Do Low Cost Carriers Provide Low Quality Service?

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Abstract

This paper addresses the question of whether low cost carriers provide low quality service. Considerable work has been done on various aspects of airline service quality, including: examining the causes of flight delays and cancellations, investigating service quality during irregular airport operations, and exploring the link between on-time performance and airline ticket prices. Little research has been conducted, however, on the performance of low cost carriers. This paper attempts to fill this void in the literature by examining the on-time performance of six million domestic flights in 2006. We find considerable evidence indicating that low cost carriers offer more reliable flight schedules.

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"We have these general beliefs about the world - for example, that cheaper products are of lower quality - and they translate into specific expectations about specific products." – Baba Shiv, Associate Professor of Marketing, Stanford Graduate School of Business (March 2008).

1 Introduction

This paper addresses the question of whether low cost carriers provide low quality service. Much work has been done on the causes of flight delays (Mayer and Sinai, 2003a, 2003b; Mazzeo, 2003; Brueckner, 2002; Rupp, 2007), flight cancellations (Rupp and Holmes, 2006), and irregular flight operations (Rupp, Holmes, and DeSimone, 2005). Researchers have also examined the link between on-time performance and air fares (Januszewski, 2004; Liu 2008). Prince and Simon (2006) explore the impact of multimarket contact on the on-time performance in the airline industry. Ito and Lee (2004) examine how incumbents will respond to entry by low cost carriers. Dresner and Xu (1995) find a positive correlation between on-time performance and airline profitability. Yet, little work has been done that explores the performance of low cost carriers.

Airline on-time performance has recently attracted considerable media attention due to an increase in flight delays and cancellations. In fact, one out of every four flights in 2006 and 2007 were either delayed or canceled. This poor performance has sparked calls for a National Airlines' Passenger Bill of Rights.[1] While as of today, no airline passenger performance bill has been approved by Congress, carriers have voluntarily agreed to prepare and submit to the Department of Transportation (DOT) service plans addressing particular issues of consumer interest.[2]

Low cost carriers have not escaped consumer scrutiny. In fact, JetBlue received considerable media attention for keeping passengers onboard its plane which was parked at the airport ramp

[1] For example, see http://strandedpassengers.blogspot.com/

[2] For example, American Airline's Customer Service Plan can be viewed at: http://www.aa.com

during a snowstorm at JFK airport for nearly nine hours on February 14, 2007. Subsequently, JetBlue has introduced a "Customer Bill of Rights".[3]

Consumers expectations about product quality are influenced by price. For example, a recent medical study (Waber, et.al. 2008) of the therapeutic efficacy effects of a high and low priced placebo reveals that subjects perceive the high priced placebo ($2.50 per dose) as a significantly more effective pain-killer than the low priced ($0.10 per dose) placebo. Turning to the airline industry, this paper examines if airline passengers receive lower quality of service from low-cost carriers which offer lower air fares.

This paper uses recent empirical evidence to examine the link between low-cost carriers and service quality. Specifically, the on-time performance of low cost carriers is compared to other carriers by using over six million domestic flights by U.S. commercial airlines in 2006. We estimate the low cost carrier effect while also controlling for important economic, logistical, and weather variables that likely influence flight delays. In addition, this paper examines flight delays from both the carrier and airline perspective.

The importance of including passenger delay experience is illustrated by Morrison and Winston (2007), who show that flight delays are more costly for airline passengers than for carriers.[4] In addition to the high passenger and airline costs associated with flight delays, poor on-time performance has also increased the number of disgruntled airline passengers. A recent Customer Satisfaction Index score for U.S. airlines from the University of Michigan in 2007 reveals that only one other industry (cable and satellite TV) of the sixteen industries surveyed, fared worse than airlines in the 2007 customer satisfaction ratings.[5]

[3] www.JetBlue.com/about/index.html

[4] Morrison and Winston (2007) estimate that on a per-minute basis the median cost of flight delays are $98.94 (in 2000 dollars). This figure is comprised of three components, median aircraft operating costs per minute ($40.16), flight attendant costs per minute ($2.52), and median value of passenger time per minute ($55.42).

[5] For more details see http://www.theacsi.org/images/stories/images/news/0507q1.pdf accessed 17 May 2007.

For the carrier perspective, we examine the length of actual travel time compared to the monthly minimum for the route. This additional travel time is attributed to airport congestion. This paper is organized as follows. The next section discusses the causes of flight delays, our choice of delay measures, and data. We then introduce the econometric model, followed by estimation results, and conclusion.

2 The Causes of Flight Delays

The monthly delay rates in 2006 averaged 25%, ranging from 21.2% (January) to 29.2% (December). Since June 2003, domestic carriers have reported the causes of flight delays to the Bureau of Transportation Statistics (BTS). In 2006, carriers reported these flight delay reasons to the BTS (with the proportion of all flights delayed in parentheses): National Aviation System delay (7.8%), late arriving aircraft (7.4%), air carrier delay due to maintenance, equipment, or crew problems (6.4%), weather delay (0.9%), and security delays (0.1%). Airlines indicate that National Aviation System delays are the leading cause of flight delays in 2006. This broad category, which is considered beyond the control of airlines, encompasses non-extreme weather conditions, airport operations, heavy traffic, and air traffic control. The second and third most relevant delay factors are, however, under the carrier's control since (i) airlines can adjust flight schedules to reduce the schedule disruption from late arriving aircraft; and (ii) airline equipment and personnel issues are endogenous for airlines.

Figure 1 illustrates that flight delays exhibit considerable fluctuations and seasonality for both low cost carriers (LCC) and non-LCCs. The winter months are typically subject to poor weather conditions, while flight delays are more common in the summer thanks to an increase in leisure travelers. Before elaborating on the causes of flight delays, we present the distinctions previously discussed by Rupp (2007) between these three measures of flight delays.[6]

Carriers are keenly interested in the overall flight time (T) of a route since this determines the availability of an aircraft for the next flight. Flight time is comprised of three components: minimum (M) travel time for the route, scheduled (S) excess travel time, and delay (D). Scheduled excess travel time S(C) depends on average airport and air traffic congestion (C) at both origination and destination. Delay D(C, X, ϵ) depends on congestion (C) since more congested airports are subject to greater disruption from random events, economic, logistical, and competitive factors (X) that represent an airline's willingness to accept delay (e.g., seating capacity, yield, monopoly route, etc.), and random influences ϵ (e.g., weather, maintenance issue, equipment failure, etc.). Hence flight time is represented as:

$$T = M + S(C) + D(C, X, \epsilon) \tag{1}$$

Airport congestion (C) depends on whether the airport is a *hub*, the airport concentration rate also known as Hirschman-Herfindahl Index (*hhi*), and the volume of airport operations. Thus equation (1) can be re-written as:

$$T = M + S(hub, hhi) + D(hub, hhi, X, \epsilon) \tag{2}$$

Hence the definition of delays from an airline's perspective is the difference between actual and minimum travel time, where M serves as a benchmark of flight time without congestion:

$$Excess = T - M = S(hub, hhi) + D(hub, hhi, X, \epsilon) \tag{3}$$

[6] We thank Jan Brueckner for his modelling suggestions in this section.

The key point here is that the effects of *hub* and *hhi* on excess travel time appear in both scheduled excess travel time and delay. In comparison, flight delays from the passenger's perspective are simply the difference between actual and scheduled travel time:

$$Delay = D(C, X, \epsilon) \tag{4}$$

For consumers the flight schedule, rather than the minimum travel time, serves as the benchmark to measure the length of flight delay. This paper uses both departure and arrival delays to capture the passenger perspective on flight delays.

3 Data

All U.S. carriers with revenues from domestic passenger flights of at least one percent of total industry revenues are required to report flight on-time performance data. We use Bureau of Transportation Statistics (BTS) data for every domestic flight between January 2006 and December 2006 for twenty one U.S. carriers. All variables are constructed from the original data set of 6,537,164 flights in 2006. We omitted all canceled and diverted flights. To enable a more manageable sized data set, we randomly select one out of every six flights (17 percent) to form our sample observations. Incomplete data reporting in addition to missing/incorrect aircraft tail numbers slightly reduces the sample to 1,065,953 usable observations.

This paper uses the excess travel time measure of airport congestion proposed by Mayer and Sinai (2003a). Following Rupp (2007), we also consider other congestion measures: on-time arrival and delays based on actual versus scheduled arrival and departure times to gauge both carrier and passenger perspectives on flight delays. One clear benefit of using excess travel time as a delay measure is that this variable is not subject to manipulation or schedule padding by carriers.[7] Moreover, excess travel time provides a measure of how quickly carriers could transport passengers under ideal circumstances of no air traffic congestion. There are, however, some shortcomings associated with excess travel time as a delay measure (Rupp 2007), since excess travel time is influenced by both weather (strong tail winds) and aircraft model (faster cruising speeds). Hence, excess travel time captures more than just airport congestion effects, it also measures speed differences between aircraft models.

In light of these shortcomings, this paper uses two additional measures of flight delays: minutes of arrival delay (the difference between scheduled and actual arrival time at the gate) and minutes of departure delay[8] (the difference between scheduled and actual time leaving the gate).[9] These two delay measures are based on the U.S. Department of Transportation definition of flight delay and are widely reported by the media. One caveat of using delays that are based upon flight schedules is that carriers can easily manipulate their performance by adding more time to the flight schedule, hence nearly guaranteeing an on-time arrival. The opportunity cost, however, of scheduling additional travel time is non-trivial, since it prevents the carrier from using this aircraft on another route and hence forgoing potential revenue. Maintaining existing flight schedules are important for another reason: it keeps passengers happy. For example, Suzuki (2000) proposes that passengers who experience repeated delays may be more inclined to switch carriers when making future travel plans. In addition, Januszewski (2004) finds lower ticket prices on routes that are more often delayed. Liu (2008) finds substantially higher airfares on routes with better on-time performance which lack competition from low cost carriers.

Table 1 provides descriptive statistics for our sample of 2006 flights. The average excess travel

[7] When carriers schedule more time than needed for a flight segment this phenomena is known as "schedule padding."

[8] Departure delay is subject to less schedule padding than arrival delay since carriers pad flight schedules by adding time to their scheduled arrival time, rather than manipulating their departure time.

[9] The U.S. Department of Transportation defines a flight as an "ontime" arrival (departure) if it arrives (departs) at the gate within 15 minutes of its scheduled arrival (departure) time.

time (36 minutes) is considerably larger than both the average departure (ten minutes) and arrival delays (nearly nine minutes). LCCs comprise approximately 25 percent of the sample, the bulk of which are Southwest Airlines flights. The individual LCC and their respective proportion of the sample are as follows: Southwest (16.8 percent), AirTran (3.7 percent), JetBlue (2.4 percent), Frontier (1.4 percent), and ATA (0.3 percent).

A majority of our variables are constructed from BTS flight data. We match aircraft tail numbers provided by the BTS to the Federal Aviation Administration (FAA) aircraft registry database to determine aircraft *age* and *seating capacity.* We also match individual flights to quarterly passenger fare data from the U.S. Office of Airline Information's *Airline Origin and Destination (DB1B) Survey.* This survey is a 10% sample of domestic airline tickets from reporting carriers. These fare data enable us to estimate the *yield* on the route since actual yield for individual flights is unavailable. *Yield* is the average nonstop one-way air fare for carrier j on route r divided by the flight distance for the route.[10] The average yield is \$0.37 per passenger mile. Another economic measure is *load factor* which is the monthly proportion of total seats occupied by passengers. This variable is obtained from Form 41 (T-100 domestic market) data. In our sample of 2006 domestic flights the average load factor is 75 percent.

We use six indicator variables for various sized (small, medium, and large) airline hubs at both origination and destination. Hub-spoke networks rely on having a large bank of flights arrive at the hub airport and then shortly thereafter having a large number of flights departing. On-time performance of hub carriers is critical to maintaining flight networks and hence this performance has important revenue implications since consumer demand is higher for airlines with large operations from an origin city (Morrison and Winston, 1989). Moreover hub airports

[10] We divide round-trip itineraries by two to obtain one-way air fare. Average air fare is the "local fare" (i.e., passengers flying nonstop).

are more likely to have passengers with domestic and international connections, therefore carriers are very interested in having on-time arrivals at their hub airports. A flight delay (or cancellation) for a *hub destination* flight can cause considerable passenger inconvenience, especially for those making connections.[11]

We control for route competition effects on schedule reliability by including indicator variables for both monopoly and duopoly routes. We make a distinction between the large and small duopoly carrier. The sample is dominated by monopoly routes which comprise almost half (49.4 percent) of the observations, while duopoly routes constitute nearly one-third (33.1 percent) of the sample. Similar to Ito and Lee (2007), we also use airport pairs (instead of city pairs) as our unit of observation since airport congestion varies substantially between airports in the same city (for example, Chicago O'Hare and Chicago Midway).

Since most U.S. airports are active weather reporting stations, we collect daily weather data at both origination and destination airports[12] from the U.S. National Oceanic & Atmospheric Administration (NOAA). In fact, we are able to obtain daily weather reports for 99 percent of our flight sample. Given that the BTS finds that weather is the leading cause of flight delay, we include controls for daily weather events including precipitation, snow, and minimum temperature at both origination and destination airports.

3.1 Estimation

Since this paper uses individual flight data we are able to control for flight-specific characteristics that influence flight delays. One important delay factor is time of departure (Rupp 2007). It is well known that airport congestion tends to build throughout the day, hence we control for

[11] For an examination of flight cancellations see Rupp and Holmes (2006).

[12] In cases of missing airport weather data, we use the nearest weather reporting station within twenty-five miles.

the scheduled departure time of each flight by normalizing the scheduled departure time to a continuous variable ranging from 0 (midnight) to 1 (11:59 p.m.). In addition to departure time, aircraft age may also play an important role in on-time performance (e.g., American Airlines recently grounded all of its aging fleet of MD-80 aircraft for multiple days to re-wrap the wires inside the wheel well.[13]) To address the reliability of older aircraft, we include controls for both aircraft *age* and *seating capacity*. We include aircraft size since flight delays of larger aircraft affect more travelers and hence cause greater passenger inconvenience.

While profitability figures are not available at the route level, we use a profit proxy: route *yield*. Carriers can increase revenues by offering more flights at attractive travel times at desirable airports. The cost, however, of over-scheduling flights at peak travel times is increased airport congestion and more delays. Flight delays impose costs on both the airline (aircraft operating costs, paying pilots and flight attendants) and passengers (value of passengers time). In fact, Morrison and Winston (2007) estimate that the median cost (in 2000 dollars) of a flight delay is $99 per minute when both airline and passenger costs are considered. Hence a carrier faces a complicated scheduling task of offering desirable travel times on popular routes while not over-burdening airport facilities and creating longer delays.

In addition, airport congestion has an influencial role in determining on-time performance. We include controls for hub airlines since these airports experience greater congestion due to the clustering or "peaking" of flights by the hub airline. Congestion problems are also especially acute at larger hub airports. Also, if carriers internalize the delay externality (Brueckner and Van Dender, 2007) then we expect to see fewer delays for dominant carriers, hence all estimations control for airport concentration.

[13] For more details see: Jeff Bailey, "Aging Jet Fleets an Added Stain on U.S. Airlines," *New York Times*, nytimes.com, 12 April 2008.

From equation (4) we model delays as a function of airport congestion (C), economic, competitive, and logistical factors (X), and random events (weather, equipment failures, etc.). Recall that airport congestion is a function of the size of the hub airline operations (if any) and airport concentration or Hirschman-Herfindahl Index (*hhi*). The included economic factors are the presence of a LCC, yield, monopoly/duopoly route, and load factor. Logistical measures include scheduled departure time and flight distance. In sum, we examine the performance of low cost carriers by estimating the following baseline delay model for flight i on carrier j at day t:

$$\begin{aligned} Delay_{ijt} &= f(hub\ airline_{orig}, hub\ airline_{dest}, hhi_{orig}, hhi_{dest}, LCC, yield, monopoly, \\ &\quad duopoly, load\ factor,\ departure\ time, distance, weather, month_t) \end{aligned} \tag{5}$$

where the subscripts *orig* and *dest* represent origination and destination airports, respectively. We use Mayer and Sinai's (2003a) definition for *hub airlines* on the basis of an airport's connectivity. For example, airlines that serve between 26 and 45 destinations are considered *small hub airlines*; 46-70 destinations are *medium hub airlines*; and, 71+ destinations are *large hub airlines*. The hhi_{orig} is the airport concentration at origination is found by summing the squared carrier share as a percentage of all daily flights at the origination (destination) airport. Because delays for a particular carrier likely occur in bunches due to unobserved events such as a weather event that we cannot control for (like high winds or unobserved labor unrest), we cluster standard errors into the following groups: carrier $\times$ month (for example, Delta, August). To address the seasonal demand fluctuations all estimations include *month* indicator variables.

In addition to the above baseline estimation, we also include indicator variables for each origination and destination airport to control for unobserved airport specific effects that may affect delays, such as airport equipment, maintenance facilities, and airport capacity. The cost of including airport fixed effects, however, is that it eliminates any time invariant airport specific effect (like airport capacity); hence, identification of airport variables relies on changes in 2006. Given that few hub airline changes occured during this twelve month period, estimations that include airport fixed effects wipe out all time invariant variables. There simply isn't enough variation in the sample to identify the hub airline and airport concentration effects.

Next, we make a minor modification to the baseline estimation by replacing LCC with indicator variables for each of the twenty one airlines. Due to space constraints, we only report the on-time performance of the five low cost carriers. The omitted dummy variable is American Airlines, hence the performance of the LCCs is made in comparison with American. The carrier effects are estimated for both with and without airport fixed effects. This enables us to determine how much of the on-time performance difference between the LCC and non-LCCs is attributed to the specific set of airports that the carrier is serving. For example, Southwest Airlines has historically registered the best on-time performance of any major carrier. Critics counter that Southwest serves uncongested (i.e., less desirable) airports. Therefore including airport fixed effects enables us to control for the "cherry-picking" of uncongested airports.

4 Results

4.1 Baseline Model

Figure 1 reveals the proportion of U.S. domestic flights arriving 15+ minutes late in 2006. In ten of the twelve months, LCC's have a smaller proportion than their non-LCC counterparts. In each of the twelve months, a Wilcoxon rank-sum test rejects the hypothesis that the proportion of flight delays for these two groups are equivalent ($p < 0.05$). Since these monthly delay rates are statistical averages, they do not control for important delay factors; however, they do provide the first piece of evidence that indicates better on-time performance by LCCs.

Figure 2 shows the proportion of U.S. domestic flights that were either canceled or diverted in 2006 for both LCC's and non-LCC's. As seen by the graph, there is a considerable performance gap between these two types of carriers with non-LCC's have substantially higher cancellation rates. More formally, a Wilcoxon rank-sum test rejects the equivalence of the monthly cancellation/diversion rate for these two groups ($p<0.01$) for each month in the sample. These findings provide additional evidence to suggest that LCCs provide more reliable service.

Returning to delays, figure 3 plots the flight delay rates for each of the five LCCs in our sample. Southwest Airlines (carrier code: WN) is the only LCC with a lower than 25 percent arrival delay rate in every month in 2006. Frontier Airlines (F9) registers the lowest delay rates for each month between April and December. On the other end of the performance spectrum, ATA (TZ) consistently posts the worst on-time arrival rates, frequently having more than 30 percent of its flights arriving late. JetBlue (B6) and AirTran (FL) performance exhibit considerable variability in 2006.

Regression results from our baseline specification (equation 5) appear on Table 3 for three delay measures: arrival delay, departure delay, and excess travel time. Each of the three delay measures is estimated both including and excluding airport fixed effects. First, we examine flight delays that are foremost on the minds of air travelers: arrival delays. Model 1 reveals that low cost carriers (LCC) have significantly shorter arrival delays (approximately 1 minute shorter) than their non-LCC counterparts. Such a finding is consistent with Figure 1 which shows superior on-time performance by LCCs for ten of the twelve months in 2006. Other notable findings from the first model include significantly shorter arrival delays on monopoly routes (more than 3 minutes) and duopoly routes for large carriers (1 minute shorter). Higher yielding routes have shorter arrival delays. Routes with higher load factors have substantially longer arrival delays since more crowded aircraft take longer to load (and unload). Later in the day departures also exhibit longer arrival delays, which suggests that flight delays commonly build throughout the day since carriers have very little "slack" built into their aircraft schedules. Hence once an aircraft is initially delayed, it is difficult for the aircraft to get back on schedule. As expected, poor weather contributes to longer arrival delays.

Arrival delays are significantly longer for larger hub airlines ranging from one minute (small hub airlines) to two minutes (medium hub) to four minutes delayed (large hub airlines). Delays of a similar magnitude are experienced for hub airline destinations. Hence the worst possible on-time performance occurs for flights between two large airline hubs (e.g., Northwest Airlines flights between Minneapolis and Detroit). More concentrated airports have significantly shorter arrival delays, which suggests that carriers with larger airport market share are more sensitive to over-scheduling flight operations. These findings are consistent with the belief that dominant airport carriers internalize the delay externality (Mayer and Sinai, 2003a; Brueckner 2002).

We find that LCC still register significantly shorter arrival delays (about one minute) after controlling for airport fixed effects (see model 2). Note the airport variables (hub airlines and airport concentration) do not change enough during the twelve month sample period to be identified when airport fixed effects are included, hence they are omitted from the estimation. This finding suggests that better on-time performance by LCC is not solely the product of serving uncongested airports since this specification holds constant airport specific effects like airport capacity. The most noticeable impact of including airport fixed effects is the change in sign of the route competition variables. While previously monopoly and duopoly routes had shorter arrival delays, following the inclusion of the airport fixed effects, we find that routes served by a single carrier are now positively correlated with slightly longer arrival delays. This result suggests that the better performance of monopoly and duopoly routes is likely a factor of serving less congested/smaller "Podunk" airports.

Next, we examine departure delays. While passengers are likely more concerned with arrival delays than departure delays, the one advantage of examining departure delays is that it provides a measure of service quality that cannot be manipulated by airline scheduling. In addition, not all departure delays are considered "evil" for passengers. For example, passengers who are making a tight connection actually benefit from a departure delay. Moreover, departure delays are less troubling for air passengers who have not yet boarded the plane, since waiting in the terminal is more enjoyable than in a cramped airline seat (i.e., arrival delay). Model 3 reveals that LCCs have longer departure delays (two minutes) than non-LCCs.

Controlling for airport fixed effects, these departure delays are slightly shorter at about one minute, yet still significant. Hence these first four models indicate that LCCs are leaving the gate slightly behind their non-LCC counterparts (between one and two minutes late), yet are arriving about a minute earlier than traditional (non-LCC) carriers. These findings suggest that either (1) LCCs experience less air traffic congestion than non-LCC carriers and/or (2) that LCCs are allocating more time to serve a route than non-LCCs. Given that the departure delay results (models 3-4) for the other economic, logistical, airport, and weather variables are comparable to the previously discussed arrival delays (models 1-2), for the sake of brevity we will proceed to the excess travel time findings.

Models 5 & 6 present excess travel time estimates for both excluding and including airport fixed effects, respectively. Given we find very similar results for both of these specifications, we will discuss them simultaneously. Most notably, LCCs have between a three and four minute shorter excess travel time. This explains why LCCs are making up time in transit. Recall that models 1-4 suggested that carriers are leaving the gate slightly behind schedule (two minutes) yet arriving one minute early. This three minute difference is captured by the three to four minutes shorter excess travel times. Recall that excess travel time captures the amount of travel time in excess of the monthly minimum: this additional travel time is attributed to air traffic congestion. LCCs experience significantly less air traffic congestion than their non-LCC counterparts even after controlling for airport specific effects. Next, we turn our attention to the on-time performance of individual low cost carriers.

4.2 Individual Low Cost Carriers

We re-estimate the six regressions (models 1-6) from Table 2 by replacing LCC indicator with the twenty individual carrier indicators in our sample. Due to space constraints, we only include the carrier coefficient estimates for the five low cost carriers on Table 3.[14] American Airlines is the omitted dummy variable, hence it serves as the benchmark for comparison. Given that Southwest Airlines is twice as large as all of the other four low cost carriers combined, it is not surprising that the sign of the Southwest coefficient (Table 3) usually matches the sign of the LCC coefficient (Table 2). Frontier and Southwest have shorter arrival delays of five and two minutes, respectively compared to American Airlines. Whereas the arrival delays for JetBlue and AirTran are not significantly different from American Airlines. Finally, ATA registers eight minutes longer arrival delays, however, since it is the smallest LCC comprising just 0.3 percent of the sample, ATA effects have little bearing on the LCC coefficient estimates from Table 2.

Controlling for airport fixed effects, model 8 reveals that the on-time arrival rate of Southwest no longer differs from American Airlines. Frontier is still significantly better and ATA signifi-

[14] Of course all carrier coefficients are available upon request of the authors.

cantly worse than American. Therefore the negative and significant LCC coefficient for arrival delays from model 2 can be attributed to the shorter arrival delays from Frontier. Turning to departure delays, model 9 shows that Southwest, ATA, and JetBlue all experience significantly longer departure delays compared to American. Only Frontier has significantly shorter departure delays. With the inclusion of airport fixed effects, departure delays at both Southwest and ATA are nearly five minutes longer than American (see model 10). Frontier departures are still leaving approximately four minutes earlier than American.

Finally we look at excess travel time for each of the low cost carriers. We see that Frontier and Southwest have significantly shorter excess travel times (eleven and five minutes respectively), while JetBlue and ATA have three and twelve minute longer excess travel times, compared to American. If all of these LCCs were of similar size, then the net effect on excess travel times would offset each other. This is not the case, however, since together Frontier and Southwest are approximately three times larger than JetBlue, AirTran, and ATA combined. The magnitude of the excess travel time advantage for Southwest dissipates with the inclusion of airport fixed effects (see model 12). A similar finding is seen in model 8 for Southwest and arrival delays. Hence a non-trivial part of Southwest's on-time performance advantage can be traced to its decision to serve uncongested airport facilities.[15]

With the possible exception of Frontier, the on-time performance of Southwest is significantly better than other low cost carriers. What factors contribute to Southwest's superior on-time performance? Three things are working in Southwest's favor. First, the nearly five minute shorter excess travel time estimation (see model 11) suggests Southwest is serving less congested airport facilities. Second, Southwest flies only one model aircraft: Boeing 737. This simplification makes life easier for maintenance crew and for personnel staffing since every pilot and flight crew are

[15] For an indepth look into low cost carrier entry and subsequent incumbent responses, see Ito and Lee, 2004.

interchangeable on every Southwest flight. Third, Southwest operates mostly as a point-to-point carrier with only 16 percent of its domestic passengers in 2006 making connections. Of the LCCs, only JetBlue in 2006 had a lower proportion of connecting travelers at just 7 percent. In comparison, Frontier and AirTran both had a higher passenger connection rate of 29 percent each. Carriers that operate hub-spoke networks rely on flight banks. A large volume of flights arrive at a similar time at the airline's hub, passengers change planes, and then all of the hub airline's flights depart at similar times. This self-inflicted airport congestion can lead to flight delays and additional travel time.

5 Conclusion

Previous research has extensively examined both the causes and effects of flight delays. This paper adds to the growing literature of on-time performance by examining the service quality of low cost carriers. While low cost carriers, especially Southwest Airlines, have historically performed very well in the DOT on-time arrival rankings, skeptics assert that Southwest primarily serves uncongested airports. A rank-sum test of the average arrival delay rates reveals that low cost carriers have significantly fewer arrival delays than non-low cost carriers in ten of the twelve months in 2006. Regressions that control for economic/competitive, logistical, airport, and weather factors reveal that low cost carriers have slightly shorter arrival delays (about one minute) and considerably shorter excess travel time (between three and four minutes) than their non-low cost carrier counterparts. These results are robust to alternative specifications including controlling for airport specific effects. The primary driver behind the better performance of low cost carriers is Southwest Airlines.

We believe that Southwest offers more reliable service for three reasons. First, Southwest primarily operates as a point-to-point carrier hence it avoids peak congestion periods from hubbing. Second, Southwest flies a single model aircraft. Hence all aircraft and flight crews are perfectly interchangeable. This minimizes downtime from an equipment/mechanical failure or a staffing issue. Third, Southwest benefits from serving less congested airports since it has significantly shorter excess travel times, these shorter travel times dissipate for Southwest after controlling for airport fixed effects.

In sum, we find considerable evidence that given the route and airport choice of the low cost carriers, their performance is better than their non-low cost carrier counterparts. So in this one instance, it appears that we may have found a contradiction to the widely-held belief that "cheaper products are of lower quality." This study shows that the less expensive airline tickets of low cost carriers provide an added benefit to travelers - more reliable flight schedules. Low cost carriers have not gotten the credit they deserve for providing superior service quality.

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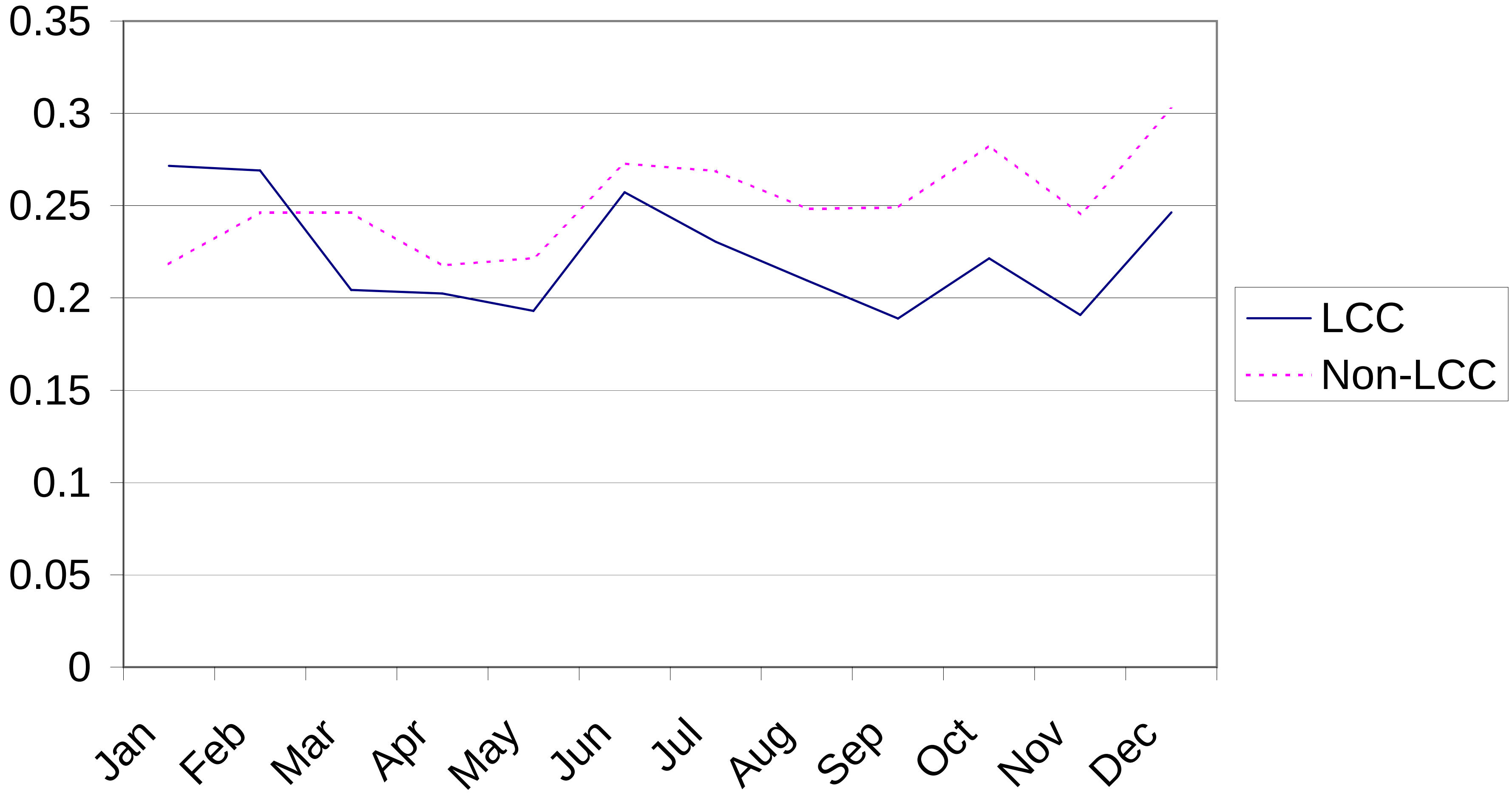
Figure 1: Proportion of U.S. Domestic Flights Arriving 15+ Minutes Late - 2006



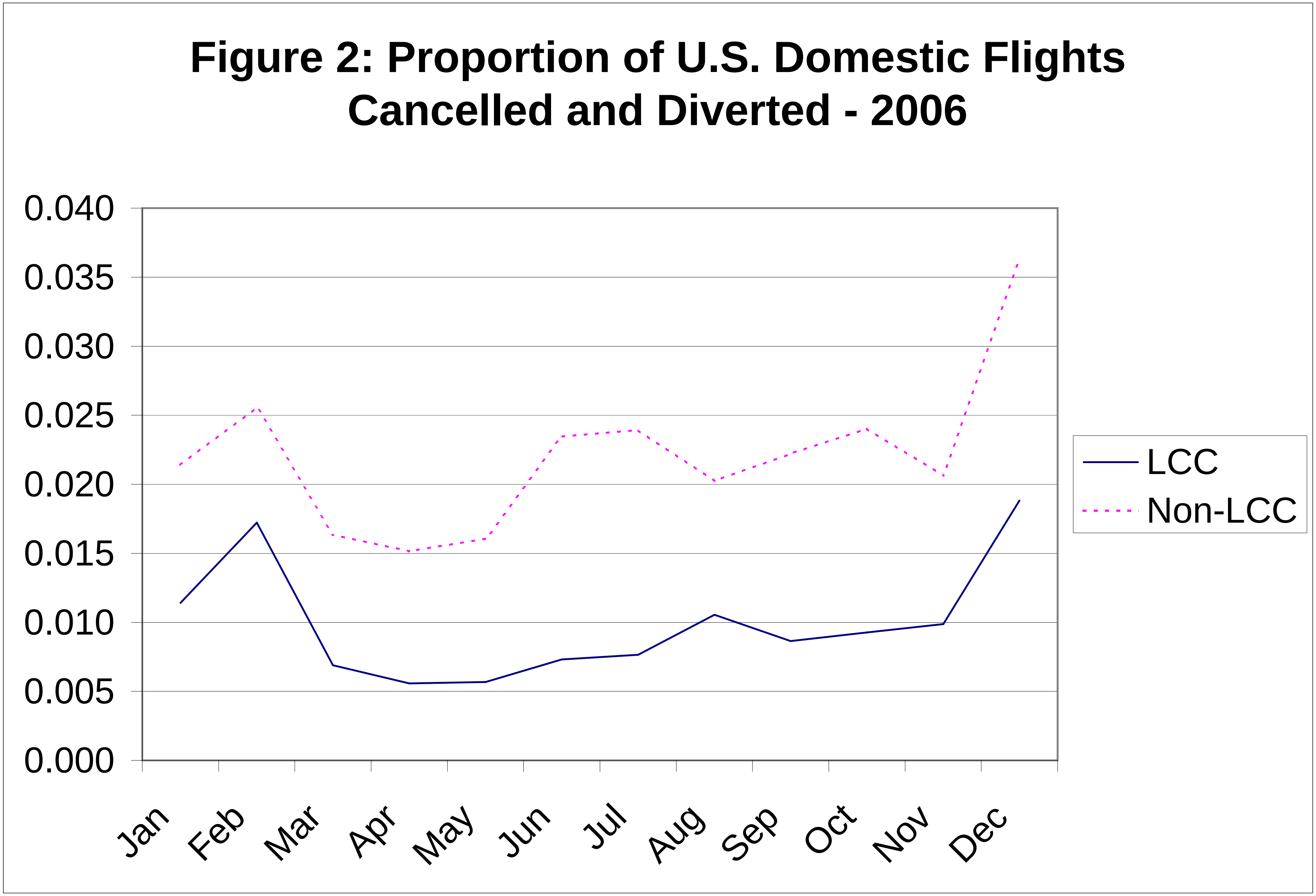


Figure 2: Proportion of U.S. Domestic Flights
Cancelled and Diverted - 2006
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
LCC
Non-LCC

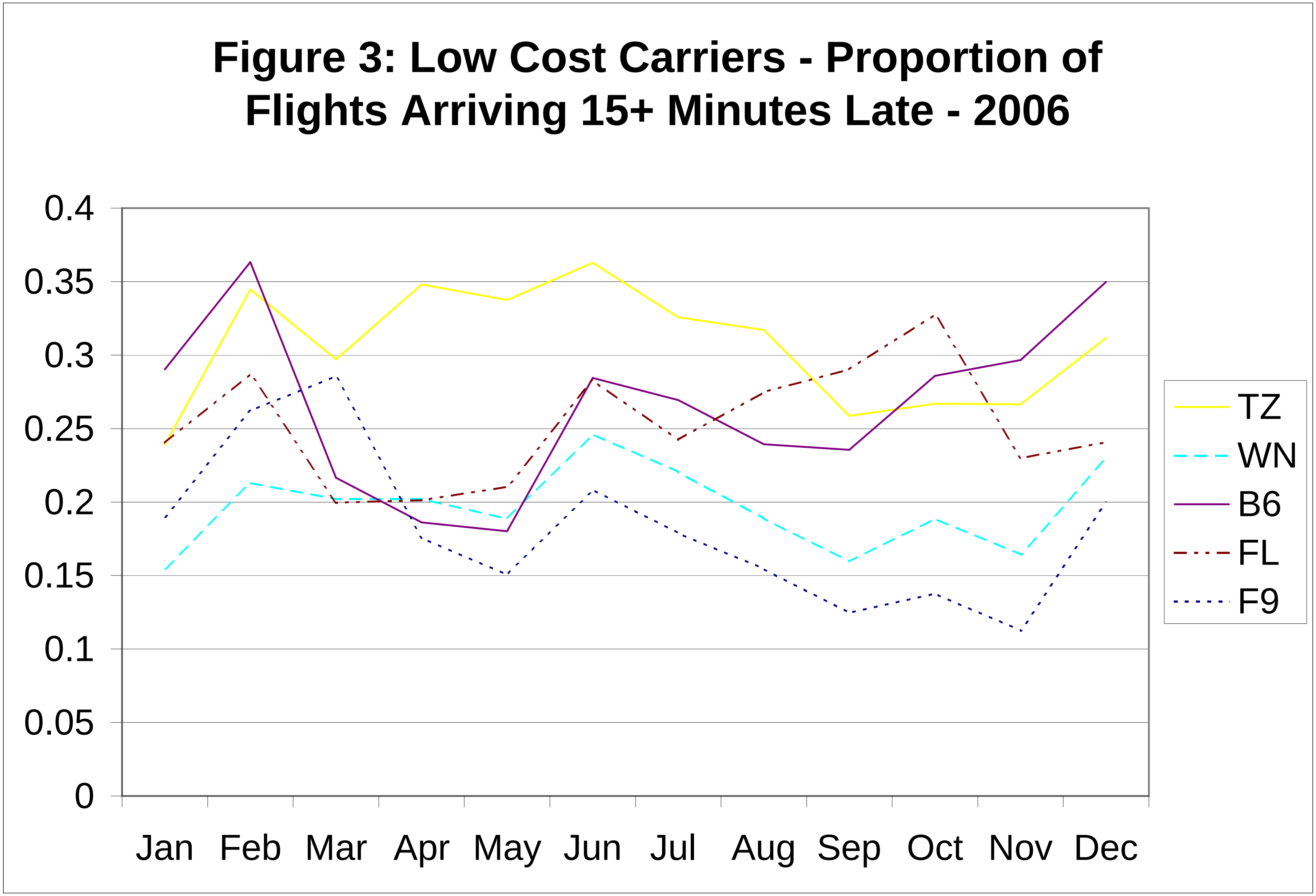


Figure 3: Low Cost Carriers - Proportion of Flights Arriving 15+ Minutes Late - 2006
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
TZ
WN
B6
FL
F9

Table 1 - Descriptive Statistics: 2006 Domestic Flights* by U.S. Carriers (n=1,065,953)

Variable	Obs	Mean	Std Dev	Min	Max
Flight Delay Measures (Minutes)					
Arrival delay	1,065,953	8.56	36.00	-92	1779
Departure delay	1,065,953	9.96	32.57	-70	1752
Excess travel time	1,065,953	35.96	38.69	0	2079
Airport Variables					
Airline Hub (origination)	1,065,953	0.439	0.496	0	1
Small Airline hub (origin.)	1,065,953	0.118	0.323	0	1
Medium Airline hub (origin.)	1,065,953	0.092	0.289	0	1
Large Airline hub (origin.)	1,065,953	0.234	0.423	0	1
Airline Hub (destination)	1,065,953	0.439	0.496	0	1
Small Airline hub (destin.)	1,065,953	0.119	0.324	0	1
Medium Airline hub (destin.)	1,065,953	0.091	0.287	0	1
Large Airline hub (destin.)	1,065,953	0.233	0.423	0	1
Airport Concentration (origin.)	1,065,953	0.403	0.216	0.114	1
Airport Concentration (destin.)	1,065,953	0.403	0.215	0.114	1
Airport Utilization (origin.)	728,469	0.455	0.198	0.009	1.038
Airport Utilization (destin.)	708,373	0.456	0.200	0.009	1.038
Airline Route Variables					
Monopoly	1,065,953	0.494	0.500	0	1
Duopoly large carrier	1,065,953	0.239	0.427	0	1
Duopoly small carrier	1,065,953	0.092	0.289	0	1
Distance (miles)	1,065,953	743.11	572.07	31	4962
Economic Variables					
Route Yield ($ per passenger mile)	1,065,953	0.366	0.372	0	11.06
Route Load Factor	1,065,953	0.752	0.116	0	1
Low Cost Carrier (LCC)	1,065,953	0.247	0.431	0	1
Aircraft Variables					
Aircraft seating capacity	964,304	122.25	63.80	17	495
Aircraft age (years)	890,637	9.50	7.47	0	54
Weather Variables					
Precipitation origin. (100ths of inch)	1,065,953	9.77	33.22	0	929
Precipitation destin. (100ths of inch)	1,065,953	9.78	33.13	0	929
Snow origin. (10th of inch)	1,065,953	0.23	2.74	0	188
Snow destin. (10th of inch)	1,065,953	0.23	2.82	0	219
Temperature origin. (Fahrenheit)	1,065,953	51.79	16.56	-55	95
Temperature destin. (Fahrenheit)	1,065,953	51.80	16.56	-51	95
Logistical Variable					
Normalized Departure Time	1,065,953	0.562	0.192	0.007	1

*1 in 6 sample from every domestic flight by 21 U.S. commerical airlines in 2006, which include: Aloha, American, Alaska, JetBlue, Continental, Delta, Atlantic Southeast, Frontier, Hawaiian, American Eagle, Northwest, Comair, Skywest, Expressjet, ATA, United, US Airways, Southwest, Continental Express, Mesa.

Table 2: On-time performance of U.S. Commerical Carriers, 1 in 6 sample of domestic flights, 2006 (n = 1,065,953).

Dependent Variable: Minutes of…	Arrival Delay				Departure Delay				Excess Travel Time			
	(1)		(2)		(3)		(4)		(5)		(6)	
	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
Economic/Competitive Factors												
Low Cost Carrier (LCC)	-1.10 *	0.50	-1.09 *	0.50	2.20 **	0.40	1.41 **	0.45	-4.07 **	0.66	-3.42 **	0.55
Yield route	-0.81 *	0.39	-1.87 **	0.26	-0.67 *	0.32	-1.63 **	0.21	0.22	0.48	-1.55 **	0.29
Monopoly route	-3.24 **	0.32	0.44	0.28	-2.08 **	0.27	0.66 **	0.23	-9.49 **	0.45	-3.41 **	0.42
Duopoly large carrier	-1.12 **	0.25	0.62 **	0.21	-0.40 ^	0.23	0.73 **	0.17	-3.12 **	0.41	-0.52	0.37
Duopoly small carrier	0.22	0.35	0.74 *	0.30	0.27	0.31	0.33	0.25	-0.77 ^	0.45	-0.13	0.40
Load factor route	7.39 **	1.11	12.00 **	0.89	5.39 **	0.95	9.82 **	0.73	0.87	1.42	8.93 **	1.05
Logistical Variables												
Departure time01	27.41 **	0.93	27.53 **	0.94	27.08 **	0.85	27.37 **	0.85	28.41 **	1.03	28.53 **	1.04
Distance (miles)	-0.002 **	0.000	-0.003 **	0.000	-0.001 **	0.000	-0.001 **	0.000	0.006 **	0.000	0.004 **	0.000
Airport Variables												
Small Airline Hub origination	0.75 *	0.37			1.56 **	0.30			2.33 **	0.64		
Medium Airline Hub origination	2.06 **	0.46			2.76 **	0.39			1.44 **	0.55		
Large Airline Hub origination	4.18 **	0.55			4.91 **	0.46			4.56 **	0.72		
Small Airline Hub destination	0.66 ^	0.38			1.02 **	0.29			2.17 **	0.36		
Medium Airline Hub destination	1.11 **	0.43			1.39 **	0.35			3.46 **	0.55		
Large Airline Hub destination	4.86 **	0.64			5.10 **	0.46			9.47 **	0.73		
Airport Concentration origin.	-2.36 **	0.62			-2.92 **	0.57			-4.34 **	0.73		
Airport Concentration destin.	-4.04 **	0.66			-3.46 **	0.48			-2.91 **	0.73		
Weather Variables												
Precipitation origination	0.13 **	0.01	0.13 **	0.01	0.11 **	0.00	0.11 **	0.00	0.14 **	0.01	0.13 **	0.01
Precipitation destination	0.14 **	0.01	0.14 **	0.01	0.09 **	0.00	0.09 **	0.004	0.15 **	0.01	0.14 **	0.01
Snow origination	0.64 **	0.05	0.68 **	0.05	0.41 **	0.05	0.45 **	0.05	0.63 **	0.05	0.67 **	0.05
Snow destination	0.33 **	0.05	0.37	0.05	0.23 **	0.05	0.26 **	0.05	0.31 **	0.05	0.37 **	0.05
Temperature origination	0.02 ^	0.01	0.09 **	0.02	0.01	0.01	0.08 **	0.01	0.03 *	0.01	0.10 **	0.02
Temperature destination	0.02 ^	0.01	0.10 **	0.01	0.01	0.01	0.05 **	0.01	0.00	0.01	0.09 **	0.01
Constant	-15.13 **	1.30			-12.57 **	1.18			14.37 **	1.61		
Airport Fixed Effects?	No		Yes		No		Yes		No		Yes	
R^2	0.07		0.09		0.06		0.07		0.09		0.12	

Note: Standard errors are clustered by month and carrier (i.e., Delta, June). Regressions include indicator variables for month (not reported).
Small, medium, and large hubs are defined as airlines that serve 26-45, 46-70, and 71+ markets. ^, *, and ** indicate 10%, 5%, and 1% significance levels.

Table 3: Carrier fixed effects - On-time performance of U.S. Commerical Carriers, 1 in 6 sample of domestic flights, 2006 (n = 1,065,953).

Dependent Variable: Minutes of…	Arrival Delay				Departure Delay				Excess Travel Time			
	(7)		(8)		(9)		(10)		(11)		(12)	
	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
Low Cost Carriers												
Southwest	-2.27 **	0.78	0.41	0.80	2.54 **	0.59	4.92 **	0.68	-4.76 **	0.88	-1.25	0.93
AirTran	-0.81	1.05	-0.29	1.02	0.96	0.92	0.61	0.90	-0.85	1.18	-1.89	1.19
JetBlue	1.29	1.30	-0.04	1.26	1.84 ^	1.07	1.52	1.02	3.04 *	1.36	-1.14	1.33
Frontier	-5.13 **	1.10	-4.13 **	1.22	-5.32 **	0.84	-3.88 **	0.97	-11.13 **	1.11	-5.35 **	1.32
ATA	8.46 **	1.54	8.42 **	1.63	4.70 **	1.16	4.77 **	1.27	12.00 **	1.99	7.21 **	2.09
Economic/Competitive Factors												
Yield route	-1.40 **	0.37	-1.85 **	0.25	-1.19 **	0.28	-1.53 **	0.18	-1.07 **	0.41	-1.61 **	0.27
Monopoly route	-4.02 **	0.27	0.49 *	0.25	-3.03 **	0.20	0.77 **	0.21	-11.11 **	0.43	-3.40 **	0.37
Duopoly large carrier	-1.60 **	0.21	0.64 **	0.19	-1.14 **	0.16	0.65 **	0.15	-4.01 **	0.35	-0.49	0.35
Duopoly small carrier	-0.68 *	0.29	0.40	0.25	-0.33	0.24	0.42 *	0.21	-2.42 **	0.40	-0.52	0.36
Load factor route	5.60 **	0.89	9.61 **	0.79	5.27 **	0.77	8.16 **	0.64	-2.41 *	1.16	4.88 **	0.93
Logistical Variables												
Departure time01	27.40 **	0.93	27.67 **	0.94	27.09 **	0.85	27.58 **	0.85	28.38 **	1.03	28.67 **	1.04
Distance (miles)	-0.002 **	0.000	-0.002 **	0.000	0.000 *	0.000	-0.001 **	0.000	0.006 **	0.000	0.005 **	0.000
Airport Variables												
Small Airline Hub origination	1.19 **	0.40			1.85 **	0.29			3.44 **	0.62		
Medium Airline Hub origination	1.93 **	0.44			2.41 **	0.32			0.88 ^	0.50		
Large Airline Hub origination	3.81 **	0.53			4.38 **	0.43			4.24 **	0.68		
Small Airline Hub destination	1.10 **	0.41			1.29 **	0.29			3.27 **	0.37		
Medium Airline Hub destination	1.00 *	0.42			1.07 **	0.31			2.95 **	0.54		
Large Airline Hub destination	4.50 **	0.63			4.60 **	0.43			9.20 **	0.71		
Airport Concentration origin.	-2.88 **	0.62			-2.68 **	0.53			-5.43 **	0.75		
Airport Concentration destin.	-4.57 **	0.67			-3.25 **	0.45			-4.05 **	0.73		
Weather Variables												
Precipitation origination	0.13 **	0.01	0.13 **	0.01	0.11 **	0.00	0.11 **	0.00	0.13 **	0.01	0.13 **	0.01
Precipitation destination	0.14 **	0.01	0.14 **	0.01	0.09 **	0.00	0.09 **	0.00	0.14 **	0.01	0.14 **	0.01
Snow origination	0.65 **	0.05	0.68 **	0.05	0.43 **	0.05	0.45 **	0.05	0.65 **	0.05	0.67 **	0.05
Snow destination	0.34 **	0.05	0.37 **	0.05	0.25 **	0.05	0.27 **	0.05	0.33 **	0.05	0.37 **	0.05
Temperature origination	0.03 *	0.01	0.09 **	0.02	0.01	0.01	0.08 **	0.01	0.03 *	0.01	0.10 **	0.02
Temperature destination	0.02 **	0.01	0.10 **	0.01	0.01	0.01	0.05 **	0.01	0.00	0.01	0.09 **	0.01
Constant	-13.11 **	1.31			-11.90 **	1.16			17.42 **	1.64		
Airport Fixed Effects?	No		Yes		No		Yes		No		Yes	
R^2	0.07		0.09		0.06		0.08		0.10		0.12	

Note: Standard errors are clustered by month and carrier (i.e., Delta, June). Regressions include indicator variables for month (not reported).
Small, medium, and large hubs are defined as airlines that serve 26-45, 46-70, and 71+ markets. ^, *, and ** indicate 10%, 5%, and 1% significance levels.
In addition to the above five LCC's reported, the regressions also include 15 other non-low cost carriers. American Airlines is the omitted carrier dummy.