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Incumbent responses to low-cost airline entry and exit: A spatial autoregressive panel data analysis

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ABSTRACT

While the US airline industry has been substantially transformed in recent years by the growth of lowcost airlines, the cost-saving benefits of lower airfares are difficult to gauge empirically. There are two important ways in which this paper contributes to the existing literature on the impact of the low-cost carriers (LCCs). First, the availability of route-level panel data allows us to examine the role of the LCCs in the long-run adjustment of airfares as well as the responses of the incumbent carriers to LCC entry and exit in a dynamic setting. Second, we capitalize on recent developments in spatial econometrics and explicitly model the spatial dependence among adjacent airline routes, an issue often ignored by previous studies. Although most of the pro-competitive effects of LCC entry take place after entry, we find evidence that the incumbent carriers also cut airfares in anticipation of entry by the LCCs. Moreover fares remain lower even after Southwest Airlines exits. Our empirical analysis confirms the spatial dependence among airfares in adjacent routes, provides estimates of the consumer benefits from lower airfares in routes affected by LCCs, and shows that there are substantial indirect benefits, i.e. lower fares in spatially-linked, nearby routes.

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1. Introduction

The degree of competition in the US airline industry has been under close scrutiny from policy makers since the industry was deregulated in 1978. The proponents of deregulation pictured an industry that would converge fairly quickly to an equilibrium characterized by intense competition and would ultimately provide lower fares and improved service. While fares have indeed declined after deregulation, waves of airline mergers and acquisitions and the success of the hub-and-spoke networks led to unexpectedly high levels of market concentration with a few large dominant airlines. In addition, bankruptcies and allegations of unfair conduct (including predatory behavior) fueled even more concerns regarding the competitiveness of the airline industry. It is no surprise then that the growth of low-cost carriers (LCCs) has been perceived as a vehicle that would eventually drive the industry toward a long-run competitive equilibrium. The cost efficiencies of the LCC business model, based on a point-to-point route expansion pattern that targets the more dense and profitable routes, give the

LCCs a degree of pricing power that the incumbent legacy carriers find very hard to match. As a result, much attention in the economic literature has been devoted to the structural changes brought about in the US airline industry by the impressive growth of the LCCs especially over the last fifteen years (Bennett & Craun, 1993; Dresner, Lin, & Windle, 1996; Goolsbee & Syverson, 2008; Ito & Lee, 2003; Morrison, 2001; Whinston & Collins, 1992; Windle & Dresner, 1999).

There are two important ways in which this paper contributes to the existing literature on the impact of LCCs on the airline industry. First, while most of the previous studies ignore the time dimension of the competition process in the airline industry, the availability of route-level panel data enabled us to examine the responses of the incumbent carriers and the long-run adjustment of airfares in the quarters surrounding the entry and exit of LCCs.¹ We focus on the magnitude and timing of the fare response of the incumbent carriers by empirically estimating how much of the change in airfares is anticipatory, how much takes place after the actual entry event and how long does it take for airfares to reach a new equilibrium after LCC entry occurs.

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¹ Goolsbee and Syverson (2008) use a similar event analysis approach to estimate the potential competition effects of Southwest Airlines.

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Fig. 1. The evolution of airfares in quarters surrounding entry and exit events.

Second, we capitalize on recent developments in spatial econometrics and explicitly model the spatial dependence among airfares in adjacent airline routes, an issue often overlooked by the existing empirical literature on the impact of LCCs. By estimating a spatial panel model with both time and routespecific fixed effects we account for the spatial correlation between airfares in routes that can be substituted by price sensitive travelers. This approach will not only provide us with superior estimates but will also make it possible to understand whether the LCCs affect airfares beyond the routes that they enter and if so, what proportion of the savings to travelers that can be attributed to the entry of LCCs is due to the indirect effects.

Our empirical analysis confirms the existence of spatial dependence among airfares in adjacent routes, provides estimates of the consumer benefits from lower airfares in routes affected by LCCs, and shows that there are substantial 'indirect' benefits, i.e. lower fares in spatially-linked, nearby routes. Moreover, we find that although most of the pro-competitive effects of LCCs take place after entry, incumbent carriers also cut airfares in anticipation of entry by the LCCs.

The rest of the paper is organized as follows: Section 2 describes the methodology. Section 3 introduces the spatial econometric approach to estimating a panel data model from the airline industry. In Section 4 we present the empirical analysis including the data and the estimation results. Our conclusions are in Section 5.

2. Methodology

Fig. 1 illustrates the hypothetical evolution of airfares on a route entered and then exited by an LCC. Presumably, even before the actual entry event takes place, incumbent airlines have incentives to reduce airfares in order to ensure a larger market base and improve on reputation before competition intensifies.² The anticipatory fare cuts are illustrated by the evolution of airfares up to quarter t_0 . The most significant decrease in airfares should occur in the first quarter after entry. It is expected however, that before reaching the long-run equilibrium level (P_1), airfares go through an adjustment process that may take several quarters. If the LCC exits the route it is expected that the initial competitive effects will be at least in part offset by the opposing fare increases that may also take some time to reach the new equilibrium level. In order to be able to quantify these short and long-run effects of LCC entry and exit, we constructed the following baseline specification for the empirical analysis which consists of the following reduced form fare equation:

$$\ln P_{rt} = \alpha_r + \delta_t + \sum_{\tau_{en} = -4}^{4+} \beta_{\tau_{en}} SW_e entry_{r,t_0 + \tau_{en}}$$

$$+ \sum_{\tau_{ex} = 0}^{4+} \beta_{\tau_{ex}} SW_e exit_{r,t_0 + \tau_{ex}}$$

$$+ \sum_{\tau_{en1} = -4}^{4+} \beta_{\tau_{en1}} LCC_e entry_{r,t_0 + \tau_{en1}}$$

$$+ \sum_{\tau_{ex1} = 0}^{4+} \beta_{\tau_{ex1}} LCC_e exit_{r,t_0 + \tau_{ex1}} + X_{rt}\beta + \varepsilon_{rt}$$
(1)

where the dependent variable is the natural logarithm of the average fare on route *r* in quarter *t*. α_r are route fixed effects, δ_t are time fixed effects and X_{rt} is a set of explanatory variables that vary by route and time.

 $SW_entry_{r,t_0+\tau_{en}}$ are time dummy variables surrounding the period when Southwest Airlines starts serving route r. For entry events at time t₀, we constructed nine such dummy variables corresponding to quarters $t_0 + \tau_{en}$, where $\tau_{en} = -4, ..., 0, ..., +4$. Similar to Ito and Lee (2003) we define an entry event for Southwest Airlines as four consecutive quarters of presence with at least 3% market share preceded by at least four observed quarters with zero or less than 3% market share, and t_0 corresponds to the first quarter of the four that meet the 3% threshold. Likewise, SW_exit_{r.t₀+ τ_{ex}} are time dummy variables for the period after Southwest exits a route. There are five such dummy variables corresponding to t_0 , the quarter when exit occurs, one, two and three quarters after exit and finally four or more quarters after exit. We define an exit event as four consecutive quarters with zero market share for Southwest preceded by an entry event where entry is defined as above. A similar set of dummy variables are specified for the time period

² Goolsbee and Syverson (2008) present a similar rationale for such anticipatory price cuts in their study of the incumbent responses to the threat of entry by Southwest Airlines, the pioneer of the low-cost business model.

surrounding entry and exit events for the group of LCCs other than Southwest.³ Pre-entry price cuts presumably begin when the incumbent's information set, which is constantly updated, leads the carrier to form a sufficiently high expected probability of entry. How early in advance of entry this threshold expectation might be reached is unknown or unobserved in the data. One approach taken here is simply to specify a number of pre-entry dummy variables to see what the estimated parameters show us about the leads in price adjustments. An alternative approach is to identify when publicly observable preconditions for entry exist. One such example, from Goolsbee and Syverson (2008), is to note when Southwest expands its service into and out of the airports at the origin and destination of a given route. When that happens, the costs of entry are dramatically lowered and it is reasonable to expect that Southwest is a likely potential entrant on that route.

The pre-entry time dummy variables capture the price effects of anticipatory actions by the incumbents before actual entry. Goolsbee and Syverson (2008) find that incumbent airlines do cut airfares in anticipation of entry from Southwest Airlines. They conclude that the rationale behind such actions is not entry deterrence but rather customer loyalty inducement, in particular among business travelers.

The post-entry time dummy variables can potentially reveal dynamic patterns of the evolution of airfares once entry has occurred. Presumably competitive adjustments in the level of airfares will not take place instantaneously when Southwest or other LCCs establish their presence on a route. More likely the adjustment will be gradual and estimating equation (1) will reveal this dynamic pattern for up until the fourth quarter after entry. Similarly, if exit by Southwest or the other LCCs will have an impact on airfares, the post-exit time dummy variables will reveal the timing of adjustments to the new equilibrium.

The time dummy variables describing the entry and exit effects are mutually exclusive. Therefore, it is important to note that the reference category for the set of dummy variables for the entry and exit of Southwest consists of route-quarters where either Southwest entry never occurs or route-quarters observed more than four quarters before Southwest entry occurs. Likewise, the reference category for entry and exit dummies for the other LCCs includes route-quarters that were either never entered by LCCs or routequarters that are observed at least five quarters before the entry occurs.

3. The spatial econometric approach to estimating a panel data model from the airline industry

Distance affects economic behavior and airline markets are no exception. Daraban and Fournier (2006) and Fournier, Hartmann, and Zuehlke (2007) show how route-level fare data from the airline industry exhibit spatial dependence. For example the San Francisco and Oakland airports are in close geographic proximity and price sensitive travelers are often willing to substitute between the two in order to pay lower fares. Therefore, airfares on the San Francisco to Atlanta route are correlated with airfares charged in the Oakland to Atlanta route. It has been shown in the literature (Anselin, 1988; Franzese & Hays, 2007) that when the spatial dependence among observations is modeled, OLS estimates might be inefficient or biased and inconsistent depending on the nature of the spatial dependence. Panel models suffer from the same problems and therefore Elhorst (2003) extended the methodology of spatial econometrics to the estimation of spatial panel data models. These models make use of all the advantages of panel data such as routespecific fixed effects and increased estimation efficiency while also incorporating the spatial dependence that may exist among observations at each point in time.

We introduce spatial dependence in our empirical specification by including the spatially lagged dependent variable as one of the regressors. According to Anselin (1999, p. 11) such a model accounts for "substantive spatial dependence in the sense of being directly related to a *spatial model* [e.g., a model that incorporates spatial interaction, yardstick competition, etc.]."⁴

This so called spatially autoregressive (SAR) model can be written as follows:

$$\ln P_{t} = \rho WP_{t} + \alpha + \delta_{t} + \sum_{\tau_{en} = -4}^{4+} \beta_{\tau_{en}} SW_entry_{t_{0}+\tau_{en}}$$
$$+ \sum_{\tau_{ex} = 0}^{4+} \beta_{\tau_{ex}} SW_exit_{t_{0}+\tau_{ex}} + \sum_{\tau_{en1} = -4}^{4+} \beta_{\tau_{en}} LCC_entry_{t_{0}+\tau_{en1}}$$
$$+ \sum_{\tau_{ex1} = 0}^{4+} \beta_{\tau_{ex1}} LCC_exit_{t_{0}+\tau_{ex1}} + X_{t}\beta + \varepsilon_{t}$$
(2)

where $E(\varepsilon_t) = 0$; $E(\varepsilon_t \varepsilon'_t) = \sigma^2 I_N$ and *W* is the spatial weighting matrix.

The parameter that differentiates the SAR specification from the classical one is ρ , the spatial autoregressive coefficient. This parameter measures the extent of spatial interdependence among prices in adjacent routes as it captures the intensity of the interdependence between the mean airfare in one route and the weighted average of prevailing airfares in adjacent routes, where the weights apply the distance decay. In the context of competition from LCCs, the autoregressive parameter will be larger for adjacent routes that are closer substitutes for travelers, and it will impute a relatively larger price effect of LCCs than in more distant or less substitutable adjacent routes.

One of the key elements of any spatial econometric model is W, the spatial weight (or spatial contiguity) matrix which embodies the structure of the spatial linkages that exist among observational units.⁵ Given that airline routes are geographically defined by two points in space, the origin and destination airports, we chose for W a distance based weight matrix. For any pair of routes *i* and *j*, the elements of the W matrix are defined as:

 $w_{ij} = 1/(d_{ij})^2$, if $i \neq j$ and routes *i* and *j* are adjacent,⁶ and $w_{ij} = 0$ if $i \neq j$ and routes *i* and *j* are not adjacent, or if i = j.

³ The other LCCs included in the analysis are Air South, AirTran/ValuJet (in 1998 AirTran was acquired by ValuJet and AirTran's name was adopted), ATA, Eastwind, Frontier, JetBlue, Kiwi, National, ProAir, Reno, Spirit, Sun Country, Vanguard, Western Pacific and America West. Given that that we group the other LCCs together and the way we define entry, for seven routes in our sample entry occurs twice. However, in constructing the time dummy variables we do not distinguish between the two events. For example, the indicator for two quarters before the first entry and the indicator for two quarters before entry' and would be coded so that the variable LCC-entry_{r,t0-2} is set equal to one.

⁴ An alternative spatial specification would be to introduce spatial autocorrelation among the error terms, which would be "appropriate when the concern is with correcting for potentially biasing influence of the spatial autocorrelation due to the use of spatial data (irrespective of whether the economic model of interest is spatial or not)."

 ⁵ For an exposition on the typology of spatial weight matrices see Anselin (1988).
 ⁶ Two routes are considered adjacent if the distance between their endpoints is

less than 75 miles. For example Oakland to Miami and San Francisco to Fort Lauderdale are adjacent because the driving distances between Oakland and San Francisco and Miami and Fort Lauderdale are less than 75 miles respectively.

Distance d_{ij} is equal to the total great circle distance between the endpoints of routes *i* and *j* and is an approximation of the distance that a fare conscious traveler would need to drive in order to substitute between the two routes.⁷ This means that the elements of the weight matrix are equal to the inverse of the squared distance between two adjacent routes and equal to zero for routes that are not adjacent. Also the diagonal elements are all zero. The power of the influence between adjacent routes is thus allowed to decay with distance, meaning that the further two routes are the weaker the link between their fares will be.⁸ Also, it is common practice in spatial econometric applications to row-standardize the W matrix such that the rows of the matrix sum to one. This way the spatial lag term actually becomes a weighted average of the airfares in the adjacent routes and thus parameter ρ measures the average influence of adjacent routes, or the strength of the spatial interdependence among adjacent routes.

The estimation procedure proposed by Elhorst (2003) for the estimation of the SAR specification is based on maximizing the corresponding likelihood functions using a two-stage iterative algorithm.

4. The empirical analysis of the incumbent responses to LCC entry

4.1. Data

The variables needed in the empirical analysis were constructed using data from the US Department of Transportation's Ticket Origin and Destination Survey (Data Bank 1B), available from the Bureau of Transportation Statistics, 2008. These data represent a 10% sample of all the tickets issued by U.S. domestic carriers and contain detailed information regarding price, number of passengers, distance, operating carrier and other itinerary-specific characteristics.

The time period for this study includes 55 quarters from the first quarter in 1993 to the third quarter in 2006. We constructed a balanced panel based on the 2000 most traveled routes in the year 2000 which are observed in every quarter. A route is defined as a non-directional airport-pair, meaning that tickets from Atlanta to Miami are pooled together with tickets from Miami to Atlanta and are part of the same route.⁹ In aggregating the ticket level data to route level, the sample was restricted to tickets involving airports in the 48 contiguous states. Only tickets containing at most two coupons per directional leg were included. Moreover, the sample included only tickets that reflect travel from one origin to one destination, excluding those tickets with multiple destinations. Finally roundtrip tickets had to return to the departure point, so those tickets that contain a ground segment are not used (e.g. Boston–Atlanta and Atlanta–Providence).

In all empirical specifications the dependent variables is the route-level passenger weighted average airfare charged by the legacy carriers. The fare screen provided in the data set was used to eliminate tickets for which the fare was considered implausible; consequently most frequent flier tickets were not included in the analysis. While route-level average fares were calculated using all interline tickets, market shares of each carrier in each route are based on on-line tickets (as opposed to interline tickets) after assigning the smaller affiliate/regional carriers to the corresponding legacy carriers.¹⁰

Because an entry event is defined as four consecutive quarters with a market share of more than 3%, the earliest quarter included in the analysis is the first quarter of 1994. Entry events in 1993 cannot be used because it's impossible to assign the correct values to the corresponding post-entry time dummy variables. Similarly, in order to be able to distinguish true exit and the pre-exit periods the observations corresponding to the final four quarters (Q4 2005–Q3 2006) can not be used in the analysis due to the four quarter leads and lags that the benchmark model uses.

To summarize, the sample is a balanced panel with 2000 (alternatively 1947) observations from the most traveled routes over the period starting in the first quarter of 1994 and ending in the third quarter of 2005, for a total of 47 quarters.

Also it should be noted that because we are grouping all LCCs other than Southwest, exit events are noted when the sum of market shares of all LCCs present in the route becomes zero. That means that if the total market share of the LCCs in the route is 15% and one LCC that serves 5% of that market exits that event is not considered exit for the purpose of this study.

4.2. Episodes of Southwest and other LCCs entry and exit

Out of the 2000 routes in the sample, 907 routes were served by Southwest and 1282 by at least one of the other LCCs at some point in the sample period. Southwest had already started serving 276 of these routes and the other LCCs were serving 296 routes at the beginning of the sample period. From 1994 to 2005 we identified 519 entry events and 30 exit events for Southwest Airlines and 785 entry events and 197 exit events were recorded for the group of other LCCs.

Figs. 2 and 3 show the number of entry and exit events in each of the years for which data are available. It can be observed that years when entry by Southwest is more predominant than entry by the other LCCs alternate with years when the ratio of the number of entries changes. As expected, Southwest exits occur much less frequently than exits by the other LCCs. Out of the 22 routes that Southwest exits in the peak year 2001, 12 exits occur in the second quarter and 10 occur in the third quarter; it's unlikely that the terrorist attacks of 9/11 were the determinant factor but rather the economic conditions of the time.

4.3. The control variables

In addition to the time dummy variables which are the focus variables in this study we also included the following explanatory variables, for which summary statistics are shown in Table 1:

potential_SW_{rt}/potential_LCC_{rt} is an indicator variable equal to one if at time *t*, Southwest Airlines/an LCC other than Southwest serves both endpoint airports of route *r* but it does not fly the route itself. Once presence is established at both endpoints the cost of starting service on the route is relatively low and

⁷ Driving time is a possible alternative to distance. Our preliminary results are qualitatively similar using driving time weights.

⁸ Alternative formulations are possible for the decay effect such as linear or of order greater than two. We chose here an order of the decay effect consistent with the formulation in the gravity model. The imposition of this structure on the spatial weight matrix is consistent with Anselin (1988, p. 21) who notes that "the weight matrix should bear a direct relation to a theoretical conceptualization of the structure of dependence, rather than reflecting an ad hoc description of spatial pattern."

⁹ Since the observational unit is a *non-directional* market, roundtrip tickets were broken into two identical trips corresponding to the outbound and inbound flights. A roundtrip ticket from A to B yields two identical observations for route A–B with the one-way fare calculated as one-half the roundtrip fare.

¹⁰ For example, if the first coupon was flown by United Airlines and the second coupon was flown by Delta, the ticket was not included in the calculation of market shares because there was no reasonable method to assign the ticket price to either of the two carriers. On the other hand when the first ticket was flown by Delta and the second one by a Delta Connection carrier, then the ticket was assigned to Delta.

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Fig. 2. Yearly number of entries for Southwest and the other LCCs during 1994–2005.

therefore incumbent carriers might respond to the increased threat of entry. Therefore the role of these variables is to capture the potential competition effects.¹¹

 HHI_{rt} (the Herfindahl Hirschman Index) measures route-level concentration in quarter *t* and was constructed using route-level market shares in terms of passengers for all the carriers serving the route in question.

% one-way_{rt} is the natural logarithm of the proportion of oneway tickets issued on route *r* in quarter *t* and it controls for the fact that one-way tickets are on average more expensive than roundtrip tickets.

% non-stop_{rt} is the natural logarithm of the proportion of nonstop tickets issued on route *r* in quarter *t* and it controls for the fact that non-stop tickets are on average more expensive than tickets that involve a plane change.

income_{rt} is the natural logarithm of the product of the per capita income levels of the origin and destination metropolitan areas.¹² The hypothesized effect of this variable is indeterminate: it would be expected to be positive if income at the origin and destination cities was a strong demand shift variable, but it could be negative as higher incomes raise the passenger density on the route.

population_{rt} is the natural logarithm of product of the population levels of the metropolitan areas that contain the two endpoint airports. The role of this variable is to capture the economies of density that might characterize the routes originating in the more densely populated areas.

4.4. OLS estimation results

Table 2 shows the estimated coefficients on the time dummy variables for Southwest entry and exit events for three empirical specifications. The coefficient estimates for the control variables are shown in Table 3. For all three specifications, the dependent variable is the logarithm of the average fare charged by the incumbent legacy carriers.¹³ Not all routes in the 2000 contained in the initial sample were served by legacy carriers. Thus the sample used contains 1947 routes observed over the same time period (Q1 1994–Q3 2005) which gives a total of 91509 observations.

The first column presents the results from the OLS estimation of the non-spatial specification (1). The estimates of the coefficients on the pre-entry, post-entry and post-exit variables for Southwest

Airlines are all significant at the 5% level and have the expected signs. The reference category for the entry variables consists of routes where Southwest entry never occurs or routes observed five or more quarters before entry. By examining the pre-entry coefficients we can now make inferences regarding the anticipatory actions of incumbent airlines in the face of entry by Southwest. The results show a small but statistically significant response of the legacy carriers beginning four quarters before Southwest actually enters the route. Incumbent fares are 4-6.7% lower over the four quarters preceding the actual entry event. One quarter before entry, the incumbent fares are 6.7% lower compared to the reference period but the most significant incumbent response in terms of airfares takes place in the quarter when entry occurs. At that point incumbents have reduced fares by 16% compared to the reference periods. The next and last significant fair cut takes place in the first post-entry quarter when incumbents charge fares that are 22% below the reference level. After that no further incumbent responses are observed and fares stabilize and remain at the same level.

This result is consistent with Goolsbee and Syverson (2008) who find that incumbents drop fares significantly in anticipation of entry. However their results indicate that most of the Southwest effect takes place before Southwest actually starts flying the route. More precisely before actual entry occurs, fares are lower by almost 20% and after entry they drop to about 26%. In comparison, while we do find a significant pre-entry effect here as well it is rather small as it amounts to about one third of the total effect. The difference in the two sets of results is not surprising, as there are several elements that distinguish the Goolsbee and Syverson (2008) study from the present one. First, they restrict their sample to routes that at some point in time exhibit potential competition defined by Southwest starting to serve both endpoints of the route but not the route itself. While the occurrence of potential competition does not always lead to actual entry, pre-emptive price cutting is tested during quarters that surround the establishment of potential competition. In fact the authors "observe Southwest threatening entry into 654 routes over the sample period, 374 of which Southwest had actually entered with direct flights by the end of the observation period." Most importantly, their study focuses on the threat of entry effect rather than on the actual competition effect. Goolsbee and Syverson (2008) also estimate a specification using only routes where Southwest had pre-announced its entry. They still find evidence of price cutting but only about one third of the price cut takes place before entry, a result consistent with our findings.

The estimates of the coefficients on the post-exit time dummies reveal the evolution of airfares once exit occurs. The reference category for this set of time dummies is also represented by routes observed more than four quarters before an entry event occurred.

¹¹ These are the focus variables in the Goolsbee and Syverson (2008) study.

¹² The income and population data were obtained from the regional economic accounts provided by the Bureau of Economic Analysis, 2008.

¹³ The group of incumbent legacy carriers includes American Airlines, Alaska Airlines, Continental, Delta, Northwestern, United and US Airways.

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Fig. 3. Yearly number of exits for Southwest and the other LCCs during 1994-2005.

As shown in the first column of Table 2, in the quarter when Southwest exits a route the legacy carriers will raise their airfares to a level that is still about 10% lower compared to the benchmark which represents an increase of about 12%. Probably due to the very small number of exit events for Southwest (only 30) the coefficients corresponding to the post-exit quarters are not all statistically significant. However, the estimates indicate that four or more quarters after the exit event, incumbents are still not raising fares to the pre-entry level as the fares they charge remain about 11% lower compared to the reference periods. This suggests that Southwest Airlines has the ability to exert a profound impact on the competitive market process and that its effects remain even after exit.

The estimated mean effects on the airfares charged by incumbent legacy carriers in time periods surrounding entry and exit events for Southwest are illustrated in Fig. 4.

The estimates of the coefficients on the time dummies surrounding the entry and exit events for the other LCCs are also reported in Table 2 and they follow a similar pattern. No significant response is elicited however, before entry takes place. One quarter before entry the legacy carriers drop their fares by 3% and their response increases to 6% in the quarter when entry takes place. Three quarters after entry, fares are 8% lower compared to the reference period while four quarters and more after entry, the legacy carriers have reduced their fares by 12%. It can thus be noted that the response of the legacy carriers when the other LCCs start service is considerably smaller than in the case of Southwest

Table 1

Summary statistics for the control variables.

Variable	Mean	Std dev	Minimum	Maximun
Average fare	170.18	55.93	16.79	548.20
Average fare legacy	174.19	55.97	26.93	856.4
ННІ	4936	2269	1094	9243
Proportion of one-way tickets	0.200	0.151	0	1
Proportion of non-stop tickets	0.313	0.217	0	1
Per capita income at origin MSA	30 079	5972	11 693	53 395
Population at origin MSA ('000)	3668	4267	39	18 801
Per capita income at destination MSA	29862	6516	10 578	53 395
Population at destination MSA ('000)	3174	3534	55	18 801
American Airlines	0.543	0.498	0	1
Continental	0.381	0.485	0	1
Delta	0.665	0.471	0	1
Northwest	0.385	0.486	0	1
United	0.422	0.493	0	1
US Airways	0.379	0.485	0	1
Alaska Airlines	0.036	0.187	0	1

Airlines. Also, unlike in the case of Southwest, the decrease in price is completely offset once exit occurs. The coefficient estimates show that once the LCCs other than Southwest leave the market the incumbent legacy carriers raise airfares to a level that is 10% lower than the benchmark followed by further increases during the postexit quarters until they bring their fares up to the pre-entry level. Fig. 5 illustrates this pattern as well.

Overall, the coefficients on the post-entry time dummies are all negative and statistically significant. As illustrated in Figs. 2 and 3 the incumbents cut fares most significantly in the quarter when entry occurs. An adjustment process follows during which the competitive effects of the LCCs continue to accumulate beyond the initial entry period. In fact the most significant post-entry drop takes place in the first quarter after entry after which airfares stabilize so the adjustment process takes place in a fairly short period of time. While the evolution of post-entry airfares follows the same pattern irrespective of the identity of the carrier, the incumbents' response to entry by Southwest is double compared to when other LCCs start competing. This confirms the hypothesis that Southwest's presence is a much stronger incentive for the legacy airlines to reduce fares than the presence of the other low-cost competitors.

4.5. Estimation results from the SAR model and savings to travelers from 1994 to 2005

Column (2) in Table 2 shows the estimation results for the spatial autoregressive model specification in equation (2). As expected, the spatial autoregressive coefficient ρ is positive and highly significant (0.258), confirming the hypothesis that airfares in adjacent routes are correlated.

Despite the potential bias of the OLS estimates due to the existence o spatial dependence, the SAR and OLS specifications yield similar point estimates for the coefficients on the time dummy variables for both Southwest and the other LCCs. It should be noted however that the interpretation of these coefficients is different in the SAR specification compared to OLS. Abreu, de Groot, and Florax (2005) show that the marginal effects of the explanatory variables in an SAR model are not given simply by the β coefficients but also factor in the spatial multiplier term $(I - \rho W)^{-1}$ where *I* is the identity matrix, *W* is the spatial weighting matrix and β is the vector of coefficients corresponding to the explanatory variables. Therefore simply comparing the estimates of the SAR and OLS specifications would not be relevant.

Another interesting effect we find suggests that there are spillover effects of potential competition to nearby routes. The existence of spatial dependence among adjacent routes combined with the statistical significance of the coefficients on the potential

Table 2		
Pre-entry, post-entry and	post-exit effects of Southwest	Airlines and the other LCCs.

	5 1						
Variable	(1) OLS legacy fares	(2) SAR legacy fares	(3) SAR redefined entry	Variable	(1) OLS legacy fares	(2) SAR legacy fares	(3) SAR redefined entry
Potential_SW	$-0.050^{a} (0.004)^{c}$	$-0.039^{a}(0.003)$	$-0.053^{a}(0.007)$	Potential_LCC	0.007 ^a (0.001)	0.006 ^a (0.001)	0.002 (0.001)
$SW_entry(-4)$	$-0.041^{a}(0.007)$	$-0.037^{a}(0.005)$	$-0.023^{a}(0.006)$	$LCC_entry(-4)$	-0.010 (0.005)	-0.004(0.004)	$-0.009^{b}(0.005)$
$SW_entry(-3)$	$-0.052^{a}(0.007)$	$-0.047^{a}(0.006)$	$-0.029^{a}(0.006)$	$LCC_entry(-3)$	$-0.012^{b}(0.005)$	-0.007(0.004)	-0.007(0.005)
$SW_entry(-2)$	$-0.052^{a}(0.007)$	$-0.046^{a}(0.066)$	$-0.027^{a}(0.006)$	$LCC_entry(-2)$	$-0.018^{a}(0.005)$	$-0.013^{a}(0.003)$	$-0.014^{a}(0.005)$
$SW_entry(-1)$	$-0.067^{a}(0.006)$	$-0.060^{a}(0.006)$	$-0.029^{a}(0.006)$	$LCC_entry(-1)$	$-0.032^{a}(0.005)$	$-0.025^{a}(0.003)$	$-0.023^{a}(0.005)$
SW_entry(0)	$-0.164^{a}(0.007)$	$-0.157^{a}(0.006)$	$-0.141^{a}(0.006)$	LCC_entry(0)	$-0.059^{a}(0.005)$	$-0.055^{a}(0.004)$	$-0.057^{a}(0.005)$
SW_entry(+1)	$-0.225^{a}(0.006)$	$-0.214^{a}(0.006)$	$-0.204^{a}(0.006)$	LCC_entry(+1)	$-0.078^{a}(0.005)$	$-0.073^{a}(0.004)$	$-0.080^{a}(0.005)$
SW_entry(+2)	$-0.227^{a}(0.007)$	$-0.213^{a}(0.006)$	$-0.198^{a}(0.006)$	$LCC_entry(+2)$	$-0.079^{a}(0.005)$	$-0.073^{a}(0.004)$	$-0.080^{a}(0.005)$
SW_entry(+3)	$-0.229^{a}(0.007)$	$-0.214^{a}(0.006)$	$-0.208^{a}(0.006)$	$LCC_entry(+3)$	$-0.081^{a}(0.005)$	$-0.074^{a}(0.004)$	$-0.084^{a}(0.005)$
SW_entry(4+)	$-0.217^{a}(0.003)$	$-0.205^{a}(0.003)$	$-0.197^{a}(0.003)$	LCC_entry(4+)	$-0.118^{a}(0.002)$	$-0.104^{a}(0.002)$	$-0.101^{a}(0.002)$
SW_exit(0)	$-0.077^{a}(0.027)$	$-0.051^{a}(0.023)$	-0.037 (0.024)	LCC_exit(0)	$-0.108^{a}(0.011)$	$-0.093^{a}(0.010)$	$-0.087^{a}(0.010)$
SW_exit(+1)	$-0.062^{b}(0.031)$	-0.030 (0.023)	-0.037 (0.028)	$LCC_exit(+1)$	-0.091 ^a (0.011)	$-0.077^{a}(0.010)$	$-0.076^{a}(0.010)$
SW_exit(+2)	-0.045 (0.031)	-0.014 (0.025)	-0.017 (0.028)	$LCC_exit(+2)$	$-0.063^{a}(0.011)$	$-0.049^{a}(0.009)$	-0.053 ^a (0.010)
SW_exit(+3)	$-0.068^{b}(0.031)$	-0.048(0.025)	-0.046(0.028)	$LCC_exit(+3)$	$-0.046^{a}(0.011)$	$-0.032^{a}(0.008)$	$-0.052^{a}(0.010)$
SW_exit(4+)	-0.119 ^a (0.010)	-0.096 ^a (0.010)	$-0.069^{a}(0.008)$	$LCC_exit(4+)$	-0.005(0.004)	-0.002 (0.004)	$-0.033^{a}(0.004)$
ρ	-	0.258 (0.002)	0.258 (0.002)	ρ	-	0.258 (0.002)	0.258 (0.002)
Ν	1947	1947	1947	Ν	1947	1947	1947

^a Statistically significant at 1%.

^b Statistically significant at 5%.

^c Standard errors in parentheses.

competition variables imply that the threat of entry effects extends to nearby routes.¹⁴ This result is in contrast with Goolsbee and Syverson (2008) who find no effect in the routes that are nearby to those where Southwest threatens to enter and confirms that the SAR model is better suited to capture such effects that are spatial in nature.

The estimation results from the SAR and OLS specifications can be used in the assessment of the aggregate effects of LCCs by quantifying the savings to travelers attributed to the LCCs over the sample period. Two questions can be asked in order to reveal the welfare effects of LCC entry. First, by how much did entry of LCCs in each route and in each quarter during the sample period lower airfares? Second, in each quarter of the sample period, how much lower are airfares due to the presence of LCCs? By weighting the estimated route-level changes in airfares by the number of passengers that traveled on each route in each quarter, we can obtain an estimate of the savings to travelers that can be attributed to the LCCs.¹⁵ While the first question focuses exclusively on the effects of new entry over the period from the fourth quarter of 1994 to the third quarter of 2005, the answer to the second question also reveals the long-run effects of all entry events, including some that took place before the sample period starts. In both cases the cumulated effects include both pre-entry and post-entry effects.

The marginal effects of Southwest entry are given by the following marginal effects matrix:

$$\frac{\Delta P_{rt}}{\Delta SW_{rt}} = (I_N - \rho W)^{-1} \sum_{\tau_{en} = -4}^{4+} \beta_{\tau_{en}} \text{Diag}\Big(SW_-\text{entry}_{r,t_0 + \tau_{en}}\Big)$$
(3)

where Diag(SW_entry_{r,t_0+τ_en}) are $r \times r$ diagonal matrices with the diagonal elements consisting of the vectors of observations on the pre-entry and post-entry time dummy variables for Southwest. The direct effects of Southwest entry will then be given by the sum of the diagonal elements of the marginal effects matrix while the indirect effects caused by the transmission of the competitive effects of entry to adjacent routes will be obtained by summing the off-diagonal elements. The savings to travelers are then calculated by weighting the marginal effects by the number of travelers in

each route. The same calculation performed using the estimation results from the OLS specification will yield a diagonal marginal effects matrix since ρ is zero which means that no indirect effects are captured.

Tables 4 and 5 show the calculated amounts of savings expressed in billions of 2004 dollars for each year of the sample period as well as for the entire period, obtained using the OLS and the SAR specifications. They include the total estimated savings attributed to the direct and indirect effects of Southwest and the other LCCs respectively, for all entry events and for entry events confined to the sample period. Given that the point estimates are very similar in the OLS and SAR specifications, the calculated direct effects are also close in magnitude. However, as the results from the SAR specification show, the indirect effects of the LCCs are an important source of consumer benefits as they account for up to 20% of the total savings, but they are completely overlooked by the OLS specification. Therefore it is important to acknowledge the utility of the spatial autoregressive model in fully assessing the welfare effects of the LCCs.

4.6. The nature of the anticipatory actions of the incumbent legacy carriers

Overall, the results presented above provide evidence that at least in the case of entry by Southwest incumbent carriers cut fares

Table 3	
Estimated coefficients on the control variables.	

Variable	(1) OLS legacy fares	(2) SAR legacy fares	(3) SAR redefined entry
log(HHI)	0.079 ^a (0.002) ^c	0.081 ^a (0.002)	0.087 ^a (0.002)
% One-way	$-0.011^{b}(0.005)$	0.014 ^a (0.002)	0.009 (0.002)
% Non-stop	$-0.299^{a}(0.007)$	$-0.280^{a}(0.006)$	$-0.281^{a}(0.006)$
Income	$0.420^{a}(0.029)$	0.318 ^a (0.027)	$0.262^{a}(0.027)$
Population	0.227 ^a (0.018)	$0.200^{a}(0.017)$	$0.218^{a}(0.017)$
AA	$0.017^{a}(0.002)$	$0.015^{a}(0.001)$	$0.016^{a}(0.001)$
AS	$-0.035^{a}(0.008)$	$-0.037^{a}(0.005)$	$-0.046^{a}(0.005)$
СО	$-0.009^{a}(0.001)$	$-0.009^{a}(0.001)$	$-0.007^{a}(0.001)$
DL	$-0.009^{a}(0.002)$	$-0.006^{a}(0.001)$	-0.002(0.001)
NW	0.0005 (0.001)	0.0002 (0.001)	0.002 (0.001)
UA	0.018 ^a (0.002)	0.016 ^a (0.002)	0.015 ^a (0.002)
US	$-0.004^{b}(0.002)$	-0.003 (0.001)	-0.003 (0.001)
Ν	1947	1947	1947

^a Statistically significant at 1%.

^b Statistically significant at 5%.

^c Standard errors in parentheses.

¹⁴ Surprisingly the coefficient on the potential competition for the LCCs other than Southwest is very small but positive.

¹⁵ In assessing the savings to travelers we assumed the price elasticity of demand to be zero.



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Fig. 4. The response of legacy carriers to entry and exit by Southwest.

almost one year before the entry event takes place. However, while statistically significant, the incumbent fare cuts are relatively small as they only amount to about a third of the total price decrease that takes place after the entry event for both Southwest Airlines and the group of other LCCs. Media reports indicate that in general, route-level entry becomes public knowledge two quarters before the new entrant starts service. But our estimates suggest that such anticipatory effects are present even earlier than that.

One reason for observing a decrease in the airfares charged by the incumbent legacy carriers before entry could be related to the way in which entry was defined. A quarter was not flagged as entry unless a market share of 3% or more was sustained. As a result, it might be the case that Southwest for example started flying a certain route but no entry was flagged because the 3% market share threshold was not met. Out of the 519 flagged entry events for Southwest, 190 are preceded by positive but less than 3% market shares. On average there is a 2.4 quarters time lag between the quarter when Southwest first issues tickets on a route and the quarter that meets the 3% market share criterion. Likewise out of the 785 entry events for the other LCCs 479 were preceded by positive but less than 3% market shares. Therefore the manner in which entry was defined might be driving the results with respect to the pre-entry incumbent responses. Column (3) of Table 2 presents the estimation results from an SAR specification where an entry event is redefined such that the flagged entry quarter coincides with the first quarter in which the LCCs issue tickets. As expected, once entry is redefined, the pre-entry coefficients for Southwest become smaller in absolute value (i.e. 0.023 compared to -0.037 four quarters before entry and -0.029 compared to -0.046 three quarters before entry) but are still statistically significant, suggesting the presence of anticipatory fare cuts in the wake of entry. Goolsbee and Syverson (2008) find evidence that the anticipatory fare cuts are motivated by loyalty inducement and increasing consumer switching costs, in the vein of Klemperer (1987), as they are directed at business travelers whose loyalty is



Fig. 5. The response of legacy carriers to entry and exit by other LCCs.

Table 4

Estimated savings attributed to Southwest Airlines (in billions of 2004 dollars)

	-					
Year	OLS		SAR			
	Total	Total effects	Direct	Total	Direct	Total effects
	effects of	of	effects of	effects of	effects of	of
	Southwest,	Southwest,	Southwest,	Southwest,	Southwest,	Southwest,
	all entries	1994-2005	all entries	all entries	1994–2005	1994–2005
		entries			entries	entries
1994	1.469	0.075	1.433	1.744	0.077	0.254
1995	1.830	0.305	1.784	2.180	0.312	0.547
1996	2.041	0.500	1.993	2.444	0.516	0.799
1997	2.390	0.725	2.333	2.881	0.723	1.077
1998	2.643	0.899	2.579	3.166	0.884	1.274
1999	2.999	1.141	2.925	3.575	1.130	1.561
2000	3.463	1.447	3.380	4.114	1.437	1.922
2001	3.109	1.367	3.035	3.646	1.372	1.779
2002	2.887	1.311	2.818	3.367	1.267	1.636
2003	2.962	1.358	2.889	3.446	1.287	1.661
2004	3.174	1.513	3.096	3.697	1.454	1.874
2005 ^a	2.560	1.287	2.496	2.981	1.222	1.565
Total	31.527	11.928	30.761	37.241	11.681	15.949

^a Quarters Q1 through Q3.

valued much more than that of the leisure travelers. One of the loyalty inducement mechanisms that well established airlines have at their disposal are frequent flier programs that make it more costly for travelers who have accumulated frequent flier miles on the incumbent's network to switch to new entrants. It should be noted however that our analysis shows that the anticipatory responses of the incumbent legacy carriers are rather small in magnitude compared to the ultimate post-entry effects that prevail once entry occurred.

Interestingly the incumbents do not act in anticipation of entry by LCCs other than Southwest. Using the new definition of an entry event, the coefficients on the time dummies for the quarters preceding entry by the other LCCs are statistically significant but very small, yielding virtually no change four and three quarters before entry and a decrease in fares of about 2.3% one quarter before entry. The difference in the incumbent reactions could be explained by the fact that the LCCs other than Southwest are not perceived as a serious threat and therefore strategic fare reductions are not needed.

Table 5

Estimated savings attributed to LCCs other than Southwest (in billions of 2004 dollars).

	•					
Year	Year OLS		SAR			
	Total effects of	Total effects of the other	Direct effects of	Total effects of	Direct effects of the other	Total effects of the other
	the other	LCCs, 1994-	the other	the other	LCCs, 1994-	LCCs, 1994-
	LCCs, all	2005 entries	LCCs, all	LCCs, all	2005 entries	2005 entries
	entries		entries	entries		
1994	1.279	0.045	1.166	1.416	0.035	0.147
1995	1.629	0.258	1.491	1.811	0.242	0.404
1996	1.846	0.461	1.684	2.058	0.426	0.630
1997	2.127	0.664	2.016	2.474	0.612	0.876
1998	2.554	0.941	2.336	2.893	0.871	1.216
1999	2.947	1.244	2.694	3.324	1.146	1.545
2000	3.499	1.631	3.200	3.940	1.503	1.982
2001	3.141	1.565	2.872	3.525	1.441	1.869
2002	2.992	1.582	2.736	3.339	1.456	1.856
2003	3.122	1.685	2.853	3.465	1.548	1.955
2004	3.281	1.794	2.994	3.619	1.645	2.058
2005 ^a	2.605	1.419	2.378	2.877	1.302	1.630
Total	31.022	13.289	28.42	34.741	12.227	16.168

^a Quarters Q1 through Q3.

4.7. The post-exit response of the incumbents

The coefficients on the post-exit time dummy variables show that when Southwest exits a route, the airfare trend is reversed. The incumbent carriers increase airfares back but by only about half of the post-entry decrease. Consequently, Southwest's presence in a route creates a hysteresis effect through which a new lower equilibrium airfare is reached and maintained even after Southwest exits the route. On the other hand, interestingly enough, when the other LCCs exit a route, all of the competitive effect that they exercised at entry is being offset as incumbents raise airfares to the pre-entry level. Such conduct has often been labeled as predatory especially by the LCC entrants who filed complaints with the DOT. The legacy carriers, they claimed, lower prices even below cost in order to weaken and ultimately force the LCCs out of the market after which they increase airfares to the pre-entry level continuing to enjoy market power. On the other hand the incumbents argue that their actions are merely determined by the market structure and reflect the competitive realities brought by the entrants and all they do is to adjust accordingly.

Holding aside the intractable question of whether any predatory conduct occurred, it is possible to modify the empirical model to find out whether there is a link between the post-entry response of the legacy carriers and the exit events in the sample. To this end we constructed two dummy variables that equal one if Southwest or the other LCCs exit route r at some point in time during the sample period. Then we interacted these variables with the post-entry time dummy variables. If the coefficients on the interaction term are significant and negative then the post-entry decrease in fares by the incumbent is greater on average in routes that are exited by the LCCs. While that could be indicative of stronger responses by the incumbents leading to more exit our results show that is not the case. The coefficients on the interaction terms are statistically insignificant for all the LCCs including Southwest and therefore the hypothesis that aggressive price cutting by the incumbents leads to exit is rejected. There is no evidence that the post-entry adjustment of fares by the incumbents in these markets is more aggressive than elsewhere.

5. Conclusions

The estimation of the SAR specification confirms that spatial autocorrelation exists in the route-level data from the airline industry. Despite the potential bias of the OLS estimates, correcting for spatial dependence does not substantially affect the point estimates. However, the interpretation of the marginal changes, affects the assessments based on the predicted values of the dependent variable. The OLS specification is unable to capture the indirect effects of the LCCs that extend beyond the route they serve to adjacent routes. These effects are an important source of consumer benefits that need to be accounted for in welfare analyses of the airline industry. By estimating an SAR panel model we find that the indirect effects of LCCs, which are completely overlooked in the OLS specification represent up to 20% of the total effects.

Incumbents significantly reduce airfares both before and after LCC entry, more so in the case of Southwest Airlines than when faced with competition from the group of other LCCs. The result that incumbent legacy carriers choose to cut fares in anticipation of entry raises interesting questions regarding their motives. Most likely the observed pre-entry fare decreases are not motivated by intentions of entry deterrence but rather by capturing important market shares and creating a good reputation before new competitors enter the routes. Frequent flier programs are also a mechanism that allows the incumbents to raise the switching costs for existing customers and therefore fare reductions in anticipation of entry may be justified. While there is some ambiguity in identifying the exact timing of entry in the data, our results are not significantly affected by how entry is defined, whether using the first quarter of operation or by evidence of a sustained market share of at least 3% for four quarters in a row.

The post-entry evolution of the airfares charged by the legacy carriers shows that most of the competitive effect (about three quarters) accumulates after entry occurs. Also, the adjustment process takes place fairly rapidly as fares reach the new equilibrium one or two quarters after entry.

Another interesting result of this study is that exit by the LCCs reverses the post-entry pro-competitive effects. Following exit by Southwest, the legacy carriers increase airfares by about 10% which represents less than half of the total post-entry decrease. On the other hand when the other LCCs exit a route all the post-entry competitive effect is offset by the increase in the fares charged by the incumbent legacy carriers. This evidence cannot be interpreted as support for the allegations of predatory conduct on behalf of the legacy airlines, but rather as normal competitive price adjustments. Moreover our analysis rejects the hypothesis that the post-entry response of the legacy airlines is larger in routes where exit occurs.

Although our results reveal very important competitive effects of the LCCs in the U.S., they cannot be projected into the future. Given the shifts in the cost structure of the legacy carriers as well as the diminishing returns nature of the point-to-point network operations, it is expected that the competitive effects of the LCCs will become smaller in the long-run.

Despite the conspicuous differences between the two business models and the products that they offer, the LCCs on the one side and the legacy carriers on the other compete aggressively with each other and this competition is reflected in the dynamics of the airfares. The LCCs and Southwest in particular have the potential to discipline airfares by exerting competitive pressures in the routes where they operate and in nearby routes. Although the presence of the LCCs is an essential determinant of the intensity of competition, the peculiarities of their current business model prevent them from being a panacea for the competition issues that often arise in the US airline industry.

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