Do Low Cost Carriers Provide Low Quality Service?*

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Master's Research Paper

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Abstract: In this study we examine the performance of the low cost carriers (LCC) in comparison with the other major carriers. Recent Growth of LCC indicates that passengers will have LCC options in the future. Our model controls for other important factors which affect on-time performance including weather, airport competition, departure time of day, hub airline and flight revenue. We find better LCC performance is due to fewer flight cancellations and higher on-time arrival rates.

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1. Introduction

The main aim of this study is to observe whether low cost carriers (LCCs)[1] provide lower service quality. In addition, we also examine the factors that affect on time performance. Ito and Lee, (2003) have suggested that LCCs are reshaping the U.S domestic airline industry by entering high-density and lucrative markets. During the past four years LCC like Southwest Airlines and Jetblue Airways have received high service quality ranking by Bowen and Headley (2004). This ranking is a weighted average of four aspects of service quality with on-time performance receiving a higher weight. One drawback of the Bowen and Headley ranking is that it ignores potentially important factors such as weather or airport congestion that affect on-time performance. In this paper we control for these important elements when determining on-time performance for each carrier. "The low-cost airline service revolution, a report from the Federal Aviation Administration" states that the growth in the domestic air traffic in recent years is due to the spread of low cost service. The mainline carriers are facing strong competition from LCCs. Given the growth of low cost carriers and the recent Bowen and Headley (2004) which shows LCCs provide favorable service quality, this study examines this further while controlling for weather, airport congestion, economic factors and other factors influencing on-time performance.

In January 2004, 40% of the domestic nonstop flights were delayed (departure and arrival) for various reasons and 3% were cancelled. There is growing concern about the bad on time performance by the carriers. Since September 11, 2001 terrorist attacks the airline industry is facing problems and has come under the scrutiny of the federal

[1] LCCs are loosely defined as carriers with low operating costs and carriers with low fares.

authorities. Since the terrorist attacks security levels have been increased on many occasions, which have caused inconvenience to the air passengers and the operators. During these alerts passengers had to report hours before the scheduled departure time and wait in long queues for the security checks before boarding. Rupp, Holmes and DeSimone, (2004) study the effects of airport closures on the airline schedules since the terrorist attacks have cited that in the six months following the attacks 2,395 flights were either cancelled or delayed. During such occurrences the passengers may blame the carriers for the delays. The economy slowed down in the later period and the industry saw sharp decrease in demand. This added to the already severe airline crisis. The two major carriers, US Airways and United Airlines filled for bankruptcy protection in 2002.

This paper observes the flights operations in January 2004 using the data from U.S. Bureau of Transportation Statistics (BTS). These data includes 520,940 observations, where the unit of observation is a non-stop flight. In this paper we include 89.2% of flight because some observations were lost due to lack of information. The total number of flights that took off in January was 583,987.

The study looks at the performance of the LCCs. In 2003 airline quality ratings by Bowen and Headley (2004), the first and third positions were held by Jetblue and Southwest. We expect the low cost carriers to perform better than the other major carriers because low cost carriers don’t have high operating costs like the majors. The majors incur heavy costs in maintaining hubs and have high labor costs. Secondly as mentioned earlier LCCs are entering highly lucrative markets and giving a strong competition to the majors with low prices. In the recent past few of them have been successful while the majors are facing increasing problems.

We expect that economic factors will influence the decision of delaying or canceling a flight. The carriers may opt to maximize revenue by providing better quality of service. The carriers would not cancel or delay flights with higher capacity. These flights fetch high revenue. Furthermore we expect competition on the route would lead to better service. A carrier's poor performance provides a positive externality for its competitors.

Third, conditions at the airport also influence on-time performance. Congestion at the airport may result in worse service. Competition at the airport or the concentration is another important characteristic of the airport since the major carriers in the industry are hub-and-spoke carriers. At the hub the quality of service is especially important since many passenger make their connections here. Hub carriers have a advantage over their competitors since the hub carriers have a back up for any kind of technical or labor problem.

Weather conditions also affect on-time performance. Carriers like Southwest, which has its many flights connecting places in the southwestern U.S, typically doesn't have to deal with severe weather conditions. On the other hand a carrier serving the northeastern region of the country faces severe winter conditions in January. Hence it becomes important to take weather conditions into considerations. Not surprisingly, we find heavy precipitation and extreme cold conditions lead to many cancellations and delays. We look into this in our fourth hypothesis.

In sum, this study uses economic variables, airport characteristics, weather variables, logistic variables and airline carriers to determine the effects on on-time performance of LCCs and major carriers.

The rest of the paper is organized as follows. The next section discusses data and its sources. Section 3 gives the results of the various logit and OLS estimations. Section 4 concludes the paper.

2. Data

The data consists of every non-stop domestic flight in the U.S. in January 2004 by nineteen carriers: American Airlines (AA), Alaska Airlines (AQ), Jetblue Airways (B6), Continental Airlines (CO), Atlantic Coast Airlines (DH), Delta Airlines (DL), Atlantic Southeast Airlines (EV), AirTran Airways Corporation (FL), Hawaiian Airlines (HA), American West Airlines (HP), American Eagle Airlines (MQ), Northwest Airlines (NW), Comair (OH), Sky West Airlines (OO), Continental Express Airline (RU), American Trans Air, Inc or ATA (TZ), United Airlines (UA), US Airways (US) and Southwest Airlines (WN). Among them Jetblue, Southwest, Air Tran and ATA are low cost carriers (LCC).

These data for the on-time performance are obtained from the website of Bureau of Transportation and Statistics (BTS)[2]. These data include arrival and departure delays for non-stop domestic flights by the above 19 carriers. This data source also provides information on scheduled arrival and departure time, actual arrival and departure time, cancelled and diverted flights, distance for the various routes. The air-fare and load factors data was taken from the DB1B file of the above-mentioned database.

[2] www.bts.gov

The information about aircraft and their characteristics like tail numbers and number of seats was obtained from Federal Aviation Administration's website[3]. Capacity is the proportion of seats occupied by passengers on an aircraft. As seen in Table 1 an average of 60% of seats were occupied on every flight in the sample. Flights with less capacity are likely to be cancelled. Rupp and Holmes (2004) have shown that fewer cancellations occur on aircrafts with more seats. But aircrafts with higher capacity will require more time for boarding. Hence this variable seems intriguing. Number of seats is also used to construct actual revenue. The tail numbers help us to identify the aircraft and get the relevant information.

We know that weather conditions affect the on-time performance of flights. The weather data of precipitation and freezing rain at origination and destination airport was taken from the National Climate Data Center's database[4]. If an airport weather station did not report data then we would use weather data from the nearest town within an area of 25 miles. Wind and snow data are incomplete; hence we exclude them from the study. Freezing rain is a proxy for snow. Freezing rain is an interaction term; amount of precipitation multiplied by one if minimum temperature is less than 33 degrees Fahrenheit and 0 otherwise. This also covers minimum temperature. When snowfall occurs the temperature is below the freezing point (<32 degrees Fahrenheit). There could be a doubt in your mind that heavy snowfall and blizzards may occur and disrupt the flight schedules. But these conditions occur very rarely and are not representative of the whole country as they occur in very few places. The average freezing rain in January was

[3] www.faa.gov
[4] http://nndc.noaa.gov

nearly 0.02 inches and average precipitation was 0.06 inches (the figures are same for destination and origination)

The variable of main interest, departure delay is a dummy variable, equal to one if the aircraft pushes back from the gate by more than 14 minutes in models 1 and 2 and by more that 29 minutes in models 3 and 4. The paper uses the U.S. Department of Transportation definition of a flight being on time (arriving within 15 minutes). In January 2004, 17% of the reported flights departed late by 15+ minutes. Another variable of interest, arrival delay is also a dummy variable, equal to one if delayed in arrival by more than 14 minutes in models 5 and 6 and more than 29 minutes in models 7 and 8. We find 22% of the total flights in the January 2004 arrived late by 15+ minutes. In the same month on average flights arrived 7.8 minutes and departed 8.4 minutes late.

The next important service quality variable is *cancelled*, also a dummy variable, equal to one if cancelled and 0 otherwise. Only 3% of the scheduled flights were cancelled. The BTS provides four reasons for cancellations; (1) because of the carrier, (2) due to weather, (3) National Aviation System (NAS) reasons and (4) security reasons. Only 6 flights were cancelled due to security reasons and 35% of the cancelled were due to carrier specific reasons. Almost 50% of the cancelled flights were weather-related. This was because the month of January is a month of severe cold all through the United States. NAS cancelled nearly 14% of the cancelled flights.

Major airlines such as American Airlines cancelled 5% of its flights, while Delta cancelled 3% and United cancelled 2.2%. Where low cost carriers like Jetblue cancelled only 24 of its flights (0.35%), Southwest and ATA cancelled 2% and Air Tran cancelled only 1% of their flights.

We assume that airlines are profit maximizers. Hence carriers should be concerned about flight revenue. *Actual revenue* is used as a revenue measure. This variable was obtained by multiplying average ticket fare, number of seats on the aircraft and monthly average load (capacity). *Effective carriers* is the inverse of the Herfindahl index, which gives the number of carriers serving a route. Herfindahl index is the sum of squared market shares of all the carriers serving the route. Rupp and Holmes have shown that monopoly routes have worse service quality, thus pointing the relevance of route competition.

Airport characteristics also play an important part in the on-time performance of carriers. If an airport is the hub of a carrier then it will have a better access to airport gates. Moreover at a hub, passengers commonly need connecting flights and hence carriers may assign a greater priority to these flights. *Concentration of destination and origination airport* is also measured by using a Herfindahl index. This gives us information about how many carriers have access to an airport, a measure of airport competition at the airport. *Daily total flights at destination (origination)* is the sum of all flights departing and landing at the airport. Since many of the major carriers have hubs it is important that we take this into account. Mayer and Sinai (2004) suggest that flights departing from and arriving at a hub airport require excess travel time. We have created dummy variables for hub airports at origination and destination airports. *Large hub* equals one if an airline has 71 or more connections at the origination (destination) airport. *Medium* hub equals one if the connections are between 45 and 70 at the origination (destination) airport. *Small hub* equals one if the connections are between 25 and 44.

Daily is the number of flights scheduled by a carrier on a route. The maximum number of flights on a route by a carrier is 32.

Minimum wait is the interval in minutes between flights of a carrier on the same route. This variable is correlated with *daily*. If a carrier has many flights scheduled on a route then the interval *(minimum wait)* between flights will be less and hence the flights on this route are likely to be delayed. The average interval is 381 minutes. *Time01* is the normalized time variable, equals 0 if the departure time is midnight and one if it is 11.59 p.m. The average flight *distance* is 862 miles. This variable is important because if a flight departs late then depending on the distance there may be time to make up for a late departure and still arrival on-time.

To assess each carrier's performance we have created dummy variables for each carrier with American Airlines being the base category. The main purpose of this paper is to assess the on-time performance of low cost carriers in comparison with others. Hence we create a dummy variable, LCC, which equals one if the carrier is a low cost carrier (ATA, AirTran, Southwest and Jetblue). Among the nineteen carriers in the sample four of them are low cost carriers. In the fourteen regression models that we have estimated, odd models (1 through 13) include the LCC dummy variable and the even numbered models (2 through 14) include dummy variables for each carrier.

The estimations also take into account the days of the week with the inclusion of dummy variables for each day. The results for the day of the week variables appear in the appendix, as they have similar affects across all models.

3. Results

Tables 2 though 8 give the results of the 14 models estimated. Since five of our dependent variables are binary variables, a logit model is used for estimation. In case of the two continuous variables, arrival delay (arr_del) and departure delay (dep_del), models 9 through 12, OLS is used. We estimate these continuous variables to verify our analysis of the dependent binary variables. In model 1 (which includes LCC) and model 2 (which includes individual carrier dummy variables), departure delay by more than 15 minutes (dep_del15) is the dependent variable and in model 3 and 4 departure delay by more than 30 minutes (dep_del30) is the dependent variable. Similarly models 5 and 6 have arrival delay by more than 15 minutes (arr_del15) as the dependent variable, whereas in models 7 and 8 it is arrival delay more than 30 minutes (arr_del30). Model 13 and 14 have cancelled as the dependent variable. As said earlier these dependent variables are binary, hence the logit model is employed and specified as follows

$$P(y = 1 \mid x) = G(b_0 + xb)$$

where y is the binary dependent variable and x is the set of independent variables.

In the logit model G is the logistic function given as:

$$G(z) = exp(z) / 1+exp(z)$$

3a. Results of Airline Carriers

The variable of interest is LCC as our prime hypothesis is based on this, whether LCCs perform better than the other carriers. As compared to other carriers we see that LCC are performing better than the other carriers in the industry (odd numbered models 1 through 13). First we focus on the likelihood of cancellations (table 8), as this is more important than the other aspects of on-time performance, arrival delay and departure delay. If a flight is cancelled then the carrier has to accommodate the passengers of the cancelled fight on another flight, which requires rebooking and causes considerable passenger inconvenience. Further if the next available flight is scheduled for the next day then the carriers must provide overnight accommodations for passengers. They have to also provide accommodation to the crew of the flight. This thus, puts more costs on the carrier. In model 13 we see that if the carrier is a LCC then the probability of being cancelled falls and is significant. Further in model 14, which includes the individual carrier dummy variables, we see that probability of cancellation falls for all the LCCs (B6, FL, TZ and WN) in comparison with American Airlines. The cancellation possibility falls by 0.5 percentage points for Southwest when compared to American Airlines.

We notice in model 1 (table 2) that LCC are more likely to have 15-minute departure delays than other carriers. This is because the low cost carriers don’t have hubs and hence have less access to the gates at the hub airports. Jetblue (B6), AirTran (FL), ATA (TZ) and Southwest (WN) all have a positive coefficient in model 2 indicating that traveling by these carriers the probability of being delayed by 15 minutes is higher. But among them only the coefficients of B6 and TZ are significant and those of WN and FL are not. Hence we can say that the insignificance of WN and FL lets LCC have a positive effect on probability of departure delay by 15 minutes in model 1. The average departure delay is 1.5 minutes for LCC (see model 11). They are less likely to be delayed (departure) by less than 30 minutes but it is insignificant. In model 4 we see that the probability of being delayed (departure) by 30 minutes falls for all the LCCs except for TZ. On the other hand they are less likely to arrive late (15 and 30 minutes) in models 5 and 7 (table 4 and 5). This could be because many of LCCs connect at small airports or at non hub airport. As compared to the other carriers the arrival delay if the carrier is LCC falls by 0.2 minutes (in model 9).

Before concluding this hypothesis we need to observe the performance of each individual low cost carrier. The individual carriers' variables are dummy variables with American Airlines (AA) being the base category. The low cost carriers are also more likely to be delayed in arrival by 15minutes except for WN but B6 is insignificant. Similarly for 30 minutes except for TZ and FL. Further in model 10 we see that by traveling by B6 and WN the delay falls and it increases for TZ and FL but FL is insignificant.

3b. Results for logistical variables

We see that there is a consistent negative relationship between daily numbers of flights (*daily*) by a carrier on a route and delay (departure and arrival). The probability of a flight being delayed decreases if a carrier has more flights on a particular route. This is because if one flight is delayed on that route then it will have a spill over effect due to which the latter flights may also get delayed. Hence the carriers try not to delay those flights. In OLS estimation (models 9-12) the delay (arrival and departure) its seen that with an increase of one flight on the route the delay falls by 0.16 – 0.23 minutes. But on the other hand the probability of a flight being cancelled increases if a carrier has more flights scheduled on a route. With a one more flight by a carrier on the route increases the likelihood of cancellations by 0.07 percentage points. The marginal effect of this variable is very small in all the models.

Along with this it is important to notice the sign of *number of seats*, is negative. This implies that larger aircraft is less likely to be cancelled. Hence if an increase in flight frequency and smaller aircraft are more likely to be cancelled. This also depends on the seats in the next flights and the minimum waiting time between two flights on the same route by the same carrier. *Minimum wait* is negatively related to *cancelled*. The carriers do this to economize on the labor cost and other costs of operating a flight. Another variable of interest is *capacity*, which has a negative relationship with cancelled. We'll discuss it later when we are analyzing the economic variables. The positive coefficient of *time01* indicates that the flights scheduled to depart (arrive) later in the day are likely to be delayed or cancelled.

Except for models 9 and 10 *distance* variable has a positive coefficient. This implies that a 100 mile increase in flight distance decreases arrival delay by 0.0004 to 0.0002 minutes. On longer distances if the flight departs late it may not arrive late as the lost time could be covered in air. In models 1 and 2 we see that with the increase in distance the probability of a flight being delayed in departure increases, by a negligible amount. So is the case in models 3 and 4 and in models 11 and 12 with continuous variable, *departure delay*. Now, on the contrary we see that with the increase in distance the probability of arrival delay (by 15 and 30 minutes) also increases. In the model with continuous variable, *arrival delay* the fall in the delay due to an increase in the distance is very negligible. We need to analyze this in relation with other independent variables as in case of *daily*. If the seats of the flight are not completely occupied, if number of seats are less and if the minimum time between next available flight on that route by the same carrier is less then irrespective of longer distance the flight is more likely to cancelled.

For all the dependent variables the minimum waiting time is inversely related. If the minimum waiting time is more then the flight is less likely to be cancelled and also delayed in arrival and departure. This variable is more important when interpreted with *distance* and *daily*, as discussed earlier.

The behavior of *number of seats* is very intriguing. When LCC is included in the regression, for all the dependent variables the variable is inversely related to the dependent variable. If carrier is a LCC and if the number of seats is more then the probability of departure delay (15 and 30 minute) and arrival delay (15 and 30 minutes) is more likely to decrease. The same behavior is seen even in the case of the continuous variables, *departure delay* and *arrival delay*. When the dependent variable is *cancelled* then the number of seats inversely affects the outcome of the flight being cancelled. An aircraft with more number of seats fetches more revenue hence the carriers will not cancel a flight with more number of seats unless compelled by unforeseen events. Furthermore canceling such flight will impose higher reimbursement cost on the carriers. This has been discussed earlier so there is no need to elaborate this.

3c. Results for Economic Variables

We expect carriers to maximize revenue. *Actual revenue* is a proxy for revenue. As expected for all the models (1 – 14) *actual revenue* has a negative sign. When *actual revenue* increases by $10,000, the probability of departure delay of more than 15 minutes falls by 0.4 to 1.1 percentage points in models 1 and 2 and the probability of a flight being cancelled falls 0.03 to 0.33 percentage points in model 13 and 14. This result is confirmed by the continuous variables also. *Number of seats* is used in the construction of this variable.

We are aware that carriers will give greater importance to flights with higher capacity. Canceling such flights would result in high losses and make it unpopular among passengers. Due to this a carrier could lose passengers to its competitors. This premise is reflected in models 13 and 14 in table 8. The higher the capacity of the flight the lesser will be the probability of the flight being cancelled. Further we see that capacity has no effect on delays, rather it has a positive effect. Flights with more capacity require more time for boarding and hence are delayed.

Mazzeo (2003) finds evidence that flights are less frequently on time on less competitive routes and in cases where the carriers market share at the airports served are higher. The same evidence is seen in our estimations. With the increase in competition on the route the probability of departure delays falls. On the other hand the probability of arrival delays increase. But this increase is very negligible as marginal effects are very small (in models 5-8).

3d. Results of Airport competition

Much of the literature in this field has shown the negative impact of airport competition in the performance of the carriers. Congestion at the airport leads to delays, since 375 flights operate at an airport on an average. *Daily total flights at the destination (origination)* airport is a measure of this. Consistently through all the regressions this variable has positive sign indicating that with an increase of one flight at the airport the delay probability as well as cancellation probability increases. Due to congestion the departure delay increases by approximately 0.004 minutes and arrival delay increases by 0.003 to 0.006 minutes.

Concentration at the destination (origination) is an airport competition measure. Rupp, Holmes and DeSimone (2004) have shown that highly concentrated airports experience many cancellations. Our results are also consistent with that study. We see that in all regressions this variable is inversely related to all the dependent variables. In highly concentrated airports the departure delay and arrival delay increases by 4 minutes. Also, the probabilities of delays and the flight being cancelled increases at concentrated airports. This again goes to prove the point that competition leads to efficiency.

We expect performance for hub airlines since these carriers have better access to equipment, crew and replacement facilities (Rupp, Holmes and DeSimone, 200). Further since they dominate the airport they even have better access to the airport gates. In order to look into this we examine the three hub variables. If the flight is destined for an airline's large hub (connections >71) then fights are less likely to be cancelled than non-hub destined flights. At the hub airports many people make connections. But there is no clear indication that it is less likely to be delayed. The case with medium hub (connections between 45 and 71) is also similar. Further, if the destination is a small hub (connections between 2 and 45) then the flights are less likely to be delayed or cancelled. The departure delay falls by one and a half minute.

As is the case with destination being a large hub so is with origination being a large hub. Flights from these airports are less likely to be cancelled. The arrival delay is likely to increase. This could if the flight is arriving from a hub and has got delayed there. There is no strong evidence with regards departure delays being less likely. The flights at medium hub are also less likely to be cancelled. But they are more likely to be delayed expect for in model 6 where the flights are less likely to have arrival delay of more that 15 minutes. In case of origination being a small hub the flights are less likely to be delayed or cancelled.

3e. Results of Weather Variables

Since half of the cancelled flights were due to the weather reasons we expect it to be negatively correlated with on time performance. The estimations fall in tandem with our expectations. With an additional inch of precipitation the flights are more likely to be delayed or cancelled. Model 9 indicates that an inch more of precipitation at the destination airport delays the flight by 8.2 minutes while an inch of rain at the origination airport delays the flights by 5.1 minutes. The effect of precipitation at origination and destination is same.

The effect of freezing rain is larger than precipitation. An inch more of it at the origination airport leads to a delay of 76.4 minutes and at the destination airport leads to delay of 50 minutes. Since this was a winter month the weather plays a major and foul role in on time performance.

4. Conclusion

This is another study in the field of airline service quality focusing on flight delays and cancellation with observing the low cost carriers more closely. The basic premise of the contestable market theory was that the increase in competition would improve quality of service and lower fares in the industry due to competition. The main aim of Airline Deregulation Act of 1978 was to allow for more operators to enter the market and hence ensure better quality of service. In the initial years after the deregulation the theory seemed to have failed as there weren't any significant entries in the industry and few of those who entered either went out of business or were bought out by the incumbent operators. But in these recent years the successful operation of the low cost carriers suggests that they can co-exist in the industry.

The low cost carriers are having profound effect on the efficiency, competition and industry structure[5]. This further goes to prove that though the contestable markets theory seemed contradictory in the short run but in the long run the theoretical results emulate the actual results. The study puts forth four hypotheses for better quality of service. The results for our prime hypothesis are consistent with Bowen and Headley, 2004. This study ranked the carriers based on their performance in four different aspects. According to this study the on time performance for December 2003 Southwest ranked first followed by Jetblue while ATA and Air Tran ranked sixth and thirteenth, respectively. The December 2003 rankings were the same for the entire year, except that ATA slipped down to the tenth position. In our analysis we created a variable, LCC in order to see the performance of low cost carriers in comparison with the other carriers in the industry. This variable indicates that LCCs have a lower probability of being cancelled. In model 14 we see that the low cost carriers are less likely to be cancelled in comparison with American Airlines. Further, LCCs are less likely to be delayed in arrival (models 5 and 7). In comparison with American Airlines (model 6) three of the four LCCs are less likely to be delayed in arrival by 15 minutes. We find that LCCs are more

[5] The low cost Airline Revolution, A Report From the Fereral Aviation Administration (U.S. Department of Transportation.)

likely to be delayed by 15 minutes. But in model 4 we saw that departure delay by 30+ minutes fall for Jetblue, AirTran and Southwest. But we see that the marginal effect of a carrier being a LCC and delayed by 15 minutes is low and in models 3 and 9 it is insignificant. The findings support our earlier findings that they are likely to be delayed but less likely to be cancelled. LCCs are doing well in two of the three (cancelled, arrval delay and departure delay) aspects of on-time performance Hence it can be said that LCCs are better service providers than the other carriers in the airline industry.

There is very little evidence that carriers consider economic aspects of a flight while making a decision to delay or cancel it. Actual revenue seems to have negligible effect on delays and cancellations though it is significant and has the expected negative effect. Further there is no strong evidence that more competition and capacity improve the on time performance.

For the third hypothesis we find considerable support that competition at the airport is an important factor for the better performance. We see that congestion leads to worst performance. Further highly concentrated airports pose better performance. There is no clear evidence that departing from and arriving at a hub may lead to delays. But they are less likely to be cancelled. We find enough evidence in support of our fourth hypothesis. We see that all the four weather variables consistently contribute to the poor on time performance.

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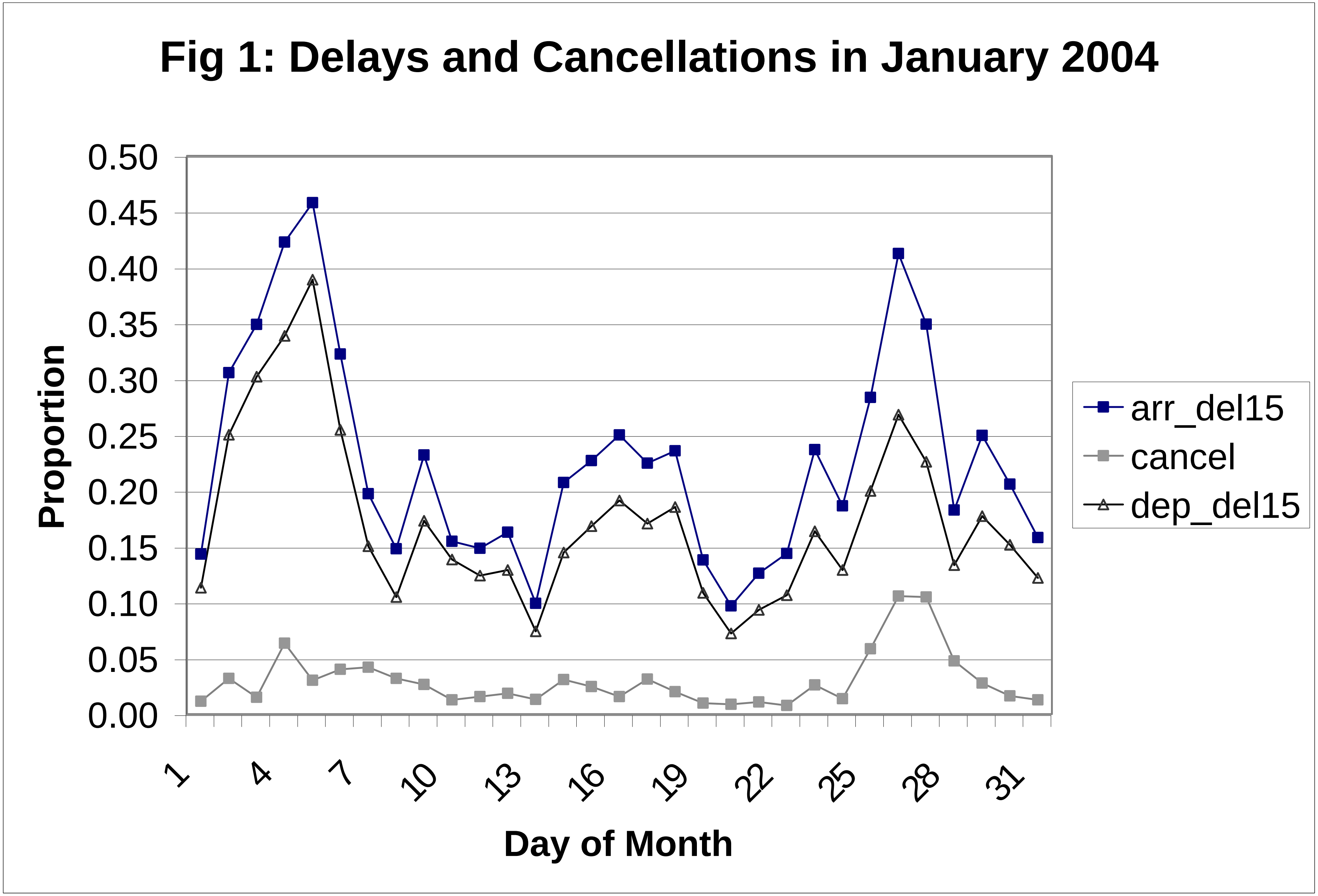

Fig 1: Delays and Cancellations in January 2004
Proportion
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1
4
7
10
13
16
19
22
25
28
31
Day of Month
arr_del15
cancel
dep_del15

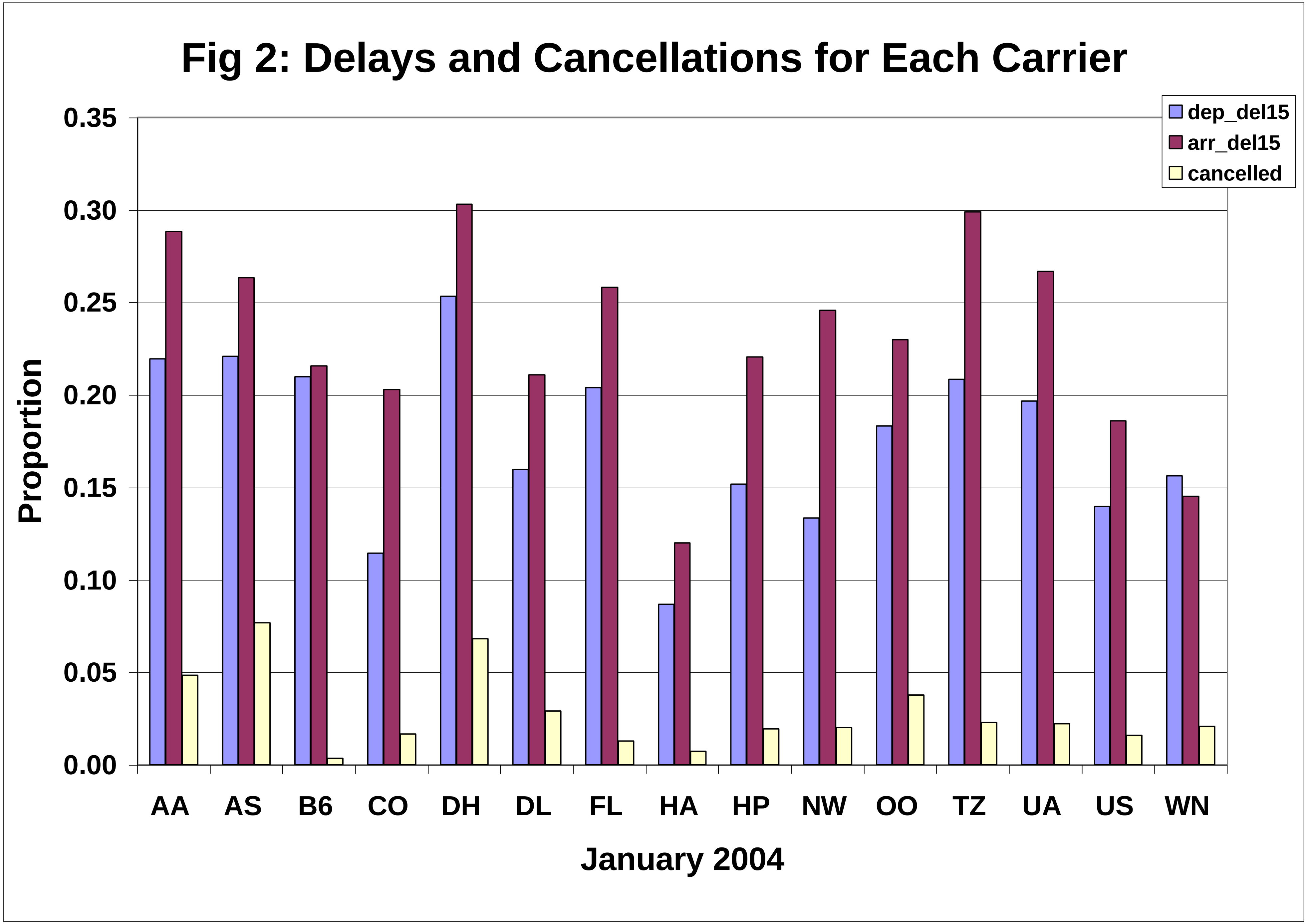
Fig 2: Delays and Cancellations for Each Carrier
dep_del15
arr_del15
cancelled
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Proportion
AA
AS
B6
CO
DH
DL
FL
HA
HP
NW
OO
TZ
UA
US
WN
January 2004

Table 1 Summary Staistics for all the Variables

Variable Name	N	Mean	Std. Dev	Min	Max
Departure delay by more than 15 minutes	583,987	0.173	0.378	0	1
Departure delay by more than 30 minutes	583,987	0.105	0.306	0	1
Arrival delay by more than 15 minutes	583,987	0.2268	0.4188	0	1
Arrival delay by more than 30 minutes	583,987	0.1308	0.3372	0	1
Departure Delay	566,376	8.39	30.5	-230	1882
Arrival delay	565,361	7.87	34.43	-950	1879
Cancelled	583,987	0.0301	0.171	0	1
Economic variables					
actual revenue	583,987	13,746.89	11,485.19	0	127,165.30
effective carriers	583,987	1.538	0.624	1	4.9
capacity	565,969	0.603	0.13	0	1
Airport competition					
daliy total flights at destination	583,987	719.16	648.52	2	2198
daliy total flights at origination	583,987	758.26	674.5	1	2265
concentration at destination	583,987	0.389	0.196	0.112	1
concentration at origination	583,987	0.389	0.196	0.112	1
destination large hub	583,987	0.2	0.4	0	1
destination medium hub	583,987	0.111	0.314	0	1
destination small hub	583,987	0.113	0.316	0	1
origination large hub	583,987	0.2	0.4	0	1
origination medium hub	583,987	0.111	0.314	0	1
origination small hub	583,987	0.11	0.313	0	1
Weather variables					
precipitation at destination	582,981	6.97	25.131	0	702
precipitation at origination	582,980	6.97	25.141	0	702
freezing rain at destination	581,418	1.812	7.041	0	97
freezing rain at origination	581,415	1.811	7.039	0	97
Logistical Variables					
Daily	583,987	5.883	3.895	1	32
distance	583,987	8.62	565.289	11	4962
minimum waiting time	583,987	381.17	385.9	0	1440
number of seats	580,132	127.269	65.788	15	495
time01	583,985	0.567	0.191	0.0069	1

Table 2 Logit Estimations for departure delays more than 15 minutes for US domestic flights in Jan '04

Dependent Variable : dep_del15

	Model 1							
	Model 1				**Model 2**			
Variable	**Coefficient**		**Std Error**	**Marg Eff**	**Coefficient**		**Std Error**	**Marg Eff**
Economic variables								
actual revenue($10,000)	-319.0000	**	0.0082	-0.0042	-0.0869	**	0.0088	-0.0113
effective carriers	-0.0110		0.0076	-0.0014	-0.0328	**	0.0079	-0.0042
capacity	0.6450	**	0.0341	0.0848	0.6108	**	0.0368	0.0791
Airport competition								
daliy total flights at destination	0.0003	**	0.00001	0.00004	0.0003	**	0.00001	0.00004
daliy total flights at origination	0.0003	**	0.00001	0.00004	0.0003	**	0.00001	0.00004
concentration at destination	-0.4479	**	0.0242	-0.0589	-0.3207	**	0.0246	-0.0416
concentration at origination	-0.5649	**	0.0253	-0.0743	-0.3698	**	0.0257	-0.0479
destination large hub	-0.1510	**	0.0172	-0.0192	0.0786	**	0.0215	0.0104
destination medium hub	-0.0113		0.0155	-0.0015	0.1417	**	0.0169	0.0191
destination small hub	-0.0909	**	0.0139	-0.0117	-0.1168		0.1440	-0.0147
origination large hub	-0.0042		0.0169	-0.0006	0.2265	**	0.0214	0.0308
origination medium hub	0.2285	**	0.0147	0.0319	0.3914	**	0.0162	0.0562
origination small hub	-0.0045		0.0137	-0.0001	-0.0246		0.0142	-0.0032
Weather variables(100th inch)								
precipitation at destination	0.0035	**	0.0001	0.0005	0.0037	**	0.0001	0.0005
precipitation at origination	0.0045	**	0.0001	0.0006	0.0048	**	0.0001	0.0006
freezing rain at destination	0.0127	**	0.0005	0.0017	0.0122	**	0.0005	0.0016
freezing rain at origination	0.0168	**	0.0005	0.0022	0.1633	**	0.0005	0.0021
Logistical Variables								
Daily	-0.0210	**	0.0013	0.00001	-0.0211	**	0.0014	0.00001
distance(100 miles)	0.0001	**	0.00001	-0.0028	0.0001	**	0.00001	-0.0027
minimum waiting time	-0.0001	**	0.00001	-0.00001	-0.0001	**	0.00001	-0.000012
number of seats	-0.0021	**	0.0001	-0.0003	0.0012		0.0017	0.0002
time01	1.9978	**	0.0227	0.2626	2.0102	**	0.0228	0.2604
Airline carriers								
LCC	0.1697	**	0.0126	0.0231	_		_	_
b6+	_		_	_	0.2579	**	0.0380	0.0364
fl+	_		_	_	0.0356		0.0319	0.0047
tz+	_		_	_	0.1619	**	0.0378	0.0221
wn+	_		_	_	0.0320		0.0212	0.0042
as	_		_	_	0.4080	**	0.0288	0.0602
co	_		_	_	-0.7759	**	0.0253	-0.0783
dh	_		_	_	0.4781	**	0.0285	0.0718
dl	_		_	_	-0.6952	**	0.0179	-0.0744
ev	_		_	_	-0.1633	**	0.0436	-0.0200
ha	_		_	_	-0.4965	**	0.0629	-0.0541
hp	_		_	_	-0.4800	**	0.0292	-0.0530
mq	_		_	_	0.2081	**	0.0243	0.0287
nw	_		_	_	-0.2916	**	0.0212	-0.0346
oh	_		_	_	0.1142	**	0.0260	0.0153
oo	_		_	_	0.2253	**	0.0283	0.0313
ru	_		_	_	-0.4525	**	0.0283	-0.0508
ua	_		_	_	-0.2156	**	0.0215	-0.0262
us	_		_	_	-0.3378	**	0.0244	-0.0395
constant	-2.6275	**	0.3332	_	-2.9805	**	0.0425	_
N	520,940				520,940			
Log Likelihood	-225,542.76				-223,213.39			
Pseudo Rsq	0.0512				0.061			

"+" indicates low cost carrier "**" indicates significant at 5% "*" indicates significant at 1%
Marg Eff indicates Marginal Effects. The std errors are robust std errors.

Table 3 Logit Estimations for departure delays more than 30 minutes for US domestic flights in Jan '04

Dependent Variable : dep_del30						
	Model 3			**Model 4**		
Variable	**Coefficient**	**Std Error**	**Marg Eff**	**Coefficient**	**Std Error**	**Marg Eff**
Economic variables						
actual revenue($10,000)	-0.0572 **	0.0105	-0.0046	-0.1270 **	0.0112	-0.0100
effective carriers	-0.0289 **	0.0093	-0.0023	-0.0495 **	0.0097	-0.0039
capacity	0.4043 **	0.0421	0.0327	0.3909 **	0.0455	0.0309
Airport competition						
daliy total flights at destination	0.0005 **	0.00001	0.00004	0.0004 **	0.00001	0.00003
daliy total flights at origination	0.0004 **	0.00001	0.00003	0.0003 **	0.00001	0.00003
concentration at destination	0.6131 **	0.0304	-0.0496	-0.4273 **	0.0308	-0.0337
concentration at origination	0.6691 **	0.0316	-0.0541	-0.4193 **	0.0320	-0.0331
destination large hub	-0.2215 **	0.0212	-0.0170	0.0310	0.0262	0.0025
destination medium hub	-0.0210	0.0191	-0.0017	0.1292 **	0.0210	0.0106
destination small hub	-0.1219 **	0.0174	-0.0095	-0.1438 **	0.0181	-0.0109
origination large hub	-0.1432 **	0.0208	-0.0112	0.1149 **	0.0263	0.0093
origination medium hub	0.1379 **	0.0182	0.0117	0.3049 **	0.0202	0.0266
origination small hub	-0.0656 **	0.0171	-0.0052	-0.0826 **	0.0179	-0.0064
Weather variables(100th inch)						
precipitation at destination	0.0037 **	0.0002	0.0003	0.0039 **	0.0002	0.0003
precipitation at origination	0.0044 **	0.0002	0.0004	0.0040 **	0.0002	0.0004
freezing rain at destination	0.0156 **	0.0005	0.0013	0.0151 **	0.0005	0.0012
freezing rain at origination	0.0192 **	0.0005	0.0016	0.0187 **	0.0005	0.0015
Logistical Variables						
Daily	-0.0297 **	0.0017	-0.0024	-0.0270 **	0.0018	-0.0021
distance(100 miles)	0.0001 **	0.00001	0.00001	0.0001 **	0.00001	0.00001
minimum waiting time	-0.0001 **	0.00002	-0.00001	-0.0001 **	0.00002	-0.000005
number of seats	-0.0025 **	0.0001	-0.0002	0.0013 **	0.0002	0.0001
time01	2.0826 **	0.0283	0.1684	2.1027 **	0.0285	0.1660
Airline carriers						
LCC	-0.0008	0.0158	-0.0001	_	_	_
b6+	_	_	_	-0.1628 **	0.0510	-0.0120
fl+	_	_	_	-0.0763 *	0.0387	-0.0058
tz+	_	_	_	0.1805 **	0.0441	0.0153
wn+	_	_	_	-0.2169 **	0.0265	-0.0161
as	_	_	_	0.2852 **	0.0353	0.0252
co	_	_	_	-0.8186 **	0.0324	-0.0479
dh	_	_	_	0.5231 **	0.0342	0.0504
dl	_	_	_	-0.8084 **	0.0224	-0.0496
ev	_	_	_	-0.2572 **	0.0533	-0.0183
ha	_	_	_	-0.5874 **	0.0849	-0.0366
hp	_	_	_	-0.6027 **	0.0366	-0.0378
mq	_	_	_	0.2014 **	0.0295	0.0171
nw	_	_	_	-0.3636 **	0.0265	-0.0253
oh	_	_	_	0.0723 *	0.0315	0.0059
oo	_	_	_	0.1727 **	0.0349	0.0145
ru	_	_	_	-0.4401 **	0.0349	-0.0296
ua	_	_	_	-0.1412 **	0.0259	-0.0106
us	_	_	_	-0.4919 **	0.0306	-0.0326
constant	-2.8989 **	0.0410	_	-3.2917 **	0.0526	_
N	520,940			520,940		
Log Likelihood	-162,287.28			-160,462.23		
Pseudo Rsq	0.0582			0.0688		

"+" indicates low cost carrier "**" indicates significant at 5% "*" indicates significant at 1%
Marg Eff indicates Marginal Effects. The std errors are robust std errors.

Table 4 Logit Estimations for arrival delays more than 15 minutes for US domestic flights in Jan '04

Dependent Variable : arr_del15								
	Model 5				Model 6			
Variable	**Coefficient**		**Std Error**	**Marg Eff**	**Coefficient**		**Std Error**	**Marg Eff**
Economic variables								
actual revenue($10,000)	0.0352	**	0.0075	-0.0058	-0.0961	**	0.0081	-0.0158
effective carriers	0.0548	**	0.0070	0.0091	0.0165	*	0.0074	0.0027
capacity	0.5003	**	0.0314	0.0829	0.3866	**	0.0341	0.0635
Airport competition								
daliy total flights at destination	0.0004	**	0.00001	0.0001	0.0004	**	0.00001	0.0001
daliy total flights at origination	0.0002	**	0.00001	0.00004	0.0002	**	0.00001	0.00004
concentration at destination	-0.4452	**	0.0241	-0.0738	-0.3753	**	0.0240	-0.0617
concentration at origination	-0.4425	**	0.0248	-0.0733	-0.3435	**	0.0246	-0.0565
destination large hub	-0.0603	**	0.0161	-0.0099	0.0675	**	0.0196	0.0112
destination medium hub	0.0879	**	0.0140	0.0148	0.2573	**	0.0154	0.0448
destination small hub	-0.1493	**	0.0134	-0.0239	-0.1758	**	0.0141	-0.0278
origination large hub	0.2448	**	0.0160	0.0423	0.3742	**	0.0198	0.0656
origination medium hub	0.2947	**	0.0140	0.0520	0.4723	**	0.0153	0.0858
origination small hub	0.0323	*	0.0133	0.0054	0.0067		0.0140	0.0011
Weather variables(100th inch)								
precipitation at destination	0.0058	**	0.0001	0.0010	0.0061	**	0.0001	0.0010
precipitation at origination	0.0043	**	0.0001	0.0007	0.0047	**	0.0001	0.0008
freezing rain at destination	0.0237	**	0.0005	0.0039	0.0234	**	0.0005	0.0039
freezing rain at origination	0.0421	**	0.0006	0.0070	0.0420	**	0.0006	0.0069
Logistical Variables								
Daily	-0.0254	**	0.0013	-0.0042	-0.0197	**	0.0013	-0.0032
distance(100 miles)	0.0001	**	0.00001	0.00002	0.0002	**	0.00001	0.00003
minimum waiting time	-0.0001	**	0.00001	-0.00001	-0.0001	**	0.00001	-0.00001
number of seats	-0.0013	**	0.0001	-0.0002	0.0018	**	0.0002	0.0003
time01	1.2407	**	0.0205	0.2056	1.2676	**	0.0207	0.2084
Airline carriers								
LCC	-0.1255	**	0.0121	-0.0203	_		_	_
b6+	_		_	_	0.0007		0.0372	0.0001
fl+	_		_	_	0.1227	**	0.0294	0.0209
tz+	_		_	_	0.3370	**	0.0346	0.0607
wn+	_		_	_	-0.3214	**	0.0200	-0.0494
as	_		_	_	0.3691	**	0.0278	0.0669
co	_		_	_	-0.4357	**	0.0213	-0.0635
dh	_		_	_	0.4824	**	0.0262	0.0895
dl	_		_	_	-0.4217	**	0.0161	-0.0627
ev	_		_	_	-0.3695	**	0.0429	-0.0544
ha	_		_	_	-0.3852	**	0.0568	-0.0564
hp	_		_	_	-0.3306	**	0.0261	-0.0495
mq	_		_	_	0.3784	**	0.0221	0.0682
nw	_		_	_	0.1233	**	0.0184	0.0209
oh	_		_	_	-0.0692	**	0.0245	-0.0112
oo	_		_	_	0.3420	**	0.0257	0.0612
ru	_		_	_	-0.1018	**	0.0247	-0.0163
ua	_		_	_	-0.1841	**	0.0198	-0.0289
us	_		_	_	-0.3840	**	0.0226	-0.0570
constant	-2.0794	**	0.0312	_	-2.3982	**	0.0386	_
N	505,221				505,221			
Log Likelihood	-252,205.07				-250,073.68			
Pseudo Rsq	0.0638				0.0717			

"+" indicates low cost carrier "**" indicates significant at 5% "*" indicates significant at 1%
Marg Eff indicates Marginal Effects. The std errors are robust std errors.

Table 5 Logit Estimations for arrival delays more than 30 minutes for US domestic flights in Jan '04

Dependent Variable : arr_del30						
	Model 7			Model 8		
Variable	**Coefficient**	**Std Error**	**Marg Eff**	**Coefficient**	**Std Error**	**Marg Eff**
Economic variables						
actual revenue($10,000)	-0.0484 **	0.0099	-0.0048	-0.1410 **	0.0106	-0.0135
effective carriers	0.0287 **	0.0087	0.0028	-0.0064	0.0091	-0.0006
capacity	0.3167 **	0.0393	0.0312	0.2527 **	0.0432	0.0243
Airport competition						
daliy total flights at destination	0.0006 **	0.00001	0.0001	0.0005 **	0.00001	0.00005
daliy total flights at origination	0.0003 **	0.00001	0.00003	0.0002 **	0.00001	0.00002
concentration at destination	-0.6925 **	0.0317	-0.0681	-0.5364 **	0.0310	-0.0516
concentration at origination	-0.6320 **	0.0325	-0.0622	-0.4435 **	0.0316	-0.0427
destination large hub	-0.1437 **	0.0203	-0.0137	0.0700 **	0.0245	0.0069
destination medium hub	0.0261	0.0174	0.0026	0.2019 **	0.0191	0.0207
destination small hub	-0.1773 **	0.0171	-0.0165	-0.2152 **	0.0181	-0.0194
origination large hub	0.1406 **	0.0203	0.0143	0.3657 **	0.0250	0.0384
origination medium hub	0.2510 **	0.0172	0.0266	0.4538 **	0.0190	0.0501
origination small hub	-0.0044	0.0169	-0.0004	-0.0353 *	0.0178	-0.0034
Weather variables(100th inch)						
precipitation at destination	0.0054 **	0.0001	0.0005	0.0057 **	0.0002	0.0005
precipitation at origination	0.0043 **	0.0002	0.0004	0.0046 **	0.0002	0.0004
freezing rain at destination	0.0256 **	0.0006	0.0025	0.0254 **	0.0006	0.0024
freezing rain at origination	0.0421 **	0.0006	0.0041	0.0421 **	0.0006	0.0041
Logistical Variables						
Daily	-0.0323 **	0.0016	-0.0032	-0.0240 **	0.0017	-0.0023
distance(100 miles)	0.0001 **	0.00001	0.00001	0.0001 **	0.00001	0.00001
minimum waiting time	-0.0001 **	0.00002	-0.00001	-0.0001 **	0.00002	-0.00001
number of seats	-0.0020 **	0.0001	-0.0002	0.0019 **	0.0002	0.0002
time01	1.6462 **	0.0257	0.1619	1.6836 **	0.0260	0.1621
Airline carriers						
LCC	-0.1322 **	0.0153	-0.0126	_	_	_
b6+	_	_	_	-0.2342 **	0.0494	-0.0206
fl+	_	_	_	0.1696 **	0.0356	0.0174
tz+	_	_	_	0.3529 **	0.0411	0.0388
wn+	_	_	_	-0.4329 **	0.0256	-0.0372
as	_	_	_	0.3073 **	0.0344	0.0332
co	_	_	_	-0.6095 **	0.0278	-0.0473
dh	_	_	_	0.5868 **	0.0318	0.0697
dl	_	_	_	-0.6572 **	0.0203	-0.0519
ev	_	_	_	-0.4589 **	0.0538	-0.0370
ha	_	_	_	-0.6422 **	0.0823	-0.0483
hp	_	_	_	-0.5485 **	0.0340	-0.0432
mq	_	_	_	0.3626 **	0.0270	0.0395
nw	_	_	_	-0.0212	0.0228	-0.0020
oh	_	_	_	-0.0987 **	0.0300	-0.0092
oo	_	_	_	0.2968 **	0.0322	0.0317
ru	_	_	_	-0.2858 **	0.0315	-0.0249
ua	_	_	_	-0.1264 **	0.0245	-0.0117
us	_	_	_	-0.4738 **	0.0287	-0.0389
constant	-2.5572 **	0.0387	_	-2.9655 **	0.0482	_
N	505,221			505,221		
Log Likelihood	178,927.59			-176,809.88		
Pseudo Rsq	0.0778			0.0887		

"+" indicates low cost carrier "**" indicates significant at 5% "*" indicates significant at 1%
Marg Eff indicates Marginal Effects. The std errors are robust std errors.

Table 5 Logit Estimations for arrival delays more than 30 minutes for US domestic flights in Jan '04

Dependent Variable : arr_del30								
	Model 7				**Model 8**			
Variable	**Coefficient**		**Std Error**	**Marg Eff**	**Coefficient**		**Std Error**	**Marg Eff**
Economic variables								
actual revenue($10,000)	-0.0484	**	0.0099	-0.0048	-0.1410	**	0.0106	-0.0135
effective carriers	0.0287	**	0.0087	0.0028	-0.0064		0.0091	-0.0006
capacity	0.3167	**	0.0393	0.0312	0.2527	**	0.0432	0.0243
Airport competition								
daliy total flights at destination	0.0006	**	0.00001	0.0001	0.0005	**	0.00001	0.00005
daliy total flights at origination	0.0003	**	0.00001	0.00003	0.0002	**	0.00001	0.00002
concentration at destination	-0.6925	**	0.0317	-0.0681	-0.5364	**	0.0310	-0.0516
concentration at origination	-0.6320	**	0.0325	-0.0622	-0.4435	**	0.0316	-0.0427
destination large hub	-0.1437	**	0.0203	-0.0137	0.0700	**	0.0245	0.0069
destination medium hub	0.0261		0.0174	0.0026	0.2019	**	0.0191	0.0207
destination small hub	-0.1773	**	0.0171	-0.0165	-0.2152	**	0.0181	-0.0194
origination large hub	0.1406	**	0.0203	0.0143	0.3657	**	0.0250	0.0384
origination medium hub	0.2510	**	0.0172	0.0266	0.4538	**	0.0190	0.0501
origination small hub	-0.0044		0.0169	-0.0004	-0.0353	*	0.0178	-0.0034
Weather variables(100th inch)								
precipitation at destination	0.0054	**	0.0001	0.0005	0.0057	**	0.0002	0.0005
precipitation at origination	0.0043	**	0.0002	0.0004	0.0046	**	0.0002	0.0004
freezing rain at destination	0.0256	**	0.0006	0.0025	0.0254	**	0.0006	0.0024
freezing rain at origination	0.0421	**	0.0006	0.0041	0.0421	**	0.0006	0.0041
Logistical Variables								
Daily	-0.0323	**	0.0016	-0.0032	-0.0240	**	0.0017	-0.0023
distance(100 miles)	0.0001	**	0.00001	0.00001	0.0001	**	0.00001	0.00001
minimum waiting time	-0.0001	**	0.00002	-0.00001	-0.0001	**	0.00002	-0.00001
number of seats	-0.0020	**	0.0001	-0.0002	0.0019	**	0.0002	0.0002
time01	1.6462	**	0.0257	0.1619	1.6836	**	0.0260	0.1621
Airline carriers								
LCC	-0.1322	**	0.0153	-0.0126	_		_	_
b6+	_		_	_	-0.2342	**	0.0494	-0.0206
fl+	_		_	_	0.1696	**	0.0356	0.0174
tz+	_		_	_	0.3529	**	0.0411	0.0388
wn+	_		_	_	-0.4329	**	0.0256	-0.0372
as	_		_	_	0.3073	**	0.0344	0.0332
co	_		_	_	-0.6095	**	0.0278	-0.0473
dh	_		_	_	0.5868	**	0.0318	0.0697
dl	_		_	_	-0.6572	**	0.0203	-0.0519
ev	_		_	_	-0.4589	**	0.0538	-0.0370
ha	_		_	_	-0.6422	**	0.0823	-0.0483
hp	_		_	_	-0.5485	**	0.0340	-0.0432
mq	_		_	_	0.3626	**	0.0270	0.0395
nw	_		_	_	-0.0212		0.0228	-0.0020
oh	_		_	_	-0.0987	**	0.0300	-0.0092
oo	_		_	_	0.2968	**	0.0322	0.0317
ru	_		_	_	-0.2858	**	0.0315	-0.0249
ua	_		_	_	-0.1264	**	0.0245	-0.0117
us	_		_	_	-0.4738	**	0.0287	-0.0389
constant	-2.5572	**	0.0387	_	-2.9655	**	0.0482	_
N	505,221				505,221			
Log Likelihood	178,927.59				-176,809.88			
Pseudo Rsq	0.0778				0.0887			

"+" indicates low cost carrier "**" indicates significant at 5% "*" indicates significant at 1%
Marg Eff indicates Marginal Effects. The std errors are robust std errors.

Table 6 OLS Estimations for arrival delays for US domestic flights in Jan '04

Dependent Variable : arr_delay						
	Model 9			Model 10		
Variable	**Coefficient**		**Std Error**	**Coefficient**		**Std Error**
Economic variables						
actual revenue($10000)	-0.9650	**	0.1120	-1.7240	**	0.1170
effective carriers	0.4443	**	0.1010	-0.1351		0.1042
capacity	9.6899	**	0.3973	8.2313	**	0.4398
Airport competition						
daliy total flights at destination	0.0063	**	0.0001	0.0058	**	0.0002
daliy total flights at origination	0.0040	**	0.0001	0.0034	**	0.0001
concentration at destination	-4.6059	**	0.2762	-3.5465	**	0.2755
concentration at origination	-4.6106	**	0.2992	-3.4418	**	0.3045
destination large hub	-1.6729	**	0.2143	0.6699	*	0.2767
destination medium hub	1.3158	**	0.1843	3.3371	**	0.1937
destination small hub	-2.6990	**	0.1638	-3.1540	**	0.1678
origination large hub	0.8539	**	0.2044	3.2128	**	0.2717
origination medium hub	2.2485	**	0.1739	4.2614	**	0.1855
origination small hub	-0.7641	**	0.1554	-1.3116	**	0.1597
Weather variables(100th inch)						
precipitation at destination	0.0820	**	0.0026	0.0849	**	0.0026
precipitation at origination	0.0515	**	0.0023	0.0544	**	0.0023
freezing rain at destination	0.4996	**	0.0136	0.4986	**	0.0135
freezing rain at origination	0.7640	**	0.0141	0.7633	**	0.0141
Logistical Variables						
Daily	-0.2335	**	0.0130	-0.1855	**	0.0136
distance(100 miles)	-0.0004	**	0.0001	-0.0002		0.0001
minimum waiting time	-0.0004	*	0.0002	-0.0005	**	0.0002
number of seats	-0.0065	**	0.0015	0.0307	**	0.0021
time01	14.4121	**	0.2612	14.7959	**	0.2613
Airline carriers						
LCC	-0.2373		0.1364	_		_
b6+	_		_	-4.7314	**	0.4038
fl+	_		_	0.4232		0.4089
tz+	_		_	6.9407	**	0.7604
wn+	_		_	-2.9785	**	0.2609
as	_		_	2.6142	**	0.3840
co	_		_	-5.8065	**	0.2757
dh	_		_	7.7977	**	0.4777
dl	_		_	-7.5333	**	0.2237
ev	_		_	-9.9003	**	0.5654
ha	_		_	-2.1165	**	0.4637
hp	_		_	-5.3605	**	0.3408
mq	_		_	3.0052	**	0.3600
nw	_		_	-0.6204	*	0.2867
oh	_		_	-3.4950	**	0.3623
oo	_		_	2.7142	**	0.3589
ru	_		_	-2.9233	**	0.3340
ua	_		_	-1.1950	**	0.2906
us	_		_	-7.6165	**	0.2798
constant	-4.0960	**	0.4068	-6.2147	**	0.5234
N	505,221			505,221		
Log Likelihood	-252,205			-250,073.68		
Pseudo Rsq	0.0638			0.0717		

"+" indicates low cost carrier "**" indicates significant at 5% "*" indicates significant at 1%
The std errors are robust std errors.

Table 7 OLS Estimations for departure delays for US domestic flights in Jan '04

Dependent Variable : dep_delay	Model 11				Model 12			
Variable	**Coefficient**		**Std Error**		**Coefficient**		**Std Error**	
Economic variables								
actual revenue($10,000)	-0.6320	**	0.1020		-1.2200	**	0.1060	
effective carriers	-0.2205	*	0.0915		-0.3738	**	0.0941	
capacity	6.7875	**	0.3528		6.3811	**	0.3917	
Airport competition								
daliy total flights at destination	0.0044	**	0.0001		0.0041	**	0.0001	
daliy total flights at origination	0.0044	**	0.0001		0.0042	**	0.0001	
concentration at destination	-4.0181	**	0.2438		-3.1642	**	0.2447	
concentration at origination	-4.0759	**	0.2660		-3.1276	**	0.2704	
destination large hub	-2.9558	**	0.1895		0.2033		0.2484	
destination medium hub	0.0131		0.1625		1.5298	**	0.1700	
destination small hub	-1.3006	**	0.1483		-1.6733	**	0.1524	
origination large hub	-1.8009	**	0.1815		1.3200	**	0.2456	
origination medium hub	1.9228	**	0.1544		3.4210	**	0.1647	
origination small hub	-0.8177	**	0.1374		-1.2676	**	0.1427	
Weather variables(100th inch)								
precipitation at destination	0.0428	**	0.0024		0.0447	**	0.0024	
precipitation at origination	0.0498	**	0.0021		0.0517	**	0.0021	
freezing rain at destination	0.3286	**	0.0112		0.3281	**	0.0112	
freezing rain at origination	0.4135	**	0.0122		0.4130	**	0.0122	
Logistical Variables								
Daily	-0.1647	**	0.0116		-0.1826	**	0.0121	
distance(100 miles)	0.0009	**	0.0001		0.0011	**	0.0001	
minimum waiting time	-0.0003		0.0002		-0.0002		0.0002	
number of seats	-0.0174	**	0.0013		0.0211	**	0.0020	
time01	16.1751	**	0.2327		16.2116	**	0.2329	
Airline carriers								
LCC	1.5281	**	0.1210		_		_	
b6+	_		_		-1.0556	**	0.3566	
fl+	_		_		-2.3731	**	0.3647	
tz+	_		_		3.5047	**	0.6349	
wn+	_		_		1.3129	**	0.2388	
as	_		_		3.4524	**	0.3581	
co	_		_		-6.6773	**	0.2482	
dh	_		_		9.6118	**	0.4338	
dl	_		_		-6.8071	**	0.2013	
ev	_		_		-1.3820	**	0.5194	
ha	_		_		-1.3113	**	0.4202	
hp	_		_		-4.4693	**	0.3155	
mq	_		_		1.8393	**	0.3265	
nw	_		_		-3.3826	**	0.2636	
oh	_		_		1.7402	**	0.3279	
oo	_		_		4.8908	**	0.3235	
ru	_		_		-3.6512	**	0.3037	
ua	_		_		-1.5075	**	0.2672	
us	_		_		-4.2422	**	0.2505	
constant	-1.2771	**	0.3662		-5.6356	**	0.4749	
N	506,001				506,001			
F Statistic	523.46				407.35			
R Square	0.0516				0.0617			

"+" indicates low cost carrier "**" indicates significant at 1% "*" indicates significant at 5%

The std errors are robust std errors

Table 8 Logit Estimations for cancelled flights for US domestic flights in Jan '04

Dependent Variable : cancelled						
	Model 13			**Model 14**		
Variable	**Coefficient**	**Std Error**	**Marg Eff**	**Coefficient**	**Std Error**	**Marg Eff**
Economic variables						
actual revenue($10,000)	-0.1750 **	0.0271	-0.0033	-0.0188	0.0251	-0.0003
effective carriers	0.0521 **	0.0179	0.0010	0.0606 **	0.0184	0.0010
capacity	-1.9728 **	0.0772	-0.0368	-2.7604 **	0.0914	-0.0473
Airport competition						
daliy total flights at destination	0.0004 **	0.00002	0.00001	0.0004 **	0.00003	0.00001
daliy total flights at origination	0.0004 **	0.00002	0.00001	0.0003 **	0.00002	0.00001
concentration at destination	-0.3013 **	0.0607	-0.0056	-0.1984 **	0.0565	-0.0034
concentration at origination	-0.2968 **	0.0612	-0.0055	-0.2316 **	0.0571	-0.0040
destination large hub	-0.4416 **	0.0391	-0.0073	-0.0974 *	0.0483	-0.0016
destination medium hub	-0.3886 **	0.0372	-0.0063	-0.0797 *	0.0403	-0.0013
destination small hub	-0.3006 **	0.0341	-0.0050	-0.4187 **	0.0352	-0.0062
origination large hub	-0.5149 **	0.0393	-0.0084	-0.1780 **	0.0480	-0.0029
origination medium hub	-0.5060 **	0.0379	-0.0079	-0.1907 **	0.0407	-0.0030
origination small hub	-0.4427 **	0.0355	-0.0071	-0.5701 **	0.0365	-0.0080
Weather variables(100th inch)						
precipitation at destination	0.0012 **	0.0004	0.00002	0.0013 **	0.0004	0.00002
precipitation at origination	0.0013 **	0.0004	0.00002	0.0014 **	0.0004	0.00002
freezing rain at destination	0.0454 **	0.0008	0.0008	0.0451 **	0.0008	0.0008
freezing rain at origination	0.0478 **	0.0008	0.0009	0.0477 **	0.0008	0.0008
Logistical Variables						
Daily	0.0378 **	0.0026	0.0007	0.0409 **	0.0027	0.0007
distance(100 miles)	0.0001 **	0.00003	0.000002	0.0000	0.00003	0.0000003
minimum waiting time	-0.0003 **	0.00003	-0.00001	-0.0003 **	0.00003	-0.00001
number of seats	-0.0042 **	0.0003	-0.0001	-0.0028 **	0.0004	0.0000
time01	0.2297 **	0.0516	0.0043	0.2359 **	0.0516	0.0040
Airline carriers						
LCC	-0.4803 **	0.0325	-0.0079	_	_	_
b6+	_	_	_	-1.5297 **	0.2200	-0.0139
fl+	_	_	_	-0.8900 **	0.0961	-0.0104
tz+	_	_	_	-0.4568 **	0.0999	-0.0064
wn+	_	_	_	-0.3277 **	0.0519	-0.0051
as	_	_	_	1.1914 **	0.0579	0.0368
co	_	_	_	-1.1093 **	0.0748	-0.0122
dh	_	_	_	0.5347 **	0.0660	0.0117
dl	_	_	_	-0.5050 **	0.0409	-0.0072
ev	_	_	_	-0.9659 **	0.1169	-0.0108
ha	_	_	_	-0.8694 **	0.2210	-0.0101
hp	_	_	_	0.0255	0.0731	0.0004
mq	_	_	_	0.2057 **	0.0569	0.0038
nw	_	_	_	-0.5673 **	0.0511	-0.0078
oh	_	_	_	-0.1832 **	0.0596	-0.0029
oo	_	_	_	0.2988 **	0.0668	0.0058
ru	_	_	_	-0.7205 **	0.0707	-0.0092
ua	_	_	_	-0.5020 **	0.0554	-0.0071
us	_	_	_	-0.8775 **	0.0625	-0.0107
constant	-2.0427 **	0.0734	_	-1.9180 **	0.1023	_
N	520,940			520,940		
Log Likelihood	-59375.005			-58214.444		
Pseudo Rsq	0.124			0.1411		

"+" indicates low cost carrier "**" indicates significant at 5% "*" indicates significant at 1%
Marg Eff indicates Marginal Effects. The std errors are robust std errors.

Appendix

Logit Model Estimates

	Model 1				Model 2		
	dep_del15 with Lcc				dep_del15 without LCC		
Variable	Coefficient		Std Error	Marg Eff	Coefficient		Std Error	Marg Eff
Sunday	-0.3021	**	0.0142	-0.0362	-0.3021	**	0.0142	-0.0362
Tuesday	-0.4768	**	0.0143	-0.0546	-0.4768	**	0.0143	-0.0546
Wednesday	-0.6711	**	0.0149	-0.0732	-0.6711	**	0.0149	-0.0732
Thursday	-0.6494	**	0.0139	-0.0723	-0.6494	**	0.0139	-0.0723
Friday	-0.2562	**	0.0130	-0.0313	-0.2562	**	0.0130	-0.0313
Saturday	-0.3257	**	0.0138	-0.0389	-0.3257	**	0.0138	-0.0389

	Model 3				Model 4			
	dep_del30 with LCC				dep_del30 without LCC			
Variable	Coefficient		Std Error	Marg Eff	Coefficient		Std Error	Marg Eff
Sunday	-0.4004	**	0.0171	-0.0287	-0.4054	**	0.0172	-0.0283
Tuesday	-0.5267	**	0.0172	-0.0365	-0.5410	**	0.0173	-0.0364
Wednesday	-0.7307	**	0.0183	-0.0477	-0.7476	**	0.0183	-0.0474
Thursday	-0.7407	**	0.0171	-0.0492	-0.7557	**	0.0172	-0.0488
Friday	-0.3070	**	0.0156	-0.0229	-0.3199	**	0.0157	-0.0232
Saturday	-0.4394	**	0.0169	-0.0313	-0.4665	**	0.0170	-0.0322

	Model 5				Model 6			
	arr_del15 with LCC				arr_del15 without LCC			
Variable	Coefficient		Std Error	Marg Eff	Coefficient		Std Error	Marg Eff
Sunday	-0.4212	**	0.0135	-0.0635	-0.4253	**	0.0135	-0.0635
Tuesday	-0.4425	**	0.0130	-0.0665	-0.4480	**	0.0131	-0.0666
Wednesday	-0.6159	**	0.0135	-0.0889	-0.6249	**	0.0135	-0.0892
Thursday	-0.6241	**	0.0127	-0.0912	-0.6329	**	0.0127	-0.0915
Friday	-0.2167	**	0.0119	-0.0344	-0.2227	**	0.0120	-0.0350
Saturday	-0.3987	**	0.0128	-0.0607	-0.4075	**	0.0128	-0.0614

	Model 7				Model 8			
	arr_del30 with LCC				arr_del30 without LCC			
Variable	Coefficient		Std Error	Marg Eff	Coefficient		Std Error	Marg Eff
Sunday	-0.5453	**	0.0164	-0.0459	-0.5509	**	0.0165	-0.0452
Tuesday	-0.5334	**	0.0159	-0.0451	-0.5451	**	0.0160	-0.0449
Wednesday	-0.7618	**	0.0169	-0.0606	-0.7788	**	0.0169	-0.0602
Thursday	-0.7746	**	0.0158	-0.0627	-0.7905	**	0.0159	-0.0623
Friday	-0.3281	**	0.0145	-0.0297	-0.3407	**	0.0145	-0.0300
Saturday	-0.5079	**	0.0157	-0.0435	-0.5311	**	0.0158	-0.0442

	Model 13				Model 14			
	cancelled with LCC				cancelled without LCC			
Variable	Coefficient		Std Error	Marg Eff	Coefficient		Std Error	Marg Eff
Sunday	-0.8072	**	0.0340	-0.0115	-0.7892	**	0.0337	-0.0104
Tuesday	-0.0973	**	0.0285	-0.0018	-0.1230	**	0.0287	-0.0020
Wednesday	-0.2189	**	0.0300	-0.0038	-0.2668	**	0.0304	-0.0042
Thursday	-0.6087	**	0.0320	-0.0095	-0.6470	**	0.0322	-0.0091
Friday	-0.4498	**	0.0312	-0.0073	-0.4812	**	0.0313	-0.0071
Saturday	-0.7638	**	0.0370	-0.0112	-0.8124	**	0.0372	-0.0108

OLS Estimates

	Model 9	
	arr_delay with LCC	
Variable	Coefficient	Std Error
Sunday	-5.5332 **	0.2046
Tuesday	-6.3004 **	0.1863
Wednesday	-8.2020 **	0.1753
Thursday	-8.3141 **	0.1729
Friday	-2.9849 **	0.1835
Saturday	-6.5834 **	0.1845

Model 10	
arr_delay without LCC	
Coefficient	Std Error
-5.5582 **	0.2038
-6.2993 **	0.1853
-8.1996 **	0.1741
-8.3273 **	0.1721
-2.9784 **	0.1822
-6.6231 **	0.1835

	Model 11	
	dep_delay with LCC	
Variable	Coefficient	Std Error
Sunday	-3.5044 **	0.1858
Tuesday	-5.4553 **	0.1677
Wednesday	-7.1144 **	0.1579
Thursday	-7.1788 **	0.1551
Friday	-2.9994 **	0.1659
Saturday	-4.5118 **	0.1673

Model 12	
dep_delay without LCC	
Coefficient	Std Error
-3.5625 **	0.1850
-5.4879 **	0.1665
-7.1558 **	0.1569
-7.2085 **	0.1545
-2.9908 **	0.1649
-4.6575 **	0.1664