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Clustered airline flight scheduling: Evidence from airline deregulation in Korea



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ABSTRACT

This paper explores the impacts of competition level on airline scheduling in the Korean domestic short-haul routes where a hub-and-spoke system is not the optimal air transport network strategy. The empirical findings using the Korean airline panel data for the period 2006–2010 suggest that competition leads to less differentiated departure flight times as expected from spatial competition theory. Unlike the previous study on the U.S. airline industry, the degree of this tendency for less differentiation differs across the type of routes: the Jeju island routes (*leisure* type) and the inland routes (*business* type), in the deregulated period. Following the May 2008 Deregulation Act we find an increasingly clustered pattern of airline scheduling in the Jeju island routes where there have been competitive pressures associated with new low cost entrants. This recent evidence would imply that airline carriers strategically schedule departure flight times and allocate flights between routes as competition increases in the deregulated period.

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1. Introduction

Low cost carriers (LCCs) have emerged and revolutionized short-haul flight markets around the world, expanding the choice of air transport to air passengers at lower fares as a global phenomenon at the end of the 20th century and the beginning of the 21st century. Even though the growth of the airline industry slowed down worldwide over the past few years, the largest LCCs, such as Southwest in the United States, have continued to grow rapidly while new smaller LCCs have collapsed. These have different product and market strategies than the traditional full service legacy carriers. Established legacy carriers, on the other hand, have responded to entry of LCC competitors by diversifying their strategies to compete for the short-haul flights market as well.

As aviation industry dynamics have changed, with deregulation around the globe, the emergence of LCCs has been linked with greater market competition. Previously, many empirical papers

assessed the effects of the U.S. Airline Deregulation Act of 1978 on travelers and carriers while there have been no such studies focused on the effects of deregulation of the Korean airline industry.² Morrison and Winston (1986) analyzed that changes in the route structures contributed greatly to the success of the deregulation of 1978 because development of hub-and-spoke route structures increased departure frequencies. Empirical studies of the U.S. deregulation have found hub-and-spoke effects to be important. The longest flight in Korean domestic routes, however, only takes about 65 min for jet airplanes and either less than or equal to 90 min for turboprop airplanes). Given that a hub-and-spoke system is not the optimal air transport network strategy for Korean domestic short-haul routes, the implications based on the U.S. airline deregulation cannot be directly applied to the point-to-point route structure in Korea.

Before 2005, the Korean domestic airline markets were characterized by duopolies: two legacy carriers, Korean Air (KAL) and Asiana Air (AAR) were the only carriers in each domestic city pair market. Since the May 2008 Deregulation Act, the Korean airline industry has undergone significant changes. The competition of the

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² With allowing carriers more freedom in pricing and in entry and exit since 1978, all fare and entry regulations were eliminated in January 1983.

markets long dominated by the two legacy carriers has increased since the deregulation as new low cost carriers (LCCs) entered a few of these markets at ticket prices of about 70 or 80 percent of the prices being charged by the legacy carriers. The two incumbents have developed new business strategies in response to the entry of LCCs in the deregulation period. The legacy carriers, KAL and AAR, rebadged and entered a few of their own markets with LCC operations either replacing their prior service or flying under both legacy carrier brand and LCC brand for some city pair routes. It is worth investigating how the two-brand strategy by legacy carriers affects intensity of competition on a route in the deregulated Korean airline market with short-haul domestic routes.

During 2006, 2010, the entry of LCCs was limited to the routes either flying to Jeju island or having the two largest metropolitan areas – Seoul and Busan – as an end point city. Due to the lack of entry to inland routes for the two years following the May 2008 Deregulation Act, deregulation is expected to have an asymmetric effect depending on the type of markets. Thus, it is interesting to examine the effects of the deregulation policy on the domestic Korean city pair markets through the intensity of competition; how deregulation affected departure flight times scheduling patterns. And second, whether there are different responses in scheduling patterns following deregulation for the type of markets: the Jeju island routes (assumed to be primarily the *leisure* route) and the inland routes (assumed to be primarily the *business* route).

1.1. The May 2008 Deregulation Act in the Korean airline industry

Domestic air passenger traffic in Korea has been decreasing since it picked up around a 16% annual growth rate in the late 1980's and early 1990's. On the other hand, international air passenger traffic has been increasing since the Severe Acute Respiratory Syndrome (SARS) epidemic had a severe negative effect on Asian air travel markets in 2002–2003 and the economic crisis swept across the nation in the late 1990s.³

While two legacy carriers, KAL and AAR, target international routes instead of pursuing relatively low profits in domestic routes following the introduction of high-speed rail services, Korean Train eXpress (KTX), in 2004, LCCs have emerged and entered some domestic city pair markets in 2005, the first independent LCC, Hansung Airlines (HAN) received its Air Operator's Certificate (AOC). LCCs in Korea can be categorized into two types from the view point of ownership; independent LCCs and dependent LCCs. First, *independent* LCCs refer to LCCs that are not owned by full service legacy carriers.⁴ Second, *dependent* LCCs refer to LCCs that are wholly-owned LCC subsidiaries of legacy carriers.⁵ In response to the emergence of the independent LCCs the two full service carriers established their own subsidiary LCCs, either replacing their prior services with them or flying under both legacy carrier brand and LCC brand. AAR replaced its service on some routes with its own LCC, Air Busan (ABL), and KAL operated under two-brand strategy through its subsidiary LCC, Jin Air (JNA).

As shown in Fig. 1,⁶ the volume of passengers using LCCs had been growing at a faster pace than before in the Korea domestic airline markets over the past few years. The volume of traffic by

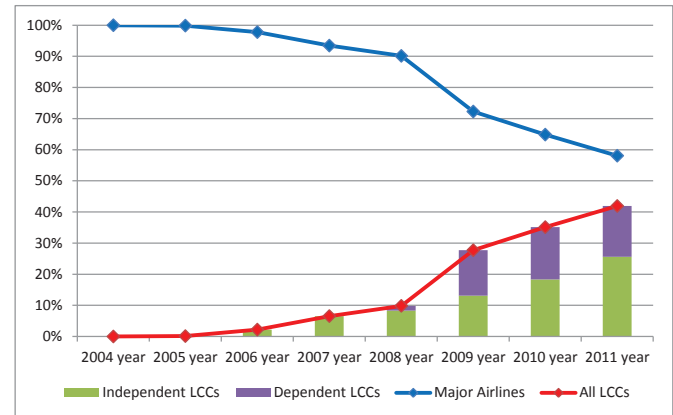


Fig. 1. Percentage of Korean domestic flight shares operated by legacy carriers and LCCs by year.

Table 1

List of aircraft carriers in Korea (June 2006–June 2010).

Types of airlines	Airline carrier	Launch date	Aircraft (fleet types)	Seats
Full service carrier	Korean Air (KAL)	March 1969	B-737-800/B-737-900 (Jet) A-300-600/A-330-300 (Jet)	149–188 266–296
Full service carrier	Asiana Airlines (AAR)	December 1988	B-737-400 (Jet) A-320-200/A-321-200 (Jet)	160 143–200
Low cost carrier	Hansung Airlines (HAN)	August 2005 ^a	ATR72-200 (Turboprop)	72
Low cost carrier	Jeju Air (JJA)	June 2006	Dash-8-Q400 (Turboprop) B-737-800 (Jet) ^c	78 186–189
Korean Airline Deregulation Act of May 2008				
Low cost carrier	Yeongnam Air (ONA)	July 2008 ^b	Fokker-100 (Turboprop)	109
Low cost carrier, KAL's subsidiary LCC	Jin Air (JNA)	July 2008	B-737-800 (Jet)	189
Low cost carrier, AAR's subsidiary LCC	Air Busan (ABL)	October 2008	B-737-400/B-737-500 (Jet)	127–162
Low cost carrier	Eastar Jet (ESR)	January 2009	B-737-600/B-737-700 (Jet)	131–149

^a Hansung Airlines suspended operations in October 2008 and was re-launched in August 2010 under the changed new name T'way Air.

^b Yeongnam Air stopped its operations in December 2008.

^c Jeju Air took its first delivery of Boeing 737 in May 2008.

LCCs has rapidly grown relative to that of the two major airlines from 2008 to 2009. The independent LCCs have shown considerable growth rate of market share, recording an 8.3% in 2008, 13.1% in 2009, an 18.3% in 2010, and 25.6% in 2011. The passengers share using the dependent LCCs recorded an 1.6% in 2008, 14.6% in 2009, 16.8% in 2010, and 16.3% in 2011. In 2011, aggregate domestic market shares of LCCs were above 40%, a new record for LCC penetration in the North Asian nation, making a significant rise from 9.8% in 2008.⁷ For the Korean airline industry, being slow to

³ Annual growth rate for the domestic air passenger traffic in Korea is 15.7% in 1978–1987, 12% in 1988–1998, and –1.6% in 1998–2007, respectively while annual growth rate for the international air passenger traffic is 8.9% in 1978–1987, 8.3% in 1988–1997, and 11.3% in 1998–2007.

⁴ Pure LCCs or true LCCs may also refer to independent LCCs.

⁵ Unlike independent LCCs, dependent LCCs may have code-share flights with their parent company on a specific route.

⁶ Data source: The Ministry of Land, Transport and Maritime Affairs (MLTM), own calculations.

⁷ LCCs in Korea held an aggregate domestic market share of 48.9% in 2013, up from the 44.5% in 2012. In terms of total domestic capacity share, like total domestic market share, LCC penetration in Korea is higher than other North Asian countries, but is slightly above the average compared to world. Source: Centre for Asia Pacific Aviation & OAG Facts.

Table 2

Act change of the Korean airline industry: pricing rules remained unchanged.

Regulation system	Before May 2008		After May 2008	
	Scheduled air service	Non-scheduled air service	Domestic service	International service
Requirement	License	Registration		
Aircraft size	No limit	80 seats Limit per plane	–	–
Aircraft age	No limit	Less than 25 years	–	–

adopt the LCC model, the major barriers are regulated regimes in Korean air industry.

Prior to May 2008 Korean airline regulation had restrictive licensing policies. This regulation system categorized airline carrier into two types: scheduled air service carriers and non-scheduled air service carriers. While non-scheduled air service carriers were only allowed to operate irregular flight services with aircraft, each having less than 80 seats, scheduled air service carriers could operate regular flight services with a license issued by a government aviation body. These restrictions on non-scheduled air service carriers, combined with irregular flights service, greatly limited their aircraft availability and selection (turboprop aircraft with less than 80 seats). Since 2005 a few independent LCCs had flown some city pair routes, but most of these were non-scheduled air service carriers subject to regulated market policy. In this context the “licensing policy” hindered prospective entrants from settling in the market (Tables 1 and 2).

The May 2008 Deregulation Act removed restrictions imposed on aircraft size for the non-scheduled airlines while fare regulations have remained unchanged; thus, all independent LCCs were then able to operate jet aircraft with more than 80 seats each. Several LCCs (including both dependent and independent LCCs) have been established over the last four years. The remaining independent LCCs were restructured by expanding their capacities.⁸

Beyond the supply side perspective of the impact of LCCs' entry on Korean airline markets, “a five-day work week” was introduced for Korea. The National Assembly cleared a legislative bill to amend the Labor Standard Act (LSA) on August 2003. This amended LSA introduced a five-day work week by reducing the maximum legal working hours from 44 to 40 per week, and the law was passed by the South Korean parliament in 2004.⁹ After gradually establishing “a 5-day work week” system since 2005 (South Korean companies of all sizes became required to switch to the five-day work week in 2011), people's leisure activities have changed greatly. A five day work week system, combined with emergence of new LCCs in the deregulated period, has prompted more people to fly and changed market structure.

The rest of this paper is organized as follows. Section 2 introduces an index for the departure flight times differentiation. Section 3 outlines the empirical framework of testing the impact of competition level on departure flight times scheduling. In Section 4, the variables used in the model are defined and the data description are presented. Section 5 presents estimation results. Finally, concluding remarks are given in Section 6.

2. Departure flight times differentiation

2.1. Theoretical framework: spatial competition model in the airline industry

The study on spatial competition model dates back to Hotelling (1929). In Hotelling's linear city model with linear transport cost, each of duopolists differentiate their products in only one dimension, geographic location. Firms are located at the same point (minimal differentiation, i.e., perfect substitutes). Given the assumption of a quadratic transport costs, D'Apremont et al. (1979) show that duopolists with a single outlet locate at opposite ends of the linear markets. An example of the study of the circle model of spatial competition is Martinez-Giralt and Neven (1988). They developed spatial competition models allowing for competition from multiple outlets. In the circle model of spatial competition with duopolists, in equilibrium each firm positions its two outlets at the same point. As summarized in Borenstein and Netz (1999), theoretical models of spatial product differentiation suggest two possible polar cases regarding location competition outcomes: minimal differentiation in order to steal customers from rivals, and maximal differentiation in order to soften price competition with competitors.

Unlike perfectly competitive markets in which firms take prices as a given, the air travel industry is characterized by differentiated products. With differentiated products, competition has both price and non-price dimensions. Airline carriers choose not only prices, but also flight frequency and flight departure times. Spatial competition theory has been applied to airline studies such that airlines compete on departure times where the departure times of flights on a route can be interpreted as locations on a 24-h clock and the air traveler's preferred departure times are non-uniformly distributed, i.e., heterogeneous consumer's preferences. One of the studies in the airline industry literature related to departure flights scheduling competition is Borenstein and Netz (1999). In this study, passenger's transport costs are assumed to be quadratically related to departure flight times in minutes. They empirically test the relationship between the level of competition and spatial product differentiation using cross-sectional U.S. airline 1975 (when fares were regulated) and 1986 (when fares were not regulated) data, respectively for a given number of flights on a route. According to their findings, airlines schedule their flights more closely to each other as competition increases for both periods. They also find that reductions in scheduling constraints increase differentiation in departure times after deregulation. Yetiskul and Kanafani (2010) also test location theory using cross-sectional U.S. airline 2005 data. They find that intense competition leads to less departure time differentiation. This tendency is lower in the presence of low cost carriers on a route. Salvanes, et al., (2005) empirically examine departure time differentiation in the Norwegian airline industry. When price is exogenous, they find evidence that an increase in competition on a route leads to a decrease in departure time differentiation.

In sum, spatial competition model in the airline industry suggests that when prices are set exogenously, then it follows that carriers would minimize departure time differentiation in the absence of price competition. On the other hand, carriers might increase departure time differentiation in order to soften price competition in the presence of potential intensive price competition. Deregulation in the Korean airline industry concentrated on eliminating regulatory barriers to entry, but did not lead to a huge reduction in the average fares due to unexpectedly introduced fuel surcharges on all domestic city-pair routes. With this small variations in fares within carriers, carriers would have engaged in non-price dimension competition. It is therefore of interest to investigate whether the pattern for scheduling departure flight times has

⁸ For example, Jeju Air (JJA) permanently removed all four Dash 8 Q400s, turboprop aircraft with 78 available seats per airplane, in June 2010, and took delivery of one Boeing 737 in 2011 on top of its existing fleet of five B737s. Another independent LCC, Eastar Jet (ESR) expanded its fleet up to six Boeing 737s in March 2010, increasing their daily flight frequency.

⁹ Previously, Korean workers had traditionally worked more hours than their counterparts in OECD countries.

changed since the 2008 Deregulation Act, and if so, the estimated effects differ depending on the types of routes: the Jeju island routes (*leisure* type) and the inland routes (*business* type).

2.2. Measure of overall differentiation: the DIFF index

The differentiation index, adapted from the one used by Borenstein and Netz (1999), *DIFF* is used as a measure for overall flight times differentiation. *DIFF* takes a value in the interval [0,1].¹⁰ This measure is calculated by using departure times of all non-stop flights. The closer the index to 1, the flights are more evenly distributed over a 24-h clock, maximizing departure time differentiation. When this index is equal to 0, all flights depart at the same time, meaning no differentiation in departure times.

3. Model

3.1. Predictions

Since the airfares are not set exogenously in the Korean airline industry, and passenger's preferred departure flight times are not uniformly distributed across the types of routes, the Hotelling's conjecture cannot be directly applied to the data.

In order to examine the effect of competition level on the scheduling differentiation, we need to control for other factors that affect airline scheduling: LCC flight shares, deregulation, route-specific profitability, load factor, flight frequency and flight duration. The emergence and failure of LCCs are linked to the LCC flight shares. Carriers are likely to diversify their competition strategies on the route where new entry of independent LCCs compete with legacy carriers in the post-deregulation period. Independent LCCs would distinguish their flights from the two legacy carriers by means of product differentiation strategy. We conjecture that the effect of competition level on airline scheduling differentiation depends on the deregulation policy which leads to the change in market structure.

The supply-side perspectives can pose constraints that affect airlines' strategic responses through departure flight times schedule differentiation. Since each route is a part of a network and the plane used on one route is in use in prior and subsequent routes, carriers strategically schedule departure flights and allocate flight frequencies between routes, taking into account all domestic routes profitability. The route-specific profitability would drive carriers to schedule flight times either more closely to or farther from each other. On a route with higher profitability as exogenous, a carrier would have a greater incentive to schedule flight times closer to each other's flights, drawing passengers off from the most nearby flights. On the other hand, carriers might try to differentiate

their departure flight times farther from each other when the route-specific average profitability per passenger is high, avoiding potentially intense price competition.

The load factor on a route would affect the degree of scheduling differentiation. From the supply side perspective, the incentive to schedule departure flight times far from each other by means of a product differentiation strategy would be strengthened in the absence of capacity constraints. With regards to the demand-driven incentive, high load factors mean that demand is high relative to the number of seats offered. Carriers would schedule their flight times closer to each other in order to capture the high demand, stealing air passengers from competitors. Flight frequency on the route controls for the market size, holding a fixed number of carriers. With regard to flight duration that we control for the distribution of passenger's preferred departure times, carriers would strategically schedule departure flight times on short-haul routes.

3.2. The model

We estimate the econometric model of departure flight times scheduling. We observe $t = 1, \dots, T$ time period. All explanatory variables are assumed to have route-specific effects: r = domestic non-stop routes. The error term ε is assumed to be *i.i.d.* The present models consider the impacts of each independent variable in an additive way. Each carrier is considered to be competing with all other carriers on a route in the model. We assume a log–log relationship (eq (1)).

$$\begin{aligned} LDIFF_t = & \beta_0^r + \beta_1^r LCOMP1_t + \beta_2^r LCCsh1_t + \beta_3^r Deregulation_t \\ & + \beta_4^r LCOMP1_t \cdot Deregulation_t + \beta_5^r LRelFare_t \\ & + \beta_6^r LLoadFac_t + \beta_6^r LFlightFreq_t + \beta_7^r LDuration_t + \varepsilon_t \end{aligned} \quad (1)$$

where $LDIFF_t$ is the logarithm of the differentiation index of departure flight times, $DIFF_t$; $LCOMP1_t$ is logarithm of the competition level variable based on flight frequency shares among all carriers; $LCCsh1_t$ is the ratio of LCC flight on the route; $Deregulation_t$ is a dummy variable, 1 for the observations following the May 2008 deregulation and 0 otherwise. Given that the estimated effect of competition might depend on deregulation, we can account for this intuition with an interactive dummy variable, estimating change in the effect of competition level depending on the value of $Deregulation_t$; $LRelFare_t$ is logarithm of the load factors; $LLoadFac_t$ is logarithm of the load factors; $LFlightFreq_t$ is logarithm of the total flight frequency; $LDuration_t$ is logarithm of the flight duration for the route. The two variables, $RelFare$ and $LoadFac$, would be correlated to the econometric error term, suggesting the use of instruments for $RelFare$ and $LoadFac$. The set of instruments and their validity are discussed in Section 4.

To compare the magnitude of the competition intensity effects, alternative model specification is testable (eq. (2)). Instead of $COMP1_t$ and $LCCsh1_t$, additional explanatory variables – $COMP2_t$ and $LCCsh2_t$ – are included in the baseline specification. In this specification, legacy carriers and their own subsidiary LCCs are considered a single entity, not competing with each other on a route.

$$\begin{aligned} LDIFF_t = & \beta_0^r + \beta_1^r LCOMP2_t + \beta_2^r LCCsh2_t + \beta_3^r Deregulation_t \\ & + \beta_4^r LCOMP2_t \cdot Deregulation_t + \beta_5^r LRelFare_t \\ & + \beta_6^r LLoadFac_t + \beta_6^r LFlightFreq_t + \beta_7^r LDuration_t + \varepsilon_t \end{aligned} \quad (2)$$

¹⁰ There are n daily direct flights on a route, which depart at d_1, \dots, d_n minutes. Each departing time, d_1, \dots, d_n , is expressed as minutes after 12AM. The average difference between flights is measured as: $AVGDIFF = 2/(n(n-1)) \sum_{i=1}^n \sum_{j>1}^n [\min\{|d_i - d_j|, 1440 - |d_i - d_j|\}]^\alpha$, $0 < \alpha < 1$ where 1440 denotes the cluster length in minutes. $AVGDIFF$ is minimized at 0 when all flights depart at the same time. $AVGDIFF$ is maximized when flights on a route are evenly distributed over a cluster, 24-h clock. The power of 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 . For comparisons across routes with different numbers of flights, $AVGDIFF$ is normalized by the maximum possible departure schedule differentiation, $MAXDIFF$, which is the value when the flights are equally spaced around the 24-h clock.

$$MAXDIFF = \begin{cases} 2/(n(n-1)) \sum_{k=1}^{n/2-1} n(k1440/n)^\alpha + n/2(720^\alpha) & , \forall n = \text{even} \\ 2/(n(n-1)) \sum_{k=1}^{(n-1)/2} n(k1440/n)^\alpha & , \forall n = \text{odd} \end{cases} . \text{ Finally, the}$$

measure that is taken to the data is $DIFF = AVGDIFF/MAXDIFF$.

Table 3
Variable definition.

Variable	Description
DIFF	Dependent variable; differentiation index used as measure for overall departure flight times differentiation
COMP1	Measure of competition level, which is the inverse of the Herfindahl-Hirschman Index (HHI); calculated using weight of flight frequency shares of each carrier competing with all other carriers on a route
COMP2	Measure of competition level, which is the inverse of the Herfindahl-Hirschman Index (HHI); calculated using weight of flight frequency shares of each carrier, but legacy carriers and their own subsidiary LCCs (<i>dependent</i> LCCs) are considered a single entity, not competing with each other on a route
LCCsh1	Proportion of flights scheduled by both the <i>independent</i> LCCs and the <i>dependent</i> LCCs (legacy carriers' own subsidiary LCCs) on a route
LCCsh2	Proportion of flights scheduled by the <i>independent</i> LCCs on a route
Deregulation	Dummy variable; 1 for the post-deregulation period and 0 for the period prior to deregulation
RelFare	Relative fare; Airfare including fuel surcharges on the route relative to the average airfare on all other domestic routes in Korea; Airfares are different across peak/off-peak months; Airfares do not incorporate any coupons or discounts
LoadFac	Load factor on a route, which is the percentage of seats occupied
FlightFreq	Total flight frequency on a route
Duration	Flight duration measured in minutes for non-stop flight on a route

4. Estimation

4.1. Data

We merged data from several sources. The data include monthly flight frequency of domestic city pair non-stop flights of each route between June 2006 and June 2010.¹¹ The dataset was then completed by information on airfares, flight schedules, aircraft size (number of available seats per plane) and flight duration in minutes. These additional data were collected from each carrier's website. Airline carriers are required by law to announce fare information in advance on its website. For the same route served by the same airline carrier, fares are lower during off-peak seasons than during peak-seasons. Not only fares but also departure flight timetables with fleet type, and flight duration in minutes are announced by each carrier every month. All variables defined in Table 3 are taken to data.¹²

We define a measure for the competition level, which is equal to the inverse of the Herfindahl-Hershman Index (HHI), ranging from 0 to 1.¹³ A higher HHI number indicates that the route is less competitive, while a lower HHI number indicates the opposite. It

decreases as the number of carriers increases, given a constant flight frequency number. The values of HHI would be greater if the inequalities in market shares between carriers are larger while holding a fixed number of carriers. When aggregating the route level competition among carriers, we use two different carrier level flight frequency weights according to LCC classification: 1) weight of domestic flight frequency shares of each carrier competing with all other carriers on a route, and 2) weight of domestic flight frequency shares of each carrier, but legacy carriers and their own subsidiary LCCs are considered a single entity, not competing with each other on a route. The weighted average aggregate competition measures take the inverse form of each of the HHI estimates, respectively. These two competition measures, *COMP1* and *COMP2*, seek to provide the upper and lower bounds of the competitive intensity, respectively. Corresponding LCC flight shares, *LCCsh1* and *LCCsh2*, are calculated, respectively.

As described in Table 3, airfares are different across peak or off-peak months. Peak months are January, April, May, July, August, and October. January and October are holiday season. July and August are summer vacation/tourist season. Elementary school, middle school, and high school in Korea schedule educational field trips in April and May. Carriers charge a wide range of prices on most routes, price discriminating by departure times. However, no disaggregated data at the route-carrier-departure flight time-day level is available.¹⁴ With insufficient data, we assume that each of airlines charges a single price for all flights departing on the same day regardless of the departure times.¹⁵ The relative fare, *RelFare*, can be used as a measure of the route level profitability, ranging from a high of 1 to a low of 0, with higher numbers implying greater profitability.

LoadFac is the load factor on a route, which is the percentage of seats occupied. Since no disaggregated data of the number of passengers at the route-carrier-departure flight time level is available, the average load factors are only available for the route-carrier-month level. *FlightFreq* is the flight frequency on a route. *Duration* is the flight duration measured in minutes for non-stop flights on a route. All explanatory variables are weighted by each carrier's flight frequency shares on a route. Alternative weight using each carrier's passenger load shares on a route has been used but the results do not qualitatively change.

4.1.1. Jeju island routes (leisure type)

All city pair routes of the Jeju island routes are flying to Jeju island and vice versa. Within the five Jeju island routes, the entry of LCCs is limited to four routes, of which three routes had significant competition (e.g., over half a year) from independent LCCs. For the Jeju island routes two independent LCCs, ESR and JJA, as well as the two dependent LCCs, JNA and ABL, have been established.¹⁶ The two incumbents have developed new business strategies in response to

¹¹ We limit the sample to routes where a substantial number of passengers fly. In addition, some domestic city pair routes are excluded if the number of flights were less than three. For the monthly flight frequency of domestic city pair non-stop flights for December 2009, no data value is stored. Source: Korea Airports Corporation (KAC) www.airport.co.kr.

¹² Time subscripts for variables are omitted. This also applies to the rest of sections.

¹³ This index is calculated as the sum of squares of the flight frequency shares of all airlines.

¹⁴ Korea Airports Corporation (KAC) data only contain aggregate information at the route-carrier-month level, including the number of passengers and the number of flights on each route.

¹⁵ A referee points out that pricing models vary greatly across legacy carriers and LCCs. In order to address a potential problem arising in aggregate-level data, mean-comparison *t*-tests for the time-invariant coefficient for *RelFare* in eqs (1)–(2) are conducted for each of legacy carriers and LCCs, respectively. There is no statistical evidence to reject the null hypothesis that H_0 : mean (relative fare during the first six months after entry - relative fare during the next six months after entry) = 0. Since the early months of an entrant's experience in a route are not significantly different from the months when it is a well-established one, the empirical findings under current static model are reliable. Thus, we proceed with the time-invariant coefficients for *RelFare* in eqs (1)–(2).

¹⁶ Contrast to these successful independent LCCs, the two independent LCCs ceased their operations in 2008: November (HAN) and December (ONA) due to intense competition, worsening economic conditions, increasing fuel costs, and difficulties in securing additional funding.

the entry of LCCs in the deregulation period. The legacy carriers, KAL and AAR, rebadged and entered a few of their own markets with LCC operations either replacing their prior service or flying under a two-brand strategy for some city pair routes.

Table 4 presents summary statistics for the average monthly values of the departure flight times differentiation indices and main explanatory variables from two perspectives: pre- and post-deregulation. For all routes connected to Jeju island, we use departures from other origin cities to Jeju island. For the Seoul-Jeju route, for example, the values of indices in each observation are derived from all non-stop flights on a directional route, from Seoul to Jeju. We also compared the value with Jeju to Seoul observation, but the results are qualitatively insensitive. The same result applies to the rest of the Jeju island routes.

A measure for scheduling differentiation, *DIFF*, slightly decreased from 0.830 in the pre-deregulated period to 0.821 in the post-deregulated period. Competition level, measured by both *COMP1* and *COMP2*, increased considerably over the 5-year period. The average value for the competition level increased from 2.465 in the pre-deregulated period to 2.959 for *COMP1* (2.696 for *COMP2* in the post-deregulated period), which is a significant rise in the airline industry competition. Interestingly, the average value of *LCCsh1* in the post-deregulation period, 26.3 per cent, was almost twice the share of LCCs in the pre-deregulation period, 14.1 per cent. The average value of *LCCsh2*, the independent LCCs flight shares, in the post-deregulation period recorded a 17 per cent, which was only 2.9 per cent higher than that of pre-deregulation. The difference between the average values for *LCCsh1* and *LCCsh2*, about 9 per cent, represents the flight shares scheduled by the legacy carriers' subsidiary LCCs. These huge gaps between the two measures could be attributed to the two legacy carriers' intense multiproduct activity through their own subsidiary LCCs operation in the post-deregulation. The value less than one for *RelFare* would imply that the average airfare for the Jeju island routes was lower than that of the inland routes. A reduction in flight duration, combined with a rise in LCC flight shares, would support an evidence that deregulation has led to structural change in the Jeju island routes, removing restrictions imposed on aircraft size and eliminating the administrative regulation of entry into the Korean airline industries.

4.1.2. Inland routes (business type)

All city pair routes of the inland routes are flying to Seoul and vice versa. Within the six inland routes, the entry of LCCs is limited to one route, Busan-Seoul, having the two largest metropolitan areas as an end point city. The other five inland routes have only been operated by the two legacy carriers, KAL and AAR.

Below we present an overview of the average values of the departure flight time differentiation indices and the other explanatory variables from two perspectives: pre- and post-deregulation (Table 5). For all routes flying inland routes, we use departures from other origin cities to Seoul. For the Seoul-Busan route, for example, the values of indices in each observation are derived from all non-stop flights on a directional route, from Seoul to Busan. We also compared the value with Busan to Seoul observation, but the results are qualitatively insensitive. The same result applies to the rest of the inland routes.

The average values for differentiation index, *DIFF*, increased rather than decreased. With respect to both competition measures with moderate variation over time, we do not draw any conclusion from the initial analysis of the data on the inland routes. The average value of *COMP1* increased from 1.872 to 1.875 during the period 2006–2010, while the average value of *COMP2* decreased from 1.872 to 1.866 over the same period. The decrease in the average value for *COMP2* and the low average value for *LCCsh2* would be consistent with the lack of entry to inland routes for the two years following the May 2008 Deregulation Act. Along with the fact that no independent LCCs operated any of the six inland routes in the deregulated period, *LCCsh2* has a virtually zero value. With respect to *RelFare*, the value greater than one would imply that the average airfare for the inland routes was higher than that of the Jeju island routes. The inland routes recorded a relatively low load factor as compared to the Jeju island routes, the country's largest island and tourist destination. This low average value for *LoadFac* is not surprising because there are substitutable transportation modes such as bus, rail, and automobile. No significant changes in the number of flights were reported.

4.2. Instruments

One potential problem can arise here due to endogeneity concerns. The two variables, *RelFare* and *LoadFac*, would be correlated to the error term if the error term incorporates unobserved seasonal effects or cyclical fluctuations. The minimal differentiation comes at the expense of the intense price competition. There clearly exists endogeneity issue between a measure for profitability, *RelFare*, and dependent variable, *DIFF*. Scheduling patterns of departure flight times constrained by both the demand side and supply side perspectives would affect the number of passengers on a route, thereby the load factor, *LoadFac*. Thus we control for these potentially endogenous variables using instrumental variables (IVs). As suggested by Borenstein and Netz (1999) carrier dummy variables operating the route, and end point city population relative to aggregate seat capacity on a route are used as the excluded instruments. In addition, the peak season dummy variable and

Table 4
Descriptive statistics: the Jeju island routes in Korea (June 2006–June 2010).

Variable	Pre-deregulation				Post-deregulation			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
DIFF	0.830	0.045	0.742	0.890	0.821	0.039	0.747	0.875
COMP1	2.465	0.496	1.780	3.469	2.959	0.911	1.978	4.781
COMP2	2.465	0.496	1.780	3.469	2.696	0.641	1.978	3.943
LCCsh1	0.141	0.132	0.000	0.346	0.263	0.238	0.000	0.726
LCCsh2	0.141	0.132	0.000	0.346	0.170	0.147	0.000	0.452
Deregulation	0	0	0	0	1	0	1	1
RelFare	0.987	0.119	0.807	1.201	0.982	0.109	0.820	1.173
LoadFac	0.758	0.093	0.552	0.960	0.760	0.090	0.497	0.937
FlightFreq	15.878	12.739	6.397	48.509	14.729	11.529	5.691	45.840
Duration	58.054	7.978	45.000	70.297	57.222	7.359	45.000	68.349

Table 5

Descriptive statistics: the inland routes in Korea (June 2006–June 2010).

Variable	Pre-deregulation				Post-deregulation			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
DIFF	0.859	0.058	0.698	0.940	0.876	0.054	0.770	0.956
COMP1	1.872	0.120	1.633	2.114	1.875	0.123	1.664	2.227
COMP2	1.872	0.120	1.633	2.114	1.866	0.120	1.664	2.000
LCCsh1	0.004	0.017	0.000	0.109	0.059	0.153	0.000	0.508
LCCsh2	0.004	0.017	0.000	0.109	0.000	0.000	0.000	0.000
Deregulation	0	0	0	0	1	0	1	1
RelFare	1.012	0.067	0.892	1.121	1.016	0.063	0.906	1.127
LoadFac	0.682	0.091	0.480	0.931	0.628	0.106	0.381	0.858
FlightFreq	11.951	10.701	2.984	36.905	11.359	9.369	2.675	33.821
Duration	54.261	2.653	50.000	58.820	53.333	2.365	50.000	55.000

meteorological variables, such as air temperature, and humidity, which are suggested by Berry and Jia (2010), are also used as the excluded instruments.¹⁷

5. Results

Departure flight times scheduling can be constrained by demand-side consideration, which will affect carriers' strategic scheduling. Even if an airline carrier changes its fare, demand may not respond when either a capacity limit has already been reached or demand is high relative to others. To capture this effect, we estimate the model for all months excluding August (based on the average load factor, August seems to face a capacity constraint problem), when demand is high relative to the seats offered. Results do not qualitatively change. The current model is robust to the capacity problem.

To provide an econometric analysis in Section 5, model specifications that differ in the set of two explanatory variables are compared: *COMP1*, *LCCsh1* in eq (1) and *COMP2*, *LCCsh2* in eq (2). For each set of the two explanatory variables, all tables below present the estimated coefficients using the IV method as well as the OLS method. A test for weak identification – which means that the instruments are correlated with endogenous regressors, but not highly correlated – is performed using STATA 11 and interpreted.

5.1. Baseline model: does competition lead to less differentiated flight times?

The estimates of four models of departure flight times differentiation are presented in Table 6; we attempt to fit a regression to pooled data from all 11 non-stop routes in Korea.¹⁸ The coefficients of interest, both *LCOMP1* and *LCOMP2*, are negative and significant across all specifications. Our results for the model of airline scheduling suggest that competition leads to less differentiated scheduling pattern. The magnitude difference in these two competition variables would be consistent with the way in which

Table 6Estimation results for all 11 domestic routes in Korea (June 2006–June 2010) dependent variable: *LDIFF*.

Variable	Coefficient			
	(1) OLS	(2) IV	(3) OLS	(4) IV
LCOMP1	−0.264*** (0.021)	−0.173*** (0.029)		
LCCsh1	0.117*** (0.018)	0.0292 (0.032)		
LCOMP2			−0.610*** (0.041)	−0.531*** (0.048)
LCCsh2			0.788*** (0.065)	0.748*** (0.076)
Deregulation	−0.0237 (0.015)	−0.0292 (0.018)	0.00345 (0.015)	−0.00875 (0.016)
LCOMP1*Deregulation	0.0535*** (0.016)	0.0468** (0.021)		
LCOMP2*Deregulation			0.0251 (0.019)	0.0277 (0.018)
LRelFare	−0.0788 (0.049)	−0.297*** (0.103)	−0.0275 (0.048)	0.0492 (0.064)
LLoadFac	−0.0681*** (0.017)	−0.367*** (0.050)	−0.0385*** (0.0150)	−0.168*** (0.035)
LFlightFreq	0.00139 (0.003)	0.0302*** (0.006)	−0.0006 (0.004)	0.0153*** (0.004)
LDuration	0.541*** (0.058)	0.606*** (0.098)	0.428*** (0.059)	0.282*** (0.067)
Constant	−2.185*** (0.220)	−2.778*** (0.403)	−1.501*** (0.233)	−1.105*** (0.279)
N. obs.	528	528	528	528
adj. R-sq	0.427	0.0731	0.575	0.497
Instrumented	N/A	LRelFare	N/A	LRelFare
	N/A	LLoadFac	N/A	LLoadFac

Robust standard errors in parentheses; Significance levels: ***1%, **5%, *10%.

the two measures are constructed; competition level is measured by *COMP1*, the upper bound of competitive intensity, and *COMP2*, the lower bound of competitive intensity. The results on *Deregulation* are not robust, and neither is significant. The point estimates for *Deregulation* with its interaction effect with competition level are positive, but less robust at 5% significance level. It would imply that there would be no significant differences in the marginal effect of competition on departure flight times differentiation across the two time periods, pre- and post-deregulation.

The estimated impacts of *LCCsh1* and *LCCsh2* are positive and significant across different specifications, indicating that the expansion of LCCs contributed to greater differentiation in departure flight times. It could be explained by the LCC's incentive to sufficiently differentiate their products. The route-specific flight service profitability, *LRelFare*, has a negative effect on *DIFF* in Column (2), implying that the higher the profitability, the smaller the *LDIFF*. The coefficient estimate for *LLoadFac* is negative in all specifications and statistically significant. This could be seen to underline the fact that carriers would schedule their flight times closely

¹⁷ Meteorological data were collected from Korea Meteorological Administration (KMA) <http://www.kma.go.kr/>. See Appendix Tables A1–A4 for detailed information.

¹⁸ According to the Cragg–Donald F-test for the two potentially endogenous variables, *LRelFare* and *LLoadFac*, there is no statistical evidence to reject the null hypothesis that the instruments are weak. One possible explanation for this failure is due to a poor fit of the first stage regression for the *LLoadFac*. The Cragg–Donald F-test, however, for multiple endogenous variables does not specify the source of failure to reject the null hypothesis. There may be a few strong instruments and many weak ones, resulting in a combined set of instruments that is weak. Weak instruments may be generating undesirable biases in point estimation results, but the OLS estimation results and the IV results are not substantially different for each of the models. One may not need to examine this more closely because the primary coefficient of interest, on *LCOMP1* (*LCOMP2*), is insensitive to the model specifications.

to each other to capture the high demand when the average load factors are high. The estimated impacts of *LFlightFreq* on the degree of departure flight times differentiation are less robust, and positive for IV model in Columns (2) and (4). The coefficient estimates for *LDuration* are all positive. Given that the longest flight in domestic routes only takes about an hour, carriers are less constrained by passengers' preferred departure times. Along with the fact that time zone change effect is irrelevant in Korea, the point-to-point service on domestic short-haul routes would lead to differentiated departure flight times over a day.

5.2. Does competition affect scheduling pattern differently across route types?

As discussed in Section 5.1, we confirm that competition would lead to less differentiated departure flight times in the Korean airline markets. The effects of the deregulation policy, however, are ambiguous. In order to disentangle the effect of deregulation on airline scheduling, we investigate two types of markets separately. These two types of markets, which are city pairs for flying to and from Jeju island and inland city pairs, differ in both types of travelers and in alternatives to air transportation. Due to the lack of entry to inland routes for the two years following the May 2008 Deregulation Act, deregulation is expected to have an asymmetric effect depending on the type of routes. Thus, it is interesting to examine the effects of the deregulation policy on the domestic Korean city pair routes through the intensity of competition; how deregulation affected departure flight times scheduling patterns across the type of routes.

5.2.1. Jeju island routes (leisure type)

The estimates of four models of departure flight times differentiation are presented in Table 7; we attempt to fit a regression to pooled data from 5 Jeju island non-stop routes in Korea.¹⁹ The estimation results reveal several interesting findings regarding clustering pattern. The coefficients for both *LCOMP1* and *LCOMP2* have the expected negative sign and statistically significant at the 5% level, implying that competition would be negatively related to the degree of airline scheduling. From comparison of the magnitude of these coefficients, an inference would seem to be that the two legacy carriers' responding strategy with their own subsidiary LCCs to the entry of new independent LCCs lowers the degree of competition in the Jeju island routes. The impacts of *Deregulation* on the degree of departure time differentiation are all negative and robust across models, implying a less differentiated departure flight times scheduling pattern in the deregulated period. The coefficients on the interaction terms are positive, and all statistically significant, which indicate that the more competitive route is, the stronger the negative impact of deregulation policy on departure flight times differentiation (i.e., the negative impact of *Deregulation* on departure flight times differentiation scheduling is greater on a highly competitive route). This empirical finding would support the statement that carriers schedule their flights closely to each other as the air services on the Jeju island routes become more competitive.

The estimated impacts of *LCCsh1* and *LCCsh2* are positive and significant for OLS model in Columns (1) and (3). These positive coefficients are possibly due to the changed industry competition configuration, indicating that new low cost entrants with the greater degree of product differentiation would compete with the

Table 7

Estimation results for the Jeju island routes in Korea (June 2006–June 2010) dependent variable: *LDIFF*.

Variable	Coefficient			
	(1) OLS	(2) IV	(3) OLS	(4) IV
<i>LCOMP1</i>	−0.126*** (0.015)	−0.122*** (0.016)		
<i>LCCsh1</i>	0.0210* (0.011)	−0.0212 (0.014)		
<i>LCOMP2</i>			−0.211*** (0.028)	−0.156*** (0.030)
<i>LCCsh2</i>			0.182*** (0.043)	0.067 (0.050)
<i>Deregulation</i>	−0.0551*** (0.012)	−0.0490*** (0.012)	−0.0595*** (0.013)	−0.0516*** (0.013)
<i>LCOMP1</i> * <i>Deregulation</i>	0.0669*** (0.011)	0.0670*** (0.013)		
<i>LCOMP2</i> * <i>Deregulation</i>			0.0702*** (0.013)	0.0623*** (0.013)
<i>LRelFare</i>	−0.304*** (0.042)	−0.497*** (0.049)	−0.230*** (0.038)	−0.384*** (0.049)
<i>LLoadFac</i>	−0.0086 (0.013)	0.0019 (0.021)	−0.0103 (0.013)	−0.0012 (0.021)
<i>LFlightFreq</i>	0.0307*** (0.003)	0.0348*** (0.003)	0.0278*** (0.003)	0.0285*** (0.003)
<i>LDuration</i>	0.577*** (0.038)	0.741*** (0.046)	0.498*** (0.039)	0.639*** (0.049)
Constant	−2.607*** (0.161)	−3.296*** (0.188)	−2.218*** (0.159)	−2.824*** (0.203)
N. obs.	240	240	240	240
adj. R-sq	0.838	0.824	0.831	0.822
Instrumented	N/A	<i>LRelFare</i> <i>LLoadFac</i>	N/A N/A	<i>LRelFare</i> <i>LLoadFac</i>

Robust standard errors in parentheses; Significance levels: ***1%, **5%, *10%.

incumbents, spreading out their scheduled flight times over a day. All coefficient estimates on *LRelFare* are statistically significant. This negative sign indicates that high profitability would drive the carriers to schedule their flights closely to each other, drawing more passengers from nearby flights. The coefficients for *LLoadFac* alternate in sign and less robust. The estimated impacts of flight frequency are all positive and robust. The coefficient estimates for *LDuration* are all positive. This can be interpreted as an evidence that carriers flying Jeju island would strategically schedule their flight times, capturing the leisure passenger's less concentrated preferred departure times.

5.2.2. Inland routes (business type)

Unlike the Jeju island routes, no entrants were observed in five out of the six inland routes in Korea. Due to the lack of the entry of the independent LCCs to inland routes during 2006–2010, the analysis using *COMP2*, *LCCsh2* is not applicable to the inland routes. The estimates of two models of departure flight times differentiation are presented in Table 8; we attempt to fit a regression to pooled data from 6 inland non-stop routes.²⁰ The estimated impacts of both *LCOMP1* and *LCOMP2* are negative, implying that competition leads to a less differentiated scheduling pattern with regard to departure times. Unlike the Jeju island routes, the coefficient estimates of *Deregulation* are all positive and statistically significant for the inland routes. The results suggest that for the inland routes the degree of this tendency for less product differentiation is relatively weak when compared with the Jeju island routes in the post-deregulated period. In other words, the larger

¹⁹ According to weak instruments test results, there is no statistical evidence to reject the null hypothesis that the instruments are weak. The results, however, look sufficiently reliable for our analysis, especially given that the *LCOMP1* (*LCOMP2*) results are robust across the four model specifications. We proceed with the OLS estimation results.

²⁰ The Cragg-Donald F-test can reject the null hypothesis that the instruments are weak at the 5% level of significance. Regarding the Hansen test, there is no statistical evidence to reject the null hypothesis that the overidentification restrictions are valid at 5% significance level.

Table 8

Estimation results for the inland routes in Korea (June 2006–June 2010)
dependent variable: *LDIFF*.

Variable	Coefficient	
	(1) OLS	(2) IV
LCOMP1	−0.672*** (0.058)	−0.697*** (0.057)
LCCsh1	0.179*** (0.020)	0.153*** (0.033)
LCOMP2	N/A	N/A
LCCsh2	N/A	N/A
Deregulation	0.195*** (0.047)	0.160*** (0.054)
LCOMP1*deregulation	−0.255*** (0.075)	−0.193** (0.087)
LCOMP2*deregulation	N/A	N/A
LRelFare	−0.507*** (0.066)	−0.771*** (0.170)
LLoadFac	0.0276* (0.016)	−0.0023 (0.056)
LFlightFreq	−0.0502*** (0.004)	−0.0571*** (0.007)
LDuration	1.130*** (0.109)	1.418*** (0.191)
Constant	−3.951*** (0.420)	−5.058*** (0.754)
N. obs.	288	288
adj. R-sq	0.694	0.673
Instrumented	N/A	LRelFare LLoadFac

Robust standard errors in parentheses; significance levels: ***1%, **5%, *10%.

gaps among departure flight times were found in the deregulated period than in the regulated period. The reason why deregulation is estimated to have route type-specific effects can be due to the fact that the Jeju island routes (*leisure* type routes) recorded high volumes of passenger traffic relative to the inland routes (*business* type routes). The Korean airline industry deregulation has led to substantial traffic growth, carrying more passengers at lower fares. In particular, competition among the two legacy carriers and independent LCCs for the Jeju island routes has intensified due to the dominance of air transportation for travel to and from Jeju island, the country's largest island and tourist's destination. Along with the demand-driven motivation, fuel costs and capacity constraints also provide an incentive for a carrier to schedule more frequent flights, which are concentrated into the route of high demand, in a more strongly clustered pattern as opposed to less frequent flights for the low demand routes, resulting an asymmetric pattern of clustered departure flight times across the type of routes in the deregulated period. We see that its interaction effect with competition level is negative and statistically significant. The more competitive route is, the weaker the positive impact of *Deregulation* on departure flight times differentiation.

LCCsh1 is estimated to have positive impacts on *LDIFF*. The LCC penetration rate would be positively related to the degree of airline scheduling. Similar to the Jeju island routes, the coefficient estimates for *LRelFare* are negative and robust. This results can be attributed to the fact that carriers would schedule their flights closely to each other in the absence of intense price competition over the sample period. The coefficients for *LLoadFac* alternate in sign and less robust across model specifications. The impacts of flight frequency are all negative. The coefficient estimates for *LDuration* are all positive. Given that the longest flight only takes about an hour in the inland routes, carriers strategically schedule departure flight times.

6. Concluding remarks

In order to investigate the competitive effects of deregulation in the Korean airline industry, we constructed panel structure data of the Korean domestic non-stop routes for the period 2006 June – 2010 June. We analyze for the first time the impact of competition on departure flight times differentiation given that a hub-and-spoke system is not the optimal air transport network strategy for the Korean domestic short-haul routes.

This new study adds to evidence that competition would lead to less differentiated flight times as conjectured by Hotelling's model, after controlling for various factors that may have determined the degree of differentiation. The most striking finding of this study is that the degree of this tendency for less product differentiation differs across the type of routes. The changed competition conditions, which culminated with the implementation of the May 2008 Deregulation Act, contributed to route-type specific consequences: the Jeju island routes (*leisure* type) and the inland routes (*business* type). We find a strongly clustered pattern of airline scheduling in the Jeju island routes where there have been competitive pressures associated with new low cost entrants. On the other hand, due to the lack of entry to inland routes, we find partial support for the clustered pattern of airline scheduling. The two legacy carriers' subsidiary LCCs operation leads to less dominant pattern of clustered flight, lowering the competition level. Consistent with the fact that the longest flight only takes about an hour and time zone change effect is irrelevant in the Korean domestic routes, carriers have a greater incentive to schedule strategically in the absence of capacity constraints. There was greater product differentiation on routes with lower profitability, which reduces the incentive to schedule flight times closer to each other's flights, drawing passengers off from the nearby flights.

Appendix

Table A1

Variable definition for excluded IVs.

Variable	Description
Airline1	Carrier dummy variable operating the route; ONA, <i>independent</i> LCC
Airline2	Carrier dummy variable operating the route; AAR, legacy carrier
Airline3	Carrier dummy variable operating the route; HAN, <i>independent</i> LCC
Airline4	Carrier dummy variable operating the route; JJA, <i>independent</i> LCC
Airline5	Carrier dummy variable operating the route; KAL, legacy carrier
Airline6	Carrier dummy variable operating the route; ABL, <i>dependent</i> LCC of AAR
Airline7	Carrier dummy variable operating the route; JNA, <i>dependent</i> LCC of KAL
Airline8	Carrier dummy variable operating the route; ESR, <i>independent</i> LCC
Peak	1 if Jan, April, May, July, August, and October, 0 otherwise
Population ratio	End point city's population relative to the seat capacity on a route
Air Temperature	Meteorological variables; absolute value of difference between origin city's air temperature and destination city's air temperature
Humidity	Meteorological variables; absolute value of difference between origin city's humidity and destination city's humidity

Table A2

Descriptive statistics for excluded IVs: all 11 domestic routes in Korea (June 2006–June 2010).

Variable	Pre-deregulation				Post-deregulation			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Airline1	0	0	0	0	0.057	0.232	0	1
Airline2	1	0	1	1	0.860	0.348	0	1
Airline3	0.167	0.373	0	1	0.038	0.191	0	1
Airline4	0.205	0.404	0	1	0.273	0.446	0	1
Airline5	1	0	1	1	1	0	1	1
Airline6	0	0	0	0	0.144	0.352	0	1
Airline7	0	0	0	0	0.129	0.336	0	1
Airline8	0	0	0	0	0.110	0.313	0	1
Peak	0.500	0.501	0	1	0.500	0.501	0	1
Population ratio	127.099	152.879	10.147	540.527	125.051	146.563	8.185	585.852
Air Temperature	2.034	1.815	0.000	8.100	2.093	1.816	0.000	9.800
Humidity	6.083	4.170	0.000	17.000	5.693	4.399	0.000	24.000

Table A3

Descriptive statistics for excluded IVs: the Jeju island routes in Korea (June 2006–June 2010).

Variable	Pre-deregulation				Post-deregulation			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Airline1	0	0	0	0	0.125	0.332	0	1
Airline2	1	0	1	1	0.850	0.359	0	1
Airline3	0.367	0.484	0	1	0.083	0.278	0	1
Airline4	0.383	0.488	0	1	0.600	0.492	0	1
Airline5	1	0	1	1	1	0	1	1
Airline6	0	0	0	0	0.150	0.359	0	1
Airline7	0	0	0	0	0.258	0.440	0	1
Airline8	0	0	0	0	0.242	0.430	0	1
Peak	0.500	0.502	0	1	0.500	0.502	0	1
Population ratio	20.571	9.254	6.967	42.486	18.810	9.268	5.612	36.860
Air Temperature	2.408	2.108	0.000	8.100	2.231	2.104	0.000	9.800
Humidity	5.583	4.150	0.000	15.000	5.608	4.678	0.000	22.000

Table A4

Descriptive statistics for excluded IVs: the inland routes in Korea (June 2006–June 2010).

Variable	Pre-deregulation				Post-deregulation			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Airline1	0	0	0	0	0	0	0	0
Airline2	1	0	1	1	0.868	0.340	0	1
Airline3	0	0	0	0	0	0	0	0
Airline4	0.056	0.230	0	1	0	0	0	0
Airline5	1	0	1	1	1	0	1	1
Airline6	0	0	0	0	0.139	0.347	0	1
Airline7	0	0	0	0	0.021	0.143	0	1
Airline8	0	0	0	0	0	0	0	0
Peak	0.500	0.502	0	1	0.500	0.502	0	1
Population ratio	215.291	160.299	40.127	540.527	213.093	149.244	41.859	585.852
Air Temperature	1.724	1.465	0.000	6.400	1.978	1.533	0.000	7.500
Humidity	6.500	4.156	0.000	17.000	5.764	4.168	0.000	24.000

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