Incumbent Responses to Lower Cost Entry: Evidence from the U.S. Airline Industry*

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Abstract

This paper analyzes the responses of incumbent hub-and-spoke carriers to low cost carrier (LCC) entry on routes served to and from their hubs over the past decade. Our analysis finds that the typical price and capacity response by incumbent hub-and-spoke carriers to LCC entry has been fairly accommodating. Moreover, our analysis also finds–somewhat surprisingly–that the likelihood of an LCC's entry into a hub market being successful is unrelated to the relative response of the incumbent.

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"Claims of predation are more credible when they involve not only price cuts, but also significant capacity increases or other changes in network operations by Incumbent."[1]

1 Introduction

The competitive confrontation between low cost carrier (LCCs) entrants and incumbent hub-and-spoke carriers has become a topic of widespread interest in the deregulated passenger airline industry, both in the U.S. and abroad (i.e. Forsyth 2003, Morrison 2001, Dresner, Lin, and Windle 1996).[2] Allegations of predatory conduct by incumbent carriers have caught the eyes of both U.S. policy makers and courts, the most notable incident being the recent case brought forth by the U.S. Department of Justice (DOJ) against American Airlines.[3] Moreover, in 1998, the U.S. Department of Transportation (DOT) issued tentative guidelines for evaluating whether incumbent hub-and-spoke carriers were engaged in "unfair exclusionary conducts."[4] In particular, the DOT statement asserted that "In recent years, when small, new-entrant carriers have instituted new low-fare service in major carriers' local hub markets, the major carriers have increasingly responded with strategies of price reductions and capacity increases not to maximize their own profits but rather to deprive the new entrants of vital traffic and revenues." This paper focuses on two main questions. Firstly, how aggressively have incumbent carriers responded to low-cost carrier entry over the past decade? Secondly, is there any relationship between the aggressiveness of an incumbent carrier's response to new LCC entry and the probability that the LCC will subsequently exit the market?

From an economic policy perspective, there appear to be two primary aspects of an incumbent's response to LCC entry that receive the majority of attention. The first area of concern revolves–not surprisingly–around the incumbent carrier's pricing behavior following entry. It has been common practice for incumbent carriers to match the fares offered by the new entrant LCC on a portion of its seats (Transportation Research Board 1999). And while the practice of "meeting competition" has been supported by notable economists (i.e. Baumol 1998) as well as U.S. courts,[5] others argue

[1] "Predation In the Airline Industry," Remarks by Roger W. Fones, Chief. Transportation, Energy, and Agricultural Section, Antitrust Division, U.S. Department of Justice, Before the American Bar Association Forum on Air and Space Law, Seattle, Washington June 12, 1997.

[2] In Canada, for example, Air Canada was recently charged by the Commissioner of Competition with predation following complaints by two low cost carriers, CanJet and WestJet. (See *Commissioner of Competition v. Air Canada*). Likewise, the Australian Competition and Consumer Commission (ACCC) recently charged Qantas with predation on the Adelaide–Brisbane route, where it faced entry by Virgin Blue. (See *Australian Competition and Consumer Commission v. Qantas Airway Limited,* In the Federal Court of Australia, New South Wales District Registry, No. N408, 2002). In Germany, the Bundeskartellamt recently issued an injunction against incumbent carrier Deutsche Lufthansa, requiring it to increase its fares on the Frankfurt-Berlin route following a price war that ensued after start-up carrier Germania entered the market. (See "Bundeskartellamt prohibits Lufthansa from hindering its rival Germania", BundesKartellamt press release, February 19, 2000).

[3] See *United States v.AMR Corp, American Airlines Inc., and AMR Eagle Holding Corporation*, Civil Action No. 99-1180-JTM, May 13, 1999.

[4] Department of Transportation, Office of the Secretary, *Docket No. OST-98-3713, Notice 98-16*, April 1998.

[5] See Memorandum and Order of Judge Thomas Marten, in *United States of America vs. American Airlines*, United States District Court for the District of Kansas, No. 99-1180-JTM.

that the price-matching response, more often than not, results in anti-competitive consequences (Edlin 2002).

The second primary concern revolves around the incumbent carriers' capacity decisions following LCC entry (or the announcement of planned entry). It has been observed that incumbent carriers often add additional flight frequencies or use larger aircraft on routes entered by low cost carriers (Transportation Research Board 1999), a practice that has been highly controversial. While Ordover and Willig (1998) argue that capacity additions by incumbents are economically rational and can be pro-competitive, Edlin and Farrell (2002) note that in the recent U.S. DOJ vs. American Airlines case, "The government claimed not that American's *prices* were predatory, but that its *expansion* of flight schedules–described as 'capacity increase'–was." Likewise, some industry observers in Canada (Lazar 2000) have suggested that "...Air Canada should not be allowed to... Increase frequencies and/or use larger capacity aircraft on routes where an entrant has announced an intention to start operating or has started flying."

In this paper, we analyze the price and capacity responses of incumbent hub-and-spoke carriers to LCC entry over the past decade in the U.S. domestic airline industry. We begin by documenting some stylized facts regarding the nature of LCC entry into hub markets, as well as the competitive response they have evoked from incumbent carriers. Using a relatively large sample of LCC entry events, we investigate how prevalent "aggressive" responses by incumbent carriers have been. Finally, and perhaps most importantly, we assess the degree to which the "aggressiveness" of an incumbent carrier's response impacts the probability of exit for a new entrant LCC using an probit exit model.

"Predatory behavior" is a controversial topic, both in industrial organization theory and its antitrust application. A predatory incumbent responds to an entrant by lowering its prices below its costs, thus forcing the entrant to endure financial losses and eventually exit the market. The source of theoretical contention often centers around the predator's rationale. The incumbent suffers financially from predating, but, a well-established incumbent may be able to sustain itself longer in a war of attrition if it has the a deeper purse than an entrant who may have more limited financial resources. Thus, the financial loss of successful predation is compensated by higher profits after the entrant exits. The promise of recoupment, however, depends on the assumption that no other entrants will threaten profitability immediately after the entrant's exit. Skeptics of predatory pricing date back to McGee (1958), who questioned the rationality of predatory conduct in comparison to other strategies such as mergers or acquisition. Milgrom and Roberts (1982) and Salonar (1987) employ models of asymmetric information where predatory action can be derived as the rational behavior of incumbents. In practice, although price wars following entry are commonly observed in many industries, questions often remain as to whether they reflect

the predatory conduct by incumbents. The Areeda and Turner (1975) Test employs a cost-based definition while Ordover and Willig (1981) propose more a general standard that takes into account preconditions of market structure and profitability.

We emphasize that our goal is not to determine whether or not incumbent carrier responses have or have not violated U.S. predatory pricing laws. Indeed, an analysis of this sort would require detailed, route-level cost data that is not publicly available. Rather, our goal is to document and empirically assess at more general level the patterns of incumbent capacity and price responses to LCC entry to determine whether or not there have been–as many have alleged–a pattern of aggressive incumbent responses to new entry over the past decade that may have hindered competition in the industry. We believe that such exercises are useful in assessing the applicability and usefulness of general rules or definitions for evaluating the "unfair exclusionary conduct" of incumbent carriers in the industry.

The paper most related to ours in the literature is that of Bamberger and Carlton (1999), which (among other things) compares the success rate of new entrant LCCs to those of major carriers in newly entered city-pair markets. As part of their analysis, Bamberger and Carlton (1999) also examine the responses of incumbent carriers to LCC entry into hub routes and find that the median response to LCC entry of the incumbents has been surprisingly modest.[6] While many of our results are consistent with those of Bamberger and Carlton (1999), our analysis differs from theirs in several important respects. First, while the sample of markets used to assess incumbent responses by Bamberger and Carlton (1999) was relatively small (39 suspected markets), our sample contains 370 entry events.[7] Second, whereas the response statistics reported by Bamberger and Carlton (1999) are independent of the LCC's level of entry, our results measure the level of response relative to both the incumbent's pre-entry service level as well as the LCC's magnitude of entry. This is an important distinction since a capacity response of 20% following LCC entry would have different competitive implications depending on whether the entrant had entered with–for example–5% of the incumbent's original capacity versus 50%. Finally, our analysis goes one step further by estimating a probit exit model to determine whether or not incumbent responses can be linked to an LCC's decision to exit a market.

In addition to Bamberger and Carlton (1999), there have also been a number of recent papers explicitly addressing issues related to predation in the airline industry. Eckert and West (2002), for example, compare the Canadian competition policy approach to predation with that of the U.S., while Edlin and Farrell (2002) provide a critical assessment of the recent Federal Court decision in

[6]For example, the authors find that incumbent carriers lowered their average fare by median value of 4.7% relative to their pre-entry levels on hub-markets entered by LCCs. Likewise, the authors found that the incumbents reduced the median number of seats offered by 1.2%.

[7]Bamberger and Carlton (1999) restrict their analysis to markets less than 750 miles that were entered by LCCs other than Southwest between May 1996 and the end of 1997.

the U.S. DOJ vs. American Airlines. A somewhat different–albeit related–segment of the literature analyzes the occurrence of price wars in the airline industry (Morrison and Winston 1995, Ross 1997, Busse 2002, Fournier and Zuehlke 2003). In general, these papers have focussed on defining precisely when price wars occur and better understanding the factors (i.e., multi-market contact, firm financial condition, etc.) leading to price wars.

In general, we find that the typical capacity response by incumbent carriers to LCC entry at their hubs–measured in terms of the percentage increase in available seats and/or flights–has been surprisingly modest. Indeed, in our sample of 370 hub markets entered by LCCs between 1991 and 2002, the incumbent introduced roughly 30% *fewer* seats and flights than the LCC entrant in the four quarters following the quarter of initial entry. Likewise, while the incumbent's average fare typically drops substantially following LCC entry, it falls on average by twenty-six percentage points less than the new entrant's average fare (relative to the incumbent's pre-entry average fare). We also find that incumbent capacity responses to LCC entry have varied widely across carriers. While Northwest and Alaska appear to be the most aggressive (in terms of capacity responses) to LCC entry, American and Continental appear to have the most restrained responses. In fact, both American and Continental reduced–on average–the number of seats offered in hub markets entered by LCCs. Finally, and perhaps most importantly, we find little evidence that the response of the incumbent carrier has any impact on the likelihood that an LCC's entry proves to be successful. In particular, when an LCC's "success" in a market is defined by whether or not it eventually exits that market, we find that the incumbent's relative capacity response is not an important explanatory factor. In terms of the incumbent's price response, our analysis find that sharp price cuts by the incumbent following LCC entry in fact *decrease* the probability of the LCC exiting the market.

The remainder of this paper is organized as follows. Section 2 outlines the data used in our analysis and documents some stylized facts about LCC entry and the responses they have evoked from incumbents over the past decade. In Section 3, we estimate LCC probit exit models. Concluding remarks are provided in Section 4.

2 Incumbent Responses to Low Cost Carrier Entry in the U.S. Airline Industry

Our analysis begins by documenting some stylized facts about the nature of LCC entry and the responses they have evoked from incumbent hub-and-spoke carriers over the past decade in the U.S. domestic airline industry.

2.1 The Data

Data on flight frequency and capacity for our analysis is taken from the U.S. DOT's domestic T100 database, which records monthly data on all flights completed by the large certified commercial carriers. Fare and passenger data for our analysis is taken from the DOT's OD1A database, a 10% sample of all domestic tickets.

Almost all predatory allegations involve the "hub" markets of incumbent carriers. Thus, we focus our attention on markets to and from major hub airports. More formally, our base data set is comprised of all non-directional airport-pair markets greater than 100 miles that (a) include the "hub" of at least one major hub-and-spoke carrier (Alaska, American, Continental, Delta, Northwest, United or US Airways) as one of its endpoints, and (b) were entered by one or more low cost carriers between 1991 and 2002.[8]

The set of low cost carriers we consider in our analysis are: Southwest, AirTran/ValuJet, Frontier, ATA, JetBlue, Spirit, Sun Country, Vanguard, ProAir, Western Pacific, Reno, Markair, Kiwi, Carnival, National and Air South.[9] Since the use of regional code-sharing partners has become increasingly important to the major carriers' hub-and-spoke systems over the past decade (especially following the introduction of regional jets), we also include flights operated by regional carriers that are wholly-owned or have exclusive (or near exclusive) code-sharing relationships with one of the major hub-and-spoke carriers.[10]

Since many low cost carriers have entered certain hub markets via service to alternative airports, we group airports in Dallas, Houston, Chicago and Detroit. In each of these four cities, carriers tend to serve–almost exclusively–only one of the two large commercial airports.[11] Since relative flight frequency is likely to be an important factor influencing competition between incumbents and entrants in most markets and since it is usually not practical for travellers to depart from and

[8]The hubs included in our analysis are: Alaska (Seattle), American (Chicago, Dallas, Miami), Continental (Cleveland, Houston, Newark), Delta (Atlanta, Cincinnati, Salt Lake City), Northwest (Detroit, Memphis, Minneapolis), United (Denver, Washington-Dulles, Chicago, San Francisco), US Airways (Charlotte, Philadelphia, Pittsburgh). We exclude America West from our set of incumbent carriers since their cost structure more closely resembles that of the LCCs than other major hub-and-spoke carriers.

[9]Our data for AirTran includes ValuJet's data, as AirTran was acquired by ValuJet in 1998 with ValuJet adopting AirTran's name. It is also important to note that all of the entry events in our sample have exclusively used "mainline" (i.e., larger than 100-seat) aircraft such as the Boeing 737, McDonald Douglas DC-9, or Airbus A319/320. Recently, Atlantic Coast Airlines–a large regional carrier–announced plans to convert its business model from regional code-sharing service to a "low cost carrier" model (Independence Air) using predominantly 50-seat regional jet aircraft. Since regional jet aircraft have much higher unit operating costs than the larger, narrow-body jets traditionally used by LCCs, some of our results may not apply to Independence Air's proposed entry.

[10]The regional carriers we include are: American Eagle and Executive Airlines (American), Continental Express/Express Jet (Continental), Comair and Atlantic Southeast (Delta), Horizon (Alaska), Mesaba (Northwest) and Air Wisconsin (United). While we were able to include many of the largest regional codesharing carriers, we note that there are a number of regional carriers that were not required to file in the DOT's T100 database during the period we study, such as Pinnacle Airlines (a Northwest Airlines subsidiary) or Atlantic Coast Airlines, which provides regional feed service for both Delta and United.

[11]For example, while both American and United have large hubs at Chicago's O'Hare airport, Southwest and ATA serve the Chicago area exclusively via Chicago's Midway airport.

return to different airports within the same metropolitan area, we want to ensure that we do not aggregate service in city-pairs where carriers may serve multiple airport-pairs. Consequently, in the other large metropolitan areas with multiple airports (i.e., Los Angeles, San Francisco, New York City and Washington, D.C.), we elected not to group airports together, as many carriers (both incumbent and low-cost) often serve more than one airport in the same metropolitan area.[12]

In our dataset, an entry event is a unique combination of market, incumbent and entrant. If there are two incumbents and one entrant in one market, we count two separate entry events in this market so that we can observe the responses of both incumbents. Since our data set encompasses thirteen years of data, it is possible for a given LCC to enter the same market more than once and such re-entry is counted as a separate entry event.[13]

From our base data set, we excluded markets where there were less than four quarters of pre-entry data for the incumbent carrier. Likewise, we excluded those markets in which there were less than four quarters of data following the LCC's entry. We also required that a carrier serve a market with at least twenty round-trips per month in order to be included. We define an entry event as four or more consecutive quarters of service by an LCC following at least four quarters where the LCC did not provide service in that market. While we recognize the possibility that there may be a number of legitimate entries where the LCC withdrew prior to serving an entire year, we wanted to minimize the impact of purely seasonal service.[14]

In total, our data set includes 370 unique entry events. Table 1 summarizes the number of entry events, according to incumbent carrier and LCC. Entry events in this table often cluster between specific LCCs and incumbent carriers (i.e, AirTran/Delta and Frontier/United) when these LCCs have established hubs of their own at pre-existing major carrier hub airports.

INSERT TABLE 1 HERE

Table 2 summarizes the distribution of the entry events in our data set by year.

INSERT TABLE 2 HERE

[12]The one exception we made was with regards to JetBlue's JFK based operations. In order to study the impact of JetBlue's entry on Continental's Newark based hub markets, we recoded each of JetBlue's JFK based flights as Newark based flights. We recognize that for antitrust purposes, the appropriate market definition is usually assumed to be city-pairs rather than airport pairs. However, for the purpose of our research questions, we felt that it was more important to use a smaller set of entry events by controlling for capacity choices in the manner described above. We acknowledge, however, that our approach does not fully account for all entry in some city-pairs markets involving hub cities such as Washington-Dulles, where there has been substantial entry by LCCs at neighboring Baltimore-Washington Airport (BWI).

[13]To account for the large-scale exit of markets by AirTran/ValuJet following the crash of Flight 592 in May 1996 and the temporary grounding of its fleet, we exclude AirTran/ValuJet observations for the third and fourth quarters of 1996 as well as the first quarter of 1997.

[14]To test the sensitivity of our results, we have performed all our analysis with another data set in which we require only two quarters of service for valid LCC entries. Neither the signs nor the magnitude of the estimated probit coefficients did changed significantly.

Eight carriers in our data set–Sun Country, Vanguard, ProAir, Western Pacific, Markair, Kiwi, Carnival, and Air South–declared bankruptcy during our sample period, while another–Reno–was acquired by American Airlines.[15]

2.2 Some Stylized Facts on LCC Entry and Incumbent Responses

Our first goal is to document some stylized facts regarding the entry behavior of the different LCCs in our sample. We begin by comparing the entrant's magnitude of entry relative to the incumbent's pre-entry service level (i.e., capacity and prices). Similarly, we compare the post-entry response of incumbents relative their own pre-entry service offerings.

We consider two common measures of a carrier's capacity: flight frequency and the number of available seats. In addition, we report both the average fare and the number of origin and destination (O&D) passengers as price and traffic measures.

2.2.1 Entrant's Price and Capacity Choices

For each entry event, we begin by computing the incumbent's pre-existing service level using data from the four quarters preceding the actual quarter of entry. We exclude data from the quarter of actual entry from this calculation since the incumbent may have already altered its service levels and fares in anticipation of entry. Next, we compute the entrant's entry statistics using data from the four quarters directly following the quarter of entry. Again, we exclude data from the entry quarter because entry may have taken place during the middle of a quarter. For example, for an entry event that took place during the first quarter of 1996, we measure the entrant's flight capacity choice as the percentage of the incumbent's pre-entry flight capacity in the following way:

$$\mathcal{E}_i(\text{Flights}) = \frac{\sum_{1996qtr2}^{1997qtr1} \text{Entrant's Flights}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Flights}} \tag{1}$$

Likewise, the entrant's seat capacity and traffic are defined as:

$$\mathcal{E}_i(\text{Seats}) = \frac{\sum_{1996qtr2}^{1997qtr1} \text{Entrant's Seats}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Seats}} \tag{2}$$

and

$$\mathcal{E}_i(\text{Pax}) = \frac{\sum_{1996qtr2}^{1997qtr1} \text{Entrant's Pax}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Pax}} \tag{3}$$

We measure the entrant's fare choice as the percentage price cut from the incumbent's pre-entry average fare:

[15] Sun Country has since re-emerged from bankruptcy and is once again operating flights to and from Minneapolis.

$$\mathcal{E}_i(\text{Fare}) = 1 - \frac{\sum_{1996qtr2}^{1997qtr1} \text{Entrant's Average Fare}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Average Fare}} \tag{4}$$

For ease of interpretation in later sections, each of the four measures are defined so that large positive numbers indicate larger and more aggressive entry. Moreover, we average the data over four quarters to avoid seasonality.

2.2.2 Incumbent Responses

As with our entry statistics, we measure the incumbent's responses as the percentage change from its pre-entry capacity and fare levels. As before, our convention is measure the change in the four quarters following entry relative to the four quarters prior to entry (excluding, once again, the quarter of actual entry from both the numerator and denominator). Thus, the incumbent's flight capacity response to an entry event that occurred during the first quarter of 1996 is defined as:

$$\mathcal{I}_i(\text{Flights}) = \frac{\sum_{1996qtr2}^{1997qtr1} \text{Incumbent's Flights}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Flights}} - 1 \tag{5}$$

Likewise, the incumbent's seat response and O&D passenger traffic are defined like:

$$\mathcal{I}_i(\text{Seats}) = \frac{\sum_{1996qtr2}^{1997qtr1} \text{Incumbent's Seats}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Seats}} - 1 \tag{6}$$

$$\mathcal{I}_i(\text{Pax}) = \frac{\sum_{1996qtr2}^{1997qtr1} \text{Incumbent's Pax}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Pax}} - 1 \tag{7}$$

Finally, the incumbent's fare response is also defined as the percentage decline from its original average fare levels.

$$\mathcal{I}_i(\text{Fare}) = 1 - \frac{\sum_{1996qtr2}^{1997qtr1} \text{Incumbent's Fare}}{\sum_{1995qtr1}^{1995qtr4} \text{Incumbent's Fare}} \tag{8}$$

2.2.3 Median Entry Style and Incumbent Responses

Table 3 summarizes, by LCC, the median values of $\mathcal{E}_i$(Flights), $\mathcal{E}_i$(Seats), $\mathcal{E}_i$(Fare) and $\mathcal{E}_i$(Pax) across all of their respective entry events during our sample period. For each of Tables 3, 4, and 5, we also checked the sensitivity of the figures by calculating the passenger-weighted median statistics, which are reported in Appendix A.

INSERT TABLE 3 HERE

Table 3 demonstrates the large competitive impact that LCC entry typically has on markets. The median fare reduction, relative to the incumbent's pre-entry average price, was slightly less than 50%, stimulating 60% growth in O&D passengers at the median relative to the incumbent's number of pre-entry passengers. The fact that LCCs can stimulate such growth in O&D passengers by adding slightly more than one-third of the incumbent carrier's pre-entry capacity level (in terms of trips or seats) reflects the fact that a substantial portion of the incumbent's capacity is intended to feed connecting traffic into its hub. For the LCC, a much larger portion (and in many cases all) of its passengers are O&D passengers, since many LCCs primarily operate point-to-point, rather than hub-and-spoke networks (the primary exceptions, in our data, being AirTran and Frontier, both of which primarily operate hub-and-spoke networks). Table 3 also indicates that LCCs differ significantly in their "style" of entry. While Southwest and JetBlue's median seat capacity in the first year following entry has been roughly 50% of the incumbents' pre-entry capacity, Spirit, ProAir and ATA's median seat capacity has been half of that. In terms of prices, Vanguard, ProAir, Air South and AirTran tend to reduces prices the most–relative to the incumbent's pre-entry average fares, while Frontier, Kiwi and National have tended to be the least aggressive in terms of pricing. This difference in entry styles is a key to understanding the nature of competition between incumbents and LCCs.

Table 4 summarizes the median values of $\mathcal{I}_i$(Flights), $\mathcal{I}_i$(Seats), $\mathcal{I}_i$(Fare) and $\mathcal{I}_i$(Pax) across each of the markets where the respective incumbent carrier faced entry.

INSERT TABLE 4 HERE

Table 4 indicates that–on average–incumbent carriers have responded somewhat passively to LCC entry at their hubs, which is consistent with the findings of Bamberger and Carlton (1999). While the median LCC entrant introduces 32.7% additional seats (relative to the incumbent's pre-entry capacity) into a hub market, the median capacity response by incumbents has only been 4.0%. In terms of averages fares, the median incumbent response has been to reduce its average fares by 15.1% (compared to 49.5% by the entrant). It is important to note that one should not–in general–expect that the incumbent's average fares will drop as much as the entrant's, since the incumbent

carriers typically offer both coach as well as first class service. Moreover, as was the case with Table 3, Table 4 demonstrates that there are significant differences in the median response across the incumbent carriers. While American and Continental have actually reduced the absolute number of available seats (on average) in the hub markets where they have faced LCC entry, Northwest and Alaska have each increased seat capacity by more than 10%. In terms of average fare reductions, Delta's median fare reduction relative to its pre-entry levels has been the largest (25.3%), while American's has been the smallest (8.6%).

2.2.4 Relative Responses Statistics

The median response statistics in Table 4 beg an obvious question: to what extent are a particular incumbent's responses in a given market a result of the magnitude of entry it faces? For example, is American's median capacity response the lowest simply because it faces the least aggressive entrants? In order to shed some insight into these questions, we now turn our attention to the incumbents' responses relative to the entry they have faced. Define an incumbent's relative flight response to entry event i as:

$$\mathcal{R}_i(\text{Flights}) = \mathcal{I}_i(\text{Flights}) - \mathcal{E}_i(\text{Flights})$$

$\mathcal{R}_i$(Seats) and $\mathcal{R}_i$(Pax), $\mathcal{R}_i$(Fare) are defined analogously. Since each of our relative response statistics are calculated as the difference between the incumbent's response and the entrant, the smaller its value (in absolute value), the less aggressive the incumbent's fare response. Table 5 summarizes the median relative response measures for each of the incumbent carriers.

INSERT TABLE 5 HERE

The first thing to notice from Table 5 is that most median relative responses statistics are strongly negative. In all categories, the entrants' scale and price cuts outpace the responses of the incumbents, which confirms the passive nature of the incumbents' responses seen in Tables 3 and 4. For example, American, US Airways and Continental on average tend to add the fewest additional seats relative to the entrant. Indeed, Table 5 shows that American–on average–has added 35.9% *fewer* seats than the LCC entrants it has faced. Northwest, on the other hand, has been the most aggressive in terms of capacity responses, adding on average 13.2% fewer seats than the LCC entrant. The primary difference between Table 4 and Table 5 with respect to capacity responses is for Alaska. While Table 4 indicates that Alaska tends to add the most seats of all the incumbents (its median value of $\mathcal{I}_i$(Seats) is 12.9%), Table 5 shows that its median relative seat response (30.1%) is on par with overall median (29.6%). This suggests that in the Seattle hub markets where Alaska has faced LCC entry, the LCC has tended to enter with relatively high levels of capacity.

Turning now to the relative fare responses, Table 5 indicates that Alaska has been the most aggressive–reducing its average fares by 17.9 percentage points less than the entrant. In contrast, both Delta and American have been the least aggressive in terms of relative fare responses, reducing fares–on average–by roughly thirty percentage points less than the entrant. The fact that Delta's median relative fare response is the largest (in absolute value) of the incumbent carriers while its absolute fare response from Table 4 was the smallest indicates that the LCCs that have entered Delta's hub markets tend to do so with very large fare reductions.

2.2.5 Capacity and Fare Interactions between Incumbents and Entrants

Although the relative response statistics in Table 5 are helpful in understanding the median response of incumbent carriers to new entry, the numbers by themselves do not reveal much about the level of post-entry competition played out between the incumbent and the entrant. For example, $\mathcal{R}_i(\text{Fares}) = 0$ cannot distinguish between a simultaneous price reduction of 40% or 5%. To better see the precise interactions between the incumbents and the entrants, we plot the data and obtain a bird's eye view of its distribution. Among the four competitive metrics we have presented (flights, fares, seats and passengers), we focus our attention on two key choice variables, fares and seats, as these have been the focus of attention in the controversy surrounding incumbent responses to LCC entry. While we recognize that flight frequency is also an important measure of capacity as well as service quality, the flights and seats variables tend to be highly correlated in our data set. Consequently, for the remainder of our analysis, we chose seats as our primary measure of capacity.

Figure 1 plots the incumbent's fare response $\mathcal{I}_i(\text{Fares})$ relative to the entrant's $\mathcal{E}_i(\text{Fares})$ in each of our 370 entry events. As in the previous section, the unit of observation is a market-incumbent-entrant. The diagonal line in Figure 1 indicates a "perfectly matched" response by the incumbent.

[INSERT FIGURE 1 HERE]

In general, the incumbents' fare responses tend to be smaller than the entrants (i.e., the data lie below the 45 degree line). While this may partly reflect the generally "modest" price responses by incumbents, it may also reflect the limitation of using average fares. There are two reasons why the average fare may not reflect the full picture of price competition. First, incumbent "full service" carriers tend to have more differentiated fare structures than LCCs, as they typically offer two different classes of service (first and coach). Second, when incumbents match the price cuts of LCCs, they typically do so on a limited inventory basis. Nevertheless, Figure 1 clearly shows the tendency for the price response of incumbent to be roughly aligned with that of the LCC entrant.

Figure 2 plots the capacity choices for incumbents and entrants in terms of the percentage increase in quarterly seats relative to the incumbent's pre-entry levels. Unlike the price responses in Figure 1, there does not appear to be any obvious correlation between the incumbent's and entrant's capacity choices. It is noteworthy that the majority (70%) of incumbent responses cluster around ±15% from their pre-entry capacity level. Approximately 38% of the incumbents have zero or negative capacity responses, electing a fully accommodating or complacent response to entry. Strongly positive incumbent responses appear to be exceptions rather than the norm. Thus, of the 370 observations, only twenty nine (or less than 8%) represent cases in which the incumbents' capacity expansion outpaced that of the LCC. Moreover, almost all of those cases are between relatively small scale entries and similarly small scale responses. Another observation worth noting is the relatively large scale of some market entries. While many entries represent a small fraction of the incumbent's pre-existing capacity, more than one-quarter (28%) of the entries are those in which the entrant chooses a capacity level of 50% or more of incumbent's pre-entry capacity.

[INSERT FIGURE 2 HERE]

In summary, we find that the response of incumbent carriers to LCC entry–both in terms of capacity expansion and prices reductions–tend to be much smaller than those of entrants. Although incumbents show a tendency to match the entrants' price cuts (albeit on a limited inventory basis), their capacity responses are often quite modest. The entry events themselves, on the other hand, tend to vary considerably, both by carrier, and often within carriers. While some LCCs such as Frontier appear have adopted a "cream skimming" strategy (entering typically on a relatively small scale and only moderately cutting prices), others carriers such as AirTran have tended to be more aggressive, both in terms of capacity and fare reductions. Naturally, we suspect that the nature of the competitive pressure facing incumbent carriers post-entry can vary significantly depending on the type of entry they face. Indeed, such variation in the competitive interaction between incumbents and LCCs may present some difficulty in defining "generally" applicable rules for characterizing exclusionary conduct.

3 Incumbent Responses and LCC Exit: Is There a Link?

Numerous LCCs and some competition authorities, both in the U.S. and abroad, have alleged that exclusionary conduct by incumbent carriers following entry into their hub markets have forced them to exit markets they would otherwise like to serve (Transportation Research Board 1999). As discussed earlier, while there is much anecdotal evidence documenting this type of behavior, there have been few–if any–general conclusions regarding the impact of such alleged actions on

an entrant's success. In this section, we attempt to determine the degree to which allegations of exclusionary conduct are supported by the data by estimating a probit exit model.

3.1 Exit Events

We define an "exit" as four or more consecutive quarters of absence from a market. Since we are interested in assessing the impact of incumbent responses (rather than other extraordinary exogenous events) on LCC exit probability, we needed to take into consideration a number of "exit" events that were primarily caused by other factors. In particular, we excluded two exit events from our dataset that came as a result of American's acquisition of Reno Air. Likewise, since we excluded AirTran data for three quarters directly following the crash of one its aircraft in May 1996 (which resulted in the subsequent temporary grounding of its fleet), some of the markets where AirTran temporarily suspended service are not counted as formal exits.[16] To minimize the potential for "right censoring" in our data set, we dropped entry events from our data set that occurred after 2000. Finally, we exclude markets that were exited as a result of the cessation of service due to bankruptcy. Note that this does not imply that we exclude all market exits by carriers that are now bankrupt, since markets that were exited in the years prior to bankruptcy are still are still included in our sample. To test the sensitivity of our results, we also estimated our probit model including the bankruptcy events and present the results in Appendix B. Neither the signs nor the magnitudes of any of our estimated coefficients changed significantly.

LCC exits from markets are not an uncommon phenomena. Indeed, after modifying our entry-event data set as described above, our data set includes 265 entry events, of which 89 were exited. Table 6 summaries the exit events by entrant and incumbent and demonstrates–not surprisingly–that there are significant firm differences in terms of entry success. For example, of the 14 hub markets that JetBlue has thus far entered, none have been exited.[17] Likewise, Southwest only exited three of sixty-seven hub markets it entered in our data set.

INSERT TABLE 6 HERE

3.2 Profile of Exit Events

Since exit from a market by an LCC is not an uncommon event, it is useful to profile some basic stylized facts of "successful" versus "unsuccessful" entry attempts. Table 7 compares the entry and response characteristics of the market events in our sample broken down by exited and non-exited events.

[16] The markets that AirTran withdrew from for more than seven quarters were counted as exits.

[17] We note that JetBlue recently announced that it would exit the Atlanta-Long Beach and Atlanta-Oakland markets. Since JetBlue entered these markets in late 2002, these entry events were not part of our data set.

INSERT TABLE 7 HERE

Market entry events that eventually result in exit are typically smaller scale entries. At the median, the exit events have 27.7% of the incumbent's original capacity while the successful entries have 37.3%. The price reductions of failed entries are slightly deeper (median of 52.2%) than the successful entries (median of 47.3%). Somewhat surprisingly, the incumbents' capacity responses tend to be slightly smaller (median of 3.5%) in exit events versus successful entries (median 4.5%). Equally surprisingly is the fact that there is no discernable difference in the incumbents' price reductions between successful and failed LCC entries. As alluded to earlier, in light of the highly differentiated fare structures of incumbent carriers, we recognize the difficulty of determining the nature of price competition using the average fares alone. Nevertheless, it appears as though the magnitudes of the incumbents' capacity and price cuts may not be significant factors in determining which market entries eventually fail. We investigate this possibility in the probit exit model in the following section.

Table 8 compares some raw pre-entry market characteristics (O&D passengers, seats, and flights) of successful and unsuccessful market entries. Unsuccessful market entries typically occur in significantly "thinner" markets by all three measures. Most importantly, these markets tend to be comparatively thin in terms of pre-existing O&D passenger traffic, serving 31% fewer local passengers than those markets where entry was successful. It is possible that LCC operations that typically rely on a large base of O&D traffic (Boguslaski, Ito, and Lee 2004) were not able to sustain themselves in those markets.

INSERT TABLE 8 HERE

3.3 Exit Probit Models

In order to determine if LCC exit choices are systematically related to the competitive behavior of incumbents prior to their exit, we estimate a basic probit model using $\mathcal{I}_i$(Seats) and $\mathcal{I}_i$(Fare) as two of our independent variables.[18] The dependent variable **D(LCC Exit)** takes the value 1 if the LCC exited the market and 0 otherwise. If aggressive responses by incumbents are partly responsible for the eventual withdrawal of the LCC, we expect the coefficients for these variables to be strongly positive and statistically significant. Since the incumbent's responses should be measured relative to the that of the entrant, we also include the entrants' capacity and pricing choices, $\mathcal{E}_i$(Seats) and $\mathcal{E}_i$(Fare), as control variables. Moreover, we are interested in determining if

[18] When calculating the incumbent's post-entry pricing/capacity decisions, we compute the average value using quarters when the LCC is present in the market. Obviously, an LCC's withdrawal from a market is likely to prompt some degree of fare and capacity adjustments from the incumbent, which we do not want to consider in our post-entry variables.

any particular entry style (i.e., small capacity, aggressive price cutting) contribute to higher failure probabilities than others. We chose not to include the flight frequency variables ($\mathcal{E}_i$(Trips) and $\mathcal{I}_i$(Trips)) in our estimations since they are highly correlated with $\mathcal{E}_i$(Seats) and $\mathcal{I}_i$(Seats).

We perform two separate probit estimations: one with Southwest and one without Southwest. As discussed earlier, Southwest is by far the largest LCC and has an extremely low exit rate. By presenting two samples, we check the sensitivity of our results to the presence or absence of Southwest.

3.4 Other Independent Variables

In addition to the price and capacity choices of the incumbent and entrant, we include several other market characteristics that we believe may influence the success or failure of entrants. When applicable, these variables are defined using the pre-entry market data averaged over the four quarters prior to entry in order to account for possible effects of seasonality.

It it well understood that LCCs have traditionally focused on serving pre-existing high density markets. Thus, we include **ln(O&D Pax)**, the natural logarithm of quarterly O&D passengers travelling in the market on all carriers as one of our independent variables. If thin O&D passenger density help to explain exit, we expect this variable to have a negative coefficient. Moreover, the high frequency, quick turn operational models of LCCs provide them with an even greater comparative advantage (vis-à-vis their hub-and-spoke carrier counterparts) in short haul markets. Furthermore, it is possible that some passengers may find the lower level of in-flight amenities offered by LCCs acceptable on short-haul flights, but less acceptable on longer-haul flights. Thus, we include **ln(distance)**, the natural logarithm of the market's distance in miles.

It is natural to suspect that well-established LCCs with large national footprints may have higher success probabilities than smaller, regional LCCs. In the long-purse story of predation, for example, the more established LCC's may have more staying power in price wars. Alternatively, larger LCCs may simply enjoy high brand recognition, learning-by-doing operational experience, or logistical advantages of larger networks. **ln(LCCsize)** is the natural log of O&D passengers served by the LCC in all of its markets and is a measure of the LCC's overall size. Since entry, by definition, occurs on an airport/city-pair basis in our model, we also include **LCC Scope**, which is defined as the mean number of destinations served by the LCC from both endpoints of the market entered.

We posit that variations in the pre-existing competitive environment may impact the likelihood of success for new entrants. **HHI** is the pre-entry Herfindahl index of the airport-pair market in terms of O&D passengers, while **D(Existing LCC)** is a dummy variable for markets with pre-existing LCC presence. In addition, to account for the possibility of right-censoring in our data,

we include dummy variables for entry events that occurred in 1999 and 2000. Since these are the last two years in our current sample, we have a shorter window of opportunity to observe their eventual exits.

Finally, in order to control for systematic incumbent differences beyond those captured by our response variables $\mathcal{I}_i$(Seats) and $\mathcal{I}_i$(Fare), we include incumbent carrier dummies (with Alaska Airlines being the base case). Summary statistics for our independent variables are provided in Table 9.

INSERT TABLE 9 HERE

3.5 Estimation Results

Estimation results from our probit model are summarized in Table 10 below. The probit coefficients are presented along with their probability derivatives evaluated at the mean.

INSERT TABLE 10 HERE

Table 10 indicates that the incumbent's capacity response following LCC entry does not have a statistically significant impact on the LCC's failure probability–both in the full sample of markets and in those excluding Southwest. The estimated coefficients on $\mathcal{I}_i$(Fares) on the other hand, is significant at the 5% level in our sample excluding Southwest, but the coefficient, somewhat surprisingly, is negative. This result may suggest that entry is often successful in markets that have pre-existing higher margins where there are large numbers of "un-tapped" passengers who previously had less (or no) access to the low fares offered by LCCs. In these markets, the incumbent carrier may realize that once they face LCC entry, their best response is to participate in the market stimulation from lower fares. Thus, the results do not support the hypothesis that aggressive price-cuts or capacity expansions contributed to the LCCs exits.

The negative and significant estimated coefficient on $\mathcal{E}_i$(Seats) indicates that the larger the initial capacity choice by the entrant, the lower the exit probability. This may reflect the scale economies necessary for successful entry. Moreover, it is well know that many passengers value high frequency service.

The estimated coefficient on $\mathcal{E}_i$(Fares) is positive, but not significant at the 5% level. The positive coefficient tends to indicate, however, that the larger the initial fare reduction by the LCC, the higher the probability of exit. This result may indicate that the LCC–for one reason or another–was unable to attract a sufficient number passengers at profitable fares. Alternatively, larger price cuts may simply be indicative of overly aggressive (and possibly ill-conceived) entry

by the LCC.[19]

Also noteworthy is the negative and significant estimated coefficient on **ln(distance)**. This result, which is contrary to our expectation, indicates that the longer the market's distance, the lower the exit probability. We caution inferring too much from this result however, as LCC entry into longer-haul markets is a rather recent phenomena. Until recently, for example, AirTran did not possess the aircraft capable of flying from its hub in Atlanta to the West Coast. Moreover, the result may be related to the fact that JetBlue, which has the longest average route length among all of the LCCs, did not experienced any exits in our data set. As expected, larger pre-existing market size measured by **ln(O&D Pax)** reduces the probability of exit, confirming well known result that LCCs are able to leverage their comparative advantage by targeting pre-existing dense markets.

As expected, the larger the LCC's absolute size and the larger the number of destinations that the LCC serves at the end-point cities of a market, the smaller the probability of eventual exit. However, while the estimated coefficient on **LCC Scope** is significant at the 5% level, the estimated coefficient on **LCC Size** is not. This suggests that brand recognition and pre-existing passenger experience with an LCC is more relevant to the eventual success of a particular market entry than the firm's overall size. Finally, there appears to be some differences (although not statistically significant) in success probability depending on the particular incumbent that is faced by the LCC. While LCCs appear to have had the best success facing United and Delta, they tend to have lower entry success probabilities when facing Northwest and Continental.

Overall, our results indicate that aggressive responses by incumbent carriers, measured in terms of percentage capacity increase or percentage price reductions, are not likely to be a general explanation for LCC exit from hub markets. We should emphasize however, that our results do not exclude the possibility that in some markets, the actions of incumbent carriers may have influenced an LCC's exit decision. For example, in a relatively small market, the survival of a small new entrant is possibly influenced by a relatively small response by an incumbent. In order to explain such outcomes, however, one needs to devise a model that accounts for more subtle strategic interactions between incumbents and entrants.

4 Conclusions and Policy Implications

This paper investigates the responses of hub-and-spoke network carriers to LCC entry on their hub routes. In addition to documenting some stylized facts regarding the pattern of entry and

[19]For example, Australian LCC Virgin Blue stated that "The failure of Compass Airlines 1 and 2 has been attributed to shortcomings in their entry strategy, which misjudged the operational, economic and regulatory obstacles to large scale entry into the domestic market." Source: *Virgin Blue Prospectus*, page 42.

response over the past decade, we examine how these responses have influenced LCC market survival probabilities.

The responses of incumbent carriers to new entry by LCCs has been a primary focus of both policy-makers and competition authorities, both in the U.S. and abroad. Indeed, numerous parties have alleged that incumbent hub carriers frequently respond to LCC entry with sharp price reductions coupled with aggressive capacity expansion. Concerns over these types of alleged practices were heightened so much during the late 1990's that the U.S. Department of Transportation issued tentative guidelines for evaluating whether an incumbent's conduct constituted exclusionary conduct (the Department eventually withdrew its proposal in favor of a case-by-case examination). Although anecdotal evidence of such practices is common, questions remains as to how prevalent those aggressive incumbent behaviors have been. This paper attempts to provide some empirical evidence to answer this question using a broad sample of market entry events.

We find that highly aggressive incumbent reactions are more the exception rather than the rule. Moreover, we find–somewhat surprisingly–that the median response of incumbents to LCC entry at their hubs has tended to be fairly accommodating. Based on our analysis of 370 market entry events, we find that while the incumbent often aligns their price to that of entrant, it rarely undercuts the entrant's average fares. As for the capacity response of incumbents, we find no clear evidence that incumbents try to out-pace or even match the entrant's capacity choice. This is contrary to the common perception that the incumbent response of aggressively expanding their capacity following LCC entry is a widespread phenomena. In this sense, our results support the conclusion of Bamberger and Carlton (1999) using an expanded scope of the data.

Perhaps the most important finding of our analysis, however, is that we found no evidence that an incumbent's capacity expansion or pricing decisions following LCC entry negatively impacts the probability that the LCC exits a market. Rather, factors such as the entrant's capacity choice, pre-existing market density and the LCC's pre-entry presence at the endpoints of a market appear to be factors which contribute to an entrant's ultimate success or failure. Thus, from a policy perspective, our results suggest that rather than focussing on the nature of post-entry competition between incumbents and entrants, policy-makers should be more concerned with ensuring that LCCs have sufficient access to airport facilities such as gates. Indeed, LCC access to gates at some highly congested hub-airports, is likely to be a topic of heated discussion in the policy arena.[20]

It is important to note that the competitive confrontation between the hub-and-spoke incumbents and LCC entrants is far from over. Based on the current market capitalizations and aircraft orders of LCCs such as Southwest, JetBlue, AirTran and Frontier, continued growth of LCCs

[20]For example, Huston (1999) argue that the number of gates in the hub-airports is the key determinant of long-run equilibrium in the industry.

is likely. Consequently, debates over incumbents' responses to LCC entry is likely to continue well into the future. The primary lesson from our analysis, however, is that a cut-and-dry rule of capacity expansion or price reduction is unlikely to define–in any meaningful or economically appropriate way–"predatory" or "exclusionary" conduct.

Table 1: Cross Tabulation of Market Entry Events by Incumbent and LCC

	Incumbent Carriers							
LCC	American	Alaska	Continental	Delta	Northwest	United	US Airways	Total
AirSouth*	0	0	0	5	0	0	0	5
AirTran	7	0	3	42	4	6	7	69
ATA	19	0	1	0	1	20	2	43
Carnival*	5	0	2	0	0	1	0	8
Frontier	2	0	1	2	1	29	0	35
JetBlue	0	0	13	1	0	1	0	15
Kiwi Int.*	2	0	5	4	0	4	0	15
MarkAir*	6	5	1	3	2	14	0	31
National	2	0	1	0	0	2	1	6
ProAir*	0	0	1	2	5	0	1	9
Reno†	0	3	0	1	0	3	0	7
Southwest	17	6	9	14	0	21	0	67
Spirit	3	0	3	0	8	4	2	20
Sun Country*	3	0	0	0	13	1	0	17
Vanguard*	6	0	0	4	1	8	2	21
Western Pacific*	1	0	0	0	0	1	0	2
Total	73	14	40	78	35	115	15	370

Notes and Sources: *Filed for bankruptcy protection during sample period. †Acquired by AMR Corp., the holding company of American Airline, on December 23, 1998. Source: U.S. DOT OD1A and T100 Databases, 1990-2002.

Table 2: LCC Entry Events by Year

	Entry Year												
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
AirSouth*	0	0	0	3	1	1	0	0	0	0	0	0	5
AirTran	0	0	8	13	14	0	2	6	4	12	7	3	69
ATA	0	0	1	6	0	0	9	6	3	9	6	3	43
Carnival*	1	2	1	2	0	0	2	0	0	0	0	0	8
Frontier	0	0	0	2	11	3	3	4	2	1	4	5	35
JetBlue	0	0	0	0	0	0	0	0	0	9	5	1	15
Kiwi Int.*	0	6	4	5	0	0	0	0	0	0	0	0	15
MarkAir*	1	5	15	10	0	0	0	0	0	0	0	0	31
National	0	0	0	0	0	0	0	0	5	1	0	0	6
ProAir*	0	0	0	0	0	0	3	4	2	0	0	0	9
Reno Air†	0	0	1	0	1	2	1	2	0	0	0	0	7
Southwest	0	7	4	15	6	3	2	2	17	2	2	7	67
Spirit	0	0	0	2	3	0	0	2	3	5	2	3	20
Sun Country*	0	0	0	0	0	0	0	0	12	5	0	0	17
Vanguard*	0	0	0	3	8	0	3	1	5	1	0	0	21
Western Pacific*	0	0	0	0	2	0	0	0	0	0	0	0	2
Total	2	20	34	61	46	9	25	27	53	45	26	22	370

Notes and Sources: *Filed for bankruptcy protection during sample period. †Acquired by AMR Corp., the holding company of American Airline, on December 23, 1998. Source: U.S. DOT OD1A and T100 Databases, 1990-2002.

Table 3: Median Entry Statistics for Low Cost Carriers

	$\mathcal{E}_i$(Flights)	$\mathcal{E}_i$(Seats)	$\mathcal{E}_i$(Fares)	$\mathcal{E}_i$(Pax)
AirSouth	30.4%	31.7%	61.5%	78.2%
AirTran	41.1%	34.1%	59.3%	60.4%
ATA	28.9%	27.3%	49.5%	49.4%
Carnival	23.4%	18.7%	15.0%	40.6%
Frontier	33.0%	30.0%	39.8%	42.3%
JetBlue	46.4%	53.7%	53.9%	68.7%
Kiwi Int.	34.2%	30.7%	42.4%	48.3%
MarkAir	18.2%	16.7%	47.7%	28.0%
National	51.4%	56.5%	29.9%	88.8%
ProAir	25.5%	29.1%	62.4%	24.5%
Reno Air	48.1%	48.1%	43.3%	60.2%
Southwest	48.9%	46.7%	48.0%	111.1%
Spirit	25.8%	25.1%	41.5%	44.3%
Sun Country	16.1%	24.1%	49.5%	38.6%
Vanguard	43.2%	43.5%	66.5%	101.8%
Western Pacific	62.7%	67.4%	49.6%	255.0%
Total	34.7%	32.7%	49.5%	59.8%

Sources: U.S. DOT OD1A and T100 Databases, 1990-2003.

Table 4: Median Response Statistics for Incumbents

	$\mathcal{I}_i$(Flights)	$\mathcal{I}_i$(Seats)	$\mathcal{I}_i$(Fares)	$\mathcal{I}_i$(Pax)
American	1.3%	-0.6%	8.6%	5.4%
Alaska	11.8%	13.0%	11.6%	41.7%
Continental	-4.4%	-0.3%	14.8%	8.1%
Delta	2.3%	5.2%	25.3%	17.2%
Northwest	11.8%	10.1%	15.0%	36.8%
United	3.9%	3.0%	16.8%	17.3%
US Airways	4.9%	6.5%	20.5%	27.3%
Total	2.9%	4.0%	15.1%	16.2%

Sources: U.S. DOT OD1A and T100 Databases, 1990-2003.

Table 5: Median Relative Response Statistics for Incumbents

	$\mathcal{R}_i$(Flights)	$\mathcal{R}_i$(Seats)	$\mathcal{R}_i$(Fares)	$\mathcal{R}_i$(Pax)
American	-33.7%	-35.9%	-28.7%	-72.9%
Alaska	-22.9%	-30.1%	-17.9%	-0.3%
Continental	-37.9%	-34.1%	-19.2%	-47.1%
Delta	-36.1%	-28.1%	-32.6%	-48.8%
Northwest	-12.1%	-13.2%	-25.6%	-0.6%
United	-32.8%	-32.3%	-25.9%	-44.9%
US Airways	-35.6%	-35.0%	-21.8%	-29.0%
Total	-32.7%	-29.6%	-25.8%	-43.4%

Sources: U.S. DOT OD1A and T100 Databases, 1990-2003.

Table 6: Cross Tabulation of Market Exits by Incumbent and LCC

	Incumbent Carriers							
	American	Alaska	Continental	Delta	Northwest	United	US Airways	Total
AirSouth	0	0	0	2	0	0	0	2
AirTran	2	0	1	12	2	4	1	22
ATA	5	0	0	0	0	4	0	9
Carnival	2	0	1	0	0	0	0	3
Frontier	0	0	0	0	0	3	0	3
JetBlue	0	0	0	0	0	0	0	0
Kiwi Int.	1	0	2	3	0	3	0	9
MarkAir	0	1	0	0	0	1	0	2
National	0	0	0	0	0	0	0	0
Southwest	0	0	1	2	0	0	0	3
Spirit	0	0	3	0	0	0	2	5
Sun Country	3	0	0	0	12	1	0	16
Vanguard	4	0	0	3	1	6	1	15
Western Pacific	0	0	0	0	0	0	0	0
Total	17	1	8	22	15	22	4	89

Sources: U.S. DOT OD1A and T100 Databases, 1990-2003.

Table 7: Statistical Profile of Market Entry Events (Median Values)

	Incumbents		Entrants	
	$\mathcal{R}_i$(Seats)	$\mathcal{R}_i$(Fares)	$\mathcal{E}_i$(Seats)	$\mathcal{E}_i$(Fares)
Non-Exits	4.5	10.8	37.3	47.3
Exits	3.5	10.7	27.7	52.2
Total	3.8	10.7	33.3	48.9

Sources: U.S. DOT OD1A and T100 Databases, 1990-2003.

Table 8: Some Market Characteristics (Median Quarterly Values)

	O&D Passengers	Seats	Flights
Non-Exited Markets	80,869	303,533	2,043
Exited Markets	56,043	229,264	1,880
All Entries	68,135	265,201	1,957

Sources and Notes: Figures are quarterly averages from the four quarters prior to the entry. Sources: U.S. DOT OD1A and T100 Databases, 1990-2003.

Table 9: Summary Statistics of Probit Variables

	Entire Dataset		Without Southwest	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
D(LCC exit)	0.336	(0.473)	0.415	(0.494)
$\mathcal{I}_i$(Seats)	0.060	(0.167)	0.055	(0.157)
$\mathcal{I}_i$(Fares)	0.140	(0.234)	0.133	(0.221)
$\mathcal{E}_i$(Seats)	0.452	(0.400)	0.389	(0.333)
$\mathcal{E}_i$(Fares)	0.459	(0.197)	0.459	(0.191)
ln(Distance)	6.429	(0.614)	6.426	(0.631)
ln(O&D Pax)	11.036	(0.977)	11.067	(0.985)
ln(LCC Size)	9.444	(4.456)	8.225	(4.313)
LCC Scope	4.211	(4.754)	3.227	(3.758)
HHI	0.492	(0.182)	0.516	(0.185)
D(Existing LCC)	0.208	(0.406)	0.222	(0.417)
D(yr 1999)	0.192	(0.395)	0.164	(0.371)
D(yr 2000)	0.166	(0.373)	0.203	(0.403)
American	0.204	(0.404)	0.193	(0.396)
Continental	0.094	(0.293)	0.087	(0.282)
Delta	0.230	(0.422)	0.227	(0.420)
Northwest	0.094	(0.293)	0.121	(0.327)
United	0.298	(0.458)	0.300	(0.459)
US Airways	0.042	(0.200)	0.053	(0.225)
Obs.	N=265		N=207	

Table 10: LCC Exit Probit Results

D(LCC exit)	All Entries		Excluding Southwest	
	Coeff.	$\partial P/\partial x$	Coeff.	$\partial P/\partial x$
$\mathcal{I}_i$(Seats)	-1.122	-0.349	-1.076	-0.403
	(0.815)	(0.251)	(0.883)	(0.330)
$\mathcal{I}_i$(Fares)	-0.774	-0.240	-1.353*	-0.507*
	(0.554)	(0.173)	(0.667)	(0.250)
$\mathcal{E}_i$(Seats)	-1.816†	-0.564†	-1.441†	-0.540†
	(0.394)	(0.120)	(0.454)	(0.171)
$\mathcal{E}_i$(Fares)	0.807	0.251	1.684	0.631
	(0.776)	(0.241)	(0.902)	(0.337)
ln(Distance)	-0.883†	-0.274†	-1.113†	-0.417†
	(0.213)	(0.066)	(0.252)	(0.095)
ln(O&D Pax)	-0.261	-0.081	-0.304	-0.114
	(0.145)	(0.046)	(0.169)	(0.064)
ln(LCC Size)	0.002	0.001	0.069*	0.026*
	(0.027)	(0.008)	(0.034)	(0.013)
LCC Scope	-0.130†	-0.040†	-0.166†	-0.062†
	(0.036)	(0.011)	(0.046)	(0.017)
HHI	-0.701	-0.218	-1.409	-0.528
	(0.714)	(0.222)	(0.794)	(0.299)
D(Existing LCC)	-0.372	-0.116	-0.664*	-0.249*
	(0.299)	(0.092)	(0.329)	(0.122)
D(1999)	0.313	0.097	0.385	0.144
	(0.308)	(0.096)	(0.348)	(0.131)
D(2000)	-0.506	-0.157	-0.843*	-0.316*
	(0.357)	(0.110)	(0.406)	(0.150)
D(American)	1.588	0.493	1.124	0.421
	(0.952)	(0.287)	(1.690)	(0.630)
D(Continental)	2.266*	0.704*	2.001	0.750
	(1.019)	(0.304)	(1.746)	(0.648)
D(Delta)	1.177	0.366	0.754	0.283
	(0.946)	(0.287)	(1.695)	(0.633)
D(Northwest)	2.099*	0.652*	1.763	0.661
	(0.985)	(0.294)	(1.706)	(0.633)
D(United)	1.213	0.377	0.745	0.279
	(0.937)	(0.285)	(1.681)	(0.627)
D(US Airways)	1.750	0.543	1.083	0.406
	(1.046)	(0.317)	(1.747)	(0.651)
Constant	8.015†	2.490†	10.081†	3.777†
	(2.444)	(0.790)	(3.236)	(1.248)
Observations	265		207	
Pseudo R^2	.3073		.3247	
% of exits correctly predicted	59.6%		73.3%	
No. of observations	265		207	

Notes: Standard errors in parentheses. †Significant at 1%. *Significant at 5%.

FIGURE 1: Fare Responses of Incumbent Carriers

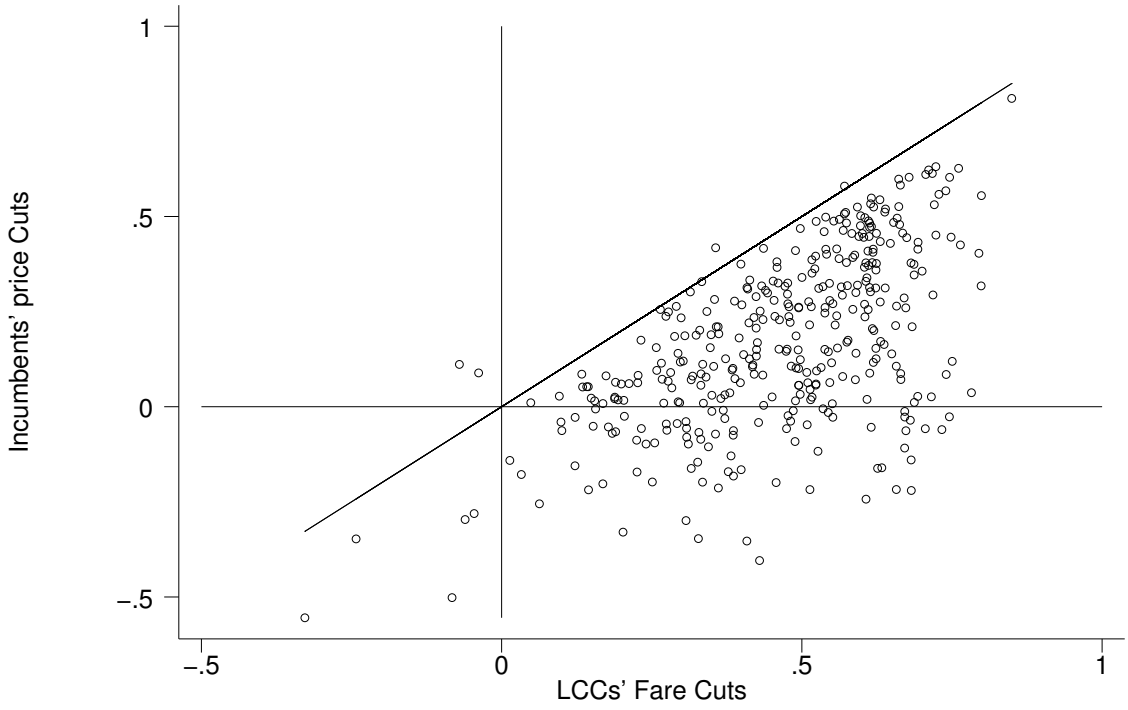
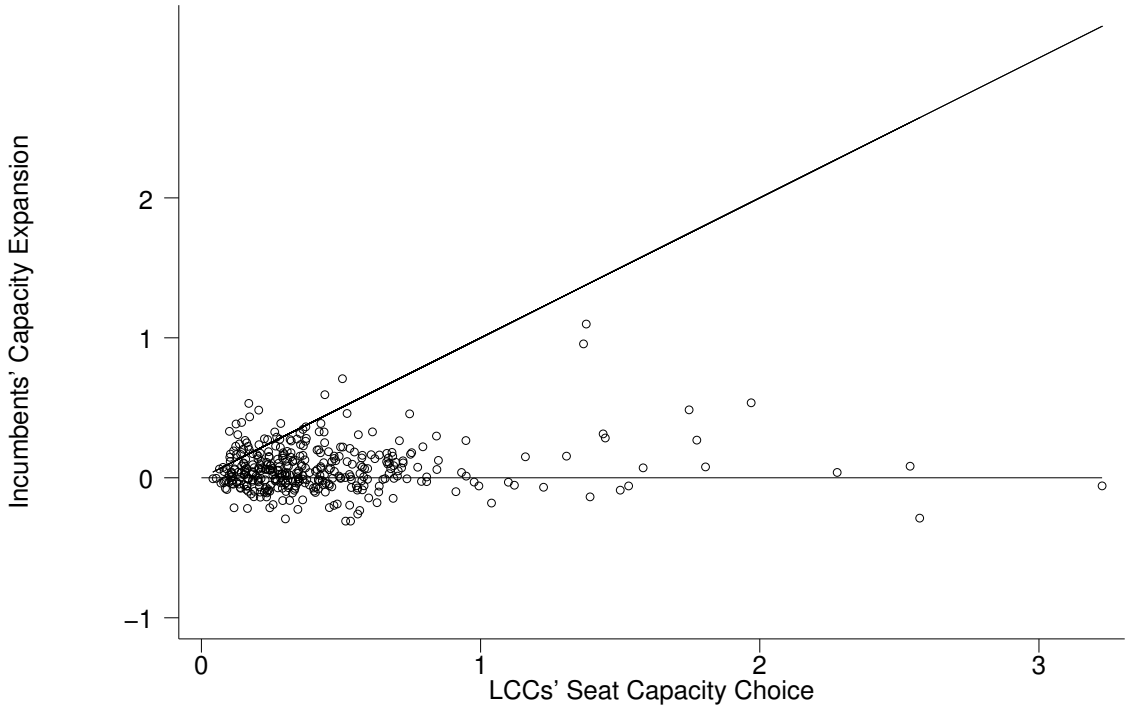


FIGURE 2: Capacity Responses of Incumbent Carriers



A Passenger-Weighted Descriptive Statistics

To check the sensitivity of our descriptive statistics in Section 2.2, we replicate Tables 3, 4 and 5 using the post-entry passenger numbers as weights.

Table 3A: Median Entry Statistics for Low Cost Carriers - Passenger Weighted

	$\mathcal{E}_i$(Flights)	$\mathcal{E}_i$(Seats)	$\mathcal{E}_i$(Fares)	$\mathcal{E}_i$(Pax)
AirSouth	41.4%	31.7%	61.5%	78.2%
AirTran	43.6%	31.8%	60.1%	65.2%
ATA	22.4%	24.5%	51.3%	48.6%
Carnival	24.5%	20.5%	15.5%	42.7%
Frontier	30.0%	25.7%	36.1%	39.9%
JetBlue	54.1%	68.3%	25.8%	74.0%
Kiwi Int.	34.5%	31.2%	43.6%	50.9%
MarkAir	19.3%	16.7%	46.2%	34.4%
National	56.9%	55.5%	27.0%	71.3%
ProAir	33.3%	35.3%	63.9%	67.3%
Reno Air	52.9%	42.4%	43.3%	60.2%
Southwest	61.2%	59.9%	49.7%	135.4%
Spirit	28.4%	29.1%	41.3%	45.6%
Sun Country	17.2%	24.2%	49.5%	97.1%
Vanguard	30.5%	37.1%	65.3%	99.8%
Western Pacific	89.9%	84.4%	37.3%	275.0%
Total	40.7%	41.9%	48.1%	71.5%

Notes: Medians are weighted by post-entry passenger figures.

Table 4A: Median Response Statistics for Incumbents

	$\mathcal{I}_i$(Flights)	$\mathcal{I}_i$(Seats)	$\mathcal{I}_i$(Fares)	$\mathcal{I}_i$(Pax)
American	1.1%	-2.5%	2.8%	-1.6%
Alaska	12.3%	12.2%	11.2%	41.5%
Continental	-6.1%	0.6%	8.5%	12.1%
Delta	2.4%	5.8%	17.2%	11.3%
Northwest	4.4%	6.7%	14.5%	20.5%
United	1.1%	-0.8%	8.3%	4.2%
US Airways	10.9%	13.9%	18.9%	27.3%
Total	1.3%	1.8%	10.5%	10.5%

Notes: Medians are weighted by post-entry passenger figures.

Table 5A: Median Relative Response Statistics for Incumbents - Weighted by Incumbents' Passengers

	$\mathcal{R}_i$(Flights)	$\mathcal{R}_i$(Seats)	$\mathcal{R}_i$(Fares)	$\mathcal{R}_i$(Pax)
American	-23.8%	-30.8%	-32.8%	-46.5%
Alaska	-22.9%	-28.0%	-15.2%	-3.6%
Continental	-37.9%	-33.0%	-17.0%	-36.3%
Delta	-33.3%	-17.6%	-32.7%	-35.0%
Northwest	-11.5%	-15.7%	-38.7%	-9.6%
United	-22.0%	-18.7%	-30.9%	-35.7%
US Airways	-26.3%	-15.9%	-24.4%	-19.3%
Total	-25.6%	-21.5%	-27.7%	-29.1%

Notes: Medians are weighted by post-entry passenger figures.

B Probit Results Including Exits Resulting From Bankruptcy

Table 10A: LCC Exit Probit Results - Bankruptcies Included

D(LCC exit)				
	All Entries		Excluding Southwest	
	Coeff.	$\partial P/\partial x$	Coeff.	$\partial P/\partial x$
$\mathcal{I}_i$(Seats)	-0.199	-0.075	-0.178	-0.071
	(0.618)	(0.233)	(0.640)	(0.255)
$\mathcal{I}_i$(Fares)	-0.376	-0.142	-0.881	-0.351
	(0.504)	(0.190)	(0.597)	(0.238)
$\mathcal{E}_i$(Seats)	-2.029†	-0.767†	-1.601†	-0.638†
	(0.371)	(0.139)	(0.427)	(0.170)
$\mathcal{E}_i$(Fares)	0.316	0.120	1.069	0.426
	(0.653)	(0.247)	(0.729)	(0.290)
ln(Distance)	-0.753†	-0.285†	-1.088†	-0.434†
	(0.191)	(0.073)	(0.234)	(0.093)
ln(O&D Pax)	-0.195	-0.074	-0.233	-0.093
	(0.126)	(0.048)	(0.144)	(0.057)
ln(LCC Size)	-0.003	-0.001	0.062*	0.025*
	(0.024)	(0.009)	(0.028)	(0.011)
LCC Scope	-0.166†	-0.063†	-0.204†	-0.081†
	(0.034)	(0.012)	(0.042)	(0.017)
HHI	-0.666	-0.252	-1.448*	-0.577*
	(0.637)	(0.241)	(0.717)	(0.286)
D(Existing LCC)	-0.573*	-0.217*	-0.868†	-0.346†
	(0.257)	(0.097)	(0.282)	(0.112)
D(1999)	0.046	0.017	0.114	0.046
	(0.286)	(0.108)	(0.318)	(0.127)
D(2000)	-0.652*	-0.246*	-0.974†	-0.388†
	(0.330)	(0.124)	(0.368)	(0.147)
D(American)	0.250	0.095	-0.503	-0.200
	(0.469)	(0.177)	(0.604)	(0.241)
D(Continental)	0.858	0.324	0.335	0.133
	(0.525)	(0.198)	(0.651)	(0.259)
D(Delta)	-0.358	-0.135	-1.080	-0.431
	(0.472)	(0.178)	(0.628)	(0.250)
D(Northwest)	0.399	0.151	-0.214	-0.085
	(0.515)	(0.195)	(0.633)	(0.252)
D(United)	-0.174	-0.066	-0.935	-0.373
	(0.450)	(0.170)	(0.591)	(0.235)
D(US Airways)	-0.040	-0.015	-0.909	-0.362
	(0.622)	(0.235)	(0.722)	(0.288)
Constant	8.555†	3.233†	11.625†	4.634†
	(2.270)	(0.863)	(2.867)	(1.140)
Observations	322.000		264.000	
Pseudo R^2	.3161		.3244	
% of exits correctly predicted	76.2%		83.6%	
No. of observations	322		264	

Notes: Standard errors in parentheses. †Significant at 1%. *Significant at 5%.

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