Low-Cost Entry, Inter-Firm Rivalry, and Welfare Implications in US Large Air Markets

Murakami, Hideki

(Citation)
神戸大学経営学研究科 Discussion paper,2009・25

(Issue Date)
2009-06

(Resource Type)
technical report

(Version)
Version of Record

(URL)
https://hdl.handle.net/20.500.14094/81001321

Graduate School of Business Administration

KOBE UNIVERSITY

ROKKO KOBE JAPAN

2009-25

Low-Cost Entry, Inter-Firm Rivalry, and Welfare Implications in US Large Air Markets

Hideki Murakami

Discussion Paper Series

Low-Cost Entry, Inter-Firm Rivalry, and Welfare Implications in US Large Air Markets[1]

Hideki MURAKAMI

Abstract

This paper empirically analyses the patterns of inter-firm rivalry between low-cost and full service carriers by carrier and airport bases, and demonstrate welfare implication of LCC, using 1163 US cross-sectional data of 1998 when LCCs were purely no-frilled carriers. Our main findings are: (1) that both LCC and full service carriers keep higher price-cost margins when LCCs enter in the secondary airport, while especially full service carriers suffer from low price-cost margin when LCCs enter the same markets, (2) that total gains of welfare are 25.5 million USD for our dataset, and 90% of welfare gains come from the gain in consumer's surplus. LCCs' cumulative profit is 4.45 million USD, but full service carriers lost 1.92 million USD in total due to the competition by LCCs, (3) that LCCs sometimes provide unreasonably small (i.e, less-than-monopoly) capacities instead of profit-maximizing ones when they have no information about own demand curves.

Key Words: low-cost carrier, inter-firm rivalry, social welfare

[1] Please do not quote or cite without author's permission.

1. Introduction

There have been many studies on the economic impact of the US low-cost carrier (LCC)'s entry into the air transportation market. Morrison and Winston (1995) empirically showed that Southwest Airlines reduces the fare of every carrier it competes with.[2] Dresner et al. (1996) and Morrison (2001) showed the airfare-reducing effect of low-cost entry in the primary and adjacent markets by incorporating LCC dummy variables. Pitfield (2005, 2008) studied the airfare change after low-cost entry by time series analysis. Goolsbee and Syverson (2005) and Oliveira and Huse (2009) studied the entry effect of LCCs on the responding behavior of incumbents. In studies on inter-firm rivalry among airlines, Brander and Zhang (1990, 1993), Oum, Zhang, and Zhang (1993), Fischer and Kamerschen (2003), and Fageda (2006) empirically estimated the conduct parameters of airline industries in the United States (the first three of four studies) and Spain (the last study). Furthermore, Fu, Lijensen and Oum (2006) bridged the studies of LCCs vs. full-service carriers (FSCs) and duopolistic inter-firm rivalry, and also incorporated the effect of pricing behavior of unregulated-monopoly airports on the competition between LCCs and FSCs.

In this study we attempt to bridge the issues of the low-cost competition and inter-firm rivalry measured by conduct parameters, following the line of research initiated by Brander and Zhang (1993). We highlight not only the duopoly but also the larger markets where more than two carriers operate,

[2] Morrison and Winston (1995), pp.132-156.

whereas previous studies have dealt with duopoly cases. Furthermore, we will demonstrate, from several aspects, not only the consumer welfare but also the total welfare derived from simultaneous demand, airfare, and profit equations, using a carrier-specific dataset with 1163 data observations. The next section derives the conduct parameter and simultaneous equations theoretically and then converts them to the econometric model. In Section 3 we present the data and in Section 4 we show the empirical results and perform several analyses of inter-firm rivalry between LCCs and FSCs. In Section 5 we present welfare implications and Section 6 is the summary and concludsions.

2. The model

Early studies on estimating conjectural variation by CPM (conduct parameter method) to analyze inter-carrier rivalry are Iwata (1979), Applebaum (1982), and Bresnahan (1981)(1989) and they are followed by the studies on airline industries listed up at Section I. Those studies on airline industry use cross-sectional data and focus on duopoly, in which two "symmetric" carriers, such as United Airlines and American Airlines, compete.

Our analysis uses, like many studies do, the cross-sectional data. Our choice of year is 1998. Now not a few LCCs, such as ATA[3] and Jetblue, have entered long distance markets and provide limited frills. However, around 1998, LCCs still persisted in their original business domains such as providing

---

[3] ATA was filed in Chapter eleven and quitted its operation in April 2008.

no frills, serving for the markets of short or medium distance, issuing no mileage service and so on. Therefore, we expect economic impacts such as the degree of airfare-discounting may be stronger than picking up the recent year for our analysis.

This study has the following distinguishing features:

(1) We incorporate triopoly and larger markets where multiple carriers enter as well as duopoly markets, and we cover a wider range of the industry than was covered in previous studies. We analyze the inter-firm rivalry of 21 carriers, and 9 out of the 21 carriers are LCCs,

(2) We compute airport-specific conduct parameters as well as carrier-specific ones.

(3) We estimate not only LCCs' own capacity-expanding and consecutive airfare discounting effects but also their impact on capacities and airfares of FSCs.

(4) We investigate how the airfares change after an LCC enters as the result of carriers' behaviors of capacity-expansion, though the number of cases for this analysis is low.

(5) We investigate how the output and airfare changed from the first year to the second year of the new entry by LCCs.

(6) We derive the total welfare, whereas previous studies focused on the consumer welfare only.

In subsection 2-1 we derive the conduct parameters, and in subsection 2-2 we explain simultaneous systems to compute the total welfare effect.

2-1 Conduct Parameter and route-specific simultaneous equations

Our dataset consists of 180 duopoly markets, 138 triopoly markets, 56 four-carrier-operating markets, 19 five-carrier-operating markets, 7 six-carrier-operating markets, and 4 seven-carrier-operating markets. Therefore, the route-specific dataset consists of 405 and the carrier-specific dataset has 1163 sample observations. As for the route-specific data, the entire data are aggregate, so airfares of this dataset mean the market-share-weighted average airfares. To estimate the conduct parameters, we use both carrier- and route-specific dataset. In the carrier-specific dataset, we derive the conduct parameter assuming the n-firm case with one LCC.[4] The market demand of route i is denoted as follows:

$$Q_i = \sum_{k=1}^{n-1} q_i^k + q_i^j \equiv \sum_{L=1}^{n} q_i^L \quad (j \neq k, k = 1, \cdots, n-1, L = 1, \cdots, n) \quad (1)$$

where both of the superscripts k denotes a full service carrier and j denote an LCC. The profit function of each carrier is denoted as follows:

$$\pi_i^L = q_i^L p_i(Q_i) - TC_i^L(q_i^L) \quad (2) \quad \text{where} \quad TC_i^k(\bullet) > TC_i^j(\bullet)$$

Taking the first-order condition of (2), we have:

$$\frac{\partial \pi_i^L}{\partial q_i^L} = p_i(Q_i) + q_i^L \frac{\partial p_i(Q_i)}{\partial Q_i} \frac{\partial Q_i}{\partial q_i^L} - MC_i^L(q_i^L) = 0 \quad (3)$$

We then define the conduct parameter as (4) and (5):

$$v_i^m \equiv \frac{d}{dq_i^m}\left(\sum q_i^{k-1} + q_i^j\right) \quad (m \neq k) \quad (4) \qquad v_i^j \equiv \frac{d}{dq_i^j}\left(\sum q_i^k\right) \quad (5)$$

[4] We also have the case of "n-2" full service carriers and two LCCs. Even for this case we can derive the conduct parameter without losing generality.

Substituting (4) and (5) into (3), respectively, we obtain:

$$\frac{\partial \pi_i^L}{\partial q_i^L} = p_i(Q_i) + q_i^L \frac{\partial p_i(Q_i)}{\partial Q_i}\left(1 + v_i^L\right) - MC_i^L\left(q_i^L\right) = 0 \quad (6)$$

where $MC_i^k(\bullet) > MC_i^3(\bullet)$.

For example, the conduct parameter (4) means the marginal change in the output of other carriers (other FSCs plus carrier *j*) against the marginal change in the output of carrier *k*. If all of them move in the same direction and have the same volume, the result is $L-1$ and this means collusion. If the conduct parameter is 0, (6) equals the first-order conditions for Cournot competition. If it is –1, the airfare equals the marginal cost.

In our model, if the airfare equals the marginal cost of an LCC, FSCs would have to exit the market, since $MC_i^k(\bullet) > MC_i^j(\bullet)$ as long as carriers operate at the minimum efficient scale where average cost equals marginal cost.

As in the previous studies, the equations (6) can be inverted to (7) by using the route-specific airfare elasticity of demand (η_i) and that the market shares of each carrier $\left(s_i^L\right)$.

$$v_i^L = \frac{\left\{p_i(Q_i) - MC_i^L\left(q_i^L\right)\right\}}{p_i(Q_i)}\frac{\eta_i}{s_i^L} - 1 \quad (7)$$

As for the variables and parameters in (7), we already have information on p_i and s_i^L, but the route-specific marginal cost for each carrier and the route-specific airfare elasticity of demand are unknown. Therefore, we need to estimate these two unknown variables and parameters in advance to compute the conduct parameters. To obtain v_i^L, we use the following proxy to approximate route-specific marginal cost for each carrier, as proposed by Brander and Zhang (1990),(1993) and Oum et al. (1993)[5].

$$MC_i^L = AC^L \left(\frac{Dist_i}{AFL^L} \right)^{-\lambda} Dist_i \quad (8)$$

where AC^L is the aggregate average cost of carrier L, $Dist_i$ is the distance of route i, AFL^L is the average distance flown by airline L [6]. Many studies on airline costs, such as Caves, Christensen, and Tretheway (CCT, 1984), Gillen, Oum, Tretheway (1990), and Fischer and Kamerschen (2003), show that economies of density exist in the airline industry. This means that the total cost function is strictly concave. Therefore, λ in (8) ranges between 0 and 1. It is apparent that if λ is 0, the carrier's marginal cost is proportional to distance, while if λ is 1, the marginal cost is indifferent to distance. According to previous empirical research such as CCT (1984), Borenstein (1990), Brander and Zhang (1990)(1993), Oum, Zhang, and Zhang (1993), λ may range between 0.15 and 0.67. Armantier and Richard (2003) predict that the route-specific marginal cost of an airline is just equal to the product of "cost per mile" and distance (this means $\lambda = 0$)[7]. Oum, Zhang, and Zhang (1993) estimated the equation (9) to obtain λ. This equation (9) is derived from the first order condition of carrier's profit function, that is, a pseudo-inverse supply function under oligopoly.

$$p_i^L = \frac{\left\{ AC^L \left(Dist_i / AFL^L \right)^{-\lambda} Dist_i \right\} \eta}{\eta - (1+\nu) s_i^L} + \varepsilon_i^L \quad (9)$$

---

[5] To estimate the route-specific marginal cost for each carrier, Fischer and Kamerschen (2003) jointly estimate a translog total cost function and then approximate the route-specific marginal cost for each carrier. See Fischer and Kamerschen (2003), pp.235-237.

[6] See Brander and Zhang (1990), pp. 572-575, Brander and Zhang (1993), pp.417-420, and Oum, Zhang, and Zhang (1993), pp. 175-178.

[7] Armantier and Richard (2003), pp. 468-469.

The system-wide conduct parameter can also be estimated in equation (9). By substituting estimated λ into (8), we can approximate the route specific marginal cost.

However, we have yet to know the (positive) route-specific price elasticity of demand η. Therefore, we estimate the Marshallian demand function. We might as well simultaneously estimate demand equation and pseudo-supply equation (9) at the same time, but what we need is the route-specific price elasticity of demand, not the carrier-specific one. In other words, the dataset for estimating (9) is different from the one for estimating the demand equation. Considering the demand and supply system, we detect the airfare on the right hand side of the demand equation and the output on the right hand side of pseudo-supply equation may be correlated with the error term of each equation. Therefore, we carry out Hausman specification test to test the null hypotheses that neither airfare nor output is asymptotically correlated with the error term of demand and the pseudo-supply equations, respectively.

Hausman test for demand equation: $H_0 : p\lim\left(\frac{p'u}{n}\right) = 0$, $H_1 : p\lim\left(\frac{p'u}{n}\right) \neq 0$

Hausman test for pseudo-supply equation: $H_0 : p\lim\left(\frac{q'\varepsilon}{n}\right) = 0$, $H_1 : p\lim\left(\frac{q'\varepsilon}{n}\right) \neq 0$

where *p* is the average airfare in a market which is weighted by the number of traffic carried by airlines, *q* is the market aggregate traffic, *e* is the error term of demand equation and *u* is also the error term of the pseudo-supply equation. Under the null hypothesis, OLS estimator is unbiased, consistent, and more efficient than 2SLS estimator, while under H_1 2SLS estimator is unbiased, asymptotically consistent, and more efficient than OLS estimator. The test result is that the second null hypothesis is rejected at 1% level ($\chi^2_{(d.o.f.=1)} = 30.49 > \chi^2_{(\alpha=0.01/d.o.f.=1)} = 6.64$), and the first null hypothesis is rejected at 7.1% level ($\chi^2_{(d.o.f.=1)} = 3.30$). Considering these results, we may have to estimate the structural demand

and pseudo-supply equation together either two stage or three stage least squares. In addition, Bailey, Graham, and Kaplan (1985) suggest that the market concentration is also an endogenous variable which is determined by output, distance and other exogenous factors such as the existence of slot controls, and this is followed by our analysis. Our route-specific simultaneous equation system is as follows.

[Route-specific demand equation] [8]

$$\ln(Q_i) = \alpha_0 - \eta \ln p_i + \alpha_1 \ln INC_i + \alpha_2 \ln DIST_i + \alpha_3 \ln POP_i + \sum_{m=3}^{7} \alpha_4^m MKT_m + \mu_i \quad (10)$$

[Route-specific pseudo-supply equation]

$$\ln(p_i) = \beta_0 + \beta_1 \ln Q_i + \beta_2 \ln DIST_i + \beta_3 \ln HERF_i + \beta_4 \ln MCD_i + \beta_5 DLCC1 + \beta_6 DLCC2 + \varepsilon_i \quad (11)$$

where p_i is the average airfare at route i weighted by market share, INC_i is the arithmetic average of per-capita income of route i, $DIST_i$ is the distance of route i. This variable enters both in demand and pseudo-supply equation, because it controls market demand, and also plays a role of proxy of the marginal cost[9]. POP_i is the arithmetic average of O/D population, MKT_m is a binary variable that takes 1 for the market where m carriers compete. For example, MKT_3 is the dummy variable that takes 1 for triopoly markets and zero otherwise. $HERF_i$ is the Herfindahl index, and higher $HERF_i$ means that the market is more concentrated. Since high concentration may lead to strong

---

[8] Since we will compute the consumer welfare in Section 5 by using this demand equation, the functional form must be carefully chosen. To determine whether the form of each equation is a simple linear, a log-linear or others, we carried out the Box-Cox transformation. According to the result of LR test, we cannot reject the hypothesis that the best functional form is the log-linear functional form at 5% level. $\chi^2_{(d.o.f.=5)} = 0.12 \leq \chi^2_{(\alpha=0.05/d.o.f.=5)} = 11.07$

[9] Since our data is the route-specific data, we have to use "distance" as the proxy on behalf of the "route marginal cost".

market power, the parameter will be positive. $DLCC1$ and $DLCC2$ are binary variables that represent the presence of LCC(s). The former takes 1 if at least one LCC serves the route and 0 otherwise. The latter takes 1 if at least 1 LCC serves the adjacent route and 0 otherwise. For example, $DLCC2$ takes 1 for both the cases as follows: the case to connect two secondary airports such as Southwest's Houston/Hobby-Chicago/Midway, and the case to connect the primary and secondary airports such as Air Tran's Atlanta/Hertsfield-Chicago Midway. If a quality-distinguished firm enters a market and tries to distinguish itself further, the market output decrease and airfare rises. Therefore, the sign of $DLCC1$ and $DLCC2$ would be positive if both carriers perfectly distinguish themselves from each other. If they are not completely distinguished, both will compete and the signs of $DLCC1$ and $DLCC2$ would be negative.

Mason et al. (1992) discuss that if the firm's structure is asymmetric (e.g., high-cost and low-cost), it needs longer time for the market to reach cooperative equilibrium than if the firms are symmetric. Their discussions are followed by our variable MCD_i, which is the standard deviation of marginal cost. If this is sufficiently large, there may be at least one LCC, and carriers in a market will hardly agree on colluding. Therefore, the parameter will have negative effect on the market airfare, and, vise-versa, positive effect on market output.

(Discussion on the use of conjectural variation to change a major firm's conduct)

In a recent analysis of the estimation of market power using the conduct parameter method

(CPM), Fisher and Kamerschen (2003) point out that in a static environment, the notions of expectation and conjectural variation are not well defined. For example, if we start our analysis by modeling a one-shot Cournot competition and try to estimate the conjectural variation by CPM, we face the problem that we cannot describe the firm's response or any dynamic change in the firm's behavior. As Bresnahan (1989) states, "The estimated parameters tell us about airfare- and quantity-setting behavior; if the estimated 'conjectures' are constant over time, and if breakdowns in the collusive arrangements are infrequent, we can safely interpret the parameters as measuring the average collusiveness of conduct."[10] Also, Corts (1999) pointed out, "CPM estimates of market power can be seriously misleading. In fact, the conduct parameter need not even be positively correlated with the true measure of the elasticity-adjusted price-cost margin, so that some markets are deemed more competitive than a Cournot equilibrium even though the price-cost margin approximates the fully collusive joint-profit maximizing price-cost margin."[11]

Taking these critics' statements into account, Fisher and Kamerschen (2003) nonetheless stressed the usefulness of conjectural variation. They insisted, following Brander and Zhang (1993) and Oum et al. (1993), that "one can view the conjectural variation as a parameter of market conduct that can capture the whole range of market performance, from perfect competition to monopolistic behavior,

---

[10] Bresnahan (1989), p.129.
[11] Corts (1999), p.299.

rather than taking it as an indicator for the firm's expectation."[12] Fageda (2006) also computed the conduct parameters of Spanish air markets by estimating the demand and pseudo-supply equation system using semi-annual (summer and winter) data of the years 2000 and 2001 by 3SLS, not stressing the problem with the dynamic features of conduct parameters but regarding conduct parameters as the set of static equilibrium.[13] Our analysis in the present essay follows this line of research and does not include a discussion of the dynamic aspect of competition. The problems pointed out by Corts (1999) arise when we model the dynamic competition and use the panel data, and Puller (2008) suggested a prescription for addressing this problem. We will discuss this issue further in the future.

2-2 Carrier-Specific Simultaneous Equations to Derive Total Welfare

Next, we try to construct the carrier-specific simultaneous demand and pseudo-supply equation system. As we did in 2-1, we assume that not only demand but also airfare is also an endogenous variable. As for the new entry and the response by incumbent carriers, Joskow et al.(1994) find that new entrants enter with low airfare, and incumbents respond by cutting airfares to keep their traffic maintained. Dresner et al. (1996) estimated the simultaneous and demand- and price (pseudo-supply) equations that incorporate the directly- and indirectly-competing LCC dummy variables. In order to ascertain the

[12] Fisher and Kamerschen (2003), p.234.
[13] Fageda (2006), pp. 388-395.

consumer welfare effect, we will follow the method performed by Dresner et al. and need to estimate the carrier-specific demand equation as well as the pseudo-supply equation in log-linear forms. Our empirical model to obtain the effects of low-cost entry on consumers' welfare is as follows. For example, a duopoly market contains four equations (demand and pseudo-supply equations for two carriers), and the largest market does fourteen equations, which means we have seven carriers in the largest market.

[Demand equation]

$$\ln\left(Q_i^L\right) = \alpha_0 - \alpha_1 \ln p_i^L + \alpha_2 \ln INC_i + \alpha_3 \ln DIST_i + \alpha_4 \ln POP_i + \sum_{N=3}^{7} \alpha_5^N MKT_m + u_i^L \qquad (12)$$

$$\left(\alpha_1 > 0, \alpha_2 > 0, \alpha_3 > 0, \alpha_4 > 0, \alpha_5^N > 0\right)$$

[Pseudo-Supply equation]

$$\begin{aligned}\ln\left(p_i^L\right) = {} & \beta_0 + \beta_1 \ln Q_i^L + \beta_2 \ln MC_i^L + \beta_3 \ln HERF_i + \beta_4 D1LCC1_i + \beta_5 D1LCC2_i + \beta_6 D1LCR1_i \\ & + \beta_7 D1LCR2_i + \beta_8 D2LCC1_i + \beta_9 D2LCC2_i + \beta_{10} D2LCR1_i + \beta_{11} D2LCR2_i + \sum_{t=1}^{2} \beta_{12}^t LCCPE(WN)_t^D \\ & + \sum_{t=1}^{2} \beta_{13}^t LCRPE(WN)_t^D + \beta_{14} LCCPE(WN)_1^T + \beta_{15} LCRPE(WN)_1^T + \beta_{16} LCCPE(HP)_2^D \\ & + \beta_{17} LCRPE(HP)_2^D + \varepsilon_i^L \qquad (13)\end{aligned}$$

$$\left(\beta_2, \beta_3 > 0,\ \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}^t, \beta_{13}^t, \beta_{14}, \beta_{15}, \beta_{16}, \beta_{17} < 0\right)$$

where u_i^L, and ε_i^L are error terms of carrier-specific demand, and pseudo-supply equations, respectively. $D1LCC1$, $D1LCC2$, $D2LCC1$, and $D2LCC2$ are binary variables that represent the presence of LCC(s). $D1LCC1$ takes 1 if an LCC originates the primary airport and 0 otherwise, and $D1LCC2$ takes 1 if two LCCs exist in the primary route, for example, the case to connect two secondary airports such as Southwest's Houston/Hobby-Chicago/Midway, and the case to connect the primary and secondary airports such as Air Tran's Atlanta/Hertsfield-Chicago Midway.. Similarly, $D2LCC1$ takes 1 if an LCC enters the adjacent route and 0 otherwise, and $D2LCC2$ takes 1 if two LCCs enter. We assume the positive price elasticity of demand is larger for LCCs than FSCs, since FSCs usually have tools to prevent passengers from switching from FSCs to LCCs, such as mileage services. As for the pseudo-supply equation, the sign of $D1LCC1$, $D1LCC2$, $D2LCC1$, and $D2LCC2$ would be positive if both carriers perfectly distinguish themselves from each other. If they are not completely distinguished, both will compete and the signs of these four binary variables would be negative. β_1 can take either negative, positive, or zero. If a carrier supplies at its short run marginal cost curve, β_1 will be positive, and if it does on its declining average cost curve, it will be negative. In addition, if a carrier supplies at minimum efficient scale, it will be zero. $LCCPE$ and $LCRPE$ are dummy variables that are intended for measuring how the airfares of a newly entered LCC and its rival's airfares change over time. In 1998, Southwest Airlines entered the Chicago (Midway) – Manchester (New Hampshire), Chicago (Midway) – Birmingham (Alabama), and Chicago (Midway) – St. Louis markets. $LCCPE(WN)_1^D$ takes 1 for Southwest in Chicago-Manchester. The superscript and the subscript stand for the market type and the year from the new entry, respectively. For example, the superscript "*D*" means that this route is a duopoly market and the subscript 1 means the first year of Southwest's entry. $LCCPE(WN)_1^T$ takes 1 for Southwest in Chicago – Birmingham and Chicago – St. Louis markets. The superscript "*T*" means that these two routes are bigger than triopoly. $LCRPE(WN)_1^D$ and $LCRPE(WN)_1^T$ take 1 for all the other carriers in these three routes. The year 1998 is the second year of Southwest's entry in Chicago (Midway) – Jackson (Mississippi) and America West's entry in Dallas/Fort Worth – Long Beach. Therefore, $LCCPE(WN)_2^D$ and $LCRPE(WN)_2^D$ take 1 for Southwest and all the other carriers in Chicago – Jackson, respectively. $LCCPE(HP)_2^D$ and $LCRPE(HP)_2^D$ are created in the same way. The effect of these "time dummy" variables is removed from the LCC dummy variables such as $D1LCC1$ described previously.

$HERF_i$ is the Herfindahl index, and higher $HERF_i$ means that the market is more concentrated, since high concentration may lead to strong market power, the parameter will be positive. In addition, $HERF_i$ and the route-basis marginal cost of a carrier, MC_i^k, are also endogenous variables. The marginal cost is the function of output and also the independent variable of pseudo-supply equation, so theoretically we have to use the instrument variable of marginal cost. To test the null hypothesis that neither $Ln(HERF_i)$ nor $\ln MC_i^k$ is correlated with the error term ε_i, we carried out Hausman test for each variable, and reject both of the null hypotheses at 1% level of significance ($\chi^2_{(1)} = 7.41 \, and \, 23.38$, respectively). In total, our structural equations have five endogenous variables, but we show the demand, and the pseudo-supply, because the estimated results of the rest equations are out of the scope of this paper. We also computed the carrier's average cost in order to deduce producers' profits and loss and derive the total welfare by adding producers' profits and consumers' surplus.

3 The Data

We use the data of the scheduled operations by city-pair route by firm: they are 1998 cross-sectional data collected from *DB1A*, 10% samples of the US domestic flight data. Airfares are "fared passenger fares" and are described in terms of the US dollar. Omitted are the carriers which do not have 10% market share in duopoly markets, and 5% share at triopoly or markets more carriers serving. Carriers whose codes are not reported in DB1A (reported as XX) are also omitted, but, for example, a tripoly market with one XX carrier are not regarded as a duopoly market, since XX carrier is thought to have competitive effects on others. Flight data are outbound and non-connecting ones from the US six large airports and their regions: New York/Newark area, (JFK, LaGuardia, Newark), Washington Ronald Reagan (National), Atlanta Hartsfield, Dallas/Fort Worth area (DFW, and Love Field), and Los Angeles.

The source of cost data are from *Air Carrier Financial Reports ,Form 41 Financial Data.* Income and population data are from *Regional Accounts Data, Bureau of Economic Analysis.* We use the Primary Metropolitan Statistical Area data (PMSA, an urbanized county or set of counties that have strong social and economic links to neighboring communities) for each city. The descriptive statistics of continuous variables are shown in Table 9 in Appendix 3.

4. Empirical Results

4-1. Conduct Parameter

Appendix 2 shows the estimated result of route-specific demand and pseudo-supply equations by Generalized two stage least squares (G2SLS) and three stage least squares (3SLS). We obtain $\eta = -1.544$ with t-statistics = -3.711 by G2SLS and $\eta = -1.756$ with t-statistics = -4.277[14]. Both of them are acceptable value according to the survey study by Oum, Waters and Yong (1992) which surveys that the price elasticity of demand of air travel estimated by cross-sectional data ranges from -0.53 to -1.90. To estimate the tapering effect of route marginal cost and system-wide conduct parameter, we use the result obtained by G2SLS, since by our simulation we have found that conduct parameters of each carriers fall in the theoretical interval (that is, $\nu \in [0,1]$) better when using $\eta = -1.544$ than using $\eta = -1.756$. Using the positive value of price elasticity, we estimate equation (9) by Non Linear Least Squares. The result is shown in Table 1.

Table 1 Estimated result of non-linear pseudo-supply equation (9)

	Parameter	SE	t-stat.	P-Value
λ	0.271	0.097	27.894	0.000
ν	-0.053	0.030	-1.782	0.075
Statistics	Log likelihood=-6454.86, n=1163,			
	Maximum Likelihood of estimated $\hat{\sigma}^2$ =3875.7			

According to Table 1, the tapering effect of marginal cost is 0.271 which falls between Oum, Zhang and Zhang (1993) and Borenstein (1990). The system-wide conduct parameter is -0.053 which is not rejected the null hypothesis that $\nu = 0$ at 5% level. Therefore, we conclude that Cournot competition is performed in the US air markets that experienced low-cost entry.

Figure 1 Market share and Distribution of Conduct Parameter

[14] See Table 7 in Appendix 1.

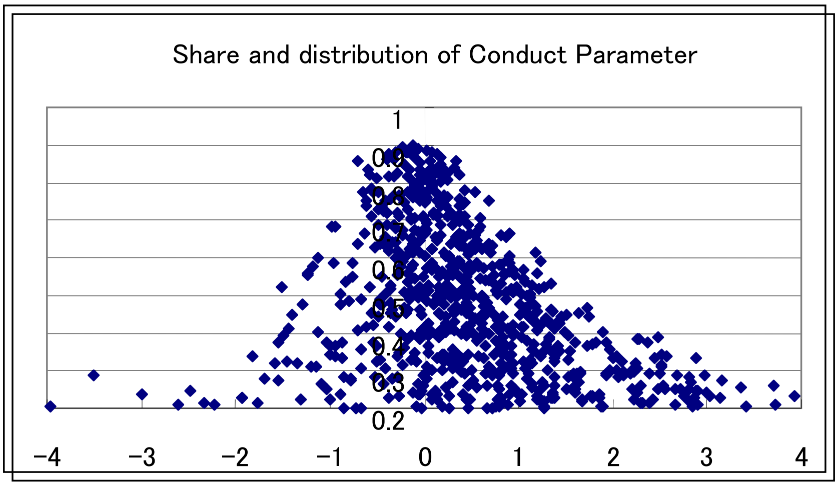
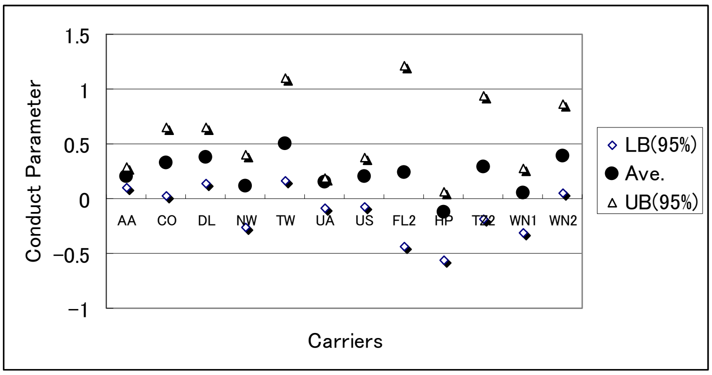


Figure 1 shows the distribution of conduct parameter of each carrier which has at least 20% market share. The horizontal axis is the conduct parameters and vertical axis is carrier's market share. The figure shows that carriers which have large market share (about 65% or more) conduct in accordance with the economic theory, but "fringe" carriers do not (their airfares conduct parameters are incredibly low or high). The low outliers of conduct parameters can be regarded as the outcome of increasing too much capacity to try to increase market share. Then as a result, equilibrium airfares go down. The high outliers may take place when a carrier does not know the demand curve for itself, and limits its capacity. In such a case it may happen that its amount of capacity is smaller than the profit maximizing level, so is its airfare higher than the monopoly level.

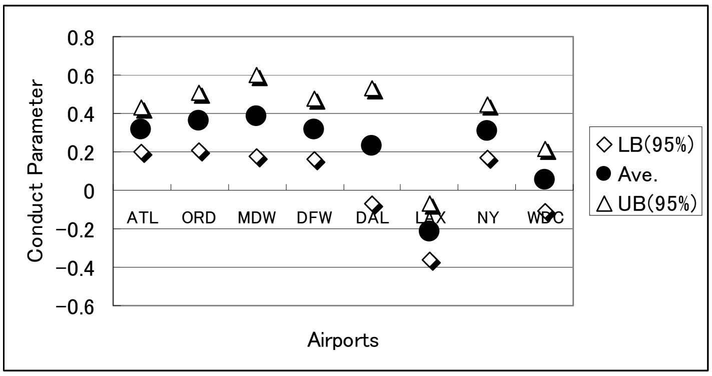
Figure 2 demonstrates the average value of each carrier's conduct parameter and its 95% confidence interval. According to Figure 2, full service carriers perform Cournot competition or more collusively than Cournot competition. On the other hand, LCC's behave more variously than full service carriers. The most interesting sample is Southwest Airline (WN)'s behavior. Its conduct parameters at the secondary airports (Dallas Love and Chicago Midway) are higher than those at primary airport (Los Angeles), probably because WN can regionally build more monopolistic situation at the secondary airports than at primary airport, although it must be competing with full service carries at the primary airport. This implies that Southwest earns its profit mainly at the secondary airport. Contrarily with the case of Southwest, America West Airlines (HP) and Spirit Airlines (NK) ,in most cases, competes with full service carriers directly at the primary airports and this leads to the result that its conduct parameters are lowest among LCCs. Other LCCs such as Air Tran (FL) and ATA (TZ), which also enter and base secondary airports like Southwest, have higher conduct parameters, but their conduct parameters vary more widely than other carriers. In some cases in our dataset, their market shares are very small, so they seems to create new demand that results in low airfares, and to counterbalance the losses generated by low airfares with higher airfares than their average at other thriving markets.

Figure 2 Average conduct parameters with 95% confidence interval



Note: AA: American Airlines, CO: Continental Airlines, DL: Delta Airlines, NW: Northwest Airlines, TW: TWA, UA: United Airlines, US: US airways

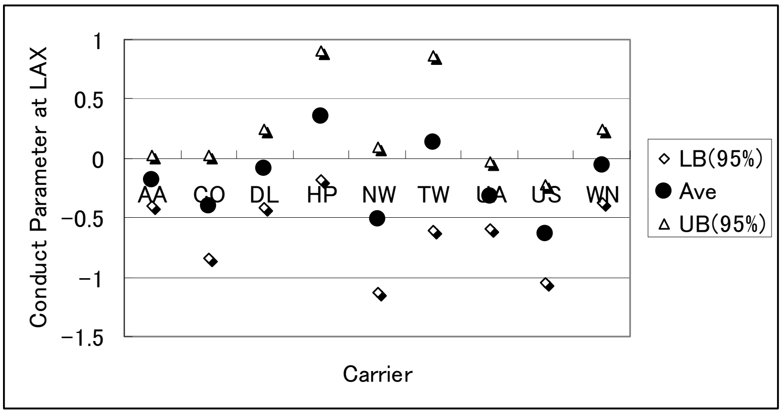
Figure 3 Average Conduct Parameter at Origin Airport



Note: LB and UB means lower bound and upper bound, respectively.

Figure 3 shows the average conduct parameter and its 95% confident interval of all the airlines which originate in ATL '(Atlanta), ORD (Chicago O'Hare), MDW (Chicago Midway), DFW (Dallas=Fortworth), DAL (Dallas Lovefield), LAX (Los Angeles), NY (average of JFK, LaGuardia, and Newark), and WAS (Washington Dulles and Ronald Regan). It is apparent that the conduct parameters at Los Angeles International Airport, where multiple numbers of LCCs enter, are lower than any other airport and those at Washington D.C., where there are multiple numbers of LCCs enters, airfares are also low. On the contrary, these results are not followed by the following two cases: one is the case in which an LCC entered but its presence is weak, and the other is the case in which LCCs entered the adjacent secondary airport. In the latter case, LCCs as well as full service carriers must have regional market power and can keep their conduct parameters higher than the level of Cournot competition. This implies that both full service carriers and LCCs benefit, despite the rivalry between carriers at the primary airports and those at the secondary airport.

Figure 4 Average Conduct Parameter of each airline at Los Angeles



Note: LB and UB means lower bound and upper bound, respectively.

Figure 4 shows the average conduct parameter of each airline with 95% confidence interval. On average, conduct parameters of full service carriers are lower than the level of Cournot competition except for TWA. Two LCCs, America West and Southwest, keep their conduct parameters a little higher than full service carriers. This fact implies that these big LCCs are better off than full service carriers.

Table 2 demonstrates the partial correlations selected variables used in our analysis. Focusing on the correlation between the conduct parameter and other variables, we find that the conduct parameter is negatively correlated with market share and distance at 1% level of significance. These results are consistent with Oum, Zhang, and Zhang (1993): a carrier with high market share tries to expel fringe carriers by expanding their supply, and then market airfare goes down. Goolsbee and Syverson (2005) , and Oliveira and Huse (2009) point out these capacity-expanding behaviors of carriers. We conclude that this type of competition takes place in long haul markets than in short haul ones.[15] The positive

[15] There are many dimensions to the discussion about the relationship between distance and degree of competition. One may insist that the competition becomes softer in long-distance markets because the

correlation between conduct parameter and profit is also consistent with the theory of economics.

Table 2 Partial Correlations between Conduct Parameter and Other Variables

	Conduct Parameter	Market Share	Distance	Herfindahl Index	Profit
Conduct Parameter	−				
Market Share	−0.359**	−			
Distance	−0.515**	−0.079*	−		
Herfindahl Index	−0.037	0.607**	−0.172**	−	
Profit	0.272**	0.242**	−0.389**	0.157**	−

Note: ** and * means it is significant at 1% and 5% level, respectively.

4-2. Carrier-Specific impact of Low-Cost Entry

This subsection investigates how the impacts of low-cost entry on full service carrier's behaviors differ when (an) LCC(s) enter(s) in the primary or secondary airport, and whether the number of LCC's affects the full service carrier's behaviors. We simultaneously estimated equation (12) and (13) by iterated 3SLS method and the results are shown in Table 8 in Appendix 4. Table 3 is the summary parameters of LCC's and their rival's dummy variables which are picked up from Table 8.

Table 3 Summary of parameters of LCC's and their rival's dummy variables

	Parameters	Standard error	Difference between one and multi carrier(s) [16]

number of surface competitors declines and because LCCs tend to enter short- and medium-distance markets. Another viewpoint is that short-distance air markets are normally small markets. Therefore, in many cases we observe more carriers entering long-distance markets than short-distance markets, and this is supported by the fact that the partial correlation between distance and the Herfindahl index is -0.172, which is statistically significant at the 1% level (see Table 2). Considering these offsetting effects, it is an empirical issue whether the competition is softer in long-distance markets.

[16] The Wald tests that test the hypothesis that two parameters are equal are not rejected at all at 5% level.

One LCC at Primary	-0.340	0.031	None at 5% level
Multiple LCCs at Primary	-0.299	0.064	
FSC at Primary competing with one LCC	-0.172	0.028	None at 5% level
FSC at Primary competing with multiple LCCs	-0.155	0.045	
One LCC at Secondary	-0.377	0.073	None at 5% level
Multiple LCCs at Secondary	-0.174	0.058	
FSC at Primary competing with one LCC at Secondary	-0.403	0.077	None at 5% level
FSC at Primary competing with multiple LCCs at Secondary	-0.190	0.067	

Table 3 tells us that the quantity competition between LCCs and full service carriers leads to significant discount in their airfares comparing with the benchmarked full service carriers. The number of LCCs does not statistically affect LCC's and rival's airfares, though it appears it does at the secondary airports. In other words, the first entry leads to significantly low market airfares, but the second or later entry does not. These results are almost consistent with the results of Dresner et al.(1996) which also introduce the dummy variables that reflect the number of competitive carriers. While they do not statistically test the difference of parameters of these dummy variables, our analysis reveals that the additional entries do not affect the rival's capacity-expanding behaviors that may affect their airfares. In the perfectly contestable markets, the number of firm does not affect the capacity or airfare. Since the first entry significantly affects the airfare, we can reject the hypothesis of perfect contestability.

: One interesting finding is that capacity-expanding and consecutive airfare-reducing effects at the secondary airport look greater than those at the primary airport, although they are not statistically significant. For example, an LCC's airfare at the secondary airport is -0.377 while that at the primary airport is -0.340[17]. To explain this phenomenon, we replace all the carrier-related dummy variables (D1LCC1, D1LCC2, D2LCC1, D2LCC2, D1LCR1, D1LCR2, D2LCR1, and D2LCR2) in Table 6 with each carrier's dummy variable, and re-estimate the carrier-specific structural equations using the same data and the same estimation method. The result is shown Table 9 in Appendix 5, and the summary of the parameters of carrier dummy variables is shown in Table 4.

The methods to introduce each carrier's dummy variable are as follows: for example, speaking of Southwest (WN), we introduce WN1, WNR1, WN2, and WNR2. WN1 takes 1 for Southwest operating in the primary airport, and WNR1 takes 1 for the full service carriers that are competing with Southwest at the primary airport. Similarly, WN2 takes 1 for Southwest operating in the secondary airport, and WNR2 takes 1 for the full service carriers that are competing with Southwest at the primary airport. This method of introducing carrier dummy variables is followed by all the other carriers shown in Table 3, except for Spirits Airlines and Tower Airlines. They did not operate the secondary airports in our dataset, so we have neither NK2, NKR2, FF2, nor FFR2.

Table 4 Carrier-specific impacts on airfare at primary and secondary airports

	LCC's airfare		FSC's airfare	
Entry by	Primary	Secondary	Primary	Secondary
KP (Kiwi Int'l)	−0.560 (0.179a)	−0.368 (0.252)	−0.132 (0.120)	0.109 (0.183)
TZ (ATA)	−0.200 (0.870b)	−0.081 (0.067)	0.007 (0.052)	0.032 (0.047)
HP (America West)	−0.042 (0.042)	−0.451 (0.254)	0.008 (0.029)	−0.015 (0.129)
FL (Air Tran)	−0.537 (0.047a)	−0.406 (0.146a)	−0.310 (0.043a)	−0.105 (0.091)
NJ (Vanguard)	−0.554 (0.090a)	−0.495 (0.147a)	−0.158 (0.069)	0.249 (0.099b)
NK (Spirit Air)	−0.556 (0.146a)		−0.255 (0.127b)	

17 The Wald test cannot reject the hypothesis that these two values are equal at 10% (Chi-square with d.o.f.=1 is 2.01).

WN (Southwest)	−0.414	(0.050a)	−0.375	(0.042a)	−0.296	(0.033a)	−0.247	(0.029a)
FF (Tower Air)	−0.754	(0.121a)			−0.106	(0.080)		

Note: Values are the parameters of carrier dummy variables, and standard errors are in parentheses. "a", "b", and "c" mean that they are significant at 1% and 5%, respectively.

Table 4 tells us that Southwest's capacity-expanding behavior at the primary airports leads to very low airfares, and so does in the secondary airports with a little higher airfares than in the primary airports. Full service carriers also expand their capacities to cope with Southwest, and subsequent airfares reduction is greater in the primary airport than in the secondary airports. These results as for Southwest are quite comprehensive, but are not necessarily followed by other LCCs. It is, indeed, almost common for LCCs to operate with very low airfare at the primary airports, but even this pricing strategy is fallacy for America West (HP). Competitions caused by Vanguard Airlines (NJ), which used to hub Chicago Midway Airport, and Air Tran (FL) lead to low airfares both at the primary and the secondary airports, but the impact of their presence on rival's airfares at the secondary airport are much weaker than that of Southwest's. Only does Southwest give competitive pressure to the full service carriers at remote airports.

The results in Table 4 that shows the entry-impact is stronger in the primary airport than in the secondary airports for most LCCs seem to contradict with the results in Table 3. One reason is that the effect of America West, the entry of which exceptionally leads to lower airfares at the secondary airports than at the primary airport, is strongly reflected for the estimation of Table 3. America West can not be regarded as a true LCC, because its average airfares are almost the same as those of typical full service carriers. However, since America West bases Chicago Midway which is less convenient than O'Hare international Airport in terms of access, it may have to discount the airfare to offset the inconvenience of access. On the other hand, Southwest and Air Tran, which also base Chicago Midway, are true LCCs and their entry consistently leads to low airfares anywhere, and discount effects are much more at the primary airports than at the secondary airports.

About relation between the conduct parameters and airfare level, we find that, as may be expected, full service carriers are better off without any entry by LCC, but they achieve higher conduct parameter with LCC(s) at the secondary airport than for the benchmark case where full service carriers are competing with each other. (See Table 5).

Table 5 Conduct parameters and airfares of FSCs and LCC(s) at the primary and secondary airports

	Full Service Carrier					Low Cost Carrier				
	Conduct Parameter	Lower Bound of CP	Upper Bound of CP	Airfare	n	Conduct Parameter	Lower Bound of CP	Upper Bound of CP	Airfare	n
No LCC	0.289	−1.250	1.828	benchmark	413					
One LCC at Primary Airport	0.100	−2.205	2.405	−0.217	169	0.394	−1.497	2.285	−0.347	56
One LCC at Seconday Airport	0.575	−0.977	2.127	−0.161	81	0.501	−0.843	1.845	−0.393	41
Two LCCs at Primary Airport	0.011	−2.012	2.034	−0.187	11	0.486	−0.853	1.825	−0.348	13
Two LCCs at Secondary Airpo	0.317	−1.572	2.206	−0.297	16	0.245	−2.078	2.568	−0.447	15

In Table 5, leaving out the outliers of conduct parameters, we take the average of average of conduct parameters and 95% confidence intervals for full service and low-cost carriers for the cases in which (an) LCC(s) enter(s) in the primary and secondary airports

When an LCC enters in the adjacent market, full service carriers may quit competition within the primary airport and try to win the competition with the LCC. In addition, both full service carriers and the LCC can keep, although not strong, the regional monopolistic power comparing with the case of head to head competition at the primary airports. This is why conduct parameters at the primary airport is comparatively high for the case in which one LCC enters in the secondary airport. One interesting finding is that LCCs at the secondary airport can keep a little large price-cost margin despite their low-airfares. One reason is that since the airport charges at the secondary airport are not so expensive as those at the primary airport, LCC can benefit though average airfares are low.

Our last findings from pseudo-supply equations are that the degree of competition started by Southwest is significant in the entry year and is continued to the second year of entry for some duopoly cases, whereas this does not hold for the other cases (See the parameters of $LCCPE(WN)_1^D$, $LCCPE(WN)_2^D$, $LCRPE(WN)_1^D$, and $LCRPE(WN)_2^D$). The factor that causes these four results is the market share an LCC gains in the entry year. If Southwest can gain a large market share in the entry year, the incumbent pays close attention to the competitor’s entry and increases its capacity, and as a result airfares are kept as low as, or much lower than the level in the entry year. On the other hand, if Southwest cannot gain much share in the entry year, the incumbent expects the competition will end soon and it actually ends in the second year. Another way of explaining the latter case may be the tacit collusion due to multi-market contacts suggested by Bernheim and Whinston (1990), and empirically tested by Evans and Kessides (1994) and Morrison and Winston (1995). Bernheim and Whinston suggested that collusive behavior due to multi-market contacts can take place even though the cost level differs between firms and the products are differentiated in the repeated game. We will investigate this dynamic issue further in a future study.

5. Welfare Effect

Our final analysis is to compute the consumer's, producer's, and total welfare. Since we do not have the supply curve under the imperfect competition, we do not compute the true producer's surplus. Instead, we compute the carrier's profit calculated by the carrier's route average cost, carrier's average yields, and the number of passengers for a carrier. The route average cost is computed by the product of the route distance and carrier's unit cost (total cost / aggregate RPM). The consumer's surplus is computed by the following method: we compute the area of "trapezoids" of our demand equation (11) which are surrounded by the benchmark airfare, lowered airfare computed from the carrier-related dummy variables, benchmark output and increased output due to low-cost competition. Figure 5 illustrates the change in consumer's surplus in a simple way. The trapezoid A is the gain in consumer's surplus due to LCC's entry in the primary airport, and trapezoid C is also the gain in consumer's surplus due to full service carrier's reaction to LCCs at the primary airport (FSC's airfare is higher than LCC's). Similarly, the trapezoids B and D are those for the cases of secondary airports. Since the market demand is the sum of the demands for each carrier, the total welfare is the sum of the trapezoids of LCCs and those of full service carriers for the entry in the primary and the secondary airports (that is, A+B+C+D).[18]

Figure 5 Gains in Consumer's Surplus

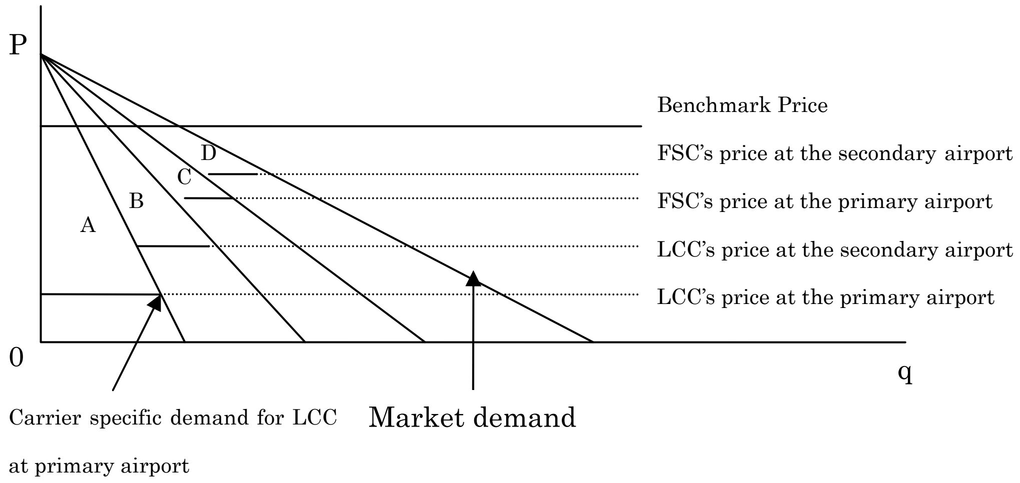


Table 6 demonstrates the gain in consumer's surplus, newly-entered LCC's profit, the change in full service carrier's profit, and the gain in total welfare. Since we limit the number of sample observations by selecting only six airport groups, the amounts themselves may not be important. However, the results imply, in overall, that the gain in consumer's surplus is very large, and LCCs also benefits by entry. On the other hand, full service carriers are losing their profits due to the low-cost entry, and especially their losses due to the competition from the adjacent airport are mostly caused by the entry by Southwest. However, since the losses of full service carriers are much smaller than the sum of the gain in consumer's surplus and LCC's profits, the gain in total welfare is apparently large. Considering the results in Figure 2, full service carriers are suffering from the decrease in profits, although they keep the conduct parameters at more than Cournot level, while LCCs are benefiting at smaller conduct parameters than full

[18] Since we introduce LCC dummy variables, the intercepts of LCCs have to be lower than those of full service carriers, but for convenience we depict them as shown in Figure 5.

service carriers.

Table 6 Summary of welfare effect of LCC's entry

Due to:	Gain in Cons. Welf.	Newly entered LCC's Profit	Change in FSC's Profit	Gain in Total Welf.
An LCC's entry into Primary Airport	5.33	1.28	−0.48	**6.13**
An LCC's entry into Secondary Airport	5.05	1.27	−0.34	**5.98**
Two LCCs' entry into Primary Airport	5.31	1.08	−0.22	**6.17**
Two LCCs' entry into Secondary Airport	7.29	0.82	−0.88	**7.23**
Sum of the Gain in Welfare	**22.98**	**4.45**	**−1.92**	**25.51**
Million USD (Cons, Welf. = Consumer's Welfare). Total Welf. = Total Welfare				

6. Summary and conclusion

Our findings on the competitive behaviors of full service- and low-cost carriers and welfares are as follows:

(1) Full service carriers suffer from the competition with LCC(s) at the primary airports: they expand their capacities and their airfares drop statistically low and so are the conduct parameters, although the differences of conduct parameters are not statistically significant. This fact implies that full service carriers do not benefit when LCC(s) enters in the same airports.

(2) The conduct parameters of LCCs are, on average, higher than those of full service carriers, and this fact implies that LCCs do not necessarily performing the cut-throat competition with thin price-cost margin but they make reasonable profits in spite of their low airfares, especially when they stay their dominant secondary airport such as Southwest's Dallas Love Field.

(3) As for the impact of the first entry of an LCC and the consecutive entry, the first entry has great impact on output and airfare, but the second and more additional entry have not much impact than the first one.

(4) Full service carriers are better off without any entry by LCC, but they achieve higher conduct parameter with LCC(s) at the secondary airport than for the benchmark case where full service carriers are competing with each other.

(5) It is recognized that an LCC's low-airfare entry has capacity-expanding and airfare-reducing effects on its rival at an initial stage, but whether these effects are maintained in the long run seems to be dependent on each carrier.

(6) It sometimes happens that competition between LCCs and full service carriers ends in the second year of a new entry, especially when a newly entered LCC cannot gain sufficient market share. We need to further investigate the issues of dynamic competition in the future.

(7) It is implied that total gains of welfare due to LCCs' entries seems to be substantial, and 90% of welfare gains come from the gain in consumer's surplus and the rest comes from the profit of LCCs. It is also implied that full service carriers do not earn profits although their price-cost margins are not necessarily low. This fact seems to be due to their high average cost level.

Furthermore, our important finding is that LCC's conduct parameters sometimes take unreasonably high value. In such a case, LCCs may not know their own demand curve and determine capacities and airfares "the left" of profit-maximizing" point. This fact may imply that the conduct parameters will take wider range than the range that the economic theory assumes.

[2009.6.12 929]

References

Armantier, O, and O. Richard (2003), "Exchanges of Cost Information in the Airline Industry," *RAND Journal of Economics* Vol.34 No.3, pp.461-477.

Applebaum, E. (1982), "The Estimation of the Degree of Oligopoly Power," *Journal of Econometrics* Vol.19, pp.287-299.

Bailey, E.E., D.R. Graham, and D.P. Kaplan (1985), *Deregulating the Airlines*, MIT Press, pp.153-172.

Bernheim,D. and M. Whinston (1990),"Multimarket Contact and Collusive Behavior," *RAND Journal of Economics*, 21, 1-26

Borenstein, S. (1990), "Hub and High Prices: Airport Dominance and Market Power in the U.S. Airline Industry," *RAND Journal of Economics* Vol.20, pp.344-365.

Brander, J. A., and A. Zhang (1990), "Market Conduct in the Airline Industry: An Empirical Investigation," *RAND Journal of Economics* Vol.21, pp.567-583.

Brander, J. A., and A. Zhang (1993), "Dynamic Oligopoly Behavior in the Airline Industry," *International Journal of Industrial Organization* Vol.11, pp.407-435.

Bresnahan, T. (1981), "Duopoly models with consistent conjectures",. *American Economic Review* 71, pp.934-945.

Bresnahan, T. (1989), "Empirical studies of industries with market power. In: Schmalansee R., and R. Willig,(Eds.), *The Handbook of Industrial Organization*, vol. II. Elsevier, Amsterdam.

Caves, D. W., L. R. Chistensen, and M. W. Tretheway (1984), "Economies of Density versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ," *RAND Journal of Economics* Vol.15, pp.471-489.

Corts, K.S. (1999), "Conduct parameters and the measurement of market power," *Journal of Econometrics,* 88, pp.227-250.

Dresner, M., J. S. C. Lin, and R. Windle (1996), "The Impact of Low-Cost Carriers on Airport and Route Competition," *Journal of Transport Economics and Policy* Vol.30, No.3, pp.309-328.

Evans, W.N. and I. N. Kessides (1994), "Living by the "Golden Rule": Mutimarket Contact in the U.S. Airline Industry," *Quarterly Journal of Economics,* Vol.109, No.2, pp.341-366.

Fageda, X. (2006), "Measuring Conduct and Cost Parameters in the Spanish Airline Market", Review of Industrial Organization 28, pp.279-399.

Fischer T. and Kamerschen D. R. (2003), "Price-Cost Margins in the US Airline Industry Using a Conjectural Variation Approach," *Journal of Transport Economics and Policy* Vol.37 No.2, pp.227-259.

Fu, X., M. Lijesen, and T.H. Oum (2006), "An Analysis of Airport Pricing and Regulation in the Presence of Competition between Full Service Airlines and Low Cost Carriers", *Journal of Transport Economics and Policy,* Vol.40, No.3, pp.425-447.

Goolsbee, A. and C. Syverson (2005), "How Do Incumbents Respond to the Threat of Entry? Evidence from the Major Airlines," *NBER Working Paper* 11072.

Hofer, C., R. Windle, and M. Dresner (2008), "Price premiums and low cost carrier competition," *Transportation Research Part E,* 44, pp.868-882.

Iwata, G. (1974), "Measurement of Conjectural Variation in Oligopoly," *Econometrica*, Vol.42, pp.947-966.

Joskow, A, G. Werden and R. Johnson (1994), "Entry, exit, and performance in airline markets," *International Journal of Industrial Organization* **12**, pp. 457–471

Mason, C. F ., O.R. Phillips, Owen and C. Nowell (1992), “Duopoly Behavior in Asymmetric Markets: An Experimental Evaluation,” Review of Economics and Statistics, Vol. 74, No. 4, pp. 662-670.

Morrison, S. A. (2001), “Actual, Adjacent, and Potential Competition: Estimating the Full Effect of Southwest Airlines,” *Journal of Transport Economics and Policy,* Vol.35, No.2, pp.239-256.

Morrison, S. A. and C. Winston (1995), *The Evolution of Airline Industry*, Brookings Institution.

Olivelia, A.V.M.(2008), “An Empirical Model of Low-Cost Carrier Entry”, *Transportation Research* A, 42-4, 673-695.

Olivelia, A.V.M., and C. Huse (2009), **“**Localized competitive advantage and price reactions to entry: Full-service vs. low-cost airlines in recently liberalized emerging markets,” *Transportation Research Part E*, 45, pp.307-320.

Oum, T. H., A. Zhang., and Y. Zhang (1993), “Inter-Firm Rivalry and Firm-Specific Price Elasticities in the Deregulated Airline Markets”, *Journal of Transport Economics and Policy* Vol.27 No.2, pp.171-192.

Oum, T.H., W. Waters II, and Yong (1992), “Concepts of Price Elasticities of transport Demand and Recent empirical Estimates”, *Journal of Transport Economics and Policy*, Vol. 26, No.2, pp.139-154.

Pitfield, D.E.(2005), “Some Speculations and Empirical Evidence on the Oligopolistic Behavior of Competing Low-Cost Airlines”, *Journal of Transport Economics and Policy*, Vol. 39, No.3, pp.379-390.

Pitfield, D.E.(2008), “The Southwest effect: A time-series analysis on passengers carried by selected routes and a market share comparison,” *Journal of Air Transport Management*, Vol.14, No.3, pp.113-122.

Puller, S.L. (2008),” Estimation of competitive conduct when firms are efficiently colluding: addressing the Corts critique,” *Applied Economics Letters*, February, pp.1-4.

Appendix 1

Table 7 Estimated result of route-specific structural equations

		Generalized 2SLS				3SLS			
Demand Equation		COEF	SE	t-RATIO	t-test	COEF	SE	t-RATIO	t-test
Constant	a0	-15.287	7.326	-2.087	b	-19.226	6.481	-2.967	a
Market airfare	a1	-1.544	0.416	-3.711	a	-1.756	0.411	-4.277	a
Income	a2	1.574	0.678	2.323	b	1.960	0.621	3.157	a
Population	a3	0.963	0.109	8.806	a	0.997	0.091	10.902	a
Distance	a4	0.195	0.205	0.950		0.272	0.181	1.499	
Triopoly Dummy	a5	0.330	0.097	3.396	a	0.333	0.098	3.399	a
4-firm Dummy	a6	0.699	0.145	4.828	a	0.632	0.145	4.365	a
5-firm Dummy	a7	0.989	0.234	4.225	a	0.931	0.222	4.199	a
6-firm Dummy	a8	0.350	0.268	1.309		0.344	0.336	1.022	
7-firm Dummy	a9	0.571	0.426	1.340		0.561	0.431	1.301	
Pseudo supply Equation		COEF	SE	t-RATIO	t-test	COEF	SE	t-RATIO	t-test
Constant	b0	0.825	0.820	1.006		0.308	0.839	0.367	
Output	b1	0.053	0.049	1.087		0.079	0.050	1.567	
Distance	b2	0.572	0.073	7.801	a	0.622	0.073	8.472	a
Herfindahl Index	b3	0.079	0.129	0.612		0.075	0.131	0.575	
Diversity of MC	b4	-0.026	0.011	-2.337	b	-0.031	0.011	-2.838	a
DLCC1	b5	-0.206	0.067	-3.084	a	-0.206	0.068	-3.016	a
DLCC2	b6	-0.190	0.092	-2.070	b	-0.155	0.093	-1.670	
Statistics	R-Square of demand equation: G2SLS=0.458, 3SLS=0.441								
	R-Square of pseudo-supply equation: G2SLS=0.430, 3SLS=0.218								
	R-Square of structure equation: G2SLS=0.546, 3SLS=0.549								
	n=405, "a": significant at 1%, "b": 5%								

Appendix 2

Table 8 Estimated result of carrier-specific structural equations

	Demand Equation					
	Model 1			Model 2		
VARIABLES	Parameter	SE	P-VALUE	Parameter	SE	P-VALUE
Airfare	-1.387	0.334	0.000	-1.260	0.271	0.000
Distance	0.092	0.138	0.501	0.029	0.113	0.801
Per-Capita Income	1.883	0.430	0.000	1.648	0.392	0.000
Average Population	0.783	0.069	0.000	0.844	0.067	0.000
Dummy for Triopoly Market	-0.092	0.082	0.265	-0.112	0.079	0.157
Dummy for 4-firm Market	-0.194	0.113	0.085	-0.186	0.105	0.075

Dummy for 5-firm Market	0.072	0.147	0.627	0.063	0.136	0.645
Dummy for 6-firm Market	-0.736	0.213	0.001	-0.674	0.199	0.001
Dummy for 7-firm Market	-0.641	0.274	0.019	-0.565	0.260	0.029
Dummy for LCCs at Primary AP	-0.582	0.159	0.000	-0.567	0.140	0.000
Dummy for LCCs at Secondary AP	-0.350	0.197	0.075	-0.283	0.170	0.097
Constant	2.458	1.282	0.055	3.013	1.266	0.017
	Pseudo-Supply Equation					
VARIABLES	Parameter	SE	P-VALUE	Parameter	SE	P-VALUE
Output	0.120	0.023	0.000	0.079	0.021	0.000
Route Marginal Cost	0.609	0.053	0.000	0.504	0.023	0.000
Diversity of MC	-0.055	0.051	0.276	-0.022	0.013	0.086
Herfindahl Index	0.141	0.045	0.002	0.183	0.035	0.000
D1LCC1	-0.340	0.031	0.000			
D1LCC2	-0.299	0.064	0.000			
D1LCR1	-0.172	0.028	0.000			
D1LCR2	-0.155	0.045	0.001			
D2LCC1	-0.377	0.073	0.000			
D2LCC2	-0.174	0.058	0.003			
D2LCR1	-0.403	0.077	0.000			
D2LCR2	-0.190	0.067	0.005			
KP at Primary Airport				-0.560	0.179	0.002
KP at Secondary Airport				-0.368	0.252	0.144
KP's Rival at Primary Airport				-0.132	0.120	0.270
KP's Rival at Secondary Airport				0.109	0.183	0.550
TZ at Primary Airport				-0.200	0.087	0.021
TZ at Secondary Airport				-0.081	0.067	0.230
TZ's Rival at Primary Airport				0.007	0.052	0.898
TZ's Rival at Secondary Airport				0.032	0.047	0.503
HP at Primary Airport				-0.042	0.042	0.324
HP at Secondary Airport				-0.451	0.254	0.076
HP's Rival at Primary Airport				0.008	0.029	0.792
HP's Rival at Secondary Airport				-0.015	0.129	0.907
FL at Primary Airport				-0.537	0.047	0.000
FL at Secondary Airport				-0.406	0.146	0.005
FL's Rival at Primary Airport				-0.310	0.043	0.000

FL's Rival at Secondary Airport				-0.105	0.091	0.251
NJ at Primary Airport				-0.554	0.090	0.000
NJ at Secondary Airport				-0.495	0.147	0.001
NJ's Rival at Primary Airport				-0.128	0.069	0.064
NJ's Rival at Secondary Airport				0.249	0.099	0.012
NK at Primary Airport				-0.556	0.146	0.000
NK's Rival at Primary Airport				-0.255	0.127	0.044
WN at Primary Airport				-0.414	0.050	0.000
WN at Secondary Airport				-0.375	0.042	0.000
WN's Rival at Primary Airport				-0.296	0.033	0.000
WN's Rival at Secondary Airport				-0.247	0.029	0.000
FF at Primary Airport				-0.754	0.121	0.000
FF's Rival at Primary Airport				-0.106	0.080	0.186
F9 at Primary Airport				-0.392	0.114	0.001
F9's Rival at Primary Airport				-0.051	0.073	0.482
LCCPE(WN)1 Duopoly	-0.363	0.298	0.222	-0.431	0.251	0.086
LCRPE(WN)1 Duopoly	-0.077	0.294	0.794	-0.116	0.251	0.644
LCCPE(WN)1 Triopoly	-0.365	0.213	0.086	-0.409	0.180	0.023
LCRPE(WN)1 Triopoly	-0.326	0.134	0.015	-0.351	0.114	0.002
LCCPE(WN)2 Duopoly	-0.351	0.292	0.229	-0.410	0.251	0.102
LCRPE(WN)2 Duopoly	-0.079	0.291	0.786	-0.145	0.252	0.566
LCCPE(HP)2 Duopoly	-0.613	0.292	0.035	-0.616	0.251	0.014
LCRPE(HP)2 Duopoly	-0.497	0.294	0.091	-0.469	0.254	0.065
Constant	1.601	0.235	0.000	1.980	0.208	0.000
Statistics of Model 1	System R-Square=0.552 Test of overall significance: $\chi^2_{(30)}$=933.1 (P-value=0.000)					
Statistics of Model 2	System R-Square=0.677 Test of overall significance: $\chi(51)$ 2=1312.7 (P-value=0.000)					

Appendix 3

Table 9 The descriptive statistics of continuous variables used for the computation of consumer's welfare

	Average	S.E.	Minimum	Maximum	Median
Output	155010.0	191486.3	10660.0	1143550.0	82185.0

Airfare	175.3	62.6	49.4	354.4	172.7
Population	3274440.1	1701878.1	161757.0	11792430.2	2958991.6
Income	31907.3	2933.5	26047.8	38346.7	32238.4
Herfindahl index	49.8	13.7	15.3	81.9	50.4