Airline-Airport Cooperation Model in Commercial Revenue Sharing

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This study develops a model to evaluate airline-airport cooperation in commercial revenue sharing. The model is an optimization game-based that is applied in a given network. It calculates earnings of airline-airport cooperation based on the equilibrium outcomes of noncooperative competition among the airlines. The cooperation is analyzed on the basis of every airport.

The effect of airline-airport cooperation can be observed in terms of airlines market share and social welfare. The result of the application example shows the same notion as the result of existing analytical approach. Commercial revenue sharing can increase social welfare, but it may have negative effect on airlines who are left out from the cooperation.

Key Words : *airline-airport cooperation, commercial revenue sharing, game theory*

1. INTRODUCTION

In the recent years, more and more airports started to form close cooperation with airlines. Both airlines and airports potentially have incentives to enter into cooperative relationships to create a win-win solution, e.g. strengthening financial position. There are several common airline-airport types of cooperation (Fu et al., 2011): (1) airlines as the signatory partner in the airport, (2) airline ownership over particular airport infrastructure, (3) airport's commercial revenue sharing with airlines. While potential synergies can indeed be achieved, such cooperation can also have negative impacts. Given that airports represent one of the essential inputs for airlines, this close cooperation between an airport and a particular airline may raise anti-competitive concerns.

Recent papers by Fu and Zhang (2010) and Zhang et al. (2010) analyzed the effects of commercial revenue sharing between airlines and airports on airline competition and welfare using analytical models. In this case, airports offer to share some part of the commercial revenue (generated by the concession activities) for a fixed fee with one or more airlines. As the authors pointed out, this type of cooperation is new but becoming common.

Fu and Zhang (2010) analyze the effects of commercial revenue sharing in two situations: single airport served by single airline, and single airport served by multiple airlines. In the first case, concession revenue sharing improves welfare as well as the joint profits of the airport and airline. In the second case, there may be either equal revenue sharing, which increase the airport's profit and welfare, or a situation where only one of the airlines shares revenues, thus increasing this airline's profits while decreasing the outsider's profits. Moreover, they also show that when one airline has a cost advantage, the airport will share revenue with this airline only.

Zhang et al. (2010) extended the study of commercial revenue sharing into involving multiple airlines and multiple airports. The airport competition results in a higher degree of revenue sharing than would be had in the case of single airports. Moreover, they analyze the relation between the degrees of revenue sharing and how airlines' services are related to each other (complements, independent, or substitutes). When carriers provide strongly substitutable services to each other, revenue sharing improves profit but reduces social welfare.

We intend to further study this particular airline-airport cooperation. We propose a model that analyzes the effect of an airline-airport cooperation in commercial revenue sharing. Our model follows similar modeling principles as the analytical approach developed by Fu and Zhang (2010) and Zhang et al. (2010). We utilize network-based model that has practicality advantage; it can be applied to relatively realistic network involving more airlines and airports and can be combined with optimization approach. Therefore, the model can be used as an evaluation tool to assist policy makers in assessing the effect of airline-airport cooperation.

The evaluation is conducted in the basis of cooperative and non-cooperative game and consists of three main steps: (1) listing all possible cooperations/subsets from certain number of airports and airlines, (2) determining optimal airlines' fares and flight frequencies for every subset based on non-cooperative-Nash game, (3) estimating the value of every subset based on the concept of cooperative game with non-transferable utility. The value of cooperation is stated as airports' and airlines' profit differences before and after revenue sharing cooperation. We identify the commercial revenue shares (%) between airlines and each airport in every coalition that meet Pareto optimal condition. Subsequently, we provide example to illustrate model's performance and applicability in practices.

There have been several researches that utilized network-based models with non-cooperative game theory approach. Some of them are Hansen (1990), Hong and Harker (1992), Dobson and Lederer (1993), Adler (2001, 2005), Wei and Hansen (2007), and Li et al. (2010). The latter discussed network-based model in air transport liberalization setting. Other researchers used networkbased model with cooperative game theory in order to evaluate airline mergers and alliances, for example: Shyr and Kuo (2008) and Shyr and Hung (2010). To our knowledge, there has not been a discussion over airline-airport cooperation utilizing a game-based optimization model, like we attempt to do in this study.

The rest of the paper is organized as follows. Section 2 explains basic set up and assumption, model formulation. Section 3 gives an application example and analysis. Section 4 discusses the possible improvements of the proposed model and concludes the study.

2. MODEL DEVELOPMENT

(1) Basic Set-up and Assumptions

Airlines' network is pre-given in this model. An airline network consists of a set of nodes/airports (n); each node represents an origin and also a destination. Every node is interconnected to each other by two-way arc/flight legs (a). A route (k) is defined as an airline's path in serving a particular origin-destination pair (m). A route consists of set of arcs. Figure 1 illustrates a simplified airlines' network where there are three nodes, three origin-destination (OD) pairs, and every route consists of maximum two flight legs.

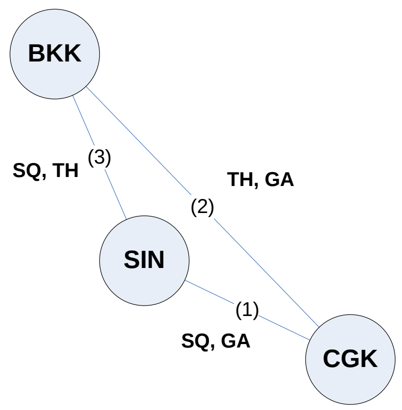

Fig. 1. Airline network example

The following assumptions and simplifications are made in this paper to facilitate the presentation of the essential ideas:

a) The model is considered as one-shot game. It is a one-time option for airline and airport to decide whether to join in revenue sharing contract.
b) Airline network is set as pre-given; each airline has its set of routes. Passenger flow in every route is calculated in one-directional flow.
c) Operational profit received by airlines and airports are operational profit from one-directional process; it is assumed that arrival and departure processes generate the same amount of revenue and cost.

(2) Model Formulation

The model is divided into three main steps (Fig. 2). There are interactions between passengers, airlines, and airports captured in this model. Airline market share is determined by passenger route and airline choice. Passengers make the choice based on their perceptions over travel disutility of the available routes. Combination (subset) of airport and airlines in the revenue sharing contract influences both airport and airline profit function. This combination subsequently influences the optimal frequency and airfare for every airline.

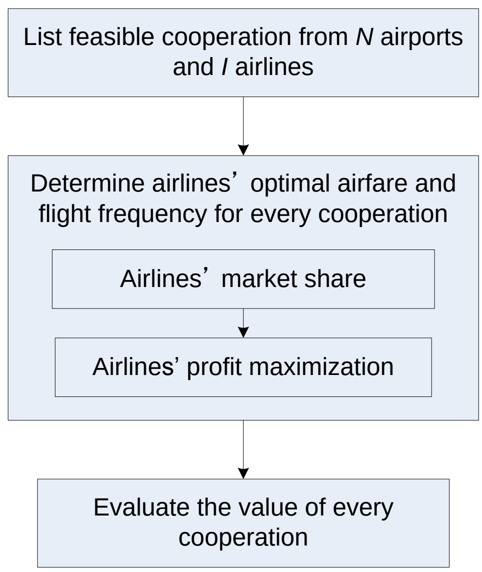

Fig. 2. Model steps

Step 1. List all the possible airline-airport cooperation.

The number of subsets depends on the number of airports and airlines in the observed network. In this study, the value of subset is analyzed on the basis of each airport. Every subset includes one airport and set of airlines that agree to cooperate with that particular airport.

$$S = (AP_n, AL_i \ldots AL_I)\ \forall n = 1, \ldots N;\ i = 1, \ldots I .$$

The maximum number of cooperation is: $N(2^I - 1)$. N denotes the number of airport, and I denotes the number of airlines. AP denotes airport and AL denotes airline.

Table 1. Subset of airport-airline cooperation

AP_n	Subset (S)	Airline strategy profile $(\delta_1^1 \ldots \delta_n^i)$
AP_1	$\{AP_1, AL_1\}$	(1, 0, 0)
	$\{AP_1, AL_2\}$	(0, 1, 0)
	$\{AP_1, AL_3\}$	(0, 0, 1)
	$\{AP_1, AL_1, AL_2\}$	(1, 1, 0)
	$\{AP_1, AL_1, AL_3\}$	(1, 0, 1)
	$\{AP_1, AL_2, AL_3\}$	(0, 1, 1)
	$\{AP_1, AL_1, AL_2, AL_3\}$	(1, 1, 1)
AP_2	…	…

Here, δ_n^i represents the strategy of airline i toward airport n. If airline i decides to cooperate with airport n, $\delta_n^i = 1$, otherwise 0.

Step 2. Calculate the optimal airline frequency and airfare for every cooperation/subset based on Nash-competition game among airlines. There are two sub-models in this step:

a) Airlines' market share

Airline market share is determined by passenger choice over airline route. Passengers choose airline routes by maximizing their travel utility (minimizing disutility). We follow multinomial logit formulation described by Takebayashi and Kanafani (2005) and Li et al. (2010). The main purpose of this sub-model is to define passenger flow on every route between OD pair (q_{mk}^i).

$$q_{mk}^i = q_m \frac{\exp(-\theta u_{mk}^i)}{\sum_k \sum_i \exp(-\theta u_{mk}^i)}, \quad \forall\, k \in K_m^i \qquad (1)$$

The parameter θ represents the variation in passenger perceptions of travel disutility. The travel disutility (u_{mk}^i) is composed of the basic airfare (p_{mk}^i), and monetary units of travel time (t_{mk}^i), scheduled delay time (d_{mk}^i), and connection time (tr_{mk}^i) if the route consist of more than one flight leg (indirect flight).

$$u_{mk}^i = \alpha_{vot}(t_{mk}^i + \alpha d_{mk}^i + tr_{mk}^i) + p_{mk}^i \qquad (2)$$

The average travel time in every route is the sum of the travel time of all its arcs. The same rule applies for passenger scheduled delay time. Passenger scheduled delay time is defined as the difference between the time at which a passenger desires to travel and the time at which he or she can actually travel due to inflexibility of the airline's schedule. It can be approximated as a quarter of the average headway (Kanafani and Ghobrial, 1985). λ_{mka} equals 1 if arc a is on route k and OD pair m, and 0 otherwise.

$$d_{mk}^i = \sum_{a \in A^i} d_a^i \lambda_{mka} \qquad (3)$$

$$t_{mk}^i = \sum_{a \in A^i} t_a^i \lambda_{mka}, \forall\, k \in K_m^i \qquad (4)$$

$$d_a^i = \frac{T}{4 f_a^i}, \forall\, a \in A^i, i \in I \qquad (5)$$

To capture the responses of passengers to the level of airfare and frequency, the exponential demand function is adopted following Li et al. (2009, 2010).

$$q_m = q_m^0 \exp(-\beta \varphi_m) \quad \forall\, m \in M \qquad (6)$$

$$\varphi_m = -\frac{1}{\theta} \ln\left(\sum_i \sum_k \exp\left(-\theta u_{mk}^i\right) \right) \quad \forall\, m \in M \qquad (7)$$

Input variable q_m^0 denotes the potential passenger demand between OD pair m. Parameter β denotes the demand sensitivity to the travel disutility by OD pair, and variable φ_m denotes the expected disutility between OD pair m.

b) Airlines' profit maximization

Airline profit is defined as the sum of profit gained from travel service and profit gained from agreed revenue sharing with airport(s). The profit gained from travel service is defined as the difference between total revenue from passenger airfares and the total costs on all of the routes that the airline operates in. Therefore, profit of airline i can be expressed as

$$\begin{aligned}\pi_i(\mathbf{x}_i, \mathbf{x}_{-i}) = {} & \sum_m \sum_k p_{mk}^i q_{mk}^i \\ & - \sum_m \sum_k \sum_a (c_a^i f_a^i \lambda_{mka} + g_a^i q_a^i \lambda_{mka}) \\ & + \sum_n \delta_n^i r_n^i h_n (\sum_i \sum_a q_a^i \sigma_{an}) - b_n^i(r_n^i, \mathbf{r}_n^{-i})\end{aligned}$$

… (8)

where $\mathbf{x} = (\mathbf{p}, \mathbf{f})$ is the vector of airfares and frequencies of all airlines. Variable c_a^i denotes airline cost per flight. We define c_a^i based on Swan and Adler (2006) where cost per flight is a function of flight distance (D_a) and aircraft size (s_a^i).

$$c_a^i = (D_a + \omega_o)(s_a^i + \omega_1)\omega_2 \quad \forall a \in A^i \qquad (9)$$

Variable g_a^i denotes marginal cost per passenger, q_a^i denotes passengers flow on arc *a* by airline *i*, where

$$q_a^i = \sum_m \sum_k q_{mk}^i \lambda_{mka} \qquad (10)$$

Variable $b_n^i(r_n^i, \mathbf{r}_n^{-i})$ denotes the fixed payment paid by airlines to airport according to the revenue share contract. Variable $\frac{b_n^i}{w}$ denotes maximum fixed payment that airport can charge, that is the 'reservation price' - when the airline is indifferent between sharing revenue or not given that all the other airlines' decisions stay the same (Fu and Zhang, 2010). Therefore, the purpose of *w* is to ensure the airlines paid less than its maximum fixed payment. Fixed payment can be calculated as:

$$b_n^i(r_n^i, \mathbf{r}_n^{-i}) = w(\pi^C{}_i(r_n^i, \mathbf{r}_n^{-i}) - \pi^C{}_i(0, \mathbf{r}_n^{-i})) \qquad (11)$$

where,

$$\pi^C{}_i(\mathbf{x}_i, \mathbf{x}_{-i}) = \sum_m \sum_k p_{mk}^i q_{mk}^i - \sum_m \sum_k \sum_a (c_a^i f_a^i \lambda_{mka} + g_a^i q_a^i \lambda_{mka}) + \sum_n \delta_n^i r_n^i h_n (\sum_i \sum_a q_a^i \sigma_{an}) \qquad \ldots (12)$$

Revenue share (r_n^i) should generate payoff vector that meets Pareto optimality condition, so that neither cooperated airline(s) nor airport becomes worse off after cooperation. For every subset, we calculated r_n^i as follows:

a) Calculate profit of airlines (π_i) and airport (Π_n) that are included in subset for all *t*. The value of *r* for every *t* follows: $r(t+1) = r(t) + 0.01$. When *t* = 0, there is no cooperation.
b) The revenue share meets Pareto optimality condition when $\pi_i(t) > \pi_i(t=0)$ and $\Pi_n(t) > \Pi_n(t=0)$. There may exist more than one value *of r* that meets this condition. Note that for every subset $0 < r_n^i \le 1$ and $\sum_i r_n^i \le 1, \ \forall i, n$.
c) When there is more than one airline in the subset, we set equal value of revenue shares for all airlines in the subset. If the revenue shares are not equal, there will always be cooperated airline that is worse off.

Airlines compete with each other by optimizing their own strategy (service frequency and airfare) considering other airlines' strategies. This is modeled as a non-cooperative Nash game. At equilibrium, no airline has an incentive to deviate or change its decision variables given all other airlines' decisions. Airline profit maximization problem is formulated as follow:

$$\text{Max}\, \pi_i(\mathbf{x}_i, \mathbf{x}_{-i}), \ \forall\, i \qquad (13)$$

subject to: (14)

$$q_a^i \le s_a^i f_a^i, \quad \forall\, a, i \qquad (15)$$

$$\sum_i \sum_a f_a^i \sigma_{an} \le y_{n_{o,(d)}}, \forall n \qquad (16)$$

The first constraint ensures the passenger flow on arc *a* is less than total seat capacity offered. The second constraint ensures the total number of arrivals (departures) must not exceed the available quota of the destination (origin) airports.

To solve airlines profit maximization problem with constraints, we utilize Lagrangian relaxation approach and penalty function, as previously done by Li et al. (2010). The Lagrangian and penalty function incorporate the constraints into the objective function.

To find the equilibrium solutions for the airlines' airfares and service frequencies we use heuristic solution algorithm utilizing Hooke-Jeeves method. This process is done for every subset.

Step 3. Calculate the value of every cooperation/subset.

The value of subset ($v(S)$) is a vector contains all players' (airport and airlines) profit differences/earnings before and after revenue sharing cooperation (E). This is compatible with the concept of cooperative game with non-transferable utility. The disagreement point of cooperation is where $E_{AR_n}, E_{AL_i} = 0$.

$$v(\{s\}) = E_{AR_n}, E_{AL_1} E_{AL_2}, E_{AL_3} \quad (17)$$

$$E_{AR_n} = \Pi_n(\delta_n^i, \ldots, \delta_N^I) - \Pi_n^O(0, \ldots, 0) \quad (18)$$

$$E_{AL_i} = \pi_i(\delta_n^i, \ldots, \delta_N^I) - \pi_i^O(0, \ldots, 0) \quad (19)$$

Airline profit function is expressed in Eq. 8, while airport profit function is expressed as

$$\Pi_n = \sum_i \sum_a q_a^i z_n^i \sigma_{an} + \sum_i \sum_a f_a^i l_n^i \sigma_{an} + (1 - r_n^i) h_n (\sum_i \sum_a q_a^i \sigma_{an}) + b_n^i (r_n^i, \mathbf{r}_n^{-i}), \ \forall n \quad \ldots (20)$$

where z_n^i denotes airport service charge for every passenger and l_n^i denotes airport aeronautical charges for every flight in one-direction process.

Subsequently, we calculate social welfare (SW) of every subset as follows:

$$SW = \sum_n \Pi_n + \sum_i \pi_i + \sum_m \frac{q_m}{\beta} \quad (21)$$

3. APPLICATION EXAMPLE

(1) Setup and input data

We present an application example to illustrate the ideas. We apply the proposed model into to the network shown in Fig. 1. We simplify the network situation, involving two airlines and three airports in Southeast Asia.

Input parameters are listed in Table 2, 3, and 4 as obtained from OAG database, airlines' and airports' websites. Capacity in every airport is assumed equal to 20. This capacity is considered acceptable to accommodate two airlines. The aircrafts that serve every arc are assumed to be narrow-body aircrafts that have seat capacity equal to 175.

Table 2. Network properties, demand, and price

OD pair (m)	Daily demand (q_m^0)	Routes			Operating Airlines (i)	Avg Price (p_{mk}^i)
		Route (k)	Arcs (a): Arc 1	Arcs (a): Arc 2		
1	4500	1	1	-	1	190
		1	1	-	2	185
		2	2	3	3	295
2	3000	1	2	-	2	206
		1	2	-	3	235
		2	1	3	1	300
3	4000	1	3	-	1	232
		1	3	-	3	228
		2	1	3	2	320

Airlines' index (i): 1 = SQ; 2 = GA; 3 = TH

Table 3. Flight, passenger charge, capacity in every airport

Airport	$z_n^i \ \forall i$ (US$)	$l_n^i \ \forall i$ (US$)	y_n
1	13.9	1,238	20
2	14.5	992	20
3	13.5	1,125	20

Airports' index (n): 1 = SIN; 2 = CGK; 3 = BKK

Table 4. Flight time and airlines' frequency

Arcs (a)	$t_a^i \ \forall i$ (hour)	D_a (km)	f_{ia}, $i = 1$	f_{ia}, $i = 2$	f_{ia}, $i = 3$
1	1.75	879	8	-	5
2	2.42	2295	8	2	-
3	3.42	1409	-	1	5

Other input parameters are obtained from previous literatures as follow: α_{vot} = 20.5 hour/$, and α = 1.3 (Hsu and Wen, 2003), θ = 0.02 (Takebayashi and Kanafani, 2005), β = 0.003 (Li et al., 2007), ω_o = 722, ω_1 = 104, ω_2 =0.019 (Swan and Adler, 2006), T = 18 hours, h_n = 10 $/passenger; g_a^i = 20 $/passenger $\forall\ a, i$ (Oum and Yu, 1998), w = 0.75.

(2) Result and analysis

The result of calculation is shown in Table 5 and Table 6. Subsets are arranged by following the configuration in Table 1.

The willingness of airlines and airports to participate in cooperation depends on what they obtain in the respective cooperation. The airlines and airports will only agree to cooperate if their profit after cooperation are higher than their profit before cooperation. Thus, the concept of Pareto optimality condition is suitable to determine the level of r as it defines the level of r that maximize the profit of airlines without making the profit of airport worse off, and vice versa. When there are more than one value of r that meets Pareto condition, we choose the one that maximizes the airport profit.

There may be a case where there is no r that can make all the cooperated parties (airport and airlines) better off. For example, in subset 7 (when airport 1 cooperates with all airlines), airline 3 actually gets lower profit. Thus, it is not profitable for airline 3 to cooperate with airport 1.

Commercial revenue sharing increases social welfare in almost all subsets. This is aligned with the analytical approach result from Fu and Zhang (2010), commercial revenue sharing can be an important source for welfare improvement.

Despite its potential for welfare improvement, commercial revenue sharing has negative impact on airlines that do not cooperate. Airlines that are left out from subset get lower profit. Furthermore, airport's profit is higher when airport cooperate with one airline, especially airline that bring the most passengers to that airport. Airport's profit decreases when the airport cooperates with more airlines. There may be cases where airport chooses to cooperate only with one particular airline to further maximize its profit.

Table 5. Earnings and social welfare in every subset

Sub set	r	Earnings				SW
		E_{APn}	E_{AL1}	E_{AL2}	E_{AL3}	
0	0	0	0	0	0	2633961
1	0.55	6591	1518	-837	-1430	2636745
2	0.4	5442	-2281	7773	-1452	2746025
3	0.5	7006	-1115	38390	2648	2762447
4	0.2	6103	26931	8932	-1983	2740921
5	0.25	5702	893	-2312	3421	2759211
6	0.2	5231	-8499	22012	5912	2633969
7	0.15	5003	500	10063	-202	2767591
8	0.55	6876	1429	-631	-1283	264198
9	0.4	7038	-2921	10431	-11087	2665149
10	0.5	5893	-9821	2276	4872	2663974
11	0.2	5781	5091	18092	-1594	2678711
12	0.25	5312	12421	-1592	9082	2790173
13	0.2	4212	-349	15349	234	2649120
14	0.15	4062	3012	6004	929	2707591
15	0.55	4502	1109	-983	-2301	2635451
16	0.4	5902	-3812	18301	-25091	2646025
17	0.5	7205	-1029	20193	4092.	2642758
18	0.2	3091	21211	450	-2208	2658297
19	0.25	4392	1203	-4231	2309	2652732
20	0.2	4054	-782	3102	2093	2672147
21	0.15	3301	2392	210	862	2684299

Table 6. Airlines' market share in every subset

Subset	Subset	OD Pair 1 (q_{im})			OD Pair 2 (q_{im})			OD Pair 3 (q_{im})		
		q_{11}	q_{21}	q_{31}	q_{12}	q_{22}	q_{32}	q_{13}	q_{23}	q_{33}
0	No cooperation	0.768	0.228	0.002	0.019	0.218	0.761	0.450	0.015	0.534
1	{AP_1, AL_1}	0.872	0.125	0.002	0.019	0.218	0.7621	0.581	0.013	0.406
2	{AP_1, AL_2}	0.669	0.329	0.002	0.019	0.2151	0.765	0.452	0.014	0.533
3	{AP_1, AL_3}	0.756	0.241	0.003	0.019	0.22	0.7602	0.309	0.014	0.677
4	{AP_1, AL_1, AL_2}	0.769	0.229	0.0015	0.019	0.219	0.7611	0.46	0.0155	0.524
5	{AP_1, AL_1, AL_3}	0.77	0.227	0.002	0.019	0.218	0.761	0.459	0.001	0.54
6	{AP_1, AL_2, AL_3}	0.769	0.229	0.002	0.019	0.218	0.761	0.44	0.02	0.54
7	{AP_1, AL_1, AL_2, AL_3}	0.77	0.229	0.0008	0.019	0.239	0.7411	0.462	0.0155	0.522
8	{AP_2, AL_1}	0.778	0.221	0.001	0.019	0.218	0.761	0.452	0.014	0.533
9	{AP_2, AL_2}	0.736	0.262	0.002	0.01	0.259	0.731	0.4503	0.015	0.534
10	{AP_2, AL_3}	0.769	0.229	0.0015	0.016	0.206	0.778	0.4529	0.014	0.533
11	{AP_2, AL_1, AL_2}	0.769	0.229	0.0019	0.0199	0.252	0.72809	0.453	0.013	0.534
12	{AP_2, AL_1, AL_3}	0.771	0.227	0.0005	0.199	0.018	0.783	0.451	0.014	0.535
13	{AP_2, AL_2, AL_3}	0.708	0.291	0.001	0.007	0.221	0.772	0.453	0.013	0.534
14	{AP_2, AL_1, AL_2, AL_3}	0.772	0.227	0.001	0.0181	0.218	0.7639	0.4529	0.014	0.533
15	{AP_3, AL_1}	0.769	0.229	0.002	0.0199	0.218	0.7621	0.551	0.009	0.44
16	{AP_3, AL_2}	0.768	0.228	0.002	0.009	0.326	0.665	0.4503	0.015	0.534
17	{AP_3, AL_3}	0.768	0.229	0.003	0.008	0.181	0.811	0.295	0.011	0.694
18	{AP_3, AL_1, AL_2}	0.769	0.229	0.002	0.0199	0.255	0.7251	0.55	0.009	0.441
19	{AP_3, AL_1, AL_3}	0.769	0.228	0.002	0.0199	0.1771	0.803	0.46	0.0001	0.539
20	{AP_3, AL_2, AL_3}	0.768	0.228	0.002	0.001	0.227	0.772	0.384	0.008	0.608
21	{AP_3, AL_1, AL_2, AL_3}	0.769	0.229	0.002	0.0198	0.2102	0.77	0.451	0.015	0.534

Table 6 shows the changes on airlines' market share on every OD pair. Airlines' market share on each OD pair is greatly affected if the airlines serving that OD pair do cooperate with the connected airport. The computation result shows that flight frequency slightly changes, but price decreaseas with cooperation. Airlines who do not cooperate tend to get lower market share.

In the analytical example, we use the several identical inputs for all airlines and airports (airlines' seat capacity, marginal cost per passenger, airports' capacity constraint, commercial gain per passenger), while in the real situation these inputs may differ. There is a need to do a comprehensive sensitivity analyses to see how each parameter affect the model result.

4. CONCLUSIONS

As the trends of privatization and liberalization keep taking place in air transport industry, we expect more practices of airline and airport cooperation in the near future. We proposed a model to evaluate airline-airport cooperation in commercial revenue sharing. The model calculates earnings from cooperation between airlines and airport based on the equilibrium outcomes of noncooperative competition among the airlines themselves. This model can serve as an evaluation tool. Airport authority can use this proposed model to help determine the amount of commercial revenue shared with airline(s), while policy makers can assess the impact of cooperation on competition level and social welfare.

The application example presented in Section 3 shows the same notion as the previous analytical approach. Commercial revenue sharing increases social welfare and airport's profit. However, commercial revenue sharing has negative impact on airlines that do not cooperate. Airlines that are left out from subset get lower market share and profit.

The model proposed in this study is subject to further improvements: (1) to include more than one airport in every subset. This can be done by imitating the concept of glove game with non-transferable utility, (2) to capture the different network behavior of full-service carriers and low-cost carriers.

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