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The Spirit Effect: Ultra-Low Cost Carriers and Fare Dispersion in the U.S. Airline Industry

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Abstract
I study the relationship between competition and price dispersion by evaluating the competitive role of "ultra-low-cost carriers" (ULCCs) in the U.S. airline industry. These carriers have significantly lower unit costs than do traditional "low-cost carriers" (LCCs), and the ULCCs focus almost exclusively on leisure travelers, and offer unbundled products with low base fares and fees for many ancillary services. Public statements in carriers' earnings calls from 2012 to 2019 indicate that "legacy carriers" responded to ULCC expansion by increasing fare segmentation and further reducing fares at the bottom of the fare distribution. Using data from 2012Q1 to 2019Q4, I show that ULCC presence significantly widens fare dispersion, whereas competition from legacy carriers and LCCs does not meaningfully affect fare dispersion in most cases. More generally, my results show that failing to account for firm-level heterogeneity could lead to inappropriate conclusions about the relationship between competition and price dispersion.

Keywords Airlines · Price dispersion · Market segmentation · Competition

1 Introduction

> *"I think there has been another structural change in the industry. And that has been in particular the growth of ultra-low-cost carriers...The structural response is twofold. It's one, to compete with them, which we are doing. And the second one is product segmentation.*
> *- Scott Kirby, President of American Airlines Group, in American's 2016Q2 earnings call*

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In the nearly three decades since the U.S. Department of Transportation first coined the "Southwest Effect" to describe the effect of Southwest's presence on competitors' airfares, researchers who study the airline industry have typically used a binary classification to distinguish between different types of marketing carriers[1]: "Legacy carriers"—such as Delta Air Lines—are those that operated interstate flight networks prior to the Airline Deregulation Act of 1978.[2] "Low-cost carriers" (LCCs)—including Southwest—disrupted the industry in the post-deregulation era: They maintained lower unit costs than did the legacy carriers and had captured roughly 50% of passenger enplanements from their legacy rivals by 2010.

In the 2010s, three carriers—Spirit Airlines, Frontier Airlines, and Allegiant Air—implemented a new business model and achieved significantly lower unit costs than the traditional LCCs. The pricing strategy that was employed by these carriers—which would come to be characterized as "ultra-low-cost carriers" (ULCCs)—also differed notably from LCCs. ULCCs focused extensively on leisure travelers and unbundled products to a far greater degree than did the legacy carriers or the LCCs. Citing these differences, Bachwich and Wittman (2017) suggested a three-tier classification that distinguishes among legacy carriers, LCCs, and ULCCs. Nonetheless, as Lewis (2021) notes, most academic papers still do not distinguish between LCCs and ULCCs, and instead classify ULCCs alongside LCCs (for example, see Brueckner et al., 2021; He & Kosmopoulou, 2021; Gaggero & Luttmann, 2023).

On the other hand, industry stakeholders began distinguishing LCCs from ULCCs during the mid-2010s. Around this time, legacy carriers further segmented their cabins by introducing "basic economy" (BE) fares; these carriers cited competitive pressure from ULCCs. This product aligned more closely with the fare structure that was offered by ULCCs, with lower base fares but additional fees for ancillary services that had traditionally been bundled with the airfare. Referring to the role of the BE product, Delta Air Lines C.E.O. Ed Bastian referred to it in Delta's 2015Q2 earnings call as the carrier's "Spirit match fare". While the role of competitor heterogeneity has received limited attention in studies on the relationship between competition and price dispersion in the U.S. airline industry, legacy carriers' motivation for fare segmentation suggests that it may be an important factor.

I consider the role of competitor heterogeneity in the relationship between competition and price dispersion by considering the competitive role of ULCCs in the U.S. airline industry. Based on public statements that have been in legacy

[1] The marketing carrier is the airline that sells tickets for the flight, whereas the operating carrier is the airline that operates the flight. Marketing carriers are often also the operating carrier, but at other times subcontract operations to a regional partner. As such, in research on vertical relations in the airline industry, researchers may instead distinguish between carriers that both market and operate flights ('majors') and carriers that operate flights but typically do not market them ('regionals'). For a more thorough discussion, see Forbes and Lederman (2009).

[2] Prior to deregulation, the U.S. Civil Aeronautics Board had widespread authority to regulate route-level entry and prices on interstate routes. During this time, carriers such as Southwest—which operated intrastate routes throughout Texas prior to deregulation—faced prohibitive barriers to entry on interstate routes. For a review of the history of regulatory reform in the U.S. airline industry, see Borenstein and Rose (2014).

carriers' earnings calls, I hypothesize that ULCC presence increases the fare dispersion of their competitors, which would differ notably from previous literature that has found mixed results for other carrier types. Using information on airfares and service from 2012 through 2019, I use a two-way fixed effects estimator to consider this hypothesis.

My results indicate that firms may exhibit markedly different responses to the presence of competitors from different market segments. In particular, I find that the number of legacy and LCC competitors in a market has an ambiguous—and relatively small—influence on fare dispersion. On the other hand, ULCC presence is associated with significantly wider fare dispersion for each of the "Big Four" carriers: American, Delta, United, and Southwest. This effect is particularly large for one of the ULCCs—Spirit Airlines—which is the largest ULCC throughout the period that I analyze. My findings suggest that researchers who do not consider the role of individual firms or groups of firms could reach erroneous conclusions about the relationship between market structure and price dispersion.

I also contribute to the literature on competition in the U.S. airline industry by documenting the distinctive role of ULCCs. While previous research has often classified the three ULCCs alongside LCCs, I show that this classification is no longer appropriate. Although traditional LCCs and ULCCs share some similarities, in other important ways the difference between LCCs and ULCCs is even more striking than is the difference between LCCs and legacy carriers. As was noted in the previous paragraph, this extends to their role in fare determination: ULCC presence is associated with a large reduction in fares near the bottom of the fare distribution, but only a modest reduction in airfares at higher points of the fare distribution. On the other hand, the presence of both legacy carriers and LCCs is associated with relatively uniform fare reductions.

This paper proceeds as follows: In the next section, I briefly summarize the prior literature that is relevant to this paper. I then discuss in Sect. 3 the characteristics of ULCCs that distinguish them from other carriers, as well as their influence on the rollout of BE fares across the U.S. airline industry. I proceed in Sect. 4 to summarize my data sources and construction prior to presenting in Sect. 5 my empirical approach and results. Section 6 offers a few concluding thoughts.

2 Literature Review

This paper broadly contributes to the literature on the relationship between competition and price dispersion, but I highlight papers on this topic that have likewise focused on the U.S. airline industry.[3] In their seminal paper on the subject, Borenstein and Rose (1994) found that conditional on the number of flights, fare dispersion is increasing in the number of competitors that serve a market. On the other hand, Gerardi and Shapiro (2009) found that competition has a negative relationship with fare dispersion, and that this effect was notably larger when legacy

[3] For a broader review of price discrimination and price dispersion, see Stole (2007).

carriers faced competition from LCCs. Chandra and Lederman (2018) highlighted the role of consumer heterogeneity in the relationship between competition and fare dispersion, and found that competition had limited effects at the bottom and top of the price distribution, but a significant effect in the middle. Dai, Liu, and Serfes (2014) documented an inverse-U relationship between competition and price dispersion in the U.S. airline industry, and similarly did not highlight the potential for asymmetric responses to different types of carriers. These papers do not distinguish between LCCs and ULCCs, as the data predates ULCCs' emergence.[4]

Within the airline industry, a vast literature has considered the relationship between competition and fares—particularly the impact of LCCs on legacy carriers' fares. In a seminal paper on the topic, Morrison (2001) studied the relationship between Southwest Airlines and competitors' fares, and found that Southwest's presence was associated with significant fare reductions on routes that were directly served by Southwest as well as on routes where Southwest was a potential entrant. Goolsbee and Syverson (2008) likewise focused on potential competition, and found that incumbents significantly reduced fares on routes that Southwest was likely to enter. Brueckner et al. (2013) evaluated the role of different types of carriers and service in fare determination using data from 2007Q3 through 2008Q2, and found that LCCs continued to exert significantly greater fare pressure on their competitors than did legacy carriers.

Given that the introduction and expansion of the ULCC model in the U.S airline industry dates to the early 2010s, much of the literature on the relationship between competition and fares typically does not distinguish between LCCs and ULCCs. For example, Kwoka et al. (2016) used data from 2009Q3 through 2010Q2 to study fare determination. By this time, LCC competition was widespread, but none of the three major ULCCs had yet transitioned to that model.[5] Two papers that do distinguish between LCCs and ULCCs are the aforementioned Bachwich and Wittman (2017) and Shrago (2022). However, Bachwich and Wittman (2017) study the relationship between ULCC presence and the average fare reduction on a route, and do not directly consider the effect on competitors' fares or the possibility of differential effects across the fare distribution. While Shrago (2022) noted that ULCC presence is associated with greater reductions in competitors' fares at the 25th percentile of the fare distribution than at the 75th, that finding was ancillary to the paper's contribution and the author does not go into detail on the matter.[6]

As will be shown in the next section, ULCCs differ notably from other carriers in their unbundling of airfares from fees for ancillary services, so I conclude this review by highlighting a few papers that shed light on the pricing implications of unbundling. Brueckner et al. (2015) built a theoretical model to hypothesize that the introduction of baggage fees should reduce base fares but have an ambiguous effect

[4] The emergence of ULCCs in Canada post-dates their emergence in the U.S. (Chong, 2018), so they are not present during the period of Chandra and Lederman's (2018) analysis.

[5] The authors categorize both Allegiant and Frontier as LCCs. Although Spirit is not explicitly mentioned in paper, they appear to be categorized as an LCC as well.

[6] Although some recent papers make this distinction, most do not. For examples of papers that do not make such a distinction, see Brueckner, Czerny, and Gaggero (2021); He and Kosmopoulou (2021); Gaggero and Luttmann, (2023).

on overall trip costs, and found that this hypothesis held when studying the period shortly after U.S. airlines introduced baggage fees in the late 2000s. Zou et al. (2017) found that baggage fees were associated with increased fares on airlines that did not charge such fees. Finally, He et al. (2022) found that competitors reduced fares in response to Spirit Airlines' introduction of carry-on baggage fees.

3 ULCCs in the U.S. Airline Industry

The three major ULCCs all began restructuring following the "Great Recession" of 2008–2009. The wide-scale introduction of fees for carry-on baggage represents the clearest date for each carrier's transition to the ULCC model. Spirit Airlines was the first U.S. carrier to introduce this fee in April, 2010 (He et al., 2022), and Allegiant Air followed suit in April, 2012. Frontier Airlines was the last to transition to the ULCC model; Frontier introduced the carry-on fee in August 2013. Throughout the paper, I refer to Frontier Airlines as Frontier (LCC) prior to their transition to ULCC, and as Frontier after their transition.

The ULCCs operated on the fringes of the industry prior to the Great Recession, but they expanded dramatically in the 2010s and captured significant market share from their competitors. During this time, the share of domestic passenger itineraries that was flown by ULCCs rose from 3.5 to 11.2%, while the shares of the legacy carrier and LCC categories each fell by about four percentage points.[7] ULCCs served 47 of the 200 largest unidirectional routes in 2012Q1.[8] By 2019Q4, they served 115 of the 200 largest unidirectional routes, and 37 of these routes were served by multiple ULCCs. Table 1 lists the carriers used throughout my analysis alongside their categorization and change in itinerary shares between 2012 and 2019. While I use carrier names throughout the paper, Table 1 also includes each carrier's 2-letter International Air Transport Association (IATA) code, which is commonly used to identify carriers in this industry.

Under the traditional Legacy/LCC taxonomy, the changes that were described in the previous paragraph would represent continued growth of LCCs at the expense of legacy carriers. However, as was noted by Bachwich and Wittman (2017), in the early 2010s ULCCs reduced costs to a level that was far below the levels of the traditional LCCs. The ULCCs also deviated from traditional LCCs by implementing a pricing model that extensively unbundled ancillary services from airfares. In Fig. 1, I plot average costs and revenues by carrier.[9] The difference between ULCCs and

[7] Throughout the paper, I use the term itinerary to refer to a passenger's entire trip from her origin to her destination, and the term segment to refer to individual flights within that trip. For example, a single itinerary from A to B with a connection at H is denoted as A:H:B and consists of two segments—A:H and H:B.

[8] I measure the largest routes by the number of passenger itineraries. A direct route between endpoint airports A and B is often denoted A:B. Research on the airline industry typically defines routes either unidirectionally or bidirectionally, with the former treating A:B and B:A as separate routes and the latter as a single aggregated route.

[9] In the airline industry, average costs and revenues are often total costs (or revenues) divided by total available seat miles, where an available seat mile represents a single seat flown one mile.

LCCs in each of these dimensions is stark; ULCCs differ more clearly from LCCs than LCCs differ from legacy carriers.[10]

ULCCs also differ significantly from both LCCs and legacy carriers in terms of their route architecture and scheduling. Although legacy carriers' networks are often described as hub-and-spoke and LCCs' as point-to-point, both use hybrid networks—with LCCs' networks closer to the point-to-point end of the spectrum than are legacy carriers' networks (Cook & Goodwin, 2008). While LCCs do not have "hubs" in the same sense as legacy carriers, "focus cities" with dense flight schedules enable LCCs to offer some convenient connecting itineraries. ULCCs' route networks and scheduling reflect their near-exclusive focus on leisure travelers, who tend to be more price-sensitive but less sensitive to departure times than are business travelers (Berry & Jia, 2010).[11] As shown in Fig. 2, the vast majority of ULCCs' routes were served no more than once daily in 2019Q3, which limits the utility of connecting itineraries. During that same year, only 4.2% of passenger itineraries on ULCCs included a connection, compared to 15.4% for LCCs and 33.4% for legacy carriers.

Although each of the ULCCs expanded rapidly, Allegiant Air differs from the others in that Allegiant still operates on the periphery of other carriers' route networks (in the sense that Allegiant overlaps less on other carriers' routes), and explicitly avoids entering competitive, high-traffic routes. On the other hand, Frontier and Spirit both aggressively expanded into markets with legacy and/or LCC incumbents.

Table 2 lists the share of passengers on direct itineraries that flew on routes that were also served directly by Allegiant, Frontier, or Spirit. As shown in the first column, only a minuscule share of legacy carriers' passengers could have flown their route directly with Allegiant. In contrast, a significant share of these passengers could have flown with either Frontier or Spirit. As such, while Allegiant does operate as a ULCC, it is possible that Allegiant is less influential than Frontier and Spirit with respect to the broader strategic response of legacy carriers and LCCs.

3.1 ULCCs and the Rollout of Basic Economy Fares

Perhaps the most important consideration as to whether ULCCs represent a distinct market segment rather than merely a subset of a broader LCC segment is whether their competitors view them differently from LCCs. The actions and statements of ULCCs' competitors suggest that this is the case. Legacy carriers—and later

[10] I denote fare revenue with an asterisk because a significant share of ancillary revenue for ULCCs during this time came from booking fees that are charged to passengers who book tickets either online or over the phone. These fees were not historically included as part of airfare in USDOT's DB1B database, despite the fees' being paid by the vast majority of passengers. Following a recommendation by USDOT's Office of Inspector General in 2020, the Department directed the Bureau of Transportation Statistics to issue a directive that clarified that such fees are to be included in future reporting.

[11] Conceptually, one could similarly order the three carrier types in terms of their interest in business versus leisure travelers. For example, JetBlue describes its customers as "neither high-traffic business travelers nor ultra-price sensitive travelers" (JetBlue 2019 10-K, p. 6) whereas Frontier states that their "product appeals to price-sensitive customers" and that they are not focused on business travel but do attract "small business travelers who bear their own travel costs" (Frontier 2016 S-1, p. 91).

Table 1 Summary of Carriers, 2012–2019

	IATA code	2012 → 2019 Itinerary share	Notes
Legacy carriers			
American Airlines	AA	11.7% → 20.5%	Merged with US in 2013
Delta Air Lines	DL	19.9% → 20.0%	
United Airlines	UA	15.0% → 14.6%	
US Airways	US	10.7% → 0.0%	Ceased operations in 2015
Low-cost carriers			
Alaska Airlines	AS	2.7% → 5.2%	Merged with VX in 2016
JetBlue	B6	5.1% → 4.9%	
AirTran Airways	FL	3.8% → 0.0%	Ceased operations in 2014
Sun Country Airlines	SY	0.3% → 0.5%	
Virgin America	VX	1.5% → 0.0%	Ceased operations in 2018
Southwest Airlines	WN	23.4% → 23.1%	Merged with FL in 2011
Ultra-low-cost carriers			
Frontier Airlines	F9	2.3% → 3.7%	Transitioned to ULCC in 2013
Allegiant Air	G4	1.4% → 2.6%	
Spirit Airlines	NK	2.0% → 4.9%	

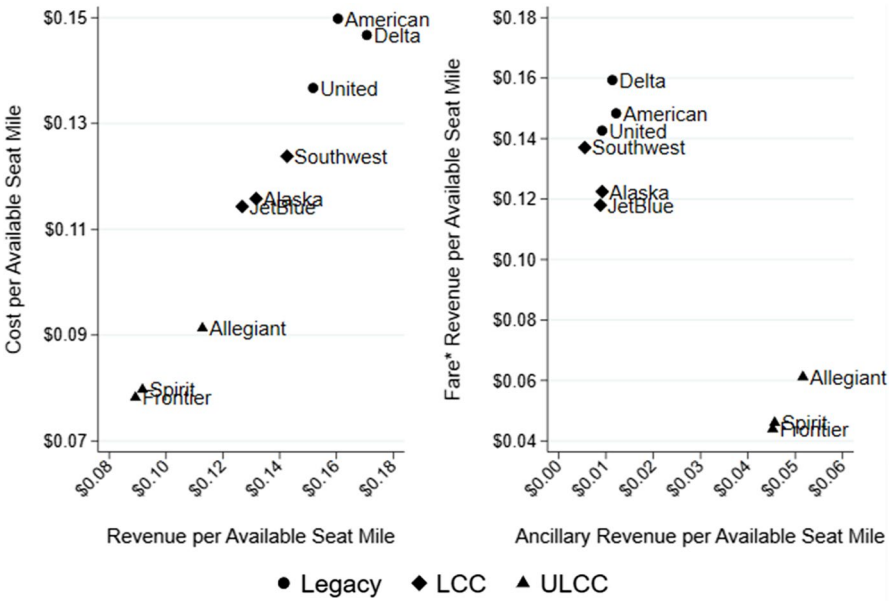

Fig. 1 Unit Costs, Revenues, and Revenue Sources by Carrier Type in 2019Q3

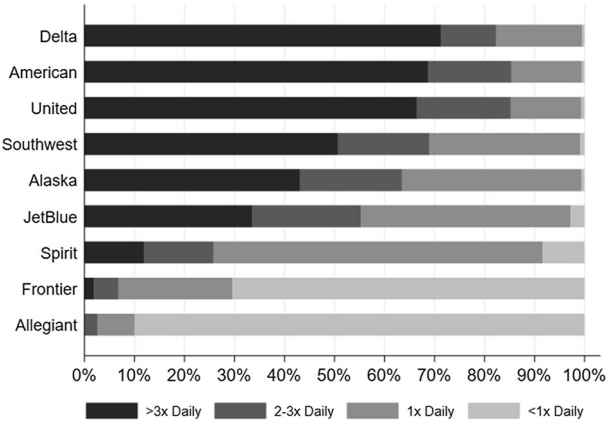

Fig. 2 Flight Frequency by Carrier, 2019Q3

Table 2 Passenger Overlap, 2019Q3

	Allegiant	Frontier	Spirit
Legacy			
American	1.3%	11.1%	30.4%
Delta	0.8%	15.3%	29.1%
United	1.5%	25.1%	31.9%
LCCs			
Alaska	1.3%	4.2%	11.3%
JetBlue	0.6%	9.5%	36.9%
Southwest	4.6%	25.7%	29.8%

LCCs—increasingly segmented their main cabins in the mid-2010s into tiers such as BE, Economy, and Economy Plus.[12] The entry-level BE product offers lower base fares but carries additional fees for services that had previously been bundled with the airfare, such as seat selection and use of the overhead bin for carry-on baggage, depending on the carrier. As will be shown in the following paragraphs, this development was catalyzed by ULCC—rather than traditional LCC—competition.

In Table 3, I present a timeline of the BE product.[13] Delta Air Lines was the first carrier to introduce BE fares in late 2012, beginning its wide-scale rollout a few

[12] Three legacy carriers previously attempted to segment their product lines in an effort to compete with LCCs by introducing separate airline brands. United Airlines introduced "Shuttle by United" in 1994 and subsequently "Ted" before shuttering Ted in 2008. Delta Air Lines similarly introduced "Delta Express" in 1996 and subsequently "Song" before shuttering Song in 2006. US Airways' launched "MetroJet" in 1998, but ceased operating under the MetroJet name by 2001.

[13] To document carriers' justifications for introducing the BE fare class as well as the timing of each carrier's BE rollout, I collected transcripts from the earnings calls of all major carriers between 2012Q1 and 2019Q4. Additionally, I supplemented the information that I obtained from these earnings calls with information from other public filings and from presentations by carriers as well as from the news media.

years later and introducing the product across their entire domestic route network by 2017Q1. United and American followed suit by announcing their BE products in 2016Q4, and rolled out the product over the next year.

Each of the legacy carriers made multiple public statements that tied the introduction of their BE product to ULCC competition. Delta Air Lines was most explicit in describing the product as a response to ULCCs, with CEO Ed Bastian referring to it as their "Spirit match fare" and noting that "Basic Economy is not something we want to grow…as we've outlined before, [it's a] defensive product against ULCCs" in separate earnings calls. As was illustrated by the quote at the beginning of this paper, American Airlines executives likewise viewed segmentation as a major part of their response to ULCC growth. Further fare segmentation may have improved the ability of legacy carriers to target the highly price-sensitive passengers that represent the customer base of ULCCs, and United CEO Oscar Munoz cited BE as a tool that has helped the carrier better respond to ULCC pricing.[14]

On the other hand, LCCs did not quickly join their legacy rivals in offering a BE product. Alaska Airlines introduced their "Saver" fare in 2018Q2 prior to its rollout the next year, but cited the need to compete with legacy carriers' BE fares rather than ULCCs. When JetBlue introduced "Blue Basic" fares across their network in 2019Q4, the discussion was likewise centered around the need to respond to exposure to BE fares. To date, Southwest Airlines is the lone major carrier (other than ULCCs) that has not introduced a BE product.

4 Data

Throughout the paper, I rely on several data sources that are commonly used in research on the US airline industry. My primary data source is the Bureau of Transportation Statistics' Airline Origin and Destination Survey (DB1B), which is a ten percent sample of airline itineraries from reporting carriers in the United States. I also use information from the Form 41 Traffic Database (T-100) and flight schedules to encode service frequency, seating capacity, and passenger enplanements into the DB1B. To control for local economic characteristics, I use county-level economic information from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages.

I prepared data from the DB1B between 2012Q1 and 2019Q4. I retained marketing carriers that recorded at least 0.1% of DB1B passengers during this time, and dropped observations with fewer than 30 passengers for the carrier on the route in the quarter or fewer than 100 passengers on the route across all carriers in the quarter. I restricted the sample by dropping business and first-class itineraries, as well as

[14] Carriers have long used inter-temporal price discrimination to price discriminate between leisure and business passengers (Escobari, Rupp, and Meskey, 2019). Nonetheless, further segmenting economy fares in addition to maintaining updated strategies of inter-temporal price discrimination could enable carriers to respond better to ULCC competition.

Table 3 Timeline of BE Rollout

2012–2014: Delta Air lines develops BE	
2012Q4	Delta introduces BE on four routes
2014Q4	Delta offers BE in 75 markets *"it's primarily used against the ultra-low-cost carriers when we have inventory to sell and we want customers to buy a competitive product."- Glen Hauenstein, Delta Air Lines*
2015—2017: Widescale rollout of BE by legacy carriers:	
2015Q2	*"Basic Economy…is our Spirit match fare if you will."—Ed Bastian, Delta Air Lines*
2016Q2	Delta rollout covers 50% of domestic revenue base
2016Q4	American and United announce rollout *"we will continue to match the ultra-low-cost carrier pricing with our Basic [BE] product"—Don Casey, American Airlines*
2017Q1	American and United begin rollout in a small number of markets Delta completes domestic rollout
2017Q2	United completes domestic rollout
2017Q3	American completes domestic rollout
2019Q4	JetBlue introduces "Blue Basic" fares across network
2018–2019: LCCs move…or don't:	
2018Q2	*"we're further segmenting our product to compete more directly with the Basic Economy fares"—Matt Grady, Alaska Air Group*
2018Q4	*"You're not going to see Basic Economy from Southwest. That's not what we do."—Gary Kelly, Southwest Airlines*
2019Q1	Alaska rolls out "Saver" fares across network
2019Q4	JetBlue introduces "Blue Basic" fares across network

round-trip itineraries with fares below $15 or above $1,000 per-leg.[15] I restrict my analysis to direct, round-trip itineraries.[16]

Based on the work of Luttmann (2019) and Brueckner et al. (2014), I define markets as unidirectional city-pair routes. Unidirectional routes treat each direction of a route as a separate observation, which could be important in this context given

[15] I do not drop JetBlue itineraries coded with first-class segments, because such segments account for the vast majority of JetBlue's itineraries in the DB1B during this time. DB1B fares recorded by legacy carriers and LCCs between $0 and $15 typically represent fares paid for in frequent flyer miles rather than dollars, so the true price is effectively unobserved in the data.

[16] During my period of analysis, the vast majority of direct itineraries are nonstop, but a small share of observations in the earliest years of my analysis include a stop but no change of aircraft.

Luttmann's (2019) evidence on directional price discrimination in the U.S. airline industry.[17] Because ULCCs often operate in secondary airports within multi-airport regions, I use the city-pairs taxonomy that is recommended by Brueckner et al. (2014).[18]

I coded local economic characteristics based on counties within 50 miles of the origin and destination airports. For cities with multiple airports, I coded the local economic characteristics based on counties within 50 miles of the primary airport.[19] Specifically, I coded both the average weekly wage and share of the population that is employed in the leisure sector separately for the origin and destination. To capture route density, I computed the geometric mean of employment at the endpoints, in millions. Because my approach relies on two-way fixed effects for carrier-time and route, the time-invariant characteristics such as distance that are often included as regressors are not present in this paper.

For each route, I encoded the number of nonstop, connecting, and potential legacy, LCC, and ULCC competitors.[20] I counted a carrier as a nonstop competitor if it served the route with no intermediary stops. I defined connecting competitors based on service information: I coded a firm as a connecting competitor on route A:B if there was any airport H such that (i) nonstop service was available on A:H and H:B at least twice-daily and (ii) A:H:B was not excessively circuitous.[21] Following earlier work, I defined a carrier as a potential competitor on route A:B if they did not serve A:B directly, but served at least one destination out of both endpoints.[22]

After filtering the data, I computed the 5th, 10th, …, and 95th percentiles of the fare distribution for each carrier-market-year-quarter. Rather than taking the itinerary corresponding exactly to the given percentile, I smoothed the data by

[17] For example, the share of leisure versus business round-trip passengers on a route between Detroit (DTW) and Las Vegas (LAS) may differ based on whether they originated at DTW or LAS. When Frontier entered this market in 2019Q2, incumbent carriers may have responded differently for DTW:LAS:DTW itineraries than for LAS:DTW:LAS itineraries, so I treat each direction as a separate market.

[18] Additionally, I grouped Phoenix-Mesa Gateway (AZA) alongside Phoenix Sky Harbor International (PHX) and Orlando Sanford International Airport (SFB) alongside Orlando International Airport (MCO) because Allegiant Air rapidly expanded their operations in both locations postdating the period studied by Brueckner, Lee, and Singer (2014).

[19] For metropolitan areas where multiple airports could be considered 'primary', I chose the airport more central within the metropolitan area as the primary airport.

[20] The sample is restricted to direct routes because the DB1B does not include information on whether a route included an intermediary stop. However, the number of competitors is determined using databases that include information on segments rather than itineraries, and as such correspond to nonstop service. During the sample period, the difference between nonstop and direct service is largely semantic, as the vast majority of direct service was nonstop.

[21] I required routes to have circuity—the ratio of total miles to nonstop miles—below the 95th percentile of the circuity distribution for connecting flights in the DB1B, which was 1.67.

[22] There were two major mergers from 2012 to 2019. US Airways and American Airlines closed their merger in 2013Q4, and retired the US Airways brand in 2015Q4. Virgin America closed their merger with Alaska Airlines in 2016Q4, and retired the Virgin America brand in 2018Q2. In cases where both carriers of a given holding company serve a route simultaneously, I code them as a single competitor.

constructing the 5th percentile of the fare distribution as the mean of fares between the 2.5th and 7.5th percentiles, the 10th percentile as the mean of fares between the 7.5th and 12.5th percentile, and so forth. I computed three measures of dispersion: the ratio between the 50th percentile and 10th percentile fares (50–10), the ratio between the 90th and 10th percentile fares (90–10), and the ratio between the 90th and 50th percentile fares (90–50).

The scope and granularity of my analysis are restricted by three limitations in the DB1B: First, the DB1B's information on fare classes does not allow the researcher to distinguish between the different segments (or sub-categories) of economy fares, such as BE or Economy+. Second, the DB1B lists the year-quarter of each itinerary but not the booking date. Insofar as price dispersion results from product segmentation and intertemporal price discrimination, these first two limitations preclude me from offering much insight into the way that carriers adjust each of these price discrimination strategies in response to the presence of different types of competitors.[23] Third, DB1B fares do not include ancillary services such as baggage and seat assignment fees; whether these are bundled with the fare differs by product segment. As a result, the differences in DB1B fares between different product segments may overstate the typical difference in the total cost of travel.

Table 4 presents the descriptive statistics for the primary estimation sample, which is weighted by the square root of passengers that correspond to each observation. For both the table and econometric work, I defined the unit of observation at the carrier-market-year-quarter level. Because I separately estimate the regression equations for legacy carriers and LCCs, I also separately present their observations in Table 4. LCCs have lower fares across the fare distribution than do legacy carriers, but both sets of carriers exhibit similar levels of fare dispersion.[24] For both legacy carriers and LCCs, the median fare is on average about 50% higher than the 10th percentile fare, and the 90th percentile fare is about 75% higher than the 50th percentile fare. As is shown by the share of (weighted) observations that face nonstop ULCC competition, legacy carriers and LCCs face competition from either Frontier, Spirit, or both carriers more frequently than from Allegiant, which reflects the peripheral nature of Allegiant's route network. Connecting competition by ULCCs is rare, but both legacy carriers and LCCs often serve routes where ULCCs are potential entrants.[25]

[23] I refer to the product segmentation that is described in this paper as price discrimination, which applies to situations where two similar products are sold at differing markups over marginal cost; in this regard I am following the definition of Stigler (1987) and used by Varian (1989). Anecdotally, there is significant variation in the price differences among economy product segments, which suggests varying markups over marginal costs. However, whether these differences are sufficient to constitute price discrimination is not entirely clear.

[24] Fares for round-trip itineraries represent the fare per-leg of travel, inclusive of taxes and government-imposed fees, and is assumed to be half the total fare for the round-trip. Rescaling the fare to the total fare for the round-trip itineraries would not affect my results given the structure of my regressions.

[25] Using my network-based definition of connecting competitors, Allegiant does not serve any routes as a connecting competitor, so the dummy variable that represents connecting competition from Allegiant is excluded from all regressions.

Table 4 Summary Stats: 2012–2019 Estimation Sample

	Legacy carriers				Low-Cost carriers			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
Fares								
10th Percentile Fare	$134.37	$40.75	$29.12	$399.19	$107.51	$33.57	$20.50	$241.83
Median Fare	$202.65	$56.58	$34.75	$696.00	$154.60	$39.72	$31.83	$372.00
90th Percentile Fare	$356.26	$105.66	$77.75	$891.50	$266.10	$65.89	$52.00	$770.08
50–10 Ratio	1.54	0.27	1.00	7.71	1.48	0.25	1.01	5.24
90–50 Ratio	1.77	0.31	1.00	5.17	1.75	0.27	1.04	3.79
90–10 Ratio	2.73	0.65	1.01	10.38	2.59	0.60	1.10	9.49
Direct Competitors								
No Legacy	0.53	0.50	0	1	0.34	0.48	0	1
1 Legacy	0.31	0.46	0	1	0.37	0.48	0	1
2+Legacy	0.16	0.36	0	1	0.29	0.45	0	1
No LCC	0.40	0.49	0	1	0.73	0.44	0	1
1 LCC	0.46	0.50	0	1	0.25	0.43	0	1
2+LCC	0.14	0.35	0	1	0.02	0.12	0	1
Frontier(LCC)	0.01	0.12	0	1	0.02	0.13	0	1
Allegiant	0.01	0.12	0	1	0.03	0.17	0	1
Frontier	0.05	0.21	0	1	0.06	0.23	0	1
Spirit	0.14	0.35	0	1	0.12	0.33	0	1
Spirit and Frontier (LCC)	0.00	0.06	0	1	0.00	0.06	0	1
Spirit and Frontier	0.04	0.19	0	1	0.04	0.19	0	1
Connecting Competitors								
No Legacy	0.27	0.44	0	1	0.25	0.43	0	1
1 Legacy	0.35	0.48	0	1	0.27	0.44	0	1
2+Legacy	0.38	0.48	0	1	0.48	0.50	0	1

Table 4 (continued)

	Legacy carriers				Low-Cost carriers			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
No LCC	0.63	0.48	0	1	0.76	0.42	0	1
1 LCC	0.30	0.46	0	1	0.19	0.39	0	1
2+LCC	0.07	0.26	0	1	0.05	0.21	0	1
Frontier(LCC)	0.04	0.20	0	1	0.04	0.19	0	1
Allegiant	0.00	0.00	0	0	0.00	0.00	0	0
Frontier	0.03	0.16	0	1	0.02	0.15	0	1
Spirit	0.03	0.18	0	1	0.04	0.19	0	1
Spirit and Frontier (LCC)	0.01	0.07	0	1	0.00	0.06	0	1
Spirit and Frontier	0.00	0.04	0	1	0.00	0.04	0	1
Potential Competitors								
No Legacy	0.13	0.33	0	1	0.07	0.25	0	1
1 Legacy	0.30	0.46	0	1	0.20	0.40	0	1
2+Legacy	0.58	0.49	0	1	0.73	0.44	0	1
No LCC	0.17	0.37	0	1	0.23	0.42	0	1
1 LCC	0.36	0.48	0	1	0.36	0.48	0	1
2+LCC	0.47	0.50	0	1	0.41	0.49	0	1
Frontier(LCC)	0.13	0.33	0	1	0.12	0.32	0	1
Frontier	0.27	0.44	0	1	0.24	0.43	0	1
Spirit	0.07	0.25	0	1	0.07	0.26	0	1
Spirit and Frontier (LCC)	0.06	0.24	0	1	0.05	0.22	0	1
Spirit and Frontier	0.11	0.32	0	1	0.11	0.31	0	1
Allegiant	0.11	0.32	0	1	0.14	0.34	0	1

Table 4 (continued)

	Legacy carriers				Low-Cost carriers			
	Mean	St. Dev	Min	Max	Mean	St. Dev	Min	Max
Economic Characteristics								
Origin Yearly Wage ($000)	58.44	12.17	29.58	119.06	58.81	13.60	29.93	119.06
Dest Yearly Wage ($000)	57.24	12.41	29.58	119.06	57.29	13.46	29.93	119.06
Origin Leisure Share	0.11	0.02	0.06	0.40	0.12	0.03	0.07	0.35
Dest Leisure Share	0.12	0.04	0.06	0.42	0.13	0.05	0.07	0.37
O/D Employment (geo mean) in 100Ks	23.20	12.80	1.13	86.32	22.14	12.56	1.12	86.32
N	86,889				55,129			

5 Results

My empirical strategy is designed to assess the role of firm heterogeneity in the relationship between competition and price dispersion, and is motivated by the evidence above that suggests that ULCCs play a much different role in fare determination than do LCCs or legacy carriers. Importantly, analyzing mean or median airfares may not capture the relevant differences between the competitive effect of ULCCs and LCCs. To consider better the possible differences, I estimate two sets of regressions. First, I consider the relationship between ULCC presence and three measures of fare dispersion: the 50–10 fare ratio; the 90–10 fare ratio; and the 90–50 fare ratio. Second, I consider the relationship between ULCC presence and various percentiles of the fare distribution.

While I consider three different measures of dispersion, the 50–10 ratio is particularly important. Although the DB1B does not include information on the specific segment of economy fares, the characteristics of seats that are sold at the 50th percentile are likely more similar to those at the 10th percentile than to those at the 90th percentile, as the latter are likely to have additional legroom. As part of the broader segmentation that included the introduction of BE fares, each of the three legacy carriers also introduced higher-end economy fares that gave passengers access to seats with additional legroom. Based on archived information on carriers' seat maps, I expect that 90th percentile fares are more likely to represent such higher-end economy fares than are 50th percentile fares.[26] In this sense, there is likely a smaller product quality difference between the 10th and 50th percentile fares than between the 50th and 90th percentile fares.

5.1 Econometric Approach

Letting r denote a route, t denote the year-quarter, and j denote the carrier, I specify a regression equation of the following form:

$$Y_{rtj} = \beta X_{rtj} + \beta_D D_{rt} + \nu_r + \mu_{tj} + \epsilon_{rtj} \tag{1}$$

where.

- Y_{rtj} is the outcome of interest, such as a measure of fare dispersion or a percentile of the fare distribution.
- X_{rtj} is a vector that includes dummy variables for the number of LCCs (other than Frontier) and Legacy competitors, and dummy variables for the presence of

[26] To gain some sense of where in the fare distribution seats are more likely to have additional legroom, I pulled archived seat maps for each legacy carrier's Airbus A-320 from SeatGuru.com (a now-defunct former subsidiary of Tripadvisor). In 2017, American allocated 18 of the 138 economy seats to their "Main Cabin Extra" product; Delta allocated 18 of their 141 or 144 to their "Comfort+" product; and United 42 of their 138 to their "Economy Plus" product.

Allegiant, Frontier, Spirit, or Frontier and Spirit. These variables are separately coded for nonstop, connecting, and potential competitors.[27]

- D_{rt} is a vector of economic characteristics for counties within 50 miles of the endpoints. I include the log of the average weekly wage at the origin and at the destination; the share of the population that is employed in the leisure sector at the origin and at the destination; and the geometric mean of employment at the origin and destination.
- ν_r is a route dummy variable.
- μ_{tj} is a carrier-time dummy variable.
- ϵ_{rtj} is an idiosyncratic error term that is assumed to be mean-independent of the regressors.

For each set of dependent variables, I use Correia (2016)'s generalized within-transform to difference out both dimensions of unobserved heterogeneity: route (ν_r) and year-quarter-carrier (μ_{tj}). This specification allows for the possibility that realizations of ϵ_{rtj} are correlated with the levels of ν_r and μ_{tj}, as identification is based on deviations in X_{rtj} conditional on ν_r and μ_{tj}. I weight observations by the square root of passengers that correspond to the route-carrier-year-quarter, and I use two-way clustered standard errors to allow for correlation within bidirectional route and carrier-year-quarter.[28]

There are two important drawbacks to this approach: First, while potential endogeneity concerns with regard to the relationship between carrier presence and unobserved route-level or carrier-year-quarter level heterogeneity are moderated, they are not entirely eliminated. For example, suppose that a major firm opens a second headquarters in a different city at time t, and the route AB represents nonstop service between the two cities. Due to the increase in demand among high-valuation business travelers on AB, the demand unobservables and competitors serving AB are likely to change. However, because I assume μ_r is constant over time, any corresponding effects on the fare distribution are attributed to changes in X_{rtj}. While the demand shock may partially be captured by changes in the vector of economic variables D_{rt}, in practice it is unlikely that D_{rt} is sufficiently granular to eliminate the endogeneity concern. As such, the coefficients on X_{rtj} should not be interpreted causally.[29]

Second, my approach focuses on the route-level response to changes in ULCC competitors, so it cannot capture the full effect of ULCC expansion on the fare distributions of legacy carriers and LCCs. Because identification is entirely driven by variation within-route conditional on carrier-time, I cannot comment on the extent to which legacy carriers might have changed their response to ULCCs on routes without variation in the number of ULCC competitors. Additionally, the public

[27] I include a separate dummy variable to capture the presence of Frontier prior to its transition to the ULCC model, which I denote in the results as "Frontier (LCC)".

[28] While markets are defined based on unidirectional routes, clustering by bidirectional routes allows for the possibility that standard errors on each direction of the route are correlated with one another.

[29] While I mostly attempt to limit causal language, doing so entirely would result in an excessively verbose discussion, so in the event that language may sound causal this is not my intent.

statements that were discussed above indicate that ULCC expansion catalyzed a wide-scale increase in fare segmentation. BE fares are now offered on routes where ULCCs are unlikely to have any competitive impact through nonstop, connecting, or potential service.[30] As such, the full effects of ULCCs on the industry as a whole are likely broader than is considered in my empirical analysis.

5.2 Fare Dispersion

I consider three measures of dispersion as the outcome variable in (1): the ratio between the 50th percentile and 10th percentile fares (50–10); the ratio between the 90th and 10th percentile fares (90–10); and the ratio between the 90th and 50th percentile fares (90–50). Conceptually, the 50–10 ratio measures the spread in prices between an entry-level fare and a typical fare; the 90–50 ratio measures the spread in prices between a typical fare and an upper-echelon fare; and the 90–10 ratio measures the spread in prices between an entry-level fare and an upper-echelon fare. Given the discussion in above, I hypothesize that ULCC presence is associated with increased 50–10 and 90–10 fare ratios.

In the leftmost three columns of Table 5, I present the determinants of legacy carrier fare dispersion from 2012 through 2019. Throughout the main body of the paper, I include only coefficients for nonstop competitors, but the Appendix includes additional tables that show the coefficient estimates and standard errors for all of the variables in the regressions. As shown in the top two rows, legacy carrier presence is associated with statistically insignificant changes in fare dispersion among legacy carriers. Routes that are served by two LCCs have moderately higher 50–10 and 90–10 ratios, although the 90–10 estimates are statistically insignificant.

On the other hand, the presence of any of the three ULCCs as nonstop competitors is associated with relatively large and statistically significant increases in both the 50–10 and 90–10 fare ratios. Estimates for the 90–50 fare ratio are either small or statistically insignificant, which is consistent with the hypothesis that ULCCs are more influential at the bottom of the fare distribution than at other points of the fare distribution. Estimates for the connecting and potential competition parameters are generally small and often statistically insignificant.

In the rightmost three columns of Table 5, I present the determinants of LCC fare dispersion from 2012 through 2019. The presence of a legacy competitor is associated with modest but statistically significant increases in LCCs' 50–10 and 90–10 fare ratios, which may capture the response of LCCs to the rollout of BE fares by legacy carriers. Nonstop competition by other LCC has no meaningful relationship with fare dispersion.

Mirroring the results from the legacy carrier specification, nonstop service by Frontier, Spirit, or both is associated with large increases in LCCs' 50–10 and 90–10

[30] For example, on November 2, 2022, I searched for flights between Des Moines, IA and Syracuse, NY. This route is not served directly by any ULCCs, and it is unlikely that any legacy carriers would view them as a potential or connecting competitor. Nonetheless, all three legacy carriers offered BE on connecting itineraries from Des Moines to Syracuse.

fare ratios, although point estimates for Allegiant are small and also statistically insignificant for the 90–10 fare ratio. Once again, I do not find any meaningful relationship between potential or connecting ULCCs and LCC fare dispersion.

In order to evaluate further whether the increased dispersion that is associated with ULCCs' presence is common across different carriers, I separately estimated the model for the four largest carriers: American, Delta, United, and Southwest. The results for each carrier's fare observations are qualitatively similar to those from the aggregated specification. As is shown in Table 6, the presence of a nonstop legacy competitor is not associated with meaningful changes in any of the fare ratios for any of these carriers. Similar to the aggregated specification, I find that routes with two nonstop LCC competitors correspond to higher 50–10 and 90–10 fare ratios, although the magnitude and statistical significance of the estimates varies by carrier.

Nonstop competition from ULCCs is associated with markedly higher 50–10 and 90–10 fare ratios for each carrier. Although observation counts are lower and standard errors are larger in the disaggregated specifications, in most cases estimates for the nonstop presence of ULCCs are statistically significant at the 1% level, and point estimates are positive even when statistically insignificant.

Overall, these results show that the differential role played by ULCCs in the relationship between competition and fare dispersion is present for each of these carriers.

As was mentioned earlier in this paper, the absence of information on booking date and limited information on fare class precludes me from discerning the mechanism that drives the relationship between ULCC presence and fare dispersion. While public statements by carriers suggest product segmentation—particularly the rollout of BE fares –played a role in this relationship, carriers may also have reoptimized intertemporal price discrimination, in some sense substituting between different strategies that serve a similar purpose.

To offer some visibility for the role of the BE product in legacy carriers' response to ULCCs, I estimated a specification that includes the coefficients in (1) as well as their interactions with a dummy variable that is coded 1 in periods after a carrier completed its BE rollout.[31] Interpretation should proceed with caution, as the difference in the pre- and post-specifications likely captures BE rollout as well as reoptimization of intertemporal price discrimination. Additionally, while I include Delta Air Lines for the sake of completeness, their rollout occured over a longer period and initially targeted routes where Spirit was present; as such the "Pre" period for Delta is contaminated by routes where BE was already offered.

The primary coefficients of interest are those for variables that are interacted with the "Post" variable, as these capture the difference in the estimated coefficients that follows the rollout of BE fares. I present the key coefficients and their standard

[31] I defined the date that a rollout was complete based on statements in earnings reports, as is shown in the timeline (Table 3): I code the post-rollout period beginning in 2016Q1 for Delta Air Lines; 2017Q3 for United Airlines; and 2017Q4 for American Airlines. Because neither of the LCCs that introduced BE-like products did so until near the onset of the Covid-19 pandemic, I present this analysis only for legacy carriers.

Table 5 Regressions: Fare Dispersion, 2012–2019 (nonstop competitors)

Dependent variables:	Legacy carriers			LCCs		
	50–10	90–10	90–50	50–10	90–10	90–50
Independent variables:						
# Legacy						
1	-0.024	-0.025	0.010	0.046***	0.110***	0.015
	(0.016)	(0.040)	(0.020)	(0.018)	(0.040)	(0.019)
2	-0.017	0.050	0.042	0.029	0.121*	0.041
	(0.030)	(0.091)	(0.041)	(0.027)	(0.066)	(0.030)
# LCCs						
1	-0.003	-0.001	-0.004	0.007	-0.033	-0.030***
	(0.016)	(0.053)	(0.021)	(0.013)	(0.027)	(0.011)
2	0.077***	0.096	-0.036	-0.003	-0.004	-0.005
	(0.022)	(0.067)	(0.030)	(0.033)	(0.088)	(0.026)
Frontier (LCC)	0.071***	0.059	-0.052*	-0.019	0.009	0.025
	(0.021)	(0.057)	(0.028)	(0.027)	(0.053)	(0.019)
ULCCs						
Allegiant	0.107***	0.229***	0.033	0.030**	0.051	0.006
	(0.020)	(0.057)	(0.024)	(0.012)	(0.039)	(0.020)
Frontier	0.131***	0.311***	0.051***	0.106***	0.190***	0.013
	(0.019)	(0.047)	(0.019)	(0.018)	(0.036)	(0.013)
Spirit	0.137***	0.231***	-0.006	0.120***	0.239***	0.018
	(0.021)	(0.058)	(0.023)	(0.015)	(0.039)	(0.016)
Spirit and Frontier (LCC)	0.178***	0.302***	-0.019	0.032	0.153	0.069*
	(0.038)	(0.108)	(0.042)	(0.078)	(0.148)	(0.042)
Spirit and Frontier	0.209***	0.443***	0.051*	0.193***	0.344***	0.012
	(0.029)	(0.073)	(0.027)	(0.024)	(0.048)	(0.017)
Specification Details						
Potential Competitors?	✓	✓	✓	✓	✓	✓
Connecting Competitors?	✓	✓	✓	✓	✓	✓
Economic Characteristics?	✓	✓	✓	✓	✓	✓
Unidirectional Route FEs?	✓	✓	✓	✓	✓	✓
Carrier-Year-Quarter FEs?	✓	✓	✓	✓	✓	✓
N	86,762	86,762	86,762	55,032	55,032	55,032
Overall R^2	0.446	0.469	0.456	0.544	0.593	0.585
Within R^2	0.052	0.037	0.022	0.043	0.032	0.017

Parameter estimates for additional variables are listed in Tables A.1 and A.2 Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 Regressions: Fare Dispersion by Carrier, 2012–2019 (nonstop competitors)

Dependent variables:	50–10				90–10				90–50			
	AA	DL	UA	WN	AA	DL	UA	WN	AA	DL	UA	WN
Independent variables:												
# Legacy												
1	-0.020	-0.014	-0.025	0.029	-0.049	-0.026	0.036	0.068	-0.002	-0.006	0.057	0.000
	(0.026)	(0.022)	(0.027)	(0.022)	(0.067)	(0.060)	(0.066)	(0.048)	(0.031)	(0.030)	(0.034)	(0.023)
2	0.009	-0.002	0.001	0.012	0.028	0.046	0.213	0.032	0.003	0.039	0.124*	-0.006
	(0.053)	(0.039)	(0.056)	(0.033)	(0.155)	(0.113)	(0.141)	(0.082)	(0.068)	(0.057)	(0.062)	(0.039)
# LCCs												
1	-0.006	0.016	0.033	0.046**	0.040	-0.019	0.132	0.044	0.030	-0.034	0.030	-0.022
	(0.022)	(0.023)	(0.025)	(0.018)	(0.069)	(0.061)	(0.084)	(0.036)	(0.032)	(0.026)	(0.029)	(0.015)
2	0.064**	0.087***	0.129***	0.081**	0.135	0.067	0.305**	0.250**	0.010	-0.063*	0.023	0.055
	(0.031)	(0.029)	(0.039)	(0.035)	(0.092)	(0.084)	(0.122)	(0.106)	(0.042)	(0.035)	(0.045)	(0.047)
Frontier (LCC)	0.058	0.046	0.055**	-0.025	0.097	0.006	0.052	0.027	-0.022	-0.063	-0.036	0.045**
	(0.073)	(0.051)	(0.026)	(0.031)	(0.144)	(0.110)	(0.074)	(0.060)	(0.045)	(0.045)	(0.037)	(0.019)
ULCCs												
Allegiant	0.110***	0.112***	0.049	0.048***	0.231***	0.233***	0.116	0.091**	0.025	0.035	0.021	0.014
	(0.029)	(0.026)	(0.037)	(0.011)	(0.079)	(0.081)	(0.095)	(0.038)	(0.035)	(0.034)	(0.038)	(0.023)
Frontier	0.172***	0.088***	0.123***	0.122***	0.320***	0.158**	0.319***	0.233***	0.015	-0.000	0.066***	0.024
	(0.041)	(0.023)	(0.024)	(0.020)	(0.087)	(0.060)	(0.054)	(0.041)	(0.025)	(0.026)	(0.023)	(0.016)
Spirit	0.184***	0.101***	0.123***	0.149***	0.354***	0.177***	0.132	0.344***	0.017	-0.003	-0.054	0.051**
	(0.039)	(0.022)	(0.032)	(0.019)	(0.100)	(0.061)	(0.100)	(0.044)	(0.029)	(0.028)	(0.043)	(0.019)
Spirit and Frontier (LCC)	0.197***	0.103***	0.196***	0.047	0.571***	-0.016	0.266*	0.227	0.133	-0.143***	-0.059	0.102**
	(0.062)	(0.037)	(0.057)	(0.081)	(0.158)	(0.098)	(0.144)	(0.156)	(0.083)	(0.048)	(0.048)	(0.043)
Spirit and Frontier	0.269***	0.099***	0.243***	0.225***	0.688***	0.129*	0.446***	0.447***	0.136***	-0.028	0.012	0.043**
	(0.051)	(0.026)	(0.044)	(0.028)	(0.121)	(0.074)	(0.104)	(0.053)	(0.041)	(0.036)	(0.037)	(0.019)

Table 6 (continued)

Dependent variables:	50–10				90–10				90–50			
	AA	DL	UA	WN	AA	DL	UA	WN	AA	DL	UA	WN
Specification Details												
Potential Competitors?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Connecting Competitors?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Economic Characteristics?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Unidirectional Route FEs?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carrier-Year-Quarter FEs?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N	25,814	28,206	26,231	35,594	25,814	28,206	26,231	35,594	25,814	28,206	26,231	35,594
Overall R^2	0.441	0.493	0.455	0.599	0.466	0.488	0.496	0.626	0.494	0.465	0.507	0.616
Within R^2	0.063	0.050	0.078	0.078	0.055	0.047	0.060	0.057	0.051	0.028	0.038	0.021

Parameter estimates for additional variables available upon request to the author. Standard errors in parentheses

*$p<0.10$, ** $p<0.05$, *** $p<0.01$

Table 7 Regressions: Fare Dispersion by Carrier and BE Rollout (nonstop competitors)

Dependent variables:	AA		DL		UA	
	50–10	90–10	50–10	90–10	50–10	90–10
Independent variables:						
# Direct Legacy*Post						
1	-0.007	-0.033	-0.020	-0.098	0.037	-0.097
	(0.027)	(0.063)	(0.030)	(0.074)	(0.051)	(0.115)
2	-0.001	-0.202	0.228	0.167	0.099*	0.083
	(0.048)	(0.120)	(0.156)	(0.177)	(0.055)	(0.102)
# Direct LCCs*Post						
1	-0.028	-0.095*	0.030	0.057	-0.013	-0.046
	(0.018)	(0.053)	(0.023)	(0.067)	(0.022)	(0.070)
2	-0.054	-0.223**	0.063*	0.143	-0.023	-0.217*
	(0.035)	(0.086)	(0.034)	(0.099)	(0.035)	(0.118)
Direct ULCCs*Post						
Frontier	0.162**	0.449***	-0.016	-0.002	0.013	0.015
	(0.069)	(0.162)	(0.033)	(0.076)	(0.034)	(0.094)
Spirit	0.142***	0.214**	0.022	-0.049	0.127**	0.146
	(0.036)	(0.090)	(0.030)	(0.092)	(0.048)	(0.117)
Spirit and Frontier	0.118*	0.210	-0.038	-0.035	0.048	0.002
	(0.058)	(0.144)	(0.031)	(0.072)	(0.071)	(0.155)
Allegiant	0.095	0.121	0.083**	0.235***	0.029	0.117
	(0.058)	(0.088)	(0.039)	(0.064)	(0.050)	(0.128)
Specification Details						
Potential Competitors?	✓	✓	✓	✓	✓	✓
Potential Competitors*Post?	✓	✓	✓	✓	✓	✓
Connecting Competitors?	✓	✓	✓	✓	✓	✓
Connecting Competitors*Post?	✓	✓	✓	✓	✓	✓
Economic Characteristics?	✓	✓	✓	✓	✓	✓
Economic Characteristics*Post?	✓	✓	✓	✓	✓	✓
Unidirectional Route FEs?	✓	✓	✓	✓	✓	✓
Carrier-Year-Quarter FEs?	✓	✓	✓	✓	✓	✓
N	25,814	25,814	28,206	28,206	26,231	26,231
Overall R^2	0.454	0.475	0.492	0.489	0.458	0.498
Within R^2	0.085	0.072	0.048	0.049	0.083	0.063

Parameter estimates for additional variables available upon request to the author. Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

errors in Table 7.[32] With the aforementioned caveats in mind, estimates suggest the presence of ULCCs is associated with significantly greater increases in American's 50–10 fare ratio following the BE rollout. Point estimates suggest the same for the 90–10 ratio, but they are statistically significant only for Frontier and Spirit. Evidence for Delta and United is mixed, as most coefficients are statistically insignificant at the 10% level. However, when point estimates are statistically significant at the 5% level, they suggest a notable increase in the relationship between ULCC presence and dispersion following the BE rollout.

5.3 Fare Determination

Although the primary purpose of this paper is to convey the role of firm heterogeneity in the relationship between competition and price dispersion, the evidence on fare dispersion does not inform with respect to the overall level of fare pressure that is exerted by ULCCs. Given the common use of such "effects" in prior research on competition in the airline industry, I estimated fare regressions across the fare distribution to compare the effects of ULCCs and other carriers across the fare distribution.[33] For each carrier-route-quarter, I computed the log of the 5th, 10th, …, 95th percentiles of the fare distribution and defined these as the dependent variable in (1). I present the key results from these regressions visually in the main body, but tables that show parameter estimates and standard errors are included in the appendix. All specifications are weighted by the square root of passengers, and standard errors are clustered by bidirectional origin–destination pairs and carrier-year-quarter.

Before proceeding, readers should note that because carriers usually enter routes after they already operate out of both of the route's endpoints, and both legacy carriers and LCCs often provided connecting service on routes prior to adding nonstop service, my estimates for nonstop competition represent the incremental change in fares when carriers shift from being a potential (or connecting) competitor to a nonstop competitor. In most cases, parameters on connecting and potential competitors do not vary significantly across the fare distribution, but they differ across different groups of competitors. This caveat is not particularly important when it comes to interpreting the gradient of the estimates across the fare distribution, but readers should keep in mind that the level of estimates capture incremental changes in the type of competition that is offered by the carrier rather than their complete competitive effects.

[32] The remaining coefficients are omitted from the table, but are available upon request to the author. Comparing across the three carriers, there is no clear change in the effect of legacy carrier presence on dispersion after the rollout of BE. Evidence for LCCs is mixed across the three legacy carriers in terms of its magnitude and statistical significance.

[33] For example, the U.S. Department of Justice cited such an effect in their suit to block JetBlue's proposed acquisition of Spirit (USDOJ, 2023). As was noted by a reviewer on an earlier draft of this paper, changes to the distribution of fares that are paid by passengers can result from some combination of changes to the support of the fare distribution offered by airlines (for example, reducing the fare floor on a route) and changes in the capacity sold at each mass point of the fare distribution. The price "effects" that are commonly described in the literature do not generally disentangle these two factors.

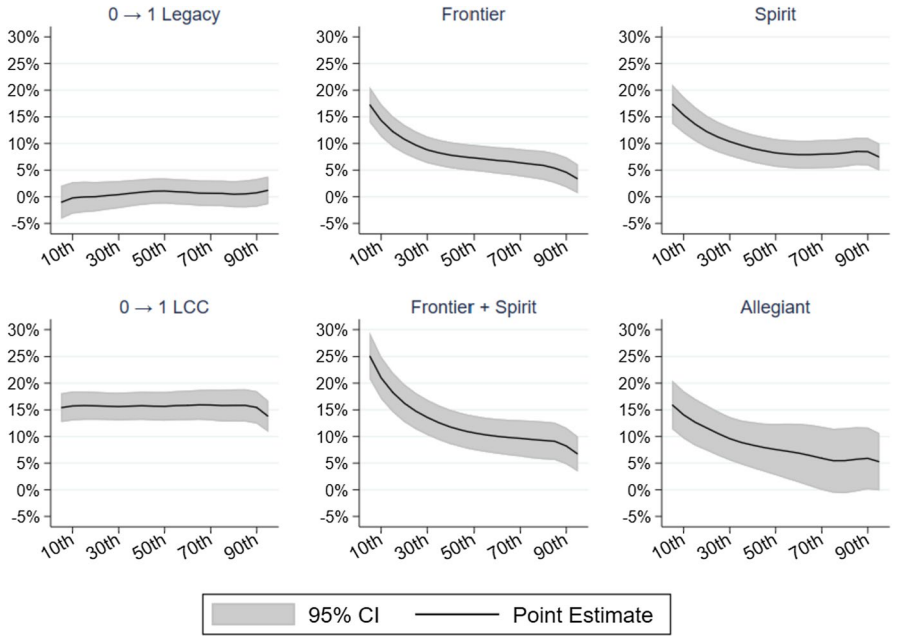

Fig. 3 Legacy Carrier Fare Reductions That Are Associated with Competitor Presence (across the quantiles of the fare distribution)

In Fig. 3, I plot the estimated percentage reduction in legacy carrier fares across the fare distribution that is associated with nonstop competition.[34] As shown by the left-most graph, the fare reductions that are associated with the presence of another legacy carrier are statistically indistinguishable from zero and relatively uniform across the fare distribution. LCC presence is associated with significant reductions in airfares, and these reductions are uniform across the fare distribution.[35]

The rightmost four graphs in Fig. 3 show that each of the three ULCCs' impacts on legacy carrier fares differ markedly across the fare distribution. While standard errors are greater for Allegiant, point estimates for all indicate that the 10th percentile of legacy fares

[34] Given the log-linear specification, the percentage reduction in fares is given by $e^{\beta} - 1$. Standard errors on marginal effects are computed with the use of the delta method. Marginal effects and their standard errors for specifications on the 10th, 50th, and 90th percentiles are presented in Table A3 in the Appendix.

[35] I estimated these specifications in log-linear form as it is conventional in the literature on airline competition. The difference in fare pressure that is exerted by LCCs versus ULCCs still results from a linear specification, but the interpretation across the fare distribution differs. ULCC presence is still associated with a greater dollar reduction in fares at the bottom of the fare distribution than at the median of the fare distribution, but the differences are not as striking as when they are compared in percentage terms. On the other hand, LCC presence is associated with greater dollar reductions in fares at the median of the fare distribution than at the bottom of the fare distribution. However, this does not change the broader implication that the fare pressure that is exerted by ULCCs is more concentrated towards the bottom of the fare distribution than is the fare pressure that is exerted by LCCs.

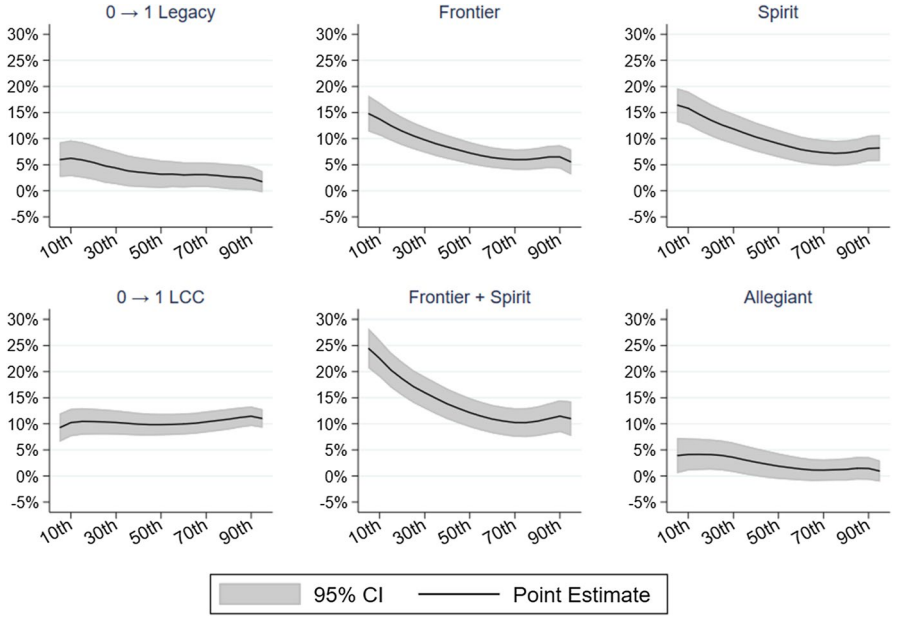

Fig. 4 LCC Fare Reductions That Are Associated with Competitor Presence (across the quantiles of the fare distribution)

is around 15% lower when facing any one of the three ULCCs, whereas the 50th percentile fares are only around 8% lower. Point estimates also indicate that when both Frontier and Spirit are present, fares at the 10th percentile decline by 6.7 (5.7) more percentage points than when only Frontier (Spirit) is present, and both differences are statistically significant at the 1% level. However, at the top of the fare distribution the differences are not economically or statistically significant, which suggests that the pressure exerted by both the first ULCC and additional ULCCs serving a route is concentrated towards the bottom of the fare distribution.

In Fig. 4, I plot the estimated percentage reductions in LCC fares associated with nonstop competition across the fare distribution. Marginal effects and their standard errors for specifications on the 10th, 50th, and 90th percentile are presented in Table A4 in the Appendix. While point estimates indicate legacy carriers have a small effect on LCC fares at most percentiles, they are somewhat larger at the bottom of the fare distribution. This result may have been counterintuitive prior to the BE rollout, but during this time frame it could capture a response to legacy carriers' use of those fares to more aggressively court leisure passengers. LCCs exert relatively uniform pressure on their peers, although point estimates do show slightly larger effects at the top of the fare distribution. Overall, differences across the fare distribution for both nonstop legacy and LCC competitors are relatively small.

Moving again to the fare reductions associated with ULCC presence, I find large impacts for Frontier and Spirit at the bottom end of the fare distribution, but these again diminish significantly by the 50th percentile. Point estimates once again suggest the incremental impact of the presence of Frontier and Spirit together is larger at the bottom of

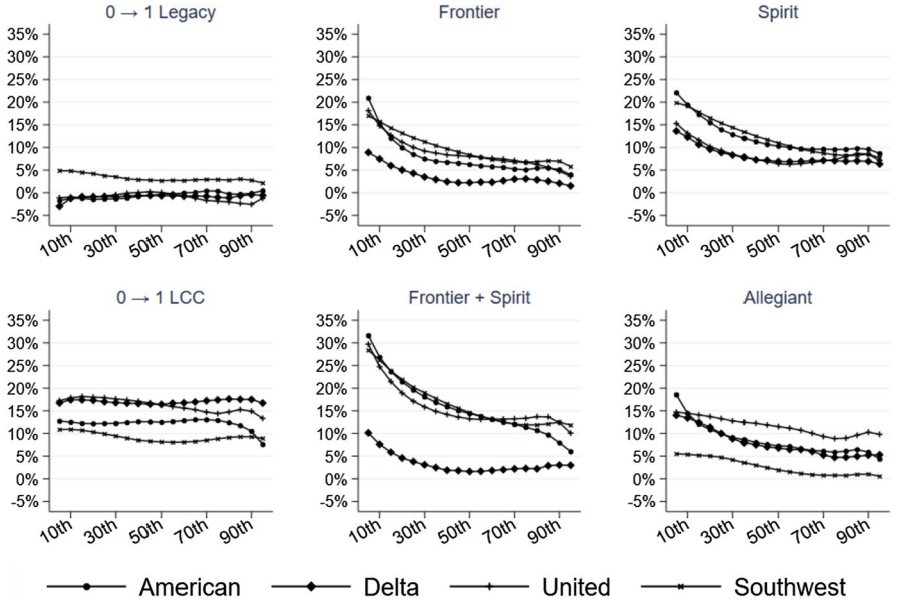

Fig. 5 Big Four Carrier Fare Reductions That Are Associated with Competitor Presence (across the quantiles of the fare distribution)

the fare distribution, but the incremental effect is still statistically significant at the 50th percentile and 90th percentile. Although BE-like fares were generally not available from LCCs during this period, LCCs may have been able to respond to ULCC presence by adjusting other means of price discrimination. While I document that responses to ULCC presence are decreasing across the fare distribution prior to increased segmentation, determining the mechanism through which LCCs responded lies beyond the scope of this paper.

In order to determine whether these results are consistent across carriers, I separately estimated the fare level regressions for American, Delta, United, and Southwest. I present the point estimates for each carrier's specification in Fig. 5, and Table A5 in the Appendix includes point estimates and standard errors for nonstop competitors in each carrier's 10th percentile, 50th percentile, and 90th percentile fare regression.

Overall, the leftmost two graphics indicate that the fare reduction that is associated with the presence of either a legacy competitor or an LCC competitor is fairly uniform, as point estimates do not differ considerably across the fare distribution. While the magnitudes vary across carriers to some degree, the results indicate that each of these carriers is more responsive to LCC presence than to legacy carrier presence. Point estimates that are shown in the four graphics on the right suggest that there is some heterogeneity across these carriers in terms of the scale of the price pressure that is exerted by ULCCs as well as its gradient across the fare distribution. However, these results again suggest that each of the ULCCs exerts greater price pressure at the bottom of the fare distribution for each of these legacy carriers than the ULCCs exert at the median of the fare distribution.

5.4 Robustness

In addition to the specifications that were described in the preceding subsections, I estimated a wide variety of alternative specifications to consider the robustness of my results to some relatively ad-hoc (albeit common in this literature) assumptions and data cleaning procedures. As mentioned earlier in the paper, I estimated the fare determination regressions with the use of two alternative market definitions—airport-pairs and extended city-pairs—but did not find significant differences from the city-pairs definition. I also considered alternative definitions for the comparison of estimates before and after BE rollout: I estimated a specification that compared the results before and after the introduction of BE, as well as comparing before the introduction of BE and after the rollout of BE was complete. Once again, the key results highlighted in the previous subsections were robust to these alternatives.

I also estimated regressions with a few key differences in terms of constructing variables and defining the sample. In terms of data construction, my primary results exclude itineraries that include any first-class or business-class legs. When such itineraries are included, my results are not meaningfully different. I likewise considered alternative definitions of connecting and potential competitors, and I found a limited effect on the coefficients on nonstop competition.[36] I estimated an unweighted specification and a specification that was weighted by the number of passengers, and found they were mostly similar to my primary results, which were weighted by the square root of the number of passengers. Finally, I estimated my regressions with alternative structures of fixed effects but once again did not find significant differences in the results.[37]

6 Conclusion

In this paper, I studied the competitive role of "ultra-low-cost carriers" (ULCCs) in the U.S. airline industry. Using public statements from carriers, I hypothesized that the competitive effects of ULCC competition differ from those of "low-cost carrier" (LCC) competition in terms of their gradient over the fare distribution. My results support this hypothesis: The presence of Frontier and Spirit are associated with significant widening of fare dispersion. Wider dispersion occurs because carriers reduce fares aggressively at the bottom of the fare distribution when Frontier or Spirit is present—but only modestly at higher points in the fare distribution when those two ULCCs are present.

[36] Notably, I considered alternative definitions of connecting competition that were not based on service availability but instead were based on whether a connecting carrier attained either a 5\% or 10\% passenger share. While the passenger share definition has been used in previous work, it poses a clear endogeneity concern as connecting service is more likely to reach a sufficient share of passengers if competitors' nonstop service is abnormally costly in a given quarter. In other words, high contemporaneous fares can cause the connecting competitor variable to shift from 0 to 1 under the passenger share construction, which can result in estimates that suggest connecting competition is associated with higher fares.

[37] Specifically, I estimated specifications with: (1) carrier and route fixed effects; (2) carrier-year-quarter and route-quarter of year fixed effects; and (3) carrier-year-quarter and route-year-quarter fixed effects.

This paper contributes two findings to the literature. First, it contributes to the literature on price dispersion and competition by highlighting the role of firm heterogeneity. I found that the presence of ULCCs corresponds to significant widening of the 50–10 and 90–10 fare ratios, whereas neither the direction or the magnitude between the legacy competitors or LCC competitors and any measure of fare dispersion is empirically clear. Importantly, this indicates that researchers who study the relationship between competition and price dispersion should take care to recognize that firm-level heterogeneity can be highly influential in determining competitors' responses. This warrants caution with regard to attempts to generalize about the relationship between competition and price dispersion.

Second, the evidence and empirical results in this paper indicate that ULCCs should not be viewed as merely a subsegment of a broader LCC segment. On the contrary, the marked differences between LCCs and ULCCs in terms of both their business models and the price pressure that they exert on competitors indicate that ULCCs represent a distinct market segment. As such, researchers should strongly consider abandoning the legacy/LCC taxonomy in favor of a new taxonomy that distinguishes among legacy carriers, LCCs, and ULCCs whenever such a taxonomy is necessary.

Finally, my results suggest that the airline industry could be a promising setting to consider the distributional effects of changes in market structure, insofar as resulting changes in consumer welfare might be heterogeneous across the income distribution. Although detailed information that links consumer demographics to itineraries is not publicly available, leisure passengers likely constitute a greater share of ticket purchases at the bottom of the fare distribution than at higher points of the fare distribution. Additionally, leisure passengers who purchase tickets at the bottom of the fare distribution may also be lower in the income distribution than are those purchasing tickets that are higher in the fare distribution. If this is the case, then the consumer welfare gains that are associated with ULCC competition could be concentrated at lower points of the income distribution than the consumer welfare gains associated with competition from other carriers. Future research on the airline industry that considers the existence and scale of such distributional effects could provide important evidence as to whether distributional effects should play a role in competition policy.

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