LOW AND LOWER: DO FLIGHTS DELAY MORE IF THEY COST LESS?

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Abstract

In recent years, low cost and ultra low cost carriers have expanded significantly to be an important part of the airline industry. Little research has been conducted considering low cost and ultra low cost carriers as two different types. This paper seeks to analyze the product quality of flights operated by these two distinct types of carriers comparing to legacy carriers and whether the presence of these carriers improve overall flight quality. Empirical results suggest that while flights operated by low cost carriers' on-time performance is slightly worse than legacy carriers, ultra low cost carriers delay much more. In addition, the presence of these types of carriers in an airport also have positive effect on the punctuality of flights departing from that airport.

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1 Introduction

Various research studies on the airline industry have looked at the competition between legacy carriers and low cost carriers. [1] Legacy airlines, which have operated before the Airline Deregulation Act in 1978, usually offer flights with extra services such as first-class seats, advanced on air service and business lounges at airports. On the other hand, low cost carriers (LCC) attract customers by reducing operating cost in order to reach lower fares. Low cost airlines have established their position in the US market: the number of airports with low cost carriers market share of domestic flights greater than 20% increased from 27 in 1990 to 95 in 2008 (Abda, Belobaba and Swelbar, 2012). However, there has been evidence showing that the gap between unit cost of low cost airlines and their legacy counterparts have shrunk (Tsoukalas, Belobaba and Swelbar, 2008). As a result, in recent years, some carriers, typically Spirit Airlines, Allegiant Air and Frontier Airlines, have utilized the opportunity to further minimize production cost, undercut fares of low cost carriers and operate as ultra low cost carriers (ULCC). They developed the strategy to unbundle their tickets: although the base prices for tickets offered by these airlines are low, every extra ancillary service including overhead baggage will be charged with an extra fee. Bachwich and Wittman (2017) argue that ULCCs have distinct cost structures as well as business strategies and should not be be grouped with LCCs. This study focuses on the effect of ULCC presence on ticket fares in different region-pair markets. In my thesis, I want to analyze the product quality of low cost carriers and ultra low cost

[1] See Mazzeo (2003), Greenfield (2014) and Rupp, Owens and Plumly(2006)

carriers as well as their effects on US domestic flight quality. Similar to many studies in this field, I will use on-time performance as a proxy for product quality. There has been substantial works on the effect of competition and LCCs on flight delay in the US [2]. However, these studies do not distinguish LCCs from ULCCs. Following Bachwich and Wittman (2017), I will treat LCCs and ULCCs as two different types of airlines when analyzing their on-time performance. This paper will use empirical evidence to contribute to the vast literature studying flight delay by re-examining LCCs' tendency to delay flights and adding new insights about ULCCs.

Flight delay is an important factor every customer considers when purchasing tickets because it heavily affects customer satisfaction (Josephat and Ismail, 2012). On the regulating side, on-time performance is also closely monitored by government departments to protect consumers. The Department of Transportation requires airlines with more than 0.5 percent of total domestic scheduled-service passenger revenue to report information about flight on-time data including the causes of delay.

Airlines can actively invest more resources to prevent delays. Although there are arguments that flight delays are caused by random and uncontrollable events such as weather conditions, most of the delays are the results of aircraft and carrier problems. From January 2015 to December 2015, the Department of Transportation on-time performance data shows that 20% of domestic flights were not on time. Flights are counted as delay if they arrive 15 minutes after they are scheduled. The DOT defines Air Carrier Delay as circumstances within the carriers' control such

[2]See Rupp, Owens and Plumly (2006), Rupp and Sayanak (2008)

as problems related to flying crew, baggage, fuel or aircraft cleaning. Late-arriving aircraft means a flight is delayed because the previous flight using the same aircraft arrived late. Figure 1 shows the shares of the causes for delay during this time period. A large proportion of delays are caused by aircraft and airlines issues, which can be minimized by hiring more stand-by crew members, recruiting higher quality maintenance and repairing crews and acquiring extra unscheduled aircraft. Investing on these aspects is expensive to airlines and will directly affect the probability and length of delays. Since LCCs and ULCCs have significantly lower operating expenses than legacy carriers, one natural hypothesis I will explore is their flights are also more likely to be delayed. Between these two types of airlines, ULCCs might even have worse on-time performance since these airlines' priority is not providing the best service but offering the lowest price.

The second hypothesis that I want to investigate is whether higher presence of LCCs and ULCCs in airports can have positive effect and decrease delay of flights from those airports. Since LCCs pursue the faster aircraft turn-around strategy in order to minimize costs, they might reduce airport congestion and therefore improve on-time performance of other flights as well. However, as ULCCs have even lower operating expense, they might be underinvesting in factors which contribute to faster aircraft turn-around time such as hiring employees to finish logistical procedures for the aircraft to be ready for the next flight. This effect might increase airport congestion and flight delay. It will be interesting to look at how LCCs and ULCCs market share in an airport affect the punctuality of flights originating from that airport.

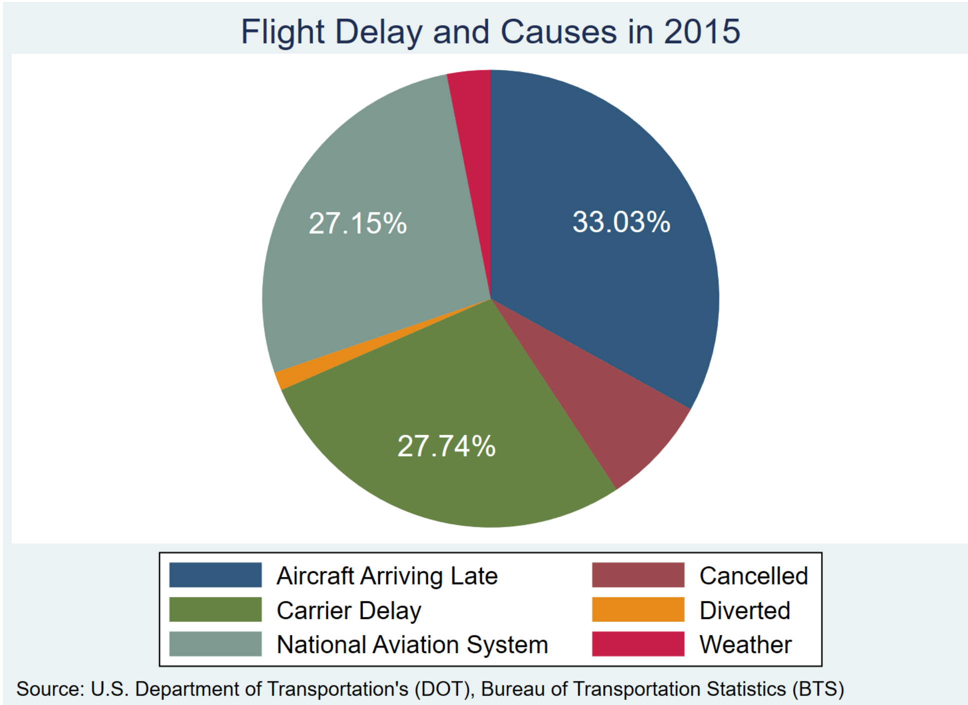

Figure 1: Flight Delay and Causes in 2015

The main motivation for this thesis is the lack of studies which focus on the effect of ultra low cost carriers on flight quality. Since flight delay is a crucial factor for consumers and regulators, further understanding about on-time performance is valuable. Using various publicly available datasets from the Department of Transportation, the National Oceanic and Atmospheric Administration's Climatic Data Center, the US Census Bureau and the US Bureau of Economic Analysis, I will conduct empirical tests for these hypotheses and provide insights about LCCs and ULCCs. The following sections review the literature, describe the data, explain the econometric model, discuss empirical results and conclude.

2 Literature Review

Some previous studies have studied the the difference in on-time performance between low cost and legacy carriers. Rupp and Sayanak (2008) examine the common myth that low cost carriers, because they offer lower airfares, usually have lower service quality in terms of the probability and length of flight delay. The authors first use a Wilcoxon rank-sum test to show that low cost carriers have significantly fewer delays in most of 2006. In addition, using individual flight data and controlling for flight-specific characteristics such as origin/destination airport concentration, route level yield and weather conditions, the authors find that low cost carriers have moderately shorter arrival delays and significantly shorter excess travel time than their legacy airlines competitors. Baker (2013) also found that during 2007 and 2011, low-cost carriers were the best in terms of on-time performance while legacy airlines trail behind using flight data from the Department of Transportation.

While most paper address the effects of overall competition on on-time performance of airlines (Mazzeo., 2003; Greenfield., 2014; Rupp, Owens and Plumly., 2006), one paper which directly studies the effect of LCCs on on-time performance is Bubalo and Gaggero (2015). The main research question in this paper is whether more LCCs serving an origin airport can make flights from that airport delay less. Data about Europeon airlines and airports is used to estimate the effect of LCCs presence on flight delay. On average, LCCs exitence in the airports is associated with an improvement in on-time performance. However, Rupp, Owens and Plumly (2008) use US flight data in 2000 and report that legacy airlines perform worse in routes where they have to compete with their low-cost counterparts. This negative impact of

LCCs is associated to the minimum horizontal differentiation effect that Hotelling (1929) describe.

The papers mentioned above do not distinguish low cost carriers from ultra low cost carriers. In a more recent paper, Bachwich and Wittman (2017) specify that these two types of airlines should not be grouped in the same category and investigate the effect of LCCs and ULCCs on ticket price in the market. The OLS regression of airfares on the presence of these two types of airlines shows that ULCC presence in a route with no LCC results in 20.5% lower mean price than a route served by only legacy airlines. However, the presence of LCC when there is no ULCC is associated with only a 7.7% lower fare. This result suggests that LCCs and ULCCs have different pricing strategy, which motivates my question of whether they are also different in terms of on-time performance.

3 Data Description

The primary source of data in this paper will be the Airline On-Time Performance Data which is publicly available on the Bureau of Transportation Statistics (BTS) website. This dataset provides information about arrival and departure of non-stop domestic flights by month, year, carrier, origin and destination airports from 1987 to 2019. I choose to analyze data in 2015. In the individual flight information, I will use the "OP_CARRIER_AIRLINE_ID" variable, which is the DOT unique airline identifier, to classify flights as being operated by Legacy Airlines, LCCs or ULCCs. A definition of ULCC is proposed by Bachwich and Wittman (2017): an ultra low cost carrier needs to have significant lower costs than low cost carriers, gain operating revenues from sale of unbundled flight services and offer lower airfares. Figure 2 shows different levels of total revenue per equivalent seat mile of airlines in 2015, based on data from the US DOT Form 41 via MIT Airline Data Project [3].

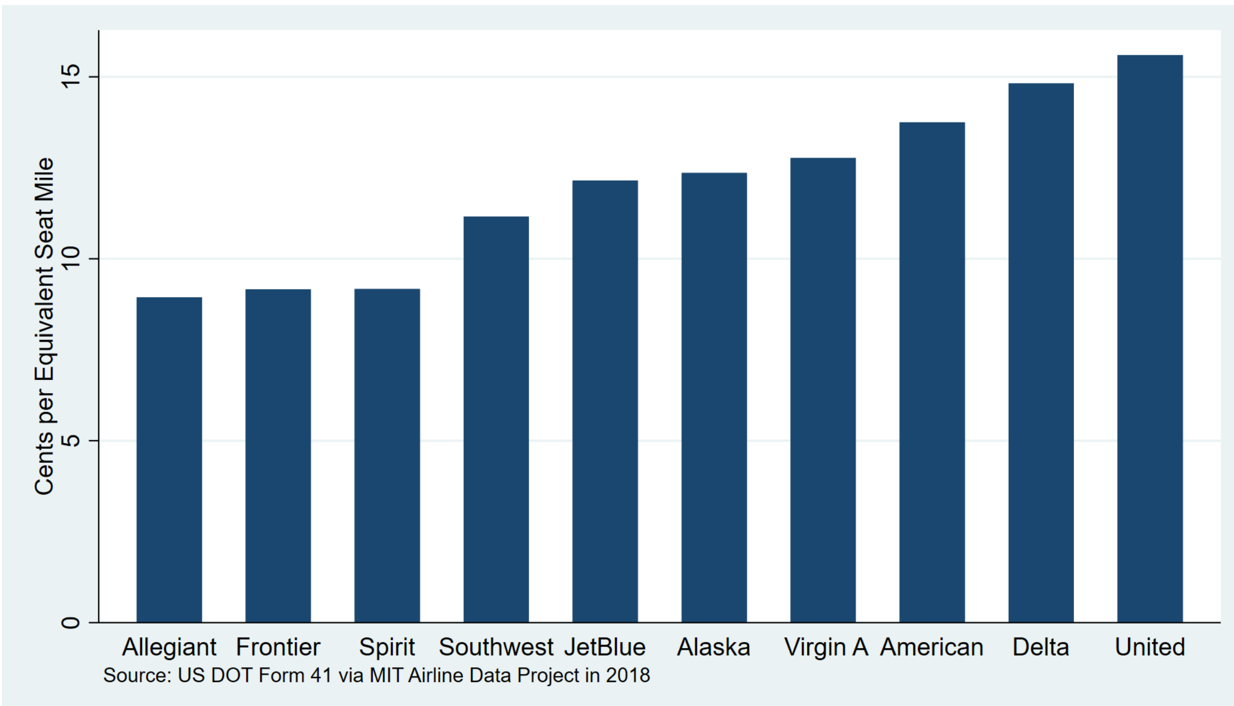

Figure 2: Total Revenue per Equivalent Seat Mile

Three distinct groups of carriers can be characterized using this figure: legacy carriers (American Airlines, Delta Airlines, United Airlines), low cost carriers (Southwest Airlines, JetBlue Airways, Alaska Airlines, Virgin American) and ultra low cost airlines (Spirit Airlines, Allegiant Air and Frontier Air). In October 2015, US Air-

[3] URL: http://web.mit.edu/airlinedata/www/RevenueRelated.html

ways merged with American Airlines so the revenue of US Airways is not included in this figure. However, based on their statistics in 2014, I consider US Airways as a legacy airline. Furthermore, regional airlines also participate in several routes in the dataset. However, in the routes where regional airlines and other types of carriers compete, regional airlines operate under the brand names of legacy airlines. Therefore, flights by regional airlines in these routes will be treated as flights managed by legacy airlines. To determine which legacy airlines these flights are operating as, I will use the Airline Origin and Destination Survey (DB1B) data which contains 10% of airlines tickets, specifically the itinerary details, to match the regional airlines with the corresponding legacy airlines. In each specific airport-pair route, one regional airline only serves one legacy airline, which makes the DB1B data sufficient to merge the reporting regional airlines with the ticketing legacy airlines.

In order to isolate the effects of LCCs and ULCCs on on-time performance, a set of control variables will be included in the regressions. The first ones are variables which account for weather conditions. Data on daily weather is retrieved from the National Oceanic and Atmospheric Administration's Climatic Data Center. Conveniently, weather conditions from this source are often reported from major airports of the cities. Using the longitudes and latitudes of the airports and the weather stations, I match the airports with the closest stations based on the Haversine formula. In addition, demographic characteristics of both origin and destination of a flight should be included to control for variation in market demand. Data on population and income is provided by the US Census Bureau and the Bureau of

Economic Analysis, respectively [4]. Another factor which can affect flights delay is airport congestion because flights are more likely to be late when the airports are crowded. The variable I will use to control for airport congestion the number of flights operated in the same hour in the origin and destination airports. I control for market competitiveness by including market concentration of the origins and destinations during the date of flight, which can be measured by the Hirschman-Herfindahl Index (HHI). Finally, aircraft characteristics such as age and capacity will be included in the model. I will match the tail number of the aircraft with the records maintained by the Federal Aviation Administration (FAA) to collect these two variables. [5]. The original dataset has 4073005 observations. To create a more manageable dataset, I randomly select 25% of flights for each type of airlines to form my sample observations.

From the raw on-time performance data, some evidence showing different product quality between types of airline can be spotted. Figure 3 indicates the quarter average arrival delay in minutes in 2015. It is clear that ULCCs delay flights much more than legacy carriers, while LCCs perform better than ULCCs but still worse than legacy airlines.

[4]Both of these variables are at the state level

[5]There are some tail numbers that do not match with any record because the FAA database is not complete. I omit these flights.

Table 1: Variables Description

Variable	Definition
DepDelay	Difference in minutes between scheduled and actual departure time. Early departures show negative numbers.
DepDel15	Departure Delay Indicator, 15 Minutes or More (1=Yes)
ArrDelay	Difference in minutes between scheduled and actual arrival time. Early arrivals show negative numbers.
ArrDel15	Arrival Delay Indicator, 15 Minutes or More (1=Yes)
AirTime	Flight Time, in Minutes
Distance	Distance between airports (miles)
DESTFL	Number of flights arrive in the same hour at the destination airport
ORGFL	Number of flights depart in the same hour at the origin airport
HHI_org	Origin airport concentration
HHI_dest	Destination airport concentration
low_cost	Low Cost Airline Indicator
ulcc	Ultra Low Cost Airline Indicator
NO_SEATS	Number of seats in the aircraft
ACRFT_AGE	Age of the aircraft
PRCP	Precipitation (tenths of milimeters)
SNOW	Snowfall (milimeters)
SNWD	Snow depth (milimeters)
DestPop	Population in Destination State
OriginPop	Population in Origin State
DestIncome	Total Personal Income in Destination State (Thousands of Dollars)
OriginIncome	Total Personal Income in Origin State (Thousands of Dollars)

Table 2: Summary Statistics

Variables	Mean	Std. Dv.	Min	Max
Flight Delay Measurements				
DepDelay	8.35	34.16	-45.00	1576.00
DepDel15	0.17	0.38	0.00	1.00
ArrDelay	3.31	36.54	-82.00	1557.00
ArrDel15	0.17	0.38	0.00	1.00
Flight Characteristics				
AirTime	113.55	72.76	8.00	690.00
Distance	825.49	613.27	31.00	4983.00
DESTFL	880.19	180.61	1.00	1128.00
ORGFL	900.48	173.48	1.00	1162.00
HHI_org	4331.18	2087.23	1421.32	10000.00
HHI_dest	4345.47	2074.52	1431.21	10000.00
Airline Types				
low_cost	0.34	0.47	0.00	1.00
ulcc	0.03	0.17	0.00	1.00
Aircraft Characteristics				
NO_SEATS	139.10	67.11	1.00	495.00
ACRFT_AGE	11.84	6.32	0.00	56.00
Weather Variables				
PRCP	25.32	84.09	0.00	3172.00
SNOW	219.10	102.26	-356.00	478.00
SNWD	115.61	98.31	-422.00	339.00
Other Control Variables				
DestPop	14828165	11942825	585668	38953142
OriginPop	14938150	11899581	585668	38953142
DestIncome	754930	661481	30535	2208915
OriginIncome	758473	658890	30535	2208915
N	1018250	1018250	1018250	1018250

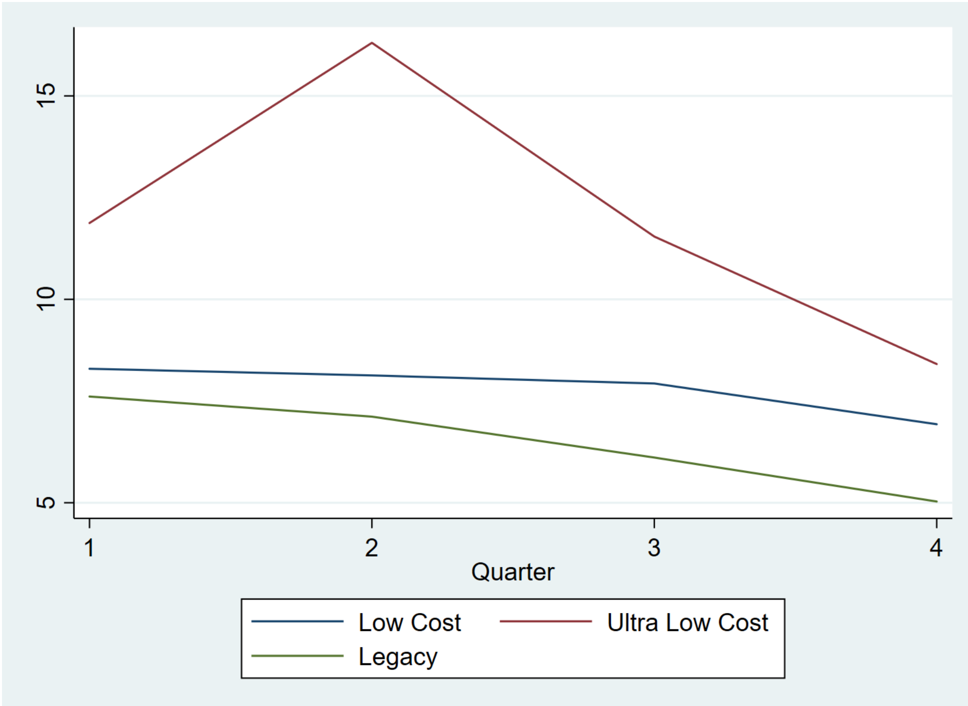

Figure 3: Average Arrival Delay by Quarter

4 Empirical Method

I will use the ordinary linear regression model to address whether low cost and ultra low cost carriers have worse on-time performance comparing to legacy airlines. The reduced-form regression will have measures of flights delay on the left hand side and indicator variables for LCC and ULCC, other market structure and control factors on the right hand side. The regression equation will have this form:

$$\text{DELAY}_{irt} = \beta_0 + \beta_1 LCC_i + \beta_2 ULCC_i + X_{irt}\gamma + \epsilon_{irt}$$

where $DELAY_{irt}$ is the length of flight delay operated by carrier i on a airport-pair route j at time t. I will run additional regressions where the dependent variable is the probability of late flight in route r at time t. LCC_i and $ULCC_i$ are indicators for whether the operating airline is a low cost carrier or an ultra low cost carrier. X_{irt} is the vector of control variables for weather conditions, aircraft and airport characteristics. These variables are defined in table 1. From this model, I expect β_1 to be negative, which is consistent with the result of Rupp and Sayanak (2008). However, β_2 might be positive since the extreme cost-minimizing strategy of ultra low cost carriers might not be able to guarantee adequate product quality.

To test for my second hypothesis, which is whether more presence of LCC and ULCC in an airport can increase the performance of flights originating from that airport, I will use the following model:

$$DELAY_{fdt} = \beta_0 + \beta_1 LCC_{ot} + \beta_2 ULCC_{ot} + X_{fodt}\gamma + \epsilon_{fodt}$$

where f is the flight code, o is the origin airport, d is the destination airport and t is the date of flight. This model is similar to the one Bubalo and Gaggero (2015) use. The dependent variables considered will be minutes of arrival delay and indicator of considerable delay. On the right hand side, the variables of interest are LCC_{ot} and $ULCC_{ot}$, which is the share of flights operated by LCCs and ULCCs in the flight date.

5 Estimation Result

5.1 First Hypothesis

The OLS estimation using minutes of departure delay as the dependent variable (Table 3) reveals that on average, low cost carriers delay about 1 minute more than the legacy airlines. On the other hand, flights operated by ultra low cost carriers depart 4.788 minutes later than their legacy counterparts. This result suggests that airlines which charge lower prices perform worse in terms of punctuality. This result is a further explanation for that of Rupp and Sayanak (2008), which suggests that LCCs delay less than non-LCCs. If we look deeper into this result, LCCs perform better than ULCCs but worse than legacy airlines. From the customers point of view, arrival delay is much more important than departure delay, since people usually plan their trips based on when they think they can arrive at the destination airports. When arrival delay is used as the dependent variable, the estimated coefficient for low_cost is not statistically different from 0, which suggests that low cost carriers and legacy carriers are not significantly different in terms of arrival on-time performance. In contrast, flights operated by ultra low cost carriers arrive almost 9 minutes later than those ran by legacy airlines. This result confirms that ultra low cost carriers do have lower product quality. As the ultra low cost business model focuses on offering extremely cheap air travels instead of the best flying experience, these airlines might have underinvested in many aspects that can approve on-time performance such as hiring and training better crew members or acquiring extra unscheduled aircraft. Coefficients for all variables, namely flight characteristics, aircraft characteristics and weather measurements, are all significant, which suggests all of these factors contribute to on-time performance.

In the second regression, I use a dummy variable indicating if the flights delay their departures for 15 minutes or more as the dependent variable. Results in table 3 suggest that low cost and ultra low cost flights are both more likely to depart late for at least 15 minutes than flights operated by legacy airlines. If we look at arrival delay instead of departure delay, while the estimated coefficient for LCCs is relatively small, the number for ULCC is large: flights operated by ultra low cost carriers are more likely to arrive late than flights operated by legacy carriers with the probability of 0.105. This estimation confirms that ultra low cost carriers not only delay more in terms of minutes but also are more likely to have longer delays than their legacy competitors.

I also created another variable called excess travel time, which is the sum of departure and arrival delay and use it as an dependent variable in the above regressions (Table 5). Unsurprisingly, the total amount of extra time spent on ULCCs flights is 13.73 minutes longer than the excess time customers have to spend on legacy flights. The number for low cost carriers is also significantly different from zero, although the magnitude is much smaller.

5.2 Second Hypothesis

To investigate my second hypothesis, which is how more presence of LCCs and ULCCs at the origin airport affects overall on-time performance, I will run multiple regressions with different specifications using the arrival delay (in minutes) as the

Table 3: Regression table

	(1) DepDel15	(2) DepDelay	(3) ArrDelay	(4) ArrDel15
low_cost	0.0211***	1.036***	0.0784	0.00182*
	(24.56)	(18.43)	(1.25)	(2.15)
ulcc	0.0834***	4.788***	8.945***	0.105***
	(32.63)	(24.91)	(42.40)	(39.65)
DESTFL	0.000153***	0.00739***	0.00793***	0.000128***
	(55.53)	(31.95)	(31.61)	(46.98)
Distance	0.0000109***	0.000844***	-0.00242***	-6.36e-09
	(15.74)	(18.41)	(-46.22)	(-0.01)
ORGFL	-0.000239***	-0.0175***	-0.0165***	-0.000194***
	(-83.07)	(-75.92)	(-67.72)	(-68.20)
NO_SEATS	-0.0000571***	-0.00154***	-0.00705***	-0.000101***
	(-9.45)	(-3.67)	(-14.81)	(-16.09)
ACRFT_AGE	0.000383***	0.0254***	-0.0376***	-0.000294***
	(6.13)	(6.09)	(-7.97)	(-4.75)
PRCP	0.000333***	0.0262***	0.0340***	0.000382***
	(55.60)	(53.57)	(60.53)	(61.53)
SNOW	-0.000319***	-0.0196***	-0.0217***	-0.000376***
	(-33.88)	(-30.31)	(-30.01)	(-39.56)
SNWD	0.000211***	0.0140***	0.0167***	0.000242***
	(21.55)	(20.83)	(22.35)	(24.49)
DestPop	-1.51e-09***	-6.38e-08***	-0.000000152***	-3.99e-10
	(-6.05)	(-3.68)	(-7.84)	(-1.59)
OriginPop	3.57e-09***	0.000000247***	0.000000222***	1.74e-09***
	(14.05)	(14.10)	(11.40)	(6.92)
DestIncome	4.36e-08***	0.00000229***	0.00000387***	2.38e-08***
	(9.58)	(7.27)	(10.99)	(5.23)
OriginIncome	-5.06e-08***	-0.00000362***	-0.00000288***	-2.01e-08***
	(-10.99)	(-11.42)	(-8.17)	(-4.40)
HHI_org	-0.000000765***	-0.0000569***	-0.000116***	-0.00000216***
	(-3.94)	(-4.31)	(-7.90)	(-11.12)
HHI_dest	-0.00000374***	-0.000238***	-0.000310***	-0.00000440***
	(-19.58)	(-18.49)	(-21.64)	(-23.06)
Constant	0.268***	16.63***	14.99***	0.298***
	(83.38)	(64.52)	(53.83)	(92.81)
Observations	1018250	1018250	1018250	1018250

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Regression table

	(1)	(2)
	excess_travel_time	excess_travel_time
low_cost	1.115***	
	(9.61)	
ulcc	13.73***	
	(34.77)	
DESTFL	0.0153***	0.0149***
	(32.35)	(31.42)
Distance	-0.00158***	-0.00165***
	(-16.64)	(-17.39)
ORGFL	-0.0340***	-0.0342***
	(-73.01)	(-73.34)
NO_SEATS	-0.00859***	-0.00617***
	(-9.88)	(-7.07)
ACRFT_AGE	-0.0122	-0.0886***
	(-1.41)	(-10.57)
PRCP	0.0602***	0.0602***
	(58.25)	(58.20)
SNOW	-0.0413***	-0.0422***
	(-30.91)	(-31.61)
SNWD	0.0307***	0.0319***
	(22.17)	(23.00)
DestPop	-0.000000216***	-0.000000138***
	(-6.03)	(-3.85)
OriginPop	0.000000469***	0.000000462***
	(13.00)	(12.62)
DestIncome	0.00000616***	0.00000479***
	(9.47)	(7.37)
OriginIncome	-0.00000650***	-0.00000624***
	(-9.95)	(-9.39)
HHI_org	-0.000173***	-0.000129***
	(-6.35)	(-4.59)
HHI_dest	-0.000548***	-0.000559***
	(-20.66)	(-21.11)
lcc_share		0.00137
		(0.64)
ulcc_share		0.169***
		(14.94)
Constant	31.62***	32.68***
	(60.07)	(61.71)
Observations	1018250	1018250

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

dependent variable. Table 5 reports significant and negative coefficients for both shares of low cost and ultra low cost carriers. This result suggests that more flights operated by LCCs and ULCCs in the origin airports will have a positive effect and reduce flight delay on the whole. The positive effect of low cost carriers is in line with Bubalo and Gaggero (2015). Low cost carriers might improve the overall flight quality by their fast turn-around strategy, which can free up more resource in the departing airports for other flights to use and leave on time. DESTFL and ORGFL have positive coefficients, which is expected since more flights might make airports more congested and therefore affect flight delay. Airport market concentration is found to have a negative effect on arrival delay. The negative signs on HHI_org and HHI_dest suggest that the lack of competition in airports can cause flights to delay more.

My second regression uses the dummy variable indicating whether the flight delays for 15 minutes or more as the dependent variable (Table 6). Although the coefficients for share of low cost carriers are negative and significant, the results for share of ultra low cost carriers are either not significant or positive. This means more flights operated by ultra low costs carriers in the origin airport has no effect on the probability of long arrival delay. If all control variables are included, the positive coefficient reveals that more ultra low cost flights in fact make flights delay for at least 15 minutes more. This is unexpected because the first regression suggests that more flights operated by ultra low cost carriers reduce the average minutes of arrival delay. Estimated coefficients for other variables behave in a similar trend as in the first regression.

Table 5: Regression table

	(1) ArrDelay	(2) ArrDelay	(3) ArrDelay	(4) ArrDelay
lcc_share	-0.0100***	-0.00285***	-0.00407***	-0.00502***
	(-21.74)	(-6.14)	(-8.60)	(-10.31)
ulcc_share	-0.0424***	-0.0244***	-0.0256***	-0.0233***
	(-16.85)	(-9.75)	(-10.24)	(-9.18)
DepDelay	1.005***	1.007***	1.007***	1.005***
	(1594.93)	(1610.89)	(1611.29)	(1610.98)
DESTFL		0.000431***	0.000506***	0.000518***
		(4.61)	(5.42)	(5.55)
Distance		-0.00337***	-0.00326***	-0.00328***
		(-137.74)	(-123.41)	(-124.81)
ORGFL		0.000959***	0.000899***	0.000898***
		(10.56)	(9.89)	(9.86)
HHI_org		-0.0000650***	-0.0000502***	-0.0000589***
		(-10.82)	(-8.34)	(-9.25)
HHI_dest		-0.0000876***	-0.0000713***	-0.0000596***
		(-14.73)	(-11.95)	(-9.61)
NO_SEATS			-0.00417***	-0.00417***
			(-18.80)	(-18.71)
ACRFT_AGE			-0.0712***	-0.0717***
			(-34.19)	(-34.28)
PRCP				0.00767***
				(37.71)
SNOW				-0.00196***
				(-6.30)
SNWD				0.00262***
				(8.18)
DestPop				-6.26e-08***
				(-7.46)
OriginPop				5.40e-09
				(0.63)
DestIncome				0.00000105***
				(6.95)
OriginIncome				0.000000144
				(0.93)
Constant	-4.654***	-2.764***	-1.535***	-1.617***
	(-212.94)	(-31.44)	(-16.31)	(-15.48)
Observations	1018250	1018250	1018250	1018250

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Regression table

	(1) ArrDel15	(2) ArrDel15	(3) ArrDel15	(4) ArrDel15
lcc_share	-0.000142***	-0.000155***	-0.000164***	-0.000165***
	(-14.23)	(-14.96)	(-15.58)	(-15.33)
ulcc_share	0.0000578	-0.0000113	-0.0000147	0.000104*
	(1.16)	(-0.22)	(-0.29)	(2.01)
DepDel15	0.723***	0.723***	0.723***	0.719***
	(700.66)	(699.17)	(699.12)	(690.14)
DESTFL		0.0000159***	0.0000166***	0.0000177***
		(9.15)	(9.54)	(10.17)
Distance		-0.00000859***	-0.00000722***	-0.00000797***
		(-18.08)	(-14.05)	(-15.44)
ORGFL		-0.0000264***	-0.0000271***	-0.0000243***
		(-14.34)	(-14.70)	(-13.15)
HHI_org		-0.00000169***	-0.00000155***	-0.00000157***
		(-13.02)	(-11.94)	(-11.51)
HHI_dest		-0.00000164***	-0.00000149***	-0.00000149***
		(-13.03)	(-11.84)	(-11.29)
NO_SEATS			-0.0000455***	-0.0000438***
			(-10.07)	(-9.63)
ACRFT_AGE			-0.000632***	-0.000647***
			(-14.90)	(-15.20)
PRCP				0.000143***
				(36.76)
SNOW				-0.000147***
				(-22.40)
SNWD				0.0000909***
				(13.42)
DestPop				9.23e-10***
				(5.30)
OriginPop				-7.10e-10***
				(-4.02)
DestIncome				-1.22e-08***
				(-3.85)
OriginIncome				1.46e-08***
				(4.55)
Constant	0.0522***	0.0842***	0.0960***	0.107***
	(117.98)	(46.94)	(49.88)	(49.83)
Observations	1018250	1018250	1018250	1018250

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6 Conclusion

Low cost and ultra low cost carriers have grown to be an important part of the airline industry. Since these two types of carriers have distinct business models, they should be treated as two different types. This paper contributes to the current literature by studying the flight quality of low cost and ultra low costs carriers. The first question asked in this paper is whether flights operated by LCCs and ULCCs have worse quality than ones operated by legacy airlines. Another question is whether the presence of LCCs and ULCCs in the origin airports has an significant impact on on-time performace of flights from there.

Using data from the Department of Transportation, the National Oceanic and Atmospheric Administration's Climatic Data Center, Federal Aviation Administration, US Census Bureau and the Bureau of Economic Analysis, I construct a dataset including flight information in 2015 and run reduced form regressions to test my hypotheses. I find significant evidence showing that low cost carriers delay slightly more and ultra low cost carriers perform much worse than their legacy counterparts. For my second hypothesis, my result suggests that the presence of both LCCs and ULCCs in an airport has a positive effect and improves the product quality of flights originating from there. However, the presence of ULCCs is associated with more probability of flight delaying for 15 minutes or more.

The limitation of this study includes the lack of measurement for product quality. Although punctuality is an important aspect of flights, customers also consider other services that a carrier can offer at the airport and on air. Further study can take these aspects into account in the analysis.

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