and ¥25.05 billion. It is expected that allied airline increase profit, however Airline(C) which allies with airline(B) increase profit little. That is, it indicates that the increase of profit by alliance is dependent on the market condition surrounding the allied airline.

Next, change of user benefit is examined. Figure-15 shows the change of user benefit at each region by the form of alliance. The user benefit is increased in all type of alliance. That is, the passenger, who lives in the region where there is no base of allied airline, still take a benefit with accordance with increasing level of service of other airlines. User benefit caused by the alliance between airline(A) and airline(C) is not as large as other alliance cases, because complement effect of this alliance form is assumed to be smaller than that of other alliance forms.

Meanwhile, alliance between airline(B) and airline(C) generates the largest user benefit among all alliance types, because these two airlines, which have a lower cost structure than airline(A), can set much lower fare owing to the CRE.

The change of social welfare is shown in figure-16. Social welfare at the region in which there is a base of allied airline increase in any alliance cases. However, social welfare at the region in which the base of allied airline does not exist is determined by changes of airline profit and user benefit. As we expected, the influence of alliance is largely different by alliance form.

Some results described below are obtained through this chapter.

(1) CRE of alliance makes market more competitive and introduce lower fare competition. That is, the user benefit is increased by alliance.
(2) Frequency increase effect contributes to obtain the additive traffic and to gain revenue on the market, and also it change the market condition.
(3) NCE contributes to increase profit of allied airline.

Table-5 Equilibrium condition before alliance occurs

Market	Airline(A) Frequency	Airline(A) Fare	Airline(B) Frequency	Airline(B) Fare	Airline(C) Frequency	Airline(C) Fare
1-2	7.6	10.4	28.8	8.3		9.0
2-1		10.2		8.9		9.0
1-3	6.8	10.3		7.5	21.1	8.2
3-1		10.4		8.2		8.5
2-3		16.6	26.5	7.7	19.1	7.4
3-2		16.9		7.9		8.1

Table-6 Market condition when airline(A) and airline(B) allied

Market	Airline(A) Frequency	Airline(A) Fare	Airline(B) Frequency	Airline(B) Fare	Airline(C) Frequency	Airline(C) Fare
1-2	7.5	0.2	2.5	-2.5		-0.2
2-1		-2.1		1.9		-0.2
1-3	3.6	-1.7		-1.1	-8.7	-0.8
3-1		-2.2		1.1		-1.6
2-3		-4.1	3.9	-0.3	-5.9	-0.2
3-2		-3.7		-1.0		-0.8

Table-7 Market condition when airline(B) and airline(C) allied

Market	Airline(A) Frequency	Airline(A) Fare	Airline(B) Frequency	Airline(B) Fare	Airline(C) Frequency	Airline(C) Fare
1-2	-3.7	-0.5	3.0	-2.1		-0.2
2-1		-0.2		-1.1		-1.4
1-3	-3.4	-0.4		1.2	4.0	-1.9
3-1		-0.2		-0.6		-0.7
2-3		4.9	4.2	2.1	6.4	-1.6
3-2		6.8		-2.1		1.7

Table-8 Market condition when airline(A) and airline(C) allied

Market	Airline(A) Frequency	Airline(A) Fare	Airline(B) Frequency	Airline(B) Fare	Airline(C) Frequency	Airline(C) Fare
1-2	2.0	-1.7	-8.1	-1.1		-1.5
2-1		-2.1		-1.7		-1.1
1-3	5.5	-0.7		-0.4	2.3	-1.6
3-1		-1.9		-0.6		0.4
2-3		-4.0	-6.2	-0.5	3.0	-0.6
3-2		-4.1		-0.5		-0.6

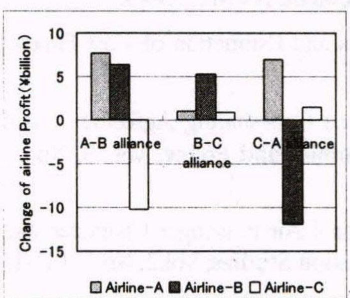


Figure-14 Change of airline profit

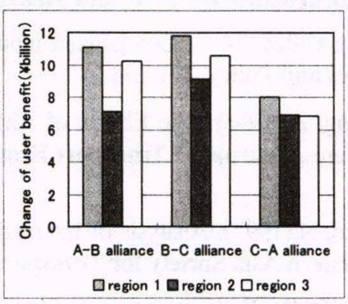


Figure- 15 Change of user benefit

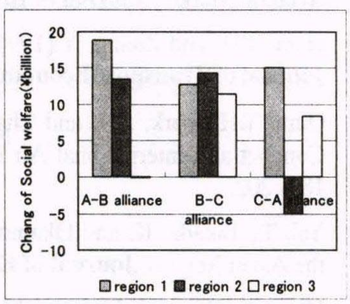


Figure-16 Change of social welfare

6. CONCLUSION

In this paper, the aviation market model is formulated from the standpoint of microeconomics. And some alliance effects such as cost reduction effect, frequency increase effect and network complementary effect, are considered to evaluate the influence of airline alliance on market. As the result, it indicated that airline alliance is one of the factors which change market condition. And it was also shown that alliance increases not only the airline profit but also user benefit and social welfare in case it makes market condition more competitive.

The results of the experiment in this study are obtained on a simple condition that every airline operates at all regions and that there is no monopolized route. Therefore, anther case such that alliance makes market condition less competitive should be examined with expanding analyzed area and with increasing number of airlines in order to induce general properties of alliance influence on market.

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