Pacific Economic Review

Pacific Economic Review, 16: 1 (2011) pp. 103–119
doi: 10.1111/j.1468-0106.2010.00537.x

EMPIRICAL ANALYSIS OF INTER-FIRM RIVALRY BETWEEN JAPANESE FULL-SERVICE AND LOW-COST CARRIERS

HIDEKI MURAKAMI* *Kobe University*

Abstract. This paper empirically analyzes dynamic change in inter-firm rivalry between Japanese low-cost carriers (LCC) and full-service carriers, and deduces the dynamic change in consumer surplus after an LCC enters a market. Our findings are that: (i) the conduct parameters of LCC and reacting full-service carriers were extraordinarily low when competition started; (ii) the conduct parameters were restored to, or even exceeded, the pre-entry level in the third year of LCC entry; and (iii) gains in total welfare were recognized for five of the nine markets, whereas in three markets only the airline industry benefited, and in one market, total welfare decreased.

1. INTRODUCTION

In 1996, responding to the worldwide tide of deregulation, Japan's Ministry of Transport allowed two air carriers to be founded to enter the domestic market. One was Hokkaido International Airlines (called Air Do, with the code ADO), founded by bankers and farm entrepreneurs in Hokkaido, who had argued that expensive airfares were damaging the economy in Hokkaido. The other was Skymark Airlines (code: SKY), founded by a travel agency, H.I.S. H.I.S. wanted to create new demand for package tours by issuing much cheaper tickets than full service carriers. In 1998, Air Do and Skymark entered Tokyo–Sapporo and Tokyo–Fukuoka, the largest and second largest city-pair routes in the world in terms of demand, respectively. Skymark also entered Osaka–Sapporo and Osaka–Fukuoka.

In 2000, the Ministry of Transport deregulated airfares and domestic market entry/exit, and two other airlines were founded: Skynet Asia Airways (SNA) and Star Flyer (SFJ). In 2002, Skynet Asia entered Tokyo–Miyazaki, followed by Tokyo–Kumamoto and Tokyo–Nagasaki, all of which are long-distance city-pair routes with few surface transportation modes to compete with airlines. Star Flyer started operating in Tokyo–Kitakyushu in 2006, and then entered Tokyo–Kansai (Osaka) in 2007.

The present paper analyzes the dynamic change in inter-firm rivalry between new and full service carriers[1] by modelling oligopolistic competition and estimating the conduct parameter derived from the oligopoly model. Our study focuses on the pre-entry strategy of full-service carriers, the strategies of new

**Address for Correspondence*: Graduate School of Business, 2-1, Rokkodai, Nada, Kobe, Hyogo 657-8501, Japan. E-mail: hidekim@panda.kobe-u.ac.jp. The author is grateful to Tae Hoon Oum, Anming Zhang and anonymous referees for helpful comments.

[1] They are Japan Airlines (JAL), All Nippon Airways (ANA) and Japan Air System (JAS). Japan Air System was formally merged by Japan Airlines in 2006, but their routes were consolidated in 2003.

entrants and full-service carriers during the fare war, and full-service carriers' 'price-recovery' behaviour after the new carriers exited. Furthermore, we investigate how the fares dynamically change from pre-entry to post-exit situations throughout the fare-war periods and compute the welfare effects by estimating a simultaneous demand and fare equation system. The next section is an overview of the characteristics of new Japanese carriers. Section 3 reviews previous studies, models the oligopolistic competition, and derives the conduct parameter and demand and fare equation system. Section 4 explains our data set and econometric method, demonstrates our empirical results and discusses the welfare effects based on the empirical results. Finally, we provide concluding remarks in Section 5.

2. OVERVIEW OF NEW JAPANESE CARRIERS: ARE THEY REALLY LOW-COST CARRIERS?

Although the Japanese Ministry of Land, Infrastructure and Transport,[2] some Japanese academics and the mass media refer to Air Do, Skymark, Skynet Asia and Star Flyer as low-cost carriers (LCC), it seems doubtful that they belong in the same category as Southwest, Ryan or Jet Blue. We first summarize their service characteristics in Table 1 and compare them with those of US and European LCC.

One characteristic is that none of the new carriers can choose to make secondary airports their base. Only Skymark appears to be close to the LCC of the United States, such as Southwest Airlines in the 1990s, in terms of no-frills service, high discount ratios, very limited mileage service and independence from full-service carriers. In addition, all of these new carriers, except for Skymark, offer a more-frilled service like the new-generation LCC, such as Jet Blue, even though the need for frills is lower than Jet Blue's, because most Japanese routes are less than two in-flight hours.

As for costs, Figure 1 shows the difference in real price index-adjusted unit costs between full-service carriers and LCC as well as the change in those costs over time.

The reasons why these new carriers cannot achieve low costs are twofold: one is that government tax, fuel prices, maintenance costs and airport charges are the same among all Japanese airlines; the other is that Japan does not have secondary airports in its metropolitan areas, such as Chicago Midway, which would charge cheaper landing fees. New carriers can choose to relegate maintenance to low-cost foreign companies, but due to the problems with the quality of those foreign services, they currently have their aircraft maintained by their rivals, full-service carriers. Only on labour costs can new carriers spend less than full-service carriers, and indeed this labour cost difference equals the total cost difference.

As we see in Table 1, all the LCC were deficit-ridden during the study period. In addition to the high cost structure of new airlines, what makes them worse off is the pricing strategy of full-service carriers, which seem to have tried to drive

[2] The Ministry of Transport merged with the Ministry of Construction in 2001 and was later reorganized as the Ministry of Land, Infrastructure, Transport and Tourism.

Table 1. Characteristics of new Japanese carriers

	Air Do (ADO)	Skymark (SKY)	Skynet Asia (SNA)	Star Flyer (SFJ)
Seating class	Economy†	Economy and Cygnus class‡	Economy‡‡	Economy‡‡
Discount ratio at its entry against full-service carrier's airfare (%)	36.0	50.0	32.3	17.0
Fleet configuration	B767 and B737	B767 and B737	B737	A320
Frequent flyer program	Yes	Limited§	Limited§§	Yes
Method for booking tickets	Internet, toll-free telephone, mobile ticket desk	Internet, telephone, mobile ticket desk, travel agent¶	Internet, toll-free telephone, mobile	Internet, telephone, mobile ticket desk, travel agent¶
Free in-flight service and/or amenity	Nothing for B737; radio & music for B767	Nothing (even for Cygnus class)	Beverages (coffee, soft drinks)	Sweets, beverages (coffee, drinks)
Code-share/partnership	ANA, SNA	None††	ANA, ADO	ANA
Base airport	Sapporo	Tokyo	Miyazaki	Kita–Kyushu
Profit/loss (in total of 2000–2006), $USm ($US1 = 120 yen)	–14.23	–69.51	–70.18 (2002–06)	–20.31 (2005–06)

Notes: †Discount tickets are available for pre-purchasing, students, the handicapped and for inhabitants of Hokkaido and business people working for companies in Hokkaido. ‡Discount tickets are available for pre-purchasing, students and the handicapped. Cygnus class offers more wide-pitched, comfortable seats than economy class for 1000 yen more than an economy fare. §Available for buyers who pay with Skymark Visa/Master Card. ¶Designated travel agents. ††Skymark once allied with Japan Airlines in 2005 in Tokyo–Osaka (Kansai) and Tokyo–Kobe, but terminated this alliance quickly. ‡‡Discount tickets are available for pre-purchasing, round-trip students, and the handicapped. §§One free ticket for every 10 flights.

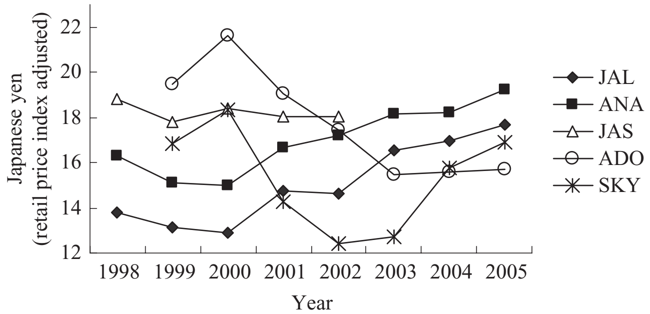

Figure 1. Changes in carriers' unit costs from 1998 to 2005
Notes: ADO, Air Do; ANA, All Nippon Airways; JAL, Japan Airlines; JAS, Japan Air System; SKY, Skymark.
Source: *JAA Civil Aviation Databook (Koku Tokei Yoran)*, Japan Aeronautic Association, 1998–2005.

their new competitors out of the market by matching their fares. For example, when Air Do entered the Tokyo–Sapporo market, full-service carriers matched its fares almost exactly. As a result, Air Do's cumulative deficit reached $US61m for its first 4 years, and it filed for protection under Japan's Corporate Reorganization Law (Minji Saisei Hou) in 2002. It was later reorganized by code-sharing with All Nippon and paid off its debt in 2005, a year earlier than scheduled. Skynet Asia's fortunes were very similar to Air Do's, and it is now code-shares with All Nippon. Only Skymark was able to reduce its costs to 20% lower than the highest-cost carrier, Japan Air System, between 2001 and 2002, but it made a profit only in 2004.

3. THE MODEL

As stated above, Japanese full-service carriers have responded to low-cost entrants by cutting fares, and seem to have tried to expel them. This section models oligopolistic competition between full-service carriers and their new rivals, and derives the conjectural variation (conduct parameter) to investigate rigidly what types of competition full-service carriers and LCC have engaged in. We also investigate how much of an impact such competition has on social welfare by constructing and estimating carrier-specific simultaneous equations of demand and price.

3.1. *Conduct parameter*

Many previous studies have used the conduct parameter to analyze inter-firm rivalry: Iwata (1974), Appelbaum (1982), Brander and Zhang (1990, 1993), Oum *et al*. (1993), and Fischer and Kamerschen (2003). In particular, the last three sets of authors have focused on the US airline industry. Those studies use cross-sectional data and focus on duopolies, in which two 'symmetric' carriers, such as United Airlines and American Airlines, compete. The present paper has two distinguishing features: (i) it focuses on asymmetric carriers (full-service carriers *vs* an LCC); and (ii) using panel data, it derives the conduct parameters of the Japanese airline industry on route-by-route and year-by-year bases.

The reason we use panel data instead of cross-sectional data is that we do not have a sufficient number of samples for each year. Therefore, the variables to be used in our model have superscripts, L and k, which denote a carrier, and subscripts i, which denotes a market, and t, which denotes a fiscal year. Our model assumes that each market has one LCC and three full-service carriers. This scenario was found more often before 2002, when Japan Airlines and Japan Air System merged, than after. We denote the three full-service carriers as carrier k ($k = 1, 2, 3$) and the LCC as carrier 4. The market demand for route i in year t is denoted as follows:

$$Q_{it} = \sum_{k=1}^{3} q_{it}^{k} + q_{it}^{4} \equiv \sum_{L=1}^{4} q_{it}^{L} \quad (k = 1,2,3,\ L = 1,2,3,4), \tag{1}$$

where superscripts k and L each denote a carrier; L includes an LCC ($L \equiv 1,2,3,4$), while k denotes full-service carriers only. The profit function of each carrier at route i in year t is denoted as follows:

$$\pi_{it}^{L} = q_{it}^{L} p_{it}(Q_{it}) - TC_{it}^{L}(q_{it}^{L}), \tag{2}$$

where $TC_{it}^{k}(\bullet) > TC_{it}^{4}(\bullet)$.

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

$$\frac{\partial \pi_{it}^{L}}{\partial q_{it}^{L}} = p_{it}(Q_{it}) + q_{it}^{L} \frac{\partial p_{it}(Q_{it})}{\partial Q_{it}} \frac{\partial Q_{it}}{\partial q_{it}^{L}} - MC_{it}^{L}(q_{it}^{L}) = 0. \tag{3}$$

We then define the conduct parameters as:

$$v_{it}^{k} \equiv \frac{d}{dq_{it}^{k}} \left(\sum q_{it}^{j} + q_{it}^{4} \right) \quad j \neq k \tag{4}$$

$$v_{it}^{4} \equiv \frac{d}{dq_{it}^{4}} \left(\sum q_{it}^{k} \right) \tag{5}$$

Substituting equations 4 and 5 into equation 3, respectively, we obtain:

$$\frac{\partial \pi_{it}^{L}}{\partial q_{it}^{L}} = p_{it}(Q_{it}) + q_{it}^{L} \frac{\partial p_{it}(Q_{it})}{\partial Q_{it}} (1 + v_{it}^{L}) - MC_{it}^{L}(q_{it}^{L}) = 0, \tag{6}$$

where $MC_{it}^{k}(\bullet) > MC_{it}^{4}(\bullet)$ and v_{it}^{L} is either (4) (the case of full-service carriers) or (5) (the case of LCC). For example, the conduct parameter (eqn 4) is the marginal change in the output of other carriers (two full-service carriers except for k plus carrier 4) 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, equation 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, full-service carriers would have to exit the market, because $MC_{it}^{k}(\bullet) > MC_{it}^{4}(\bullet)$ as long as carriers operate at the minimum efficient scale where average cost equals marginal cost. In Japan's case, we might have observed this scenario once with Tokyo–Asahikawa (the second-largest city in Hokkaido), from which All Nippon and Japan Air System (just before it merged with Japan Airlines) exited and only one LCC (Air Do) stayed. However, in most cases, full-service carriers stay, so we expect that the market price rarely falls close to an LCC's marginal cost level.

As in the previous studies, equation 6 can be inverted to equation 7 by using the price elasticity of demand (η_{it}) and the market share of each carrier (s_{it}^{L}):

$$v_{it}^{L} = \frac{\{p_{it}(Q_{it}) - MC_{it}^{L}(q_{it}^{L})\}}{p_{it}(Q_{it})} \frac{\eta_{it}}{s_{it}^{L}} - 1. \tag{7}$$

As for the variables and parameters in equation 7, we already have information on p_{it} and s_{it}^{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 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.[3] However, it is impossible to arrive at marginal cost by estimating the translog cost function of Japanese carriers, because no Japanese LCC have officially disclosed their costs for labour, capital materials and so on. Alternatively, 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):

$$MC_{it}^{L} = AC_{t}^{L}\left(\frac{Dist_i}{AFL_t^{L}}\right)^{-\lambda} Dist_i, \tag{8}$$

where AC_t^L is the aggregate average cost of carrier L in year t, $Dist_i$ is the distance of route i regardless of time, and AFL_t^L is the average distance flown by airline L in year t.[4] Studies on airline costs, such as Caves *et al.* (1984), show that economies of density exist in the airline industry, and this means that the total cost function is strictly concave. Therefore, λ in equation 8 ranges between 0 and 1. It is apparent that if λ is 0, the carrier's marginal cost is proportional to distance, whereas if λ is 1, the marginal cost is indifferent to

[3] See Fischer and Kamerschen (2003, pp. 235–7).

[4] See Brander and Zhang (1990, pp. 572–5), Brander and Zhang (1993, pp. 417–20) and Oum *et al.* (1993, pp. 175–8).

distance. Oum *et al*. (1993) statistically estimate that $\lambda = 0.43$. They construct the following nonlinear price equation to obtain λ and the system-wide conduct parameter v:

$$p_{it}^{L} = \frac{\left\{AC_t^L\left(Dist_i/AFL_t^L\right)^{-\lambda} Dist_i\right\}\eta}{\eta - (1+v)s_{it}^{L}} + \varepsilon_{it}^{L}. \tag{9}$$

Before we can estimate the price equation (9), we need the route-specific price elasticity of demand, η. We estimate the following Marshallian demand function by using route-specific unbalanced panel data to obtain the information on η:

$$\ln(Q_{it}) = A - \eta \ln p_{it} + \beta \ln INC_{it} + \gamma \ln Dist_i + \delta \ln POP_{it} + \rho \ln HI_{it} + \mu_{it}, \tag{10}$$

where p_{it} is the lowest price of each airline at route i in year t, and INC_i is the arithmetic average of per-capita income of route i in year t. Both p_{it} and INC_i are adjusted by the retail price index. POP_i is the arithmetic average of the population of route i in year t, and HI_{it} is the Herfindahl index of route i at year t. The Herfindahl index is expected to have a negative effect on the number of passengers when price elasticity of demand is relatively small, because carriers with monopolistic power will reduce output to maximize profit.

3.2. *Structural equations of demand and price*

Our second interest is in how much the route-specific social welfare gain has been since the new entry of LCC and, for a couple of routes where competition ended, how much the welfare loss might be after the LCC exited. To determine this, we need to know: (i) how the price and demand have dynamically changed from the pre-entry situation to the years of the fare-war; (ii) in the route from which the LCC exited, whether or not (or by how much) the price recovered after the competition ended; and (iii) the yearly profit/loss of each carrier.

The effect of the entry of LCC on carriers' airfare at primary and secondary airports has been analyzed empirically by Dresner *et al*. (1996) and Morrison (2001). We build upon the method proposed by Dresner *et al*. (1996), who estimated the simultaneous demand and airfare equations using three-stage least squares. To ascertain the consumer welfare effect, we also need to know the demand for LCC as well as the airfare, both of which are simultaneously related to each other in the demand and supply system. To incorporate the simultaneous relations of airfare and demand, we construct the following structural equation system for full-service carriers:

$$\begin{aligned}\ln q_{it}^{k} = {} & \alpha_0 + \alpha_1 \ln p_{it}^{k} + \alpha_2 \ln p_{it}^{4} + \alpha_3 \ln POP_{it} + \alpha_4 \ln INC_{it} \\ & + \alpha_5 \ln Dist_i + \alpha_6 \ln FRQ_{it}^{k} + \alpha_7 \ln MSHE_{it}^{k} + \alpha_8 MJJ \\ & + \sum_{n=1}^{4} \alpha_{9n} ADO_l + \sum_{n=1}^{4} \alpha_{10n} SKY_l + \sum_{m=1}^{3} \alpha_{11m} SNA_m + e_{it}^{k} \\ & (k = 1,2,3,\ n = 1,2,3,4,\ m = 1,2,3)\end{aligned} \tag{11}$$

$$\ln p_{it}^k = \beta_0 + \beta_1 \ln q_{it}^k + \beta_2 \ln MC_{it}^k + \beta_3 \ln FRQ_{it}^k + \beta_4 \ln MSHE_{it}^k + \sum_{n=1}^{4} \beta_{5n} JAL_n + \sum_{n=1}^{4} \beta_{6n} ANA_n + \sum_{n=1}^{4} \beta_{7n} JAS_n + \beta_8 EXJ + \beta_9 EXA + \beta_{10} EXD + \beta_{11} EXH + u_{it}^k \quad (n = 1,2,3,4) \tag{12}$$

where FRQ_{it}^k is the number of departures of carrier k at route i in year t, MJJ is the Japan Airlines–Japan Air System merger's dummy variable. For MJJ, the three elements of Japan Airlines' years 2003, 2004, and 2005 take the value 1, and all the other elements take the value 0. JAL_n, ANA_n, JAS_n, ADO_n, SKY_n and SNA_m are the dummy variables showing the dynamic effect of an LCC's entry. For example, the elements of ADO_1 are 1 for Air Do's first year of entry and 0 for the other year of Air Do and the other carriers, and the observation of JAL_1 is 1 for the first year of any LCC's entry. Therefore, JAL_n, ANA_n and JAS_n reflect the strategy full-service carriers took against LCC. $MSHE_{it}^k$ shows the market share of carrier k at route i in year t. This structural equation has five endogenous variables. Considering the demand and supply system, it would make sense to assume that demand, own price, cross price and marginal cost are endogenous. In addition, a carrier's market share is determined by the market structure and is also assumed to be endogenous. Similarly, the structural equation system for carrier 4 is obtained by replacing $a_2 \ln p_{it}^4$ with $a_2 \ln p_{it}^j$ in the demand equation, where j is the full-service carrier having the lowest airfare among Japan Airlines, All Nippon and Japan Air System, and replacing all the other superscript k with superscript 4.

Because we assume the case of a four-carrier oligopoly, we have to have three cross-price terms in the demand equation. However, full-service carriers set almost the same airfares as each other. Therefore, we introduce one cross term, and by doing this we mean that three full-service carriers pay attention to the LCC's fare,[5] while the LCC sets its fare below the lowest fare or the collusion fare of the full-service carrier(s).

As for the dummy variables related to exit, we have created the dummy variables EXJ, EXA and EXD to see the effect of the full-service carriers' fare-restoring behaviour. These variables are each 1 for the legacies' elements in the year after an LCC's exit. EXH is the dummy variable to show Air Do's fare-restoring behaviour after the full-service carriers have exited. The element of EXH is 1 for the year after a full-service carrier's exit.

3.3. *Implications for market welfare*

This section demonstrates how to compute the change in market welfare, referring to each carrier's price and output after an LCC enters. Our method is simply to compute the triangle surrounded by the intercept of the demand function, output and price before and after an LCC's entry, and compare. The 'benchmark' for computing consumer welfare is the triangle surrounded by the

[5] According to Mr Go Nishimura, chief researcher of ANA (All Nippon Airways) Strategic Research Institute Co., Ltd, this practice actually occurs.

horizontal intercept of the demand curve, $Int_0^{K,i}$, the pre-entry price, $p_0^{K,i}$, and the corresponding market output, $q_0^{K,i}$. Both $p_0^{K,i}$ and $q_0^{K,i}$ are estimated values computed from the simultaneous equations. The superscript i denotes the market, that is, i = Tokyo–Sapporo, Tokyo–Fukuoka, Tokyo–Asahikawa, Tokyo–Aomori, Tokyo–Tokushima, Tokyo–Miyazaki, Tokyo–Kagoshima, Osaka–Sapporo and Osaka–Fukuoka; and K is the carrier in the market including the LCC. Letting this benchmark consumer surplus be $\widehat{CS}_0^K$, we can describe the $\widehat{CS}_0$ of a market as:

$$\widehat{CS}_0 = \sum_K \widehat{CS}_0^K, \quad where \quad \widehat{CS}_0^K = \int_{p_0^{K,i}}^{Int_0^{K,i}} f(p_0^{K,i})dp_0^{K,i}, \tag{13}$$

where $f(\bullet)$ is the carrier-specific demand function defined as equation 11 in the previous subsection.

Next, we compute the size of the triangle surrounded by $p_t^{K,i}$, $q_t^{K,i}$ and the horizontal intercept of the demand curve adjusted by a carrier-entry dummy variable, $Int_t^{K,i}$. The subscript t denotes the years after the LCC entry and the subscript 0 denotes the years before LCC entry. Letting the post-entry consumer surplus be $\widehat{CS}_t$, we can describe $\widehat{CS}_t$ as:

$$\widehat{CS}_t = \sum_K \widehat{CS}_t^K, \quad where \quad \widehat{CS}_t^K = \int_{p_t^{K,i}}^{Int_t^{K,i}} f(p_t^{K,i})dp_t^{K,i}. \tag{14}$$

Then, we take the ratio $\hat{W}_t \equiv \widehat{CS}_t / \widehat{CS}_0$ and show the change in consumer surplus graphically. After we compute the consumer surplus, we deduce the total welfare by summing consumer surplus and the route-specific profits of carriers. We use carrier profit as a proxy of producer surplus because we might not be able to find the true producer surplus, because the Japanese airline market is not perfectly competitive.

4. EMPIRICAL RESULTS

4.1. *Conduct parameter*

The former half of this section derives each carrier's conduct parameter per route per year. The data sources for carrier costs, passengers and flight frequency are *Koku Tokei Yoran* (*JAA Civil Aviation Handbook*) published by the Japan Aeronautic Association and *Koku Yuso Tokei Nempo* (*Yearly Statistical Survey of Japanese Aviation*) published by the Ministry of Land, Infrastructure, Transport and Tourism. The fare information is obtained from *Jikoku Hyo* (a timetable of railways and airlines that is published monthly). The demographic data sources are *Kakei Chosa Hokoku* (*Family Income and Expenditure Survey*), which is published by the Japan Statistics Bureau, and web pages of related prefectures and cities. For each year studied, the statistics on fares, population, flight frequency and income are data from April, when airline demand is lowest. The reason we use data only from April is that we can recognize a carrier's fare strategies best in that month, because carriers issue many varieties of discount tickets to convert potential demand to actual demand.

We estimated the demand equation (eqn 10) using the route-specific unbalanced panel data of nine routes for 4–8 years. Values in parentheses are t-values computed using heteroskedasticity-robust standard errors, and 'a' means that the parameters are significant at the 1% level:

$$\ln(Q_{it}) = \underset{(-1.441)}{-41.479} - \underset{(-4.269a)}{1.252}\ln p_{it} + \underset{(1.197)}{2.254}\ln INC_{it} + \underset{(1.272)}{0.604}\ln DIST_i + \underset{(3.692a)}{1.894}\ln POP_{it} - \underset{(3.291a)}{1.299}\ln HI_{it}$$

$$\bar{R}^2 = 0.503 \quad \hat{\sigma}^2 = 0.536 \quad n = 43$$

The price elasticity of demand (η) is –1.252, and we will use this information to estimate λ and v in equation 9. The data set for estimating equation 9 is different from the one used for estimating the demand equation (eqn 10). It is the carrier-specific unbalanced panel data of two to four carriers on nine routes for 4–8 years ($n = 130$). Using the nonlinear least-squares method, we obtain the estimated results shown in Table 2.

According to Table 2, we recognize that economies of density also might exist in Japan's airline industry, although we do not treat all the domestic markets. The system-wide conduct parameter is –0.242, so the markets where an LCC enters are regarded as more competitive than the Cournot competition level.

First, we discuss two major LCC markets: Tokyo–Sapporo and Tokyo–Fukuoka. Figure 2a shows the dynamic change in conduct parameters of the four airlines operating in Tokyo–Sapporo.

Table 2. The estimated parameters of the price equation (9)

Parameter	Parameter value	Asymptotic t-statistic	Test result
λ	0.374	7.274	***
v	–0.242	–6.119	***

Note: Log-likelihood = –1317.63, $n = 130$; ***represents significant at the 1% level.

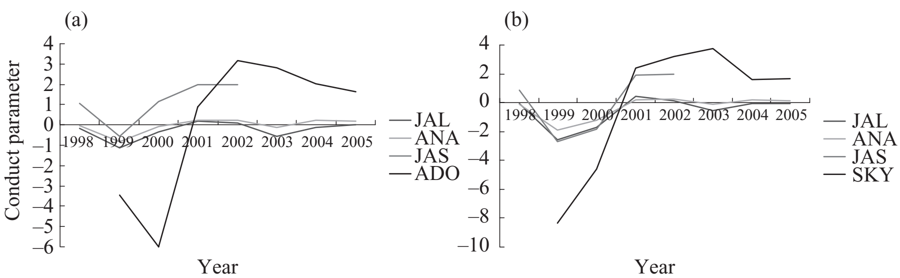

Figure 2. Conduct parameter change in (a) Tokyo–Sapporo and (b) Tokyo–Fukuoka.
Notes: The vertical axis is the conduct parameter and the horizontal is the fiscal year. ADO, Air Do; ANA, All Nippon Airways; JAL, Japan Airlines; JAS, Japan Air System; SKY, Skymark.

Because the Tokyo–Sapporo market has few alternative surface transportation modes that can compete with airlines, three airlines could have colluded and shared a monopoly profit. Rather, it seems that before Air Do entered, two big full-service carriers, Japan Airlines and All Nippon, engaged in Cournot competition to try to obviate intervention by the Japan Fair Trade Commission (FTCJ, Kosei Torihiki Iinkai). Because Japan Air System's marginal cost was lower than those of the big two, whereas its fares were almost the same as theirs, its conduct parameter is closer to the collusion level. Then, in 1998, Air Do entered with an incredibly low conduct parameter that was theoretically impossible in the equilibrium. Air Do, which had less than 10% market share, adopted such behaviour because it wanted to create new demand by reducing fares, and subsidized the loss in the low-demand month by the profit earned in high-demand months. According to Ito (2003), FTCJ was about to intervene at that time, as it considered this behaviour to be predatory pricing, but ultimately it did not act, because 'predatory pricing is difficult to establish unless fares increase after new entrants exit the market'. Three full-service carriers quickly matched their fares to the marginal cost level, and the fierce fare war lasted until 2001, by which time Air Do had accumulated serious deficits. The next year, Air Do filed for protection under Japan's Corporate Reorganization Law (*Minji Saisei Hou*) and reorganized under All Nippon's support. Because Air Do code-shared with All Nippon, its conduct parameter substantially increased and now appears to be converging to the collusion level. In Figure 2b, we observe almost the same behaviour in Tokyo–Fukuoka as was seen in Tokyo–Sapporo in Figure 2a. The logic of Skymark's behaviour seems to be almost the same as Air Do's, and it had become deficit-ridden by the end of 2000.

Figure 2 also shows that the conduct parameter of Japan Airlines moves in the same direction as that of All Nippon. The correlation coefficient between Japan Airlines' and All Nippon's conduct parameters is 0.955 for Tokyo–Sapporo and 0.984 for Tokyo–Fukuoka, and both are statistically significant at the 5% level. These results imply a higher probability that Japan Airlines and All Nippon are colluding. However, it appears that they were exhibiting Bertrand competition between 1999 and 2000 and then Cournot competition after 2001, at least during the off-season, rather than colluding, probably due to the anti-trust consideration mentioned above.

A similar finding is that Skynet Asia entered Tokyo–Miyazaki in 2003 with a conduct parameter equal to –0.118, and it always kept the parameter at low levels: –0.050 and –0.186 between 2003 and 2005. Japan Airlines tried to match its fares in the first year of entry but restored fares when the year was over, whereas All Nippon matched its fares for the first 2 years. During the competition period, Skynet Asia's deficit had grown to $US61.6m by 2005. Although Skynet Asia made efforts to keep its fares low a little longer than Air Do and Skymark, it finally resorted to code-sharing with All Nippon, and market-averaged airfares increased. Tokyo–Kagoshima, where low-cost competition lasted more than 4 years, experienced Skymark's entry in 2002. It is interesting that the conduct parameter movement is quite similar to the right-hand side of Figure 2b; that is, the high conduct parameter of Skymark and the low conduct parameters of the full-service carriers. Skymark was already suffering from deficits in Tokyo–Fukuoka, so it had to set airfares high to make profits, whereas it seems that full-service carriers were trying to expel Skymark from the market. This scenario also holds for Tokyo–Tokushima, where low-cost competition lasted 3 years.

The only market where an LCC seems to have won a fare war against full-service carriers is Tokyo–Asahikawa, as mentioned in Subsection 3.1. Before Air Do entered this route, the Japan Airlines–Japan Air System group had an 85% market share, whereas All Nippon had a 15% share, with conduct parameters of –0.422 and 1.868, respectively. Then, in 2004, Air Do entered with a conduct parameter of 0.810, after its code-share partner, All Nippon, exited. This value is close to a monopoly level, but Air Do's fare was 16.4% less than Japan Airlines–Japan Air System's. By doing this, the All Nippon–Air Do group increased its market share from 15 to 30%, and Japan Airlines exited due to the low profitability of the route, even though it still had a 70% market share.

Three other markets (Osaka–Sapporo, Osaka–Fukuoka and Tokyo–Aomori) experienced only 1 or 2-year price wars initiated by Skymark. The pre-entry conduct parameter of the full-service carriers was 0.148, and the full-service carriers kept that parameter just above the Cournot competition level even after the fare wars ended, whereas Skymark entered with a very low conduct parameter (–1.750) and then exited the next year. The full-service carriers might have anticipated that Skymark would exit soon without any price-matching strategy, because they knew that potential demand was too low for Skymark to achieve profitability.

Next, we focus on the relationship between conduct parameters and market share. Usually, firms with strong market power will increase their price-to-cost margins as their market share increases. However, firms with higher market share sometimes choose low price (and, as a result, low conduct parameters) in order to expel rivals. Oum *et al.* (1993) empirically recognize this behaviour through an analysis of duopolistic competition between American Airlines and United Airlines. Japanese full-service carriers appear to have chosen almost the same behaviours as American Airlines and United Airlines. The correlation coefficient between a full-service carrier's conduct parameter and its market share is –0.517, which is statistically significant at the 1% level by *t*-test, whereas that of an LCC is 0.072, which is not statistically significant. This implies that LCC behave as the oligopolistic theory predicts.

Oum *et al.* (1993) also argue that an airline's conduct parameter inversely correlates with market distance. Usually, US long-haul markets are so large and thriving that more entrants try to enter and compete in them than in short-haul markets. As a result, conduct parameters decrease. This situation also occurred in Japan. By carrying out a simple regression of the conduct parameter on distance, we observe a negative, although weak, relationship between conduct parameter and distance.[6] Furthermore, this result tends to be stronger for LCC than full-service carriers. These results seem attributable to the 'seemingly predatory' prices in the first and second years of Air Do's and Skymark's entry into Tokyo–Sapporo and Tokyo–Fukuoka.

4.2. *Market welfare*

The latter half of this section discusses the effect of an LCC's entry on consumer surplus. Information for computing consumer surplus is obtained from the following simultaneous equations of carrier-specific demand and price. Table 3 shows the estimated results.

Our estimation method is the iterative three-stage least squares. The empirical statistic is that the system R^2 is 0.991. The letter 'a' beside a t-statistic means the parameter is significant at the 1% level, and 'b' indicates significance at the 5% level.

Before performing a welfare analysis using the results of the econometric model, we do a preliminary analysis of how the price per distance has changed from the LCC pre-entry year to their post-exit year. Figure 3 describes the change in fares per distance. Each is the passenger-weighted average of six carriers. We have nine routes for the pre-entry year and for the first year of LCC entry. The low-cost competition ended within 1 year in Osaka–Sapporo and Tokyo–Aomori, and within 2 years in Osaka–Fukuoka and Tokyo–Asahikawa. For these four routes, we observe the full-service carrier's fares after an LCC has exited. For the other five routes, the cost competition continued for more than 3 years. Therefore, we do not observe a post-exit price.

Figure 3 shows the fare drops by 25% after LCC entry. In the routes in which low-cost competition ended within 1 or 2 years, the initial significant price drop reversed, eventually exceeding the pre-entry price, probably because the full-service carriers tried to compensate for the loss incurred during the fare war (see the dotted and dashed lines, which jump from 1 to exit and 2 to exit). In the routes in which the wars lasted more than 4 years, the fare was restored close to the pre-entry fare in the third year.

Figure 4 describes the change in two kinds of consumer surplus using the real values of price and output (W_t), as well as using estimated output and price in our simultaneous equation ($\hat{W}_t$). Looking at the graphs in those figures, our estimated results ($\hat{W}_t$), which predict that consumer-surplus curves will slope down in the long run, look 'pessimistic' compared with the case using the real values.

However, for Tokyo–Sapporo and Tokyo–Fukuoka, consumer surplus increased in the first year and the first 2 years, respectively, of LCC entry, but

[6] Because we detect the heteroskedasticity for this regression (Breusch-Pagan/Godfrey (BPG) test: $\chi^2_{(3)} = 25.45$ with p-value 0.000), we use the maximum likelihood method. '*a*' and '*b*': significant at 1 and 5%:

$$CP^L_{iAv} = \underset{(3.122a)}{1.314} - (\underset{(-2.159b)}{0.00083} + \underset{(-3.474a)}{0.00447}\,DLCC)Dist_i + \underset{(3.191a)}{4.301}\,DLCC \quad Log-likelihood = -68.206,$$

where *DLCC* is the dummy variable, each of which is 1 for LCCs' elements. The subscript '*Av*' beside *CP* means that the conduct parameter used here is the average value of each firm at route i after an LCC enters. $n = 30$.

Table 3. Empirical results of demand and price equations

Demand equation	Parameter	*t*-statistic	Price equation	Parameter	*t*-statistic
Own price elasticity	–1.089	–3.709***	Output	–0.464	–4.696***
Cross price elasticity	0.383	2.043**	Route marginal cost	1.196	8.520***
Distance	0.775	3.958***	Frequency	0.537	4.486***
Population	0.249	1.921*	Market share	0.212	4.325***
Frequency	1.186	25.540***	First year of JAL	–0.150	–2.263**
Market share	0.245	2.768***	Second year of JAL	–0.058	–1.019
First year of ADO	–0.057	–0.375	Third year of JAL	0.093	1.451
Second year of ADO	0.079	0.382	Fourth and further years of JAL	–0.129	–2.040**
Third year of ADO	–0.184	–0.852	First year of ANA	–0.080	–1.137
Fourth and further years of ADO	–0.345	–2.637***	Second year of ANA	0.047	0.587
First year of SKY	–0.212	–0.952	Third year of ANA	–0.143	–1.964**
Second year of SKY	–0.155	–1.021	Fourth and further years of ANA	–0.101	–1.449
Third year of SKY	–0.342	–2.673***	First year of JAS	0.008	0.077
Fourth and further years of SKY	–0.396	–2.699***	Second year of JAS	–0.213	–2.843***
First year of SNA	–0.568	–2.931***	Third year of JAS	–0.060	–0.912
Second year of SNA	–0.450	–2.433**	Fourth year of JAS	0.179	1.721
Third year of SNA	–0.523	–2.508**	Post-exit price of JAL	0.072	0.857
JAL–JAS Merger	–0.143	–2.515**	Post-exit price of ANA	0.202	2.214**
Income	–247.130	–2.277**	Post-exit price of JAS	0.408	3.769***
Income*Income	9.460	2.263**	Post-exit price of ADO	0.208	0.992
Constant	1614.400	2.292**	Constant	–0.240	–0.186

Notes: AD, Air Do; ANA, All Nippon Airways; JAL, Japan Airlines; JAS, Japan Air System; SKY, Skymark; and SNA, Skynet Asia. ***, ** and * are statistically significant at the 1, 5 and 10% levels, respectively.

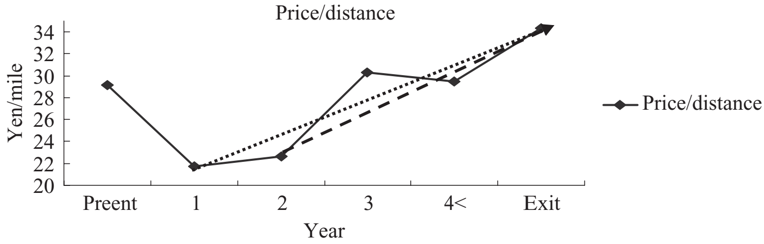

Figure 3. Dynamic change in market average price before, during and after competition between low-cost carriers (LCC) and full-service carriers.
Notes: The vertical axis is airfare in Japanese yen per mile, and the horizontal axis is the nth year of LCC entry ('Preent' is the pre-entry average fare per distance, '4<' denotes the average fare per distance in the fourth year and after, and 'exit' denotes the average fare of full-service carriers after an LCC has exited).

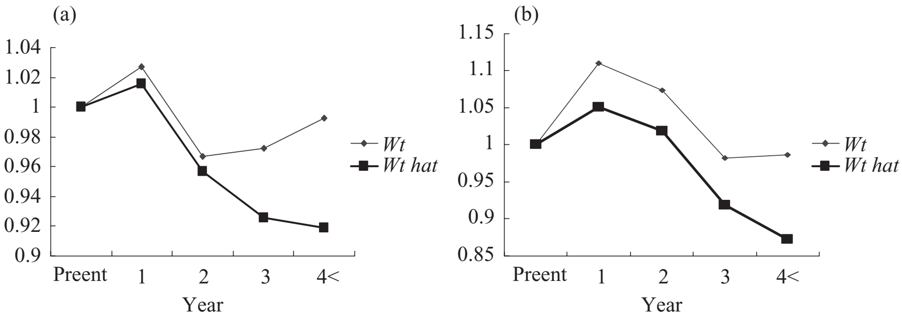

Figure 4. Change in consumer surplus in (a) Tokyo–Sapporo and (b) Tokyo-Fukuoka.
Notes: The vertical axis is the index, the benchmark of which is unity (one) for both figures. The horizontal axis is the *n*-th year of LCC entry. Preent is the pre-entry year of an LCC, and 4 < denotes the fourth year and after.

decreased from the second and third years. The total consumer surpluses from the first years can be summarized as follows: the surplus decreased in Tokyo–Sapporo from the optimistic viewpoint (1% decrease) as well as the pessimistic viewpoint (6% decrease). As for Tokyo–Fukuoka, consumer surplus might have increased by 1.5% from the optimistic computation using real value, but decreased by 7.5% from the pessimistic computation by estimated output and price. Among the other seven markets, those where low-cost competition lasted more than 3 years saw relatively large gains in consumer welfare, whereas other markets did not. Table 4 summarizes the percentage change in consumer welfare on a route-by-route basis.

Finally, we comment on issues of social welfare. The industry's profit in the pre-entry year (1998) was $US42m for Tokyo–Sapporo and $US44m for

Table 4. Percentage change in consumer welfare by low-cost competition

O/D	Sapporo	Fukuoka	Asahikawa	Aomori	Tokushima	Miyazaki	Kagoshima
Tokyo	−1.00	1.50	0.04	−2.60	3.52	6.98	4.23
Osaka	−2.17	−7.50					

Note: OD, Origin and Destination.

Table 5. Cumulative industry profit during low-cost competition

O/D	Sapporo	Fukuoka	Asahikawa	Aomori	Tokushima	Miyazaki	Kagoshima
Tokyo	374.00	289.67	9.27	−28.03	61.25	26.56	71.57
Osaka	26.19	24.01					

Notes: OD, Origin and Destination. Values are million US dollars, and we assume $US1 = 120 yen.

Tokyo–Fukuoka. Profit significantly dropped in the first year of new entry, but recovered and even surpassed the previous levels in the third year ($US61m and $US72m, respectively) and stabilized from the fourth year on. The cumulative industry profit during low-cost competition is shown in Table 5.

Jointly considering consumer welfare and industry's profits as shown in Tables 4 and 5, it is apparent that total welfare increased in five of the nine markets but decreased in Tokyo–Aomori, a thin demand route. Meanwhile, only the industry-side benefited in Tokyo–Sapporo, Osaka–Sapporo and Osaka–Fukuoka.

5. CONCLUDING REMARKS

Summarizing the findings of the empirical analyses, the first and second years of LCC entry saw very fierce fare wars in the two biggest markets, such that the antitrust sector was about to intervene. Despite the fare wars, consumer welfare did not increase very much in any of the markets, probably due to the limited size of the market pie in the off-peak season. To recover the losses incurred during that period, the industry quickly tried to collude to restore prices to the pre-entry level or higher. At the same time, the full-service carriers tried to expel the LCC by financially battering them, and eventually succeeded in establishing code-share arrangements with them. The industry succeeded in making a profit even during the fare ware period, and now the profits continue through such collusive behaviour, while the gain in consumer welfare has been relatively small and might actually decrease from now, especially in the two biggest markets. Therefore, our conclusion is that Japanese regulatory sectors seem to stand by the industry rather than protecting consumers. Because this analysis was performed using off-peak data, our next focus will be on the analysis of high-season data.

REFERENCES

Appelbaum, E. (1982) 'The Estimation of the Degree of Oligopoly Power', *Journal of Econometrics* 19, 287–99.

Brander, J. A. and A. Zhang (1990) 'Market Conduct in the Airline Industry: An Empirical Investigation', *RAND Journal of Economics* 21, 567–83.

Brander, J. A. and A. Zhang (1993) 'Dynamic Oligopoly Behavior in the Airline Industry', *International Journal of Industrial Organization* 11, 407–35.

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* 15, 471–89.

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* 30, 309–28.

Fischer, T. and D. R. Kamerschen (2003) 'Price–Cost Margins in the US Airline Industry Using a Conjectural Variation Approach', *Journal of Transport Economics and Policy* 37, 227–59.

Ito, T. (2003) 'Political Economy of Competition Policy in Japan: Case of Airline Services', handout presented by the committee of Japan Fair Trade Commission.

Iwata, G. (1974) 'Measurement of Conjectural Variation in Oligopoly', *Econometrica* 42, 947–66.

Morrison, S. A. (2001) 'Actual, Adjacent, and Potential Competition: Estimating the Full Effect of Southwest Airlines', *Journal of Transport Economics and Policy* 35, 239–56.

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* 27, 171–92.