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(Citation)
神戸大学経営学研究科 Discussion paper,2010・31

(Issue Date)
2010-05

(Resource Type)
technical report

(Version)
Version of Record

(URL)
https://hdl.handle.net/20.500.14094/81003427

Graduate School of
Business Administration

KOBE UNIVERSITY

ROKKO KOBE JAPAN

2010-31

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Discussion Paper Series

Time Effect of Low-Cost Carrier Entry and Social Welfare in US Large Air Markets

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Abstract

In this study we empirically analyzed the airfare level at which most low-cost carriers (LCCs) entered the market, what impacts LCCs had on the airfares of incumbent carriers, whether the impacts differed depending on how many LCCs existed in a market and on whether LCC(s) entered a full-service carrier (FSC)'s hub airport or an adjacent airport, whether the low-airfare impact continued for the years following entry, and finally what are the welfare implication of LCCs' entries. We modeled and estimated the simultaneous demand and price (pseudo-supply) equation to derive these four economic impacts of LCCs' entries by using published data of 1998. Our main findings are: (1) overall, LCCs entered with very low airfare, and their entry lowered the full-service carrier's airfare, but the impacts of entries depended on individual LCCs; (2) neither the number of LCCs nor the location of entry by LCC(s) had different impacts; (3) the impact of LCCs' entries did not differ between the entry year and the second year; (4) the social welfare gains are substantial, and 90% of welfare gains come from the gain in consumers surplus.

Key Words: LCC, impact on airfare, time effect of entry, social welfare

1. Introduction

There have been many studies on the economic impact of low-cost carriers (LCCs) entry into the air transportation market. Morrison and Winston (1995) empirically showed that Southwest Airlines forces its competitors to reduce their fares.[1] Dresner et al. (1996) and Morrison (2001) have measured the airfare-reduction effect of LCC entry into the primary and adjacent markets by incorporating LCC dummy variables in their econometric work. Vowles (2000) empirically analyzed the U.S. domestic air markets that includes a number of LCCs and found that Southwest Airlines, other LCCs, and the market share of LCCs had statistically significant effects on the decrease in carriers' airfares. Alderighi et al. (2004) estimated the price

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

equations derived from oligopoly theories and found that competitions between European LCCs and FSCs reduced all classes of FSCs' airfares. Pitfield (2005, 2008) studied the airfare changes after LCC entry in a time series analysis. Goolsbee and Syverson (2005) analyzed the incumbent's strategy to deter the threat posed by new entrants, and Oliveira and Huse (2009) studied the effects of LCC entries on the incumbents' responses. In a study on inter-firm rivalry between LCCs and FSCs, Murakami (2010, forthcoming) empirically estimated the conduct parameters of airline industries in Japan and estimated the welfare effect caused by LCCs' entries. Methods to derive the conduct parameter of airline industries were introduced by Brander and Zhang (1990, 1993), and have been developed by Oum, Zhang, and Zhang (1993), and Fischer and Kamerschen (2003), who analyzed the situation in the United States, and by Fageda (2006), who analyzed the situation in Spain. Furthermore, Fu, Lijensen and Oum (2006) incorporated duopolistic inter-firm rivalry explicitly into their LCCs vs. full-service carriers (FSCs) competition study, and also as well as incorporating the effect of pricing behavior of an unregulated-monopoly airport on the downstream competition between LCCs and full-service carriers. Hofer et al. (2008) introduced the concept of "price-premium" as part of the LCC issue.

In our empirical analyses we attempted to analyze:

(1) at what airfare level LCCs entered,
(2) what impacts LCCs had on the airfares of incumbent carriers,
(3) whether the impacts differed depending on how many LCCs existed in a market and on whether LCC(s) entered an FSC's hub airport or an adjacent airport,
(4) whether the impacts of LCC entry continued for the years following entry,
(5) the increase in social welfare, as opposed to previous studies that focused on the consumers surplus only.

Many authors have studied the topics (1), (2), and (3), but none of the previous studies have answered question (4) or (5). Previous authors have been interested in the "first year" impacts of new entry on airfares and consumers surplus. The distinguishing features of the present study are that we revealed the impact of the second years of new entries by LCCs, and we computed social welfare by using rigid statistical methods. In addition, we performed more rigid statistical analysis of topics(1), (2), and (3) than was performed in previous studies.

In the next section we will model the simultaneous equations for each carrier's demand and a pseudo-supply equation to estimate the impact of LCC entry on the incumbent carrier's airfares, the time effect of LCC entry on airfares, and the effect of LCC entry on social welfare. In Section 3 we show the data, and in Section 4 we present the empirical results and perform several analyses of the impacts of LCC entry on FSCs' behaviors. In Section 5 we discuss welfare implications, and in Section 6 we present concluding remarks.

2. Carrier-specific simultaneous equations

An initial activity was to construct a carrier-specific simultaneous demand and pseudo-supply equation system to estimate the economic impact of LCCs' entries. Joskow et al. (1994) found that new carriers enter with low airfares, and incumbents respond by cutting airfares to maintain their traffic. Dresner et al. (1996) estimated simultaneous demand and price (pseudo-supply) equations that incorporate the directly and indirectly competing LCC dummy variables. To ascertain the consumer welfare effect, we used the method of Dresner et al. and estimated the carrier-specific demand equation as well as the pseudo-supply equation in log-linear forms. Our empirical model to obtain the economic effects of low-cost entry is as follows:

[Demand equation]

$$\ln\left(Q_i^L\right) = \alpha_0 - \alpha_1 \ln p_i^L + \alpha_2 \ln INC_i + \alpha_3 \ln POP_i + \sum_{N=3}^{7} \alpha_4^N MKT_N + u_i^L \qquad (1)$$

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

[Pseudo-supply equation]

$$\begin{aligned}\ln\left(p_i^L\right) &= \beta_0 + \beta_1 \ln Q_i^L + \beta_2 \ln MC_i^L + \beta_3 \ln HERF_i + \beta_4 \ln MCD_i + \beta_5 D1LCC1_i + \beta_6 D1LCC2_i \\ &+ \beta_7 D1LCR1_i + \beta_8 D1LCR2_i + \beta_9 D2LCC1_i + \beta_{10} D2LCC2_i + \beta_{11} D2LCR1_i + \beta_{12} D2LCR2_i \\ &+ \sum_{t=1}^{2} \beta_{13}^t LCCPE(WN)_t^D + \sum_{t=1}^{2} \beta_{14}^t LCRPE(WN)_t^D + \beta_{15} LCCPE(WN)_1^T + \beta_{16} LCRPE(WN)_1^T \\ &+ \beta_{17} LCCPE(HP)_2^D + \beta_{18} LCRPE(HP)_2^D + \varepsilon_i^L \qquad (2)\end{aligned}$$

$$\left(\beta_2, \beta_3 > 0,\ \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}^t, \beta_{13}^t, \beta_{14}, \beta_{15}, \beta_{16}, \beta_{17}, \beta_{18} < 0\right)$$

where p_i^L and Q_i^L are the average airfare and output at route i, respectively. INC_i is the arithmetic average of per-capita income of route i. MC_i^L is the route marginal cost that we derived following the method used by Brander and Zhang (1990, 1993) and Oum, Zhang, and Zhang (1993)[2]. Since many authors have used the distance as a proxy variable of marginal cost and have found that this variable positively affects a carrier's airfare, we considered both marginal cost and distance as explanatory variables of the pseudo-supply equation, and chose the one that fit better.

Mason et al. (1992) noted that if a firm's structure is asymmetric (e.g., high-cost or low-cost) compared with that of competing firms, it needs a 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 MCD_i 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 a negative effect on the market airfare, and, vice-versa, a positive effect on market output.

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2 The way of deriving MC_i^L is as follows:

$$MC_i^L = AC^L \left(\frac{Dist_i}{AFL^L}\right)^{-\lambda} Dist_i \qquad (3)$$

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.

POP_i is the arithmetic average of O/D population. MKT_N is a binary variable that takes 1 for the market where N carriers compete, and the benchmark markets of this binary variable is duopoly markets. For example, MKT_3 is the binary variable that takes 1 for triopoly markets and zero otherwise. This MKT_N variable is introduced to control the market size in the demand equation, and the parameters of this variable could be positive or negative. In the negative case, for example, if too many carriers enter a market and compete for limited demand, the demand that each carrier faces could be smaller than what each carrier would face in a duopoly market. $HERF_i$ 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. The variables u_i^L and ε_i^L are error terms of carrier-specific output 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 at the primary airport and 0 otherwise, and $D1LCC2$ takes 1 if two LCCs exist in the primary airport, for example, the case of connecting two secondary airports such as Southwest's Houston/Hobby-Chicago Midway, and the case of connecting primary and secondary airports such as Air Tran's Atlanta/Hartsfield-Chicago Midway. The definition of a primary airport in our analysis is that it is the largest airport where full-service carrier(s) are mainly based in a certain area, regardless of the airport size or whether an LCC(s) is(are) present in the airport.

Similarly, $D2LCC1$ takes 1 for an LCC if an LCC enters the adjacent secondary airport such as Dallas-Lovefield and Chicago Midway airport 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 for 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 signs of the parameters of $D1LCC1$, $D1LCC2$, $D2LCC1$, and $D2LCC2$ would be negative if LCC(s) take(s) the capacity-expanding or airfare-discounting strategy. β_1 can be negative, positive, or zero. If a carrier supplies at its short-run marginal cost curve, β_1 will be positive, and if it does so on its declining average cost curve, it will be negative. If a carrier supplies at minimum efficient scale, it will be zero.

$D1LCR1$, $D1LCR2$, $D2LCR1$, and $D2LCR2$ are binary variables that represent the presence of the competing carrier(s) of LCC(s). Like $D1LCC1$ and other binary variables explained above, the former number represents either the primary airport (this is one) or the secondary airport (this is two), and the latter number represents the number of LCC(s) that compete with the FSC(s). For example, $D1LCR1$ takes 1 for FSC(s) if it(they) originate(s) at the primary airport and compete(s) with one LCC and 0 otherwise, and $D2LCR2$ takes 1 for (a) FSC(s) if it(they) remotely compete(s) with two LCCs that exist in the adjacent secondary airport. The signs of the parameters of these binary variables would also be negative if rival carriers are involved in the competition between LCCs.

$LCCPE$ and $LCRPE$ are binary 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 Midway-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 triopolies. $LCRPE(WN)_1^D$ 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 into Chicago Midway – Jackson (Mississippi) and America West's entry into Dallas/Fort Worth – Long Beach. Therefore, $LCCPE(WN)_2^D$ and $LCRPE(WN)_2^D$ take 1 for Southwest Airlines 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.

As noted above, higher $HERF_i$ means that the market is more concentrated, and 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. Bailey, Graham, and Kaplan (1985) suggested 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 our analysis follows their suggestions. 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 the Hausman test for each variable and subsequently rejected both of the null hypotheses at the 1% level of significance ($\chi^2_{(1)} = 7.41 \textit{ and } 23.38$, respectively). In total, our structural equations have five endogenous variables, but we show the demand and the pseudo-supply equations only, because the estimated results of the remaining 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 derived the social welfare by adding producers' profits and consumers surplus.

3. The data

We used the data of the scheduled operations by city-pair route by firm, which are cross-sectional data of the year 1998 collected from *DB1A*, comprised of 10% samples of the U.S. domestic flight data. We used the data of airfares actually purchased by passengers (this, in turn, means that we omitted "zero-price airfares" and passengers who obtained these airfares from our dataset). We omitted carriers that did not have 10% market share in duopoly markets and those that did not have 5% share in triopoly or greater markets. Carriers with no IATA shown in *DB1A* were also omitted. These carriers are reported as carrier XX in *DB1A*. However, when we computed $HERF_i$,we considered the market share of carrier XX as long as its market share met the conditions explained above. Flight data represent outbound and non-connecting flights from the six largest U.S. airports and their regions[3]: New York/Newark area, (JFK, LaGuardia,

[3] We omitted the connecting passengers because, in general, LCCs do not have hub and spoke systems. There were few cases in which an LCC competed with FSCs in the two-segment

Newark), Washington D.C. area (National, Dulles, Baltimore), Atlanta/Hartsfield, Dallas/Fort Worth area (DFW and Love Field), and Los Angeles. 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. Our data contains the routes where FSCs compete with each other as well as the routes where LCCs and FSCs compete. The former routes are introduced as the benchmark of dummy variables that are intended to show the impact of price wars between LCCs and FSCs, which are explained in the last section.

In this study we were especially interested in the changes in airfare and welfare caused by the competition between the top-three mega carriers vs. formidable LCCs such as Southwest Airlines, Air Tran, and "mid-cost" carriers such as America West Airlines. Therefore, we selected the following large hub airports that compete with adjacent secondary airports where these LCCs are based: Dallas-Fort Worth (American Airlines), Chicago O`Hare (American Airlines and United Airlines), and two airports in Washington D.C (American Airlines and United Airlines and other mega carriers). We also selected Los Angeles International Airport and Atlanta/Hartsfield Airport, where LCCs and FSCs compete in an airport, to demonstrate the difference of competitive impacts against the case where carriers compete remotely. Three airports in the New York area, which had few flights of LCCs, are included in the dataset as the benchmark samples to investigate the degree of impact of LCCs' entries. This means that there are no LCC dummy variables introduced for these three airports. We acknowledge that there may be room for further analysis by expanding the number of data samples and updating the year, and we will do these analyses in the next study. As for the method to determine whether a primary airport competes with an adjacent secondary airport, we followed the market classification done in *DB1A*.

Table 1

The descriptive statistics of continuous variables

	Mean	S.E.	Minimum	Maximum	Median
Passengers	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
Per capita income	31907.3	2933.5	26047.8	38346.7	32238.4
Herfindahl index	49.8	13.7	15.3	81.9	50.4
Distance (miles)	1223.0	804.4	94	4975	1016

Note: Airfare and income are in 1998 U.S. dollars. The source of the cost data is the *Air Carrier Financial Reports, Form 41 Financial Data.* Per-capita individual income and population data are from *Regional Accounts Data, Bureau of Economic Analysis.*

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connecting markets in such a way as "airport A – a mega carrier's hub (or adjacent airport) – airport B".

We used the population that is filed in 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 cost and demographic data are also the data for the year 1998. The descriptive statistics of continuous variables are shown in Table 1.

4. Empirical results: Carrier-specific impact of low-cost entry

We investigated how the impacts of low-cost entry on an FSC's behaviors differ when (an) LCC(s) enter(s) a primary or secondary airport, and whether the number of LCCs affects the FSC's behaviors. We analyzed the inter-firm rivalry of 21 carriers, and 9 out of the 21 carriers were LCCs. Now not a few LCCs, such as ATA[4] and Jetblue, have entered long-distance markets and provide small frills and airfares do not much differ from those of FSCs in certain routes. However, around 1998, LCCs still persisted in their original business domains such as providing no frills, serving markets of short or medium distance, issuing no mileage service, and so on. Therefore, we expect the economic impacts such as the degree of airfare-discounting may be stronger in past years, and this is why we chose the data of 1998 to see the economic impacts of the entries of "pure LCCs".

Table 2

Summary of parameters of LCCs and their rivals' dummy variables in the pseudo-supply equation

	Para-meters	S.E.	Difference between one and two carrier(s) [5]
One LCC at Primary Airport (*D1LCC1*)	-0.444	0.032	None
Two LCCs at Primary Airport (*D1LCC2*)	-0.522	0.044	at 5% level
FSC at Primary competing with one LCC Airport (*D1LCR1*)	-0.188	0.029	None
FSC at Primary Airport competing with two LCCs (*D1LCR2*)	-0.194	0.032	at 5% level
One LCC at Secondary Airport (*D2LCC1*)	-0.549	0.064	None
Two LCCs at Secondary Airport (*D2LCC2*)	-0.587	0.068	at 5% level
FSC at Primary competing with one LCC at Secondary Airport (*D2LCR1*)	-0.175	0.056	None
FSC at Primary competing with two LCCs at Secondary Airport (*D2LCR2*)	-0.217	0.064	at 5% level

We simultaneously estimated equation (1) and (2) by an iterative 3SLS method and the results are shown in Table 6 in the Appendix. Table 2 is the summary of parameters of LCCs and their rivals' dummy variables which are picked up from Table 6. Table 2 tells us that the airfare wars between LCCs and FSCs led to significant discounts in LCC airfares compared with the benchmarked FSCs.

[4] ATA filed for Chapter Eleven and discontinued its operation in April 2008.
[5] The Wald tests that tested the hypothesis that two parameters are equal were not rejected at the 5% level.

The results shown in Table 2 are fairly consistent with the results of Dresner et al. (1996), who also introduced dummy variables to represent the number of competitive carriers. Our analysis reveals that the additional entries do not statistically affect the rival's airfares comparing the parameter of "*D1LCR1* and *D1LCR2*", and "*D2LCR1* and *D2LCR2*". We also find that an LCC's airfare level at the primary airport and that at the secondary airport do not statistically differ. We tested the hypothesis that the parameter of *D1LCC1* and that of *D2LCC1* are equal, and we found that this hypothesis can be rejected with a P-value equal to 0.132 by the Wald test, and this result also holds for other cases including FSCs (these are the comparisons between "*D1LCC2* and *D2LCC2*", "*D1LCR1* and *D2LCR1*", and "*D2LCR2* and *D2LCR2*" where P-values of the Wald test range from 0.396 to 0.834).

Our next area of interest was to determine whether the airfare levels of each carrier differed between primary and secondary airports. To do this analysis, we replaced all the carrier-related dummy variables (*D1LCC1, D1LCC2, D2LCC1, D2LCC2, D1LCR1, D1LCR2, D2LCR1*, and *D2LCR2*) of Model 1 in Table 6 in the Appendix with each carrier's dummy variable, and re-estimated the carrier-specific structural equations using the same data and the same estimation method. We called this Model 2, and it is also presented in the Appendix, and the summary of the parameters of carrier dummy variables is shown in Table 3.

The method for introducing each carrier's dummy variable was as follows. In the case of Southwest (WN), for example, we introduced *WN1, WNR1, WN2*, and *WNR2. WN1* takes 1 for Southwest Airlines operating in the primary airport, and *WNR1* takes 1 for the FSCs that are competing with Southwest at the primary airport. Similarly, *WN2* takes 1 for Southwest Airlines operating in the secondary airport, and *WNR2* takes 1 for the FSCs that are remotely competing with Southwest Airlines at the primary airport. This method of introducing carrier dummy variables was used for all the carriers shown in Table 3, except for Spirits Airlines (NK), Tower Airlines (FF), and Frontier Airlines (F9). These three airlines did not operate in the secondary airports in our dataset, so we did not have *NK2, NKR2, FF2, FFR2, F92*, or *F9R2*.

Table 3 tells us that Southwest's low-airfare strategy at the primary airports led to very low airfares, and the same was true in the secondary airports. FSCs also lowered their airfares to cope with the competition from Southwest Airlines. The degree of declines in airfares was statistically the same between the primary and the secondary airports, and this result held for both Southwest Airlines and the FSCs. These results for Southwest Airlines were not necessarily followed by other LCCs, however. It was almost common for LCCs other than Southwest Airlines to operate with very low airfare at the primary airports. However, America West Airlines (HP) seems to have used the low-airfare strategy only when it entered the secondary airport (that is, Chicago Midway). America West cannot be regarded as a true LCC, because its average airfares were almost the same as those of typical FSCs. However, since America West is based at Chicago Midway, where other LCCs such as Southwest Airlines and Air Tran operate, it may have to discount its airfares to compete with these carriers. We cannot recognize its low-airfare impact on the airfares of FSCs that operate in Chicago O'Hare airport. ATA (TZ), Vanguard Airlines (NJ), which used Chicago Midway airport as a hub, and Air Tran (FL) entered the secondary airports with low airfares, but the impacts of their entries on their rivals' airfares at the secondary airports were much weaker than that of Southwest Airlines due to their small market shares at the secondary airports. Kiwi International Airlines (KP) seems to have taken the low-airfare strategy only when it competed with FSCs directly at the primary airports, and when it entered the secondary airports, it took various kind of, or ad-hoc, strategies, since its parameter in the third column and third row is comparatively large but insignificant.

Table 3

Carrier-specific impacts on airfare at primary and secondary airports

	LCC's airfare at Primary/Secondary A.P.		FSC's airfare at Primary A.P.	
Entry by	Primary	Secondary	Primary	Secondary
KP (Kiwi Int'l)	-0.601 (0.183a)	-0.391 (0.257)	-0.223 (0.127)	0.043 (0.188)
TZ (ATA)	-0.247 (0.090a)	-0.149 (0.073b)	0.003 (0.052)	0.029 (0.048)
HP (America West)	-0.045 (0.043)	-0.611 (0.266b)	0.032 (0.031)	0.030 (0.132)
FL (Air Tran)	-0.538 (0.048a)	-0.486 (0.152a)	-0.318 (0.044a)	-0.133 (0.094)
NJ (Vanguard)	-0.582 (0.092a)	-0.583 (0.154a)	-0.154 (0.071b)	0.185 (0.103)
NK (Spirit Air)	-0.689 (0.158a)		-0.332 (0.133b)	
WN (Southwest)	-0.501 (0.061a)	-0.516 (0.070a)	-0.314 (0.035a)	-0.320 (0.041a)
FF (Tower Air)	-0.660 (0.129a)		-0.041 (0.087)	
F9 (Frontier Air)	-0.360 (0.117a)		-0.040 (0.074)	

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

Our last area of interest in this section was whether LCCs maintained their low airfares until the next year of entry and whether the impact of their entries on their rivals' airfares continued. To investigate these two issues, we performed the Wald test to test the hypothesis that the airfares of the first year of entry equal those of the years following the entries by LCCs. In our analysis, the parameters of dummy variables *WN1* and *WN2* stand for the degree of Southwest's airfare discounts from the benchmark carriers' airfares (that is, the average airfares of FSCs that do not compete with LCCs), and these parameters are the average values for the cases in which Southwest Airlines entered the markets at least before 1996 and the years of entries are unknown. Therefore, if, for example, we test the hypothesis that the parameter of WN2 equal that of $LCCPE(WN)_1^D$ and find that there is no statistically significant difference between them, we can explicitly conclude that Southwest's first-year airfare remains unchanged over time. We tested the ten hypotheses shown in Table 4 using the Wald test.

Since both Southwest Airline and America West Airlines entered the secondary airport of Chicago (that is, Midway) in this case, we compared the time-effect dummy variables with *WN2*, *WNR*2, *HP*2, and *HPR*2. According to the tested results of hypotheses (1), (2), (3), and (7) in Table 4, it is apparent that the airfare levels of Southwest' first year of entry were maintained in the second year and the following years, since we can reject no hypotheses with regard to these cases at the 5% level of significance. The same results were obtained for the case of Southwest's rivals according to the tested results of hypotheses (4), (5), (6), and (8). Therefore, once Southwest Airlines entered secondary airports, it continued the airfare war with FSCs, and the airfares of Southwest Airlines and FSCs remained at a low level over time according to the tested result in (9). America West Airlines also played a role as a low-airfare carrier when it entered Chicago Midway airport, and its airfare stayed at a low level over time due to the rivalry with other LCCs in the same airport. However, as we mentioned in the analysis of Table 3, its entry had no impact on the FSCs that hub in Chicago O'Hare airport, and this was true over time according to the tested result (10) in Table 4.

Table 4

Results of the time effect test

Tested hypotheses	Chi-square statistics	P-value
(1) The parameter of *WN2* equals that of $LCCPE(WN)_1^D$	0.029	0.865
(2) The parameter of *WN2* equals that of $LCCPE(WN)_2^D$	0.002	0.962
(3) The parameter of *WN2* equals that of $LCCPE(WN)_1^T$	0.151	0.698
(4) The parameter of *WNR2* equals that of $LCRPE(WN)_1^D$	0.299	0.584
(5) The parameter of *WNR2* equals that of $LCRPE(WN)_2^D$	0.221	0.638
(6) The parameter of *WNR2* equals that of $LCCPE(WN)_1^T$	1.655	0.198
(7)The parameter of $LCCPE(WN)_1^D$ equals that of $LCRPE(WN)_2^D$	0.024	0.876
(8) The parameter of $LCRPE(WN)_1^D$ equals that of $LCRPE(WN)_2^D$	0.003	0.959
(9) The parameter of *HP2* equals that of $LCCPE(HP)_2^D$	0.003	0.960
(10) The parameter of *HPR2* equals that of $LCRPE(HP)_2^D$	2.187	0.139

5. Welfare effect

Our final analysis was to compute the change in consumers, producers, and social welfare. Since we did not have the supply curve under the imperfect competition, we did not compute the true producer's surplus. Instead, we computed 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 was computed by obtaining the product of the route distance and the carrier's unit cost (total cost / aggregate RPM). The consumers surplus was computed by computing the area of "trapezoids" of our demand equation (1) that 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 1 illustrates the change in consumers surplus in a simple way. Trapezoid A is the gain in consumers surplus due to LCCs' entry in the primary airport, and trapezoid C is also the gain in consumers surplus due to FSCs' reaction to the LCCs at the primary airport (the FSCs' airfares are higher than those of the LCCs). Similarly, trapezoids B and D show the cases of secondary airports. Since the market output is the sum of the outputs for each carrier, the social 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).[6]

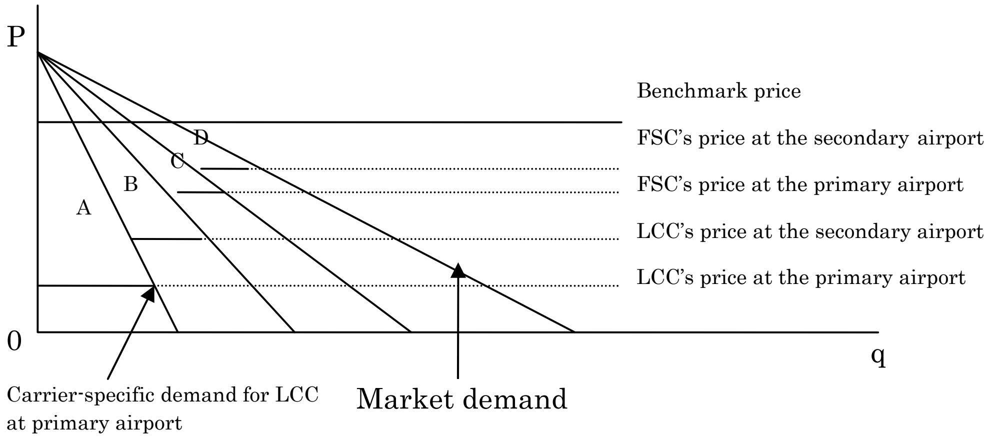

Fig. 1

Gains in consumers surplus

Table 5

Summary of welfare effect of LCC's entry on route bases

Due to:	Gain in cons. surplus	Newly entered LCC's profit	Change in FSC's profit	Gain in social welfare
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**

Note: Gains are shown in millions of U.S. dollars.

Table 5 demonstrates the gain in consumers surplus, newly entered LCC's profit, the change in FSC's profit, and the gain in social welfare on route bases. Since we limited the number of sample observations by selecting only six airport groups, the amounts themselves may not be important. However, the results imply, overall, that the gain in consumers surplus is very large, and LCCs also benefited by entry.

[6] Since we introduce LCC dummy variables, the intercepts of LCCs have to be lower than those of FSCs, but for convenience we depict them as shown in Figure 1.

FSCs lost profits due to the low-cost entries, and especially their losses due to the competition from the adjacent airport were mostly caused by the entry of Southwest. However, since the losses of FSCs were much smaller than the sum of the gain in consumers surplus and LCC's profits, the gain in social welfare was apparently large.

6. Summary and conclusion

Our findings regarding the economic impacts of LCCs' entries are as follows:

(1) On average, LCCs operate with very low airfares, and they involve FSCs in airfare wars.
(2) Investigating further, we find that LCCs' entry impact on FSC airfares depends on individual LCCs. Only Southwest Airlines always involves FSCs in airfare wars, regardless of whether it enters primary or secondary airports.
(3) Additional entries of LCC(s) do not affect the degree of airfare wars.
(4) The type of airport, primary or secondary, does not affect the degree of airfare wars when LCC(s) enter market, on average.
(5) Once Southwest Airlines enters secondary airports, a lasting airfare war with FSCs occurs, and the airfares of Southwest Airlines and the FSCs remain at a low level over time.
(6) Our findings imply that the gain in social welfare due to LCCs' entries is substantial, and 90% of welfare gains come from the gain in consumers surplus and the rest comes from the profit of LCCs. The results also imply that FSCs do not earn profits, which seems to be due to their high average cost of operation.

Among these findings, (5) and (6) are the most important ones. Southwest Airlines has a large market share in many cases, so its presence has a big impact on its rivals' airfares, and this low-airfare impact lasts a long time. On the other hand, other LCCs do not have strong impacts, especially on rivals at remote airports, and this is due to the fact that these LCCs sometimes have only a limited number of slots (sometimes their market shares are around 10%). As long as the entries of LCCs generate a gain in social welfare and this gain is accumulated over time, it may be an important policy to assign more slots to LCCs.

The limitation of this study is, as already mentioned that we need to update the dataset to a more recent one and increase the number of samples to minimize the possible selection bias. This will be done in a future study.

[2010.5.26 981]

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Appendix

Table 6

Estimated result of carrier-specific structural equations

	Demand Equation					
	Model 1			Model 2		
VARIABLES	Parameter	SE	P-VALUE	Parameter	SE	P-VALUE
Airfare	-1.164	0.115	0.000	-1.290	0.143	0.000
Per-capita income	1.966	0.330	0.000	1.588	0.392	0.000
Average population	0.760	0.063	0.000	0.849	0.064	0.000
Dummy for triopoly market	-0.079	0.076	0.299	-0.127	0.078	0.103
Dummy for 4-firm market	-0.151	0.094	0.111	-0.183	0.097	0.059
Dummy for 5-firm market	0.086	0.118	0.735	0.088	0.121	0.467
Dummy for 6-firmmMarket	-0.593	0.184	0.001	-0.650	0.187	0.001
Dummy for 7-firm market	-0.583	0.238	0.014	-0.543	0.243	0.025
Dummy for LCCs at primary AP	-0.495	0.118	0.000	-0.581	0.114	0.000
Dummy for LCCs at econdary AP	-0.265	0.159	0.095	-0.310	0.153	0.042
Constant	1.674	1.212	0.167	3.566	1.297	0.006
	Pseudo-Supply Equation					
VARIABLES	Parameter	SE	P-VALUE	Parameter	SE	P-VALUE
Output	0.151	0.025	0.000	0.077	0.021	0.000
Route marginal cost[7]	0.412	0.017	0.000	0.338	0.070	0.000
Diversity of MC				-0.039	0.028	0.161
Herfindahl index	0.161	0.039	0.000	0.149	0.037	0.000
D1LCC1	-0.444	0.032	0.000			
D1LCC2	-0.522	0.044	0.000			
D1LCR1	-0.188	0.029	0.000			
D1LCR2	-0.194	0.032	0.000			

[7] We used distance for Model 1 as a proxy of marginal cost, and it is treated as an exogenous variable.

D2LCC1	-0.549	0.064	0.000			
D2LCC2	-0.588	0.068	0.000			
D2LCR1	-0.175	0.056	0.002			
D2LCR2	-0.217	0.064	0.001			
KP at Primary Airport				-0.601	0.183	0.001
KP at Secondary Airport				-0.391	0.257	0.128
KP's Rival at Primary Airport				-0.223	0.127	0.079
KP's Rival at Secondary Airport				0.043	0.188	0.818
TZ at Primary Airport				-0.247	0.090	0.006
TZ at Secondary Airport				-0.149	0.073	0.043
TZ's Rival at Primary Airport				0.003	0.052	0.957
TZ's Rival at Secondary Airport				0.029	0.048	0.542
HP at Primary Airport				-0.045	0.043	0.292
HP at Secondary Airport				-0.611	0.266	0.022
HP's Rival at Primary Airport				0.032	0.031	0.306
HP's Rival at Secondary Airport				0.030	0.132	0.816
FL at Primary Airport				-0.538	0.048	0.000
FL at Secondary Airport				-0.486	0.152	0.001
FL's Rival at Primary Airport				-0.318	0.044	0.000
FL's Rival at Secondary Airport				-0.133	0.094	0.155
NJ at Primary Airport				-0.582	0.092	0.000
NJ at Secondary Airport				-0.583	0.154	0.001
NJ's Rival at Primary Airport				-0.154	0.071	0.031
NJ's Rival at Secondary Airport				0.185	0.103	0.074
NK at Primary Airport				-0.689	0.158	0.000
NK's Rival at Primary Airport				-0.332	0.133	0.012
WN at Primary Airport				-0.501	0.061	0.000
WN at Secondary Airport				-0.516	0.070	0.000
WN's Rival at Primary Airport				-0.314	0.035	0.000
WN's Rival at Secondary Airport				-0.320	0.041	0.000
FF at Primary Airport				-0.660	0.129	0.000
FF's Rival at Primary Airport				-0.041	0.087	0.637
F9 at Primary Airport				-0.360	0.117	0.002
F9's Rival at Primary Airport				-0.040	0.074	0.586

LCCPE(WN)1 Duopoly	-0.641	0.289	0.027	-0.560	0.261	0.032
LCRPE(WN)1 Duopoly	-0.076	0.289	0.793	-0.179	0.257	0.485
LCCPE(WN)1 Triopoly	-0.633	0.207	0.002	-0.588	0.196	0.003
LCRPE(WN)1 Triopoly	-0.379	0.131	0.004	-0.473	0.126	0.000
LCCPE(WN)2 Duopoly	-0.602	0.289	0.038	-0.504	0.259	0.051
LCRPE(WN)2 Duopoly	-0.201	0.291	0.488	-0.198	0.258	0.443
LCCPE(HP)2 Duopoly	-0.793	0.290	0.006	-0.630	0.256	0.014
LCRPE(HP)2 Duopoly	-0.532	0.293	0.069	-0.459	0.259	0.076
Constant	1.257	0.254	0.000	2.744	0.371	0.000
Statistics of Model 1	System R-Square=0.560					
Statistics of Model 2	System R-Square=0.663					