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Inter-Firm Rivalry: Maximum or Minimum Departure Flight Times Differentiation?*

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Abstract

This paper explores the impact of concentration levels on airline flight scheduling behaviors. Airline-level data were collected for each of the five domestic Jeju Island non-stop routes from June 2006 to June 2010. Unlike previous studies on the U.S. airline industry, the present empirical findings suggest that the decrease in concentration (increase in competition) on the Jeju Island routes is associated with smaller inter-firm departure times differentiation. We confirm that the smaller inter-firm differentiation is the driving force of the decline in departure times differentiation with competition. This tendency for less inter-firm differentiation is weaker on the routes with LCCs.In the presence of legacy carriers' diversified responding strategies on the routes with significant entry of low-cost carriers (LCCs), *independent* LCCs differentiate their flight services from those of legacy carriers through maximum product differentiation.

Keywords Airline, Low-cost carriers, Two-brand strategy, Product differentiation, Deregulation

JEL Classification L51, L93

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1. INTRODUCTION

The recent worldwide deregulation of aviation has led to the emergence of low-cost carriers (LCCs) as a direct result of increased market competition. Korean Air (KAL) and Asiana Air (AAR) were the only domestic carriers in Korea until 2004. As aircraft size and age restrictions for the non-scheduled air service carriers were lifted by the 2008 Deregulation Act, all LCCs were allowed to operate jet aircrafts with more than 100 seats. In addition, since May 2008, the competition, long dominated by the two legacy carriers, KAL and AAR, was intensified as emerging LCCs began offering lower airfares.

Airline industry business strategies are necessarily tied to network choices: the full service business model utilizes a hub-and-spoke network, while the LCCs business model operates within a point-to-point network. In the hub-and-spoke system, all traffic moves along spokes connected to the hub airport at the center. By contrast, the point-to-point network is a route where origin and destination traffic is only focused upon by an airline. A time zone change effect is irrelevant in all domestic routes in Korea and even the longest non-stop route between Jeju Island and Seoul takes less than 90 minutes. The legacy carrier in Korean airline industry is characterized by an airline that it usually provides higher quality services than a LCC; for example, a legacy carrier offers business class seating, a frequent-flyer program, and better cabin services, such mean service, but operates under a point-to-point network.

Korea's domestic short haul routes cannot be appropriately managed with a hub-and-spoke system. Consequently, KAL and AAR developed alternative business strategies. These two legacy carriers show different strategies in response to the intensified competition by independent LCCs. The KAL's strategy of responding with a start-up subsidiary, Jin Air (JNA), has had only limited success as of 2010. JNA was launched in July 2008 and competed with its parent company, KAL, on the routes where both KAL and JNA operated flights under their own badges, i.e., Jeju-Seoul, and Busan-Jeju. Since the launch of its business in October 2008, Air Busan (ABL) operated out of Busan airport, its base airport, and shared service with its parent company, AAR, in the form of a code-share operation system, yielding remarkable synergies. As of 2010, ABL continues to fly the routes out of Busan, showing considerable growth of market share over the past few years.

The aviation industry is characterized by differentiated products. Therefore, competition relies on price as well as flight frequency and flight departure times. The LCCs' introduction to the domestic market is expected to increase the competition. Theoretically, incumbents would have two options in terms of spatial product differentiation strategies: minimal differentiation in order to steal customers from rivals and maximal differentiation in order to reduce the price competition with competitors. Martinez-Giralt and Neven (1988) analyzed duopoly competition in a two-stage game, with two firms locating multiple outlets facing price competition. They found that, in equilibrium, each firm selects a single point to allocate its stores because the incentive to avoid price cuts dominates the incentive to segment the market.

Borenstein and Netz (1999) applied the spatial competition theory to the airline industry, in order to investigate the competition with regard to departure flights scheduling. Departure flight times were assigned to locations on a 24-h clock. They empirically tested the relationship between the level of competition and spatial product differentiation using cross-sectional U.S. airline data for 1975 and 1986 for a given number of flights on a route. They concluded that, in both periods, airlines scheduled their flights more closely to rivals' flights as competition increased.

Yetiskul and Kanafani (2010) also tested the location theory using cross-sectional U.S. airline data for 2005. They found that, for a given number of flights on a route, intense competition led to less departure flight times differentiation, in accordance with Hotelling's model. However, this tendency is lower when the route is also covered by LCCs. Netz and Taylor (2002) revealed the opposite effect for gasoline station firms; in fact, they located their stations farther to reduce price competition as competition increased. Sun (2015) confirmed that competition leads to less-differentiated departure flight times for 11 Korean domestic city-pair routes. This clustered pattern of departure flight time scheduling differs between the Jeju Island routes and the inland routes in the deregulated period.

It is therefore of interest to investigate whether changes in the market structure, and thus the competition level, among carriers induced by the 2008 Deregulation Act have affected inter-firm departure flight times scheduling. We investigate the ratio of average inter-firm differentiation to average differentiation among all pairs of flights, $BtwnDIFF$, while Sun (2015) discusses the ratio of average differentiation among all pairs of flights to maximum differentiation among all pairs of flights, $DIFF$.

The empirical findings using time-series data from June 2006 to June 2010 in this paper suggest that the decrease in concentration levels on the Jeju Island routes is associated with a small inter-firm departure flight times differentiation. We confirm that the smaller inter-firm differentiation is the driving force of the decline in departure times differentiation with competition: the degree of inter-firm differentiation would be less than the degree of average differentiation among all pairs of flights. This tendency for less inter-firm differentiation is weaker on the routes with LCCs. In particular, legacy carriers showed diverse response strategies on the routes with significant LCC entry, whereas independent LCCs differentiated their flight services from those of legacy carriers through maximum product differentiation.

The rest of this paper is organized as follows. The Korean airline industry and the deregulation act of May 2008 are outlined in Section 2, along with the concentration measure, which is modified in the present study. The measure of inter-firm departure flight times differentiation is defined in Section 3. Section 4 outlines the empirical testing framework of the competition impact between airline carriers on the inter-firm departure flight time scheduling. The data and the estimation results for two sets of Jeju Island routes in Korea are presented in Section 5. Finally, the concluding remarks are given in Section 6.

2. BACKGROUND

2.1. KOREAN AIRLINE INDUSTRY AND THE DEREGULATION ACT OF MAY 2008

Jeju Island routes, city pairs for flying to and from Jeju Island, are primarily used by vacation travelers, and there is no closely comparable ferry service to Jeju Island. As a result, the competition between the two legacy carriers and LCCs for some of the Jeju Island routes is very high, since Jeju Island is the country's largest island and a major tourist destination.

LCCs in the Korean domestic airline industry are categorized into two types, based on ownership:independent LCCs and dependent LCCs. Independent LCCs are LCCs that are not owned by full-service legacy carriers, while dependent LCCs are subsidiaries of legacy carriers. In 2005, the first independent LCC, Hansung Airlines (HAN), received its Air Operator's Certificate and was thus formally approved, with the delivery of its ATR-72 turboprop aircraft with 78 available seats.

Prior to May 2008 Korean airline regulation had restrictive licensing policies. While non-scheduled air service carriers were only allowed to operate irregular flight services, scheduled air service carriers could operate regular flight services with a license issued by a government aviation body. Only registration was required to be a non-scheduled air service carrier, but the license was necessary to be a qualified scheduled air service carrier. In order to earn the "license," airline carriers had to fulfill all required criteria of safety with a record minimum of two years operation with over 20,000 flights without accidents. Non-scheduled air service carriers were only allowed to operate aircraft with less than 80 available seats per airplane and there was a restriction on their fleet age (requiring less than 25 years age limit for each aircraft) as well. These restrictions on non-scheduled air service carriers forced them to use only small turbo-prop aircraft.

In accordance with Paragraph, Article 117 of the Ministerial Regulation of Aviation Act, domestic carriers should provide information on monthly airfares with at least twenty days' prior notice. The Deregulation Act of May 2008 removed restrictions on aircraft size and fleet age among non-scheduled airline carriers, which were subject to regulatory market policy; at the same time, pricing rules remained unchanged (i.e., an advanced notice system). Restrictions imposed on both aircraft size and aircraft age for the non-scheduled airlines were eliminated so that LCCs were able to operate jet aircraft which had more than80 seats per airplane.

Two independent LCCs ceased operations in 2008—HAN in November and Yeongnam Air (ONA) in December—due to the intense competition, severe economic conditions, increasing fuel costs, and difficulties in securing additional funding. The remaining independent LCCs were restructured by expanding their capacities. For example, Jeju Air (JJA) permanently removed all four Dash 8 Q400s, turboprop aircraft with 78 available seats per airplane, in June 2010 and added a Boeing 737 in 2011 to its existing fleet of five B737s. Another independent LCC, Eastar Jet (ESR), expanded its fleet to six Boeing 737s in March 2010. In addition, these airlines increased their daily flight frequency on some routes (Jeju–Cheongju/Seoul).

In response, the two established full service carriers could establish subsidiary LCCs of their own, either to replace their prior services with them or to compete with them. For example, AAR replaced its services on some routes with its own LCC, ABL, whereas KAL's subsidiary LCC, JNA, competed with KAL flights on some routes.

2.2. KOREAN AIRLINE INDUSTRY AND DEGREE OF CONCENTRATION MEASURE: $DHHI$

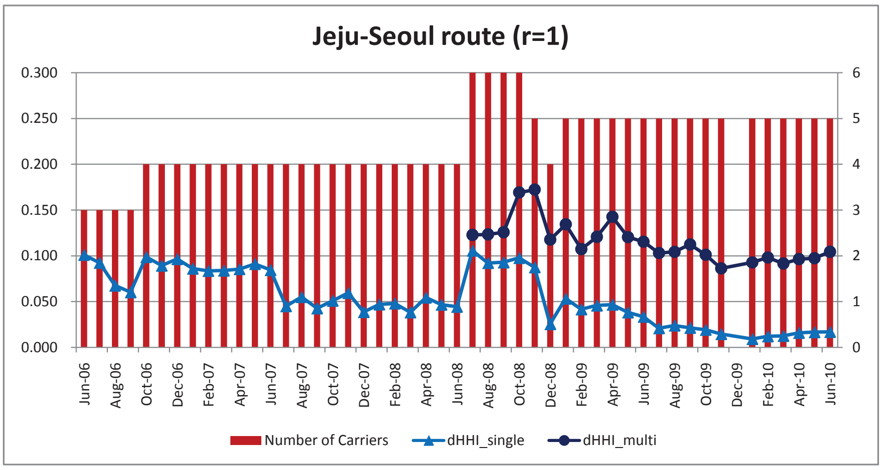
As discussed by Depken (2002), the Herfindahl-Hershman Index (HHI) is difficult to interpret. Thus, we adapted the measure of the concentration level for carriers on a route to $dHHI$, which is equal to the deviation of HHI from the ideal egalitarian (equal) distribution (market shares). HHI is calculated as the sum of the squares of the flight frequency shares of all airlines. HHI values reflect the number of carriers and the inequality in the market shares across carriers on a route. It decreases as the number of carriers increases, given a constant flight frequency number. Thus, for a fixed number of carriers, the value of HHI is greater if the inequalities in the market shares between carriers are larger. A higher $dHHI$ value indicates that the route is less competitive, whereas a lower $dHHI$ value (i.e., close to 0) indicates the opposite. In order to aggregate the route-level concentrations, we used two flight-frequency weights according to LCCs' classification: 1) the weight of the flight frequency shares of each carrier competing with all other carriers on a route and 2) the weight of the flight frequency shares of each carrier when legacy carriers and their respective subsidiary LCCs (dependent LCCs) were considered together, as a single entity, not competing with each other on the same route. Thus, the corresponding concentration measures, $dHHI_{SINGLE}$ and $dHHI_{MULTI}$, were calculated.

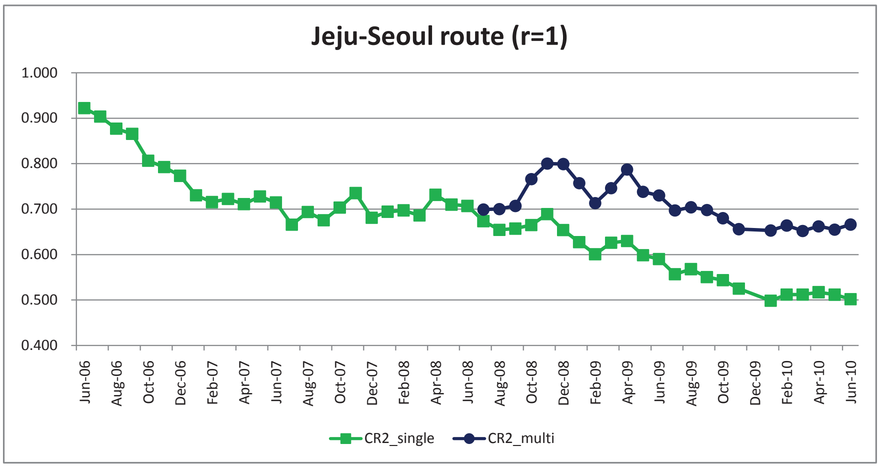
Since May 2008, competition has intensified, as emerging LCCs began offering lower airfares. The volume of passengers using LCCs has been growing at a faster pace than before in the Korea domestic airline markets. For each route, the flight-frequency concentration ratio, $CR2$, was depicted as a measure of the percentage market share held by the two largest firms in an industry by using data on the two largest carrier shares, KAL and AAR, from June 2006 to June 2010. For the deregulated period, after May 2008, $CR2_{SINGLE}$ and $CR2_{MULTI}$ were calculated accordingly.

Jeju-Seoul is the largest domestic sector for LCCs. As shown in Figure 1, several LCCs have been established on the Jeju-Seoul route (r = 1): two independent LCCs, ESR and JJA, and the dependent LCC, ABL. It is clearly observed that $dHHI_{SINGLE}$ has been declining over time. KAL launched its own subsidiary LCC, JNA, and started the route service in July 2008, two months after the May 2008 Deregulation Act. From July 2008 to November 2008, spikes were observed in the competition measures $dHHI_{SINGLE}$ and $dHHI_{MULTI}$. The huge gaps between the two measures can be attributed to KAL's two-brand strategy in the post-deregulation period. Moreover, the larger values of $CR2_{MULTI}$, as compared to those of $CR2_{SINGLE}$, indicate that the two legacy carriers still dominate the market, with combined shares of around 65% in the deregulated period.

Jeju-Busan route (r = 2) is the second largest domestic route for LCCs. The two major airlines actively engage in competition, responding with their own subsidiary LCCs (Figure 2). In November–December 2008, AAR established ABL and replaced its prior services with it. Thus, AAR minimized the switching costs for their passengers by using the code-share operation system with ABL, charging higher airfares than the competing independent LCCs, but lower than KAL. In contrast to AAR's repositioning brand strategy, KAL flew under the

Figure 1. Jeju-Seoul route (r = 1): June 2006–June 2010





Notes: 1) HHI: Herfindahl-Hershman Index;

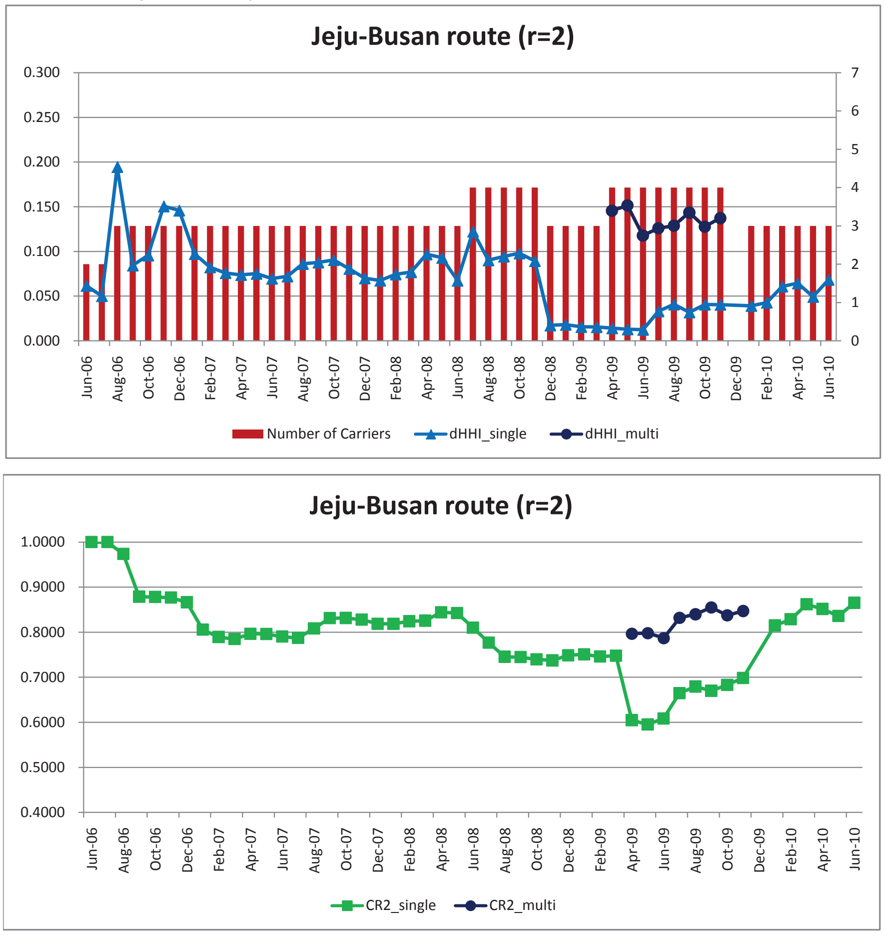
2) $dHHI_{SINGLE}$: deviation of HHI from an ideal egalitarian (equal) distribution (market shares) calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route;

3) $dHHI_{MULTI}$: deviation of HHI from an ideal egalitarian distribution (market shares) calculated using the weight of flight frequency shares of each carrier, when legacy carriers and their own subsidiary LCCs (dependent LCCs) are considered a single entity, not competing with each other on a route;

4) $CR2_{SINGLE}$: concentration ratio 2 calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route;

5) $CR2_{MULTI}$: concentration ratio 2 calculated using the weight of flight frequency shares of each carrier when legacy carriers and their own subsidiary LCCs (dependent LCCs) are considered a single entity, not competing with each other on a route.

Figure 2. Jeju-Busan route (r = 2): June 2006–June 2010



Notes: 1) HHI: Herfindahl-Hershman Index;

2) $dHHI_{\mathrm{SINGLE}}$: deviation of HHI from an ideal egalitarian (equal) distribution (market shares) calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route;

3) $dHHI_{MULTI}$: deviation of HHI from an ideal egalitarian distribution (market shares) calculated using the weight of flight frequency shares of each carrier, when legacy carriers and their own subsidiary LCCs (dependent LCCs) are considered a single entity, not competing with each other on a route;

4) $CR2_{SINGLE}$: concentration ratio 2 calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route;

5)$CR2_{MULTI}$: concentration ratio 2 calculated using the weight of flight frequency shares of each carrier when legacy carriers and their own subsidiary LCCs (dependent LCCs) are considered a single entity, not competing with each other on a route.

JNA badge on the Jeju-Busan route between April and November 2009, maintaining its KAL badge as well. In the present study, the differences between the values of $dHHI_{SINGLE}$ and $dHHI_{MULTI}$ are attributed to KAL's two-brand strategy during that period. The market shares of around 80% for the two legacy carriers indicate their dominant positions even in the deregulated period.

The carriers on the Jeju-Cheongju route (r = 3) belong either to the two major airlines or to the independent LCCs. Neither KAL nor AAR launched their own subsidiary LCCs on the Jeju-Cheongju route (Figure 3). The number of carriers increased on this route, reflecting the entries of two independent LCCs, JJA in June 2008 and ESR in June 2009.

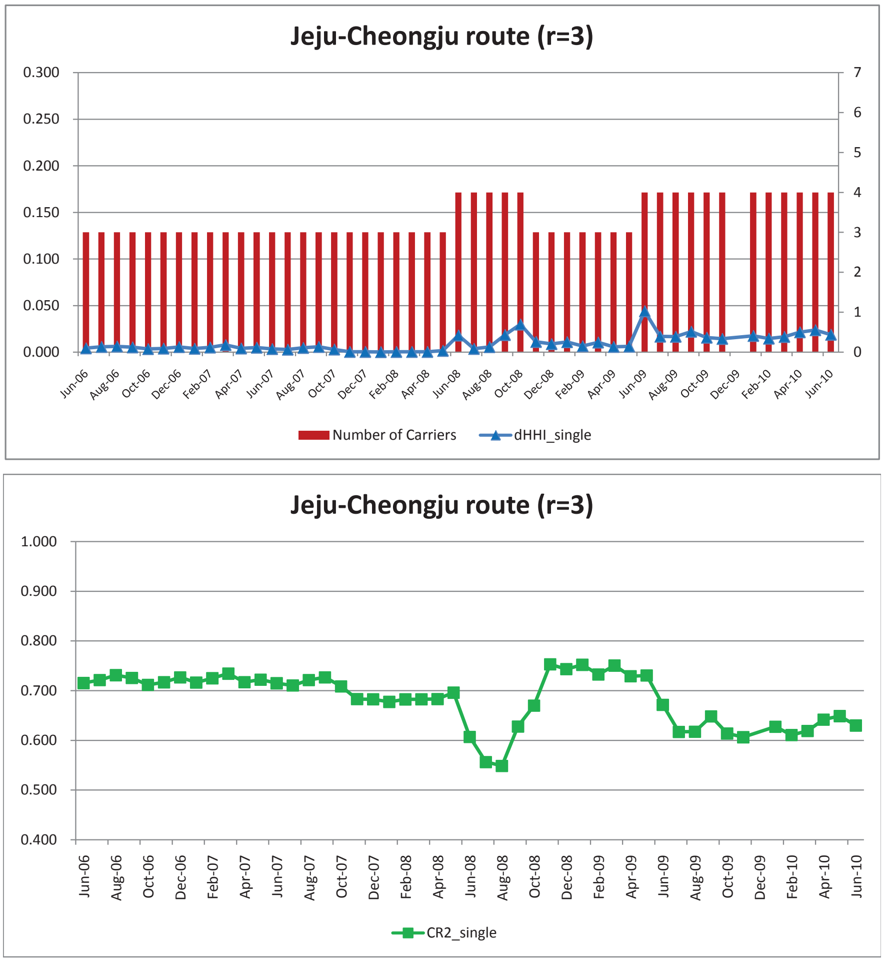
On the Jeju-Daegu route (r = 4), only one LCC entered the market during the study period (Figure 4); ONA, an independent LCC, launched its flight services for the Jeju-Seoul, Jeju-Busan, and Jeju-Daegu routes in July 2008, two months after the Deregulation Act, but ceased its operations in December 2008.Unlike the two major airlines, ONA operated only one propeller-powered aircraft, Fokker 100 (a turboprop aircraft with less than 80 seats), and flew once each day on the Jeju-Daegu route. On the Jeju-Gwangju route (r = 5), where no entrant was observed, there is no point in looking at legacy carrier strategic behavior in response to the entry of LCCs. The Jeju-Gwangju route was only operated by the two legacy carriers, KAL and AAR, throughout the study period.

3. INTER-FIRM DEPARTURE TIMES DIFFERENTIATION: $BTWNDIFF$ INDEX

To capture how an airline carrier on a route chooses departure flight times, competing with its rivals' flights, $BtwnDIFF$ is adapted from Borenstein and Netz (1999). $BtwnDIFF$ is the ratio of the inter-firm differentiation to the differentiation among all pairs of flights on a route. For n daily direct flights on a route, which depart at $d_1, \dots, d_n$ minutes after 12 a.m. (midnight), the time distance between consecutive flights is calculated. For example, if one flight is scheduled at 8 a.m. and another at 9 a.m., the time distance between the first and the second flight during a day, on a 24-h clock, will be$|d_1 - d_2| = |480 - 540| = 60$. The average time distance between the flights is calculated as

$$AVGDIFF = \frac{2}{n(n-1)} \sum_{i=1}^{n} \sum_{j>1}^{n-1} \left[min\left\{\left|d_i - d_j\right|, 1440 - \left|d_i - d_j\right|\right\}\right]^{\alpha}, 0 < \alpha < 1 \tag{1}$$

Figure 3. Jeju-Cheongju route (r = 3): June 2006–June 2010

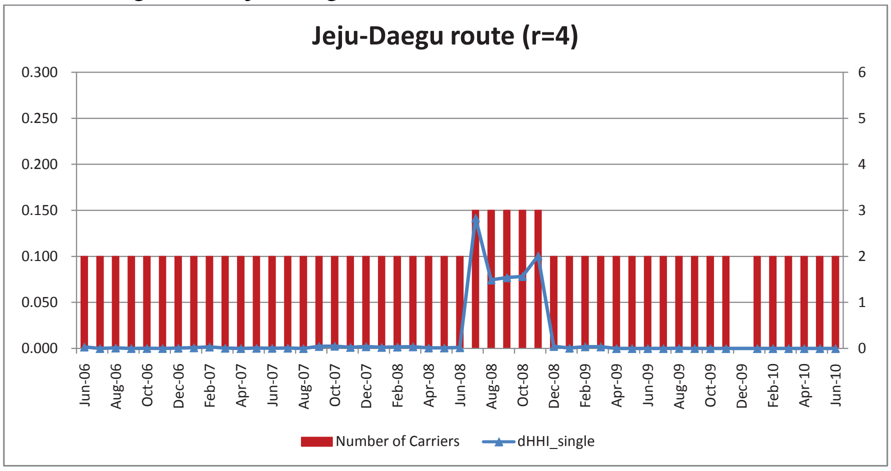


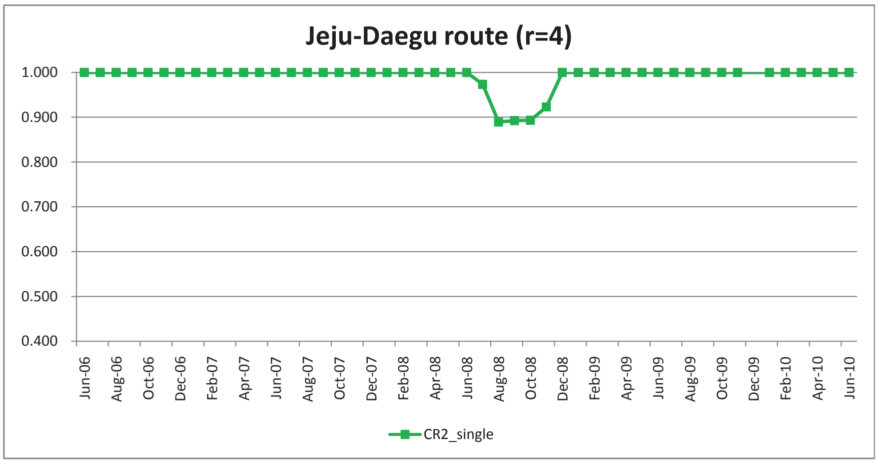
Notes: 1) HHI: Herfindahl-Hershman Index;

2) $dHHI_{\mathrm{SINGLE}}$: deviation of HHI from an ideal egalitarian (equal) distribution (market shares) calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route;

3) $CR2_{SINGLE}$: concentration ratio 2 calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route.

Figure 4. Jeju-Daegu route (r = 4) : June 2006–June 2010





Notes: 1) HHI: Herfindahl-Hershman Index;

2)$dHHI_{\text{SINGLE}}$: deviation of HHI from an ideal egalitarian (equal) distribution (market shares) calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route;

3) $CR2_{SINGLEs}$: concentration ratio 2 calculated using the weight of flight frequency shares of each carrier competing with all other carriers on a route.

where 1440 is the number of minutes in a day. $AVGDIFF$ is maximized when the flights on a route are evenly distributed over the day. The power α denotes the marginal effect of changes in time differences between flights on a route. We arbitrarily choose $\alpha = 0.5$, and the results do not qualitatively change across alternative values of α.

$BtwnDIFF$ is the ratio of the average time distance between all flights scheduled by different carriers (applying $AVGDIFF$ to the subset of flight differences $|d_i - d_j|$, where the carriers scheduling flights departing at d_i and d_j are different) to the average time distance among all pairs of flights (i.e., $AVGDIFF$). The inter-firm differentiation index is $BtwnDIFF$, and its value can be larger than 1, implying that the inter-firm differentiation is greater than the overall differentiation between all flights on a route. The departure times of all non-stop flights on a route are used to calculate $BtwnDIFF$.

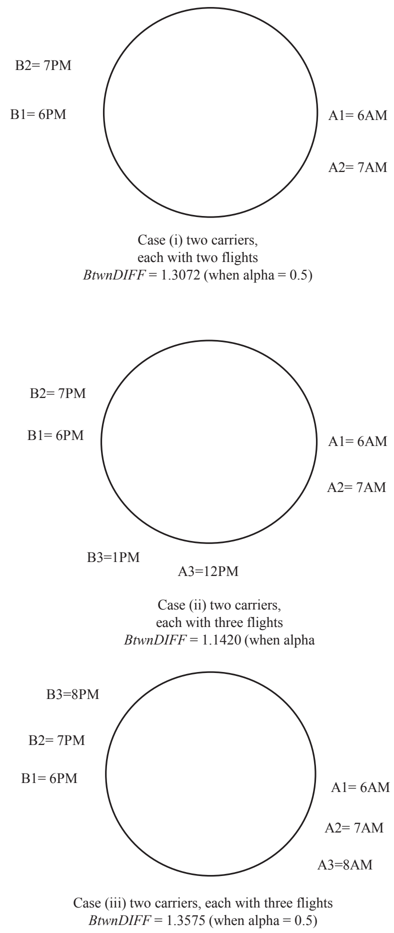
Firms would minimize product differentiation in order to steal customers from competitors. On the other hand, firms would maximize product differentiation in order to avoid intense price competition. One extreme case of maximum differentiation in spatial competition theory is the situation in which there are products capable of high differentiation, i.e., market segmentation by firm (carriers' own flights are clustered together in our context).

Furthermore, we investigate how $BtwnDIFF$ reflects the configuration of the market structure: the number of carriers–the flight frequency. As seen in Figure 5 ($BtwnDIFF$ calculations are offered in the appendix), in Case (i), carrier A schedules two flights in the morning ($d_{A1} = 6AM$, $d_{A2} = 7AM$), and carrier B schedules two flights in the evening ($d_{B1} = 6PM$, $d_{B2} = 7PM$). $BtwnDIFF$ is 1.3072 in this case. Since the value is greater than 1, the carriers schedule departure flight times far from those of their rivals' flights.

In Cases (ii) and (iii), carriers A and B schedule one additional flight, respectively. The departure flight schedules contain three cluster groups in Case (ii): clustered flights in the morning for carrier A, clustered flights at lunchtime, and clustered flights in the evening for carrier B. The departure time schedules in Case (iii) crowd together a carrier's own flights. Case (iii) configuration simply leads to market segmentation by carriers: clustered flights in the morning for carrier A and clustered flights in the evening for carrier B.Consequently, $BtwnDIFF$ has a larger value in Case (iii) (1.3575) than in Case (ii) (1.1420).

Given the same market structure, i.e., where both the total number of flight frequency and carriers are fixed, $BtwnDIFF$ maps the carrier's strategic behaviors. For both Cases (ii) and (iii), the two carriers locate their third flight farther from each other rather than more closely to each other, but the departure time

Figure 5. Inter-firm differentiation in scheduling and $BtwnDIFF$



schedules in Case (iii) crowd together a carrier's own flights. However, the departure flight schedules contain three cluster groups in Case (ii): Clustered flights in the morning for carrier A, clustered flights at lunchtime, and clustered flights in the evening for carrier B. The more clustered flight by carrier there is, the larger the *BtwnDIF*F is.

4. MODEL

When prices are set exogenously, carriers minimize departure time differentiation in the absence of price competition. However, if there is intense price competition, carriers might increase departure time differentiation soften the price competition. Since the prices are not set exogenously in the Korean airline industry and consumers are not uniformly distributed, Hotelling's conjecture (i.e., carriers minimize departure time differentiation to steal passengers from each other) cannot be directly applied to the data. Thus, we attempt to identify which incentives dominate in the post-deregulation period.

Airline carriers strategically adjust their departure flight times with respect to their rivals' flight times as the concentration level on that route increases. The emergence and failure of LCCs are linked to changes in market structure, and thus competition level, among carriers. It is therefore interesting to investigate whether changes in market structure have affected inter-firm departure flight time scheduling.

Apart from a measure for route-level concentration, we also need to control route-level profitability, load factor, and total flight frequency. The relative fare can be used as a measure of route-level profitability, with higher numbers implying greater profitability. The load factor on a route, which is the percentage of seats occupied, affects the degree of inter-firm differentiation. The total flight frequency on a route controls for the market size because it reflects the degree of inter-firm differentiation fora fixed number of carriers.

We estimate the econometric model of inter-firm departure flight times differentiation. To provide empirical estimation results, we present two model specifications that differ in two explanatory variables: Model 1 controls for route-level concentration ($dHHI_{SINGLE}$) and route-level LCC flight shares ($LCCshare_{SINGLE}$) without considering multiproduct firm behavior, and Model (2) controls for route-level concentration ($dHHI_{MULTI}$) and route-level LCC flight shares ($LCCshare_{MULTI}$) taking account of a multiproduct firm.

The observations are for $t = 1,..,T$ (June 2006 to June 2010) on routes $r = 1,2,3,4,$ and 5. Assuming that the marginal effect of competition on inter-carrier flight time differentiation is the same for any period between June 2006 and June 2010,the following equation (Equation (2)) addresses Model 1.

$$\begin{aligned} BtwnDIFF_t^r = &BtwnDIFF_t^r = \beta_0 + \beta_1 dHHI_{SINGLE}{}_t^r + \beta_2 deregulation_t^r \\ &+ \beta_3 dHHI_{SINGLE}{}_t^r \cdot deregulation_t^r + \beta_4 LCCshare_{SINGLE}{}_t^r \\ &+ \beta_5 relfare_t^r + \beta_6 loadfac_t^r + \beta_7 flightfreq_t^r + \varepsilon_t^r \end{aligned} \tag{2}$$

Where $BtwnDIFF_t^r$ is the inter-firm differentiation index.$dHHI_{SINGLE}{}_t^r$ is the HHI based on flight frequency shares among all carriers. $deregulation_t^r$ is a dummy variable,which becomes 1 for the observation following the May 2008 Deregulation and 0 otherwise. Based on the hypothesis that the estimated effect of route-level competition might be different before and after the deregulation, an interactive dummy variable ($dHHI_{SINGLE}{}_t^r \cdot deregulation_t^r$) is used, which estimates the change in the effect of route-level concentration depending on the status of the deregulation policy. Here, the effect of concentration on the inter-carrier scheduling differentiation for the post (pre)-deregulation period is measured by $\beta_1 + \beta_3$ (β_1). $LCCshare_{SINGLE}{}_t^r$ is the ratio of LCC flights on the route. Furthermore, $relfare_t^r$ is the relative fare on the route relative to all other Jeju Island routes. $loadfac_t^r$ is the passenger load factor on the route. $flightfreq_t^r$ is the route-level total flight frequency. The error term ε_t^r is i.i.d.

Equation (3) addresses Model 2, providing an econometric analysis of a multiproduct firm such as KAL. In this specification, KAL and its own subsidiary LCC (JNA) are considered a single entity, not competing with each other on a route.

$$\begin{aligned} BtwnDIFF_t^r = &\beta_0 + \beta_1 dHHI_{MULTI}{}_t^r + \beta_2 deregulation_t^r \\ &+ \beta_3 dHHI_{MULTI}{}_t^r \cdot deregulation_t^r + \beta_4 LCCshare_{MULTI}{}_t^r \\ &+ \beta_5 relfare_t^r + \beta_6 loadfac_t^r + \beta_7 flightfreq_t^r + \varepsilon_t^r \end{aligned} \tag{3}$$

5. ESTIMATION

5.1. DATA AND VARIABLES

We built a panel of airline carrier-level data for each of the five Jeju Island routes from June 2006 to June 2010 .Our data consist of carrier-level total monthly passengers of city-pair non-stop flights of each of the routes and carrier-level total monthly flight frequency of city-pair non-stop flights for each of the routes collected from the Korea Airports Corporation (KAC) website. The data on the carrier level include monthly list fares and carrier-level aircraft sizes (number of available seats per plane) are obtained from each carrier's website. Then, the load factor at the carrier-route-month level is calculated as the percentage of seats occupied.

As the next month's published fares and monthly flight departure timetables with fleet types are announced at the beginning of every month on the website of each carrier, we visited the websites to get information on ticket prices per month (around the 15th day of each month) for a period of 48 months. Then the fares for any given month are always the same, regardless of when we observe them. For the same route served by the same airline carrier, the monthly published fares are lower during off-peak seasons than during peak seasons (January, April, May, July, August, and October). The monthly published fares on weekdays are the same for Monday to Thursday, and the monthly published fares on the weekends are the same for Friday to Sunday. The average of daily published fares for the month is taken as the data.

Since no disaggregated data of the number of passengers at the route-carrier-departure flight time level are available, the explanatory variables are only considered for the route-carrier-month and are weighted by each carrier's flight frequency shares on a route, assuming that each airline charges a single price for all flights departing in the same month regardless of the departure times. We calculated the share of business passengers seated relative to total passengers seated per fleet type. We limit this analysis to the two legacy carriers offering business class seats. The business class seats shares are relatively small, and the majority of business travelers receive reimbursement for expenses incurred while traveling on business trip. We believe the current aggregated fare data does a good job of representing the average fares actually paid by consumers (their employers).

Within the Jeju Island routes, only three routes show significant competition (e.g., over half a year) from independent LCCs: Jeju-Seoul (r = 1), Jeju-Busan (r = 2), and Jeju-Cheongju (r = 3). The observation period includes 48 months, from June 2006 to June 2010. The monthly flight frequencies of the domestic city-pair non-stop flights for December 2009 are not available (Source: KAC).

Table 1 describes the available variables. Along with the $dHHI_{SINGLE}$ ($dHHI_{MULTI}$) variable discussed in Section 2.2 and $BtwnDIFF$ variable discussed in Section 3, all variables defined in Table 1 are taken to estimation. Specifically, $relfare$ can be used a measure of route-level profitability, with higher numbers implying

Table 1: Variables: Jeju Island routes (June 2006–June 2010)

Variable	Description
$BtwnDIFF_t^r$	dependent variable; Monthly route-level variable; the ratio of the average time distance between all flights scheduled by different carriers to the average time distance among all pairs of flights on a route
$dHHI_{SINGLE}{}_t^r$	Monthly route-level concentration intensity measure; Multiproduct firm behavior is not considered. the deviation of Herfindahl-Hershman Index (HHI) from the ideal egalitarian (equal) distribution;
$dHHI_{MULTI}{}_t^r$	Monthly route-level concentration intensity measure; Multiproduct firm behavior is considered. the deviation of Herfindahl-Hershman Index (HHI) from the ideal egalitarian(equal) distribution; The two legacy carriers and their respective subsidiary LCCs (dependent LCCs) were considered together, as a single entity, not competing with each other on the same route.
$LCCshare_{SINGLE}{}_t^r$	Monthly route-level proportion of flights scheduled by LCCs. Multiproduct firm behavior is not considered.
$LCCshare_{MULTI}{}_t^r$	Monthly route-level proportion of flights scheduled by LCCs. Multiproduct firm behavior is considered. The two legacy carriers and their respective subsidiary LCCs (dependent LCCs) were considered together, as a single entity, not competing with each other on the same route.
$relfare_t^r$	Monthly route-level profitability on a route; the ratio of CPI-adjusted airfares including fuel surcharges (expressed in 2005 year) on a route to CPI-adjusted airfares including fuel surcharges (expressed in 2005 year) on all the other routes; for each route, flight share weighted average values of airfares are used. Fares do not incorporate any coupons or discounts.
$loadfac_t^r$	Monthly route-level load factor, which is the percentage of seats occupied; weighted by fleet type shares on a route during the month
$flightfreq_t^r$	Monthly route-level total flight frequency

Table 2: Descriptive statistics: Jeju Island routes (June 2006–June 2010)*

	Pooled 5 Jeju Island routes					Pre-deregulation: pooled 5 Jeju Island routes					Post-deregulation: pooled 5 Jeju Island routes				
Variable	Obs	Mean	Std. Dev	Min	Max	Obs	Mean	Std. Dev	Min	Max	Obs	Mean	Std. Dev	Min	Max
$BtwnDIFF_t^r$	240	0.9635	0.0233	0.9282	1.0013	120	0.9596	0.0254	0.9282	1.0013	120	0.9675	0.0204	0.9336	0.9977
$dHHI_{SINGLE_t^r}$	240	0.0290	0.0376	0.0000	0.1946	120	0.0326	0.0423	0	0.1946	120	0.0254	0.0321	0	0.1418
$dHHI_{MULTI_t^r}$	240	0.0397	0.0483	0.0000	0.1946	120	0.0326	0.0423	0	0.1946	120	0.0468	0.0529	0	0.1723
$LCCshare_{SINGLE_t^r}$	240	0.2022	0.2014	0.0000	0.7260	120	0.1409	0.1321	0	0.3457	120	0.2635	0.2377	0	0.7260
$LCCshare_{MULTI_t^r}$	240	0.1557	0.1401	0.0000	0.4525	120	0.1409	0.1321	0	0.3457	120	0.1704	0.1468	0	0.4525
$relfare_t^r$	240	1.0035	0.1318	0.7901	1.2408	120	1.0038	0.1376	0.7901	1.2408	120	1.0032	0.1264	0.8139	1.2242
$loadfac_t^r$	240	0.7583	0.0965	0.5000	1.0000	120	0.7600	0.0991	0.6000	1.0000	120	0.7567	0.0941	0.5000	0.9000
$flightfreq_t^r$	240	15.3037	12.1374	5.6900	48.5100	120	15.8783	12.7388	6.3967	48.5100	120	14.7292	11.5294	5.6900	45.8400

	3 Jeju Island routes with significant entry of LCCs					Pre-deregulation: 3 Jeju Island routes with significant entry of LCCs					Post-deregulation: 3 Jeju Island routes with significant entry of LCCs				
Variable	Obs	Mean	Std. Dev	Min	Max	Obs	Mean	Std. Dev	Min	Max	Obs	Mean	Std. Dev	Min	Max
$BtwnDIFF_t^r$	144	0.9766	0.0186	0.9430	1.0013	72	0.9750	0.0207	0.944	1.0013	72	0.9782	0.0163	0.943	0.9977
$dHHI_{SINGLE_t^r}$	144	0.0447	0.0379	0.0002	0.1946	72	0.0540	0.0430	0.0002	0.1946	72	0.0354	0.0295	0.0036	0.1225
$dHHI_{MULTI_t^r}$	144	0.0625	0.0478	0.0002	0.1946	72	0.0540	0.0430	0.0002	0.1946	72	0.0710	0.0511	0.0036	0.1723
$LCCshare_{SINGLE_t^r}$	144	0.3340	0.1543	0.0000	0.7260	72	0.2349	0.0828	0	0.3457	72	0.4331	0.1454	0.19	0.726
$LCCshare_{MULTI_t^r}$	144	0.2565	0.0834	0.0000	0.4525	72	0.2349	0.0828	0	0.3457	72	0.2781	0.0788	0.1349	0.4525
$relfare_t^r$	144	1.0388	0.1244	0.8483	1.2408	72	1.0480	0.1251	0.8826	1.2408	72	1.0297	0.1238	0.8483	1.2242
$loadfac_t^r$	144	0.7660	0.0917	0.6000	1.0000	72	0.7778	0.0923	0.6000	1.0000	72	0.7542	0.0903	0.6000	0.9000
$flightfreq_t^r$	144	20.1129	13.7066	5.6900	48.5100	72	21.0187	14.3128	6.3967	48.5100	72	19.2070	13.1097	5.6900	45.8400

	2 Jeju Island routes without significant entry of LCCs					Pre-deregulation: 2 Jeju Island routes without significant entry of LCCs					Post-deregulation: 2 Jeju island routes without significant entry of LCCs				
Variable	Obs	Mean	Std. Dev	Min	Max	Obs	Mean	Std. Dev	Min	Max	Obs	Mean	Std. Dev	Min	Max
$BtwnDIFF_t^r$	96	0.9440	0.0142	0.9282	0.9795	48	0.9365	0.0089	0.9282	0.9709	48	0.9515	0.0146	0.9336	0.9795
$dHHI_{SINGLE_t^r}$	96	0.0055	0.0218	0.0000	0.1418	48	0.0006	0.0007	0	0.0026	48	0.0105	0.0301	0	0.1418
$dHHI_{MULTI_t^r}$	NA					NA					NA				
$LCCshare_{SINGLE_t^r}$	96	0.0045	0.0205	0.0000	0.1105	48	0	0	0	0	48	0.0089	0.0284	0	0.1105
$LCCshare_{MULTI_t^r}$	NA					NA					NA				
$relfare_t^r$	96	0.9504	0.1253	0.7901	1.0991	48	0.9374	0.1295	0.7901	1.0777	48	0.9634	0.1209	0.8139	1.0991
$loadfac_t^r$	96	0.7469	0.1025	0.5000	0.9000	48	0.7333	0.1038	0.6000	0.9000	48	0.7604	0.1005	0.5000	0.9000
$flightfreq_t^r$	96	8.0900	0.4222	6.8833	8.9067	48	8.1676	0.4541	6.8833	8.8100	48	8.0124	0.3766	7.1300	8.9067

Note: * The numbers are rounded.

greater profitability. The value for $relfare$ can be larger than 1, implying that the CPI-adjusted airfares on a route are greater than the CPI-adjusted airfares on all the other routes. A ratio of less than 1 for $relfare$ indicates the opposite. One can raise a concern about $relfare$ that carriers with relatively high prices and high costs may not record a remarkable amount of profit gains. Taking account of airline fuel efficiency, the two legacy carriers' Boeing 737s (Airbus 320/321) with 138–188 (156-200) available seats are with 2.32–2.68 (2.5–2.61) liters per 100 kilometers per passenger, recording a high load factor. On the other side, the less efficient was Dash 8 Q400 (independent LCC's fleet in the regulated period) with 78 available seats at 3.38 liters per 100 kilometers per passenger (In the deregulated period, even independent LCCs added Boeing 737s). Thus, we use $relfare$ as a measure of route-level profitability, with higher numbers implying greater profitability.

Table 2 presents a summary of the statistics for the average monthly values of the inter-firm differentiation indices and the main explanatory variables from two perspectives: pre- and post-deregulation. The values of $BtwnDIFF$ and $dHHI_{SINGLE}$ ($dHHI_{MULTI}$) for each observation month are derived from all direct flights on a directional route, from other origin cities to Jeju Island. We also compare these values with Jeju Island to other origin cities' observation, but the results are qualitatively insensitive.

As can be seen from the table, several interesting trends are evident. For the two Jeju Island routes without LCC entry, the average value for $BtwnDIFF$ increases from 0.9365 in the pre-deregulation period to 0.9515 in the post-deregulation period, while for the three Jeju Island routes with significant entry of LCCs the average value for $BtwnDIFF$ is fairly constant across pre- and post- deregulation period, having a smaller standard deviation in the deregulated period. The average values of $BtwnDIFF$ for the three Jeju Island routes with significant entry of LCCs and the two Jeju Island routes without entry of LCCs are less than 1, implying that the average inter-firm differentiation is less than the average over all differentiations among all flights on the route.

The degree of concentration, measured with $dHHI_{SINGLE}$ and $dHHI_{MULTI}$, differs across the three Jeju Island routes with significant entry of LCCs and the two Jeju Island routes without entry of LCCs. No significant changes in $dHHI_{SINGLE}$ are reported for the two Jeju Island routes without entry of LCCs, which give average values near zero. For the three Jeju Island routes with significant entry of LCCs, the average value for the concentration level, $dHHI_{SINGLE}$, decreases from 0.0540 in the pre-deregulation period to 0.0354 in the post-deregulation period. However, the average value for the concentration level, $dHHI_{MULTI}$, rather increases from 0.0540 in the pre-deregulation period to 0.0710 in the post-deregulation period when taking account of a multiproduct firm behavior, implying degree of concentration in fact is intensified by the two legacy carriers' own subsidiary LCCs (dependent LCCs) operation on the three Jeju Island routes that faced direct competition from LCCs. This higher value indicates a greater industry concentration when considering a multiproduct firm and its own subsidiary LCC a single entity on a route.

The intensive multiproduct operations of the two legacy carriers' subsidiary LCCs, KAL's two brand strategy and AAR's rebadging strategy, are supported by data. The average value of $LCCshare_{MULTI}$ for the three Jeju Island routes with significant entry of LCCs in the post-deregulation period is 0.2781, which is approximately 0.1550 less than $LCCshare_{SINGLE}$. The difference between the average values of $LCCshare_{SINGLE}$ and $LCCshare_{MULTI}$ represents the flight shares scheduled by the legacy carriers' subsidiary LCCs, not the independent LCCs.

For the two Jeju Island routes without entry of LCCs, the average value for $relfare$ value is less than 1 across pre- and post- deregulation period. The value less than one implies that the average CPI-adjusted airfares for the two Jeju Island routes without entry of LCCs are lower than those for the other Jeju Island routes with significant entry of LCCs. For the three Jeju Island routes with significant entry of LCCs, the average value for $relfare$ decreases from 1.0480 in the pre-deregulation period to 1.0297 in the post-deregulation period. This reduction in $relfare$ would provide an evidence of establishment of new LCCs with price competitiveness in the post-deregulation period. With a higher load factor, these higher airfares indicate that airline operations on the routes with significant entry of LCCs can be more profitable. The average values for the route-wide total flight frequencies are larger on the three Jeju Island routes with significant entry of LCCs than on the two Jeju Island routes without entry of LCCs.

5.2. ESTIMATION RESULTS

A problem may arise in estimating the effect of concentration on inter-carrier scheduling differentiation due to endogeneity. The two variables, $relfare$ and $loadfact$, would be correlated to the error term if the error term incorporates unobserved seasonal effects or cyclical fluctuations. The incentive to avoid price cuts and make the route service profitable would be associated with airline carriers' departure time scheduling pattern (whether to prefer to segment the market or not). The load factor is supposed to have opposing effects on inter-firm differentiation with respect to the departure times. With regard to the demand-driven incentive, the load factor might have a negative effect on the inter-firm departure flight times differentiation. Carriers would schedule their flight times closer to those of their rivals' flights in order to capture the high demand on a route, stealing air passengers from competitors. From a supply perspective, there might be no reason for each carrier to schedule its flights closer to its rivals' flights in order to steal air passengers from rivals on the routes with high load factors when the flights are almost full capacity. In this context, the load factor might have a positive effect on the inter-firm departure flight times differentiation, leading to more product differentiation between carriers when the average load factors are high.

A test for endogeneity that $relfare$ and $loadfac$ are actually exogenous variable is performed using STATA estat endogenous command and is interpreted using the Durbin and Wu–Hausman test. If the endogenous regressors are in fact exogenous, then the OLS estimator is more efficient. The Durbin and Wu–Hausman test statistics are statistically significant at 5% level, rejecting the null hypothesis. It implies that $relfare$ and $loadfac$ are endogenous. In addition, a test for endogeneity that the $dHHI_{SINGLE}$ ($dHHI_{MULTI}$) is actually exogenous variable is conducted. The Durbin and Wu–Hausman test statistics are not statistically significant at 5% level, so we fail to reject the null of exogeneity. Thus, $dHHI_{SINGLE}$ and $dHHI_{MULTI}$ are assumed to be exogenous in each model specification.

As suggested by Borenstein and Netz (1999), destination city populations relative to aggregate seat capacity on a route are used as excluding instrumental variables (IVs). In addition, meteorological variables (data collected from the Korea Meteorological Administration website) such as air temperature and humidity are also used as the excluding instruments, as previously suggested by Berry and Jia (2010).

We present the estimated coefficients using the IV method as well as the OLS method for each of the model specifications in Table 3. We also experimented with interacting deregulation dummy variable with aircraft size variable, in addition to controlling for aircraft size, however, this imposes high multicollinearity and we therefore report the estimation results in Table A2 in the Appendix. First, an attempt is made to fit a regression to the pooled data from all five Jeju Island routes (Columns (1)–(4)). Next, a regression is fit separately to the pooled data from the three Jeju Island routes with significant entry of LCCs (Columns (5)–(8)). For each dataset, two different model specifications are applied, which only differ with regard to two explanatory variables: Model 1 controls for the route-level competition ($dHHI_{SINGLE}$) and route-level LCC flight shares ($LCCshare_{SINGLE}$) without considering multiproduct firm behavior, and Model 2 controls for the route-level competition ($dHHI_{MULTI}$) and route-level LCC flight shares ($LCCshare_{MULTI}$) in the presence of a multiproduct firm.

As shown in Table 3, the positive coefficient estimates for both $dHHI_{SINGLE}$ and $dHHI_{MULTI}$ are statistically significant at the 1% level and robust across all specifications, showing associated shifts in the same direction. It implies that concentration intensity has positive impact on the degree of differentiated flight times scheduling between different carriers. In other words, this positive impact of concentration intensity on $BtwnDIFF$ indicates a competition tendency toward less inter-firm differentiation in departure flight times. The smaller inter-firm differentiation is the driving force of the decline in departure times differentiation with competition: the degree of inter-firm differentiation would be less than the degree of average differentiation among all pairs of flights. Overall, the estimates for IV regression when controlling for unobserved heterogeneity are larger than for OLS. This finding is consistent with the correlation between the two endogenous variables and unobserved flight quality that would generate a downward bias in the estimates.

The estimated impact of deregulation on the degree of inter-firm departure time differentiation has a positive sign, since larger gaps between inter-firm flight times on the five Jeju Island routes are found in the deregulated period (Columns

Table 3: Estimation results: Jeju Island routes (June 2006–June 2010)

Dependent variable: $BtwnDIFF_t^r$

Coefficient	Pooled 5 Jeju Island routes				3 Jeju Island routes with significant entry of LCCs			
	(1) IV	(2) OLS	(3) IV	(4) OLS	(5) IV	(6) OLS	(7) IV	(8) OLS
$dHHI_{SINGLE}{}_t^r$	0.300***	0.283***			0.317***	0.122***		
	(0.036)	(0.034)			(0.080)	(0.041)		
$dHHI_{MULTI}{}_t^r$			0.274***	0.279***			0.168***	0.136***
			(0.036)	(0.037)			(0.033)	(0.030)
$deregulation_t^r$	0.009***	0.010***	0.010***	0.010***	0.004	0.006**	0.004*	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)
$dHHI_{SINGLE}{}_t^r \cdot deregulation_t^r$	-0.118***	-0.130***			-0.113**	-0.101**		
	(0.043)	(0.040)			(0.050)	(0.040)		
$dHHI_{MULTI}{}_t^r \cdot deregulation_t^r$			-0.138***	-0.148***			-0.076**	-0.061**
			(0.033)	(0.033)			(0.031)	(0.029)
$LCCshare_{SINGLE}{}_t^r$	0.039***	0.039***			0.052***	0.020***		
	(0.003)	(0.003)			(0.013)	(0.006)		
$LCCshare_{MULTI}{}_t^r$			0.052***	0.051***			0.059***	0.071***
			(0.005)	(0.005)			(0.011)	(0.009)
$relfare_t^r$	0.001	-0.023***	-0.040***	-0.039***	0.021	-0.071***	-0.082***	-0.111***
	(0.011)	(0.006)	(0.011)	(0.007)	(0.028)	(0.010)	(0.014)	(0.009)
$loadfac_t^r$	0.001	-0.017**	-0.001	-0.015**	-0.0004	-0.025***	-0.016*	-0.016**
	(0.013)	(0.007)	(0.012)	(0.007)	(0.016)	(0.007)	(0.010)	(0.006)
$flightfreq_t^r$	0.027***	0.034***	0.034***	0.034***	0.022**	0.049***	0.048***	0.056***
	(0.004)	(0.003)	(0.004)	(0.003)	(0.009)	(0.004)	(0.004)	(0.003)
Constant	0.930***	0.964***	0.968***	0.977***	0.910***	1.026***	1.021***	1.044***
	(0.017)	(0.007)	(0.015)	(0.008)	(0.038)	(0.013)	(0.014)	(0.009)
Number of obs.	240	240	240	240	144	144	144	144
$R^2_{Adjusted}$	0.836	0.849	0.848	0.851	0.77	0.855	0.887	0.895
Instrumented	$relfare_t^r$ $loadfac_t^r$		$relfare_t^r$ $loadfac_t^r$		$relfare_t^r$ $loadfac_t^r$		$relfare_t^r$ $loadfac_t^r$	
+Sargan-Hansen over-id. test	4.491 [0.344]		17.315 [0.002]		8.385 [0.079]		4.359 [0.359]	

Notes: 1) Robust standard errors in parentheses;
2) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;
3) A test for weak identification is performed using STATA 11 and interpreted. + refers to Sargan-Hansen test statistic, p-values in square brackets. In Column (3), we fail to reject the null hypothesis at 5% significance level.

(1)–(4)). In contrast, the positive coefficients for *deregulation* are less robust on the three Jeju Island routes with significant entry of LCCs (Columns (5)–(8)). The point estimates for $dHHI_{SINGLE}$ ($dHHI_{MULTI}$) with its interaction effect with *deregulation* are negative and statistically significant at the 5% level. This finding implies that the more concentrated a route is, the weaker the positive impact of the concentration intensity on *BtwnDIFF* is in the deregulated period.

The magnitude of coefficients shows that an increase in competition (a decrease in concentration intensity) leads to less product differentiation between carriers with respect to departure flight times scheduling, but this tendency becomes weaker in the deregulated period.The effect of concentration on the inter-firm scheduling differentiation for the post (pre)-deregulation period is 0.182

(0.300) in Column (1), 0.153 (0.283) in Column (2), 0.136 (0.274) in Column (3), and 0.131 (0.279) in Column (4) on the five Jeju Island routes. The effect of concentration on the inter-firm scheduling differentiation for the post (pre)-deregulation period is 0.204 (0.317) in Column (5), 0.021 (0.122) in Column (6), 0.092 (0.168) in Column (7), and 0.075 (0.136) in Column (8) on the three Jeju Island routes with significant entry of LCCs. The estimates using $dHHI_{MULTI}$ yield a relatively small size of coefficients than the estimates using $dHHI_{SINGLE}$ and this is expected one since degree of competition in fact is reduced by the two legacy carriers' own subsidiary LCCs (dependent LCCs) operation on the three Jeju Island routes that faced direct competition from LCCs, namely the Jeju-Seoul route (r = 1), Jeju-Busan route (r = 2), and Jeju-Cheongju route (r = 3), and on which a substantial number of passengers fly.

On these three Jeju Island routes, several LCCs have been established since the May 2008 Deregulation Act: two independent LCCs, ESR and JJA, as well as the two dependent LCCs, JNA and ABL. The emergence of established independent LCCs is linked to change market structure, thus, concentration level, among carriers. Each route is a part of a Jeju routes network so airlines may face operational rigidities. Operational rigidities can pose constraints that affect airlines' strategic responses through schedule differentiation. The less robust coefficient estimates for deregulation on these three Jeju Island routes would be consistent with the case where each carrier schedules its flights more closely to its rivals' flights on high volume routes, taking into account departure time crowding into peak-demand routes. The robust and positive coefficient estimates for deregulation on the five Jeju Island routes would be consistent with the case where each carrier schedules its flights farther away from its rivals'flights on low volume routes, namely the Jeju-Daegu route (r = 4), and Jeju-Gwangju route (r = 5). This would imply that for each carrier the minimum differentiation incentive as opposed to the rival's flight times outweigh the maximum differentiation incentive when competition intensifies on these three Jeju Island routes.

Positive and highly significant coefficients are given for both $LCCshare_{SINGLE}$ and $LCCshare_{MULTI}$ are due to the industry competition configuration. This empirical finding would support the statement that the newly established independent LCCs would compete with the incumbents, differentiating their flights in departure times scheduling.An inference would seem to be that a tendency for less inter-firm differentiation is weaker on the routes with LCCs. Independent LCCs are expected to distinguish their flights from the two legacy carriers through product differentiation. At the same time, the two legacy carriers tend to schedule their departure flight times farther from independent LCCs' flight times. The incentive to schedule departure flight times far from rivals' flights by means of a product differentiation strategy would be strengthened in the presence of independent LCCs.

The coefficients for other time varying factors are significant. After controlling for endogeneity of flight service profitability, the estimated coefficients for $relfare$ alternate in sign and are less robust in the estimation without considering multiproduct firm behavior. In the specification in which the two legacy carriers and their dependent LCCs are considered a single entity, the estimated impacts of $relfare$ on $BtwnDIFF$ are negative and more robust, implying that the higher the profitability, the smaller the $BtwnDIFF$. The minimum differentiation incentive may drive the carriers to schedule their flights more closely to their rivals' flights, drawing in passengers from nearby flights. The coefficients for $loadfac$ when controlling for endogeneity are negative, but the estimated impacts are less robust at the 5% level. The negative sign indicates that high load factors lead to a minimum departure flight times differentiation between competitors.

With regard to the impact of market structure on the degree of inter-firm departure time differentiation, the route-wide total flight frequencies are controlled. The coefficient estimates for $flightfreq$ are all positive and highly significant; flights that are more frequent provide larger values of $BtwnDIFF$. More variety of departure flight times would generate a larger value of the degree of inter-firm differentiation.

6. CONCLUSION

The presented empirical findings contribute two new insights into the study of the Korean airline industry. First, we focus on the departure flight time differentiation scheduled by different airline carriers, not the flight time differentiation between all flights. Second, the model design differs from those in previous U.S. airline studies in that it uses panel data from June 2006 to October 2010 for five Jeju Island routes in the Korean airline industry, capturing the inter-firm scheduling pattern created by the May 2008 Deregulation Act.

The results presented in this study imply that increasing competition (decrease in the concentration level) is associated with smaller inter-firm departure time differentiation. We confirm that the smaller inter-firm differentiation is the driving force of the decline in departure times differentiation with competition. This tendency for less inter-firm differentiation is weaker on the routes with LCCs. Moreover, independent LCCs may try to differentiate their flight services from those of legacy carriers through maximum non-price (e.g., quality) product differentiation. Departure flight times differentiation between different airline carriers is greater in the deregulated period.

Appendix

Calculation of the inter-firm departure flight times differentiation index, $BtwnDIFF$.

1. $BtwnDIFF_{Case(i)}$= 1.3072 in Figure 5

In Case (i), $AVGDIFF_{Case(i)}$ is the average time distance between each pair of four flights,
$|d_{A1}-d_{A2}| = |6AM-7AM|$, $|d_{A1}-d_{B1}| = |6AM-6PM|$, $|d_{A1}-d_{B2}| = |6AM-7PM|$,
$|d_{A1}-d_{B1}| = |7AM-6PM|$, $|d_{A2}-d_{B2}| = |7AM-7PM|$, $|d_{B1}-d_{B2}| = |6PM-7PM|$

The average time distance between all flights scheduled by different carriers is calculated by applying Equation (1) to the subset of flight differences, $|d_i-d_j|$, where the carriers scheduling flights departing at d_i and d_j are different: $|d_{A1}-d_{B1}| = |6AM-6PM|$, $|d_{A1}-d_{B2}| = |6AM-7PM—$, $|d_{A2}-d_{B1}| = |7AM-6PM|$, $|d_{A2}-d_{B2}| = |7AM-7PM|$.

When $\alpha = 0.5$,
$BtwnDIFF_{Case(i)} = \frac{\frac{1}{4}\times\left(720^{0.5}+780^{0.5}+660^{0.5}+720^{0.5}\right)}{\frac{1}{6}\times(60^{0.5}+720^{0.5}+780^{0.5}+660^{0.5}+720^{0.5}+60^{0.5})} = 1.3072$

2. $BtwnDIFF_{Case(ii)}$ = 1.1420 in Figure 5

In Case (ii), $AVGDIFF_{Case(ii)}$ is the average time distance between each pair of six flights,
$|d_{A1}-d_{A2}| = |6AM-7AM—$, $|d_{A1}-d_{A3}| = |6AM-12PM|$, $|d_{A1}-d_{B1}| = |6AM-6PM|$,
$|d_{A1}-d_{B2}| = |6AM-7PM|$, $|d_{A1}-d_{B3}| = |6AM-1PM|$, $|d_{A2}-d_{A3}| = |7AM-12PM|$,
$|d_{A2}-d_{B1}| = |7AM-6PM|$, $|d_{A1}-d_{B2}| = |7AM-7PM|$, $|d_{A2}-d_{B3}| = |7AM-1PM|$,
$|d_{A3}-d_{B1}| = |12PM-6PM|$, $|d_{A3}-d_{B2}| = |12PM-7PM|$, $|d_{A3}-d_{B3}| = |12PM-1PM|$,
$|d_{B1}-d_{B2}| = |6PM-7PM|$, $|d_{B1}-d_{B3}| = |6PM-1PM|$, $|d_{B2}-d_{B3}| = |7PM-1PM|$

The average time distance between all flights scheduled by different carriers is calculated by applying Equation (1) to the subset of flight differences, $|d_i - d_j|$, where the carriers scheduling flights departing at d_i and d_j are different: $|d_{A1} - d_{B1}| = |6AM - 6PM|$, $|d_{A1} - d_{B2}| = |6AM - 7PM|$, $|d_{A1} - d_{B3}| = |6AM - 1PM|$, $|d_{A2} - d_{B1}| = |7AM - 6PM|$, $|d_{A2} - d_{B2}| = |7AM - 7PM|$, $|d_{A2} - d_{B3}| = |7AM - 1PM|$, $|d_{A3} - d_{B1}| = |12PM - 6PM|$, $|d_{A3} - d_{B2}| = |12PM - 7PM|$, $|d_{A3} - d_{B3}| = |12PM - 1PM|$.

When $\alpha = 0.5$,
$BtwnDIFF_{Case(ii)} =$
$$\frac{\frac{1}{9}\times\left(720^{0.5}+780^{0.5}+420^{0.5}+660^{0.5}+720^{0.5}+360^{0.5}+360^{0.5}+420^{0.5}+60^{0.5}\right)}{\frac{1}{15}\times(60^{0.5}+360^{0.5}+720^{0.5}+780^{0.5}+420^{0.5}+300^{0.5}+660^{0.5}+720^{0.5}+360^{0.5}+360^{0.5}+420^{0.5}+60^{0.5}+60^{0.5}+300^{0.5}+360^{0.5})}$$
$= 1.1420$

3. $BtwnDIFF_{Case(iii)} = 1.3575$ in Figure 5

In Case (iii), $AVGDIFF_{Case(iii)}$ is the average time distance between each pair of six flights,
$|d_{A1} - d_{A2}| = |6AM - 7AM|$, $|d_{A1} - d_{A2}| = |6AM - 8AM|$, $|d_{A1} - d_{B1}| = |6AM - 6PM|$,
$|d_{A1} - d_{B2}| = |6AM - 7PM|$, $|d_{A1} - d_{B3}| = |6AM - 8PM|$, $|d_{A2} - d_{A3}| = |7AM - 8AM|$,
$|d_{A2} - d_{B1}| = |7AM - 6PM|$, $|d_{A2} - d_{B2}| = |7AM - 7PM|$, $|d_{A2} - d_{B3}| = |7AM - 8PM|$,
$|d_{A3} - d_{B1}| = |8AM - 6PM|$, $|d_{A3} - d_{B2}| = |8AM - 7PM|$, $|d_{A3} - d_{B3}| = |8AM - 8PM|$,
$|d_{B1} - d_{B2}| = |6PM - 7PM|$, $|d_{B1} - d_{B3}| = |6PM - 8PM|$, $|d_{B2} - d_{B3}| = |7PM - 8PM|$

The average time distance between all flights scheduled by different carriers is calculated by applying Equation (1) to the subset of flight differences,$|d_i - d_j|$, where the carriers scheduling flights departing at d_i and d_j are different: $|d_{A1} - d_{B1}| = |6AM - 6PM|$, $|d_{A1} - d_{B2}| = |6AM - 7PM|$, $|d_{A1} - d_{B3}| = |6AM - 8PM|$, $|d_{A2} - d_{B1}| = |7AM - 6PM|$, $|d_{A2} - d_{B2}| = |7AM - 7PM|$, $|d_{A2} - d_{B3}| = |7AM - 8PM|$, $|d_{A3} - d_{B1}| = |8AM - 6PM|$, $|d_{A3} - d_{B2}| = |8AM - 7PM|$, $|d_{A3} - d_{B3}| = |8AM - 8PM|$.

When $\alpha = 0.5$,
$BtwnDIFF_{Case(iii)} =$

$$\frac{\frac{1}{9}\times\left(720^{0.5}+780^{0.5}+840^{0.5}+660^{0.5}+720^{0.5}+780^{0.5}+600^{0.5}+660^{0.5}+720^{0.5}\right)}{\frac{1}{15}\times(60^{0.5}+120^{0.5}+720^{0.5}+780^{0.5}+840^{0.5}+60^{0.5}+660^{0.5}+720^{0.5}+780^{0.5}+600^{0.5}+660^{0.5}+720^{0.5}+60^{0.5}+120^{0.5}+60^{0.5})}$$
$$= 1.13575$$

Table A1. Pearson Correlation Coefficients using Data (June 2006–June 2010)*

Pooled 5 Jeju Island routes

No.	Variable	1	2	3	4	5	6	7	8
1	$dHHI_{SINGLE}{}_t^r$	1							
2	$dHHI_{MULTI}{}_t^r$	0.7984*	1						
3	$LCCshare_{SINGLE}{}_t^r$	0.2254*	0.5167*	1					
4	$LCCshare_{MULTI}{}_t^r$	0.2674*	0.3610*	0.7833*	1				
5	$relfare_t^r$	0.1573*	0.2386*	0.2067*	0.4285*	1			
6	$loadfac_t^r$	0.032	0.0497	0.0806	0.0201	-0.0242	1		
7	$flightfreq_t^r$	0.5123*	0.6346*	0.3609*	0.3958*	0.6229*	0.1702*	1	
8	$acsize_t^r$	0.3477*	0.4217*	-0.2488*	-0.4242*	0.1338*	0.0555	0.4551*	1

*Note: Correlation is significant at *0.05 level.

3 Jeju Island routes with significant entry of LCCs

No.	Variable	1	2	3	4	5	6	7	8
1	$dHHI_{SINGLE}{}_t^r$	1							
2	$dHHI_{MULTI}{}_t^r$	0.6710*	1						
3	$LCCshare_{SINGLE}{}_t^r$	-0.4407*	0.0829	1					
4	$LCCshare_{MULTI}{}_t^r$	-0.5861*	-0.4846*	0.2504*	1				
5	$relfare_t^r$	-0.1021	0.0203	-0.1503	0.3790*	1			
6	$loadfac_t^r$	0.0954	0.0884	0.0314	-0.1465	0.1012	1		
7	$flightfreq_t^r$	0.3891*	0.5296*	-0.057	-0.0825	0.7277*	0.1870*	1	
8	$acsize_t^r$	0.6273*	0.7649*	-0.1086	-0.4997*	0.1984*	0.1455	0.6893*	1

*Notes: 1) Correlation is significant at *0.05 level;

2) A high degree of multicollinearity (i.e., between $acsize_t^r$ and $dHHI_{MULTI}{}_t^r$) is detected.

Table A2. Estimation results: Jeju Island routes (June 2006–June 2010)

Dependent variable: $BtwnDIFF_t^r$

Coefficient	pooled 5 Jeju Island routes				3 Jeju Island routes with significant entry of LCCs			
	(1) IV	(2) OLS	(3) IV	(4) OLS	(5) IV	(6) OLS	(7) IV	(8) OLS
$dHHI_{SINGLE_t}^r$	0.295*** (0.040)	0.290*** (0.041)			0.214*** (0.069)	0.092** (0.046)		
$dHHI_{MULTI_t}^r$			0.255*** (0.043)	0.266*** (0.046)			0.078** (0.034)	0.056* (0.031)
$deregulation_t^r$	0.013 (0.019)	0.004 (0.018)	0.014 (0.018)	0.015 (0.017)	0.058** (0.026)	0.031* (0.016)	0.063*** (0.014)	0.058*** (0.013)
$dHHI_{SINGLE_t}^r \cdot deregulation_t^r$	-0.116** (0.048)	-0.136*** (0.047)			0.058 (0.078)	-0.045 (0.054)		
$dHHI_{MULTI_t}^r \cdot deregulation_t^r$			-0.129*** (0.041)	-0.139*** (0.042)			0.061 (0.043)	0.067 (0.042)
$LCCshare_{SINGLE_t}^r$	0.039*** (0.004)	0.037*** (0.004)			0.073*** (0.015)	0.025*** (0.008)		
$LCCshare_{MULTI_t}^r$			0.060*** (0.008)	0.057*** (0.008)			0.073*** (0.010)	0.083*** (0.009)
$relfare_t^r$	-0.0003 (0.012)	-0.024*** (0.007)	-0.044*** (0.011)	-0.039*** (0.007)	0.058* (0.032)	-0.064*** (0.013)	-0.080*** (0.014)	-0.105*** (0.008)
$loadfac_t^r$	-0.001 (0.012)	-0.017** (0.007)	-0.006 (0.012)	-0.014** (0.007)	-0.006 (0.015)	-0.025*** (0.007)	-0.017** (0.009)	-0.012** (0.006)
$flightfreq_t^r$	0.027*** (0.005)	0.036*** (0.004)	0.033*** (0.004)	0.033*** (0.004)	0.003 (0.011)	0.047*** (0.005)	0.043*** (0.005)	0.050*** (0.003)
$acsize_t^r$	0.0310 (0.091)	(0.0560) (0.085)	0.1010 (0.095)	0.0790 (0.097)	0.596*** (0.174)	0.122 (0.096)	0.329*** (0.072)	0.304*** (0.066)
$acsize_t^r \cdot deregulation_t^r$	-0.025 (0.112)	0.033 (0.104)	-0.026 (0.109)	-0.028 (0.101)	-0.393** (0.171)	-0.167 (0.101)	-0.392*** (0.091)	-0.370*** (0.087)
Constant	0.927*** (0.028)	0.976*** (0.019)	0.958*** (0.025)	0.963*** (0.020)	0.786*** (0.061)	1.000*** (0.025)	0.967*** (0.021)	0.988*** (0.014)
Number of obs.	240	240	240	240	144	144	144	144
$R^2_{Adjusted}$	0.837	0.849	0.849	0.85	0.761	0.856	0.901	0.907
Instrumented	$relfare_t^r$ $loadfac_t^r$		$relfare_t^r$ $loadfac_t^r$		$relfare_t^r$ $loadfac_t^r$		$relfare_t^r$ $loadfac_t^r$	
+Sargan-Hansen over-id. test	4.836 [0.305]		18.668 [0.0009]		13.100 [0.011]		6.278 [0.179]	

Notes: 1) Robust standard errors in parentheses;
2) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;
3) A test for weak identification is performed using STATA 11 and interpreted. + refers to Sargan-Hansen test statistic, p-values in square brackets. In Columns (3) and (5), we fail to reject the null hypotheses at 5% significance level.

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