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Low-Cost Entry, Inter-Firm Rivalry, and Welfare
Implications in Large U.S. Air Markets

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Low-Cost Entry, Inter-Firm Rivalry, and Welfare Implications in Large U.S. Air Markets

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Abstract

In this paper we analyze empirically the patterns of inter-firm rivalry between low-cost carriers (LCCs) and full-service carriers (FSCs) by carrier and airport base, and demonstrate what the social welfare gains were, using 1163 samples of U.S. cross-sectional data of 1998.   Our main findings are: (1) that both LCCs and FSCs maintained higher price-cost margins especially when LCCs used secondary airports, (2) that total gains of welfare were 25.5 million USD for our dataset, and 90% of welfare gains came from the gain in consumer surplus, and (3) that LCCs sometimes set more-than-monopoly prices instead of profit-maximizing ones.

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

1. **Introduction**

    There have been many studies on the economic impact of the U.S. low-cost carrier (LCC)'s

entry into the transportation market.   Dresner et al (1996) and Morrison (2001) showed the

price-reducing effect of low-cost entry on the primary and adjacent markets by incorporating LCC

dummy variables.   Pitfield (2005) studied the price change after low-cost entry by time series analysis.

In studies on inter-firm rivalry, Brander and Zhang (1990) (1993), Oum, Zhang, and Zhang (1993),

Fischer and Kamerschen (2003), and Murakami (2008) empirically estimated the conduct parameters of

airline industries, the first three in the U.S. and the last one in Japan. Fu, Lijensen, and Oum (2006)

studied the question of LCCs vs. FSCs (full-service carriers) 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 also examine the issues of low-cost competition and inter-firm rivalry

measured by conduct parameters, highlighting not only the duopoly but also the larger markets where

more than two carriers operate, whereas previous studies deal with the duopoly case.   The present study

has the following distinguishing features:

(1) We apply the theory of conduct parameters to the analysis of the competition between low-cost and

full-service carriers, and analyze the carrier-specific competitive behaviors.

(2) 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 previous studies, i.e., we analyze the inter-firm rivalry of

21 carriers, 9 of which are LCCs, and 1163 cross-sectional samples.

(3) We try to explain precisely why the entry of LCCs lowered the price using the idea of "vertical

differentiation of product" and predict in which directions market output and price would move if an LCC

lowered its marginal cost against those of FSCs. The authors of many previous works skip this

analytical process.

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

(5) We estimate not only the effects of LCCs' price discounting on LCCs but also the impact of such

discounting on airfares of FSCs.

(6) We present the total welfare, whereas the authors of previous studies focus on the consumer welfare

only.

In Section II the conduct parameter and simultaneous equations are derived and then converted

to an econometric model. In Section III the data and the empirical results are demonstrated and several

analyses of inter-firm rivalry between LCCs and FSCs are performed. In Section IV welfare

implications are presented as concluding remarks.

2. **The model**

Early studies on the conduct parameter (conjectural variation) used to analyze inter-carrier

rivalry were written by Iwata (1979) and Appelbaum (1982), and they were followed by the studies on

airline industries listed in Section I. The studies on the airline industry use cross-sectional data and

focus on duopolies, in which two "symmetric" carriers, such as United Airlines and American Airlines,

compete.

Like many studies, this analysis uses cross-sectional data. Our choice of year was 1998. This was before LCCs such as ATA and Jetblue entered the long distance market and provided "some frills" service. Around 1998, LCCs persisted in their original business domains, such as providing no-frill services, serving the markets of short or medium distance, issuing no mileage service, and so on. We selected this era because we suspect that the economic impacts such as the degree of price discounting may have been stronger then than in more recent years.

2.1 Conduct Parameters and Route-Specific Simultaneous Equations

Our dataset consists of 180 duopoly markets, 138 triopoly markets, 56 four-carrier markets, 19 five-carrier markets, 7 six-carrier markets, and 4 seven-carrier markets. The route-specific dataset consists of 405 sets of data, and the carrier-specific dataset has 1163 samples. All of the route-specific data are aggregates, so airfares of this dataset are the market-share-weighted average prices. To estimate the conduct parameters, we used both carrier- and route-specific datasets. In the carrier-specific dataset, we observed triopoly samples most frequently, so we first derive the conduct parameter assuming the triopoly case. The market demand of route i is denoted as follows:

$$Q_{it} = \sum_{k=1}^{2} q_i^k + q_i^3 \equiv \sum_{L=1}^{3} q_i^L \quad (k=1,2, L=1,2,3) \quad (1)$$

where the superscript k denotes legacy carriers and L denotes the carriers in a market including an

LCC (carrier 3 is an LCC).   The profit function of each carrier at route i is denoted as follows:

$$\pi_i^L = q_i^L p_i(Q_i) - TC_i^L(q_i^L) \quad (2) \quad \text{where} \quad TC_i^k(\bullet) > TC_i^3(\bullet)$$

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 follows:

$$v_i^k \equiv \frac{d}{dq_i^k}(q_i^j + q_i^3) \quad (j \neq k) \quad (4) \qquad v_i^3 \equiv \frac{d}{dq_i^3}\left(\sum q_i^k\right) \quad (5)$$

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

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

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 (another

FSC plus carrier 3) against the marginal change in the output of carrier k.   If both of them move in the

same direction and have the same volume, the result is 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 price equals

the marginal cost, and this is considered Bertrand competition.

In our model, if the price equals the marginal cost of an LCC, FSCs would have to exit the

market, since $MC_i^k(\bullet) > MC_i^3(\bullet)$ as long as carriers operate at the minimum efficient scale where

average cost equals marginal cost.

As in the previous studies, equation (6) can be inverted to (7) by using the route-specific price

elasticity of demand (η_i) and given that the market shares of each carrier are represented by (s_i^L), as

follows:

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

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 price 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 the

route-specific marginal cost for each carrier, as proposed by Brander and Zhang (1990, 1993) and Oum et

al. (1993)[2]:

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

where AC^L is the aggregate average cost of carrier L, $Dist_i$ is the distance of route i, and

AFL^L is the average distance flown by airline L.[3] Many studies on airline costs, such as those of

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, and 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

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[2] To estimate the route-specific marginal cost for each carrier, Fischer and Kamerschen (2003) jointly

estimated a translog total cost function and then approximated the route-specific marginal cost for each

carrier. See Fischer and Kamerschen (2003), pp. 235-237.

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

and Zhang (1993), pp. 175-178.

indifferent to distance. Oum, Zhang, and Zhang (1993) estimated the price equation (9) to obtain λ.

Equation (9) is derived from the first-order condition of a carrier's profit function and implies that the

price is determined by marginal cost, the route-specific price elasticity of demand, and market share.

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.

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

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 the

demand equation and the price equation (9), but what we need is the route-specific price elasticity of

demand, not the carrier-specific price 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 estimated

route-specific simultaneous equation system, but since the estimated results of the remaining equations

are out of the scope of this paper, we show the demand equation only.

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

where p_i is the average price at route i weighted by market share, INC_i is the arithmetic average

of per-capita income of route i, and $DIST_i$ is the distance of route i. POP_i is the arithmetic

average of the 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.

2.2 Carrier-Specific Simultaneous Equations to Derive Total Welfare

Next, we construct a carrier-specific simultaneous price and demand equation system. As we did in 2-1, we assume that not only demand but also price is an endogenous variable. Dresner et al. (1996) estimated the simultaneous price and demand equations that incorporate the directly and indirectly competing LCC dummy variables. To ascertain the consumer welfare effect, we will follow the method of Dresner et al. and estimate the carrier-specific demand equation as well as the price equation. Our empirical model to obtain the effects of low-cost entry on total welfare is as follows. A duopoly market requires eight equations, and the largest market requires twenty-eight equations.

(Demand Equation)

$$\ln\left(Q_i^k\right) = \alpha_0 - \left\{\rho_1 + \rho_2\left(D1LCC1 + D2LCC1\right) + \rho_3\left(D1LCC2 + D2LCC2\right)\right\}\ln p_i^k + \alpha_1 \ln INC_i$$
$$+ \alpha_2 \ln DIST_i + \alpha_3 \ln POP_i + \sum_{m=3}^{7} \alpha_4^m MKT_m + u_i^k \quad (11)$$

$$\left(\rho_1 > 0,\ \rho_2 > 0,\ \rho_3 > 0,\ \alpha_1 > 0,\ \alpha_2 > 0,\ \alpha_3 > 0,\ \alpha_4^m > 0\right)$$

(Price Equation)

$$\ln\left(p_i^k\right) = \beta_0 + \beta_1 \ln Q_i^k + \beta_2 \ln MC_i^k + \beta_3 \ln HERF_i + \beta_4 D1LCC1_i + \beta_5 D1LCC2_i + \beta_6 D1LCR1_i$$
$$+ \beta_7 D1LCR2_i + \beta_8 D2LCC1_i + \beta_9 D2LCC2_i + + \beta_{10} D2LCR1_i + \beta_{11} D2LCR2_i + \varepsilon_i^k \quad (12)$$

$$\left(\beta_2 > 0,\ \beta_3 > 0,\ \beta_4,\ \beta_5,\ \beta_6,\ \beta_7,\ \beta_8,\ \beta_9,\ \beta_{10},\ \beta_{11} < 0\right)$$

where $u_i^k, \varepsilon_i^k, \kappa_i^k$, and e_i^k are error terms. $D1LCC1$, $D1LCC2$, $D2LCC1$, and

$D2LCC2$ are binary variables that represent the presence of LCC(s). $D1LCC1$ takes 1 if an LCC

originates at 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/Hartsfield-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 that 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 price 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 (see proposition 1 in Appendix 1).

β_1 can be negative, positive, or zero. If a carrier supplies on a short-run marginal cost curve, β_1 will

be positive, and on its declining average cost curve, it will be negative. In addition, if a carrier supplies

at minimum efficient scale, it will be zero.

$HERF_i$ 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.

$HERF_i$ and the route-basis marginal cost of a carrier, MC_i^k, are also endogenous variables.

$HERF_i$ is determined by output, distance, and other exogenous factors such as the existence of slot

controls, as Bailey, Graham, and Kaplan (1985) suggest.   The marginal cost is the function of output and also the independent variable of price equation, so theoretically we have to use the instrument variable of marginal cost.   In total, our structural equations have five endogenous variables (output, price, marginal cost, Herfindahl index , and market share[4]), but we show the demand, the price, the profit, and the market share functions only, because the estimated results of the remaining two equations are out of the scope of this paper.

3   The Data

We use the data of the scheduled operations by city-pair route by firm; there are a total of 1998 sets of cross-sectional data collected from *DB1A*.   Omitted are the carriers that do not have 10% market share in duopoly markets and those that do not have 5% share in triopoly markets or markets served by more than three carriers..   Carriers whose codes are not reported in DB1A (reported as XX) are also omitted, but, for example, a 3-firm oligopoly market with one XX carrier is not regarded as a duopoly market, since XX carrier is thought to have competitive effects on the others.   Flight data are outbound and non-connecting ones from the six largest U.S. 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 and input price data is the *Air Carrier Financial Reports, Form 41 Financial Data.*   Income and population data are from *Regional Accounts Data, Bureau of Economic Analysis.*   We use the metropolitan area data (PMSA) for each city.

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[4] The market share equation is introduced so that we can see the cross effect of a firm's price on its rival's market share.

4   Empirical Results

4.1   Conduct Parameter

By performing generalized two-stage least squares (G2SLS), we obtain $\eta = -1.544$ with

t-statistics = -3.711[5].   This is acceptable according to the survey study by Oum, Waters, and Yong (1992)

in which they determined that the price elasticity of demand for air travel estimated by cross-sectional

data ranges from -0.53 to -1.90.   Using the positive value of price elasticity, we estimate equation (9) by

the non linear least squares method.   The result is shown in Table 1.

Table 1 Estimated result of non-linear price 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 the estimates of

Oum, Zhang, and Zhang (1993) and Borenstein (1990).   The system-wide conduct parameter is -0.053

with SE=0.03, and this result does not reject the null hypothesis that $\nu = 0$ at the 5% level.   Therefore,

[5] We estimated *route-specific* simultaneous demand, supply, and Herfindahl equations to obtain η by

generalized 2SLS and 3SLS, due to our detection of heteroskedasticity.   Since we cannot obtain the

carrier-aggregate marginal cost, we used distance as a proxy of route-aggregate marginal cost.   The test

of the overall significance of these simultaneous equations using decomposed binary variables gives the

following result: $\chi^2_{(33)}$ =603.3, P-value=0.000, n=405.

we conclude that Cournot competition is performed in the U.S. air markets that experienced low-cost

carrier entry.

Figure 1 shows the distribution of the conduct parameter of each carrier that has at least 20%

market share.   The horizontal axis is the conduct parameters, and the vertical axis is the carrier's market

share.   The figure shows that carriers with large market share (about 65% or more) conduct themselves

in accordance with the economic theory, but "fringe" carriers that have small market shares set their

prices incredibly low or high.   The low outliers of conduct parameters can be regarded as the outcome of

predatory pricing to rob other carriers of the passengers or to create new demand.   The high outliers may

take place when a carrier does knot know the demand curve for itself, and sets its airfare a little lower

than that of its FSC rival in the large market, but this airfare level exceeds its profit maximizing level.

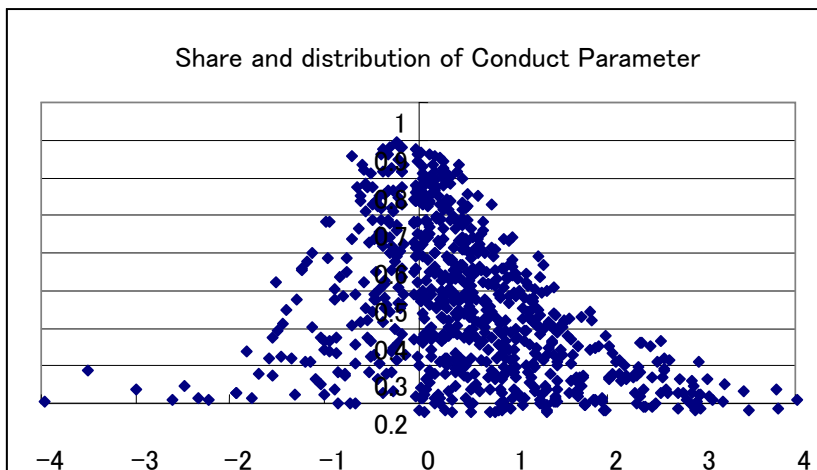Figure 1   Market share and distribution of the conduct parameter

Figure 2 demonstrates the average value of each carrier's conduct parameter and its 95% confidence

interval.   According to Figure 2, FSCs perform Cournot competition or more collusively than Cournot

competition.   On the other hand, LCCs behave more variously than FSCs.
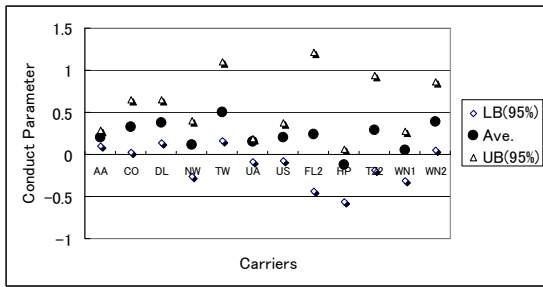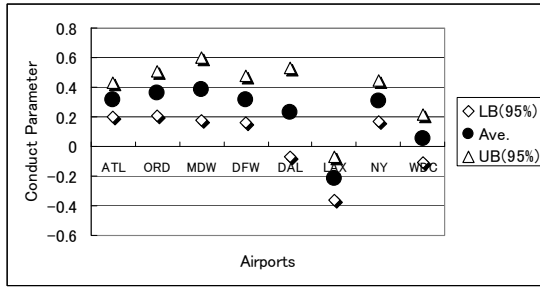
Figure 2 Average conduct parameters with 95%   Figure 3 Average conduct parameter at origin
confidence interval   airport

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

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 its primary airport (Los

Angeles), probably because WN can regionally build a more monopolistic situation at the secondary

airports than at the primary airport, although it must be competing with FSCs at the primary airport.

This implies that Southwest earns its profit mainly at the secondary airport.   In contrast, America West

Airlines (HP), in most cases, competes with FSCs directly at the primary airports, and this leads to its

having the lowest conduct parameters among the LCCs and performing more closely to Bertrand type

competition.   Other LCCs such as Air Tran (FL) and ATA (TZ), which also enter and use as bases

secondary airports like Southwest does, behave more collusively, but their conduct parameters vary more

widely than do those of other carriers.   In some cases in our dataset, Air Tran's and ATA's market shares

are very small, so they seem to create new demand by offering extraordinarily low prices, and to

counterbalance the losses generated by low prices with higher airfares than their average in other thriving

markets.

      Figure 3 shows the average conduct parameters and their 95% confident intervals of all of the

airlines that originate in ATL (Atlanta), ORD (Chicago O'Hare), MDW (Chicago Midway), DFW

(Dallas/Fort Worth), 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 those at any

other airport, and those at Washington D.C., where multiple LCCs enter, are also low.   On the contrary,

these results are not realized when an LCC enters but its presence is weak, or when an LCC enters the

adjacent secondary airport.   In the latter case, LCCs as well as FSCs must have regional market power

and be able to keep their conduct parameters higher than the level of Cournot competition.   This implies

that both FSCs and LCCs benefit, despite the rivalry between carriers at the primary airports and those at

the secondary airport.

Table 2   Partial correlations between the conduct parameter and other variables

	Conduct Parameter	Market Share	Distance	Herfindahl Index	Profit
Conduct Parameter	–				
Market SHARE	−0.359a	–			
Distance	−0.515a	−0.079b	–		
Herfindahl Index	−0.037	0.607a	−0.172a	–	
Profit	0.272a	0.242a	−0.389a	0.157a	–

      Table 2 demonstrates the partial correlations among 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 a 1% level of significance. These

results are consistent with those of Oum, Zhang, and Zhang (1993), and we conclude that a carrier with

high market share tries to expel fringe carriers by setting low prices, and price competitions are fiercer in

long-haul markets than in short-haul ones. The positive correlation between conduct parameter and

profit is also consistent with the theory of economics.

4.2   Carrier-Specific Impact of Low-Cost Entry on Price

In this subsection we discuss our investigation of how the impacts of low-cost entry on FSCs'

airfares differ when (an) LCC(s) enter(s) in the primary or secondary airport, and whether the number of

LCCs affects the FSCs' airfares. We simultaneously estimated equations (11) to (14) by the iterative

3SLS method, and the results are shown in Table 8 in Appendix 2. Table 3 is the summary parameters of

LCCs and their rival's dummy variables selected from Table 6.

Table 3 tells us that both LCCs and FSCs significantly discount their airfares compared with

the benchmarked FSCs. LCCs set prices 16.3-27.2% lower than those of FSCs in the same market, but

the number of LCCs does not statistically affect LCCs' and rivals' prices, though it appears it does at the

secondary airports. In other words, the first entrant significantly lowers the market prices, but the

second or later comer does not. These results are fairly consistent with the results of Dresner et al.

(1996), who also introduce dummy variables that reflect the number of competitive carriers. While

Dresner et al. did not statistically test the difference of parameters of these dummy variables, our analysis

reveals that the additional entries do not affect the rival's price.　In the perfectly contestable markets, the

number of firms does not affect the price.　Since the first entry significantly affects the price, we can

reject the hypothesis of perfect contestability.

Table 3　Summary of parameters of LCCs and their rivals' dummy variables

	Parameters	t-stat.	Difference between one and multi carrier(s) [6]
One LCC at Primary	-0.347	-11.39	None at 5% level
Multiple LCCs at Primary	-0.348	-8.607	
FSC at Primary competing with one LCC	-0.217	-8.047	None at 5% level
FSC at Primary competing with multiple LCCs	-0.187	-6.106	
One LCC at Secondary	-0.393	-6.502	None at 5% level
Multiple LCCs at Secondary	-0.447	-6.904	
FSC at Primary competing with one LCC at Secondary	-0.161	-3.031	None at 5% level
FSC at Primary competing with multiple LCCs at Secondary	−0.297	−4.905	

Our next findings about the relation between the conduct parameters and airfare level are that,

as may be expected, FSCs are better off without any entry by LCCs, but they achieve higher conduct

parameters with LCC(s) at the secondary airports than for the benchmark case where FSCs are competing

with each other (see Table 4).

In Table 4, leaving out the outliers of conduct parameters, we take the average of conduct

parameters and 95% confidence intervals for full-service and low-cost carriers for the cases in which (an)

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[6] The Wald tests test the hypothesis that two parameters are equal if they are not rejected at all at the 5% level, but the bottom one is rejected at the 9.9% level.

LCC(s) enter(s) the primary and secondary airports

Table 4 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

When an LCC enters the adjacent market, FSCs may quit competing within the primary airport

and try to win the competition with the LCC.   In addition, both FSCs and the LCC can keep, although

not securely, the regional monopolistic power compared with the case of head-to-head competition at the

primary airports.   This is why conduct parameters at the primary airport are comparatively high for the

case in which one LCC enters the secondary airport.   One interesting finding is that LCCs at the

secondary airport can keep a slightly large price-cost margin despite their low airfares.   One reason is

that since the airport charges at the secondary airport are not as expensive as those at the primary airport,

the LCC can benefit even though average airfares are low.

Our last finding is that the parameter of the cross-price term in the share equation is significant

at 1% level (See Table 6 in Appendix 2).   This implies that the quality distinction between LCCs and

FSCs are not perfect and passengers may easily switch from FSCs to LCCs and vice versa.

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 finding the

product of the route distance and the carrier's unit cost (total cost / aggregate RPM).   The consumer's

surplus is computed by the following method: we compute the area of the "trapezoid" of our demand

function (11), which is surrounded by the benchmark price, the lowered price computed from the

carrier-related dummy variables, the benchmark output, and the increased output due to low-cost

competition.

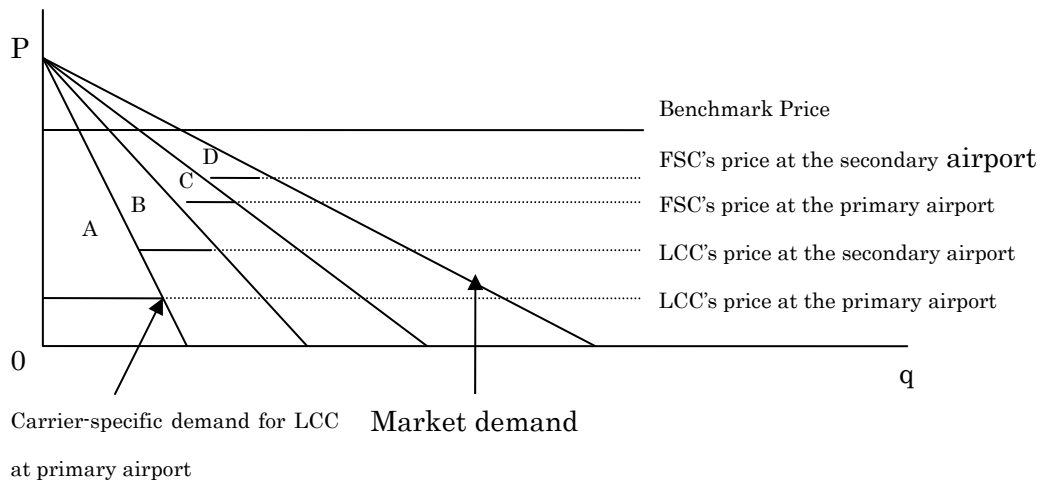Figure 5 Gains in consumer's surplus

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 an LCC's entry in the primary airport, and trapezoid C is the gain in

consumer's surplus due to the FSC's reaction to the LCC at the primary airport (the FSC's price is higher

than the 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 FSCs for the entry in the primary and the secondary airports (that is, A+B+C+D).

Table 5   Summary of the welfare effect of LCC entry

Due to:	Cons. Welf.	LCC's Profit	FSC's Profit	Total Welf.
An LCC's entry into Primary Airport	3.36	1.28		4.64
An LCC's entry into Secondary Airport	3.37	1.27		4.64
FSC's reaction at Primary Airport against an LCC	1.97		−0.48	1.49
FSC's reaction at Secondary Airport against an LCC	1.68		−0.34	1.34
Two LCCs' entry into Primary Airport	3.88	1.08		4.96
Two LCCs' entry into Secondary Airport	4.51	0.82		5.33
FSC's reaction at Primary Airport against two LCCs	1.43		−0.22	1.21
FSC's reaction at Secondary Airport against two LCCs	2.78		−0.88	1.91
Sum of Welfare (per route per carrier)	**22.98**	**4.45**	**−1.92**	**25.51**
Million USD (Cons, Welf. = Consumer's Welfare). Total Welf. = Total Welfare				

Table 5 demonstrates the gain in consumer's surplus, LCC profits, FSC profit, and the change in total welfare.   Overall, the gain in consumer's surplus is very large, and LCCs also benefit by entry. However, FSCs 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 FSCs 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, FSCs are suffering the deficits although they keep the conduct parameters at more than Cournot level, while LCCs are benefiting at smaller conduct parameters than FSCs.

6   Summary of Findings and Concluding Remarks

Our findings on the conduct parameters, prices, and welfares are as follows:

(1) FSCs suffer from the competition with LCC(s) at the primary airports: FSCs' prices are statistically

low and so are the conduct parameters, although the differences of conduct parameters are not

statistically significant.   This fact implies that FSCs do not benefit when (an) LCC(s) enter(s) the

same airports.

(2) The conduct parameters of LCCs are, on average, higher than those of FSCs, and this fact implies

that LCCs do not necessarily offer cut-throat competition with thin price-cost margins but instead

make reasonable profits in spite of their low airfares, especially when they use as a base 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 price and output.   This fact also implies that the quality distinction between FSCs and

LCCs is imperfect.   The second and additional entries do not have as great an impact as that of the

first one.

(4) FSCs are better off without any entry by LCC(s), but they achieve higher conduct parameters with

LCC(s) at the secondary airport than for the benchmark case where FSCs are competing with each

other.

(5) Total gains of welfare were 25.5 million USD for our dataset, and 90% of welfare gains came from

the gain in consumer's surplus.   LCCs' cumulative profit was 4.45 million USD, but FSCs lost 1.92

million USD in total due to the competition by LCCs.   This implies that FSCs do not earn profits

although their price-cost margins exceed the Cournot-competition level.   This fact seems to be due

to their high average cost level.

Possibly our most important finding is that LCCs' conduct parameters sometimes take unreasonably high

values, especially when LCCs trace an FSC's airfare and determine their price level slightly below the

FSC's.   In such a case, LCCs may not know their own demand curve and determine airfares above the

"profit-maximizing" level which is derived from carrier-specific demand function and their route

marginal cost.   This fact may imply that the conduct parameters can cover a wider range than that

assumed by the economic theory.

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Appendix 1: Effects of quality distinction on outputs and prices

Appendix 1 will examine the effects of a firm's vertical differentiation on its own and its rival's

outputs and prices.　　Assume the following general profit functions of firm 1 (FSC) and firm 2 (LCC),

which perform Cournot competition with each other:

$$\max_{q_1} \pi^1\left(q_1, q_2; \gamma_1\right) \quad \text{...(1)} \qquad \max_{q_2} \pi^2\left(q_1, q_2; \gamma_2\right) \quad \text{...(2)}$$

where γ_1 and γ_2 are the coefficients of the firm's own output in the inverse demand function usually

assumed in a Cournot model.　　We assume that if a vertical differentiation is perfectly achieved, a group

of consumers who love high quality will choose only high-quality goods with high price, while

consumers who will accept low quality will choose low-quality goods with lower expenditures, and

people in each group will not switch to buy the other goods. Therefore, γ s will vanish in such a case.

In our assumption γ s have a negative sign in front of them. For convenience, let γ_1 and

θ_1 be the numeraire, and γ_2 and θ_2 be $\gamma^* \in (0,1)$. We can rewrite (1) and (2) as follows:

$$\max_{q_1} \pi^1(q_1, q_2) \quad \text{...(1)'} \qquad \max_{q_2} \pi^2(q_1, q_2; \gamma^*) \quad \text{...(2)'}$$

Taking the F.O.C. of (1)' and (2)' with regard to each output, we obtain the best reply function described

as the form of implicit function:

$$\pi_1^1(q_1, q_2) = 0 \quad (3)$$

$$\pi_2^2(q_1, q_2; \gamma^*) = 0 \quad (4) \quad \text{where} \quad \pi_i^i \equiv \frac{\partial \pi^i}{\partial q_i}$$

Solving for each output, we obtain $q_1^*(\gamma^*)$ and $q_2^*(\gamma^*)$, and substituting $q_1^*(\gamma^*)$ and $q_2^*(\gamma^*)$ into

(3) and (4), we obtain:

$$\pi_1^1(q_1^*(\gamma^*), q_2^*(\gamma^*)) = 0 \quad (5)$$

$$\pi_2^2(q_1^*(\gamma^*), q_2^*(\gamma^*); \gamma^*) = 0 \quad (6)$$

To see the effect of the change in product differentiation, we totally differentiate (5) and (6) as follows:

$$\pi_{11}^1 \frac{\partial q_1}{\partial \gamma^*} + \pi_{12}^1 \frac{\partial q_2}{\partial \gamma^*} = 0 \quad (7)$$

$$\pi_{21}^2 \frac{\partial q_1}{\partial \gamma^*} + \pi_{22}^2 \frac{\partial q_2}{\partial \gamma^*} + \pi_{2\gamma^*}^2 = 0 \quad (8)$$

Rewriting (7) and (8) into a matrix from, we obtain:

$$\begin{pmatrix} \pi_{11}^1 & \pi_{12}^1 \\ \pi_{21}^2 & \pi_{22}^2 \end{pmatrix} \begin{pmatrix} \dfrac{\partial q_1}{\partial \gamma^*} \\ \dfrac{\partial q_2}{\partial \gamma^*} \end{pmatrix} = \begin{pmatrix} 0 \\ -\pi_{2\gamma^*}^2 \end{pmatrix} \quad (9)$$

Let $H \equiv \begin{pmatrix} \pi_{11}^1 & \pi_{12}^1 \\ \pi_{21}^2 & \pi_{22}^2 \end{pmatrix}$, and since this is the symmetric nonsingular matrix, H can be inverted:

$$\begin{pmatrix} \dfrac{\partial q_1}{\partial \gamma^*} \\ \dfrac{\partial q_2}{\partial \gamma^*} \end{pmatrix} = \frac{1}{\pi_{11}^1 \pi_{22}^2 - \pi_{12}^1 \pi_{21}^2} \begin{pmatrix} \pi_{22}^2 & -\pi_{12}^1 \\ -\pi_{21}^2 & \pi_{11}^1 \end{pmatrix} \begin{pmatrix} 0 \\ -\pi_{2\gamma^*}^2 \end{pmatrix} \quad (10)$$

From (10) we obtain:

$$\frac{\partial q_1}{\partial \gamma^*} = \frac{\pi_{12}^1 \pi_{2\gamma^*}^2}{\pi_{11}^1 \pi_{22}^2 - \pi_{12}^1 \pi_{21}^2} \quad (11) \qquad \frac{\partial q_2}{\partial \gamma^*} = \frac{\pi_{11}^1 \pi_{2\gamma^*}^2}{\pi_{11}^1 \pi_{22}^2 - \pi_{12}^1 \pi_{21}^2} \quad (12)$$

Matrix H is a negative definite matrix due to the S.O.C. condition for profit maximization. Therefore,

$\pi_{11}^1 < 0$ and $\pi_{11}^1 \pi_{22}^2 - \pi_{12}^1 \pi_{21}^2 > 0$. In addition, since we assume Cournot competition, $\pi_{12}^1 < 0$,

$\pi_{21}^2 < 0$ due to the "strategic substitute" effect. γ^* is the index of the degree of vertical

differentiation and comes to the right-hand side of inverse demand having a negative effect on price. To

see the sign of $\pi_{2\gamma^*}^2$, let us take the first derivative of π^2 with regard to q_2 and then take the second

derivative with regard to γ^*:

$$\pi_2^2 = p(q_1, q_2; \gamma^*) + q_2 \frac{\partial p(q_1, q_2; \gamma^*)}{\partial q_2} - MC_2(q_2) \quad (13)$$

$$\pi_{2\gamma^*}^2 = \frac{\partial p(q_1, q_2; \gamma^*)}{\partial \gamma^*} + q_2 \frac{\partial^2 p(q_1, q_2; \gamma^*)}{\partial q_2 \partial \gamma^*} \quad (14)$$

As mentioned above, the first term of the right-hand side is negative, and the second term is also negative.

Therefore, $\pi_{2\gamma^*}^2 < 0$. Substituting this result into (11) and (12), we obtain:

$$\frac{\partial q_1}{\partial \gamma^*} = \frac{(-)\pi_{12}^1 (-)\pi_{2\gamma^*}^2}{(+)\left(\pi_{11}^1 \pi_{22}^2 - \pi_{12}^1 \pi_{21}^2\right)} > 0 \quad (15) \qquad \frac{\partial q_2}{\partial \gamma^*} = \frac{(-)\pi_{11}^1 (-)\pi_{2\gamma^*}^2}{(+)\left(\pi_{11}^1 \pi_{22}^2 - \pi_{12}^1 \pi_{21}^2\right)} > 0 \quad (16)$$

and we can give the following proposition:

Proposition 1: If a firm distinguishes itself from its rival, not only its own output but also its rival's output decreases and the prices of both rise as long as they face a down-sloping demand curve, since each one will be a monopolist.

Appendix 2

Table 6   Estimated result of carrier-specific structural equations

	Parameter	SE	t-stat.	P-Value
Demand equation				
Own Price	−3.574	0.766	−4.666	0.000
Own Price*(D1LCC1)	−0.305	0.064	−4.745	0.000
LCC's Price Elasticity at Primary Airport	−3.878	0.824	−4.705	0.000
Own Price*(D1LCC2)	−0.270	0.077	−3.506	0.000
LCC's Price Elasticity at Secondary Airport	−3.844	0.835	−4.602	0.000
Distance	0.827	0.297	2.784	0.005
Per-Capita Income	3.143	0.613	5.131	0.000
Weighted Population	0.961	0.095	10.120	0.000
Dummy for Triopoly Market	0.051	0.089	0.570	0.569
Dummy for 4-firm Market	−0.076	0.147	−0.515	0.606
Dummy for 5-firm Market	0.185	0.202	0.919	0.358
Dummy for 6-firm Market	−0.160	0.250	−0.639	0.523
Dummy for 7-firm Market	−0.177	0.349	−0.507	0.612
Constant	3.952	1.284	3.078	0.002
Price equation				
Output	0.137	0.022	6.178	0.000
Marginal Cost	0.585	0.022	27.100	0.000
Herfindahl Index	0.282	0.037	7.658	0.000
D1LCC1	−0.347	0.030	−11.390	0.000
D1LCC2	−0.348	0.040	−8.607	0.000
D1LCR1	−0.217	0.027	−8.047	0.000
D1LCR2	−0.187	0.031	−6.106	0.000
D2LCC1	−0.393	0.060	−6.502	0.000
D2LCC2	−0.447	0.065	−6.904	0.000
D2LCR1	−0.161	0.053	−3.031	0.002
D2LCR2	−0.297	0.060	−4.905	0.000

CONSTANT	1.013	0.226	4.479	0.000
Profit equation				
Output	2.620	0.307	8.537	0.000
Own Price	9.107	0.976	9.327	0.000
Marginal Cost	−7.273	0.605	−12.030	0.000
CONSTANT	−20.279	3.334	−6.082	0.000
Market Share equation				
Own Price/Distance	−3.761	1.116	−3.370	0.001
Cross Price/Distance	3.908	1.085	3.604	0.000
D1LCC1	−1.509	0.337	−4.485	0.000
D1LCC2	−1.124	0.387	−2.905	0.004
D1LCR1	0.611	0.266	2.293	0.022
D1LCR2	0.807	0.271	2.985	0.003
D2LCC1	−0.386	0.332	−1.163	0.245
D2LCC2	−0.869	0.348	−2.494	0.013
D2LCR1	1.320	0.421	3.135	0.002
D2LCR2	0.702	0.418	1.681	0.093
CONSTANT	−0.704	0.197	−3.581	0.000

TEST OF THE OVERALL SIGNIFICANCE : $\chi^2_{(30)}$ =130.79, P−value=0.000, n=1163