# Analysis of Airports Served by Ultra Low-Cost Carriers

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*Resubmitted January 31, 2023*

**Keywords:** ULCC, enplanements, airline, catchment area, cost per enplanement.

**Funding**
The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research is partially funded through by the Graduate Research Award Program on Public-Sector Aviation Issues of the Airport Cooperative Research Program (ACRP), which is administered by the Transportation Research Board (TRB).

**Data Availability Statement**
The statistical data are available for sharing at:
https://dataverse.asu.edu/dataset.xhtml?persistentId=doi:10.48349/ASU/OMASM4.

**ABSTRACT**

Recently the domestic aviation industry has been influenced by rapidly growing ultra low-cost carriers (ULCCs). The pattern of airport markets served by ULCCs is incongruous with legacy carriers and low-cost airlines alike. Existing literature, however, is limited for North American ULCCs, and prior research has only recently begun to identify them separately from mainstream low-cost carriers. This paper seeks to understand the market factors that influence ULCC service decisions. The relationship between ULCC operations and airport market factors was analyzed using three methods: mapping 2019 flight data for four ULCCs combined, two regression analyses to evaluate variables, and three case studies examining distinct scenarios through interviews with airport managers. Enplanement data were assembled for every domestic airport offering scheduled service in 2019. Independent variables were collected for each Part 139 airport. The first model estimated an OLS regression model to analyze ULCC enplanements. The second model estimated a binary logistic equation for presence of ULCC service. Case studies for Bellingham, Waco, and Lincoln were selected using compelling airport factors and relevant ULCC experience. Maps of ULCC enplanements revealed concentrations of operations on the East Coast. Both regression analyses showed strong relationships between population and non-ULCC enplanements (two measures of airport market size) and ULCC operations. A significant relationship also exists between tourism and enplanements. In the logit model, distance and competition variables were associated with ULCC presence. Case studies emphasized the importance of airport fees and competition in ULCC preferences, although aeronautical costs were generally not significant in the regressions.

## INTRODUCTION

The United States' domestic commercial aviation market has continued to evolve and expand since federal deregulation in 1978, when air carriers were awarded freedom to pursue new routes, expand operations to new aviation markets, and charge competitive fares for flights (*1*). In the twenty-first century, a new class of airlines has grown quickly to capture 9% of domestic market share by available seat miles (*2*). Ultra low-cost carriers (ULCCs) create a new level in the hierarchy of U.S. airlines by undercutting the low-cost model to even greater depths. Influenced by the success of European low-cost carriers, the primary objective of American ULCCs is to provide mostly short- and medium-length, direct, point-to-point flights that do not depend on connecting passengers at hubs, with ancillary fees assessed for most amenities. Four ULCCs implemented this revenue scheme to varying degrees within the United States in 2019: Allegiant Air, Frontier Airlines, Spirit Airlines, and Sun Country Airlines.

The first two decades of the 2000s witnessed consistent growth in domestic air travel. Much of the expansion of the domestic aviation sector in this time period was a result of the proliferation of ULCCs, which have consistently grown faster in terms of flights and enplanements than their legacy and low-cost rivals (*3*). One causal factor for this success may be the aggressive pursuit by ULCCs of new aviation markets with negligible existing commercial service. In contrast, legacy carriers have for decades relied on a model of hub-and-spoke connections across the United States, consolidating operations to hub airports with high levels of service while reaching nearly every major population center at primary airports (*4*). The rapid growth of low-cost carrier Southwest Airlines in the 1980s and 1990s relied on attracting a loyal cohort of flyers to secondary airports with lower fees, better reliability, and room to expand operations (*5*). ULCCs do not seem to fit entirely into either one of these business models. A brief examination of the domestic markets served by ULCCs reveals a collection of major primary hubs, secondary metropolitan airports, tourist destinations, as well as rural and underserved areas with spotty commercial aviation histories. This incongruous pattern of market selection defies the norms of the U.S. airline industry. Existing research has not fully examined this aspect of ULCCs or rationalized why many rural, disconnected, and small airports receive ULCC air service yet others do not. While studies have extensively reviewed domestic and European low-cost carriers, analyses of American ULCCs and their criteria for airport selection are few.

This paper will analyze the domestic aviation markets served by ULCCs and determine which market factors are the most conducive for enabling this specialized sector of commercial air service. The outcomes document ULCC business priorities, analyze the preferences and criteria that promote the airport-ULCC relationship, and provide context to their significance, which can each be used to guide future development at U.S airports.

## LITERATURE REVIEW

The term "low-cost carrier" (LCC) refers generally to a spectrum of airlines, including ULCCs, that offer passenger travel at bare minimum fares, often with added charges for ancillary services such as seat selection and baggage, but sometimes bundled with other products and services such as hotel and rental car bookings, all while pursuing strategies to reduce operational costs. There is agreement in the literature that LCCs tend to: rely on single aircraft types (*6*), prefer shorter point-to-point routes(*7*), and limit in-flight perks for passengers (*8*). Recently, a few reports have recognized ULCCs as a separate category, though the term seems to be more prevalent in literature reviewing domestic airlines than those examining European carriers. In a 2013 ACRP

Report, Parella (*9*) distinguished the ULCC business model using Allegiant and Spirit as examples and highlighting additional commonalities such as flight frequencies daily or less dictated by aircraft availability, minimal partnering with other airlines, and often not signatories to airport use/lease agreements to keep overhead low and maintain flexibility to enter and exit markets. The Oliver Wyman *Airline Economic Analysis 2018-2019 Edition* (*2*) expanded the number of airline categories from two (Network and Value) to three by splitting an Ultra Low-Cost group from the Value class and placing Allegiant, Frontier, and Spirit in the new category. This was based on the three ULCCs having the lowest domestic revenues per available seat mile and lowest cost per available seat mile, compared with Alaska, JetBlue, Hawaiian, and Southwest Airlines, which make up their Value category. Spirit, for example, achieves low unit costs from high aircraft utilization, simplified operations, and minimal hub-and-spoke inefficiencies compared to other carriers (*10*). The ULCC category also stood out by getting 25-42% of their revenues from baggage, reservation change, and miscellaneous fees, as compared with 7-16% for the Value Category *(2)*. The 2020-2021 Oliver Wyman *Airline Economic Analysis* confirmed Sun Country Airlines as a fourth member of the ULCCs, and noted that the category produced the best operating results of any category during the difficult second and third quarters of 2020, and was in fact the only passenger airline category to gain employment during 2020 (*11*).

Many studies of low-cost airlines have focused on the success of Southwest Airlines. While Southwest offers a minimum level of in-flight perks, offers cheap fares for short-haul service, and collects some ancillary revenues from passengers, the overall business strategy is to build a robust brand identity as much as it has been to utilize a purely low-cost model (*7*). Southwest has reduced service to secondary airport markets in recent years, cutting 10% of capacity to its core secondary markets between 2007 and 2012 while growing at major hubs (*12*). Secondary airports are generally considered to include the other commercial service airports in a metropolitan region that are not major hubs or gateways. As of 2015 they operated to many more hub or main airports (44%) than to secondary airports (24%) (*13*). In contrast, Allegiant routed only 4% of its service through main airports while 30% of seats were out of secondary airports (*13*) and charged ancillary fees for every aspect of the flight (*14*). Southwest maintains a cost per available seat mile that is higher and a daily aircraft utilization that is lower than Spirit (*10*). Thus, given the criteria that mark carriers as ULCCs, Southwest cannot be considered in this category.

The aviation industry in Europe provides important lessons for the U.S. market because of its array of LCCs and their impacts on airports across the continent. Legacy carriers in Europe have shrunk drastically in the last two decades due to intense competition from LCCs at hub airports (*15*). Not only are LCCs poaching travelers from mainline carriers, they are also gathering them from greater distances. European LCCs tend to increase the passenger catchment area of airports to a greater degree than legacy or regional carriers offering the same service (*8*). Dobruszkes, Givoni, and Vowles (*13*) established that LCCs often operate with a heterogeneous pairing of flight origins and destinations. Airports such as Charleroi in Belgium serve mostly as "departure" airports (for the first flight of a round trip, presumably from a passenger's home region) to destinations across Europe, while others, especially in southern Europe, tend to be "arrival" airports. This observation acknowledges the importance of tourism in the context of low-cost carriers' airport choices as well as the fundamentally different purposes of airport markets for LCCs.

Tourism is especially important to LCCs in part because tourists place a lower value on the loyalty rewards and amenities of legacy airlines (*16*). The main factor considered when planning a leisure trip is cost, and therefore LCCs can generate interest in a route through low fares alone (*17*). Leisure travelers spend more time searching for lower fares before booking and are more likely to book as the departure date gets closer, meaning that LCC fares stand out (*18*). Dennis (*8*) found that LCCs take advantage of suppressed demand for travel by undercutting the fares of legacy carriers to expand existing markets, or to open new ones entirely. There is agreement in the literature that the conventional thinking in regards to European LCC's airport choice strategy has not painted a complete picture. It has long been assumed that LCCs' growth in Europe is primarily driven by warm-weather tourist destinations routes, which have untapped potential to expand catchment areas and attract tourists primarily. However, Dobruszkes (*17*) found that LCCs also compete directly with legacy airlines on existing routes, while Davison and Ryley (*19*) noted the attraction of LCC passengers to colder-weather cultural destinations such as Prague and Berlin. LCCs serve many business travelers on high-density routes as long as the flight schedule is frequent, and to an extent can exploit a classic domain of legacy airlines (*8*). This is especially true when there are factors that constrain demand for legacy carriers, such as high fares close to departure or many sold-out flights (*20*). Pels (*21*) explored the potential for LCCs to compete with legacy carriers for long-haul markets. In another paper, Pels (*22*) suggested that the true purposes of aviation travel for leisure is not monolithic; many book leisure trips to see family and friends in populated areas across the country rather than escape to a vacation destination only. While the airport choice of LCCs can be broadly categorized as leaning towards major city catchment areas and tourist destinations that are urban or coastal (*17*), these findings underscore that LCC and ULCC service may not be as heavily oriented towards secondary or tourist airports as commonly assumed.

A critical discussion of airport choice involves studies of market leakage. Distance, flight frequency, and cost have been proven as relevant factors influencing leakage at U.S. airports (*23*, *24*). Fu and Kim (*25*) found a positive feedback loop between the overall passenger enplanements of an airport and its ability to retain passengers to continue growth. Intervention measures may be required to break the cycle of leakage from smaller or rural airports. LCCs are uniquely positioned to conquer these obstacles due to their efficiency and ability to quickly adjust service. Parella (*9*) proved that LCCs are able to overcome distance and competition disadvantages for smaller airports in multi-airport regions by providing cheap point to point service to leisure destinations. The experience of smaller and regional airports in Europe has shown that LCCs seek to monopolize aviation markets and bargain to keep costs low, often threatening to remove service quickly if conditions are not being met (*26*). An analysis of airport pricing found that LCCs are disproportionally impacted by increases to airport user fees as opposed to other airline models (*27*). Elian and Cook (*10*) found that Spirit Airlines rigidly sought markets that could demand at least 200 passengers per day each way, and an earnings before interest margin of 24% to 26%. A critical portion of the monopolization strategy is to reach the new market first. Research shows that the first-mover advantage stymies potential competition (*26*) and saves costs by establishing long-term service contracts with airports(*7*). Further, survey data shows that existing LCC competition at an airport disincentivizes other airlines considering the same market (*28*). The presence of a legacy carrier at an airport generally does not deter LCC entry because legacy fares are usually higher.

Airports generally covet LCC service for several reasons. The shift toward the hub-and-spoke model of the legacy carriers in the U.S. created so-called fortress hubs; a market in which a single airline controls 70% or more of the passenger share and travelers often face fare premiums (*1*). In response, ULCC entry to the market can trigger a drop in fares. Bachwich and Wittman (*6*) confirmed that North American ULCCs induce a 20% drop in fares on all carriers operating to an airport following their entry into the market, compared to an 8% reduction for new LCCs. This may explain why the route network of Spirit Airlines shares a 60% overlap with American Airlines, including a focus on American's largest hub at Dallas-Fort Worth (*10*). In expanding to accommodate new service, the fixed costs of new airport infrastructure can be high when the airport is congested, but at airports with spare capacity, the marginal costs of accommodating additional passengers are relatively low, especially compared with marginal airport revenues (*16*). In addition to the income earned by the airport from aeronautical operations such as landing fees, taxes, and fueling services, non-aeronautical revenues such as parking charges, retail sales, and food services are critical to the financial success of an airport. LCCs have unique traits that provide further economic advantages. As LCC passengers are frequently leisure travelers, they tend to arrive earlier than those flying for business, especially because LCCs charge premiums for food and other in-flight goods. Francis, Fidato, and Humphreys (*16*) found that LCC passengers on average spend between one to two hours in the terminal prior to boarding. Critically, expanding non-aeronautical revenue sources allows airports to reduce airport fees, a key enabler of low-cost carrier operations.

Overall, the reviewed literature establishes a base of knowledge surrounding European low-cost carriers, with limited comparison to North American carriers and without correlating service to airport factors or geography in the same vein as Dobruszkes (*17*). Compelling arguments are created for further investigation such as exploring how ULCCs have been able to rapidly expand throughout the United States and which airport choice factors have enabled their success. ULCCs capture a greater share of the aviation market every year, and it is critical that researchers, airport managers, government agencies, airport planning consultants, and regional economic development organizations understand how operational decisions are made by such airlines.

## METHODS

The focus of this analysis is on airports served by ULCCs and the region, potential customers, and competing airports around them, rather than on origin-destination (O-D) flight-market pairs, and is motivated by several phenomena. First, ULCCs have gained recognition by renewing scheduled flights at many smaller airports that lacked commercial service (*14*). Second, and conversely, their operations at larger airports and airports not traditionally seen as tourist markets have received insufficient attention (*6*). Third, in multi-airport regions, "the choice of which airport, among several, to serve may be the most significant" decision that ULCCs make once they have decided to operate in the region, given their "relatively less complex business plans" (*9*). Fourth, airlines make considerable investments in employees, leases, local advertising, regulatory costs, and transaction costs in general, when establishing service at a previously unserved airport (*16*). Fifth, cost is recognized as a fundamental consideration in ULCC strategy, but evaluating airport markets on an equal playing field is difficult because of local conditions unique to each airport market, such as labor costs, aeronautical fee agreements, or air service incentive programs. (*16*). The authors acknowledge that ULCC decisions to operate from a particular airport are intertwined with the decision of which O-D markets to serve from the airport, and a modeling analysis that evaluates airports on an individual basis may not fully capture the complexities of the origin and destination relationship.

To answer the primary research question, the first step in the analysis was to establish a baseline of data for the current operations of the four ULCCs. Using domestic flight information from 2019, a roster of all airports in the United States served by ULCCs was created. We then hypothesized a list of demographic and aviation-related variables that may be important to ULCCs and aid in explaining service patterns. Linear and logistic multiple regression models were estimated using the statistical program SPSS to analyze the relationship and significance of independent variables with the presence and volume of ULCC service. A Heckman selection modeling approach was also tested, which involved estimation of a joint probit model of ULCC service presence and a linear regression model of ULCC enplanements. This statistical modeling approach adjusts the coefficients in the model of ULCC enplanements to test for and remove potential bias stemming from the fact that those airports without ULCC service are not included in the enplanements model at all (*29*). The Heckman approach yielded similar results to the independent logit and OLS models presented in this paper.

Finally, three case studies of airport markets were examined qualitatively through interviews with airport managers to capture a more detailed understanding of ULCC business characteristics and any special circumstances unaccounted for by quantitative analysis.

**Dependent Variables – Data Sources, Pre-processing, and Sample Size**

Data for non-stop flight segments for calendar year 2019 were downloaded for all U.S. carriers from the Bureau of Transportation Statistics T-100 domestic segment table (*30*). The data were trimmed to leave only flights by the four identified ULCCs. Next, ULCC flights of service class "L – Non-scheduled civilian passenger/cargo service" including charter and non-revenue flights were removed, leaving service class "F – Scheduled civilian passenger/cargo service" remaining. The list of Part 139-certified airports in 2019 was acquired from the Federal Aviation Administration (*31*). Part 139-certificd airports were selected because such airports must meet the stipulated infrastructure and safety criteria in order to handle scheduled commercial flights. Therefore, any airport currently or readily able to handle ULCC service would need to be Part 139-certified. Finally, for each Part 139 airport, enplanements were summed for all four identified ULCCs.

For the binary logit regression, the dependent variable was the presence of ULCC service at an airport. The logit model assesses what factors are statistically associated with the presence or absence of ULCCs at an airport. For the ordinary least squares (OLS) regression, the dependent variable is the enplaned ULCC passengers transformed by taking the logarithm base 10 to normalize the highly and positively skewed values and enable a better fit to a linear model **(Figure 1)**. The OLS model estimates what factors are statistically associated with higher or lower ULCC enplanements at airports that have ULCC service.

Based on an analysis of outliers, we removed observations for airports in Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands due to problematic catchment areas caused by sparse road data, missing airport and demographic data, or both. Branson, MO (BKG) was removed from the statistical analysis due to internal inconsistencies in the T-100 data. The final sample sizes were n=471 for the logit regression (using all Part 139 airports in the lower 48 states with and without ULCC service) and n=178 for the OLS regression (using only those with ULCC service).

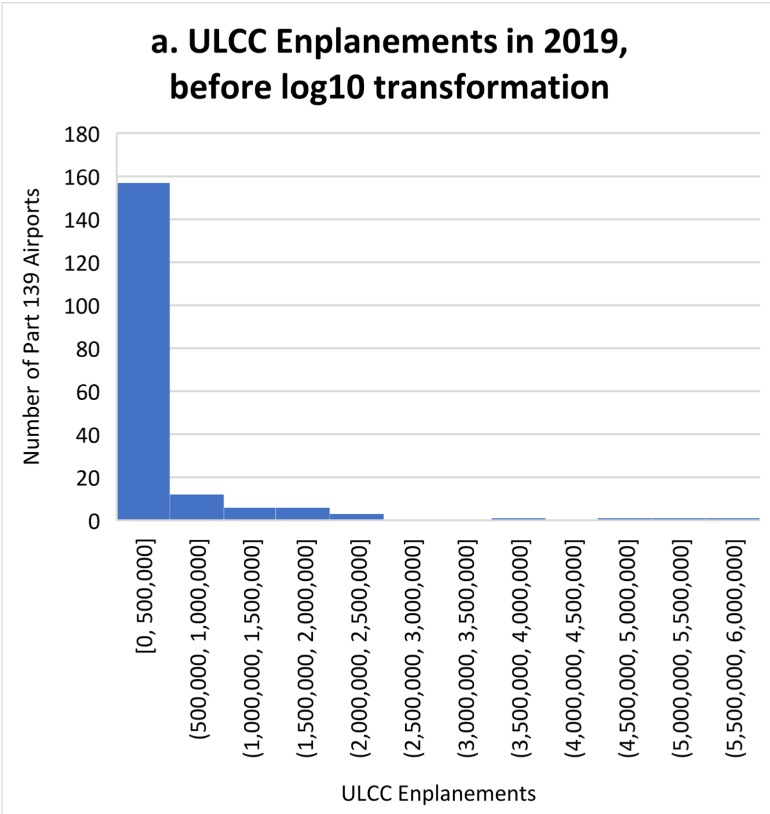


**Figure 1a Histogram of ULCC enplanements for the 178 Part 139 airports with ULCC service in 2019.**

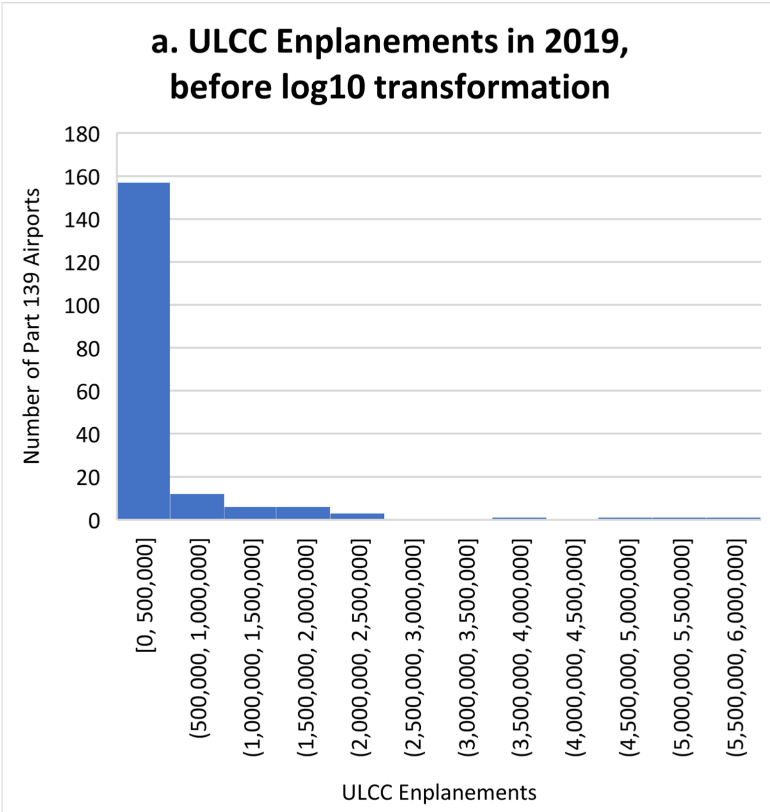


**Figure 1b Histogram of ULCC enplanements for the 178 Part 139 airports with ULCC service in 2019, after $\log_{10}$ transformation.**

## Independent Variables

The list of independent variables was informed by previous research on ULCC market factors. The independent variables were chosen to represent characteristics of the airport's services, costs, and location, and the airport's surrounding market area. Other independent variables were considered but were eliminated because of multicollinearity or data unavailability or incompleteness.

Driving distance catchment areas and distance variables were calculated using the ArcGIS Online network analysis tool. The catchment areas were generated using a 70-mile driving distance based on  the original FAA criteria for Essential Air Service (EAS), which has been used by Grubesic et al. (*32*) among others. While EAS community eligibility criteria were updated in 2015 to a complicated set of criteria involving 210 miles or 175 driving miles from medium- or large-hub airports and 40 miles from small-hub airports, this could not provide a consistent standard for all Part 139 airports. The 70-mile standard is consistent with research by Fuellhart (*33*), who used a 75-mile buffer to define the "core" market for a study on airport leakage in the Harrisburg, PA multi-airport region, and Yirgu, Kim, and Ryerson (*23*), who found that 76% of passengers traveled less than 80 miles to reach their chosen airport in the US Midwest. The 70-mile standard is also compatible with findings from Dennis (*8*) and Lieshout (*34*) that while LCCs draw some passengers from great distances, passenger access time usually remains under two hours, and that core markets and rates of distance decay vary greatly due to factors such as airport size, competition, services offered, and geographic setting.

Our approach uses overlapping catchment areas rather than mutually exclusive hinterlands in which areas are assigned exclusively to their nearest airport by driving distance. We think this best represents the flexibility of air travelers to seek out low-cost ULCC service at any airport within reasonable driving distance, especially in multi-airport regions. **Figure 2** shows an example of the overlapping 70-mile buffers created for airports in Arizona.

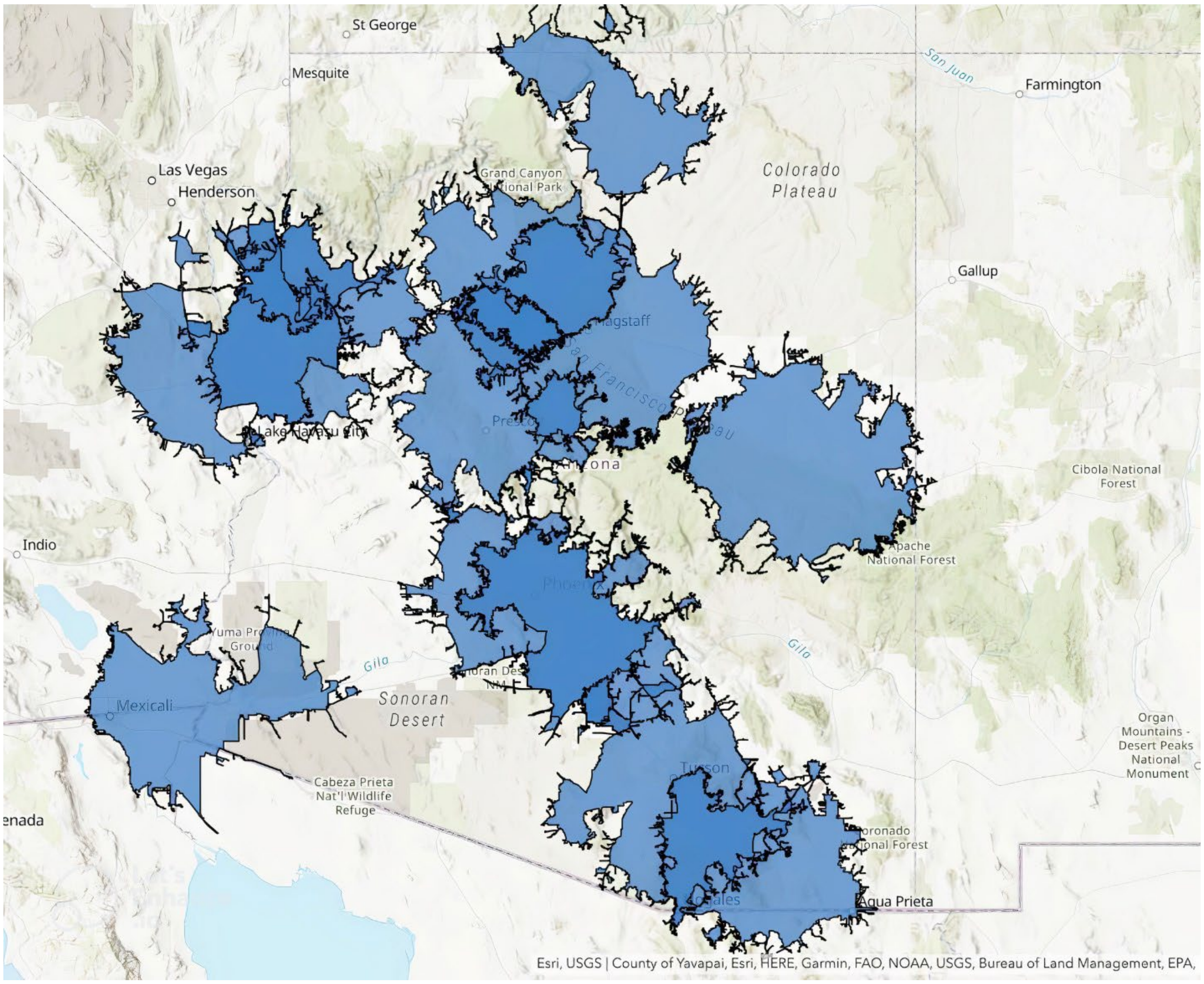


**Figure 2 An example of the overlapping 70-mile driving-distance catchment areas in Arizona. Catchment areas were generated using hierarchical routing, assuming travelers favor freeways over local roads when possible even if it leads to a longer trip. Note that the "twig-like" extensions of service areas are a result of using hierarchical routing in areas with sparse road networks.**

*Airport Market Size*

- $\log_{10}$ of airport catchment area population: The driving distance catchment areas were overlaid on 2019 U.S. Census Bureau census tract population data (*35*) to estimate the total population living within each airport's 70-mile catchment area. For the regression analysis, the population variable was also positively skewed and was transformed by $\log_{10}$ to linearize its scatter plot with $\log_{10}$ of enplanements.

- $Log_{10}$ of Non-ULCC enplanements: Using the T-100 data (*30*), ULCC enplanements were subtracted from total enplanements to obtain the non-ULCC enplanements. Non-ULCC enplanements were also high skewed and thus log-transformed. Given that there were 85 Part 139 airports serviced only by ULCCs, which means their non-ULCC enplanements were 0, and given that $log_{10}$ of 0 is undefined, we substituted a value of 0.0, which is the $log_{10}$ value if there were exactly one passenger enplaned annually instead of zero, which is a very close approximation.

Both market size variables are hypothesized to have positive effects on attracting ULCC service and generating higher ULCC enplanements. We included this second measure of airport market size because non-ULCC enplanements may not align with catchment area population due to hub and focus-city operations, international gateways, multi-airport regions, and airport enplanements. Multicollinearity is not a problem for either sample, given that the correlation coefficient between these two airport market size metrics is -.005 for the full sample of n=471 airports used in the logit model, and .277 for the n=178 sample of airports with ULCC service used in the OLS regression.

*Travel Purpose*

- Tourism importance for local economy ("Tourism"): The emphasis of ULCCs on serving leisure and tourism travel is widely acknowledged in the literature. Tourism employment was derived from County Business Patterns employment data (*36*) for North American Industry Classification System (NAICS) codes for the Arts, Entertainment, and Recreation industries (71) and the Accommodation and Food Services industries (72). The tourism employment was then standardized according to the following formula:

$$Tourism\ Importance = \frac{NAICS\ tourism\ employees\ of\ catchment\ area}{Total\ employed\ population\ of\ catchment\ area}$$

For counties that are only partially covered by the catchment area, the calculation above includes the entire county's data if any part of it is reached by an airport's 70-mile driving-distance catchment area.

*Airport Cost per Enplanement (CPE)*

- CPE categories: Given their ultra low-cost business model, ULCCs are hypothesized to favor airports with lower airport fees. Data for 2019 airport costs were gathered from the FAA Certification Activity Tracking System (CATS), Operating and Financial Line Item Report 127 (*37*). The cost data reflect total aeronautical revenue across all carriers divided by the number of total enplanements at the airport. Although the data are not specific to ULCCs, it is likely that higher CPE averages at an airport are experienced by all carriers. Initially, 189 of the airports in this study were missing CPE data in the CATS-generated Operating and Financial Line Item Report 127 for Passenger Airline CPE. However, by searching for the Operating and Financial Summary Reports 127 filed by individual airports in the CATS, we were able to find aeronautical revenue data for an additional 79 airports, which we converted to CPE by dividing by the T-100 total enplanements. Then, to avoid eliminating the remaining 110 Part 139 airports that were still missing these data, the CPE data were recoded categorically with three equal classes sorted by dollar amount ($0-$3.99; $4-$7.99; $8+) and a fourth category for missing CPE data. The $0-$3.99 dummy variable was set as the base case and omitted from the regressions, which enables the model to test for significant differences between the low-CPE base group and the two high-CPE groups, and for the missing-CPE group as well. Despite these limitations, the CPE data are worth including as a frequently mentioned factor in ULCC business decisions.

*Competition*

- Distance to other ULCC airport: Each airport was mapped to the closest airport with existing ULCC service using the driving distance network analysis tool in ArcGIS Online. Greater distance from competing ULCC airports is hypothesized to positively affect ULCC service and enplanements.
- Essential Air Services (EAS) airport: Airports with EAS service in 2019 were denoted by a categorical variable value of "1" (*38*). Subsidized EAS competition at the same airport is hypothesized to deter ULCC service and decrease ULCC enplanements.

*Proximity*

- Distance from airport to city center: This variable tests the hypothesis that ULCCs tend to favor more peripheral airports. The same network analysis tool was used to calculate a driving distance in miles from the airport point to the nearest city with 50,000+ residents.
- Within 70 miles of a border crossing: The network analysis tool was used to generate 70-mile driving distances from each airport. If the network extended across an international border, the airport was assigned a categorical value of "1". This variable was included because of reports of Canadian citizens crossing the border to save money using ULCCs on the American side.

*Special Case State Dummy Variables*

Three state dummy variables were identified by examining maps of residuals from regressions using the other independent variables. In either the OLS or logit regression, these states' residuals stood out as almost uniformly positive (underpredicted) or negative (overpredicted) and conforming largely to state boundaries. Also, in all three cases a reasonable rationale can be offered for the observed effect.

- Florida: 1 for airports in Florida, 0 otherwise. Florida's ULCC service was consistently underpredicted, perhaps due to intense tourism traffic and proximity to population centers of the eastern U.S.
- Texas: 1 for airports in Texas, 0 otherwise. Texas airports were routinely overpredicted, possibly due to the widespread presence of Southwest Airlines throughout the state.
- California: 1 for airports in California, 0 otherwise. Likewise, California ULCC service was overpredicted probably because of strong competition from Southwest and other carriers for intrastate and western routes.

Note that tourism importance and the two distance variables were not log-transformed because they were not notably skewed and their scatterplots with respect to $\log_{10}$ of ULCC enplanements did not indicate clear nonlinearity. Relationships in the OLS regression model results must be interpreted accordingly, with these variables producing increasingly large or asymptotic effects on actual ULCC enplanements, as the independent variables get larger or smaller.

**Case Study Interviews**

Three case studies of airports helped to uncover information that may be left out of a conventional quantitative analysis. Bellingham, WA (BLI) was selected due to the continued presence of a ULCC at the airport. Waco, TX (ACT) did not have ULCC service in 2019 despite having a compelling location in a growing urban region and limited aviation competition. Finally, Lincoln, NE (LNK) was selected as an airport that lost ULCC service. Interviews were conducted with a representative of the airport management staff for each airport. The format of the interview was a short, structured discussion using an identical list of questions. Notes from each interview were transcribed in process, and limited follow-up questions were asked to gain further insight to specific topics.

# RESULTS

## Existing ULCC Operations

A total of 178 airports in 49 states were served by scheduled ULCC commercial passenger service in 2019 (**Figure 3**). McCarran International Airport (as it was called in 2019) in Las Vegas (LAS) led all airports with nearly 5.7 million total ULCC enplanements, followed by Orlando (MCO), Denver (DEN), and Fort Lauderdale (FLL) each of which exceeded at least 3.8 million enplanements. The top four ULCC airports were served by all four ULCCs during 2019 with the exception that Allegiant serves Orlando via Orlando Sanford (SFB). There is a large drop-off to the next closest airport, Chicago O'Hare (ORD), with 2.2 million enplanements. At the other end of the distribution, nine airports served fewer than 10,000 enplaned passengers for reasons including seasonal, terminated, or new service.

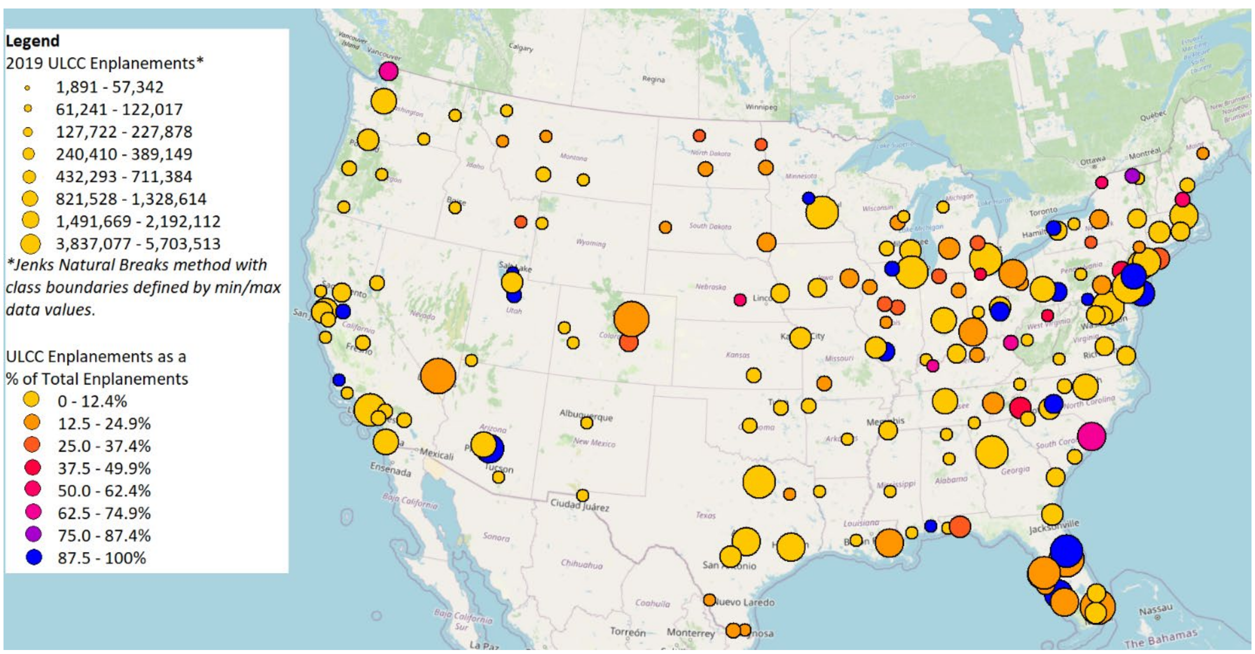


**Figure 3 ULCC enplanements combined from Allegiant, Frontier, Spirit, and Sun Country Airlines, 2019, showing the number of ULCC enplanements and ULCC enplanements as a percentage of total airport enplanements.**

In percentage terms, there is a bimodal distribution of the ULCC percentage of total enplanements at each airport, with 86 airports with a ULCC share under 10% and 31 airports with a share over 45%. Allegiant Air is the most aggressive among ULCCs in pursuing untapped markets, serving as the exclusive regular commercial operator to airports such as Punta Gorda, FL (PGD), Belleville, IL (BLV), and Phoenix-Mesa, AZ (AZA). In addition, exclusive service is provided by Frontier Airlines at Trenton, NJ (TTN), and Spirit Airlines at Atlantic City, NJ (ACY) and Latrobe, PA (LBE). ULCCs capture a minority of market share at 160 airports, normally due to competition from legacy and low-cost carriers at large airports, or from regional airlines at small airports.

Florida stands out with both high enplanements and market shares. Nearly every Part 139 airport in Florida has ULCC service. The Northeast Corridor and a belt of competitive large airports in the Midwest also emerge. Denver and Las Vegas are the two largest ULCC markets in the west, where few airports exceed 14% in ULCC market share. Higher enplanements in the eastern US reflect the national population distribution and also point to ULCCs' competitiveness against legacy carriers and LCCs in the east. ULCC route maps clearly indicate the primary business strategy of ULCCs connecting northern cities to tourist areas primarily in Florida.

**Airport Cost per Enplanement Categories**

To help understand which airports are missing CPE data, **Table 1** compares descriptive statistics for the four CPE categories. The airports for which we could not find aeronautical revenues for 2019 stand out as having extremely low ULCC and non-ULCC enplanements. While the missing category includes many small airports, they are not necessarily in small cities: the average population in their catchment areas is second-highest (2.89 million), and almost as high as for the high-CPE category (3.03 million). The distance to the nearest other airport for this category also stands out: 67.7 miles, while all the other categories average 90-100 miles. Charles B. Wheeler Downtown Airport (MKC), Teterboro (TEB), and Fort Worth Meachem International (FTW) are good examples of small airports in major multi-airport regions with missing CPE data. Other types of airports missing these data include regional airports such as Anniston, AL (ANB) and Texas Gulf Coast (LBX), as well as airports with limited ULCC service such as St. Cloud, MN (STC) and Glacier Park International (FCA) in Montana. Then, as CPE increases from low to high, both ULCC and non-ULCC enplanements increase substantially, indicating that busier airports report these costs more consistently and report higher values per passenger.

The relationship between CPE and enplanements is, however, significantly more complex than indicated by the average enplanements for the four CPE categories in Table 1. **Figure 4a** plots $\log_{10}$ of total enplanements vs. CPE, while **Figure 4b** does the same for ULCC-only enplanements. In terms of total 2019 enplanements, most of the low-CPE airports (<$4) enplaned under 1 million passengers, with the notable exception of Atlanta Hartsfield in the upper left corner. The high-CPE airports (≥$8) include a range of small, medium, and large airports, but above about $12 these high-cost airports mostly bifurcate into the very large (over 10 million passengers) or relatively small (under 10,000 per year). Figure 4b, on the other hand, tells a different story for the ULCCs, which appear to find the lower-right section of this scatter incompatible with their ultra low-cost business model. We found only three airports with ULCC service with CPE greater than $12.35 and ULCC enplanements under 10,000: Parkersburg (PKB) and Clarksburg (CKB) in West Virginia and Huntsville, Alabama (HSV).

**TABLE 1 Descriptive Statistics for Airport CPE Categories (Mean and Standard Deviation)**

| CPE Category | Count | Distance to Nearest City | Distance to Other ULCC Airport | Tourism | Population | ULCC Enplanements | Non-ULCC Enplanements | ULCC Airports | EAS Airports |
|---|---|---|---|---|---|---|---|---|---|
| CPE Missing | 110 | 43.6 (49.2) | 67.7 (43.4) | 11% (4%) | 2,889,877 (3,809,905) | 1,687 (11,116) | 27,685 (58,149) | 4 | 14 |
| CPE $0-$3.99 | 75 | 35.2 (46.4) | 96.0 (60.7) | 10% (3%) | 2,153,627 (3,603,817) | 103,349 (299,029) | 919,651 (6,100,523) | 33 | 12 |
| CPE $4-$7.99 | 146 | 41.2 (54.8) | 95.3 (53.1) | 11% (4%) | 1,447,522 (1,683,158) | 163,097 (578,734) | 1,576,680 (3,912,116) | 71 | 28 |
| CPE $8+ | 143 | 49.4 (63.2) | 91.0 (53.5) | 12% (6%) | 3,028,051 (4,699,102) | 248,391 (720,558) | 3,812,245 (8,029,534) | 71 | 32 |

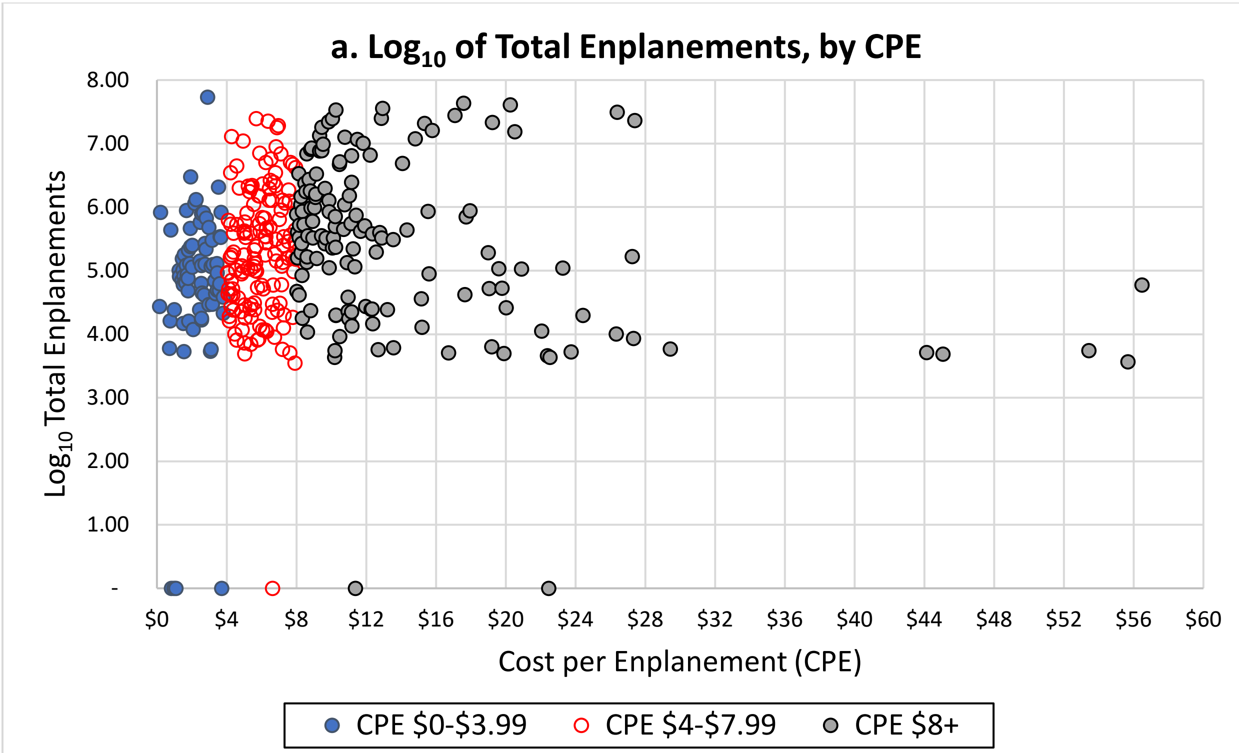


**Figure 4a Scatterplot of 2019 $\log_{10}$ *total* enplanements, by cost per enplanement and CPE categories used in the regression models.**

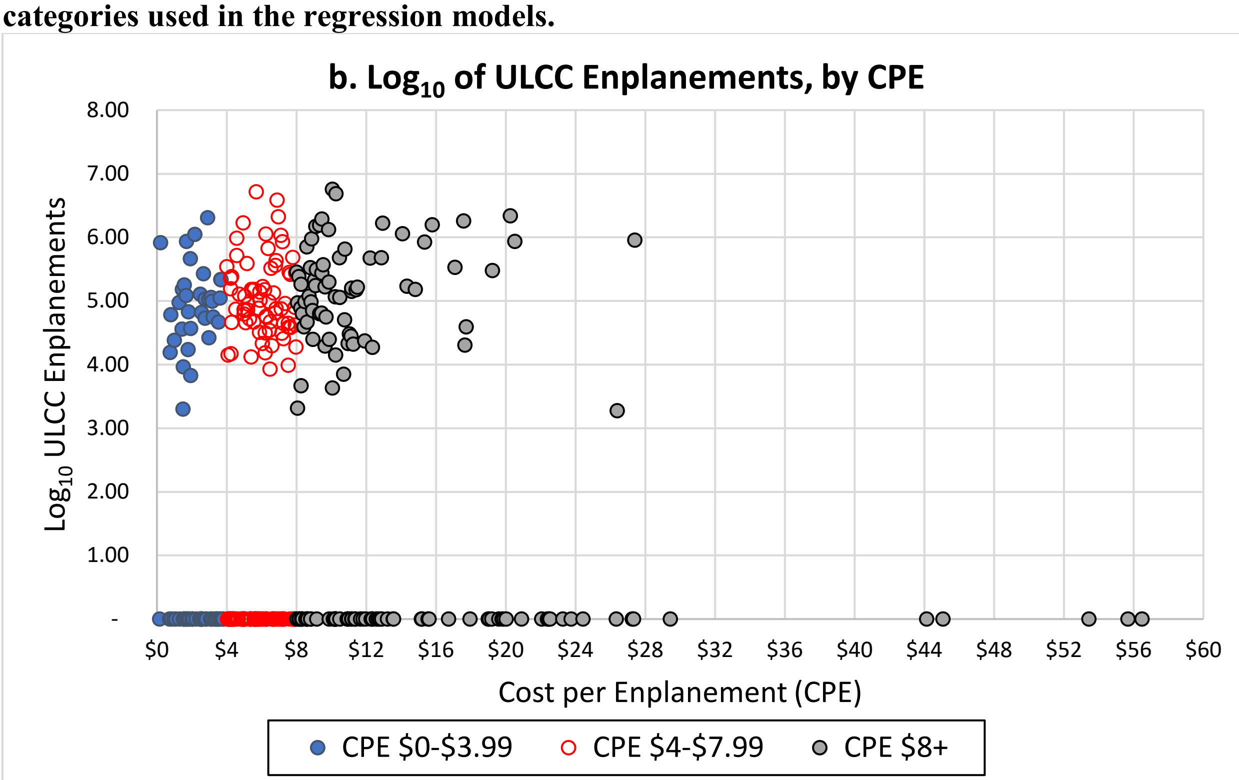


**Figure 4b Scatterplot of 2019 $\log_{10}$ *ULCC* enplanement, by cost per enplanement and CPE categories used in the regression models.**

## Regression Results

Multivariate models of ULCC service and ULCC enplanements are available in **Table 2**. Gauss-Markov assumptions were tested for multicollinearity, autocorrelation of residuals, linearity, and homoscedasticity among the variables. Variance inflation factors (VIFs) ranged from 1.11 to 2.68. The goodness-of-fit statistics for both models are acceptable, with the $R^2$ of the ULCC enplanements model at 0.48 and the McFadden's pseudo-$R^2$ of the ULCC service model at 0.46. Both models were run a second time omitting the non-significant independent variables, with no statistically significant changes to the coefficient magnitudes and no change to the statistical-significance levels of the variables.

*OLS Regression on ULCC Enplanements*

The main takeaways from the ULCC enplanements analysis are the highly significant and positive relationships between catchment area population, non-ULCC traffic, and tourism importance in predicting ULCC enplanements. For every 10-fold increase in the catchment area population, ULCC enplanements increase by 4.63 times. Tourism importance and non-ULCC enplanements were also highly significant and positively associated with ULCC enplanements. The positive relationship between tourism importance (which ranges from 0% to 44.8%) and $\log_{10}$(enplanements) indicates an exponential relationship between tourism importance and enplanements, or conversely, a relationship that is asymptotic towards zero enplanements as tourism percentage declines towards zero. None of the CPE categories were statistically significant; however, all three cost categories had negative coefficients compared with the base category (CPE $0-$3.99), and the magnitude of the negative coefficient increased with cost, as hypothesized. The dummy variables for California and Florida were significant but showed opposite relationships to enplanements, with Florida positive and California negative.

With moderate collinearity between the two distance variables (r=0.407) and between distance to the nearest city and the EAS dummy variable (r=0.521), we tested OLS model specifications with these three variables included alone or in all combinations of two, but they were never close to being statistically significant.

*Logit Regression on ULCC Service*

More independent variables were significant in the logit model for 0-1 existence of ULCC service, which is partly a result of the larger sample size (*n*=471). Highly significant relationships at the .01 level or better are evident for five independent variables, with two others significant at 0.05 or better.

As in the enplanements model, airports with higher catchment area populations had a much greater likelihood for ULCC service, with the odds of service 2.9 times higher for every 10-fold increase of catchment population, which implies a positive but rapidly diminishing effect of each additional catchment-area resident. The variable for non-ULCC enplanements was highly significant in both models along with population, providing justification for busy airports being attractive to ULCCs. Once again, all of the airport CPE categories had negative coefficients relative to airports with $0-$3.99 CPE, but only the CPE-missing category was significantly so.

**TABLE 2 Model Results**

| | OLS Model<br>Dep. Var.=$Log_{10}$(ULCC Enplanemts.)<br>n=178<br>$R^2$=0.48 | | Logit Model<br>Dep. Var.=1 if ULCC service, 0 if not<br>n=471<br>McFadden's pseudo-$R^2$ = 0.46 | | |
|---|---|---|---|---|---|
| Independent Variable | Estimate (SE) | p-value† | Estimate (SE) | p-value† | Exp(B) (odds ratio[a]) |
| (Constant) | -.488 (.706) | .490 | -9.592 (2.606) | .000** | .000 |
| $Log_{10}$(Population) | .666 (.104) | .000** | 1.060 (.371) | .004** | 2.886 |
| $Log_{10}$(nonULCC Enplanements) | .145 (.042) | .001** | .796 (.149) | .000** | 2.217 |
| Tourism | .057 (.018) | .002** | -.018 (.049) | .714 | .982 |
| CPE Missing | -.039 (.316) | .902 | -2.332 (.800) | .004** | .097 |
| CPE $4.00-$7.99 | -.033 (.125) | .790 | -.530 (.377) | .160 | .589 |
| CPE $8+ | -.110 (.129) | .394 | -.585 (.407) | .151 | .557 |
| Distance to Nearest Other ULCC Airport (Miles) | .0003 (.001) | .771 | .003 (.003) | .380 | 1.003 |
| EAS Service in 2019 | .126 (.254) | .621 | -1.425 (.567) | .012* | .240 |
| Distance to Nearest City (Miles) | -.001 (.001) | .278 | -.009 (.004) | .021* | .991 |
| Within 70 miles of a Border Crossing | .103 (.146) | .483 | 2.428 (.604) | .000** | 11.337 |
| CA Dummy | -.465 (.146) | .002** | .048 (.592) | .936 | 1.049 |
| FL Dummy | .478 (.161) | .003** | -.096 (.612) | .876 | .909 |

| | | | | | |
|---|---|---|---|---|---|
| TX Dummy | -.025 (.190) | .897 | -2.226 (.570) | .000** | .108 |

†Significant at the 95% (*) or 99% (**) level.
[a]The odds ratio = the odds that an airport will have ULCC service per unit increase in the independent variable (X). In the case of a 0-1 independent variable such as EAS presence, location near an international border, the CPE categories, or state dummy variables, the odds ratio is the odds of an airport having ULCC service in the presence of such conditions divided by the odds in the absence of such conditions. In the case of a continuous independent variable such as distance or tourism importance, it is the increase of the odds of ULCC service per unit increase of the X variable. In the case of log-transformed independent variables such as $\log_{10}$ of population and nonULCC enplanements, it is the increase of the odds of ULCC service per 10-fold increase of the X variable.

The Heckman selection model results confirmed that the CPE categories are not statistically significant predictors of ULCC service. The odds of a ULCC operating at a given airport with EAS service are 24% of the odds of a ULCC operating at an airport without EAS subsidies, indicating a reluctance by ULCCs to compete with EAS service. Distance to the nearest city was significantly and negatively associated with an airport having ULCC service, but distance from an airport with existing ULCC service was not significant. Location within 70 miles of an international border was not significant in predicting enplanements in the OLS regression but is highly significant for predicting existence of ULCC service. Specifically, it increases the odds of having ULCC service 11.34 times relative to the odds of ULCC service at airports not near a border. The variable for tourism importance and the California and Florida dummy variables were also not statistically significant in the logit model, but the Texas dummy variable is highly significant, suggesting that Southwest Airlines' domination of its home state discourages ULCC service.

**Case Studies**

Three case studies provide additional context and qualitative analysis to the 2019 operational data and regression analyses.

*Bellingham, Washington – Existing ULCC Service*

Bellingham International Airport (BLI) has been attractive to LCCs since deregulation. More recently, Allegiant began service to BLI in 2008, and in 2019 held two-thirds of the airport's market share (*39*). Frontier established ULCC service at Bellingham in 2015, but ceased all flights to the airport a few years later (*40*).

Several factors may explain the appeal of Bellingham to ULCCs. First, BLI is only 20 miles from the Canadian border and close to Vancouver. Combining Vancouver's metropolitan area population of 2.5 million and the 4 million north of Seattle, Bellingham has a large catchment area population despite relatively low population densities in the vicinity of the airport itself. According to airport management, roughly 65% of air passengers at Bellingham are Canadian residents. Many cross the border to Bellingham when the exchange rate is favorable. Canada tends to have higher airfares due to steep fees and taxes imposed by government authorities on airline operations (*41*). Bellingham also assesses low fees per passenger to airlines and discounted rates for car parking. Fees for car parking account for 60% of BLI's revenues in a given year. Smaller airports like BLI want to attract carriers that will draw travelers to drive and park their cars on airport property; airlines with a leisure focus tend to facilitate that goal by attracting passengers who place a lower value on time spent traveling to and moving through an airport (*34*).

While the presence of Allegiant at Bellingham corroborates the importance of select border locations to ULCC business models, the case suggests that airports that rely heavily on cross-border travelers are vulnerable to shifts in currency exchange rates. Due to a decline in enplanements since 2012, Bellingham initiated an Airline Incentive Program in 2018, seeking to offer benefits such as waived landing fees and remain-overnight fees for new airlines or current airlines offering new routes for a fixed duration. It remains to be seen whether existing or new carriers will take advantage of such incentives or if the Bellingham market is substantial enough for the incentives to be worth the costs of service.

*Waco, Texas – No Existing ULCC Service*

Waco Regional Airport (ACT) lies a mere six miles from downtown Waco, located between Dallas-Fort Worth and Austin. Home to Baylor University and nearly one million residents, Waco is a steadily growing population hub in central Texas. Currently, American Airlines operates five daily flights aboard regional jets connecting Waco to its Dallas-Fort Worth (DFW) hub for onward connections. ACT reported fewer delays on arriving flights than nearly all other Texas airports. While Waco's tourism importance metric was average for the state, the median income, distance to the nearest city, and distance to other airport variables were favorable to Waco in relation to airports that currently host ULCCs. The scarcity of service can be attributed primarily to the lack of a sizeable population in the immediate vicinity of Waco and few substantial pull factors for tourists. While the proximity of Waco to Dallas and Austin would indicate the potential for ULCC service as a secondary airport to either destination, the airport is perhaps too far from either location to be viewed as a successful market for a ULCC. Lieshout (*34*) estimated that prospective passengers are not likely to drive farther than two hours when seeking an airport. Per airport management, expansions to Interstate 35 connecting Dallas, Waco, Austin, and points beyond will reduce the time and hassle of driving, likely increasing the degree of air traveler leakage to other airports. Also, Waco may simply be too far south to be a source of tourists to Florida and other Gulf Coast beaches. A similar airport with metropolitan area proximity and size in the northern half of the country would probably be better positioned to market itself as a source for leisure travelers escaping to warmer climates.

*Lincoln, Nebraska – Lost ULCC Service*

Many airports in the United States have been featured on a ULCC route map at one time or another, only to have service cancelled by the carrier. Allegiant Air service to Lincoln Airport (LNK), Nebraska commenced in 2006 with twice-weekly flights to its Las Vegas hub. The flights were meeting their load factor targets at about 90% capacity per flight (*42*). Two and a half years later, the airline announced that service would be transferred 85 miles west to Central Nebraska Regional Airport in Grand Island (GRI) instead. GRI is eligible for EAS-subsidized flights and is served by American Eagle offering daily flights to Dallas-Fort Worth (DFW). It may not seem logical for a leisure-driven airline to shift service from a city of 290,000 to a distant EAS market less than one-fifth the size, however this reality underscores the ULCC strategy of maximum cost efficiency. Despite its status as a prominent university town and state capital, Lincoln has struggled for years to maintain and grow LCC service. LNK leaks 75% of potential passengers to Omaha (OMA), the core of the regional economy 62 miles northeast. At one hour's driving time, Omaha – and the seven major carriers that fly there, including Southwest Airlines – can quickly be reached from Lincoln, but not from Grand Island, 155 miles distant.

Allegiant's own statements following its move to Grand Island in 2008 confirmed that competitive influences from Southwest coupled with high fuel costs at Lincoln triggered the shift in service (*42*). Further, some of the highest demanded destinations from Lincoln are in Texas, due largely to University of Nebraska athletics. Currently, flights to Texas operate out of Omaha as well as Grand Island. This is a losing scenario for Lincoln in which even highly demanded flights are deemed unprofitable. LNK is restricted by an arrangement with its fixed base operator, which sets fuel prices for all carriers. Typically, at an airport of its size, airport management would be granted more control over fuel prices. As a result, operational costs are higher at Lincoln than at Grand Island specifically, which matters to ULCC operators. Ultimately the case study outlines the importance of cost in a competitive multi-airport environment and provides indication that ULCCs may be willing to adjust service solely because of cost.

## DISCUSSION

One of the most surprising findings of this study are the relatively few similarities and many differences in which independent variables are significant between the OLS and logit regression results. The main similarity is the significance and large positive coefficients of the size variables (population and non-ULCC enplanements), which to a certain extent represent control variables. In the OLS, the standardized beta coefficients (not shown in Table 2) indicate a much larger effect on ULCC enplanements of a one-standard-deviation change in the population variable (.519) vs. that for a similar change in tourism (.188). This difference in effect size could be related to population being important to both origins and destinations while tourism employment is mainly important for ULCC destinations.

There were many differences between the two models, some of which are explainable while others require further research. First, it makes sense that tourism is much more significant for enplanements than existence of service, given that the largest ULCC airports are entertainment hubs, while there are a range of origin airports sending passengers to these and other tourist destinations. Airports on both ends of a route do not need to be tourist-focused. Route maps strongly suggest that some ULCCs tend to pair tourism-low origins and tourism-high destinations together in ways that would detract from a binary regression analysis. The tourism variable also suffered from special cases in the data, although these cases were too numerous to be considered outliers. Only one of the sixteen airports among the largest values for tourism importance supported ULCC service in 2019. Airport markets including Aspen, CO (ASE), Key West, FL (EYW), and Grand Canyon, AZ (GCN) had tourism values exceeding 0.2 but did not have ULCC service. Furthermore, some of the lowest-ranked airports for tourism such as Idaho Falls, ID (IDA), Tyler, TX (TYR), and Fayetteville, AR (XNA) feature ULCC service despite tourism levels under 0.08 within their catchment areas; these ULCCs appear to be serving tourist destinations farther away than 70 miles.

Second, two of the three distance variables—to the nearest cities (-) and within 70 miles of an international border (+)—are significant in the logit model but not in the OLS regression for ULCC enplanements. Because the majority of ULCC airports are in small-to-medium size cities, these distance variables do not necessarily lead to high-volume traffic but their effect on whether or not ULCCs offer service is clearer. While it seems natural that areas farther from the nearest city would have fewer ULCC enplanements, the lack of significance may be explained by the range of airports served by ULCCs which can be urban or remote. The distance relationships are complicated by conflicting effects of competition, leakage, and accessibility, and warrant further study. The lack of significance of distance to the nearest existing ULCC airport in both regressions is likely due to isolation from other ULCC airports being viewed as an asset or a barrier. Certain ULCCs, such as Allegiant Air, seem to seek secondary or regional airports with lower costs and less competition. Other ULCCs such as Spirit Airlines see the benefits of competing directly with legacy carriers based on fares, and will operate to major hub airports. Parella (*9*) found that individual ULCCs may try to serve a multi-airport region from a single airport. Therefore, enplanements are split between outlying and primary airports, and the relationship between distance from non-ULCC airports and enplanements is muddied by these factors.

Third, the existence of EAS service is a factor in whether ULCCs choose to operate in small markets, and would not be expected to explain high enplanements in a sample that excludes airports with zero ULCC enplanements.

Fourth, it makes sense that Florida is associated with higher enplanements but not with greater likelihood of ULCC service. Florida's coastlines are densely populated with many Part 139 airports, which makes it possible for ULCCs to provide convenient service while operating out of a smaller *percentage* of airports.

Finally, airport CPE is widely assumed to be important to the business models of all four ULCCs. While the signs and sizes of the B coefficients on CPE $4.00-$7.99 and CPE $8.00+ are consistent with the hypothesis that higher CPE increasingly reduces the likelihood and volume of ULCC service, none of these variables are statistically significant. This may be because, in addition to being attracted to low-fee airports, ULCCs also operate at many highly demanded airports because these airports serve major tourist destinations, major metropolitan areas, or both, despite these airports historically having higher aeronautical fees levied for ramp, gate, and overnight storage than smaller airports (*16*).

## CONCLUSIONS

The aim of this paper was to analyze the domestic aviation markets served by ultra low-cost carriers, and to determine which market factors are the most conducive for enabling the expansion of these carriers. Based on previous research and a preliminary review of ULCC business patterns, it was hypothesized that ULCC operations are heavily dependent on tourist passengers to stimulate air service and sought out airports with lower airport fees, but the signal from these variables were mixed. Several other factors that may influence whether or not ULCC service is established, especially at smaller airports, were found. Gaps in available data made a comprehensive analysis of airport costs a challenge.

Through an examination of literature, documentation of existing conditions for ULCC operations, regression analysis, and qualitative case studies, several conclusions can be drawn in regards to the relationship between ULCCs and airport choice factors. The regression analyses yielded strong ties between the airport market size variables—the population of an airport's catchment area and the non-ULCC enplanements—and ULCC operations in terms of enplanements and presence of service. The importance of the local tourism economy also is significant to ULCCs from a volume standpoint but not for explaining the existence of ULCC service. However, several variables including proximity to the nearest city and to a border crossing were significant in predicting whether or not ULCC service exists. A lack of EAS service also favored airports to receive ULCC service. Several state dummy variables highlighted Florida airports for larger enplanements and California and Texas for lower likelihood of ULCC service, all else being equal.

For airport-level analysis, further research is warranted into the complex relationships between ULCC service and distance to the nearest city, airport CPE, climate, and demographic characteristics. A single 70-mile driving distance standard was applied to all airport catchment areas here; testing of other distances, flexible distance standards, or a multi-band approach, could improve on these initial results. A more sophisticated approach to modeling multi-airport regions, in terms of both competition and catchment population, could also prove fruitful. Classification of airports into tourism origins versus tourism destinations might be valuable but challenging considering the wide variety of leisure trips and distances from airports to tourist destinations. A more promising direction may be to extend this research to analyze origin-destination data, which could better indicate the extent to which tourism origins and destinations are paired for ULCC service and whether high-tourism locations were consistently the destinations of ULCC round trips. This study was not able to analyze this hypothesis, and ultimately the tourism independent variable was significant only in the OLS regression. More case studies, multi-year analyses, single-airline or multinomial logit analyses, and passenger survey research into preferences and choices are promising directions to deepen our understanding of ULCCs.

**ACKNOWLEDGMENTS**

This work was sponsored by the Graduate Research Award Program on Public-Sector Aviation Issues of the Airport Cooperative Research Program (ACRP), which is administered by the Transportation Research Board (TRB) of the National Academies. The Graduate Research Award Program includes input from expert advisers, in this case involving researchers, economists, and network planners of commercial airlines. The authors are grateful for the guiding contributions from panel advisers Levi Anstine, Eric Amel, David Byers, John Fischer, and Bill Spitz, along with Larry Goldstein. Additional guidance was received from Drew Mongell. The authors would also like to sincerely thank David Haring of the Lincoln Airport Authority, Matthew Rodriguez of the Port of Bellingham, Joel Martinez of the City of Waco, Chris Davidson of Salisbury Airport, and Vince Maniaci of the Town of Mammoth Lakes for allowing interviews for this study.

**AUTHOR CONTRIBUTIONS**

The authors confirm contribution to the paper as follows: study conception and design: Drew Taplin, Michael Kuby, Deborah Salon; data collection: Drew Taplin; analysis and interpretation of results: Drew Taplin, Michael Kuby, Deborah Salon, David King; draft manuscript preparation: Drew Taplin, Michael Kuby, Deborah Salon. All authors reviewed the results and approved the final version of the manuscript.

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