Flight Service Quality and Competition: Evidence from Regional Airports in Korea

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Abstract This study analyzes the effect of competition among carriers on short-haul domestic routes on departure flight delay rates at provincial airports. We construct panel data for each of two airports under a point-to-point network, covering the 2010–2018 period. The following two airports are compared: Daegu International Airport with night curfew restrictions imposed and Cheongju International Airport with no night curfew. The airport-by-airport estimation results from the ordinary least square and instrumental variable estimations are compared. Departure flight delay rates increase with competitive flight services, implying that competition among airline carriers would accelerate the delay in congested air traffic. For Daegu International Airport with curfew time restrictions, low-cost carriers' timely flights would partly account for on-time performance improvement, but easing the night curfew from 8 hours to 5 hours would have no significant effect.

Keywords airport capacity · regional airport · curfew · low cost carriers
JEL classifications L52 · L93 · N75 · R41

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Introduction

Korea's international airports in provincial cities face airport congestion and flight delay problems. Before 2005, two legacy carriers were the only carriers that operated on domestic city-pair non-stop routes, where a point-to-point network is the optimal air transportation network structure. The emergence of low-cost carriers (LCCs) has been linked to greater market competition in domestic short-haul routes with the problem of air traffic expansion at the busiest airports. Air traffic delays in the Korean domestic airline market grew dramatically in the mid-2010s.

There are eight international airports in Korea. The city-pair non-stop routes for flying to and from Jeju Island, located in the Korea Strait off the southern tip of the peninsula, are classified as severely congested routes. The annual number of aircraft takeoffs and landings at Jeju International Airport reached 175,366 in 2019, showing a significant increase from 168,331 in 2018. This new record exceeds the airport's capacity of 172,000. Passenger terminal users at Jeju International Airport numbered 29.45 million in 2018 and 31.31 million in 2019, approaching the capacity limit of 31.7 million. Runways are congestible during the peak season. Currently, a maximum of 35 aircraft can be allocated per hour for Jeju International Airport, showing a high runway utilization rate of 97.9%. The airport has been operating near its capacity limit for several years, increasing runway congestion and flight delays, and affecting the safe operation of aircraft.

These runway capacity constraints raise the air transportation management issue of how to cope with growing airport traffic and delays during peak times. Aggravated congestion leads to policy debate about easing airport-specific night curfew restrictions. It is of interest to investigate how this easing of airport-specific night curfew has affected the on-time performance of regional airports.

The airlines departing from Korea's two largest cities, Seoul and Busan, also face capacity constraints due to airport traffic congestion, with runway utilization rates of 62.4% and 94.0%, respectively. The annual number of aircraft takeoffs and landings at Gimhae (Busan) International Airport reached 111,276 in 2019, remaining at around the same level of 110,924 in 2018. Passenger terminal users at Gimhae International Airport numbered 17.06 million in 2018 and 16.93 million in 2019, approaching the capacity limit 18.99 million. The annual number of aircraft takeoffs and landings at Gimpo (Seoul) International Airport reached 140,422 in 2019, remaining at the same level, 141,080 in 2018. Passenger terminal users at Gimpo International Airport, which has a capacity limit of 35.75 million, numbered 24.6 million in 2018 and 25.45 million in 2019.

The runways of major domestic airports, which include the international airports of Jeju, Gimpo, and Gimhae, are in constant use from 7 a.m. to 11 p.m. However, Incheon International Airport operates 24 hours with no night curfew restrictions.[1] Owing to the saturation of the runway at Jeju, the departure flight delay rate is also high. Flights departing from Jeju International Airport are often detoured to Incheon International Airport (not the original destination). For flights departing from Jeju International Airport to Gimpo International Airport, 216 aircraft detoured to Incheon Airport (not to Gimpo) owing to the curfew time from

[1] Incheon and Gimpo are the closest airports to Seoul. Incheon is 2 hours from downtown Seoul by car.

2016 to October 2018. In this situation, it is impossible for an aircraft to land within Gimpo's strict operating hours, forcing it to detour to Incheon, which has no night flying restrictions.

Daegu International Airport has three destinations: Gimpo, Incheon, and Jeju. Cheongju International Airport offers only a single route service to Jeju. The two regional airports, Daegu and Cheongju, are not constrained by runway capacity. Cheongju International Airport operates for 24 hours, while Daegu International Airport must operate within the strict operational hours. In July 2008, flying night curfew restrictions were imposed for Daegu International Airport, from 10 p.m. to 6 a.m. In July 2014, a new curfew was implemented from midnight to 5 a.m.

In this study, we assess how competition affects departure flight delay rates on domestic routes using airport-level panel data. This study is the first to examine the flight service quality and competition in domestic routes from a regional airport in Korea given that the point-to-point network structure is optimal for short-haul routes. We conjecture that flight delays depend on the airport-specific capacity constraint and seasonality. We find that departure flight delay rates increase with competitive flight services, implying that competition among airline carriers would accelerate the delay in congested air traffic. For Daegu International Airport with curfew time restrictions, LCCs' timely flights would partly account for on-time performance improvement, but easing the night curfew from 8 hours to 5 hours would have no significant effect.

The remainder of this paper is organized as follows. A literature review is presented in Section 2. Section 3 outlines the empirical specifications of the airline on-time performance model. Section 4 describes the data and presents the airport-by-airport estimation results. Finally, Section 5 concludes.

Literature review

Previously, the analysis of airport congestion has been discussed by modeling market structures, with the focus on either airport congestion's effect on airfare pricing or the role of dominant hub airports. Evaluation of the airport congestion pricing model has received much attention. One of the airport peak-load pricing studies regarding congestion externalities is Daniel (1995), who examines the airport congestion pricing model with time-dependent stochastic queuing, adding to the bottleneck model of Vickrey (1969). Daniel (1995) shows that a Stackelberg-dominant airline internalizes the congestion delays imposed on itself. Daniel and Pahwa (2000) predict the optimal congestion fee structure by comparing three different models. Structural assumptions include intertemporal adjustments of traffic and the generation of realistic traffic patterns.

Morrison and Winston (1989) examine optimal pricing and investment at congested airports in a deregulated U.S. air transportation system. Basso and Zhang (2008) examine sequential peak loading pricing for a private airport and show that airport privatization would overcharge for congestion delays compared with socially optimal levels.

The linkage between market power and congestion pricing has been explored in airline studies (Brueckner, 2002, 2005; Brueckner & Spiller, 1994; Pels & Verhoef, 2004). Brueckner and Spiller (1994) estimate the magnitude of the traffic density effect at a hub airport in an oligopolistic market. They show the existence of economies of traffic density effect, examining a structural model of airline competition, and find empirical evidence of a negative relationship between airfares and traffic density.

Brueckner (2002) tests the hypothesis that internalization of airport traffic congestion rises with airport level concentration by comparing monopoly with Cournot duopoly settings. The empirical finding using cross-sectional data from the 25 most delayed U.S. airports confirms that concentration has a negative effect on flight delays. Extending Brueckner (2002), Brueckner (2005) proposes a model of computation for congestion pricing with tolls in the context of a hub airport network structure. Extending the set-up of Brueckner and Spiller (1994), Pels and Verhoef (2004) develop a congestion pricing model that assumes airlines operate in an oligopolistic market. They present a two-node network, considering the second-best optimal congestion tolls.

Greenfield (2014) tests the hypothesis that competition positively influences flight delays in the U.S. airline market by examining two different airline service quality measures. The mean difference between the scheduled arrival time and actual arrival time of flights and the log odds of an arrival delay are used for on-time performance measures. The quarterly data estimation results for the period from 2005 to 2010 suggest that concentration is associated with flight delays. In other words, competition improves on-time performance.

Prince and Simon (2015) examine how incumbents adjust on-time performance during the period from 1993 to 2004 in response to potential entry of active LCC, Southwest, providing evidence of a worsening of airline service quality on routes with competition. Bubalo and Gaggero (2015) examine the relationship between the LCC presence and on-time performance in European airports using panel data during the period from 2011 to 2012. The empirical findings suggest that the LCCs are associated with service quality improvement in terms of delay of the flights. Bendinelli et al. (2016) investigate the impact of airline competition on flight delays in Brazilian airline industry between 2002 and 2013, confirming that airlines internalize the costs incurred by congestion.

Fageda and Flores-Fillol (2016) investigate whether network structures affect airport congestion, showing that, in response to more frequent delays, fully connected airlines serving a point-to-point network reduce frequencies and hub-and-spoke airlines increase frequencies. Pitfield, Caves, and Quddus (2010) investigate aircraft size and flight frequency in terms of traffic capacity using cross-sectional data for nine routes that link European airports to those in the U.S. The estimation results from three-stage least squares estimators suggest that no statistically significant evidence for competition among airlines is observed, controlling for simultaneity in the relationship between aircraft size and frequency. According to Givoni and Rietveld (2010), on short-haul high density routes, airlines face more aircraft choice and frequency considerations than they do on long-haul routes.

This study differs from previous research in the following respects. The analysis of the U.S. airline market has received considerable attention, for example, via the U.S. Airline Origin and Destination Survey (DB1B), which, however, samples only 10% of airline tickets sold. We construct panel data from 2010 to 2018 covering all non-stop domestic flights for each of the regional airports in our study. We present airport-by-airport analysis rather than focusing on aggregate information from multiple airports. Although evaluation of the effect of hub airports on congestion is important for the hub and spoke network structure in the U.S. airline market, the implications are not directly applicable to the point-to-point network structure in the Korean domestic airline market.

Model

Models

We present a model of flight service quality and airline competition at a Korean regional airport. On-time performance levels in terms of the departure time delay rate are presented at the airport level for *domestic* routes.[2] We limit the sample to two regional airports that are not constrained by the allocation of airport time slots and have substantial passenger traffic: Daegu International Airport (r = 1) and Cheongju International Airport (r = 2). Passengers would not consider taking a flight from Cheongju to fly non-stop from Daegu, and vice versa.[3] This implies that the airline on-time performance model needs to be specified for each provincial airport.

Assume that we have t = 1, ... , T time periods on non-stop domestic routes departing from regional airports t = 1, ... , R. The departure time differentiation of airport r on domestic routes at time t depends not only on competition intensity but also on flight characteristics and airport-level characteristics. We set the observation unit for this study as monthly. The error term ε is assumed to be independently and identically distributed. For the empirical estimation results, we present two model specifications that differ in the LCC flight share variable: AllLCCShare in Eq. (1a) for Daegu International Airport, (Eq. (2a) for Cheongju) and IndLCCshare in Eq. (1b) for Daegu International Airport (Eq. (2b) for Cheongju).

Daegu International Airport (r = 1)

$$Delay_t^r = \beta_0^r + \beta_1^r COMP_t^r + \beta_2^r Flightfreq_t^r + +\beta_3^r Curfew_t^r + \beta_4^r Peak_t^r + \beta_5^r AllLCCshare_t^r + \beta_6^r Nonsched_t^r + \beta_7^r Wind_t^r + \beta_8^r Pop_t^r + \varepsilon_t \quad (1a)$$

[2] The reviewer raises a concern for on-time performance on international routes departing from regional airports. To identify the control variables needed here, one could control for various factors that would have determined the flight frequency and departure flight scheduling pattern. Since each route is a part of point-to-point network, airlines strategically allocate flight frequency between domestic and international routes. Airline carriers scheduled a total of 407 (163) monthly flights for domestic (international) routes from January 2010 to December 2018 from Daegu airport. Airline carriers scheduled a total of 410 (100) monthly flights for domestic (international) routes from January 2010 to December 2018 from Cheongju airport. Although the average airtime duration on international routes is less than 3 hours, the time zone change effect may affect the allocation of departure flight times. Southeast Asia bound flights such as non-stop routes to Daegu to Vietnam, Thailand, Cambodia, for instance, involve a two-hour time loss including the time change. For such a route, capacity constraints induced by night curfew restrictions on Daegu International airport cause flights to depart before 10 pm local time in South Korea before July 2014, as flights would arrive in destination airports in the very early morning hours. Specifically, destination airport-specific slot controls at capacity controlled airport through foreign authorities are thus considered to be important determinant.

[3] The traffic in Cheongju (Daegu) is likely to originate from its metropolitan areas.

where Delay is the delay rate of departure flights; COMP is the competition level variable based on the weights of domestic flight frequency share of each carrier; Flightfreeq is the total flight frequency; and Curfew is a dummy variable, with a value of 1 for observations following July 2014 for the period of reduced night curfews and 0 otherwise. Peak is a dummy variable, with a value of 1 for peak seasons and 0 otherwise; AllLCCShare is the flight share scheduled by all types of LCCs; Nonsched is the non-scheduled flight share; Wind is the average monthly wind speed for origin city;[4] and Pop is the population for origin city.

To compare the effect of the flight share scheduled by LCCs on the delay rate of departure flights, an alternative model specification is presented (Eq. (1b)). Instead of AllLCCShare, the explanatory variable, IndLCCshare, the proportion of flights scheduled by independent LCCs, is included in the baseline model specification.

$$Delay_t^r = \beta_0^r + \beta_1^r COMP_t^r + \beta_2^r Flightfreq_t^r + +\beta_3^r Curfew_t^r + \beta_4^r Peak_t^r + \beta_5^r IndLCCshare_t^r + \beta_6^r Nonsched_t^r + \beta_7^r Wind_t^r + \beta_6^r Pop_t^r + \varepsilon_t \quad (1b)$$

Cheongju International Airport (r = 2)

For Cheongju International Airport, all explanatory variables are included in the models except the effects of curfews on departure flight on-time performance given that it has no curfews (Eqs. (2a) - (2b)).

$$Delay_t^r = \beta_0^r + \beta_1^r COMP_t^r + \beta_2^r Flightfreq_t^r + \beta_3^r Peak_t^r + \beta_4^r AllLCCshare_t^r + \beta_5^r Nonsched_t^r + \beta_6^r Wind_t^r + \beta_7^r Pop_t^r + \varepsilon_t \quad (2a)$$

$$Delay_t^r = \beta_0^r + \beta_1^r COMP_t^r + \beta_2^r Flightfreq_t^r + \beta_3^r Peak_t^r + \beta_4^r IndLCCshare_t^r + \beta_5^r Nonsched_t^r + \beta_6^r Wind_t^r + \beta_7^r Pop_t^r + \varepsilon_t \quad (2b)$$

Instruments

Another consideration in airline industry research is the estimation of capacity constraints in the departure flight on-time performance model. The *Flightfreq* variable would be correlated to the error term if the error term incorporates unobserved cyclical fluctuations. Change in a total flight frequency induced by an increased in air travel demand on high-volume routes would have no impact on the flight delay rates in a capacity-constrained congested route when the airport has already operating near its capacity limit. The potential endogeneity issue between flight frequency and delay rate would generate a downward bias in the frequency coefficient estimates.

To capture this effect, we estimate the flight delay rate model with frequency treated as

[4] For robustness purposes, alternative meteorological data for origin cities such as average temperatures, the variation between a high temperature and a low temperature are used as explanatory variable with no qualitative change to the results. The estimation results are presented in the Appendix.

endogenous. We instrument flight frequencies. The fitted departures are obtained from the regressions of flight frequencies on the following exogenous variables: number of seats supplied and passenger load factors. The validity of the instruments, along with the point estimate robustness, requires comparison of the estimated results among the different sets of instrumental variables. The estimation results using a different set of exogenous variables, such as the number of airline carriers departing from the origin city airport and passenger load factors, are qualitatively insensitive.

Estimation

Data

We build a panel of domestic flight-level data for each of the two airports from January 2010 to December 2018. Our data consist of the total monthly flight frequency of domestic non-stop flights of each of the regional airports collected from the Korea Airports Corporation website. Then, the airport-level flight departure delay rate is calculated as the percentage of delayed departure flights, and the LCC flight shares at the domestic flight level are calculated for each of the two airports. The dataset is supplemented with monthly meteorological data for origin cities, including data that pertain to average wind speed and average temperatures. In this way, we control for seasonality in air flight supply. The monthly meteorological data for the two origin cities are obtained from the Korea Meteorological Administration website. The data on monthly origin city populations for measuring market size are collected from the Statistics Korea website. Table 1 describes the variables.

Table 1 Description of variables

Variable	Description
Delay	Dependent variable; monthly airport-level delay rate of departure flights used as measure for flight service quality/on-time performance
COMP	Monthly airport-level competition level as measured by the inverse of the Herfindahl-Hershman index (HHI)
Flightfreq	Monthly airport-level total flight frequency
Curfew	Dummy variable; 1 for observations following July 2014 for the period of reduced night curfews and 0 otherwise
Peak	Dummy variable; 1 for peak seasons (January, April, May, July, August, and October) and 0 otherwise
AllLCCshare	Monthly airport-level departure flight share scheduled by all types of low-cost carriers (LCCs)
IndLCCshare	Monthly airport-level departure flight share scheduled by independent LCCs
Nonsched	Monthly airport-level non-scheduled departure flight share
Wind	Average monthly wind speed for origin city (m/s)
Pop	Monthly population for origin city divided by 100,000

Tables 2 and 3 provide airport-by-airport summary statistics for the variables employed in the empirical analysis. The values of all variables are derived from non-stop domestic flights departing from origin cities. For Daegu (Cheongju) International Airport, for example, the values of the Herfindahl－Hershman index (HHI) are derived using departures from Daegu (Cheongju) to other cities on a directional domestic route.

For Daegu International Airport, the average value of the flight departure delay rate, *Delay*, which is a measure for on-time performance, is 9.5%, with a maximum value of 27.3%. The average value of the competition level, measured by COMP, is 3.054, which corresponds to an HHI value of 0.3275. The average value of AllLCCShare, 0.2503, is higher than that of IndLCCShare. The difference between the average values, about 0.0368, represents the flight shares scheduled by the legacy carriers' subsidiary LCCs.

Table 2 Summary statistics: Daegu International Airport (2010-2018) with night curfew

Variable	Obs	Mean	Std. Dev.	Min	Max
Delay	108	0.0951	0.0534	0.0194	0.2732
COMP	108	3.0538	1.1373	1.8077	4.6490
Flightfreq	108	407	104	251	567
Curfew	108	0.5000	0.5023	0.0000	1.0000
Peak	108	0.5000	0.5023	0.0000	1.0000
AllLCCshare	108	0.2503	0.2441	0.0000	0.5744
IndLCCshare	108	0.2135	0.2044	0.0000	0.4639
Nonsched	108	0.0139	0.0193	0.0000	0.1100
Wind	108	2.1120	0.2985	1.3000	2.8000
Pop	108	24.9346	0.1331	24.6177	25.1292

For Cheongju International Airport, the average value of flight departure delay rate, *Delay*, the measure for on-time performance, is 10.5%, with a maximum value of 29.9%. The average value of the competition level, measured by COMP, is 4.1591, which corresponds to an HHI value of 0.2404. The average value of AllLCCShare, 0.4891, is approximately 0.1 higher than that of IndLCCShare. This huge gap between the two LCC flight share measures could be attributed to the two legacy carriers' subsidiary LCC operations. Comparing the Cheongju and Daegu domestic routes, significant LCC operations intensified competition among carriers, which is supported by the data.

Table 3 Summary statistics: Cheongju International Airport (2010-2018) with no night curfew

Variable	Obs	Mean	Std. Dev.	Min	Max
Delay	108	0.1055	0.0595	0.0219	0.2991
COMP	108	4.1591	0.4941	3.6140	4.9456
Flightfreq	108	410	106	282	636
Peak	108	0.5000	0.5023	0.0000	1.0000
AllLCCshare	108	0.4891	0.1170	0.3516	0.6993
IndLCCshare	108	0.3901	0.0378	0.3227	0.5175
Nonsched	108	0.0185	0.0230	0.0000	0.1000
Wind	108	1.4898	0.2399	0.9000	2.0000
Pop	108	15.7320	0.1855	15.2794	15.9925

Airport-by-airport results

Tables 4 and 5 show the airport-by-airport estimation results from the ordinary least square (OLS) and instrumental variable (IV) estimations for Daegu and Cheongju International Airports, respectively.[5] We test whether *Flightfreq* is an exogenous variable by using the STATA *estat endogenous* command. The test statistics are not statistically significant at the 5% level, and thus, we fail to reject the null of exogeneity. Thus, *Flightfreq* is assumed to be exogenous in each model specification.

In Table 4, the coefficients of interest, *COMP*, are positive and statistically significant across the four specifications (1) - (4) for Daegu International Airport, showing associated shifts in the same direction. Our results for the model of flight departure delay rates suggest that competition among airline carriers would accelerate the delay in congested air traffic. The coefficients for *Flightfreq* are all negative but less robust. The point estimates for *Curfew* are less robust and significant under specifications (3) - (4). Easing of Daegu International Airport's specific night curfew, from 8 hours to 5 hours, would have no significant effect on the on-time performance of domestic flights.

Strong seasonality effects are estimated. The coefficients for *Peak* have the expected positive sign and remain significant at the 5% level. The impacts of the flight share scheduled by LCCs on the delay rate of departure flights, *AllLCCShare* and *IndLCCShare*, are all negative and statistically significant. Our results for the model of departure flight on-time performance suggest that LCC operations lead to lower delay rates for domestic routes departing from Daegu International Airport. The coefficients on *Nonsched* are not the expected sign and are statistically insignificant. This implies that there would be no significant impact of non-scheduled flights on the delay rates for Daegu International Airport. The coefficients for meteorological factors and demographic factors of the origin city are not significant. The estimated coefficients for Wind and Pop are not robust, and are not significant. This implies that there would be no significant impacts of average wind speed/population of origin city on departure flight delay rates.

For Cheongju International Airport, the coefficients of interest, *COMP*, are positive and statistically significant across all specifications, as shown in Table 5. This empirical finding confirms the existence of intense competition among airline carriers, and thus, airport congestion would lead to flight departure delays. The coefficients for *Flightfreq* are not robust. The coefficients for *Peak* are positive and significant at the 5% level across the four specifications, implying a higher delay rate in August and semi-peak months. The estimated coefficients for AllLCCShare and *IndLCCShare* are all negative, but statistically insignificant. The point

[5] The reviewer raises a concern for the wholly owned subsidiary LCCs of legacy carriers in constructing the competition measure, COMP. The emergence of new independent LCCs and creation of dependent LCCs (AAR's subsidiary LCC, ABL, and KAL's subsidiary LCC, JNA) are linked to changes in the market structure, and competition level among carriers at regional airports. AAR and ABL should not be considered as separate "competitors", likewise for KAL and JNA.
Instead of COMP, COMPmulti is included in the baseline specification where legacy carriers and their own subsidiary LCCs are considered a single entity on a non-stop city pair route. The results for the primary coefficient of interest, COMPmulti, are not robust across the two regional airports. Strong seasonality effects are observed, suggesting that departure flight time on-time performance would be associated with peak season. Regression tables are available upon request.

estimate results suggest that the effects of flight share scheduled by LCCs on the delay rate of departure flights are not supported by the data for Cheongju International Airport. The coefficients for *Nonsched* are positive and statistically significant. This finding implies that the more frequent non-scheduled flights are, the higher are the departure flight delay rates for Cheongju International Airport. The coefficients for Wind are negative and significant at the 5% level. The coefficients for Pop are less robust and not significant.

Table 4 Regression results: Daegu International Airport with night curfew (2010-2018)

	Dependent variable *Delay*			
	(1) OLS	(2) IV	(3) OLS	(4) IV
COMP	0.132***	0.136***	0.0950***	0.0968***
	(0.045)	(0.043)	(0.029)	(0.028)
Flightfreq	-0.0004	-0.000449*	-0.0004	-0.000394*
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Curfew	-0.0121	-0.0130	0.0355*	0.0351*
	(0.0269)	(0.0259)	(0.0190)	(0.0184)
Peak	0.0369***	0.0379***	0.0367***	0.0369***
	(0.008)	(0.007)	(0.0079)	(0.0074)
AllLCCshare	-0.340*	-0.318*		
	(0.1800)	(0.1750)		
IndLCCshare			-0.292***	-0.290***
			(0.0739)	(0.0708)
Nonsched	-0.0228	-0.0514	0.043	0.035
	(0.290)	(0.283)	(0.2830)	(0.2740)
Wind	0.017	0.015	0.0142	0.0138
	(0.011)	(0.011)	(0.0118)	(0.0112)
Pop	-0.0591	-0.0608	-0.0143	-0.0151
	(0.0565)	(0.0542)	(0.0592)	(0.0568)
Constant	1.349	1.416	0.3090	0.3330
	(1.459)	(1.398)	(1.5080)	(1.4460)
No. of observations	108	108	108	108
Adj. R^2	0.483	0.483	0.518	0.518
Instrument	NA	*Flightfreq*	NA	*Flightfreq*
Chi^2		2.4179		0.3140
p-value		0.12		0.5752

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

Table 5 Regression results: Cheongju International Airport with no night curfew (2010-2018)

	Dependent variable *Delay*			
	(1) OLS	(2) IV	(3) OLS	(4) IV
COMP	0.137***	0.136***	0.118***	0.120***
	(0.0297)	(0.0287)	(0.0219)	(0.0208)
Flightfreq	0.00005	0.00004	-0.0002	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Peak	0.0243***	0.0243***	0.0246***	0.0246***
	(0.0077)	(0.0074)	(0.0078)	(0.0075)
AllLCCshare	-0.2680	-0.2510		
	(0.2320)	(0.2230)		
IndLCCshare			-0.1920	-0.1970
			(0.1510)	(0.1460)
Nonsched	0.448*	0.438*	0.423**	0.427**
	(0.2350)	(0.2280)	(0.2070)	(0.1990)
Wind	-0.0520***	-0.0519***	-0.0588***	-0.0587***
	(0.0169)	(0.0163)	(0.0178)	(0.0172)
Pop	0.0089	0.0076	-0.0014	-0.00003
	(0.0392)	(0.0373)	(0.0307)	(0.0300)
Constant	-0.4380	-0.4180	-0.1560	-0.1770
	(0.6240)	(0.5950)	(0.4330)	(0.4250)
No. of observations	108	108	108	108
Adj. R^2	0.556	0.556	0.557	0.557
Instrument	NA	*Flightfreq*	NA	*Flightfreq*
Chi^2		0.6235		1.3643
p-value		0.4297		0.2428

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Conclusion

This study assesses the effect of competition among carriers on domestic routes on departure flight delay rates at provincial airports in Korea. A panel dataset for each of the airports from 2010 to 2018 is constructed. The estimation results for the two provincial airports in Korea under consideration reveal that competition among airline carriers is estimated to have a positive effect on departure flight delay rates. The more competitive the route service is, the higher the departure flight delay rate is, implying that competition is positively associated with airport congestion. For short-haul routes, such as Korean domestic routes with point-to-point network structure, flight frequency is estimated to have no statistically significant effect on the delay rate. The estimated impacts of LCC flight shares on flight delays differ between Daegu and Cheongju International Airports. Delay rates decrease as LCC flight shares increase at Daegu International Airport, which has a new night curfew, while the delay rate has no statistically significant impact on flight delays at Cheongju airport, which has no night curfew. LCCs' timely flights would partly account for on-time performance improvement, but easing the night curfew from 8 hours to 5 hours would have no significant effect on domestic flights at Daegu International Airport.

The analysis of on-time performance on international routes departing from regional airports is left for future work. Specifically, concern may arise about other factors that affect the delay of domestic flights. International flight departures on short- or medium-haul routes could pose constraints that affect airlines' strategic responses through allocation of departure times. An aircraft used on one route is also in use on prior and subsequent routes. Therefore, carriers strategically schedule departure flights and allocate flight frequencies between domestic and international routes.

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Appendix

Table A1 Regression results: Daegu International Airport with night curfew (2010-2018)

Dependent variable *Delay*

	(1) OLS	(2) IV	(3) OLS	(4) IV
COMP	0.134***	0.139***	0.101***	0.104***
	(0.0450)	(0.0431)	(0.0284)	(0.0274)
Flightfreq	-0.00047	-0.000573**	-0.00044	-0.000474*
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Curfew	-0.01740	-0.01790	0.0309*	0.0304*
	(0.0275)	(0.0264)	(0.0184)	(0.0177)
Peak	0.0384***	0.0391***	0.0380***	0.0382***
	(0.0083)	(0.0079)	(0.0082)	(0.0078)
AllLCCshare	-0.29300	-0.26900		
	(0.1920)	(0.1860)		
IndLCCshare			-0.283***	-0.280***
			(0.0759)	(0.0727)
Nonsched	-0.03680	-0.08540	0.03750	0.02010
	(0.2880)	(0.2820)	(0.2830)	(0.2740)
Temp	-0.00001	0.00007	-0.00005	-0.00002
	(0.0006)	(0.0005)	(0.0005)	(0.0005)
Pop	-0.06310	-0.06410	-0.01930	-0.02010
	(0.0573)	(0.0550)	(0.0601)	(0.0577)
Constant	1.51300	1.56000	0.47100	0.49700
	(1.4840)	(1.4250)	(1.5380)	(1.4750)
No. of observations	108	108	108	108
Adj. R^2	0.475	0.475	0.512	0.512
Instrument	NA	*Flightfreq*	NA	*Flightfreq*
Chi^2		3.1661		0.676852
p-value		0.0752		0.4107

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

Table A2 Regression results: Cheongju International Airport with no night curfew (2010-2018)

Dependent variable *Delay*

	(1) OLS	(2) IV	(3) OLS	(4) IV
COMP	0.131***	0.131***	0.120***	0.121***
	(0.0260)	(0.0251)	(0.0195)	(0.0184)
Flightfreq	-0.0001	-0.0001	-0.000215**	-0.000222**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Peak	0.0292***	0.0293***	0.0295***	0.0295***
	(0.0080)	(0.0077)	(0.0081)	(0.0078)
AllLCCshare	-0.1600	-0.1490		
	(0.2100)	(0.2030)		
IndLCCshare			-0.1300	-0.1340
			(0.1310)	(0.1260)
Nonsched	0.528**	0.523**	0.528***	0.531***
	(0.2160)	(0.2090)	(0.1920)	(0.1840)
Temp	-0.00169***	-0.00170***	-0.00177***	-0.00177***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Pop	0.0155	0.0147	0.0121	0.0130
	(0.0353)	(0.0336)	(0.0273)	(0.0266)
Constant	-0.5750	-0.5610	-0.4450	-0.4600
	(0.5510)	(0.5270)	(0.3840)	(0.3730)
No. of observations	108	108	108	108
Adj. R^2	0.587	0.587	0.589	0.589
Instrument	NA	*Flightfreq*	NA	*Flightfreq*
Chi^2		0.2944		0.7901
p-value		0.5874		0.3741

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01