# Product Quality Choices and Competition: Evidence from the U.S. Airline Industry

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**Abstract**

This paper examines how network carriers adjust product quality given the competition from a low cost carrier (LCC). While previous research has shown that product quality (measured by on-time performance) suffers from heightened competition by LCC (Prince and Simon, 2015), our results find the contrary. Network carriers differentiate themselves by offering higher product quality through lower seat density and more first class/business class seating. Network carrier's product quality response to other LCCs depends on market overlap. When considerable overlap exists, network carriers offer higher product quality by reducing seating density and/or increasing the proportion of first class/business class seats.

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## 1.0 Introduction

The bulk of the empirical literature studying competition in the airline industry has focused on various aspects of price competition. Examples of early studies conducted in the wake of the industry's deregulation focused on the impact of the hub-and-spoke system on airfares include Borenstein (1989), Brueckner and Spiller (1994) and Evans and Kessides (1993). These papers were followed by a series of papers (for example, Brueckner and Whalen (2000), Brueckner (2003), Whalen (2007), Ito and Lee (2007), Gayle (2008), Brueckner, Lee, and Singer (2012) examining the impact of code sharing, alliances and antitrust immunity on both domestic and international airfares. More recently, a number of papers (for example, Brueckner, Lee, and Singer (2013) and Goolsbee and Syverson (2008)) have studied the dramatic impact on prices resulting from competition from low cost carriers (LCCs).

In contrast to the vast literature examining various facets of price competition, less attention has been paid to aspects of *non-price* competition within the airline industry. The primary exception are a small handful of papers studying the provision of inflight amenities (Kim, Liu, and Rupp (2018)), schedule competition, either in terms of flight frequency (for example, Brueckner and Luo (2014), Brueckner (2010), Wei and Hansen (2005)), or the timing of when flights depart (Borenstein and Netz (1999)). In addition, previous work has examined how on-time performance affects pricing (Forbes (2008), Morrison and Winston (1989)), the impact of mergers on on-time performance (Prince and Simon (2017)), how multimarket contact influences on-time performance (Prince and Simon (2009)), and the role of competition in both on-time performance (Greenfield (2014), Mazzeo (2003), Rupp, Owens, Plumly (2006)) and flight cancellations (Rupp and Holmes (2006)).

Although price plays a paramount role in a passenger's decision on whether to fly and which carrier to choose, a variety of structural changes over the past decade suggest that *non-price* elements of competition are playing an increasingly important role. For example, the widespread proliferation of LCCs that began in the early 1990s and has continued unabated to the present day means that most passengers now have the option of flying on an LCC.[1] Thus, since fares in most city-pairs are now subject to price competition from LCCs, large network carriers are likely to increasingly seek ways to differentiate their product from LCCs in terms of product quality.[2]

Another key structural change in the U.S. airline industry has been the growing importance of regional carriers in providing services on behalf of large network carriers (for example, American, Delta, United, US Airways).[3] Regional carriers are airlines that operate relatively smaller turbo-prop and regional jet "RJ" aircraft, typically with between 19 and 90 seats. Mainline

[1] For example, in 2012, the number of domestic U.S. origin and destination passengers traveling on city-pairs where LCCs had at least a 5 per cent share was over 75 per cent, up from 50 per cent in 1998. Source: U.S. DOT DB1B database.

[2] For example, in its Chapter 11 court filings, American Airlines recently noted that "Both United and Delta have announced significant investments in onboard product and service improvements, including installing lie-flat seating, adding additional high value seating, and providing more in-flight services such as on-board Wi-Fi and personal entertainment centers. This, combined with the growth of our competitor networks, has helped our competitors compete for 'high value' customers in the face of ever-increasing LCC competition, and thus continue to maintain a healthy premium over low fares charged by this competition, while American's revenue premium has been falling." (See Memorandum In Support Of Debtors' Motion To Reject Collective Bargaining Agreements Pursuant To 11 U.S.C. \S\ 1113, Part One: Principal Memorandum Of Law. In re: AMR Corporation, et. al, Debtors. United States Bankruptcy Court, Southern District of New York, Chapter 11 Case No. 11-15463 (SHL).)

[3] Regional carriers operate the flights marketed under the "Delta Connection," "United Express," "US Airways Express," and "American Eagle" marketing brands of Delta, United, US Airways and American, respectively, during the sample period.

carriers contract with regional carriers using what are referred to as "capacity purchase agreements" (CPAs), whereby regional carriers adopt the two-letter marketing code and livery of their mainline partner in a way that is intended to be transparent to passengers, but where the mainline carrier dictates and controls virtually all aspects of the service, including which routes to fly, the flight schedule and aircraft type to used, as well as pricing and inventory management. As large network carriers began to experience reduced demand for their services in domestic markets (due to a combination of competition from LCCs and a decline in the overall demand for short-haul traffic as a result of post-September 11th "hassle factor"), regional carriers have played an increasingly important role in the "right-sizing" of the domestic networks of the large network carriers. This growing importance of regional carriers is evidenced by the fact that in 2012, regional carriers accounted for more than 60 per cent of all domestic flights marketed by the large network carriers.

Notwithstanding their growing importance in the product portfolios of the large network carriers, regional carriers are not perceived by all passengers as having an equivalent product quality as mainline service. For example, the operational performance of regional carriers (in terms of on-time performance, cancellations, etc.) has traditionally lagged that of the mainline carriers.[4] Likewise, many regional aircraft (particularly, those with 50 or fewer seats) are characterized by less spacious passenger cabins and have less overhead luggage space.[5]

[4] Forbes and Lederman (2010) also show that wholly-owned regional carriers typically have better operational performance than independent regional carriers.

[5] See, for example "United one-ups small regional jets", *USA Today*, February 6, 2006: "There are plenty of reasons to hate 50-seat regional jets. You bang your head on the low ceiling. There's no room for carry-on luggage because the overhead bins are no bigger than shoe boxes. Seating is all coach and so cramped that you might not be able to open your laptop. A passenger with a gazillion frequent-flier miles who normally flies first class can end up in the plane's last row."

As noted below, each of the large network carriers has re-configured each of their "large" (greater than 50-seat) regional jets with first class seating. More recently, however, the "quality gap" between regional and mainline aircraft has been narrowed with the advent of larger RJs that mimic many aspects of narrow-body (single aisle) mainline aircraft. Moreover, each of the "large" RJs currently deployed by the large network carriers are configured with both economy and first class seating.[6]

The purpose of our paper is to examine the *quality* choices of the large network carriers in response to competition from low cost carriers. The question of quality choices in response to entry in airline markets has been explored by Prince and Simon (2015), which find lower on-time performance and hence lower quality of service by the incumbent carrier following either entry or the threat of entry by Southwest Airlines. Rather than on-time performance, which is observed by the traveler ex-post, this paper proposes two alternative measures of product quality that the traveler can observe before they purchase the ticket, both of which are set by the airline - relative seat density and proportion of first class seats. The relative seat density is the average number of seats on a particular aircraft type compared to the maximum seating capacity for the aircraft across all carriers. Unlike Prince and Simon (2015) which focus on routes that have experienced entry by Southwest or another LCC, this paper uses a panel of flights from 1998 to 2013 to examine the product quality differences across all airline routes both entered and not-entered by LCCs.

While it has been well documented that the presence of a LCC lowers fares (Brueckner, Lee, and Singer (2012)) less well understood is how the presence of LCCs impacts the quality choices of large network carriers. One key factor in determining product quality choices can be

[6]United Express large RJs include both regular economy and Economy Plus seating.

potential restrictions that firms face in making what might otherwise be "optimal" product quality choices. In the airline industry, for example, contractual restrictions contained in contracts between each of the large network carriers and their pilots known as "scope clauses" limit not only the size and number of regional aircraft a carrier can deploy, but in some cases, the routes on which regional aircraft can be flown. Thus, the empirical estimations include controls for both quarter and year effects to account for changes overtime in scope clauses that can restrict the types (size) and numbers of regional aircraft the large network carriers can deploy. The remainder of this paper is organized as follows. Section 2 provides a discussion of aircraft choice, product quality, and pilot scope clauses. Section 3 includes a discussion of the data, entry events, and estimation results. Concluding comments appear in Section 4.

## 2.0 Background on Aircraft Choices For Large Network Carriers

Both of our quality measures - seating density and proportion of first class seats are influenced by the type of aircraft operated by the large network carrier on the route. The fleets of the large network carriers are comprised of two principal types of aircraft: mainline and regional. Mainline aircraft are large jet aircraft (typically configured with more than 90 seats) that are operated by the mainline entity itself (for example, American Airlines, Delta Air Lines, United Airlines, and US Airways) using their own employees. For domestic services, the bulk of mainline flights are operated using a variety of narrow-body aircraft such as the Boeing 737/757, MD-80/88/90 or variants of the Airbus A320. For a given airline, the quality differences across different mainline aircraft deployed in domestic services are likely to be slight.

Regional aircraft, on the other hand, are the relatively smaller turbo-prop and regional jet aircraft (typically configured with between 19 and 90 seats) that are not operated by the mainline

carrier, but rather, by a variety of regional airlines such as Republic (including its subsidiaries Chautauqua and Shuttle America), SkyWest (including its subsidiaries ExpressJet and ASA), Trans States (including its subsidiaries Compass and GoJet), Pinnacle, Piedmont and Mesa.[7] Mainline carriers contract with regional carriers using CPAs, whereby the regional carriers adopt the marketing "code" and livery of their mainline partner in a way that is intended to be transparent to passengers, but where the mainline carrier dictates and controls virtually all aspects of the service, including which routes to fly, the flight schedule and aircraft type employed, as well as pricing and inventory management. Similarly, under a CPA, the mainline pays the regional carrier a fixed fee in exchange for operating the aircraft (regardless of the number of passengers onboard, or the fares they pay) and thus receives all of the ticket revenue. Thus, the mainline carrier assumes all of the risk associated with passenger demand, airfares and fuel price volatility.[8]

Over the past 15 years, the large network carriers have relied upon regional carriers to operate an increasing share of their short- and medium-haul domestic flights. For example, as shown in Figure 1, the proportion of domestic flights marketed by the large network carriers but operated by their regional carrier partners has grown from 43 per cent in 1998 to 61 per cent 2012.

The shift towards a greater reliance on regional carriers on domestic routes is attributable to several factors. First, the growth of LCCs such as Southwest, JetBlue, AirTran, and Spirit is widely credited with transforming domestic airline service into commoditizing the industry. Between 1998 and

[7] Although several mainline carriers formerly owned one or more regional carriers, the bulk of today's regional carriers are independent carriers. The exceptions are American Eagle and Executive Airlines (owned by AMR Corporation) and Horizon Airlines (owned by Alaska Air Group).

[8] For a further discussion of contracting forms between mainline and regional carriers, see Forbes and Lederman (2009, 2013).

2012, for example, LCCs' collective share of domestic O&D passengers has increased from just under 20 per cent to nearly 40 per cent.[9] This growth in share has come, by and large at the expense of the large network carriers, which, as a result, have been forced to reduce domestic capacity in order to restore profitability.[10]

Second, the demand for short-haul air service has also been diminished by the more onerous passenger screening procedures that followed in the wake of the September 11th terrorist attacks (commonly referred to as the "hassle factor" that made traveling by air more time consuming and less convenient relative to other forms of transportation (train, automobile or bus).[11] For example, between the year ending June 30, 2001 (the last four quarters prior to September 11, 2001) and 2012, the number of airline passengers traveling less than 250 miles has dropped by nearly 45 per cent while airline passenger traffic on routes of 250-500 miles has dropped by more than 18 per cent.[12] In aggregate, the reduction in short-haul demand has resulted in the loss of approximately 30 million annual domestic O&D passengers (compared to pre-9/11 levels).[13] Finally, the advent of small regional jet aircraft starting in the late 1990s that could travel at altitudes and speeds comparable to those of larger mainline jets (albeit with less range) greatly expanded the number of routes where regional aircraft were attractive to deploy. Because of their

[9] Source: U.S. DOT DB1B data.

[10] Since 1998, the large network carriers have reduced their domestic capacity by approximately 18 per cent. Source: OAG.

[11] Delta Air Lines CEO Leo F. Mullin stated on April 9, 2002: "The current high hassle factor in aviation security is causing many passengers, especially business travelers, to choose driving or other forms of transportation whenever feasible." https://www.bizjournals.com/atlanta/stories/2002/04/15/story1.html accessed 21 August 2017.

[12] Source: U.S. DOT DB1B data.

[13] Source: U.S. DOT DB1B data.

relatively smaller seating capacity and operating versatility, RJs quickly became a popular choice for the large network carriers across a wide variety of short- and medium-haul routes, particularly those where traffic had declined as a result of LCC competition and the after-effects of September 11th. Likewise, RJs' smaller size have been an effective means for a large network carrier to maintain flight frequency on routes where traffic has declined.

### 2.1 Aircraft Density Choice and Product Quality

The choice of aircraft seating density on a particular route depends on a variety of factors which may include distance, the mix of leisure/business traffic, the proportion of connecting versus "local" passengers, and the desired level of product quality. For example, although mainline aircraft have higher trip costs per flight (due to their larger size and higher hourly labor costs), they tend to have lower unit (for example, seat-mile) costs because of their greater fuel efficiency and the fact that operating costs are spread across a larger number of seats. As a result, mainline aircraft are typically deployed on routes with sufficient number of passengers to support the more cost-efficient mainline jet. Similarly, mainline aircraft are deployed on longer routes that are outside of the practical range of regional aircraft (longer than 1,500 mile). Regional aircraft, on the other hand, are frequently deployed on more thinly traveled routes, or on routes where a carrier wants to maintain a high level of flight frequency despite lower levels of traffic.[14]

It is well understood that aircraft selection reflects a product quality choice on the part of airlines. For example, Coldren et al. (2003) estimate a typical "quality of service" or "QSI" model

[14] This might include,for example, short-haul routes where a large proportion of passengers make connections to other long-haul domestic or international flights or routes with high proportions of business travelers.

used by airlines to predict passenger shares and find that all other things equal, mainline jets drive the highest shares (are most preferred by passengers), with RJs being less preferred than mainline jets, but preferred over turboprops. This preference ordering by passengers is likely the result of several factors. For example, prior to 2005 virtually all regional aircraft were configured in a single class of service (Economy Class). Likewise, most regional aircraft are perceived by passengers as being less spacious than their mainline counterparts in terms of passenger space, overhead storage space, and lavatories. Moreover, at many airports, flights on regional carriers may be concentrated in areas of the airport with fewer passenger amenities (such as airport lounges and restaurants) and/or may require longer walks or walking outdoors in order to board a flight. Finally, regional carriers often have worse on-time performance and higher cancellation rates than their mainline counterparts.[15]

Over the past several years, the large network carriers have taken steps to improve the product quality offerings for their regional flights by deploying relatively larger (greater than 50-seat) RJs with characteristics closer to those of narrow body mainline aircraft. For example, in 2005 United Airlines announced that it would include both economy and first class seating in all of its "70-seat" RJs (those with more than 50 seats such as the Embraer E-170/175 and CRJ-700/900).[16] United's decision to configure its large RJ fleet with a first class cabin was followed

[15] For example, *Airline Quality Rating 2012* (by Brent Bowen and Dean Headley) calculates a quality index for major U.S. airlines annually based on a weighted average of various operational performance measures such as on-time performance, cancelations, customer complaints and mishandled bags. Of the 15 airlines included in the 2011 study, the four regional carriers either ranked at the bottom (American Eagle (#15), Mesa (#14), Atlantic Southeast (#13)) or middle of the pack (SkyWest (#9)).

[16] See "United Express Introduces the Industry's Most Spacious Regional Jet Cabin," United Airlines Press Release, October 26, 2004 and "Introducing Explus, United Airlines' Regional Jet Redefined," United Airlines Press Release, August 15, 2005.

by Delta in 2008,[17] American in 2010[18] and US Airways in 2011.[19] The clear goal of each carrier's decision to re-configure their large RJ fleets to improve the product quality by offering first class seating (in addition to other amenities such as Wi-Fi and meal service).[20] These actions have also closed the product quality gap with mainline flights.[21]

Unlike Lee and Luengo-Prado (2005), we examine how carriers change their seating density in response to competition from LCCs. The typical LCC business model involves high seat density, which serves as a key driver of lower costs. Spirit's 10-K filing in 2013 (page 9) makes this point very clear "each of our aircraft is configured with a high density seating configuration, which helps us maintain a lower unity cost and pass savings to our consumers." The large network carrier must decide whether to adjust its seat density on routes with LCC competition. If we find that network carriers are increasing density (hence lowering service quality) such a result would

[17] See "Delta Connection Goes First Class with More Two-Class Jets, Upgraded Onboard Amenities", Delta Air Lines Press Release, May 24, 2007.

[18] See "American Eagle Airlines to Introduce First Class Service on All CRJ-700 Jets", AMR Corporation Press Release, February 25, 2010.

[19] See "Small Market Flyers Get First Class Option on US Airways Express," US Airways Press Release, April 6, 2011.

[20] See Kim, Liu, and Rupp (2016) for a discussion of which routes carrier opt to provide higher quality inflight amenities such as Wi-Fi and entertainment.

[21] For example, as one SkyWest (a regional carrier partner of several large network carriers) executive notes: "Over time [Delta has] heard back from their customers that they want that consistency, if flying Delta they want a Delta experience. They don't want a fluctuation." See "In Focus: How larger regional aircraft are upscaling interiors", *Airline Business*, December 2011. Similarly, as noted by American's Senior Vice President of Customer Service: "The mission I've got is to make Eagle's first-class service have the look and feel of the first-class cabin of our mainline jets. And when American serves a meal in first, Eagle will service a meal in first." See "American adds first class on regional jets," Orbitz Travel Blog (by Joe Brancatelli), April 23, 2010, http://www.orbitz.com/blog/2010/04/.

be consistent with prior work by Prince and Simon (2015) which found worse on-time performance following LCC competition. On the other hand, a network carrier may choose to offer a higher quality product with lower seat density to differentiate its product from the LCC. Large network carriers have recently begun to retrofit aircraft to add seats and bring them in line with industry standards. The economy class seat in a Boeing 777 is 17" across, which is smaller than a stadium seat in the Barclays Center (19" across), Amtrak Coach (20.5"), and first class in Boeing 777 (21").

### 2.2 Pilot Scope Clauses

A key factor in a carrier's ability to alter its product quality (in terms of its mix of aircraft) are the various restrictions in their collective bargaining agreements with pilots' unions (known as "scope clauses") that limit the size and number of regional aircraft that a large network carrier can deploy within its regional operations. Prior to the round of restructuring (largely under Chapter 11) of the large network carriers that began in 2002, carriers were severely limited in the number of large RJs they could deploy, and some carriers (such as Continental) were prohibited from deploying RJs with greater than 50 seats altogether. Following their restructuring, however, each of the large network carriers gained varying degrees of "scope relief" that allowed them to deploy greater numbers (though still subject to certain limitations) of large RJs. Table 1 illustrates the changes in large RJ scope clauses at each of the large network carriers resulting from their Chapter 11 reorganizations up through the time of our analysis.[22]

Table 1 demonstrates the heterogeneity across the large network carriers both in terms of when their scope clause restrictions were relaxed and the size and number of large RJs each carrier

[22] In 2012, Delta and United reached agreements with their pilots that increased the number of large RJs both carriers could deploy, subject to the growth of their mainline fleet.

can deploy. For example, although United (along with US Airways) was one of the first carriers to have the ability to deploy substantial numbers of large RJs, that carrier was restricted from flying RJs with more than 70 seats until very recently, and thus, had not deployed the 76-80 seat CRJ-900s and E-175s deployed by Delta and US Airways.[23] Likewise, Continental had been precluded from flying any RJs with more than 50 seats, a restriction that applied even after it had merged with United at the merged entity's former Continental hubs. Likewise, American has only recently been granted relief from its scope clause that had limited its ability to deploy large RJs to 47 aircraft. Figure 2 illustrates how the relaxation of a carrier's scope clause results in a substantial increase in the number of large RJ hours flown.

## 3.0 Estimation of Product Quality Choices

Our goal is to empirically examine how product quality choices by airlines vary across routes in response to competition by LCCs. In particular, we seek to determine how the route-level product quality choices by the large network carriers when competing with Southwest Airlines and more generally with any LCC. To this end, we estimate a series of reduced form regressions with product quality serving as the dependent variable along with several key variables which are likely to influence the product quality selection.

### 3.1 The Data and Summary Statistics

[23] The new joint CBA between United and former Continental pilots post-merger permits United to use 76-seat RJs. See "United pilot agreement allows for up to 255 large RJs", *Flight International*, November 19, 2012.

Our data come from two sources. The Official Airline Guide (OAG) provides a complete quarterly schedule of all domestic U.S. flights between 1998 and 2013. The Department of Transportation T100 data is used to derive equipment specific seat density. The sample is comprised of quarterly, non-directional,[24] carrier-route observations for six large U.S. network carriers (American, Continental, Delta, Northwest, United, and US Airways) and seven LCCs (Southwest, AirTran, JetBlue, Sun Country, Spirit, Allegiant, and Frontier). Only routes originating and ending in the United States are eligible for inclusion. Because airlines make aircraft quality choices at the city-pair level (Lee, Brueckner, and Singer (2014)), we use city-pairs as our unit of observation. Hence we examine both network carrier and LCC competition in the city-pair market.[25] In addition to quality choices made by airlines on a route-by-route level, since network carriers also make quality choices on a fleet-wide level, we also include a fleet-wide *LCC exposure* variable in the estimations to account for the average level of competition across routes. This variable represents the proportion of a network carrier flights in city-pair markets that have LCC competition.

For each route-carrier-quarter observation, we compute the average seat density by comparing the aircraft seating capacity with the maximum observed seating capacity for the identical aircraft across all airlines in the same year. For example, Spirit Airlines configured its Airbus A-320s with 178 seats in 2010 (the maximum for this aircraft type among all carriers in 2010). In 2010, if United Airlines deployed an A-320 which averaged 140, then United's relative seat density is 140/178 = 0.7865. Seat density is the seat weighted average of the aircraft-type

[24] For example, Boston (BOS) to Los Angeles International (LAX) is treated as the same route as LAX to BOS.

[25] Several studies (for example, Brueckner, Lee, and Singer (2013, 2014), Morrison (2001) have shown that competition by an LCC in an adjacent airport-pair market has a substantial effect on airline behavior. However for tractability, our analysis focuses on city-pairs.

specific densities on aircraft deployed by a carrier on the city-pair in question each quarter. We also calculate a second service quality measure - the average proportion of first class and business class seats for the identical aircraft.

We are interested in assessing how a large network carrier alters its product quality given the presence of an LCC on the city-pair market. Shaked and Sutton (1982) suggest that when two firms with similar products compete, the equilibrium outcome which ensures positive economic profits is for the firms to reposition their products by offering distinct qualities. To eliminate routes with infrequent service, we only include domestic city-pair markets that average at least one daily scheduled departure. Since Brueckner, Lee, and Singer (2013) found that presence by Southwest results in substantially greater downward pressure on fares than other LCCs, we include separate indicator variables for the presence of each low cost carrier.[26][27] Since airline schedules are set well in advance of the service actually being offered, consumers can determine the product quality (relative seat density or proportion of first and business class seats) prior to departure. This is a marked difference from prior work by Prince and Simon (2015) which linked on-time performance and product quality since on-time performance is not revealed to the consumer until after the flight has occurred.

Seat density varies substantially across carriers and within a carrier over our sample period. For example, United Airlines introduced Economy Plus in 2001 hence a reduction in average

[26] An LCC is present in a city-pair market if the LCC has at least five percent market share.

[27] At the tail-end of our sample period, Southwest Airlines announced the acquisition of AirTran Airways (September 2010). This acquisition was approved by the US Department of Justice in April, 2011 and completed in May, 2011. The carriers, however, have not yet begun operations using a single operating certificate, and thus, we are able to distinguish between Southwest and AirTran entry events throughout our entire sample period.

seating capacity for its mainline aircraft. In 2003, JetBlue added two inches more legroom by removing a row of seats.[28] Four years later in 2007, JetBlue announced "Even More Space" which further reduced the seat density. Figure 3 shows the differences in seating density on a given aircraft type (Airbus A-320) across carriers. Spirit Airlines has considerably higher seating density 178 seats, compared to the large network carriers Delta (150 seats) and United (144 to 150 seats).

A second illustration of seating differences across carriers is provided by the Boeing 737-800 in Figure 4. Southwest Airlines has the highest seat density for this aircraft at 175 seats. In comparison, for the same aircraft, the network carriers' seat density fluctuates during the sample period with American Airlines experiencing the largest variation with the introduction of "More Room Through-out Coach" in 2000,[29] only to cancel this program in 2004.[30] Seating density changes are not limited to large mainline aircraft as Figure 5 shows differences in seating density for the regional jet: Bombardier CRJ-700 across carriers. Each of the network carriers have adjusted the typical seat density of this aircraft during the sample period, in some instances decreasing density (United adding first class and Economy Plus to its regional fleet in 2004; US Airways, Delta, and American following suit in 2013), and in other instances increasing density with United reducing seat pitch (the distance between seats) in 2014.

Figure 6 provides average density measures by year for both network carriers and LCCs. This heat mapping of densities reveals two stylized facts about seat densities. First, LCCs (with

[28] "JetBlue to sell more shares, add legroom," *USA Today*, July 6, 2003, http://usatoday30.usatoday.com/travel/news/2003/07/04-jetblue-legroom.htm (accessed August 4, 2015).

[29] "American Air to Put More Room in Coach," The New York Times, February 4, 2000, http://www.nytimes.com/2000/02/04/business/american-air-to-put-more-room-in-coach.html (accessed August 4, 2015).

[30] "American Airlines squeezes passengers in tighter to make money," *USA Today*, October 21, 2004, http://usatoday30.usatoday.com/travel/news/2004-10-20-more-seats_x.htm (accessed August 4, 2015).

the exception of Virgin America) typically have higher seat densities than their network carrier counterparts. Second, network carriers have experienced more variation in their seat densities, while more recently, seating densities have been rising for network carriers.

In addition to seat density changes for the same aircraft type, there were also changes in city-pair competition during the sixteen year sample period. From the late 1990s through 2013, there was considerable expansion by LCCs with Southwest initiating service on 170 routes. Southwest commenced service to Denver (DEN), with the airport becoming its fifth largest destination measured by daily flights. As a result approximately one-fourth of all Southwest entry events involve Denver (46 routes). Other notable expansion at existing Southwest airports during our sample period include adding 24 routes at Chicago Midway (MDW), 21 new routes for Philadelphia (PHL), and 18 new routes from Las Vegas (LAS). The six other LCCs in our sample (Frontier, AirTran, Allegiant, Sun Country, JetBlue, and Spirit) also expanded their offerings. Jointly these other LCCs had more than twice as many entry events (357) as Southwest (170) with AirTran experiencing the largest domestic route expansion (139 new routes), followed by Frontier (85 routes), and JetBlue (64 new routes).[31] Compared to Southwest, the other LCCs appear to select less competitive routes for entry. For example, Table 2 shows that approximately one-half of the non-Southwest LCC entries occurred on routes without large network carrier service (in comparison, only 40 percent of Southwest entries occurred on routes without network carrier service). About 40 percent of these LCC entries were on routes served by a single large network carrier compared to one-half of Southwest. Less common was entry by non-Southwest LCCs on more competitive routes, with just 12 percent of routes being served by two large network carriers

[31] The remaining three LCCs had fewer new routes: Spirit (31), Allegiant (23), and Virgin America (12) during our sample period.

and only two percent of entry occurring on routes with non-stop service by three or more large network carriers.

### 3.2 Econometric Specification

Our goal is to assess changes in product quality of large network carriers to competition from LCCs. Hence, we begin by estimating the following baseline model:

$$Y_{itr} = a + \beta X_{itr} + \gamma LCC_{itr} + \delta LCC\ exposure_{it} + Year_{itr} + Quarter_{itr} + Route_{itr} + \epsilon_{itr} \quad (1)$$

where *Y* is the dependent variable that measures product quality for each carrier. Our two measures of quality are seat density and proportion of first class seats. *Density* is the natural logarithm of the average relative seat density of network carrier *i* in quarter *t* in city-pair route *r* relative to the maximum seating capacity employed across all airlines for the particular aircraft type on the route in that year. Our second quality measure *1st class %* is the proportion of first and business class seats in the aircraft. Also, β represents the estimated regression coefficients of $X_{itr}$, a vector of route characteristics that likely impact the quality decision. We use $\gamma$ to represent the estimated regression coefficients of $LCC_{itr}$, a vector of indicator variables which indicate the presence of LCC *j* at quarter *t* in the city-pair route *r*. Likewise, $\delta$ indicates the estimated regression coefficients of *LCC exposure*, which represents the proportion of network carrier *i*'s flights that are exposed to LCC competition in the city-pair during quarter *t*. The inclusion of *Year* and *Quarter* fixed effects enables us to control for both changes in seating configuration and fleet composition over time and potential seasonal changes in seat density. The *Year* and *Quarter* fixed effects are particularly needed in the estimation given the proliferation of regional jets during the sample period along with the relaxing of pilot scope clause restrictions post-9/11 (see Figure 2). We present separate estimations with and without city-pair *Route* fixed effects since the inclusion of *Route* wipes away

all route variables that do not change over time in our sample (for example, temperature differences between city-pairs, distance between airports). In addition to temperature difference and distance, we also include the natural logarithm of the geometric mean of both the metropolitan statistical area (MSA) population and income at origination and destination. The final route characteristic included in vector *X* is the number of network competitors who are serving the same city-pair. This enables an additional measure of route competition above and beyond the presence of an LCC on the route.

The above specification is used to estimate each of the six large network carriers separately for the sixteen year sample period (1998-2013) followed by a joint estimation for all network carriers. This specification allows us to separately examine how each network carrier responds to route competition from both other network carriers and competition from LCCs.

### 3.3 Estimation Results

Table 3 presents results for the panel of 1998 through 2013 domestic flights for each of the six large network carriers. The seventh column is an aggregation of the six network carriers. There are five primary takeaways from Table 3. First, network carriers' quality response to LCC exposure differs by carrier. For example, both Delta Airlines and United Airlines have significantly reduced density (increased quality) after an increase in LCC exposure, while on the other hand Continental Airlines took the opposite approach and increased density (lower quality) in response to more network-wide LCC exposure. We did not detect any significant fleet-wide density response by American Airlines, US Airways, or Northwest Airlines to heightened LCC competition.

Second, what is more important to network carriers than the overall LCC exposure is the composition of the LCC competition. The presence of the largest LCC, Southwest Airlines in a

city-pair market significantly reduces seat density (improves the product quality) for most network carriers. Due to the log density specification in Table 3, we interpret the magnitude of the estimated coefficients for the presence of Southwest Airlines in the city-pair market which range from -0.0168 (United) to -0.0393 (American), as follows: 100(Exp(-0.0168)-1) = -1.7 percent (United) and 100(Exp(-0.0393)-1) = -4.0 percent (American). To put this into perspective, the typical configuration of an American Airlines Boeing 777-800 would have about six fewer seats on city-pair routes where Southwest Airlines is present.

Third, the presence of an LCC (other than Southwest) also reduces seat density by the network carrier when the LCC and network carrier have considerable multi-market contact. Table 4 presents a summary of the LCC city-pair market observations in the sample along with the number of overlapping routes with service by the network carriers. For example, Southwest Airlines has 22,568 quarterly route observations in the sample. American Airlines is the network carrier with the most overlapping routes with Southwest as 4,374 of 22,568 (or about 19 per cent) of Southwest city-pair routes are served by American. The entries in bold from Table 4 indicate the network carrier with the greatest overlap with a particular LCC.

Table 3 reveals significantly lower seat density (hence higher quality) for network carriers with substantial LCC overlap. This result is in contrast to Prince and Simon (2009) who find that multimarket contact increases flight delays (or reduce quality) with the effect magnified for contacts on more concentrated routes. For example, our results suggest that Delta provides service on 56 per cent of routes served by AirTran. Table 3 shows that the presence of AirTran in a city-pair market reduces Delta's logged seat density by 2.1 percent, which translates to about three fewer seats on a Boeing 777. This effect is not limited to just AirTran and Delta, as we find similar results (reduction in seat density by network carriers) by Delta in JetBlue markets. Specifically,

Delta has the largest network carrier presence, appearing in 42 per cent of JetBlue markets. Once again Delta significantly reduces seat density 1.4 percent in JetBlue markets. The network carrier with the highest degree of LCC market overlap is United Airlines, which appears in 88 per cent of Frontier's markets. Similar to previous network carrier findings, United's coefficient estimate suggests a 3.1 percent lower seat density in Frontier markets.

American is also the network carrier with the most overlap with Southwest Airlines, hence it is not surprising that American has the largest reduction in density of any network carrier on routes with a Southwest presence. American is also the network carrier with the highest overlap with Spirit Airlines. Once again, American has significantly lower density (3.0 percent) and hence higher product quality on routes served by Spirit. The one network carrier that has chosen to add density on routes with a substantial LCC presence is Northwest Airlines. We find that Northwest Airlines increases seat density (hence lower quality) by 1.6 percent given the presence of Sun Country. Given that Allegiant has little multimarket contact with any network carrier ( for example, United has the largest network carrier presence appearing in less than ten percent of Allegiant routes), we find that the presence of Allegiant has minimal impact on seat density of any network carrier.

As previously discussed, network carriers respond to the presence of LCC competition when there is considerable multi-market contact by adjusting seat density. Specifically, most network carriers (other than Northwest) offer higher product quality in response to LCC competition. These competitive responses, however, are limited to the presence of low cost carriers. Hence our fourth finding is that the source of competition matters, since seating capacity of network carriers is largely independent of the amount of network carrier competition on the

city-pair route. These findings are consistent with Brueckner, Lee, and Singer (2013) who report that competition between network carriers generates minimal price changes.

Fifth, and finally, Table 3 shows that network carriers have significantly lower density (higher quality) on longer distance routes. As a robustness check, we include route fixed effects in the estimations (see appendix). These additional market controls drain the explanatory power and reduce the magnitude of most coefficients estimates by about 50 percent. Hence the aggregated results across all carriers are qualitatively similar yet quantitatively smaller.

### 3.4 Proportion of 1st Class and Business Class Seats

Next we examine a second measure of product quality - the proportion of 1st class and business class seats in the aircraft. While one would expect the findings to be similar to the seat density results since the proportion of business class seats is highly correlated with seat density, however, these two quality measures are not identical. The proportion of 1st class and business class seats is a measure of the proportion of high quality seats offered within the aircraft. Whereas density is constructed by comparing the number of aircraft seats to the maximum possible seating configuration for that aircraft model across carriers. For example, a carrier could retrofit an aircraft by installing thinner seats with less seat pitch in economy to create room for an additional row of business class seats, hence substantially increasing the proportion of business class seats while only modestly increasing seat density. The empirical results for the proportion of 1st class and business class seats are similar to the seat density findings since all five takeaways previously discussed still hold.

Unlike seat density where negative coefficients indicate higher product quality, now positive coefficients for the proportion of 1st class and business class seats indicate higher quality

in Table 5. We find once again network carriers have no clear cut consensus on how to adjust product quality from an increase in system-wide LCC exposure. Some network carriers (American, Delta, United, and Northwest) have chosen to increase the percentage of 1st class and business class seats in response to greater LCC exposure, while other network carriers (Continental and US Airways) have opted to reduce their proportion of premium seating following more LCC exposure.

What is more important than the overall LCC exposure is the presence of Southwest Airlines. We find that for the five network carriers with largest city-pair overlap with Southwest Airlines (see Table 4) all have significantly higher proportions of 1st class and business class seats on Southwest markets. Only Northwest Airlines has no significant change in premium seating in Southwest markets and this may be attributed to the fact that Northwest has more overlap with smaller LCCs of Sun Country and Spirit Airlines than Southwest Airlines. The magnitude of this effect ranges from approximately 1 percent (United, Delta, and US Airways) to 2 percent (American and Continental) increase in the proportion of first class and business class seats in city-pair markets where Southwest Airlines is present.

Network carriers are also responsive to competition from non-Southwest LCCs when there is considerable market overlap between the two competitors (see Table 5). We find that network carriers are increasing the proportion of 1st class and business class seats in response to a significant presence of a competing LCC. For example, American has the most overlap with Spirit Airlines. We find that American responds to the presence of Spirit by increasing the proportion of its 1st class and business class seats by 2.0 per cent. Also, Delta is the legacy carrier with the most overlap with AirTran and we find similar results as the presence of AirTran drives Delta to offer 3.1 percent more 1st class and business class seats. In a similar fashion United responds to Frontier's presence by also increasing the proportion of 1st class and business class seats by 2.0 percent. Delta doesn't

appear to adjust the proportion of first class/business class seats given the presence of JetBlue (we previously found a reduction in seat density by Delta on JetBlue routes). Likewise, we find no adjustment in the proportion of 1st class and business class seats by Northwest in Sun Country routes.

As indicated in both Table 3 and Table 5, American Airlines has the largest quality response among all network carriers to Southwest Airlines competition by reducing seat density (4.0 percent) and increasing 1st class/business class seats (2.5 percent). We attribute this magnified response by American Airlines to the fact that American Airlines had the most variation in average seat density during the sample period (see Figure 6). American Airlines initiated, in 2001, the "More Room Through Coach" campaign (see Figure 4) in an effort to attract quality consensus coach travelers. In 2004, however, American Airlines discontinued the "More Room Through Coach" program citing that seat availability at low prices is the predominant factor its consumers use when choosing a carrier.[32]

In sum, the source of the competition matters when network carriers are deciding how to adjust quality in response to competition from LCCs. We find that the presence of an LCC, especially an LCC with a large degree of overlapping markets, will prompt the typical large network carrier to improve product quality as measured by the proportion of 1st class and business class seats. We find little product quality adjustments (as measured by the proportion of 1st class and business class seats) due to the presence of other large network competitors. Finally, one other route characteristic matters in determining the proportion of first class/business class seats - route distance. We find that longer flights attract more first class and business class seats.

[32] https://www.disboards.com/threads/american-airlines-to-eliminate-more-room-through-coach-on-some-of-its-fleet.377414/ accessed 8 Dec 2017.

## 4.0 Conclusion

This paper examines how network carriers adjust product quality given the presence of an LCC along the route. While previous research has shown that product quality (measured by on-time performance) suffers from heightened competition by LCC (Prince and Simon, 2015)) our results find the contrary. Given the presence of Southwest Airlines in their market, most network carriers typically differentiate themselves from their LCC competitors by offering higher product quality through lower seat density and more first class and business class seating. More generally, our result is consistent with Shaked and Sutton (1982) who suggest that it is profitable for two competing firms to reposition their products by offering distinct quality differences. Unlike service quality measures such as on-time performance or flight cancellations, our product quality measures are known to both the traveler and airline at the time that the ticket is purchased.

Beyond Southwest Airlines, we find that the quality response to other LCCs depends on the amount of market overlap between the network carrier and LCC. When there is considerable overlap between two competitors, network carriers are much more likely to offer higher product quality by reducing seating density and/or increasing the proportion of first class and business class seats. We find that competition from other network carriers prompts little product quality changes by the network airline. Finally, product quality is higher on longer distance routes.

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Figure 1: Proportion of Domestic Flights on Large Network Carriers, 1998-2012

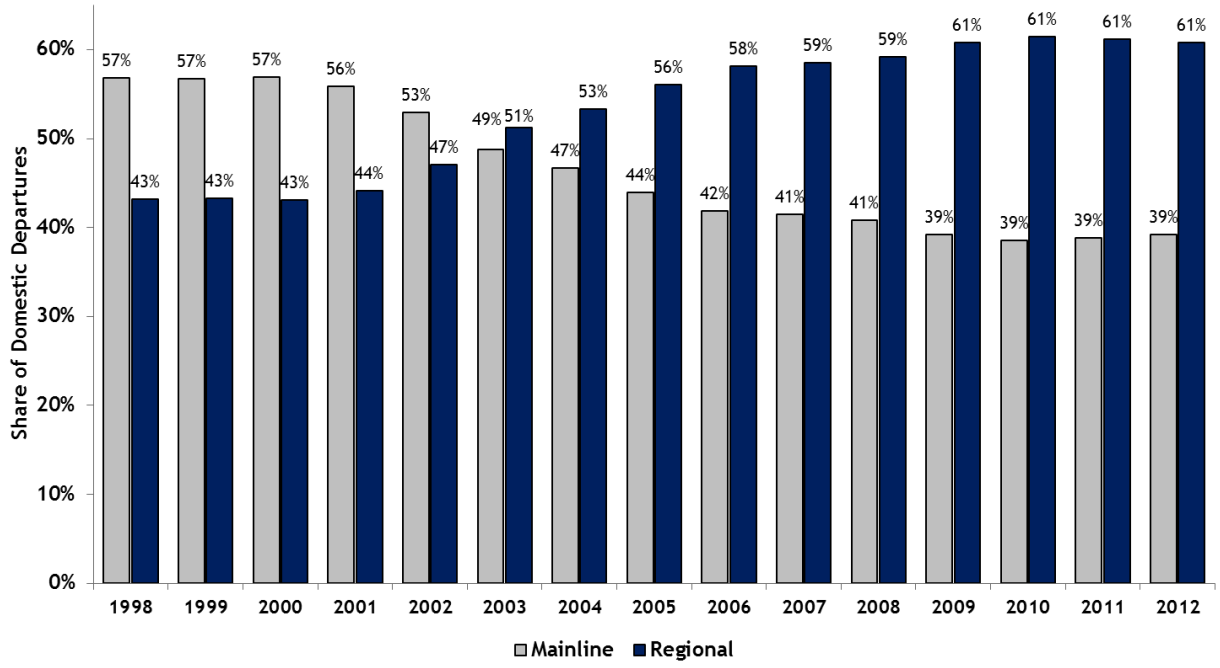
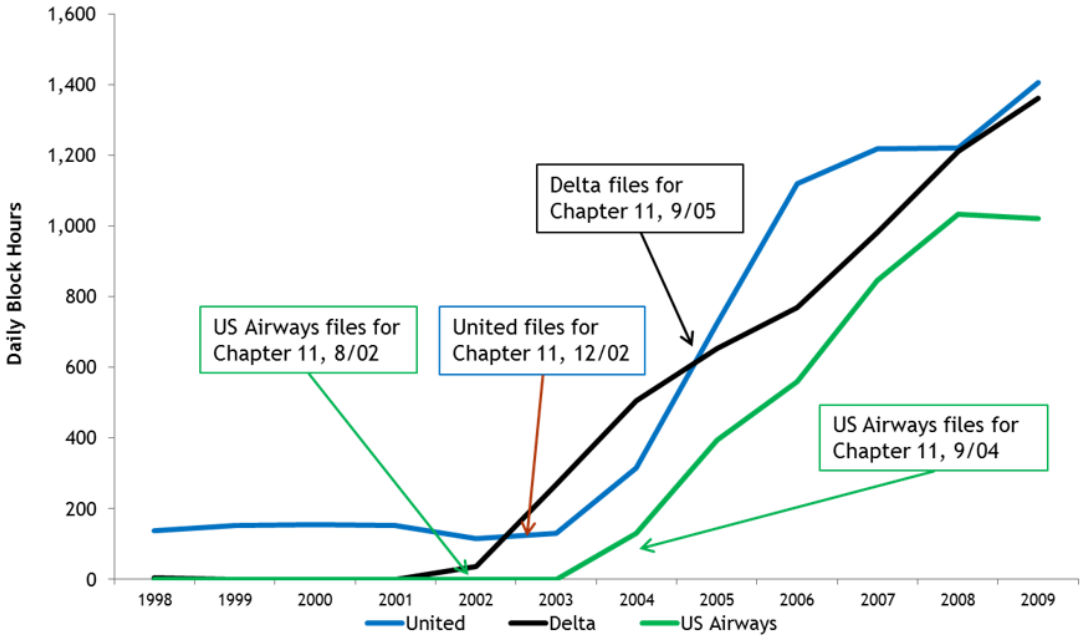
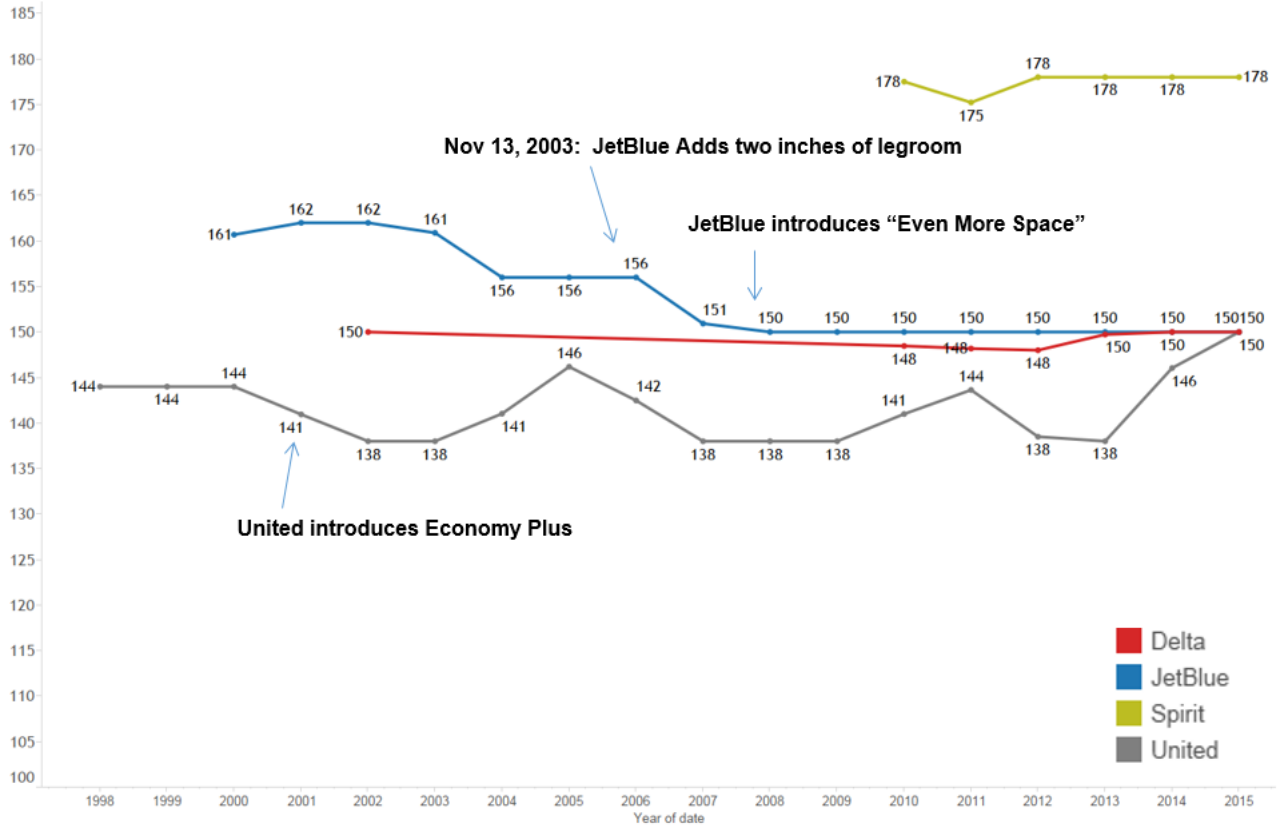


Figure 2: Daily block hours on large RJs before and after loosen scope clause restrictions



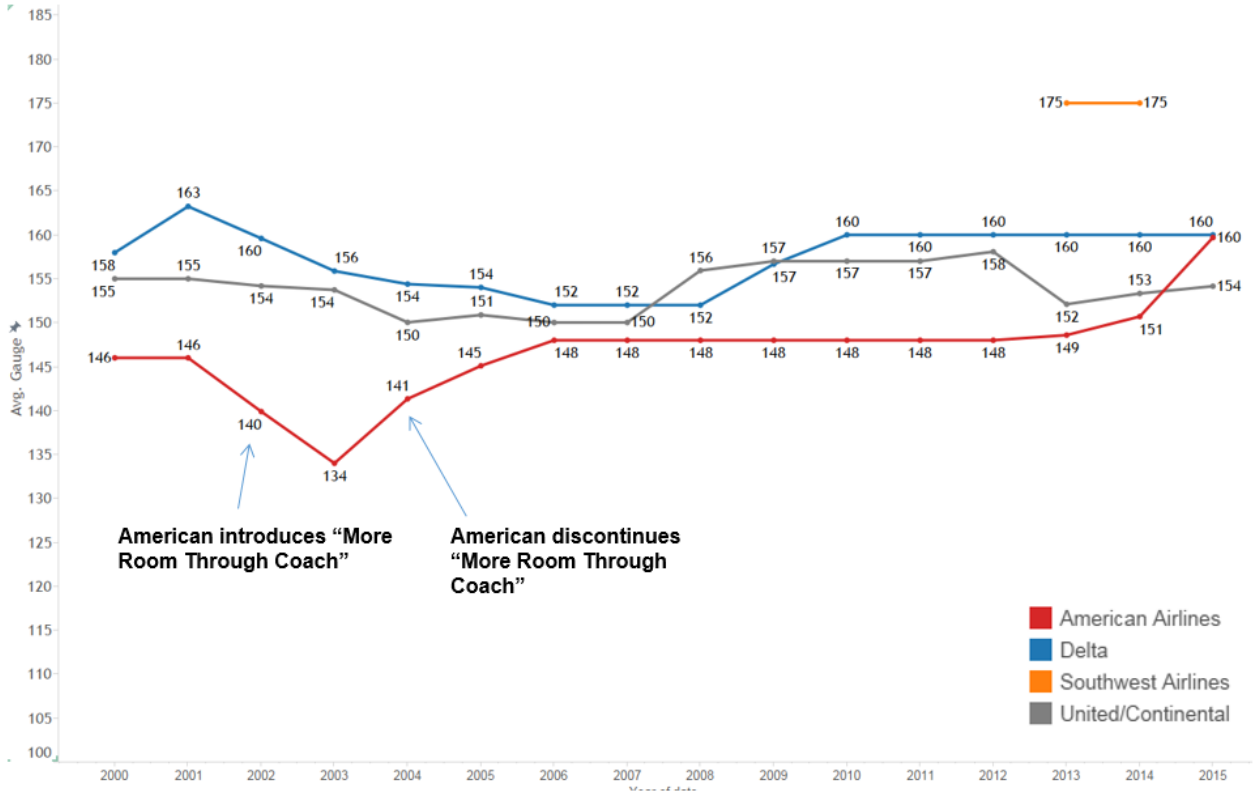

Source: OAG Data.
Notes: United does not include Continental, Delta does not include Northwest, US Airways does not include America West. 70-Seat Regional Jets Include CRJ-700, CRJ-900, E-170/175, AVRO RJ70, and BAE-146/200.

**Figure 3: Differences in Average Seat Density of Airbus A-320**



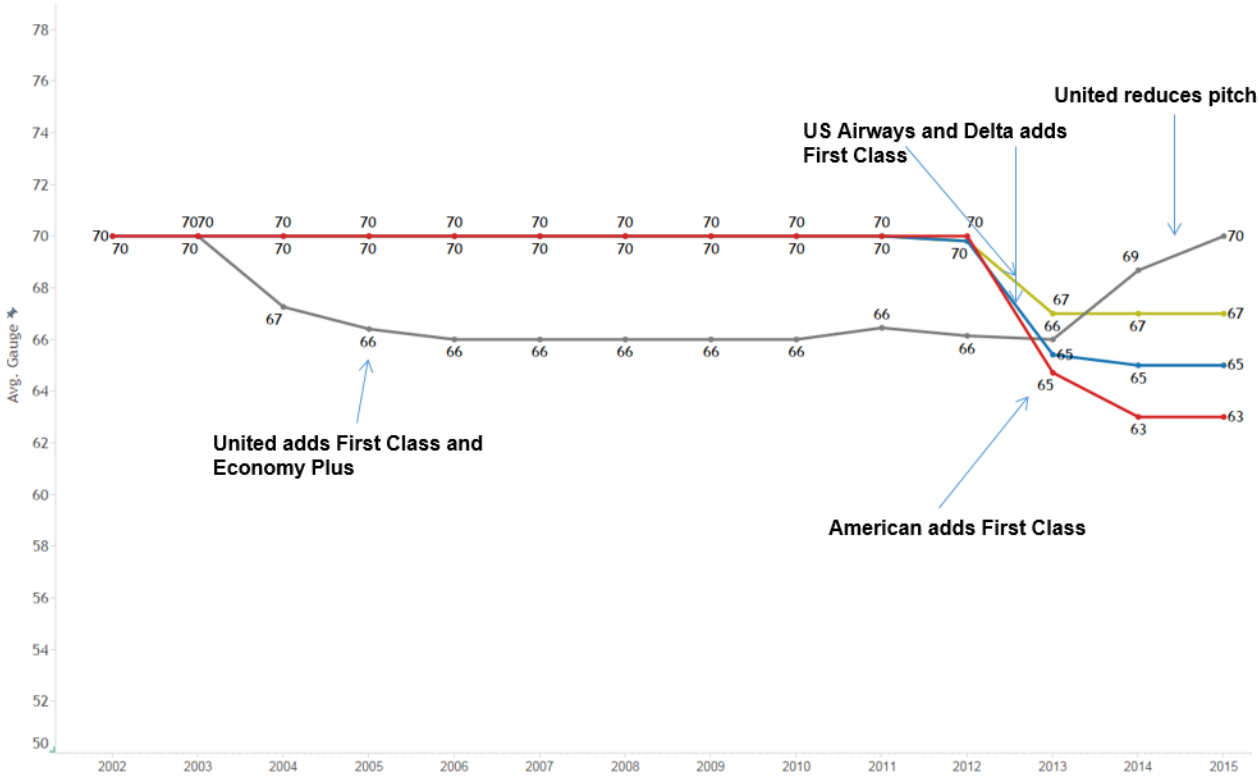

Source: OAG.
Notes: Domestic Operations

**Figure 4: Differences in Average Seat Density of Boeing 737-800**




Source: OAG.
Notes: Domestic Operations

**Figure 5: Differences in Average Seat Density of Bombardier CRJ-700**




Source: OAG.
Notes: Domestic Operations

Figure 6: Yearly Average Density Measures for Legacy Carriers and LCCs for domestic flights

**Legacy Carriers**

| Carrier Mkt | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| American | 89.3% | 91.5% | 88.7% | 87.6% | 87.2% | 88.4% | 89.0% | 89.8% | 94.9% | 95.5% | 96.3% | 96.6% | 96.3% | 93.3% | 93.1% | 92.1% |
| Alaska | 95.3% | 95.2% | 94.9% | 94.7% | 95.8% | 93.9% | 95.7% | 95.9% | 97.1% | 96.1% | 97.0% | 97.3% | 96.4% | 94.9% | 90.0% | 87.4% |
| Continental | 90.5% | 92.1% | 92.9% | 92.3% | 93.4% | 94.8% | 95.0% | 95.7% | 96.3% | 96.9% | 97.6% | 97.9% | | | | |
| Delta | 92.0% | 91.3% | 92.5% | 93.3% | 94.2% | 94.4% | 95.3% | 95.6% | 97.1% | 96.6% | 97.4% | 96.4% | 95.6% | 93.7% | 94.2% | 93.5% |
| Northwest | 88.4% | 89.6% | 92.6% | 93.0% | 91.1% | 95.5% | 97.7% | 97.7% | 96.9% | 96.6% | 96.1% | | | | | |
| United | 92.2% | 92.3% | 89.6% | 88.9% | 92.2% | 94.0% | 94.3% | 95.0% | 94.3% | 94.1% | 94.8% | 93.8% | 95.6% | 94.6% | 94.4% | 94.6% |
| US Airways | 83.9% | 88.9% | 91.8% | 92.8% | 94.9% | 96.9% | 96.5% | 96.1% | 96.5% | 96.0% | 96.6% | 95.0% | 95.6% | 94.7% | 94.4% | 94.3% |

**LCCs**

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AirTran | 88.0% | 73.7% | 92.4% | 93.5% | 93.3% | 94.4% | 94.3% | 100.0% | 98.4% | 100.0% | 100.0% | 100.0% | 100.0% | 95.1% | 99.0% | 99.4% |
| Frontier | 88.1% | 93.2% | 95.9% | 94.5% | 94.9% | 96.5% | 94.7% | 91.4% | 88.3% | 87.2% | 92.9% | 93.6% | 95.8% | 92.9% | 95.8% | 95.2% |
| JetBlue | | | 99.9% | 100.0% | 100.0% | 98.8% | 96.5% | 100.0% | 100.0% | 98.1% | 95.3% | 95.4% | 90.5% | 87.0% | 89.5% | 89.9% |
| Southwest | 97.9% | 98.8% | 99.1% | 96.0% | 97.6% | 97.5% | 95.8% | 96.6% | 99.3% | 100.0% | 100.0% | 100.0% | 100.0% | 95.1% | 97.7% | 99.2% |
| Spirit | 83.2% | 88.5% | 96.6% | 96.5% | 95.6% | 94.6% | 88.3% | 86.6% | 91.9% | 93.4% | 99.7% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Virgin America | | | | | | | | | | 95.0% | 89.7% | 88.7% | 83.1% | 83.0% | 82.7% | 82.6% |

| Table 1: Change in Large RJ Scope Clauses | | |
|---|---|---|
| Carrier | Chapter 11 filing | Notes |
| American | 2011 | Pre-Chapter 11: 47 RJs with up to 70 seats |
| | | Post-Chapter 11: Up to 255 RJs with up to 88 seats |
| | | |
| Continental | N/A | No RJs with more than 50 seats prior to merger with United. |
| | | Joint CBA with United (post-merger) in late 2012 allows for |
| | | up to 255 large RJs |
| | | |
| Delta | 2005 | Pre-Chapter 11: 82 70-seat RJs. |
| | | Post-Chapter 11 (and Northwest merger): 325 RJs with 51-76 |
| | | seats, of which 223 can be with 76 seats |
| | | |
| Northwest | 2005 | Pre-Chapter 11: 36 69-seat RJs. |
| | | Post-Chapter 11 (and Delta merger): 325 RJs with 51-76 seats |
| | | of which 223 can be with 76 seats |
| | | |
| United | 2002 | Pre-Chapter 11: No RJs with more than 50 seats. |
| | | Post-Chapter 11: Unlimited RJs with a maximum of 70 seats; |
| | | Not permitted to fly RJs with more than 70 seats. Joint CBA |
| | | with Continental in late 2012 allows for up to 255 large RJs |
| | | |
| US Airways | 2002 & 2004 | Pre-Chapter 11: No RJs with more than 50 seats. |
| | | Post-Chapter 11: Up to 212 RJs with 51-70 seats; Up to 153 |
| | | RJs with 71+ seats. |
| *Notes and Sources*: Declaration of Jerrold Glass, In Support of Motion to Reject Collective Bargaining Agreements Pursuant To 11 U.S.C. § 1113(c), In re: AMR Corportation, et al., Debtors. United States Bankruptcy Court, Southern District of New York. March 2012 and UBS Airline Research, November 23, 2004. | | |

| Table 2: Southwest Airlines and other low cost carrier (LCC) entry events In U.S. | | | | | |
|---|---|---|---|---|---|
| | Existing Network Carriers on Route at LCC Entry | | | | Total Entry |
| | Zero | One | Two | Three+ | Events |
| Southwest (WN) | 68 | 84 | 15 | 3 | 170 |
| LCC (exclude WN) | 162 | 121 | 41 | 7 | 331 |
| Total | 230 | 205 | 56 | 10 | 501 |

Table 3: *ln(density)* coefficient estimates from 1998-2013 domestic flights for city-pair routes with at least one daily departure

| | American | Continental | Delta | United | US Airways | Northwest | All Carriers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| VARIABLES | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* |
| *ln(income)* | 0.0355 | -0.0543 | -0.00965 | -0.0248 | 0.0665** | -0.0297 | 0.00657 |
| | (0.0379) | (0.0435) | (0.0167) | (0.0193) | (0.0190) | (0.0297) | (0.0116) |
| *ln(population)* | -0.0615 | 0.0453 | -0.00357 | 0.00990 | -0.0804** | 0.0229 | -0.0211 |
| | (0.0407) | (0.0472) | (0.0176) | (0.0201) | (0.0207) | (0.0309) | (0.0125) |
| temperature difference | 3.04e-05 | -0.000879** | 5.22e-05 | 0.000755** | 3.36e-05 | -0.000250 | 9.22e-06 |
| | (0.000302) | (0.000258) | (0.000153) | (0.000206) | (0.000188) | (0.000275) | (0.000109) |
| *ln(distance)* | -0.0459** | -0.0246** | -0.0159** | -0.0274** | -0.0179** | -0.00945* | -0.0247** |
| | (0.00356) | (0.00297) | (0.00227) | (0.00212) | (0.00185) | (0.00401) | (0.00127) |
| legacy competitors | 0.00920** | 0.000818 | 0.00923** | -0.00622* | 0.00103 | -0.00363 | 0.00224 |
| | (0.00286) | (0.00265) | (0.00243) | (0.00270) | (0.00231) | (0.00596) | (0.00145) |
| LCC exposure | 0.0108 | 0.0336** | -0.0986** | -0.131** | -0.0174 | 0.0253 | -0.00630 |
| | (0.0128) | (0.0103) | (0.0141) | (0.0216) | (0.0112) | (0.0203) | (0.00899) |
| Southwest | -0.0393** | -0.0293** | -0.00479 | -0.0168** | -0.0250** | -0.00781 | -0.0223** |
| | (0.00593) | (0.00694) | (0.00379) | (0.00382) | (0.00353) | (0.00917) | (0.00251) |
| Sun Country | -0.0449** | -0.00630 | -0.00850 | -0.0626** | -0.0385** | 0.0162* | 0.000906 |
| | (0.00930) | (0.00524) | (0.00859) | (0.0226) | (0.00529) | (0.00753) | (0.00713) |
| Spirit | -0.0292* | -0.00895 | -0.00481 | -0.0223* | 0.00763 | 0.00886 | -0.0135* |
| | (0.0116) | (0.0110) | (0.00635) | (0.00871) | (0.0125) | (0.00696) | (0.00582) |
| JetBlue | 0.000140 | -0.0195** | -0.0143** | -0.0170 | -0.00974 | | -0.0101* |
| | (0.00952) | (0.00623) | (0.00495) | (0.00972) | (0.00783) | | (0.00458) |
| AirTran | -0.00885 | -0.0356** | -0.0210** | -0.00840 | -0.0107 | -0.00647 | -0.0142** |
| | (0.0105) | (0.0108) | (0.00408) | (0.00663) | (0.00710) | (0.00805) | (0.00307) |
| Frontier | -0.0450** | -0.0263** | -0.0118 | -0.0301** | -0.0321* | -0.0147 | -0.0272** |
| | (0.0132) | (0.00722) | (0.00632) | (0.00443) | (0.0152) | (0.00916) | (0.00430) |
| Allegiant | | | | 0.0150** | 0.0144 | | 0.0117* |
| | | | | (0.00552) | (0.00905) | | (0.00595) |
| Constant | 0.474** | 0.375** | 0.321** | 0.527** | 0.0283 | 0.140 | 0.296** |
| | (0.116) | (0.103) | (0.0567) | (0.0752) | (0.0572) | (0.0910) | (0.0361) |
| Observations | 18,595 | 11,488 | 28,016 | 21,296 | 18,121 | 11,324 | 108,840 |
| R-squared | 0.441 | 0.431 | 0.200 | 0.348 | 0.395 | 0.265 | 0.265 |

Robust standard errors are clustered by airline market appear in parentheses. Year and quarter fixed effects are included (yet not reported. * and ** represent statistical significance at the 5 per cent and 1 per cent levels, respectively.

Table 4 - City-pair market overlap: The number of LCC city-pair routes served by network carriers

| LCC | *n* | American | Continental | Delta | United | US Airways | Northwest |
|---|---|---|---|---|---|---|---|
| Southwest | 22,568 | **4,374** | 1,567 | 2,413 | 6,145 | 3,435 | 296 |
| Sun Country | 640 | 82 | 42 | 197 | 43 | 50 | **427** |
| Spirit | 1,830 | **717** | 210 | 460 | 428 | 148 | 350 |
| JetBlue | 3,074 | 913 | 793 | **1,284** | 833 | 772 | - |
| AirTran | 4,589 | 695 | 308 | **2,583** | 908 | 873 | 242 |
| Frontier | 2,601 | 257 | 114 | 296 | **2,283** | 119 | 81 |
| Allegiant | 491 | - | - | - | **45** | 40 | - |

Note: *n* represents the number of quarterly observations in sample (1998-2013) where the LCC averages at least one daily departure on the city-pair route. The bolded entries above indicate the network carrier with the greatest overlap with a particular LCC.

Table 5: *1st class %* coefficient estimates from 1998-2013 domestic flights for city-pair routes with at least one daily departure

| | American | Continental | Delta | United | US Airways | Northwest | All Carriers |
|---|---|---|---|---|---|---|---|
| | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| VARIABLES | *1st class %* | *1st class %* | *1st class %* | *1st class %* | *1st class %* | *1st class %* | *1st class %* |
| *ln(income)* | -0.00507 | 0.0317 | 0.000537 | 0.0119 | -0.0509** | 0.0902** | 0.00214 |
| | (0.0250) | (0.0280) | (0.0137) | (0.0141) | (0.0168) | (0.0238) | (0.00928) |
| *ln(population)* | 0.0193 | -0.0222 | 0.00697 | -0.00534 | 0.0689** | -0.0815** | 0.00880 |
| | (0.0269) | (0.0305) | (0.0145) | (0.0145) | (0.0181) | (0.0248) | (0.00991) |
| temperature difference | -2.38e-05 | 0.000448* | -0.000190 | -4.08e-05 | 0.000310 | 0.000352 | 4.62e-05 |
| | (0.000192) | (0.000196) | (0.000132) | (0.000125) | (0.000160) | (0.000210) | (8.07e-05) |
| *ln(distance)* | 0.0407** | 0.0235** | 0.0265** | 0.0282** | 0.0184** | 0.00911** | 0.0264** |
| | (0.00247) | (0.00245) | (0.00187) | (0.00173) | (0.00179) | (0.00307) | (0.00110) |
| legacy competitors | -0.00243 | 0.000117 | -0.00189 | 0.00663** | -0.00982** | -0.000743 | -0.00114 |
| | (0.00226) | (0.00190) | (0.00198) | (0.00170) | (0.00223) | (0.00261) | (0.00130) |
| LCC exposure | 0.0895** | -0.0338** | 0.0556** | 0.184** | -0.0477** | 0.0415** | -0.0145* |
| | (0.00843) | (0.00808) | (0.0115) | (0.0144) | (0.00716) | (0.0124) | (0.00685) |
| Southwest | 0.0243** | 0.0236** | 0.0102* | 0.00868** | 0.0114** | 0.00824 | 0.0122** |
| | (0.00415) | (0.00571) | (0.00427) | (0.00233) | (0.00322) | (0.00975) | (0.00196) |
| Sun Country | 0.0214 | -0.000655 | 0.0202** | -0.000808 | 0.0324** | -0.00655 | 0.00698 |
| | (0.0138) | (0.00393) | (0.00547) | (0.00422) | (0.00706) | (0.00410) | (0.00413) |
| Spirit | 0.0197* | 0.0119 | 0.0117* | 0.00600 | -0.00168 | -0.00752 | 0.00982* |
| | (0.00807) | (0.00694) | (0.00503) | (0.00586) | (0.00948) | (0.00485) | (0.00384) |
| JetBlue | 0.00898 | 0.0183** | -0.000468 | 0.0119* | 0.00978 | | 0.00524 |
| | (0.00615) | (0.00454) | (0.00394) | (0.00595) | (0.00607) | | (0.00325) |
| AirTran | 0.00294 | 0.0235* | 0.0308** | -0.00238 | 0.0128* | 0.000448 | 0.0145** |
| | (0.00719) | (0.00927) | (0.00438) | (0.00418) | (0.00539) | (0.00811) | (0.00301) |
| Frontier | 0.0170 | 0.0212* | 0.0172 | 0.0198** | 0.0184 | 0.0230** | 0.0176** |
| | (0.0109) | (0.0102) | (0.00971) | (0.00337) | (0.0118) | (0.00499) | (0.00295) |
| Allegiant | | | | -0.00831* | -0.00938 | | -0.00887 |
| | | | | (0.00408) | (0.0114) | | (0.00509) |
| Constant | -0.472** | -0.357** | -0.241** | -0.404** | -0.114* | -0.472** | -0.279** |
| | (0.0760) | (0.0695) | (0.0452) | (0.0565) | (0.0551) | (0.0695) | (0.0298) |
| Observations | 18,595 | 11,488 | 28,016 | 21,296 | 18,121 | 11,324 | 108,840 |
| R-squared | 0.498 | 0.501 | 0.361 | 0.454 | 0.422 | 0.241 | 0.332 |

Robust standard errors are clustered by airline market appear in parentheses. Year and quarter fixed effects are included (yet not reported. * and ** represent statistical significance at the 5 per cent and 1 per cent levels, respectively.

# Appendix

Appendix Table 1A: Route fixed effects for *ln(density)* coefficient estimates from 1998-2013 domestic flights for city-pair routes

| | American | Continental | Delta | United | US Airways | Northwest | All Carriers |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| VARIABLES | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* | *ln(density)* |
| *ln(income)* | -0.210** | 0.0590 | -0.0892 | -0.0661 | 0.0735 | -0.126 | 0.0218 |
| | (0.0664) | (0.0642) | (0.0567) | (0.0630) | (0.0680) | (0.105) | (0.0264) |
| *ln(population)* | 0.107 | 0.0765 | -0.0595 | -0.0933 | -0.310** | -0.0248 | -0.155** |
| | (0.0816) | (0.100) | (0.0758) | (0.0758) | (0.0670) | (0.182) | (0.0355) |
| legacy competitors | -0.00193 | 0.00591* | 0.00175 | -0.000333 | 0.00839* | -0.0171* | 0.00681** |
| | (0.00342) | (0.00298) | (0.00295) | (0.00309) | (0.00416) | (0.00792) | (0.00159) |
| LCC exposure | 0.00984 | -0.00559 | -0.0523** | -0.0686** | -0.00475 | 0.0429* | -0.0249* |
| | (0.0121) | (0.00790) | (0.0126) | (0.0187) | (0.0111) | (0.0181) | (0.0111) |
| Southwest | 0.0184** | -0.0166 | -0.00613 | -0.00844* | -0.0288** | -0.0287 | -0.0107** |
| | (0.00695) | (0.00903) | (0.00822) | (0.00407) | (0.00582) | (0.0224) | (0.00316) |
| Sun Country | -0.0121 | 0.0338* | 0.0234** | -0.00552 | 0.0421** | -0.0137 | -0.000415 |
| | (0.00870) | (0.0158) | (0.00499) | (0.00611) | (0.00361) | (0.0114) | (0.00617) |
| Spirit | -0.0248** | 0.00421 | -0.00901 | -0.0205* | -0.0190 | -0.0323* | -0.0173** |
| | (0.00537) | (0.00817) | (0.0111) | (0.00843) | (0.0126) | (0.0151) | (0.00435) |
| JetBlue | -0.00698 | -0.0174* | -0.0159* | -0.0172 | -0.00929 | | -0.0135** |
| | (0.00886) | (0.00807) | (0.00686) | (0.00969) | (0.00853) | | (0.00411) |
| AirTran | 0.00513 | -0.00307 | -0.00606 | 0.00460 | 0.000582 | -0.00405 | -0.00115 |
| | (0.00669) | (0.00566) | (0.00548) | (0.00717) | (0.00673) | (0.00820) | (0.00345) |
| Frontier | -0.00178 | 0.00253 | 0.00775 | 0.00343 | -0.0334 | -0.0390** | -0.0119* |
| | (0.0258) | (0.00582) | (0.00842) | (0.00465) | (0.0194) | (0.0148) | (0.00502) |
| Allegiant | | | | -0.0456** | -0.0251** | | 0.0702 |
| | | | | (0.00316) | (0.00475) | | (0.0396) |
| Constant | 2.251* | -2.265** | 2.481* | 2.618** | 3.190* | 2.591 | 1.844** |
| | (0.973) | (0.843) | (1.022) | (0.918) | (1.442) | (1.809) | (0.417) |
| Observations | 18,595 | 11,488 | 28,016 | 21,296 | 18,121 | 11,324 | 108,840 |
| R-squared | 0.347 | 0.253 | 0.120 | 0.084 | 0.344 | 0.283 | 0.110 |
| Number of markets | 552 | 447 | 1,058 | 675 | 575 | 380 | 2,284 |

Robust standard errors are clustered by airline market appear in parentheses. Market, year and quarter fixed effects are included (yet not reported). * and ** represent statistical significance at the 5 per cent and 1 per cent levels, respectively.

Appendix Table 2A: Route fixed effects estimates for *1st class and business class per cent* from 1998-2013 domestic flights

| | American | Continental | Delta | United | US Airways | Northwest | All Carriers |
|---|---|---|---|---|---|---|---|
| | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| VARIABLES | *1st class %* | *1st class %* | *1st class %* | *1st class %* | *1st class %* | *1st class %* | *1st class %* |
| *ln(income)* | 0.0929** | -0.0132 | -0.120** | -0.0442 | 0.104** | 0.106* | -0.0935** |
| | (0.0342) | (0.0299) | (0.0342) | (0.0322) | (0.0348) | (0.0442) | (0.0140) |
| *ln(population)* | 0.0918* | 0.0319 | 0.173** | 0.0287 | 0.0601 | 0.00515 | 0.155** |
| | (0.0426) | (0.0497) | (0.0427) | (0.0401) | (0.0314) | (0.0667) | (0.0198) |
| legacy competitors | -0.00270 | -0.00248 | -0.0104** | -0.00116 | -0.00420* | -0.00652 | -0.0101** |
| | (0.00163) | (0.00134) | (0.00221) | (0.00164) | (0.00203) | (0.00373) | (0.000866) |
| LCC exposure | 0.0949** | 0.00405 | 0.0406** | 0.142** | -0.0604** | 0.0264* | -0.00271 |
| | (0.00690) | (0.00510) | (0.0104) | (0.0127) | (0.00647) | (0.0115) | (0.00764) |
| Southwest | 0.000729 | 0.0129** | 0.00271 | 0.00148 | 0.00609 | -0.00845 | -0.00117 |
| | (0.00299) | (0.00403) | (0.00543) | (0.00206) | (0.00352) | (0.00848) | (0.00153) |
| Sun Country | 0.00306 | -0.0191* | -0.00179 | -0.00403 | 0.00287 | 0.000313 | 0.00354 |
| | (0.00638) | (0.00879) | (0.00559) | (0.00772) | (0.00187) | (0.00576) | (0.00366) |
| Spirit | 0.00297 | -0.00393 | 0.00572 | 0.00535 | 0.00377 | -0.00809 | 0.000386 |
| | (0.00262) | (0.00476) | (0.00777) | (0.00691) | (0.0116) | (0.00767) | (0.00231) |
| JetBlue | 0.000197 | 0.00363 | 0.00395 | 0.000538 | 0.00407 | | 0.000333 |
| | (0.00380) | (0.00301) | (0.00610) | (0.00504) | (0.00537) | | (0.00209) |
| AirTran | 0.000861 | 0.00496 | 0.0190** | -0.00900 | 0.0117* | 0.00324 | 0.00787** |
| | (0.00307) | (0.00421) | (0.00365) | (0.00459) | (0.00511) | (0.00398) | (0.00228) |
| Frontier | -0.00113 | 0.0105** | 0.0174 | 0.000207 | 0.0135 | -0.00896 | 0.000340 |
| | (0.0109) | (0.00276) | (0.0133) | (0.00223) | (0.00844) | (0.00683) | (0.00271) |
| Allegiant | | | | 0.0399** | 0.00534 | | -0.0665 |
| | | | | (0.00193) | (0.00292) | | (0.0389) |
| Constant | -3.141** | -0.203 | -0.282 | 0.363 | -2.733** | -1.942** | -0.502* |
| | (0.496) | (0.397) | (0.559) | (0.471) | (0.588) | (0.616) | (0.199) |
| Observations | 18,595 | 11,488 | 28,016 | 21,296 | 18,121 | 11,324 | 108,840 |
| R-squared | 0.146 | 0.119 | 0.203 | 0.059 | 0.369 | 0.209 | 0.055 |
| Number of markets | 552 | 447 | 1,058 | 675 | 575 | 380 | 2,284 |

Robust standard errors are clustered by airline market appear in parentheses. Market, year, and quarter fixed effects are included (yet not reported). * and ** represent statistical significance at the 5 per cent and 1 per cent levels, respectively.