Title: Incumbent Responses to Low Cost Airline Entry: An SAR panel data analysis

Bogdan Daraban,
Assistant Professor
Harry F. Byrd Business School
Shenandoah University

and

Gary M. Fournier
Professor of Economics
Department of Economics
Florida State University

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Abstract:

While the US airline industry is being substantially transformed in recent years by the growth of low-cost airlines, the cost-saving benefits of lower airfares are difficult to gage 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 prior 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 pre-emptively in the quarters preceding entry by the LCCs. 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, perhaps predatory behavior) fueled even more concerns regarding the competitiveness of the airline industry. It is no surprise then that from 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. 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. For a survey of these developments, see e.g. Borenstein and Rose (2007).

There are two important ways in which this paper contributes to the existing literature on the impact of LCCs. First, the availability of route-level panel data enabled us to examine the role of the LCCs in the long run adjustment of airfares as well as the response of the incumbent carriers to LCC entry and exit in a dynamic setting. Unlike Windle and Dresner (1995) but similar to Goolsbee and Syverson (2006), the empirical analysis examines the effects of entry and exit for the quarters surrounding these events controlling for other factors affecting airfares including time and route specific fixed effects. In contrast to Goolsbee and Syverson (2006), our focus is on actual competition and we use a different approach in selecting our sample. 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. By estimating a spatial panel model with both time and route specific fixed effects we account for the spatial correlation between airfares in routes that can be substituted by price sensitive travelers. As a result we are able to quantify the savings that can be attributed to the entry of LCCs not only in the routes that they serve, but also in adjacent routes to obtain a clearer image of their overall effect on the industry.

With a more efficient cost structure and a point-to-point route expansion pattern that targets the more dense and profitable routes, the LCCs were able to charge low airfares. We are concerned here with the strategic responses of the incumbents given the choices that they have in terms of the magnitude and timing of their response. Therefore the first question that we will focus on is: *What is the timing of the incumbents' price response to entry by LCCs?* That is how much of the response is pre-emptive, how much takes place after the actual entry event and how long does it take for airfares to reach a new equilibrium?

The success story of Southwest Airlines, the pioneer of the LCC model, has encouraged other airlines to follow a similar strategy in competing with the established legacy carriers. While many attempts were unsuccessful, among those LCCS who succeeded there is an important degree of heterogeneity with respect to their business approach, and we expect that the incumbents' responses to their entry would differ accordingly. The second question is: *Do incumbents respond differently to entry by Southwest Airlines compared to entry by the other LCCs? Are the competitive effects on airfares different in timing and magnitude in the case of entry by Southwest compared to the other LCCs?*

The events of 9/11 represent an important landmark in the US airline industry. The effects of the economic recession in the US at the time were greatly amplified by the terrorist threat and the legacy airlines were severely hurt. With the financial distress weighing on the legacy carriers, the market conditions became more favorable to new entry. By 2001, the legacy carriers had been exposed to multiple LCC entry episodes and were better informed about their potential to compete. Another question that we will address is: *Has there been a change in the price response strategy to LCC entry after 9/11?*

The existing empirical literature on the impact of LCCs has largely overlooked spatial dependence among route level airfares. Explicitly modeling the spatial dependence among airfares in adjacent routes will not only provide us with superior estimates but also will make it possible to answer the following questions: *Do LCCs affect airfares beyond the routes that they* *enter? If yes, what proportion of the savings to travelers that can be attributed to the entry of LCCs is due to the indirect effects, i.e. those benefits due to lower fares in adjacent routes?*

2. Methodology

Figure 1 illustrates the hypothetical path of average airfares on a route entered and then exited by a LCC. 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. The pre-emptive fare cuts by incumbent carriers 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 a reduced form fare equation of the following form:

$$\begin{aligned} \ln \mathrm{P_{rt}} &= \alpha_{\mathrm{r}} + \delta_{\mathrm{t}} + \sum_{\tau_{\mathrm{en}}=-4}^{4+} \beta_{\tau_{\mathrm{en}}} \mathrm{SW\_entry}_{\mathrm{r,t_0+\tau_{en}}} + \sum_{\tau_{\mathrm{ex}}=0}^{4+} \beta_{\tau_{\mathrm{ex}}} \mathrm{SW\_exit}_{\mathrm{r,t_0+\tau_{ex}}} + \\ & \sum_{\tau_{\mathrm{en1}}=-4}^{4+} \beta_{\tau_{\mathrm{en1}}} \mathrm{LCC\_entry}_{\mathrm{r,t_0+\tau_{en1}}} + \sum_{\tau_{\mathrm{ex1}}=0}^{4+} \beta_{\tau_{\mathrm{ex1}}} \mathrm{LCC\_exit}_{\mathrm{r,t_0+\tau_{ex1}}} + \mathrm{X_{rt}}\beta + \varepsilon_{\mathrm{rt}} \end{aligned} \tag{1}$$

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 the route in question. For entry events at time t_0, we constructed nine such dummy variables corresponding to $t_0 + \tau_{en}$ quarters, where τ_{en}=-4,…,0….+4. Similar to Ito and Lee (2004) 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 out of the four that meet the 3% threshold. Likewise, $SW\_exit_{r,t_0+\tau_{ex}}$ 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 surrounding entry and exit events for the group of LCCs other than Southwest.[1]

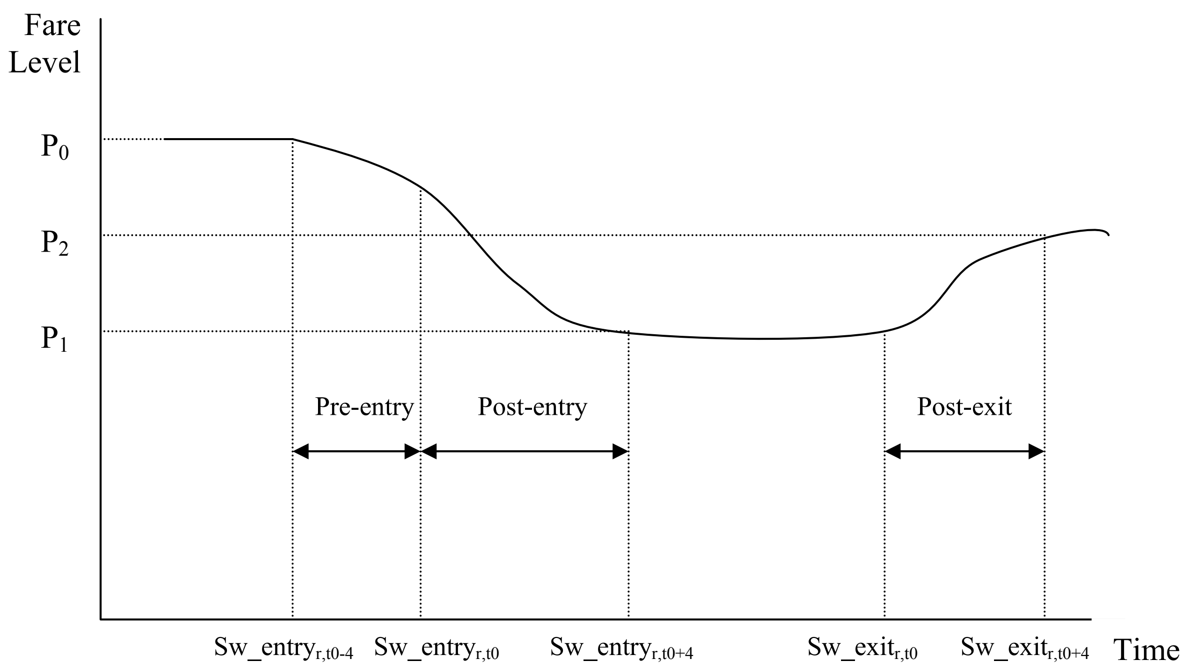

Figure 1 The Evolution of Airfares in Quarters Surrounding Entry and Exit Events

The pre-entry time dummy variables capture the price effects of pre-emptive actions by the incumbents before actual entry. Goolsbee and Syverson (2006) find that indeed 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 are rather motivated by the intention of the incumbents to increase loyalty, especially among business travelers.[2]

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[1] The LCCs included in the analysis are Air South, AirTran/ValueJet (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.

[2] While conceptually similar, their methodology differs from the model we propose in several ways. Given that their focus is the effect of potential competition they restrict the sample only to routes that at some point in time exhibited

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. A similar reasoning can be applied when explaining the use of time dummy variables for the post-exit periods. If indeed 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 of other LCCs includes route-quarters that were either never entered by LCCs or route-quarters that are observed at least five quarters before the entry occurs.

The Spatial Econometric Approach to Estimating Panel Data from the Airline Industry

Distance affects economic behavior and airline markets are no exception. Daraban and Fournier (2006) show how route level fare data on 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 and Hays (2004)) 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 are no exception and therefore Elhorst (2003) extends the methodology of spatial econometrics to allow for the estimation of spatial panel data models. These models make use of all the advantages of panel data such as route-specific fixed effects and increased estimation efficiency while also incorporating the spatial dependence that may

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potential competition. Also they only use observations for the quarters up to three years before and after the quarter when potential competition starts.

exist among observations at each point in time. As in the case of cross-sectional data there are two ways in which spatial dependence can be modeled using spatial econometrics methods: through a spatial autoregressive process in the error term (a so called spatial error model – SEM) or by including a spatial autoregressive spatially lagged dependent variable (called a spatial autoregressive model - SAR).

In the case of spatial autocorrelation among the error terms equation 1 can be rewritten in stacked vector form[3] and with a different structure of the error term as:

$$\ln \mathrm{P_t} = \alpha + \delta_\mathrm{t} + \sum_{\tau_{en}=-4}^{4+} \beta_{\tau_{en}} \mathrm{SW\_entry}_{\mathrm{t_0}+\tau_{en}} + \sum_{\tau_{ex}=0}^{4+} \beta_{\tau_{ex}} \mathrm{SW\_exit}_{\mathrm{t_0}+\tau_{ex}} + \sum_{\tau_{en1}=-4}^{4+} \beta_{\tau_{en1}} \mathrm{LCC\_entry}_{\mathrm{t_0}+\tau_{en1}} + \sum_{\tau_{ex1}=0}^{4+} \beta_{\tau_{ex1}} \mathrm{LCC\_exit}_{\mathrm{t_0}+\tau_{ex1}} + \mathrm{X_t}\beta + \phi_\mathrm{t} \quad (2)$$

where $\phi_\mathrm{t} = \lambda \mathrm{W} \phi_\mathrm{t} + \varepsilon_\mathrm{t}; \mathrm{E}(\varepsilon_\mathrm{t}) = 0; \mathrm{E}(\varepsilon_\mathrm{t}\varepsilon_\mathrm{t}^{'}) = \sigma^2 \mathrm{I_N}$ and W is the spatial weighting matrix.

The same equation can be rewritten with a spatially lagged dependent variable as follows:

$$\ln \mathrm{P_t} = \rho \mathrm{WP_t} + \alpha + \delta_\mathrm{t} + \sum_{\tau_{en}=-4}^{4+} \beta_{\tau_{en}} \mathrm{SW\_entry}_{\mathrm{t_0}+\tau_{en}} + \sum_{\tau_{ex}=0}^{4+} \beta_{\tau_{ex}} \mathrm{SW\_exit}_{\mathrm{t_0}+\tau_{ex}} + \sum_{\tau_{en1}=-4}^{4+} \beta_{\tau_{en1}} \mathrm{LCC\_entry}_{\mathrm{t_0}+\tau_{en1}} + \sum_{\tau_{ex1}=0}^{4+} \beta_{\tau_{ex1}} \mathrm{LCC\_exit}_{\mathrm{t_0}+\tau_{ex1}} + \mathrm{X_t}\beta + \varepsilon_\mathrm{t} \quad (3)$$

where $\mathrm{E}(\varepsilon_\mathrm{t}) = 0; \mathrm{E}(\varepsilon_\mathrm{t}\varepsilon_\mathrm{t}^{'}) = \sigma^2 \mathrm{I_N}$ and W is the spatial weighting matrix.

The parameters that differentiate the spatial models from the classical ones are ρ, the spatial autoregressive coefficient, and λ the spatial autocorrelation coefficient. These parameters measure the extent of spatial interdependence among prices in adjacent routes. They capture the intensity of the interdependence between the mean airfare in one route and the weighted average of mean airfares in adjacent routes, where the weights apply the distance decay. In the context of competition from low cost carriers, the autoregressive parameter will be larger for adjacent routes that are close substitutes for travelers, and it will impute a relatively larger price effect of low cost carriers 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 and it embodies the structure of the spatial linkages that exist among

[3] By stacked vector form, we mean that $\mathrm{LnP_t}$ is the R by 1 column vector of fares for the R routes at time t. Thus, the subscript r is suppressed in the equations throughout.

observational units.[4] 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[5], and

$w_{ij}=0$ if $i \neq j$ and routes *i* and *j* are not adjacent, or if $i=j$.

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.[6] 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 prices will be.[7]

Anselin (1999) discusses the distinction between the two approaches and argues that the spatial lag model is appropriate when the focus of interest is the assessment of the existence and strength of spatial interaction. Such a model accounts for substantial spatial dependence in the sense of being directly related to a spatial model, a model that incorporates regressors reflecting spatial competition. On the other hand, a spatial error model that incorporates spatial dependence in the regression disturbance term (referred to as nuisance dependence) is 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).

The estimation procedure proposed by Elhorst is based on maximizing the corresponding likelihood functions using a two-stage iterative procedure in the SAR version and for the spatial autoregressive model a simple two-stage procedure can be used. These procedures can be implemented using the Matlab routines available at www.spatial-econometrics.com.

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[4] For an exposition on the typology of spatial weight matrices see Anselin (1988).

[5] Two routes are considered adjacent if the distance between their end points 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.

[6] Driving time is a possible alternative to distance. Our preliminary results are qualititatively similar using driving time weights.

[7] 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." In addition, estimated savings reported below, are robust to models with linear distance weights.

4.The Empirical Analysis of the Incumbent's Response 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). 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 2,000 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.[8] 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)

The average fare for each route was calculated by summing the revenues obtained by all carriers in the route and dividing by the number of passengers that traveled in that market. 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. Additionally, the average fare charged by the legacy carriers alone will serve as a dependent variable in some of the estimated specifications. While route level average fares were calculated using all interline tickets, market shares of each carrier in each route are based on online tickets (as opposed to interline tickets) after assigning the smaller affiliate/regional carriers to the corresponding legacy carriers[9].

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[8] 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.

[9] For example, if the first coupon was flown by United Airlines and the second coupon was flown by Delta was not included in the calculation of market shares because there was no reasonable method to assign the ticket 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.

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 can not 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 (2005) 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.

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 2,000 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 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.

Figures 2a and 2b 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.

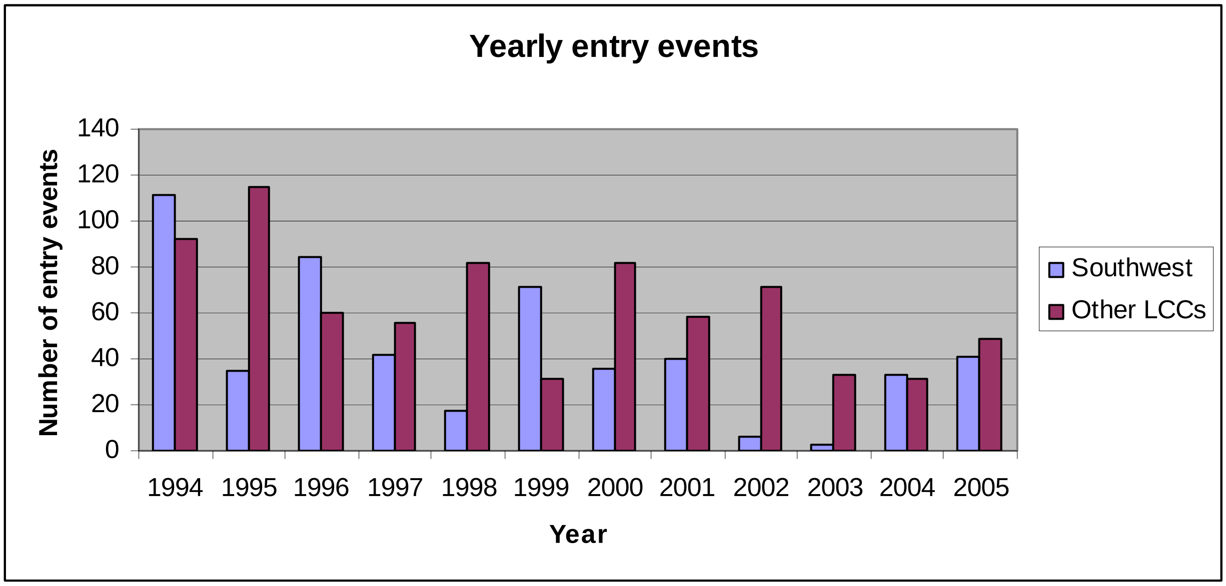

Figure 2a Yearly Number of Entries for Southwest and the other LCCs during 1994-2005

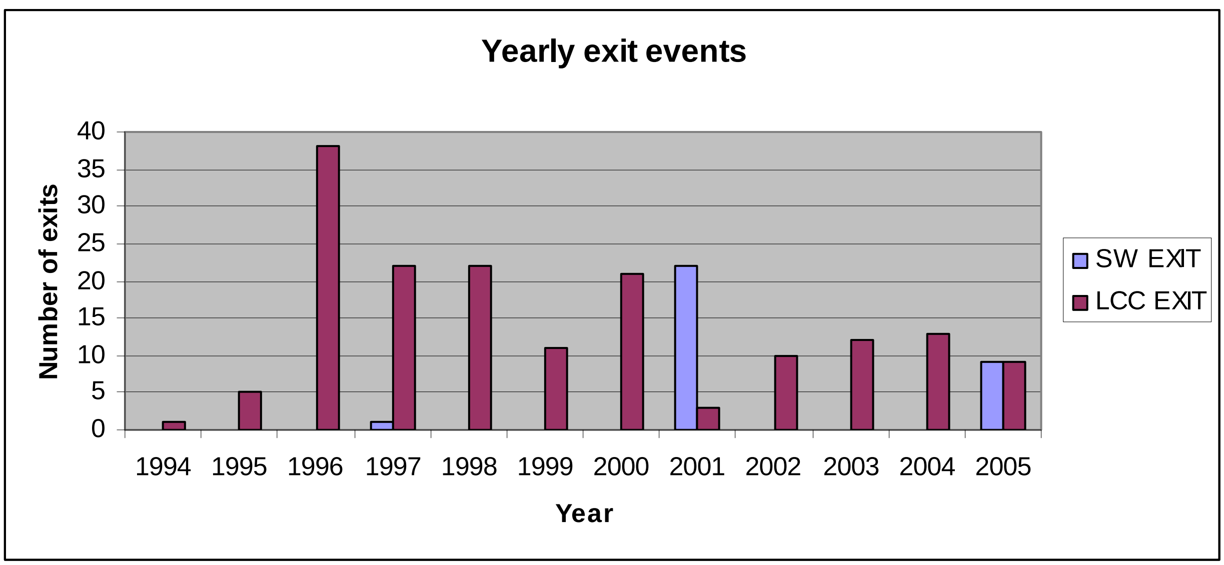

Figure 2b Yearly Number of Exits for Southwest and the other LCCs during 1994-2005

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:

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

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

$NSPROP_{rt}$ is the natural logarithm of the proportion of non stop 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 per capita income of the origin and destination metropolitan areas. The estimated coefficient on this variable is indeterminant: 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 the population 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 more dense routes.

5. Results

5.1 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 first column presents the results from the OLS estimation of the specification in (1) and using the full sample which contains the most traveled 2,000 in the year 2000. The dependent variable is the logarithm of the route level average fare (using fares from all carriers serving the route) and the independent variables are constructed as described above. 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 either where Southwest entry never occurs or else routes observed five or more quarters before entry. The estimation results show a small but significant decrease in average fares beginning four quarters before Southwest actually enters the route. Average fares are lower by about 3.5% to 6.7% over the four quarters preceding the actual entry event. One quarter before entry the difference grows to 6.7% but the most significant drop in airfares takes place in the quarter when entry occurs. At that point fares are lower by 18.6% compared to the reference category and continue to drop in the post entry quarters until they stabilize at a level that is about 23.3% lower and persisting four quarters and more after the entry event.

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. After reaching a level that is 23.3% lower compared to five or more quarters before entry, starting with the quarter when Southwest exits the route, airfares rebound and stabilize at a level that is 13% lower. The estimated mean effects on airfares in time periods surrounding entry and exit events for Southwest is illustrated in Figure 3.

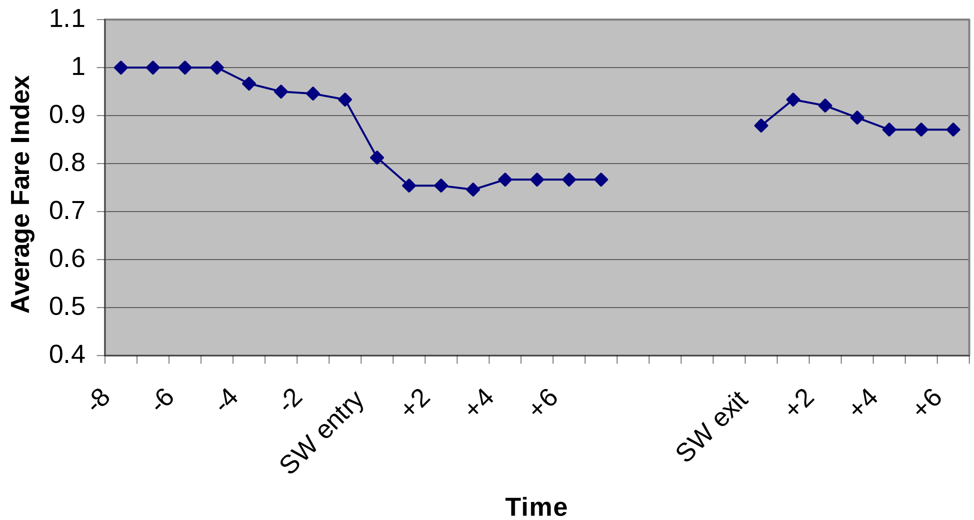

Figure 3 The Effect of Southwest Entry and Exit on Average Route Level Airfares

The estimates 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. While still significant the magnitude of the pre-entry coefficients is much smaller than in the case of Southwest. One quarter before entry, fares are only 3% lower compared to the reference category. At entry fares are almost 9% lower and continue to drop until they reach a level that is 13% lower. Unlike the case of Southwest, the decrease in price is completely offset once exit occurs. The coefficient estimates show that once the LCCs leave the market there is an initial average fare increase in airfares to a level that is 10% lower than the benchmark followed by further increases in the post exit quarters that lead to a level of only 1% below the benchmark. Figure 4 illustrates this pattern as well.

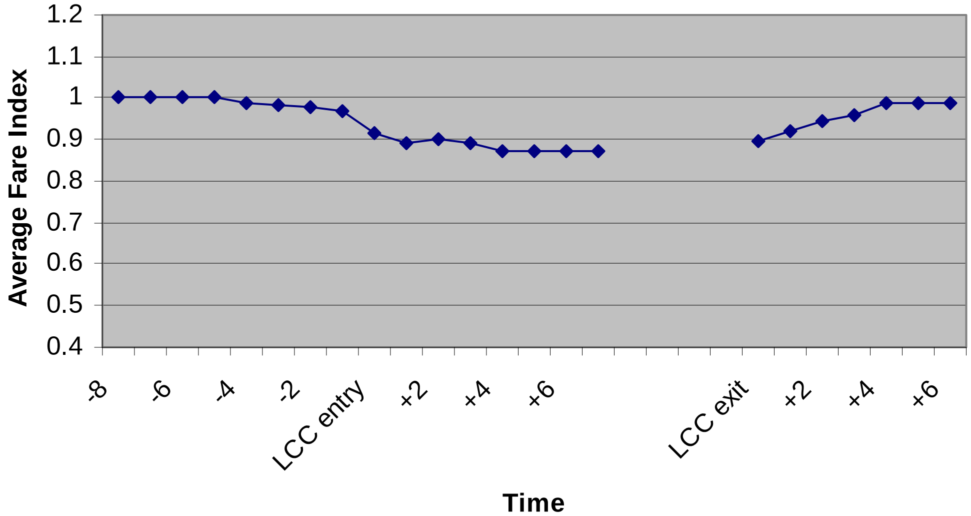

Figure 4 The Effect of LCC (other than Southwest) Entry and Exit on Average Route Level Airfares

The results presented above show the effect of LCC entry and exit on average fares calculated using the tickets issued by all the carriers serving the routes. A more interesting question however refers to the reaction of the incumbent legacy carriers[10] to LCC entry. Therefore we estimated the same specification as above using the log average fare charged by the incumbent legacy carriers. Not all routes in the 2,000 contained in the initial sample were served by legacy carriers. Thus the sample used in the second estimation contains 1,947 routes observed over the same time period (Q1 1994 – Q4 2005) which gives a total of 91,509 observations.

The estimation results are shown in the second column of Table 2. By examining the pre-entry coefficients we can now make inferences regarding the pre-emptive actions of incumbent airlines in the face of entry from LCCs. The estimates for the Southwest pre-entry period are similar to those obtained in the previous specification. Four quarters before Southwest entering

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

the route, legacy carriers cut fares by about 4% and then more down to 6.7% in the quarter preceding the actual entry. Still the bulk of the fare reduction by the incumbents takes place in the quarter of entry and afterwards. The airfares charged by the legacy carriers are 16% percent lower (compared to the reference category defined as above) when entry occurs and then they decrease by another 6%-7% in the post entry quarters and are on average 21% lower four and more quarters after entry.

This result is consistent with Goolsbee and Syverson (2006) 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%. While we do find a 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 however, as there are several elements that distinguish the Goolsbee and Syverson (2006) 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, the focus of their study is not given by actual entry events but by the threat of entry and therefore differences with the current study might be expected. Goolsbee and Syverson (2006) 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 second column of Table 2 also shows that in the quarter when Southwest exits a route the legacy carriers will raise their airfares to a level that is 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. Four or more quarters after the exit event fares will remain at about 11% lower compared to the base category.

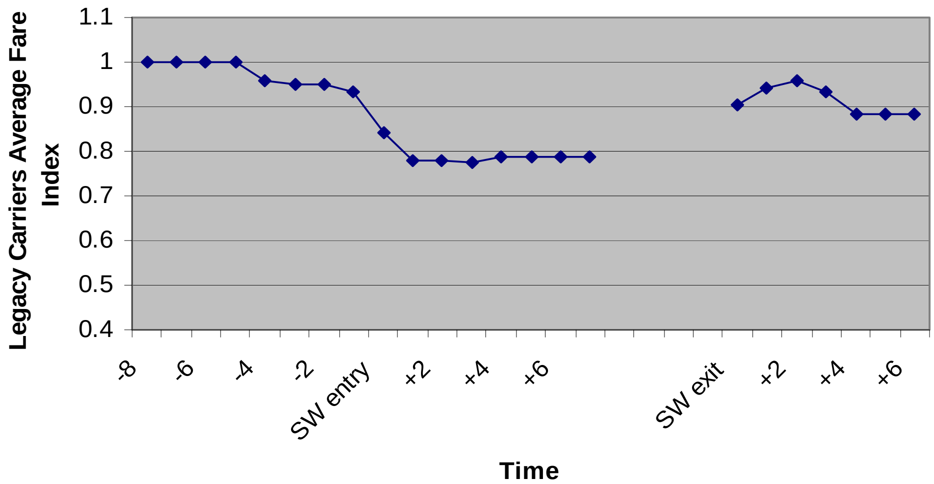

Figure 5 The Response of Legacy Carriers to Entry and Exit by Southwest

The second column of Table 2 also shows that incumbent legacy carriers also adjust the airfares that they charge in response to entry and exit by the other LCCs. No significant response is elicited however, before entry takes place. One quarter before entry the legacy carriers drop their fares by around 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 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 Airlines. Just like in the previous specification when all fares were used in the calculation of the dependent variables, once exit occurs the legacy carriers bring their fares up to the pre-entry level.

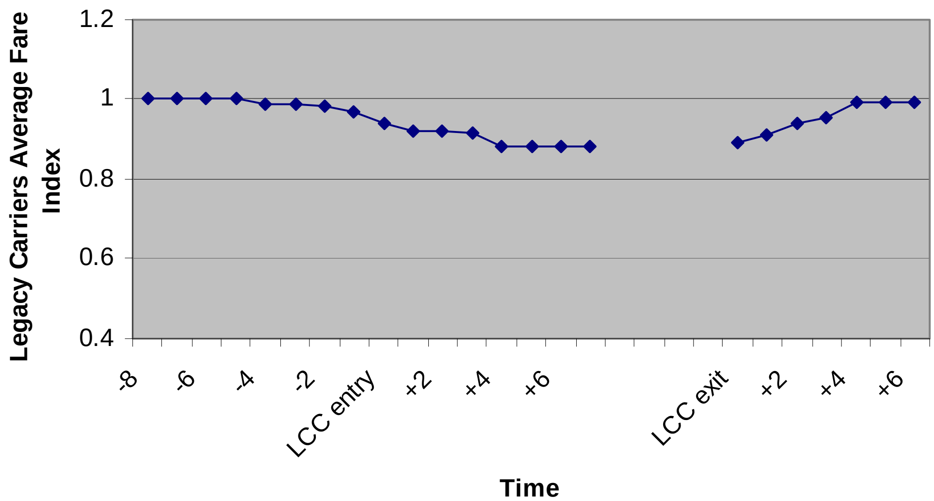

Figure 6 The Response of Legacy Carriers to Entry and Exit by Other LCCs

5.2 Estimation Results from the SAR Model

Column (3) in Table 2 shows the estimation results for the spatial autoregressive model specification. As expected, the spatial autoregressive coefficient ρ is positive and highly significant, confirming the hypothesis that airfares in adjacent routes are correlated.

The SAR and OLS specification yield very 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 et al (2004) show that the marginal effects of the explanatory variables are not give simply by the β coefficients but by the following term $(I- \rho W)^{-1} \beta$ where I is the identity matrix, W is the spatial weighting matrix and β the estimate on the variable for which the marginal effect is being calculated. Therefore simply comparing the estimates of the SAR and OLS specifications would not be relevant.

5.3 Estimating the Savings to Travelers from 1994 to 2004

The estimation results from the SAR specification can be used in the assessment of the aggregate effects of LCC's. Point estimates from columns (1) and (2) in Table 2 can be employed to predict the savings to travelers attributed to the LCCs over the sample period . The predictions compare the OLS and SAR estimation results where the route level average fare calculated using fares charged by all carriers was used as the dependent variable.

Two questions can be asked in order to reveal the welfare effects of LCC entry. First, by how much did entry by 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. While the first question focuses exclusively on the effects of new entry over the period from the fourth quarter of 1994 to the fourth quarter of 2004[11], 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:

$$\frac{\Delta P_{rt}}{\Delta SW_{rt}} = (I_N - \rho W)^{-1} \sum_{\tau_{en}=-4}^{4+} \beta_{\tau_{en}} Diag(SW\_entry_{r,t_0+\tau_{en}}) \tag{19}$$

where $Diag(SW\_entry_{r,t_0+\tau_{en}})$ are rxr 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.[12]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 6a and 6b show the calculated amounts of savings expressed in billions of dollars for each year of the sample period, obtained using the OLS and the SAR specifications. These tables reveal the 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.

[11] Although data were available starting from 1993 to 2006 as explained in the text several quarters at the beginning and at the end of the period had to be dropped in order to ensure that the entry and exit events are correctly defined.
[12] In order to obtain the savings attributed to entry events that took place during the sample period the summation over the elements of the marginal effects matrix is done only for the appropriate routes.

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 amount to about 10% 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.

However, it is also important to recognize that the structure of spatial linkages among observational units is exogenously imposed and different choices for the spatial weights might lead to different results. The results presented so far were based on spatial models that used the inverse squared distances between observational units as weights in the spatial lag term. Alternatively, the estimation of the spatial models can be performed using the inverse distance between adjacent routes as weights. This choice would be consistent with a scenario in which the cost of substituting between adjacent routes is equal to the time costs plus other factors that are proportional to distance. The main implication of using inverse distance weights as opposed to inverse distance squared weight is that routes that are farther apart are penalized less and a broader scope is allowed for the spatial dependence effect.

Column (3) in Table 5 shows the estimation results for an SAR specification with spatial weights based on the linear inverse distance. While the point estimates are very similar to those in column (2) (based on inverse squared distance), the estimated spatial autoregressive parameter ρ is smaller (.276 compared to .457). Allowing the spatial effects to decay less rapidly increases the spatial weights, but decreases the estimated spatial correlation. To highlight the effects of specifying different spatial weights, Table 7 presents the savings attributed to Southwest Airlines using the point estimates from the specification based on inverse distance weights. It can be noted that the direct effects do not change, given that the point estimates are very similar. However, the estimated indirect effects are more than double than in the case of the inverse distance weights. When a slower decay in the intensity of the spatial dependence is imposed, the spatial weights are increased and the estimated spatial correlation coefficient decreases and the resulting overall effects is an increase in the estimated indirect effects. Thus while the choice of the spatial weights does not affect the point estimates, the results of aggregate assessments of the indirect effects are sensitive to the manner in which the spatial dependence is modeled by the weighting matrix.

5.4 Incumbent Responses Before and After 9/11

The events of 9/11 represent an important landmark in the evolution of the US airline industry. The legacy airlines were severely hurt by the effects of the economic recession in the US at the time, that were greatly amplified by the complications of terrorist threats.. As before in times of financial distress for the legacy carriers, market conditions became more favorable to new entry. By 2001, the legacy carriers had been exposed to multiple LCC entry episodes and were better informed about their potential to compete. Therefore, an interesting hypothesis concerns changes in the competitive interaction of carriers after 9/11. In order to identify differences in the response of the incumbent carriers before and after 9/11 we constructed a dummy variable that equals one for the time periods that precede 9/11 and interacted it with the variables of interest. Results presented in Table 3 are similar to specification (1) with the interaction terms added. These results show that the incumbent legacy carriers did not respond differently to Southwest entry before and after 9/11. The only exceptions are the periods three and four or more quarters after entry. The corresponding coefficients are negative and significant suggesting that before 9/11 the long term effects of Southwest entry were more pronounced than after 9/11. After 9/11 fare charged by the incumbent carriers four or more quarters after entry were 17% lower while during the pre-9/11 period the competitive effect of Southwest amounts to 26%.

The change in the response of the incumbents between the two periods is more predominant for the entry of the other LCCs. All coefficients on the pre and post entry periods for the other LCCs are positive and statistically significant at the 1% level starting with three quarters prior to entry. Therefore we conclude that after 9/11 the response of the incumbent legacy carriers the entry of the other LCCs is larger in magnitude than before 9/11. The estimates on the interaction terms for the other LCCs indicate that for the most part the pre-9/11 effect was 5% lower than the post-9/11 effect. A possible explanation could be that historically the LCCs thrived during periods of distress for the legacy carriers. Recessions such as that of the early 2000's can create a favorable environment for new entry due to more favorable terms in the acquisition of resources such as aircraft, personnel and even slots and gates. As a result the legacy carriers are facing strong competition from the new entrants and might be forced to respond more aggressively. These results should however be interpreted with caution given the relatively short post-9/11 period covered by our sample. While our results suggest that indeed incumbents responded differently to the entry of other LCCs in the post-9/11 period further investigation is needed to understand how the 9/11 events affected the U.S. airline industry.

6. Implications for Incumbent Responses

6.1 The Nature of the Pre-emptive Actions of the Incumbent Legacy Carriers

In the light of the results presented above we can now attempt to answer the questions posed in the introductory section. First of all, can we say anything with regards to the nature of the pre-emptive actions of the incumbent carriers in the wake of LCC entry? While statistically significant, the price drops in the incumbents' airfares 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. 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. Therefore theoretically 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 (count includes only first entries) 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. The results from estimating a specification for which the flagged entry quarter coincides with the first quarter in which the LCCs issue tickets show that even after including only those routes for which the entry event can be defined with more certainty the pre-entry coefficients for Southwest are still negative and significant which indicates that incumbent carriers do act pre-emptively and do reduce fares. Given that we are examining routes where entry does occur such behavior can not be interpreted as entry deterrence. More likely, the rationale behind the preemptive fare cuts is to induce loyalty among consumers before the new entrant comes in.[13]Besides reputation

[13] This interpretation was pointed out in a similar context in Goolsbee and Syverson (2006).

effects, important fare cuts could also facilitate the use of frequent flier programs to lock in consumers and increase switching costs. It should be noted however that the pre-emptive 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 pre-emptively in anticipation of LCC entry. The coefficients on the time dummies for the quarters preceding entry by the other LCCs are statistically significant but very small, yielding a decrease in fares of up to 3% one quarter before entry. Again, the results are not affected when only those routes are included for which defined entry coincides with the first occurrence in the market. The difference in the incumbent reactions might be given by the fact that the LCCs other than Southwest are not perceived as a serious threat and therefore important fare reductions are not needed. A similar conclusion can be reached after analyzing the post-entry evolution of the airfares charged by the incumbent carriers.

6.2 The Post-entry Response of the Incumbents

The coefficients on the post-entry time dummies are all negative and statistically significant. As illustrated in Figures 2 through 6 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.

6.3 The Post-Exit Response of the Incumbents

The coefficients on the post exit time dummy variables suggest that when Southwest exits a route, the airfare trend is reversed. The incumbent carriers increase airfares to a level where almost half the drop that occurred at entry is being offset. Consequently, Southwest's presence in a route creates a mechanism through which a new lower equilibrium airfare is reached even after Southwest exits the route. On the other, interestingly enough, when the other LCCs exit a route, all of the competitive effect that they exercised at entry is being offset by the incumbents who 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' response is 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 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 called $exit\_SW_r$ and $exit\_LCC_r$ 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 the estimation 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.

6.4 Relation to other Studies

Numerous studies have confirmed that the low cost carriers (LCCs) have the ability to considerably reduce airfares in the markets where they operate and beyond. Most studies have used cross sectional snapshots of the industry to investigate the difference in fares between routes with and without LCCs at different points in time. Work by Dresner et al. (1996), Windle and Dresner (1999), Morrison (2001), Ito and Lee (2004) presents compelling evidence that on average travelers on routes served by LCCs benefit from airfares that are considerably lower than those charged in routes where LCCs do not operate. Morrison (2001) estimates that in 1998 fares were 46% lower on routes served by Southwest, Ito and Lee (2004) calculate that from 1991 to 2002 the airfares charged by the new LCC entrants were on average 49.5% lower than those of the incumbents, while Daraban and Fournier (2006) showed that in 2004 airfares were 30% lower in routes served by LCCs.

Despite the availability of data only a few studies take a longer view of the industry and consider the dynamic effects of the LCCs. Windle and Dresner (1995) investigate the short and long-run effects of LCCs on route level airfares. For a selected sample of routes they look at the evolution of market concentration as measured by the Herfindahl Index, average fares and passenger traffic, four quarters before and after entry occurs as well as in the period surrounding exit events. The authors perform the analysis for three types of carriers (pre-deregulation carriers, Southwest and other new carriers (post-deregulation)) and find evidence that the entry of Southwest Airlines had the largest effect on all route level indicators. In routes entered by Southwest, the Herfindahl Index declined by 25% in the first quarter after entry, while the decreases associated with entry by the other carriers and the legacy carriers were 16% and 11% respectively. Similarly, upon entry by Southwest, average fares decreased by 52% by the first quarter after entry and remained at about the same level even four quarters after entry. On the other hand entry by the other new carriers was associated with an 18% by the fourth post-entry quarter, while four quarters after the entry of the pre-deregulation carriers, airfares were 5% lower compared to the pre-entry quarter. As expected the evolution of airfares is translated into a similar pattern for the levels of passenger traffic. Also evidence is presented with respect to the pre-entry period. Airfares are found to decline by about 5% prior to Southwest's entry and by almost 10% prior to the entry of the new carriers, while in the wake of entry by the post-deregulation carriers fares are basically unchanged. In analyzing the exit events, the authors group all types of carriers together and conclude that exit has little effect on fares and passenger levels. Given the descriptive nature of their analysis which does not control for other effects that might affect the constructed indicators, the authors also estimate an empirical model trying to explain variation in route level airfares. They construct dummy variables for all quarters and all carriers, which does not allow them to estimate the pre-entry and post entry effects of entry.

A similar approach is taken by Goolsbee and Syverson (2006) who examine the evolution of airfares in quarters surrounding the establishment of Southwest as a potential competitor in a route. Thus, they focus on incumbents' responses to threats of entry as opposed to actual entry.

One of the inherent difficulties in the empirical analysis of potential competition has to do with defining potential competition. Goolsbee and Syverson consider Southwest Airlines to be a potential competitor on a certain route when it already operates out of one endpoint airport and starts serving the other endpoint of the route in question but not the route itself. For example suppose Southwest flies out of Jacksonville, FL but not out of Boston, MA. Then if it starts service out of Boston, MA and it does not fly the Jacksonville-Boston route there will be a high probability of offering the route in the near future and therefore it can be considered a potential competitor in the route. Using this definition for threat of entry Goolsbee and Syverson select a sample of routes that at some point between 1993 and 2004 exhibit potential competition from Southwest airlines. Quarterly data on carrier specific average fares and capacity for these routes are then used to analyze a 24 quarter/six year time window surrounding the quarter in which Southwest becomes a potential competitor as defined above. The main finding is that incumbents preemptively cut prices once Southwest Airlines starts threatening to enter a route. More precisely, "about half the total price effect takes place before Southwest ever actually starts flying." The authors also investigate the nature of this preemptive action. They find that pre-emptive price cuts take place almost exclusively in concentrated markets and that incumbents do not strategically invest in excess capacity. Moreover an analysis of routes where Southwest begins direct service without first being a potential competitor reveals a "pricing behavior similar to that in the benchmark specification". Since preemptive price cuts occur in routes where entry can not be deterred the authors conclude that incumbents' motivation is not entry deterrence but accommodation. Finally, in the search for evidence that the incumbents' motivation to act preemptively is to ensure consumer loyalty before entry occurs, the authors classify and analyze separately leisure and business intensive routes. The estimates of price cuts are larger for business intensive routes. This suggests that indeed the pre-emptive price 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 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.

7. Conclusions

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 legacy carriers choose to pre-emptively cut fares even if entry can not be stopped gives credence to the idea that the pre-entry fare decreases are not motivated by intentions of entry deterrence but 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, these results are not 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) is accumulated after entry occurs. Also, the adjustment process takes place fairly rapidly as fares reach the new equilibrium one or two quarters after entry.

As expected, 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 can not be interpreted as support of the allegations of predatory conduct on behalf of the legacy airlines, but rather as normal competitive price adjustments. Moreover our evidence rejects the hypothesis that the post-entry response of the legacy airlines is larger in routes where exit occurs.

The estimation of the SAR specification confirms that spatial autocorrelation exists in the route level data on the airline industry. While correcting for spatial dependence does not substantially affect the point estimates, 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 on the airline industry. Moreover we show that while not relevant for the point estimates, the specification of the spatial weight is essential in the assessment of welfare effects. Models of Southwest find total effects and indirect effects of $4.3 billion and $445 million, respectively, when spatial weights are the inverse squared distance, weightsthat imply a rapid decay of the spatial effects. In contrast, with spatial weights based oninverse distance, the estimated direct effects are unchanged, but the estimated indirect effects almost triple ($1.3 billion).

While the estimation results suggest that very important competitive effects of the LCCs in the U.S., they can not 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 especially Southwest have the potential to discipline airfares by exerting competitive pressures in the routes where they operate and in nearby routes. It should be noted however that although the presence of the LCCs is an essential determinant of the intensity of competition the current nature of their business model prevents them from being a panacea for the competition issues that often arise in the US airline industry.

Table 1 Summary Statistics for the Control Variables

Variable	Mean	Std Dev	Minimum	Maximum
Average_fare	165.71	57.11	60.1	548.20
Average_fare_legacy	172.36	57.10	0	856.4
HHI	5,234	2,416	1,094	9,243
Proportion of one way tickets	0.218	0.168	0	1
Proportion of non stop tickets	0.342	0.222	0	1
Income_origin	29,661.35	5,825.29	11,693	53,415
Population_origin	3,802,641	4,431,870.6	39,516	18,754,585
Income_destination	29,471	6,349	10,578	53,415
Population_destination	3,273,884	3,670,372	55,059.25	18,754,585
American Airlines	0.501	0.500	0	1
Continental	0.355	0.478	0	1
Delta	0.607	0.488	0	1
Northwest	0.349	0.476	0	1
United	0.387	0.487	0	1
US Airways	0.354	0.478	0	1
Alaska Airlines	0.037	0.189	0	1

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

Variable	(1) OLS All fares	(2) OLS Legacy fares	(3) SAR Legacy fares	Variable	(1) OLS All fares	(2) OLS Legacy fares	(3) SAR Legacy fares
SW_entry(-4)	-0.035 (0.006)	-0.040 (0.007)	-0.039 (0.005)	LCC_entry(-4)	-0.012 (0.005)	-0.010 (0.005)	-0.007 (0.004)
SW_entry(-3)	-0.051 (0.006)	-0.050 (0.007)	-0.049 (0.006)	LCC_entry(-3)	-0.017 (0.005)	-0.012 (0.005)	-0.011 (0.004)
SW_entry(-2)	-0.055 (0.006)	-0.051 (0.007)	-0.051 (0.066)	LCC_entry(-2)	-0.020 (0.005)	-0.018 (0.005)	-0.016 (0.003)
SW_entry(-1)	-0.067 (0.006)	-0.067 (0.006)	-0.066 (0.006)	LCC_entry(-1)	-0.032 (0.005)	-0.032 (0.005)	-0.028 (0.003)
SW_entry(0)	-0.186 (0.006)	-0.159 (0.007)	-0.159 (0.006)	LCC_entry(0)	-0.084 (0.005)	-0.062 (0.005)	-0.058 (0.004)
SW_entry(+1)	-0.245 (0.006)	-0.220 (0.006)	-0.218 (0.006)	LCC_entry(+1)	-0.107 (0.005)	-0.081 (0.005)	-0.079 (0.004)
SW_entry(+2)	-0.247 (0.006)	-0.222 (0.007)	-0.219 (0.006)	LCC_entry(+2)	-0.101 (0.005)	-0.081 (0.005)	-0.078 (0.004)
SW_entry(+3)	-0.256 (0.006)	-0.225 (0.007)	-0.221 (0.006)	LCC_entry(+3)	-0.107 (0.005)	-0.084 (0.005)	-0.078 (0.004)
SW_entry(4+)	-0.233 (0.003)	-0.213 (0.003)	-0.211 (0.003)	LCC_entry(4+)	-0.130 (0.002)	-0.120 (0.002)	-0.110 (0.002)
SW_exit(0)	-0.120 (0.024)	-0.097 (0.027)	-0.066 (0.023)	LCC_exit(0)	-0.105 (0.010)	-0.107 (0.011)	-0.101 (0.010)
SW_exit(+1)	-0.068 (0.028)	-0.060 (0.031)	-0.025 (0.023)	LCC_exit(+1)	-0.079 (0.010)	-0.089 (0.011)	-0.082 (0.010)
SW_exit(+2)	-0.081 (0.028)	-0.043 (0.031)	-0.010 (0.025)	LCC_exit(+2)	-0.056 (0.010)	-0.061 (0.011)	-0.055 (0.009)
SW_exit(+3)	-0.103 (0.028)	-0.066 (0.031)	-0.059 (0.025)	LCC_exit(+3)	-0.039 (0.010)	-0.046 (0.011)	-0.039 (0.008)
SW_exit(4+)	-0.130 (0.010)	-0.115 (0.010)	-0.103 (0.010)	LCC_exit(4+)	-0.011 (0.004)	-0.005 (0.004)	-0.001 (0.0004)
N	2,000	1,947	1,947	N	2,000	1,947	1,947
ρ	-	-	.445 (.006)	ρ	-	-	.445 (.006)

Table 3 Pre-entry, post-entry and post-exit effects of Southwest Airlines and the other LCCs before and after 9/11

SW_entry(-4)	-0.033 (0.016)	**SW_entry(-4) Pre9/11**	-0.008 (0.018)	**LCC_entry(-4)**	-0.022 (0.011)	**LCC_entry(-4) Pre9/11**	0.020 (0.013)
SW_entry(-3)	-0.041 (0.016)	**SW_entry(-3) Pre9/11**	-0.013 (0.018)	**LCC_entry(-3)**	-0.032 (0.010)	**LCC_entry(-3) Pre9/11**	0.030 (0.012)
SW_entry(-2)	-0.055 (0.016)	**SW_entry(-2) Pre9/11**	0.0004 (0.018)	**LCC_entry(-2)**	-0.056 (0.010)	**LCC_entry(-2) Pre9/11**	0.057 (0.012)
SW_entry(-1)	-0.081 (0.015)	**SW_entry(-1) Pre9/11**	0.013 (0.016)	**LCC_entry(-1)**	-0.064 (0.009)	**LCC_entry(-1) Pre9/11**	0.050 (0.011)
SW_entry(0)	-0.186 (0.015)	**SW_entry(0) Pre9/11**	0.017 (0.017)	**LCC_entry(0)**	-0.098 (0.010)	**LCC_entry(0) Pre9/11**	0.053 (0.011)
SW_entry(+1)	-0.224 (0.015)	**SW_entry(+1) Pre9/11**	-0.013 (0.017)	**LCC_entry(+1)**	-0.120 (0.010)	**LCC_entry(+1) Pre9/11**	0.055 (0.012)
SW_entry(+2)	-0.225 (0.016)	**SW_entry(+2) Pre9/11**	-0.017 (0.018)	**LCC_entry(+2)**	-0.122 (0.010)	**LCC_entry(+2) Pre9/11**	0.057 (0.012)
SW_entry(+3)	-0.209 (0.015)	**SW_entry(+3) Pre9/11**	-0.040 (0.017)	**LCC_entry(+3)**	-0.112 (0.009)	**LCC_entry(+3) Pre9/11**	0.043 (0.011)
SW_entry(4+)	-0.174 (0.003)	**SW_entry(4+) Pre9/11**	-0.093 (0.002)	**LCC_entry(4+)**	-0.139 (0.002)	**LCC_entry(4+) Pre9/11**	0.048 (0.002)
SW_exit(0)	-0.113 (0.036)	**SW_exit(0) Pre9/11**	-0.002 (0.053)	**LCC_exit(0)**	-0.038 (0.020)	**LCC_exit(0) Pre9/11**	-0.074 (0.023)
SW_exit(+1)	-0.063 (0.031)	**SW_exit(+1) Pre9/11**	0.055 (0.150)	**LCC_exit(+1)**	-0.057 (0.019)	**LCC_exit(+1) Pre9/11**	-0.021 (0.023)
SW_exit(+2)	-0.044 (0.031)	**SW_exit(+2) Pre9/11**	0.006 (0.151)	**LCC_exit(+2)**	-0.028 (0.020)	**LCC_exit(+2) Pre9/11**	-0.023 (0.023)
SW_exit(+3)	-0.066 (0.031)	**SW_exit(+3) Pre9/11**	0.001 (0.151)	**LCC_exit(+3)**	-0.014 (0.019)	**LCC_exit(+3) Pre9/11**	-0.023 (0.023)
SW_exit(4+)	-0.111 (0.010)	**SW_exit(4+) Pre9/11**	0.024 (0.148)	**LCC_exit(4+)**	0.012 (0.005)	**LCC_exit(4+) Pre9/11**	-0.028 (0.005)

Table 4 Estimated coefficients on the control variables

Variable	(1) OLS All fares	(2) OLS Legacy fares	(3) SAR Legacy fares
log(HHI)	0.087 (0.002)	0.079 (0.002)	0.081 (0.002)
% one-way	-0.079 (0.004)	-0.011 (0.005)	-0.001 (0.002)
% non-stop	-0.341 (0.006)	-0.299 (0.007)	-0.285 (0.006)
income	0.361 (0.026)	0.420 (0.029)	0.305 (0.027)
population	0.286 (0.016)	0.227 (0.018)	0.205 (0.017)
AA	0.032 (0.002)	0.017 (0.002)	0.016 (0.001)
AS	-0.013 (0.008)	-0.035 (0.008)	-0.039 (0.005)
CO	0.008 (0.001)	-0.009 (0.001)	-0.007 (0.001)
DL	0.001 (0.001)	-0.009 (0.002)	-0.006 (0.001)
NW	0.006 (0.001)	0.0005 (0.001)	0.0002 (0.001)
UA	0.027 (0.002)	0.018 (0.002)	0.018 (0.002)
US	0.012 (0.002)	-0.004 (0.002)	-0.002 (0.001)
N	2,000	1,947	1,947

Table 5 Point Estimates Used in the Calculation of Savings Attributed to LCCs

Variable	OLS All fares	SAR (inverse squared distance) All fares	SAR (inverse distance) All fares
	(1)	(2)	(3)
SW_entry(-4)	-0.035	-0.033	-0.033
	(0.006)	(0.006)	(0.006)
SW_entry(-3)	-0.051	-0.049	-0.048
	(0.006)	(0.005)	(0.006)
SW_entry(-2)	-0.055	-0.053	-0.052
	(0.006)	(0.005)	(0.006)
SW_entry(-1)	-0.067	-0.065	-0.063
	(0.006)	(0.005)	(0.006)
SW_entry(0)	-0.186	-0.185	-0.184
	(0.006)	(0.006)	(0.006)
SW_entry(+1)	-0.245	-0.243	-0.241
	(0.006)	(0.006)	(0.006)
SW_entry(+2)	-0.247	-0.244	-0.241
	(0.006)	(0.006)	(0.006)
SW_entry(+3)	-0.256	-0.252	-0.249
	(0.006)	(0.006)	(0.006)
SW_entry(4+)	-0.233	-0.231	-0.229
	(0.003)	(0.002)	(0.003)
LCC_entry(-4)	-0.012	-0.009	-0.008
	(0.005)	(0.005)	(0.005)
LCC_entry(-3)	-0.017	-0.015	-0.015
	(0.005)	(0.003)	(0.005)
LCC_entry(-2)	-0.020	-0.017	-0.016
	(0.005)	(0.005)	(0.005)
LCC_entry(-1)	-0.032	-0.028	-0.027
	(0.005)	(0.005)	(0.005)
LCC_entry(0)	-0.084	-0.080	-0.080
	(0.005)	(0.005)	(0.005)
LCC_entry(+1)	-0.107	-0.103	-0.103
	(0.005)	(0.005)	(0.005)
LCC_entry(+2)	-0.101	-0.097	-0.096
	(0.005)	(0.005)	0.005)
LCC_entry(+3)	-0.107	-0.101	-0.100
	(0.005)	(0.005)	(0.005)
LCC_entry(4+)	-0.130	-0.119	-0.118
	(0.002)	(0.002)	(0.002)

Table 6.a Estimated Savings Attributed to Southwest Airlines (in billions of dollars)

	OLS			SAR (inverse squared distance weights)			
Year	**Total effects Southwest, all entries**	**Total effects Southwest, 1994-2004 entries**		**Direct effects of Southwest, all entries**	**Total effects of Southwest, all entries**	**Direct effects of Southwest, 1994-2004 entries**	**Total effects of Southwest, 1994-2004 entries**
1995	1.773	0.278		1.780	2.087	0.277	0.456
1996	2.036	0.473		2.042	2.386	0.470	0.680
1997	2.439	0.713		2.441	2.839	0.707	0.954
1998	2.737	0.903		2.736	3.159	0.893	1.157
1999	3.173	1.179		3.170	3.643	1.166	1.464
2000	3.777	1.548		3.772	4.316	1.531	1.872
2001	3.546	1.521		3.539	3.999	1.503	1.779
2002	3.364	1.486		3.356	3.767	1.469	1.707
2003	3.515	1.567		3.504	3.915	1.547	1.782
2004	3.847	1.781		3.835	4.282	1.758	2.015

Table 6.b Estimated Savings Attributed to LCCs other than Southwest (in billions of dollars)

	OLS			SAR (inverse squared distance weights)			
Year	**Total effects of the other LCCs, all entries**	**Total effects of the other LCCs, 1994-2004 entries**		**Direct effects of the other LCCs, all entries**	**Total effects of the other LCCs, all entries**	**Direct effects of the other LCCs, 1994-2004 entries**	**Total effects of the other LCCs, 1994-2004 entries**
1995	1.381	0.215		1.306	1.556	0.206	0.366
1996	1.631	0.412		1.537	1.827	0.388	0.579
1997	2.057	0.648		1.938	2.310	0.610	0.864
1998	2.451	0.935		2.317	2.787	0.889	1.223
1999	2.923	1.269		2.772	3.323	1.212	1.607
2000	3.622	1.739		3.449	4.145	1.673	2.180
2001	3.348	1.703		3.186	3.790	1.636	2.071
2002	3.237	1.731		3.078	3.637	1.658	2.058
2003	3.443	1.871		3.270	3.839	1.787	2.187
2004	3.721	2.048		3.532	4.137	1.955	2.383

Table 7 Estimated Savings Attributed to Southwest Airlines Using Inverse Distance Weights (in billions of dollars)

SAR (inverse distance weights)				
Year	**Direct effects of Southwest, all entries**	**Total effects of Southwest, all entries**	**Direct effects of Southwest, 1994-2004 entries**	**Total effects of Southwest, 1994-2004 entries**
1995	1.812	2.707	0.276	0.707
1996	2.076	3.072	0.470	0.977
1997	2.477	3.604	0.706	1.303
1998	2.775	3.967	0.893	1.523
1999	3.214	4.571	1.166	1.898
2000	3.823	5.389	1.530	2.371
2001	3.586	4.950	1.503	2.201
2002	3.399	4.618	1.469	2.072
2003	3.548	4.765	1.548	2.140
2004	3.881	5.199	1.758	2.403

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