ITLS

WORKING PAPER
ITLS-WP-06-01

The Effect of Service Quality and Price on International Airline Competition

By
Rong-Chang Jou*, Soi-Hoi Lam**, David A Hensher &
Chung-Wei Kuo***

* Rong-Chang Jou, National Chi Nan International University, Taiwan
** Soi-Hoi Lam, Nanyang Technological University Singapore
*** Chung-Wei Kuo, National Taiwan University, Taiwan

January 2006

ISSN 1832-570X

INSTITUTE of TRANSPORT and LOGISTICS STUDIES
The Australian Key Centre in
Transport and Logistics Management

The University of Sydney
Established under the Australian Research Council's Key Centre Program.

NUMBER: Working Paper ITLS-WP-06-01

TITLE: The Effect of Service Quality and Price on International Airline Competition

ABSTRACT: A game theoretic model, integrated with passenger's international choice behaviour, for the competition between international airlines is developed and used to identify the role of competing service quality. The empirical evidence suggests that safety, convenience, and service quality have a major influence on the choice decision of air passengers. Passengers respond strongly to decreases in price, safety, service comprehensiveness and increases in convenience. In a Cournot model, airlines are predicted to increase service quality, with China Airlines, a dominant carrier, the winner on safety and service quality. Foreign companies are beneficiaries in providing convenient service quality. In a Stakelberg model, all the airlines will increase safety and diversify service quality to a reference point. Foreign airlines will additionally be winners in safety and convenience with China Airlines a winner in diversifying service quality. This research can be used by the airline companies as a reference for making tactical decisions and gaining a competitive advantage in the air transportation market. By this, we can raise the quality of service of the aviation market as a whole and deliver a win-win situation to all stakeholders.

KEY WORDS: ***Service quality, reference point, asymmetric response model, linear structural relations model, game theory, Cournot model, Stakelberg model.***

AUTHORS: Rong-Chang Jou*, Soi-Hoi Lam**, David A Hensher, Chung-Wei Kuo***

CONTACT:
Institute of Transport and Logistics Studies (C37)
An Australian Key Centre
The University of Sydney NSW 2006 Australia

Telephone: +61 9351 0071
Facsimile: +61 9351 0088
E-mail: itlsinfo@itls.usyd.edu.au
Internet: http://www.itls.usyd.edu.au

DATE: January 2006

* Rong-Chang Jou, National Chi Nan International University, Taiwan
** Soi-Hoi Lam, Nanyang Technological University Singapore
*** Chung-Wei Kuo, National Taiwan University, Taiwan

1. Introduction

For most cities that have high air travel demand and an open skies policy, international flight markets are highly competitive. In the Asia Pacific region, such examples can be found in Singapore, Hongkong, and Taipei. In these cities, the popular routes attract a large number of air carriers giving a large number of choices for international air travellers. Jou *et al.* (2005) described a decision model to capture these travellers' decisions in choosing an international air carrier. In this paper, the focus is on how airlines compete with each other to gain market share in the international air travel market. The validation of the model is based on data obtained in Taiwan.

The international flight market in Taiwan is served by a number of local and international airlines (Table 1). The two local carriers, China and EVA Airlines, are the dominant airlines and have the largest share of passengers in the international flight market (62.9% in total). Another six airlines have the remaining market share.

Table 1: The passenger distribution between airlines in the international flight market in Taiwan

Airline	**Numbers of Passengers**	**Percentage**
China Airlines	952160	32.4%
EVA Airlines	897186	30.5%
North-Western	263428	9.0%
United Airlines	226454	7.7%
SIA	212237	7.2%
Canadian Airlines	207162	7.0%
Malaysian Airlines	127270	4.3%
Thai Airways	53000	1.8%
Total	2938897	100.0%

Source: Numbers of Passengers are from the data supplied by airline companies above and tourist agencies in Taiwan.

In order to be more competitive, the airlines actively provide a number of competitive strategies to expand their own market share. These strategies include incentive pricing, convenient flight arrangements, flight safety, and priority services worldwide. How to improve their service quality to attract more passengers and expand market share is of vital interest for airlines in the highly competitive Taiwan market.

In this paper, we focus on how changes in service quality of one airline could affect the market share of all operators. Service level is measured by a combination of qualitative and quantitative measures, identified as influences through a linear structural equation model system developed in Jou et al. (2005). To study the dynamic market processes among airlines, game theoretic competition models were set up to understand how the changes in service quality of one airline could affect the market share of itself and others.

The paper is structured as follows. Section 2 reviews past studies involving the use of game theory in airline competition. The static and dynamic games used to investigate service competition between the airlines are discussed in Sections 3 and 4. The results of competition are given in Section 5 followed by conclusions and suggestions for further research in Section 6.

2. Literature Review

There are a growing number of transport applications of game theory in the context of airport landing fees (Littlechild and Thompson, 1977), merging behaviour on freeways (Kita et al., 2001), how jurisdictions choose to finance their roads (Levinson, 1999, 2000, 2005), aviation (Hansen and Wenbei, 2001), and the political acceptability of road pricing (Marini and Marcucci, 2003). We highlight three studies that relate to airlines.

The international flight market in Taiwan is essentially an oligopoly and thus it is appropriate to apply game theory to analyze the reactions between airline companies if one of them adopts a specific competitive strategy. Game theory is traditionally used to analyze decision behaviour in the presence of interactions and dynamics between a number of competing parties.

Hansen (1990) studied competition between direct air flight and hub-based operations with the use of non-cooperative game theory and an assumption of a single fare structure. Competitive strategies in flight scheduling designed to maximize profits were analyzed. The market share, operation cost models and demand models of direct flight and hub-based operations of airlines were established. It was assumed that the flight schedules of competing airlines were known and airlines scheduled their flights to maximize profits. The results showed that if the hub can be operated at a lower cost, with less delays and easier transfers, then the market share of the hub-based airlines would increase. It was suggested that the predictive power would increase if traveller preferences, specific aircraft features and the economic behaviour of the airlines were included.

Zubieta (1998) studied competition in levels of service among private bus operators, in an oligopoly environment. It was assumed that private bus companies operate their own fixed routes and compete on levels of service. The bus operator’s objective was to maximize profits whereas passengers emphasised shortest travel time paths, establishing a Nash equilibrium. Nash equilibrium needs to satisfy two conditions: (i) no private bus operators can increase their profits by unilaterally changing any of their routes, and (ii) no passengers can shorten their travel times by unilaterally changing their choice of operators and routes. The model was tested on a small road network (29 nodes, 86 links and 8 bus routes), with bus fares fixed at a flat fee of $1. The test results indicated that this games-based model realistically described the behaviour of private bus operators and passengers.

Hansen and Kanafani (1990) investigated airport capacity problems at Tokyo-Narita airport. An airline network competition model suitable for Asian conditions was developed. Assuming equilibrium under Cournot, a different network configuration and hub location, and how the airport related to the profit maximization of airlines, results indicated that Tokyo-Narita's passenger/airline market share would reduce if the capacity problem was solved through the expansion of facilities. The market share could drop by 50% if airport costs increased by 40% since this would increase the airlines' costs and would prompt the airlines to use other hubs. As a result, the profits for the airport as a whole would reduce.

3. Profit and Cost Functions

In oligopolistic game theory, the competitive behaviour between individual firms can be divided into two categories: Nash and Stakelberg price competition and Cournot and Stakelberg quantity competition[1]. Our focus is on the service quality of each airline; and we investigate airline competitive behaviour in terms of service quality strategies. Assuming an equilibrium process underlying competitive behaviour, we use Cournot's model to represent the way firms compete on service quality, and Bertrand's model to represent price competition. In the Cournot model, airlines are assumed to select a level of service quality that maximizes their own profits under the assumption that other firms would not change their service quality at the same time. The assumptions in a Bertrand model are similar; however the airlines will choose their price levels in response to any unilateral change in price by one of the airlines. A Stakelberg model is used to describe dynamic competition because the dominant firm in the industry would most likely adjust its competitive behaviour according to its prediction of how other small firms react to the strategies taken to achieve the maximum level of profit.

In formulating the profit and cost functions of each style of competition the following assumptions are made. First, we focus on competition in service quality and price between airlines excluding competition in numbers of flights and routes. Second, we assume that the games are non-cooperative and played under perfect information. Third, in the Bertrand and Cournot models, the firms are homogenous and similar in size; but in the Stakelberg model, the larger firms are the "leaders", and the rest are "followers".

3.1 The Profit Function

The profit function (equation 1) of an airline is the total revenue received by providing the service minus the total cost needed to run the company and to supply products to passengers within a given time period.

$$\pi_i = P_i T W_i - C_i \qquad (1)$$

where π_i = profit of airline i (dollars/year);

W_i = ticket price of airline i (dollars/time);

---

[1] A brief definition of Cournot, Stakelberg and Bertrand methods is given in Appendix A.

T = total demand in international flight market (passengers/year);
P_i = market share of airline i in international flight market;
C_i = total cost of airline i (dollars/year).

and $P_i\,TW$ is the revenue of airline i.

3.2 The Cost Function

Given the difficulties in obtaining detailed cost information from airlines, the estimating method proposed by Kane (1990) was used to calculate operating costs (equation 2). Kane defined the cost of every flight as cost in unit distance plus the unit cost of service quality a passenger perceived.

$$C_i = \sum_{p,q} B_{i,\,pq} S_i M_{i,\,pq} + l_i R_i \sum_{k=1}^{K} Q_{ik}$$

$$R_i = T\,P_i \tag{2}$$

where C_i = total cost (\$/year) of airline i;
$B_{i,\,pq}$ = unit operating cost (dollar/kilometre-flight) from starting point p to destination q of airline i;
S_i = number (times/year) of international flights for airline i;
$M_{i,\,pq}$ = distance (km) between starting point p and destination q of airline i;
l_i = unit cost (dollar/time) of service quality a passenger perceived from airline i;
Q_{ik} = the k^{th} service quality measure of airline i;
R_i = total passengers (passengers/year) of airline i in a year
P_i = market share (%) of airline i in the international flight market

3.3 Objective Function

The objective function incorporating the service quality and price level an airline needs to set is the first order condition from the profit function with respect to each choice variable W_i and Q_{ik} depending on whether other firms' prices or service quality levels are known.

A. Service quality

$$MAX \qquad \pi_i = P_i\, T W_i - \left(\sum_{p,q} B_{i,\,pq} SM_{i,\,pq} + l_i T P_i \sum_{k=1}^{K} Q_{ik}\right) \tag{3}$$

$$\frac{\partial \pi_i}{\partial Q_{ik}} = 0, \text{ and since } \frac{\partial P_i}{\partial Q_{ik}} = Z_{ik} P_i\,(1-P_i)\ , \quad where \ \begin{Bmatrix} Q_{ik} - Q_{kr} > 0 & , Z_{ik} = \beta_k \\ Q_{ik} - Q_{kr} < 0 & , Z_{ik} = \beta_k h_k \end{Bmatrix}$$

$$\therefore \frac{\partial \pi_i}{\partial Q_{ik}} = T P_i \left\{ Z_{ik}(1-P_i)\left[W_i - l_i \sum_{k=1}^{K} Q_{ik} \right] - l_i \right\} = 0 \tag{4}$$

Equation (4) represents the reaction of airline *i* after other airlines have decided their service quality levels. The partial derivative of P with respect to Q in equation (4) can be obtained through the direct elasticity of a demand or choice model. A similar expression is given in equation (5).

B. Price

$$\frac{\partial \pi_i}{\partial W_i} = 0, \text{ and since } \frac{\partial P_i}{\partial W_i} = E_i P_i\,(1-P_i) \ where \ \begin{Bmatrix} W_i - W_r > 0 & , E_i = \alpha_i \\ W_i - W_r < 0 & , E_i = \alpha_i \delta_i \end{Bmatrix}$$

$$\therefore \frac{\partial \pi_i}{\partial W_i} = T P_i \left\{ E_i\,(1-P_i)\left[W_i - l_i \sum_{k=1}^{K} Q_{ik} \right] - 1 \right\} = 0 \tag{5}$$

In equations (1) to (5), the market share P_i is derived from an airline choice model reported in Jou et al. (2005). The partial derivative of P with respect to W in equation (5) can also be obtained through the direct elasticity of a choice model (Hensher et al. 2005).

4. Competitions between Airlines

The basic models of Stakelberg, Cournot, and Bertrand only describe competition between airlines in a duopoly. In Cournot and Bertrand models the size of airlines in the market are the same. But in the Stakelberg model, there is a dominating big airline and another small one in the market. A market containing two airlines only is not representative of the actual international airline market in Taiwan (Table 1). Therefore, we need to expand the number of players in the models to represent the real market conditions of interest.

4.1 Static Service Quality Competition

The most important assumption of the Cournot model is that an airline determines the optimal service quality level while the service quality of other airlines is taken as given. Such is called a static model. In this paper, the procedure to determine the optimal condition of each firm is as follows:

Step 1: construct the profit function of each airline using equation (3) and incorporate the estimated parameters from the discrete choice model, i.e. average price, total passenger numbers, and annual flight numbers of an airline;

Step 2: calculate the first order conditions of each airline's profit function to find the reaction functions respectively, as shown in equation (4). The market share P^a would now be the probability of airline *a* in the multinomial logot (MNL) choice model; and

Step 3: determine the optimal service quality level of each airline by solving the reaction functions of all airlines simultaneously.

4.2 Static Price Competition

Instead of focusing on competition based service quality levels between airlines in a Cournot model, a Bertrand competition model emphasizes the competition of prices between airlines, who would set their own optimal prices to maximize their profit simultaneously, given other airlines' prices remain unchanged. The procedures to determine the optimal conditions are quite similar to the Cournot model (static service quality competition), the difference is that the choice variable is replaced by price.

Step 1: construct the profit function of each airline using equation (3) and incorporate the estimated parameters from the MNL choice model, i.e. average price, total numbers of passengers, and annual numbers of flights of an airline;

Step 2: calculate the first order conditions of each airline's profit function to determine the reaction functions respectively, as shown in equation (5). The market share P^a is the probability of firm *a* in the MNL model; and

Step 3: determine the optimal price level of each airline by solving the reaction functions of all firms simultaneously.

4.3 Dynamic Competitions

Based on a dynamic game like Stakelberg's model, the airlines do not act at the same time. The dominant one (or the leader) first sets a service quality (or price) level and the other small airlines (or followers) choose their optimal competition strategies according to this level. The leading airline then chooses its optimal service quality level to maximize its profit according to the followers' reactions to the level it sets. The detailed competition procedure in this Stakelberg's model is as follows:

Step 1: construct the profit function of each airline using equation (3) and incorporate the estimated parameters from the MNL choice model, i.e. average price, total numbers of passengers, and annual numbers of flights;

Step 2: take the actual values of average prices, service quality, and social-economic characteristics of passengers into the MNL choice model to determine the market share of each airline; set the airline with the highest market share to be the leading airline, the second highest one to be the first follower, the third highest one to be the second follower and so on;

Step 3: incorporate the original service quality levels of the leading firm, second, third airline etc. and the final followers into the profit function of the first follower and determine the optimal condition (profit maximization, first order condition) of the first follower on service quality. With this procedure, we can identify the reaction function on service quality of the first follower;

Step 4: incorporate the original service quality of leading firm, third follower etc. up to the final follower, and the optimal service quality level of the first follower calculated from step 3 into the profit function of the second follower. Determine its optimal level of service quality from the first order conditions of its profit function; by this procedure, we can obtain the reaction function on service quality of the second follower;

Step 5: repeat step 3 to calculate the optimal level of service quality of the third to final follower; thus the reaction functions of all other followers, except the first and second ones, can be obtained;

Step 6: incorporate all the reaction functions of the followers into the profit function for the leading airline and calculate the optimal level of its service quality;

Step 7: given the service level obtained in step 6, repeat steps 3~5 to find out the service quality level of all followers under the profit maximization condition; and

Step 8: verify the convergent possibility of each airline's service quality level under profit maximization conditions; if possible, the convergent value is the optimal service quality level under Stakelberg competition; otherwise, repeat steps 6 and 7 until the values converge.

5. The Empirical Setting

Over the period May to June 2001, a sample of passengers whose first or last landing destination was North America, the most popular (> 50%) destination for passengers originated from Taiwan, were interviewed. The sample was stratified random based on the shares of each airline in this market segment (Table 2). An effective sample of 602 (out of the 702 interviews) was obtained who completed all the questions on their trip, their socioeconomic background and a series of attitudinal questions that measure their degrees of satisfaction with the airlines they used.

Table 2: Sample Distribution of Each Airline Company

Airline	Numbers of Passenger*	Ratio	Sample Number	Useful Sample Number **	Ratio (Sample)
China	952160	32.4%	272	225	32.1%
EVA	897186	30.5%	256	216	30.8%
North-West	263428	9.0%	76	63	9.0%
United	226454	7.7%	65	53	7.5%
Singapore	212237	7.2%	61	52	7.4%
Canada	207162	7.0%	59	49	7.0%
Malaysia	127270	4.3%	36	30	4.3%
Thailand	53000	1.8%	15	14	2.0%
Total	2938897	100.0%	810	702	100.0%

Note:

* Numbers of Passenger comes from the data supplied by individual airlines and tourist agencies in Taiwan.

** The Useful Sample Number is on the basis of usable sample number after excluding out the samples which the answers in social-economic part in the survey is not clear or not satisfy our basic requirements.

Table 3: Service Indices and their Grades by Airlines

Indices of Service Quality	Aspects of Service	CA	Eva	FC
Comprehensiveness of services and comfort of seat	Comfort	3.26	3.56	3.42
Design and cleanliness of passenger compartment	Comfort	3.51	3.71	3.63
Entertainment programs	Comfort	3.35	3.60	3.45
Appearance, manner, attitude, and service efficiency of air hostess or steward	Service Attitude	3.62	3.67	3.67
Quality of food and drinks	Service Comprehensiveness	3.44	3.42	3.36
Reputation in flight safety	Safety	3.01	3.96	3.90
Ease of purchasing tickets	Convenience	3.62	3.79	3.80
Number of flights	Convenience	3.61	3.66	3.63
Convenience of flight times	Convenience , Service Comprehensiveness	3.55	3.65	3.58
Baggage handling	Convenience	3.58	3.69	3.60
Attitude of ground personnel on incident	Professional Capability	3.32	3.46	3.49
Attitude of the flight crew on incident	Professional Capability, Safety	3.36	3.52	3.51
Level of language ability	Professional Capability, Convenience	3.54	3.53	3.69
Complimentary gifts	Service Comprehensiveness	3.08	3.08	3.02
Frequent flight program	Service Comprehensiveness	3.43	3.43	3.49
In-flight supplies	Service Comprehensiveness, Convenience	3.30	3.38	3.17
In-flight duty-free merchandising	Service Comprehensiveness, Convenience	3.29	3.32	3.24

Note: The numbers are the average values of each index.

The degree of satisfaction on each index clustered around 3 grades. The index with the lowest grade is the “Complimentary gifts”, from 3.02 of FC to 3.08 of CA and EV. The grades of index “Attitude of ground personnel on incident” on three airlines is rather low as well. As for the “Design and cleanliness of passenger compartment”, “Appearance”, “Manner”, “Attitude”, and “Service efficiency of air hostess or steward”, “Ease of purchasing tickets”, “Number of flights”, “Convenience of flight times”, “Baggage handling”, and “Level of language ability”, the grades of all three airlines in these indices are higher than 3.50 points.

6. Analysis of Competitions between Airlines

In section 4, we have indicated that there are “leaders” and “followers” in the Stakelberg competition model, but not in the Bertrand and Cournot models. In the current study, we define the leader in the international flight market in Taiwan as the airline with the biggest market share, and the followers as the other airlines. Airlines compete with each other through price and service quality, such as safety, convenience, and comprehensiveness, assuming that the total market demand stays constant after competition. Price and service quality, including safety, convenience, and comprehensiveness are included in objective functions above based on the empirical evidence in the choice models in Jou et al. (2005) (Appendix B is the estimation results of choice model). The input data for the models are presented in Table 4.

6.1 Competition on Safety

We firstly focus on the competition in standards of safety. The results are shown in Table 5 based on information given in Table 4. For the market as a whole, profit decreases with enhanced levels of competition in safety, regardless of whether there is static or dynamic competition. For the effects on an individual airline, CA and EV would benefit in terms of market demand and profit from static competition on safety, where FC would be the loser. In contrast, FC and CA would benefit in terms of safety from dynamic competition and gain greater market share and profit. Only EV will dramatically lose its market demand and profit under dynamic competition. The advantages from dynamic competition of FC and CA may result from their dominant positions in the market.

Table 4: The Input Data for the Competition Models

Items		CA	EVA	FC
Cost function	Fixed operation costs (NT$)	10,067,217,053	10,662,466,437	24,057,342,058
	Unit cost of service quality a passenger perceived (NT$)	45.016	48.681	38.979
	Air Ticket(NT$)	29,733	30,752	30,573
Reference point	Price (NT$)	31,250	31,550	31,500
	Safety (Grades)	2.142	2.678	2.877
	Convenience (Grades)	3.315	2.711	2.106
	Comprehensiveness (Grades)	2.816	3.377	3.048
Service quality	Safety $LOSS$	-0.162	-0.138	-0.167
	Convenience $GAIN$	0.575	0.269	0.174
	Comprehensiveness $LOSS$	-0.206	-0.097	-0.108

Note:

1. Reference point of price was obtained from travel agents (average price) in 2001.
2. Reference points of service quality were obtained from the estimation results of LISREL.
3. Service quality $GAIN$ and $LOSS$ were obtained by calculating the average of the difference between the samples and reference point.
4. Air ticket was calculated from the average ticket of all samples.
5. Unit cost of service quality a passenger perceived=service cost of airline company/(passengers x total grades of service quality)
6. 1 US$ is approximately 34.97 NT$.

6.2 Competitions on Convenience

For competition linked to convenience, the profit of the total market would decrease in static competition and increase under dynamic competition, according to the results shown in Table 6.This increased profit of the total market from dynamic competition should contribute to exceptional profit growth of FC, at the expense of profits for CA, which would become negative. Although the profit of CA would also decrease under static competition, the magnitude is not as under the dynamic condition. The profit of EV would decrease when competing on convenience under both the static and dynamic conditions. This phenomenon is contrary to the competitive result of profits for FC, whose profits would increase after increases in convenience, especially under dynamic competition. The market share of each airline also changes dramatically. The market share of CA would increase slightly under static competition, but decrease immensely under the dynamic condition. The rise of convenience in EV would cause losses in market share in all forms of competition, which is contrary to the results for FC. Overall, FC would receive the most benefit from competition in convenience.

Table 5: The Results of Competition in Safety Levels

Company	Competition	Safety Degree (Grades)	Market Share (%)	Market Demand (Persons)	Profit (NT Dollar*)
CA	Original	1.98	31.22%	917,418	16,434,561,905
	Static	2.12	33.37%	980,847	18,251,515,893
	Dynamic	2.14	31.53%	926,758	16,697,616,660
EV	Original	2.54	33.92%	996,837	19,044,880,657
	Static	2.65	34.29%	1,007,697	19,358,284,868
	Dynamic	2.68	32.96%	968,528	18,194,713,762
FC	Original	2.71	34.86%	1,024,641	6,537,880,892
	Static	2.77	32.34%	950,353	4,331,778,751
	Dynamic	2.88	35.51%	1,043,611	7,097,517,768
Total Market	Original	--	100%	2,938,897	42,017,323,454
	Static	--	100%	2,938,897	41,941,579,512
	Dynamic	--	100%	2,938,897	41,989,848,190

*:1 US$ is approximately 34.97 NT$.

Table 6: The Results of Competition in Convenience Levels

Company	Competition	Convenience Degree (Grades)	Market Share (%)	Market Demand (Number)	Profit (NT Dollar)
CA	Origin	3.89	31.22%	917,418	16,609,660,721
	Static	4.012	31.43%	923,835	16,434,561,905
	Dynamic	5.000	10.64%	312,573	-1,053,421,362
EV	Origin	2.98	33.92%	996,837	19,044,880,657
	Static	3.009	31.08%	913,368	16,564,080,275
	Dynamic	5.000	28.97%	851,469	14,628,944,694
FC	Origin	2.28	34.86%	1,024,641	6,537,880,892
	Static	2.467	37.49%	1,101,694	8,827,939,875
	Dynamic	5.000	60.39%	1,774,854	22,212,763,123
Total Market	Origin	--	100%	2,938,897	42,017,323,454
	Static	--	100%	2,938,897	42,001,680,871
	Dynamic		100%	2,938,897	42,326,167,346

6.3 Competition in Service Comprehensiveness (or Quality diversification)

As shown in Table 7, total market profit would decrease under static and dynamic competition of service quality diversification. For CA, its profits would increase in both forms of competition, resulting in expansion of market share, producing a greater increase under static than under dynamic competition. But this is not the case for EV and FC, who would find their profits decreasing under both forms of competition. Their market share would shrink as well and only CA would benefit from competition in levels of service quality under either static or dynamic competition.

Table 7: The Results of Competition in Service Comprehensiveness

Company	Competition	Levels of Convenience (Grades)	Market Share (%)	Market Demand (Persons)	Profit (NT Dollar)
CA	Origin	2.61	31.22%	917,418	16,434,561,905
	Static	2.76	33.31%	978,959	18,201,328,006
	Dynamic	2.82	33.05%	971,212	17,968,198,653
EV	Origin	3.28	33.92%	996,837	19,044,880,657
	Static	3.32	33.25%	977,152	18,458,627,777
	Dynamic	3.38	32.87%	965,910	18,125,563,945
FC	Origin	2.94	34.86%	1,024,641	6,537,880,892
	Static	2.95	33.44%	982,786	5,289,912,218
	Dynamic	3.05	34.09%	1,001,774	5,855,642,390
Total Market	Origin	--	100%	2,938,897	42,017,323,454
	Static	--	100%	2,938,897	41,949,868,001
	Dynamic	--	100%	2,938,897	41,949,404,988

6.4 Static Price Competition

In section 4.1, for static price competition, airlines choose their optimal prices simultaneously while others' prices are fixed. Results in the international airline market under such competition are shown in Table 8. Assuming fixed market demand, total market profits decrease after competing on price. The equilibrium prices of all three airlines also decrease. CA lowered its price much more than EV and FC.

By this price cutting competition, CA gains in market share and profits. For EV and FC, although they also lower their prices under Bertrand competition, their market shares and profits still decrease. This might be because their amount of price-cutting is less than CA's, which indicates that CA benefits from this price competition. Finally, the percentage of profit change in the whole market in Bertrand competition (5.77%) is greater than that in the competition on the three aspects of service quality (0.18% in safety, 0.04% in convenience, and 0.16% in diversification).

Table 8: The Results of Static Competition in Price

Company	Situations	Price (NT dollar)	Market Share (%)	Market Demand (Persons)	Profit (NT Dollar)
CA	After Competition	28758	35.01%	1,028,808	18,649,140,126
	Before Competition	29733	31.22%	917,418	16,434,561,905
	Comparison	-975	3.79%	111,390	2,214,578,221
EV	After Competition	30035	32.60%	958,160	17,204,928,694
	Before Competition	30752	33.92%	996,837	19,044,880,657
	Comparison	-717	-1.32%	-38,678	-1,839,951,963
FC	After Competition	29913	32.39%	951,929	3,738,078,198
	Before Competition	30573	34.86%	1,024,641	6,537,880,892
	Comparison	-660	-2.47%	-72,713	-2,799,802,694
Total Market	After Competition	--	100%	2,938,897	39,592,147,017
	Before Competition	--	100%	2,938,897	42,017,323,454
	Comparison	--	0	0	-2,425,176,437

6.5 Dynamic Price Competition

Under dynamic price competition, airlines observe each others' price to adjust theirs to maximize their own profits. Through price competition, airlines may need to lower their prices continuously until their objectives are met. In the following, we discuss the situation until the profit of one firm becomes zero. Figures 1, 2, 3, and 4 are the estimated results of ticket prices, market shares, firm profits, and market-level profit.

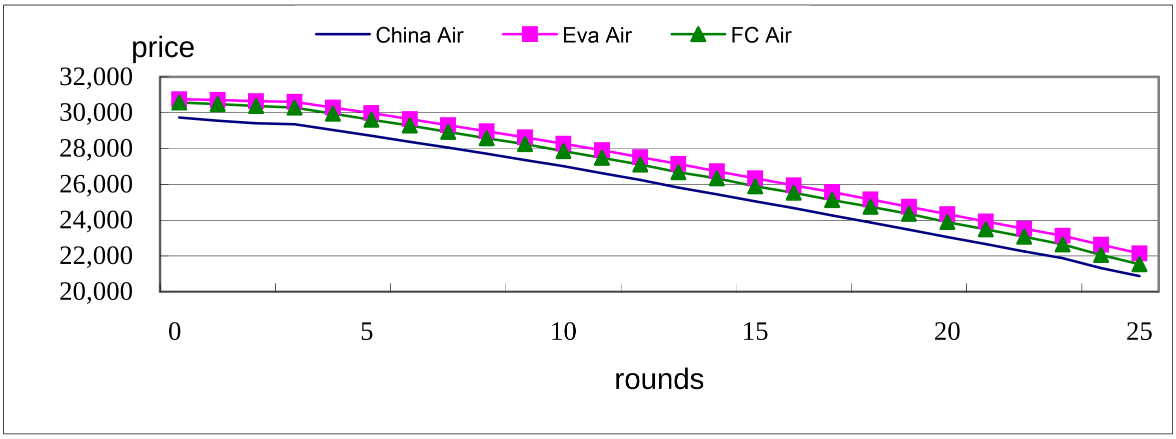

Figure 1: Changes in Prices under Dynamic Price Competition

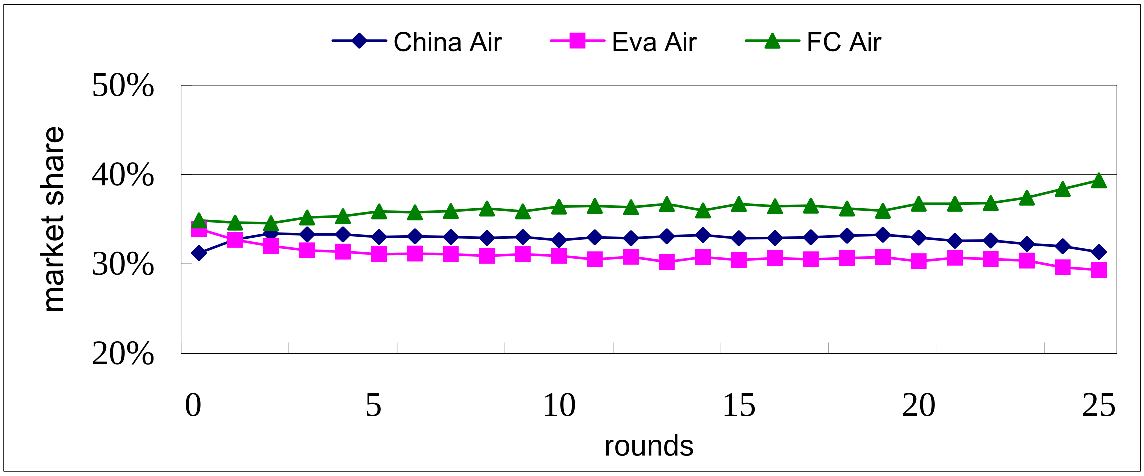

Figure 2: Changes in Market Share as Ticket Prices are Cut

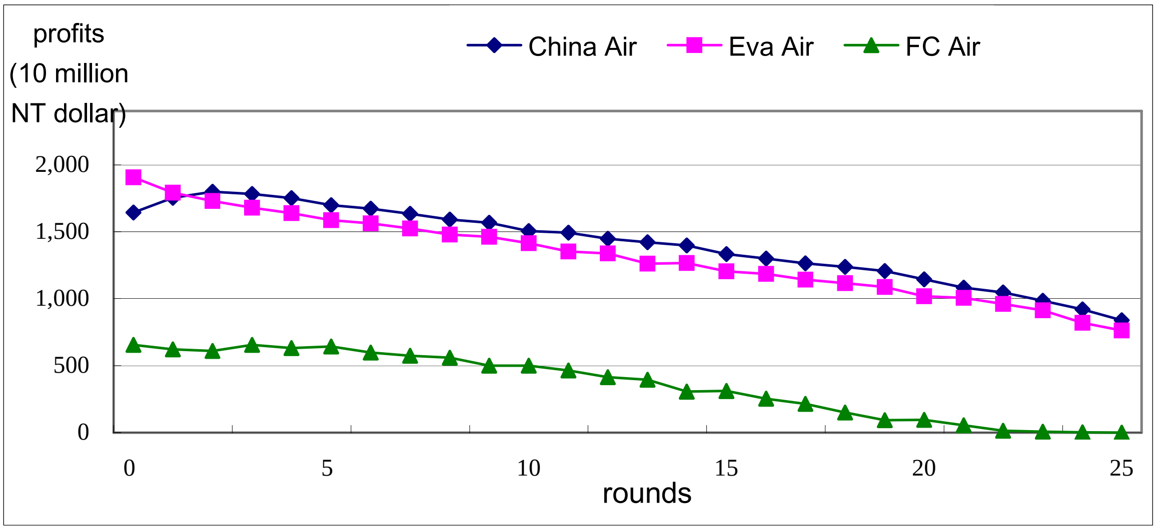

Figure 3: Changes in Airline Profits

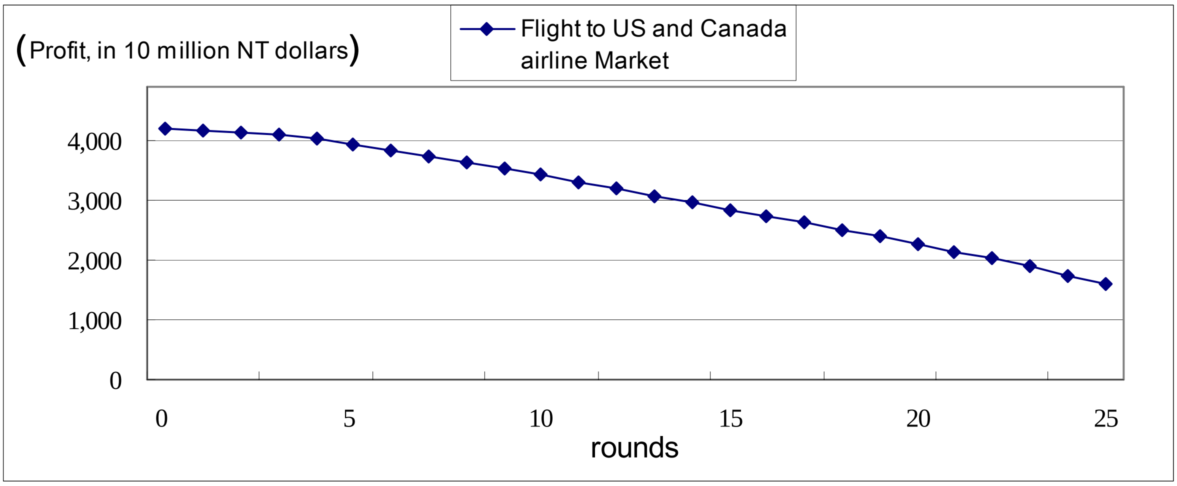

Figure 4: Change of International Flight Market Profits

Figure 1 clearly shows that the price that each airline would need to continuously reduce in the quest for gains in market shares from of price-cutting. Prices of CA are always the lowest. But in the case of EV, its prices are the highest all the time, and thus contribute to its lowest market share (Figure 2), which also shows that FC would gain the highest share of the market under dynamic price competition, even though its price in Figure 1 is not the lowest. Finally, in Figure 2, the lines of market share of CA and EV intercept in the second round of competition. This means that, from competition round 2, the market share of EV would be lower than CA's in the following rounds.

The profit changes in the international flight market under dynamic competition are shown in Figures 3 and 4. Firstly, the profits of all three firms decrease gradually through the rounds of competition (Figure 3). A similar pattern can be found for profits in the international flight market in Figure 4. Secondly, the profit of FC remains the lowest throughout the competitive process and turns negative after round 21. Finally, the profits in the first round of CA are lower than that of EV. However this is reversed after the second round. Overall, CA, the leader, earns more profit by adopting a price-cutting strategy than the other two airlines. By this strategy, FC is forced to reduce its price continuously. Although this strategy helps it to earn more market share, this is not the case of its profit. FC runs into losses after competition round 21.

7. Concluding Remarks

The effects of static and dynamic competition on service quality and price between firms in the international flight market in Taiwan were investigated through a game-based simulation. In these games, which are duopoly based, the leading firm is CA with two major followers EV and FC. Static competition results show that CA would benefit more than the other two firms from safety and service quality enhancements. Its profits would increase 10.78% and 10.46% respectively. FC would benefit more from static competition when service convenience is improved, with its profit increasing by

31.57%. As for the static price competition, the total profit of the market as a whole would decrease significantly. CA would need to reduce its price more than the other airlines to stay competitive, earning more market share than before as a result. Under dynamic competition, FC would benefit more than the other airlines from competition on safety and convenience due to its profit being the highest. On the other hand, CA would be more profitable than the other airlines from dynamic competition based on service quality comprehensiveness. FC is the clear champion under dynamic competition and benefits more than under the static case, thus implying the leader's advantage. Under dynamic price competition, in spite of FC having the advantage of being a leader, continuous price cutting would result in a loss for airlines as competition heightens.

Based on the findings discussed in this paper, a passenger considers not only the price, but also the service quality when choosing an airline. For an airline to attract more passengers, the safety aspect of service quality, in particular, should be improved. Convenience of service quality is also important in a passenger's choice of airline. This implies that the airlines should improve the various aspects of convenience, e.g. ease in purchasing tickets, baggage handling, or flight times, etc. Passengers would prefer receiving comprehensive service, for example - frequent flyer programs, better food and drinks, in-flight supplies, or duty-free merchandise, etc.; all effective strategies to win more passengers.

In this study, the sample has insufficient passengers travelling first-class and business class to have enough information to separately analyze their service quality requirements. Given the keen competition between airlines, the formation of airline alliances has become a popular strategic instrument to expand their own markets. Thus, further research should focus on the formation process of the alliances and their effects on service quality of airlines.

Acknowledgements

This paper is based on research at National ChiNan International University which was funded by the National Science Council of Taiwan and completed while the senior author was on leave at the Institute of Transport and Logistics Studies, the University of Sydney. The cooperation of the participants and the numerous research assistants conducting the survey is particularly appreciated. Remaining errors are the responsibility of the authors.

References

Hansen, M. (1990), Airline Competition in a Hub-Dominated Environment An Application of Non-Cooperative Game Theory, *Transportation Research,* 24B, pp.27-43.

Hansen, M. and Kanafani, A. (1990), Airline Hubbing and Airport Economics in the Pacific Market, *Transportation Research,* 24A, pp.217-230.

Hansen, M., Wenbei, W., (2001). An airline"s choice of aircraft size in a competitive environment. In: Proceedings Presented at INFORMS Conference Miami.

Hensher, D.A., Rose, J,M. and Greene, W.H. (2005) Applied Choice Analysis: A Primer, Cambridge University Press, Cambridge.

Jou, R.C., Lam, S.H., Guo, C.W. and Chen, C.C. (2005). The Asymmetric Effects of Service Quality on Passengers' Choice of Carriers for International Air Travel, submitted to Journal of Advanced Transportation.

Kane, R. M. (1990), *Air Transportation*, Kendall/Hunt Publishing Co.

Kita, H., Tanimoto, K., Fukuyama, K., (2001). An inverse analysis of merging–giveway game: focusing on the equilibrium selection, Presented at the Second Berkeley-Tottori Joint Seminar on Evolution Processes of Transportation Systems: Analyses and Policy Implications, June.

Levinson, D., (1999). Tolling at a frontier: a game theoretic approach. In: Proceedings of the 14th International Symposium on Transportation and Traffic Theory, pp. 173-187.

Levinson, D., (2000). Revenue choice on a serial network. *Journal of Transport Economics and Policy* 34 (1), pp.69-98.

Levinson, D., (2005). Micro-foundations of congestion and pricing: a game theory perspective. *Transportation Research A*, 39, pp. 691-704

Littlechild, S.C., Thompson, G.F., (1977). Aircraft landing fees: a game theory approach. The *Bell Journal of Economics* 8, pp.186-203.

Marini, Marco A., Marcucci, E., (2003). Political acceptability of road pricing policies under individual specific uncertainty. In: Schade, J., Schlabe, K. (Eds.), Acceptability of Transport Pricing Strategies. Elsevier Science, pp.279-297.

MOTC Taiwan (2002). Traffic Statistic Outlook 2002.

Proussaloglou, K. and Koppelman, F., (1995), Air Carrier Demand-An Analysis of Market Share Determinants, *Transportation*, 22, pp.371-388.

Zubieta, L., (1998), A Network Equilibrium Model for Oligopolistic Competition in City Bus Service. *Transportation Research B,* 32, pp.413-422.

Appendix A : A brief definition of Cournot, Stakelberg and Bertrand methods (From Wikipedia, the free encyclopedia. (http://en.wikipedia.org/wiki/Main_Page)

Cournot competition is a model used to describe industry structure. It so called after Antoine Augustin Cournot (1801-1877) after he observed competition in a spring water duopoly. It has the following features:

1. There are two firms producing homogeneous products;
2. Firms do not cooperate.
3. Firms have market power;
4. There are barriers to entry;
5. Firms compete in quantities, and choose quantities simultaneously;
6. There is strategic behaviour by the firms;

Price is a commonly known decreasing function of total output. All firms know N and take the output of the others as given. Each firm has a cost function ci(qi) (cost per unit multiply quantity). Normally the cost functions are treated as common knowledge. The cost functions are normally the same for all firms. The market price is set at a level such that demand equals the total quantity produced by both firms.

The Stackelberg leadership model is a model of duopoly in economics. It is named after the German economist Heinrich von Stackelberg who published Marktform und Gleichgewicht in 1934 which described the model. In game theory terms, the players of this game are a leader and a follower and they compete on quantity. The leader moves first, choosing a quantity. The follower observes the leader's choice and then picks a quantity. There are some further constraints upon the sustaining of a Stackelberg equilibrium. The leader must know ex ante that the follower observes his action. The follower must have no means of committing to a future non-Stackelberg follower action and the leader must know this. Indeed, if the 'follower' could commit to a Stackelberg leader action and the 'leader' knew this; the leader's best response would be to play a Stackelberg follower action. Firms may engage in Stackelberg competition if one has some sort of advantage enabling it to move first. More generally, the leader must have commitment power. Moving observably first is the most obvious means of commitment: once the leader has made its move, it cannot undo it - it is committed to that action. Moving first may be possible if the leader was the incumbent monopoly of the industry and the follower is a new entrant. Holding excess capacity is another means of commitment

Bertrand competition is a model of competition used in economics, named after Joseph Louis François Bertrand (1822-1900). Specifically, it is a model of price competition between duopoly firms which results in each charging the price that would be charged under perfect competition, known as marginal cost pricing.

The model has the following assumptions:

1. There are two firms producing homogeneous products;
2. Firms do not cooperate;
3. Firms have the same marginal cost (MC);
4. Marginal cost is constant;
5. Demand is linear;
6. Firms compete in price, and choose their respective prices simultaneously;
7. There is strategic behaviour by both firms;
8. Both firms compete solely on price and then supply the quantity demanded;
9. Consumers buy everything from the cheaper firm or half at each, if the price is equal.

Competing in price means that firms can easily change the quantity they supply, but once they have chosen a certain price, it is very hard, if not impossible, to change it, for example bars or shops or other companies that publish non-negotiable prices.

Appendix B: Estimation results of the choice model (Jou et al., 2005)

Explanatory Variables	Coefficients (t values)
Constant of EV	0.695(2.37)
Constant of FC	1.579(2.96)
Frequency of going abroad (FC)	-0.368(-2.67)
$WGAIN$ (price)	0.000543(2.27)
$QLOSS_3$ (safety)	1.643(2.81)
$QGAIN_4$ (convenience)	1.01(4.54)
$QLOSS_6$ (diversification)	0.806(2.21)
LL (0)	-293.3295
LL($\hat{\beta}$)	-172.640
ρ^2	0.411
$\bar{\rho}^2$	0.399
sample size	267