Competition and Price Dispersion: Product Differentiation Matters *

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Abstract

We revisit the relationship between competition and price dispersion in the airline industry using a longer panel and show that the outcome hinges on product differentiation. Using data from 1993 to 2013, we find that competition does not have a significant effect on price dispersion when both one-way and round-trip tickets are used to calculate price dispersion. Distinguishing between one-way and round-trip products, on the other hand, leads to the results that competition has a positive effect on price dispersion in one-way products, and a negative effect in round-trip products. However, the effect on round-trip products is not robust to the inclusion of carrier-time fixed effects, whereas the effect in one-way products is robust to a number of controls, such as carrier-time fixed effects and cost-shifter proxies. In addition, we find that the positive effect on price dispersion in one-way products is driven by a bigger decrease in the 10th percentile of the price distribution in one-way products.

Keywords: Price Dispersion, Competition, Product Differentiation, Market Definition, Airline Industry
JEL codes: D43, L13, L93

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"To determine which buyers and sellers to include, we must first determine the extent of a market – its boundaries, both geographically and in terms of the range of products to be included in it."

p8, Microeconomics 8th edition by Robert S. Pindyck and Daniel L. Rubinfeld

1 Introduction

Price dispersion is one of the most salient features of many markets. The literature has documented that deviations from the "law of one price" seem to be the norm rather than the exception in the following industries: airlines, retail gasoline, prescription drugs, automobiles, and mutual funds, to name a few.[1] Price dispersion can arise for two reasons: search costs (e.g., Salop and Stiglitz 1982; Sorensen 2000) and price discrimination (e.g. Holmes 1989, Borenstein and Rose 1994, Gerardi and Shapiro 2009). This paper focuses on the effect of competition on price dispersion in the airline industry resulting from price discrimination. Our findings suggest that firms differentiate between one-way and round-trip products and distinguish the extent of a market by the direction of a route.[2] Using a panel from 1993 to 2013, we find that an increase in competition leads to an increase in price dispersion in one-way products. This is driven by a bigger decrease in the 10th percentile of the price distribution in one-way products. The effect of competition on price dispersion is negative for round-trip products, however this result is not robust to the inclusion of additional controls such as the carrier-time fixed effects. If both one-way and round-trip products are treated as one product in a route, the effect of competition has no significant effect on the carrier's price dispersion on the route.

Studies of price discrimination often focus on the airline industry because two important prerequisites for price discrimination are present. First, consumers have different demand elasticities. Second, airlines are able to distinguish between these consumers with ticket restrictions. A number of research papers have empirically examined the relationship between competition and price dispersion in the U.S. airline industry, but reached different conclusions. Borenstein and Rose

[1]Airline industry: Borenstein and Rose (1994), Gerardi and Shapiro (2009), Celmons, Hann, and Hitt (2002). Retail gasoline: Chandra and Tappata (2011), Lewis (2008). Prescription drugs: Sorensen (2000). Automobiles: Goldberg and Verboven (2011). Mutual funds: Hortacsu and Syverson (2004).

[2]e.g. A flight with American Airlines from MCI to BOS is a different market than a flight with American Airlines from BOS to MCI.

(1994, hereafter BR) find that competition increases price dispersion using a cross-sectional data. Gerardi and Shapiro (2009, hereafter GS), on the other hand, find that competition lowers the price dispersion using a panel from 1993 to 2006.

The principal contribution of our study is demonstrating how product differentiation and market definition can resolve the debate on the effect of competition on price dispersion with heterogeneous consumers. Our empirical findings are consistent with a model of third-degree price discrimination where firms can offer one-way and round-trip as differentiated products and segment the market based on the direction in a route. A market, as defined in the existing literature, is a carrier-specific route that often has the following features: price dispersion for a carrier-specific route is constructed using both one-way fares and round-trip fares (divided by two to count as one-way fares); and one direction in a carrier-specific route is dropped to avoid double counting.[3] Competition is then measured at the route level. For reasons outlined below, firms may have incentives to offer one-way and round-trip products as differentiated products in a route and further segment the market by the direction in a route.

First, the distribution of customers' demand elasticities may be different for one-way and round-trip tickets provided by a firm in a given route. Round-trip tickets are bound by the airline tariff rules that "requires travelers to use *all* portions of a ticket or risk having the next leg of their trip canceled under what airlines call non-sequential use of ticket segments"[4] while one-way tickets are more flexible. Therefore, customers who value flexibility, especially in the case of business travelers, may prefer one-way tickets. In this case, this represents a higher share of customers who are price inelastic in one-way tickets compared to round-trip tickets. In addition, customers who are price sensitive may choose to "mix and match" airlines for their trip and purchase one-way ticket from an airline one way and another one-way ticket from another airline on the way back as opposed to purchasing a round-trip ticket from the same airline. In this case, this represents a higher share of customers who are price elastic in one-way tickets compared to round-trip tickets. In other words,

[3]For example, Gerardi and Shapiro (2009) define a market with those features. Borenstein and Rose (1994) use fares from one-way and round-trip/2 from both directions. Dai, Liu and Serfes (2014) use fares from one-way and round-trip/2 but kept two directions as two different markets.

[4]NY times, 12/3/06

a firm in a route is facing heterogeneous consumers and the distribution of consumers' demand elasticities in round-trip products may be second-order stochastic dominant over the distribution of consumer demand elasticities in one-way products. Firms take this into account and can offer one-way and round-trip tickets on the same route as differentiated products, and the effect of competition on price dispersion for one-way vs. round-trip may be different.

Second, firms can further segment the market by the direction of a route. A one-way (round-trip) flight by a carrier from $A \rightarrow B$ ($A \rightleftharpoons B$) is a separate market than $B \rightarrow A$ ($B \rightleftharpoons A$) if the distribution of consumers' demand elasticities is different for each market. In our empirical work, we include both directions in a route as two separate markets and address the effect of competition on dispersion by controlling for characteristics of origin and destination city. We find that firms in fact differentiate between one-way and round-trip products in a directional route and an increase in competition leads to higher price dispersion in one-way products and has no significant effect on price dispersion in round-trip products.

In addition, defining a market as it is in the existing literature may lead to measurement errors in price dispersion and competition for reasons outlined below. Price dispersion is measured within a firm in a given route. If ticket fares in one direction are systematically different than the other direction, arbitrarily dropping one direction lowers the overall price dispersion. If round-trip fares are on average cheaper than the sum of two one-way fares, dividing round-trip fares by two skews the price distribution to the left. [5] Dividing round-trip fares by two also assumes that the fares for each direction are exactly the same. However, if fares from one direction are on average cheaper than fares from the other, dividing round-trip fares by two skews the price distribution to the right on the former and skews the distribution to the left on the latter. In the case of competition measures, because competition is measured at route level, if some airline carriers choose to provide only one-way tickets on certain routes as opposed to providing both one-way and round-trip tickets, then this leads to measurement errors on the amount of competition in a route. Our data reveals

[5]For example, on American Airline website, a round-trip from MCI to BOS is \$602 for 7/10/2017-7/17-2017. On the other hand, two one-way tickets, with the same departure and arrival date and time with the same aircraft carrier, cost \$632. Prices quotes on 6/20/2017. Other major airlines such as Delta and United also quote a round-trip ticket at a cheaper price than two one-way tickets.

substantial changes in the share of round-trip fares on a route over time, as shown in Figure 1. This cannot be captured by time fixed effects and carrier-route fixed effects as specified in the existing literature (e.g. Gerardi and Shapiro (2009) and Dai, Liu and Serfes (2014)) and estimates suffer from the omitted variable bias.

In order to study the causal effect competition on price dispersion, the instrumental variable approach relies on the assumption that, conditional on the controls, the instruments used only affect price dispersion through the competition measures. We follow BR and GS approach and use the same set of instruments and conduct the following robustness checks to address the concerns on the use of these instruments. The first one is that the arithmetic and geometric means of the metropolitan population of end point cities used in BR and GS may affect price dispersion on the route between these two end point cities through the potential correlation between population and income. To address, in our robustness checks, we control for the GDP of the two end cities on a route over time. In cases when cities are small and we cannot obtain their GDP data from the BEA, we use the GDP data from the MSA closest to these cities.

The second concern about the instruments used by BR and GS is that the total enplaned passengers on a route at a time may directly affect price dispersion through its effect on airline's entry and pricing decisions on the route. To address this, in our robustness checks, we replace it with the BLP-style instrument (Berry, Levinsohn, and Pakes (1995)): the average number of enplaned passengers in other routes.

The last concern about the instruments used by BR and GS is that IRUTHERF, a measure based on the market shares, may have a direct impact on price dispersion. In practice, this is not a problem as long as we assume that "the concentration of the flights on a route that are not performed by the observed airline is exogenous with respect to the price of the observed carrier" (BR, pp680). Nevertheless, to be cautious, our analysis addresses this by controlling for: (i) carrier-time fixed effects that capture changes in carriers over time and (ii) weather variables that serve as cost shifters on a route and capture other changes over time on a route that could affect demand for tickets.

To better understand the underlying mechanisms, we provide several additional results. First, we explore the importance of directions by constructing a measure of relative price dispersion between $A \to B$ ($A \rightleftharpoons B$) and $B \to A$ ($B \rightleftharpoons A$) for one-way (round-trip) products. In both one-way and round-trip products, the effect of competition on the relative price dispersion measure is positive and significant. This suggests that direction matters when it comes to estimating the effect of competition on the price dispersion in a route. In addition, an increase in competition leads to price dispersion in one direction to be increasing faster than the price dispersion in the other direction. Therefore when combining both one-way and round-trip products together and dropping one direction, the positive effect of competition on price dispersion in one-way products and the insignificant effect on price dispersion in round-trip products lead to an overall insignificant effect of competition on price dispersion from 1993 to 2013.

Finally, we provide suggestive evidence that one-way products have higher markups than round-trip products between the same origin and destination city. We construct the one-way cost of a round-trip based on the sum of one-way tickets in each direction, and find that at both the 10th and 90th percentile of price distribution, one-way tickets are more expensive than round-trip tickets between the same origin and destination city. This may be the reason that low cost carriers (LCC) are more likely to compete in one-way products than in round-trip products. [6]

To summarize, in one-way products, we find support for BR's original theory that the effect of competition on price dispersion is positive, characterized by two phenomena that may be driving the results on the upper and lower tail of the price distribution. First, airlines compete more aggressively in the bottom tail of the price distribution from disproportionate entry of LCCs in one-way products. Second, there has been a series of mergers of legacy airlines, namely, US Airways' merger with America West in 2005, Delta's merger with Northwest in 2010, United Airlines' merger with Continental in 2012, and American Airlines' merger with US Airways in 2013. Mergers allow legacy carriers to cover even larger networks and increase the value of their frequent flyer programs, especially to business travelers. Low cost carriers (LCCs), on the other hand, have much smaller

[6] For example, Southwest airline is a LCC and is a major seller of one way tickets. In our data, 50% of Southwest sales is in one-way tickets since 2010.

and much less attractive frequent flyer programs. Consequently, legacy carriers after mergers derive higher market power and maintain the ability to charge high fares to their frequent flier customers. More aggressive competition in the bottom tail of the price distribution, coupled with airlines' ability to cultivate brand loyalty among their high-paying customers, leads to higher price dispersion from increased competition in one-way products. In round-trip products, we do not find the negative effect of competition on price dispersion to be robust after controlling for carrier-time fixed effects.

Our findings contribute to several literatures. This paper is closely related to BR and GS. Both papers examined price dispersion in the airline industry but ended up with opposite findings. Dai, Liu and Serfes (2014) argue that there is a non-monotonic relationship between competition and price dispersion from 1993 to 2008.[7] Stavins (2001) find that as competition increases, price dispersion increases due to restricted tickets. Earlier studies such as Alam, Ross and Sickles (2001) document that airlines have significant market power in a large number of routes. Busse and Rysman (2001) study the relation between competition and price discrimination in Yellow Page advertisements. Williams (2018), Aguirregabiria and Ho (2012), Mantin and Koo (2009), and McAfee and Te Velde (2006) study competition and pricing dynamics.

Price discrimination in the airline industries arises for many reasons reasons, such as the date of purchase (e.g. Alderighi, Nicolini, and Piga 2015, Puller and Siegert and Ulbricht 2014, Lazarev 2013, Taylor 2012, Gaggero and Pigga 2011, and Dana 1998), peak-load pricing or exogenous shifts in demand (e.g. Cornia, Gerardi and Shapiro 2011, Carlton 1997, Gerstner 1986, and Panzar and Willlig 1981), seat availability (Alderighi, Nicolini, and Piga 2015). On the other hand, Puller, Sengupta and Wiggins (2015) find that scarcity of seats does not affect price dispersion and only modestly affects fare levels. Kim, Liu and Rupp (2018) find that seat pitch, aircraft amenities and flight schedules have no significant impact on the average economy class fares for each seat class after controlling for aircraft types.

More generally, this paper contributes to a line of research that relies on precisely defining the extent of a market. In mergers and acquisitions, the FTC and DOJ investigate the competitive

[7]We also check for non-monotonicity but do not find the effect to be significant.

effects of such transactions based on the relevant companies' market shares. In order to do so, the FTC and DOJ need to first define the market (FTC 2016).[8] In addition, the findings in this paper may also be extended to study the price discrimination behavior in other industries, such as the automobile industry where SUVs and compact cars may be considered as differentiated products and each commuting zone may be considered a different market.

The rest of the paper is structured as follows. Section 2 contains a detailed discussion of the data and definition of a market. Section 3 discusses the empirical specifications. Section 4 reports the results, and section 5 explores the underlying mechanisms. In section 6, we present conclusions.

2 Data

2.1 Industry background

The U.S. domestic airline industry is one of the most dynamic, complex, and diverse markets. On average, about 100 certificated U.S. commercial airlines operate over 11.2 million flight departures per year, and recently its traffic accounts for one third of the world's total air traffic. In terms of volume, U.S. airlines deliver about 31,000 domestic flights per day, and the U.S. commercial airline business takes up about 8% of the U.S. GDP.[9] The US domestic aviation market is also noteworthy for periods of regulations and deregulations over the last 80 years. The biggest turning point in the U.S. aviation market is arguably the Airline Deregulation Act in 1978.

Since the deregulation in 1978, many new carriers emerged and as a consequence competition in the U.S. domestic aviation market increased. Low cost carriers (LCCs) started up their businesses and entered into the competitive and deregulated U.S. airline industry. Low cost carriers' pricing strategy is very aggressive in providing discounts and promotions in ticket fares. To combat the emergence of low cost carriers, legacy airlines strategically developed alliances through code-sharing

[8]For example, in 2007, FTC filed an injunction against the acquisition of Wild Oats by Whole Foods because the two companies are the largest operators in the "premium, natural, and organic" supermarkets. Whole Foods, by contrast, asserted that the relevant product market is all supermarkets, because many supermarkets, such as Walmart, sell organic foods.

[9]According to Air Transport Association of America (ATA), Statement on the State of the Airline Industry, Statement for the Record of the Sub-committee on Aviation, Transportation and Infrastructure Committee, US House of Representatives

and capacity agreements with other airlines and attempted to lower costs (e.g. Gayle (2008) and Brueckner (2003)). Figure 2 shows a sharp rise in the average number of LCCs per route, weighted by the of number of passengers. In addition, there is an increase in competition per route over time. Figure 3 shows that the average number of carriers per route over time is increasing over time, and this increase is predominantly driven by an increase in LCCs.

2.2 Data sources and variable construction

We study domestic, direct, economy class airline tickets from 1993:Q1 to 2013:Q4. Our sample includes on average 36 domestic carriers, among these are the large legacy carriers American, United, Continental, Delta, TWA, Northwest and US Airways as well as low cost carriers (LCCs), such as Southwest, JetBlue, Spirit and regional carriers.[10] Ticket prices are obtained from the DB1B database, a 10% random sample of all domestic tickets sold by airlines. The sample, constructed based on the DB1B database, contains a number of variables, including prices, origin, destination, number of passengers (per ticket), number of planes changes, distance, and a round-trip indicator. We obtain route characteristics from the BTS T-100 data and construct a proxy for peak-time operation based on the OTP data from DB1B. Our data construction follows GS closely and therefore we leave the details to the Appendix on a more comprehensive discussion of data sources and variable constructions.

We first define a route as it is defined under GS, where a route includes both round-trip and one-way fares. One direction in the route is always dropped to avoid double counting, and the round-trip fare is divided by two to count as the one-way fare. GS definition of a route is denoted by both one-way and round-trip route in our empirical results. We then distinguish between one-way and round-trip products. We define one-way products to include only one-way fares. For example, ticket fares between PHL to MCO (Philadelphia to Orlando, PHL→MCO) are included in the one-way products between these two cities if the round-trip indicator in the DB1B database is 0. The other direction in this route, MCO→PHL, is dropped. We define round-trip products

[10]We follow the LCC specification introduced in Ito and Lee (2003). The list of legacy carriers and low cost carriers is available upon request.

to include tickets fares from PHL to MCO and back (PHL$\rightleftharpoons$MCO) if the round-trip indicator is 1, and drop the other direction MCO$\rightleftharpoons$PHL. Next, we take directions into account. In directional one-way trips, PHL$\rightarrow$MCO and MCO$\rightarrow$PHL are considered to be two separate routes and both directions are included in the directional one-way sample. In directional round-trips, PHL$\rightleftharpoons$MCO and MCO$\rightleftharpoons$PHL are considered to be two separate routes and both directions are included in the directional round-trip sample.[11]

We utilize data on GDP in origin and destination cities from the Bureau of Economic Analysis (BEA) as additional controls to study the effect of competition on price dispersion.

Our calculation of the Gini coefficient to measure price dispersion follows BR and other studies of airline pricing and is equal to twice the expected absolute difference between two ticket prices drawn randomly from the population. An increase in the Gini coefficient suggests an increase in price dispersion. A Gini coefficient equal to 0 means that every passenger pays the same price. Note that in our baseline estimates, we follow GS and include regional airlines in the sample. Following GS, price dispersion is calculated based on the tickets sold by the ticketing carrier, not by the operating carrier. This is relevant in the case of some regional airlines where all their tickets are sold by another ticketing carrier; in this case, there is no price dispersion constructed for this regional airline on this route, and instead, these tickets enter into the price dispersion constructed for the ticketing carrier. The competition measures on this route are also adjusted accordingly. In this case, the regional airline does not enter into the construction of the competition measures if the regional airline sells all of its tickets through another ticketing carrier. Many airline related papers drop regional airlines because their tickets are sold by other ticketing carriers. This is not a concern in the construction of the price dispersion in our sample because we credit these tickets to the price dispersion of the ticketing carrier and adjust the competition measures accordingly. Nevertheless, in our robustness checks, we drop price dispersion observations from regional carriers (even though the tickets used to construct price dispersion for these regional airlines are sold by themselves) and adjust the competition measures accordingly, and find the results to be similar to

[11]We also repeat our analysis for big-city routes as done in the GS study and our results for big-city routes are similar to to those for all routes. These results are available upon request.

our baseline results.

The Gini coefficient, a measure of price dispersion, is calculated based on ticket fares and the number of passengers at each fare level within a ticketing carrier in a route. It is affected by what tickets are included. Therefore, we first discuss why it is important to make the distinction between one-way vs. round-trip products.

2.3 Distinction between one-way and round-trips

The proportion of one-way tickets to round trip tickets has been steadily growing since early 2004 as shown in Figure 1.[12] The difference between the fraction of one-way tickets in 2002 and 2010 is about 10 percentage points. This coincides with a disproportionate increase in the entry of LCCs in one-way routes. For example, Southwest Airlines emerged and is well-known to be a seller of one way tickets (Mueller and Hüschelrath (2011)). While round-trip tickets are bound by the airline tariff rules, one-way tickets are more flexible. This means that consumers who value flexibility might prefer one-way ticket.

Table 1 reports the summary statistics on the Gini coefficient, three measures of competition, and airline carriers' characteristics. We measure competition in three ways. First, we use the Herfindahl index (HERF) of a given route j at time t as a measure of market concentration. An increase in HHI implies an increase in concentration, which means that there is less competition. Therefore, we use -ln HERF to measure competition. An increase in -ln HERF indicates more competition. For robustness purposes, we also employ the logarithm of the number of competitors operating on route j in time t. Lastly, we distinguish between the number of legacy and low-cost carriers on a route.[13] Airline carriers' characteristics include if the airline carrier is undergoing mergers or filing bankruptcy.[14]

[12] Note there are some ups-and-downs in the share of round-trip products over time in Figure 1. As a result, in one of our robustness checks not reported in this paper, but available upon request, we drop the transitional years from 2003 to 2007 and find the results to be similar to our baseline results.

[13] N_{jt} is the number of competitors and is equal to zero if the airline is a monopoly in route j at time t. In addition, $N_{jt} + 1 = N^{LEG} + N^{LCC}$. It is also worth mentioning that our results are not affected if we use total number of carriers on a route in place of the number of competitors as one measure of competition.

[14] Airlines' bankruptcy time line is presented in the Appendix. It is a list of carriers including all legacy, regional and LCCs that have filed for bankruptcy protection through Chapter 11 in the United States. The bankruptcy case under Chapter 7 is not included in the construction of the bankruptcy variable in this study because those

In panel A, we define a route to include both one-way and round-trip fares (divided by two) in one direction and calculate the corresponding Gini coefficient and competition measures.[15] In panel B, we define a route based on one-way fares in one direction. In Panel C, we define a route based on round-trip tickets in one direction. It is worth pointing out that the average number of LCCs in round-trip routes is much lower than the average number of LCCs in one-way routes. The Gini coefficient is also significantly higher in one-way markets than it is in round-trip markets. If the effect of competition on price dispersion have different effects on one-way and round-trip products, combining one-way and round-trip tickets may lead to omitted variable bias. We explain the potential bias in detail in section 4.2

While the overall trend in the data shows that one-way and round trip markets are different, we next demonstrate the difference with a representative route. We look at the correlation between competition and price dispersion for a route operated by US Airways from Philadelphia (PHL) to Orlando (MCO). We calculate the Gini coefficient as a measure of price dispersion and the Herfindahl index as a measure of market concentration based on one-way and round-trip tickets, respectively. We then plot the log odds ratio of Gini coefficient on the y-axis and the logarithm of Herfindahl Index multiplied by -1 on the x-axis for one-way in Figure 4a and round-trip in Figure 4b.[16] An increase in -ln Herfindahl Index implies a decrease in market concentration, or an increase in competition. An increase in the log odds ratio of Gini coefficient implies an increase in price dispersion. Figure 4a shows a strong and positive relationship between competition and price dispersion based on one-way tickets. As shown, in one-way tickets, for a route from PHL to MCO, an increase in competition is associated with an increase in price dispersion. Similarly, figure 4b shows a strong and negative relationship between competition and price dispersion based on round-trip tickets.

Our sample, based on both one-way and round-trip products for a route in one direction,

happened outside the timer period of our sample. There have been only two cases through Chapter 7: National Florida in December 1980 and Evergreen International Airlines in December 2013.

[15]The summary statistics for panel A before 2007 are very similar to those presented in GS (2009). These are available upon request.

[16]Plotting Gini coefficients and -Herfindahl Index gives similar figure in one way and round-trip market, respectively. Figure 5 used the log version because we follow GS in our empirical strategy and used log odds ratio of Gini as the dependent variable, and -ln Herfindahl index as the independent variable, outlined in detail in section 3.

contains 52 different carriers with 4900 distinct carrier-route observation in 2470 distinct routes over the 84 quarters between 1993 and 2013. In one-way products, there are 49 carriers with 3226 distinct carrier-route observations in 1662 routes in one direction. For example, US Airways operating in PHL→MCO is included and US Airways in MCO→PHL is dropped. There are 48 carriers, 4232 carrier-routes, and 2098 routes in the round-trip sample. In the directional one-way sample, there are 49 carriers, 6416 carrier-routes, and 2280 routes, where a route operated by US Airways in PHL→MCO is considered a different route than US Airways in MCO→PHL, and both directions are included. In the directional round-trip sample, there are 48 carriers, 8433 carrier-routes, and 3324 routes, where a route operated by US Airways in PHL⇌MCO is considered a different route than US Airways in MCO⇌PHL. In the next section, we explain the empirical strategy and study the relationship between competition and price dispersion with statistical rigor.[17]

3 Empirical strategy

We follow GS and start by first considering the Gini coefficient. Then we examine the effect of competition on the 10th and 90th percentile of the price distribution. Analyzing the top and bottom of the price distribution separately provides information regarding the source of the change in price dispersion.

As in GS, let the Gini log-odds ratio be given by $G_{ijt}^{lodd} = ln(G_{ijt}/(1-G_{ijt}))$. The Gini log-odds ratio is unbounded by construction.[18] The main model specification is:

$$G_{ijt}^{lodd} = \alpha + \beta\ Competition_{jt} + \gamma_{ij} + \kappa\ X_{it} + \delta_t + \varepsilon_{ijt} \tag{3.1}$$

where the Gini coefficient captures the price dispersion of carrier i in route j at time period t. We measure $Competition_{jt}$ in three ways. First, we use the Herfindahl index of a given route as

[17] Less than 10% of the tickets are sold by small regional airlines. Prince and Simon (2017) focused their analysis on the top 10 airlines, our results on competition and price dispersion are not affected if we restrict our sample to top 10 airline carriers. These results are available upon request.

[18] The estimation results are not sensitive to this transformation because the Gini coefficient in any route is not close to 1 in the sample.

a measure of market concentration. For robustness purposes, we also employ the logarithm of the number of competitors operating on route j in time t.[19] Lastly, we distinguish between the number of legacy and low-cost carriers using the logarithm of the number of legacy and low-cost carriers, respectively, on a route.

In X_{it}, in addition to controlling for whether an airline i is in bankruptcy at time t as done in GS, we also control for whether airline i is merging at time t. This is relevant because previous studies analyzed the effect of competition on price dispersion in the airline industry before a series of mergers happened. We include carrier-route fixed effects, γ_{ij}, to control for time-invariant carrier route characteristics. Throughout all the regression specifications, we control for exogenous cost and stochastic demand effects through a full set of year-quarter dummies, δ_t. We cluster standard errors by route to account for serial correlation and correlation between pricing decisions of carriers on the same route.

Since the Herfindahl index is constructed based on airlines' market shares on a route and market shares are dependent on prices, there are endogeneity concerns for the competition measures. To resolve the endogeneity problem, we follow GS and use the instrumental variable approach throughout this paper. Specifically we instrument the competition measures with following: the arithmetic means of the metropolitan population of end point cities, the geometric means of the metropolitan population of end point cities, the log of total enplaned passengers on route j in time t, and IRUTHERF from BR, an instrument based on the square of the fitted value of carrier i's market share in route j at time t from its first-stage regression, plus the rescaled sum of the squares of all other carrier's shares.[20] Note that BR and GS' list of instruments also included the log distance on a route. Since distance only varies by route and not over time, it is absorbed by the carrier-route fixed effects in our specification. See Appendix B for a detailed description of the instruments.

Causal inference using the instrumental variable approach relies on the assumption that, con-

[19]We also used the logarithm of the total number of carriers operating on route j in time t. The results are very similar and are available upon request.

[20]IRUTHERF has been used as the main instrument for HERF, for example, Borenstein (1989), Borenstien and Rose (1994) and Gerardi and Shapiro (2009).

ditional on the controls, the instruments used only affect price dispersion through the competition measures. There are several concerns with this assumption. The first one is that the arithmetic and geometric means of the metropolitan population of end point cities used in BR and GS may affect price dispersion on the route between these two end point cities through the potential correlation between population and income. To address, in our robustness checks, we control for the GDP of the two end cities on a route over time. In cases when cities are small and we cannot obtain their GDP data from the BEA, we use the GDP data from the MSA closest to these cities. The second concern about the instruments used by BR and GS is that the total enplaned passengers on route j in time t may directly affect price dispersion through its effect on airline's entry and pricing decisions on the route. To address this, in our robustness checks, we replace it with the BLP-style instrument (Berry, Levinsohn, and Pakes (1995)): the average number of enplaned passengers in routes other than j. Results are similar to the baseline results.[21] The last concern about the instruments used by BR and GS is that the measure based on the market shares, IRUTHERF, may have a direct impact on price dispersion. In practice, this is not a problem as long as we assume that "the concentration of the flights on a route that are not performed by the observed airline is exogenous with respect to the price of the observed carrier" (BR, pp680). Nevertheless, to be cautious, our analysis addresses this with additional carrier-time fixed effects that capture changes in carriers over time and weather variables that capture other changes over time on a route that could affect demand and therefore price dispersion. We discuss these controls in detail in Section 4.3.

The use of Gini coefficient as a dependent variable allows for a more direct interpretation of the effect from competition on price dispersion. However, one statistic often does not disclose the full picture on the entire distribution. For example, Gini coefficient can increase because the lower portion of the price distribution falls more than the upper portion, or it can increase because of a rise in the upper portion relative to the lower portion. In order to better understand the effect of

[21]We did not include the variable GENSP, i.e. geometric mean ratio of average quarterly enplanement at the two end point airports in GS. The Cragg-Donald statistic for all instruments excluding GENSP is relevant at the 1% level. Results are not affected by the inclusion of GENSP as an additional instrument and these results are available upon request. See Appendix B for a detailed description of the instruments.

competition on the price distribution, we follow GS and estimate the following regressions:

$$p(k)_{ijt} = \alpha + \beta \; Competition_{jt} + \gamma_{ij} + \kappa \; X_{it} + \delta_t + \varepsilon_{ijt} \tag{3.2}$$

where $p(k)$ denotes the log price at k =10th or k =90th percentile of the price distribution. If brand loyalty among high-paying customers dominates, an increase in the level of competition on a given route will decrease the prices at the 90th percentile of the distribution more than those in the 10th percentile, therefore increasing the overall degree of price dispersion. If, on the other hand, the textbook theory of competition lowering price discrimination dominates, an increase in competition will decrease the 90th percentile prices more than the 10th percentile prices.

4 Baseline estimates

4.1 Both one-way and round-trip in a route

We begin the analysis by first reporting the estimates of equations (3.1) and (3.2) for routes defined in GS. That is, for a route between PHL and MCO, the price dispersion is calculated using both round-trip fares and one-way fares. For round-trip fares, fares for PHL$\rightleftharpoons$MCO are divided by two. In addition, for both one-way and round-trip fares, one direction is dropped.[22]

Panel A in Table 2 contains estimation results for equation (3.1) using the Gini coefficient as the dependent variable. Panels B and C report the estimation results for equation (3.2) using the 10th and 90th percentiles of the price distribution as the dependent variables. A hat on the variable indicates the use of instrument variable estimation. All instruments are relevant at the 1% level as measured by the Cragg-Donald statistic.[23]

Column (1) in Panel A reports the effect of an increase in competition, measured by market concentration $-\ln \widehat{HERF}$, on price dispersion is negative but insignificant from 1993 to 2013. In order to make a comparison of our results to those in GS, we limit the sample to the same years

[22]One direction is dropped based on a random draw.

[23]Results on big-city routes are reported in the Appendix. Results on leisure-routes are similar and are available upon request.

used in GS, from 1993-2006. Between 1993 and 2006, we are able to replicate the results from GS and find the effect of competition on price dispersion to be negative and significant.

Next, we take a closer look at the estimates from the percentile regressions. If competition leads to more price dispersion, we would expect the negative effect of competition on the 10th percentile of the price distribution to be larger in magnitude than its effect on the 90th percentile of the price distribution. If competition leads to less price dispersion, we would expect the opposite, that the decrease in the 90th percentile of the price distribution to be larger in magnitude than the 10th percentile of the price distribution. The estimates in column 1 in Table 2 Panel B and C show that the effect of an increase in competition on the 10th percentile of the price distribution is not significantly different from the effect on the 90th percentile of the price distribution. This is driving the result in Panel A that competition *does not* lead to lower price dispersion between 1996 and 2013. For 1993-2006, we find in column 4 the effect of competition on the 10th percentile of the price distribution is significantly smaller in magnitude than the effect on the 90th percentile of the price distribution, leading to the negative effect of competition on price dispersion.

Using different measures of competition, including the logarithm of the number of competitors on a given route[24] and the number of LCCs and legacy carriers on a given route,[25] Columns 2-3 and 5-6 also present the dichotomous results between the two periods. The effect of competition on price dispersion is negative and significant from 1993-2006, and the effect is not significant from 1996-2013.

One possible explanation for the above results is that the effects of competition on one-way and round-trip products may be different. As the share of one-way products rises, the estimates above suffer from the omitted variable bias and the coefficient of interest is biased towards zero in the full panel. The effects of competition on one-way and round-trip products may be different because the distribution of consumer demand elasticity may be different for one-way vs. round-trip products. For example, round-trip tickets are bound by the airline tariff rules that requires travelers to use

[24]For routes that are operated by only one carrier are dropped because the number of competitors is zero, thus the difference in the number of observations in column 1 and 2.

[25]The number of LCCs (N^{LCC}) and number of legacy carriers (N^{LEG}) cannot be instrumented because relevant instruments have to be correlated with N^{LCC} and N^{LEG} distinctly, therefore we follow GS and report those with OLS estimations.

all portions of a ticket or risk having the next leg of their trip canceled under what airlines call non-sequential use of ticket segments while one-way tickets are more flexible. On the one hand, consumers who value flexibility, especially in the case of business travelers who are relatively price inelastic, may prefer one-way tickets. This represents a higher share of price inelastic consumers for one-way products than round-trip products. On the other hand, consumers who are price sensitive may choose to "mix and match" airlines for their trip and purchase one-way ticket from an airline one way and another one-way ticket from another airline on the way back as opposed to purchasing a round-trip ticket from the same airline. In this case, this represents a higher share of price elastic consumers for one-way products than round-trip products. In addition, it is possible that both are true for one-way products, i.e. there are higher shares of very price inelastic and very price elastic consumers, and little share of consumers with intermediate level of price elasticity. In other words, a firm in a route is facing heterogeneous consumers and the distribution of consumers' demand elasticities in round-trip products may be second-order stochastic dominant over the distribution of consumer demand elasticities in one-way products. Firms take this into account and can offer one-way and round-trip tickets on the same route as differentiated products, and the effect of competition on price dispersion for one-way vs. round-trip may be different.

4.2 One-way vs. round-trips

Estimations of equations (3.1) and (3.2) are based on a panel analysis that exploit time variation along a carrier-route by controlling for carrier-route fixed effects and aggregate time trends through time fixed effects. However, if a route is not carefully defined, carrier-route fixed effects cannot fully capture carrier-route specific shocks. This leads to two problems in the estimation of the effect of competition on price dispersion. First, because price dispersion and the 10th and 90th percentile of the price distribution are calculated based on what ticket fares are included, including both one-way and dividing round-trip fares by two leads to measurement errors on the dependent variable. Measurement error on the dependent variable alone does not generate biased estimates if it is not correlated with the independent variables and the error term, but only gives rise to bigger standard errors (Wooldridge 2010). However, if the measurement error on the dependent variable is correlated with the share of round-trip tickets offered by a carrier i on route j at time t, we end up with omitted variable bias in the estimated coefficients. Second, for a route j at time t, defining a route that includes both one-way and round-trips may lead to measurement error on the competition measures if some carriers only sell their tickets as one-way tickets as opposed to selling both one-way and round-trip tickets. Because the share of round-trip fares on a route changes over time, this effect cannot be captured by time fixed effects and carrier-route fixed effects. This leads to omitted variable bias on the estimated coefficients. Therefore, we first distinguish between one-way and and round-trip products. Price dispersion in one-way route is calculated using only one-way fares in one direction while the fares in the other direction are dropped. Similarly for a round-trip route, round-trip fares originating from one direction are included to calculate the price dispersion.

Table 3 reports the estimation results for equations (3.1) and (3.2) for one-way routes using the three competition measures. Columns 1 and 4 show that for both the full sample and the period between 1993-2006, an increase in competition, measured by the Herfindahl index, leads to more price dispersion.[26] Focusing on Panels B and C, columns 1 and 4 suggest that the increase in price dispersion is driven by a bigger decrease in the 10th percentile of the price distribution than the decrease from the 90th percentile of the price distribution.

Competition measured in the number of competitors confirms the results in columns 1 and 4. Columns 2 and 5 suggest that competition has a positive effect on price dispersion from 1993-2013 and from 1993-2006. However, competition measured in the log number of low-cost carriers has a negative effect on price dispersion and the log number of legacy carriers has no significant effect on price dispersion. One potential explanation for the negative effect from the number of low-cost carriers on price dispersion in one-way products could be that because we cannot separately instrument for the number of low-cost carriers and the number of legacy carriers, the OLS estimates are biased due to omitted variables. We later show that once we control for changes that vary over carriers and time using carrier-time fixed effects, the effect of an increase in the number of

[26]We would expect to observe larger effects from competition on price dispersion on big-city routes, where we have more price-inelastic consumers. We limit the sample to big-city routes and repeat our analysis in Tables 3-8. The effect is in fact stronger for one-way products in big-city routes. These results are available upon request.

low-cost carriers on price dispersion becomes positive. We discuss the full set of robustness checks in section 4.3.

Table 4 reports the estimation results for equations (3.1) and (3.2) for round-trip products using the three competition measures. In the full sample, column 1 suggests that an increase in competition leads to less price dispersion in round-trip products. The negative effect is robust to other measures of competition, as shown in columns 2 an 3. The decrease in the price dispersion is driven by by a larger decrease in the 90th percentile price level than in the 10th percentile. Similarly, in the 1993-2006 subsample, we also find that an increase in competition leads to less price dispersion for round-trip products, and this finding is robust to different measures of competition.

Tables 2-4 present the results from the full sample from 1993-2013 and the subsample from 1993-2006 which is used in GS for comparison reasons. If the effect of competition on price dispersion is different for one-way products compared to the round-trip products, then the share of round-trip products offered by airline carriers on a route may affect the price dispersion for that carrier i in a route j at time t when we combine one-way and round-trip products. Based on Figure 1, the fraction of round-trip tickets to total tickets starts to decline in 2005. We split the full sample and check for the results for years 1993-2005 and find similar results to those in Tables 2-4. In addition, based on Figure 4, one could also argue that between 2003 to 2007 there appears to be a significant amount of transitioning in terms of airlines offering fewer round-trip tickets. We drop the transitional years from 2003-2007, repeat the analysis for Tables 2-4, and find similar results to those in Tables 2-4. These results are available upon request.

In the next section, we discuss in detail the additional controls we include to ensure that the effect of competition on price dispersion is causal and different for one-way and round-trip products.

4.3 Robustness

We now check the robustness of our results. In each of the following robustness checks, we build on the previous robustness checks by adding additional controls. We first examine the sensitivity of the baseline estimates on the one-way products and round-trip products to the inclusion of GDP variables for two end point cities on each route. In cases when cities are small and we cannot obtain their GDP data from the BEA, we use the GDP data from the MSA closest to these cities.[27] In addition, in the instruments, we use the BLP-style instrument, the average number of enplaned passengers in routes other than j, to replace the total number of enplaned passengers on a route. Estimates are reported in Table 5. Columns 1-6 report estimates for one-way products and columns 7-12 report estimates for round-trip products. As shown, the estimates are similar to the baseline estimates and we continue to find the positive effect of competition on price dispersion in one-way products and the negative effect of competition on price dispersion in round-trip products when competition is measured by the Herfindahl Index and the number of competitors on a route. Note that the OLS estimate of the effect of the number of LCC on price dispersion in one-way products remains negative, and we show later that with additional controls, this becomes positive.

Second, we check the robustness of our estimates in Table 5 to the use of an alternative sample. Our baseline sample includes legacy, low-cost and regional carriers from 1993 to 2013. One concern with the sample is the treatment of regional carriers as separate carriers. In our baseline estimates, we try to construct the sample as closely as the sample constructed in GS, which treated regional carriers as separate carriers. However, other airline-related literature ignore regional carriers since tickets from these airlines are sold by ticket carriers (for instance, United Airline is the ticketing carrier for Air Wisconsin, a regional airline). To address this concern, we drop the regional carriers and re-calculate the competition measures based on only legacy and low-cost carriers and report the estimates in Table 6, while controlling for the GDP at end point cities over time and the enplanement IV from other routes. As before, columns 1 to 6 report the results for one-way products and columns 7 to 12 report the results for round-trip products. The estimates are similar to the baseline estimates and we continue to find the positive effect of competition on price dispersion in one-way products and the negative effect of competition on price dispersion in round-trip products when competition are measured in the Herfindahl Index and number of competitors on a route.

We next check the robustness of our estimates from Table 6 to control for other changes that affect carriers occur over time, such as changes in carrier-specific costs, technology, and access

[27]For small cities with missing GDP on a route, instead of using the GDP from the nearby MSA, we also drop those routes and find the results to be similar. We also use the average GDP of the two end cities instead of one GDP variable for each end point city and find the results to be similar. These are available upon request.

to credit markets, with carrier-time fixed effects. Carrier-time fixed effects will absorb the main effects of bankruptcy and merger dummies and time fixed effects. Results are reported in Table 7. The positive effect on one-way products remains. In addition, as shown in columns 3 and 6, the effect of competition measured in the number of low-cost carriers becomes positive for one-way products. However, columns 7-8 suggest that the effect of competition on price dispersion is no longer significant in round-trip products for the entire sample period. The negative remains though for round-trip products during the GS sample period.

Finally, there may exist other changes happening on a route over time that could affect price dispersion for a carrier on that route, even after controlling for the variables mentioned above. We cannot include route-time fixed effects because the variable of interest, namely the competition measure, varies over route and time. To address this concern, we use weather variables on a route over time, including precipitation, snowfall, minimum and maximum temperatures, to control for other changes on a route over time that could affect demand and therefore the price dispersion. In addition, the weather variables are also proxies for cost shifters that could affect airlines' operational cost over time on a route. Results are reported in Table 8. Columns 1-3 suggest that the positive effect of competition on price dispersion remains for one-way products for all three measures of price dispersion, and this is driven by a larger decrease in the bottom 10th percentile of the price distribution from 1993-2013. The effect for round-trip products, however, remains insignificant.

In the next section, we further make the distinction based on directions. Flights originating from A to destination B often have different prices than flights originating from B to destination A. Dropping one direction may lead to sample selection bias. There are four possible products between A and B, two in round-trips: $A \rightleftarrows B$ and $B \rightleftarrows A$, and two in one-ways: $A \to B$ and $B \to A$. As explained in Mayer and Sinai (2003), routes are directional to allow for prevailing winds and other physical differences in travel, so we consider PHL→MCO to be a different route than MCO→PHL and these routes enter into the directional one-way sample as two separate observations. Both routes PHL⇄MCO and MCO⇄ PHL enter into the directional round-trip sample as two separate observations. Instead of using GDP from two end cities as controls, we now can distinguish between the origin and destination city GDP and control for demand in directional one-way and directional round-trip products.

4.4 Directional routes

Because origin and destination cities on a given route have different GDP and GDP growth rate over time, there may exist systematic differences in the price distribution on a given route based on direction of the flight.[28] We control for the characteristics of the origin and destination using origin and destination cities log GDP and estimate the following regressions:

$$G^{lodd}_{ijt,direction} = \alpha+\beta_1 Competition_{jt}+\theta_1 Origin_{jt}+\theta_2 Destination_{jt}+\gamma_{ij,direction}+\kappa_{it}+Weather_{jt}+\delta_t+\varepsilon_{ijt}. \tag{4.1}$$

where $Origin_{jt}$ and $Destination_{jt}$ are measured using the origin and the destination city's log GDP on route j at time t, respectively. $\gamma_{ij,direction}$ is the carrier-route fixed effect for each direction and controls for time-invariant directional carrier-route characteristics. κ_{it} is the carrier-time fixed effect and controls for carrier-specific changes over time. $Weather_{jt}$ controls for other changes on a route over time that could affect demand and therefore affect carrier i's price dispersion on route j at time t.

In addition to using the Gini coefficient as the dependent variable, we estimate the following regressions:

$$p(k)_{ijt,direction} = \alpha+\beta_1 Competition_{jt}+\theta_1 Origin_{jt}+\theta_2 Destination_{jt}+\gamma_{ij,direction}+\kappa_{it}+Weather_{jt}+\delta_t+\varepsilon_{ijt} \tag{4.2}$$

for the log price at the 10th and 90th percentiles of the price distribution. If the effect from brand loyalty among high-paying customers dominates, an increase in the level of competition on a given route will decrease the prices at the bottom 10th percentile of the distribution more than those

[28] A→B and B→A are considered as two separate routes in a directional route and as one route in a non-directional route. The literature has used both directional and non-directional routes in the past without distinguishing one-way vs. round-trip. For non-directional routes: Borenstein (1991), Mazzeo (2003), Forbes (2008), Forbes and Lederman (2009), and Goolsbee and Syverson (2008). For directional routes, Roberts and Sweeting (2012), Mayer and Sinai (200), Prince and Simon (2014), Forbes and Lederman (2010), and Berry and Jia (2008).

at the 90th percentile, therefore increasing the overall degree of price dispersion. If, on the other hand, the textbook theory of competition lowering price discrimination dominates, an increase in competition will decrease the 90th percentile prices more than the 10th percentile prices.

Table 9 reports the results on directional one-way products using equations (4.1) and (4.2). The sample used for estimating equation (4.1) and (4.2) is smaller than the sample in Table 8. This is because GDP is not available for smaller origin/destination cities, which significantly reduces the sample for estimating equation (4.1) and (4.2).[29] Using all the controls used in Table 8, we report the results for directional one-way products and round-trip products in Table 9. Estimates from columns 1-3 suggest that an increase in competition leads to more price dispersion using all three measures of competition in Panel A for the full sample period. The effect is positive for the period from 1993-2006, but is only significant when competition is measured by the number of competitors. Panel B and C show that the positive effect on price dispersion is driven by a larger decrease in the bottom 10th percentile of the price distribution than the decrease in the 90th percentile of the price distribution.

Columns 7-12 report the results on directional round-trip products using equations (4.1) and (4.2). Panel A shows that an increase in competition, using all three measures, in the full panel, does not have significant effect on the price dispersion, except in the case when competition is measured in the number of competitors in column 8. Suffice to say, the negative effect of competition on price dispersion on round-trip products is not very robust.

5 Underlying mechanisms

5.1 Direction

Having established that the effect of competition is different in one-way vs. round-trip and directional routes, next we explore the underlying mechanism by studying the effect of competition on the relative price dispersion in directional routes. The price distribution on a route served by the

[29]We re-estimate regressions for equation (3.1) and (3.2) for one-way and round-trip products using the reduced sample in Table 9, and find the direction of the effect of competition on price dispersion is not affected. These results are available upon request.

same carrier in the same period varies substantially by direction. We calculate the Gini coefficients $G_{ijt}^{A \rightleftharpoons B}$ and $G_{ijt}^{B \rightleftharpoons A}$ for each direction in a round-trip route j from carrier i at time t, and the Gini coefficients $G_{ijt}^{A \to B}$ and $G_{ijt}^{B \to A}$ for each direction in an one-way trip route. We denote the direction from $A \to B$ in one-way routes and $A \rightleftharpoons B$ in round-trip routes to be the direction with higher Gini coefficients. We construct the ratio of directional Gini coefficients as follows:

$$GR_{ijt}^{one-way} = G_{ijt}^{A \to B} / G_{ijt}^{B \to A}, \; GR_{ijt}^{round-trip} = G_{ijt}^{A \rightleftharpoons B} / G_{ijt}^{B \rightleftharpoons A}.$$

The ratio GR_{ijt}^{l}, $l \in \{$one-way, round-trip$\}$, is by definition always greater than 1. The mean of $GR_{ijt}^{one-way}$ is 1.191. This implies that the average difference in price dispersion by direction for a given round-trip route j, a carrier i, and time t is 19.1%. The standard deviation is 45%. The difference in price dispersion by direction for a given round-trip route j, a carrier i, and time t, the $GR_{ijt}^{round-trip}$, is 5.7% with 17% standard standard deviation. We estimate the following regression:

$$\log GR_{ijt}^{l} = \alpha + \beta \; Competition_{jt} + \gamma_{ij} + \kappa_{it} + Weather_{jt} + \delta_t + \varepsilon_{ijt}. \tag{5.1}$$

By construction, $GR_{ijt}^{l} > 1$. We use the same set of controls as in Table 8 and use the ratio of the Gini coefficients on a route j for carrier i at time t as the dependent variable. If β is positive and significant, the the ratio of directional Gini coefficients is increasing from an increase in competition. This implies that the price dispersion in one direction is increasing faster than the price dispersion in the other direction. If β is insignificant, this implies that direction does not matter when it comes to estimating the effect of competition on the price dispersion in a route.

Table 10 reports the results estimated using equation (5.1). Columns 1-3 report the results using each measure of competition in one-way products. Columns 4-6 report the results using each measure of competition in round-trip products. In both one-way and round-trip products, the effect of competition on the ratio of directional Gini coefficient is positive and significant. This suggests that direction matters when it comes to estimating the effect of competition on the price dispersion in a route. As a result, grouping one-way and round-trip together and dropping one direction lead to measurement error in the dependent variable, and if this is correlated with the share of round-trip products offered by carrier i on route j at time t, it could lead to the result that an increase competition has no significant effect on price dispersion, as shown in column 1 Table 2.

In addition, we can look at the difference in the average fares based on the direction of the flight. We construct the ratio of directional average fares as follows:

$AvgR_{ijt}^{round-trip} = AvgFares_{ijt}^{A \rightleftharpoons B} / AvgFares_{ijt}^{B \rightleftharpoons A}$, and

$AvgR_{ijt}^{one-way} = AvgFares_{ijt}^{A \to B} / AvgFares_{ijt}^{B \to A}$.

$AvgFares_{ijt}^{l}$ is the average fare for carrier i on route j at time t for $l \in \{$one-way, round-trip$\}$. The difference in the directional average fares for one-way products is 12.8% with standard deviation 38%. The difference in the directional average fares for round-trip products is 8.4% with standard deviation 9.8%. We estimate the following regressions:

$$\log AvgR_{ijt}^{l} = \alpha + \beta \; Competition_{jt} + \gamma_{ij} + \kappa_{it} + Weather_{jt} + \delta_t + \varepsilon_{ijt} \tag{5.2}$$

where $AvgR_{ijt}^{l}$ is the ratio of directional average fare for carrier i on route j at time t.

Table 11 reports the results estimated using equation (5.2). Columns 1-3 report the results using each measure of competition in one-way products. Columns 4-6 report the results using each measure of competition in round-trip products. The effect of competition on the average fare ratio is positive and significant for round-trip products, and the effect is not significant for one-way products. This confirms the result that dropping one direction and combining one-way and round-trip products could lead to biased estimate on the effect of competition on price dispersion.

5.2 Average Markups

Table 1 summary statistics show that LCCs offer a disproportionate share of one-way products. To examine why, we construct the cost of round-trip based on the sum of one-way tickets in each direction. We estimate the following regressions:

$$p(k)_{jt}^{\cos t} = \beta p\,(k)_{jt}^{round-trip}$$

where $p(k)_{jt}^{\cos t}$ is the cost of round-trip based on one-way ticket prices at the kth percentile of the distribution, $k \in (10, 90)$, for route j at time t. $p\,(k)_{jt}^{round-trip}$ is the round-trip ticket price at the kth percentile of the distribution. Table 11 reports the estimated β at 10th and 90th percentile. We find that at both the 10th and 90th percentile of price distribution, β is bigger than one and significant, suggesting that buying two one-way tickets is more expensive than buying a round-trip ticket between the same origin and destination city. This suggests that one-way tickets on average have higher markups than round-trip tickets between the same origin and destination city. If LCCs are more likely to offer the one-way products than round-trip products due to higher markups, our result that an increase in competition leads to more price dispersion in one-way product is consistent with the story that LCCs are more likely to compete in the lower tail of the price distribution leading to a bigger decrease at the 10th percentile of the price distribution than at the 90th percentile.[30]

5.3 Consumer heterogeneity and product differentiation

The central proposition of this study is that a market is not necessarily just bounded geographically, but also in terms of the products in it. This concept has been emphasized repeatedly in the introduction of every microeconomics textbook. However, empirical works that attempt to answer the exact same research question using the same sources of data tend to use different definitions of a market. It is therefore not surprising that answers to the same research question reach opposite conclusions. In this paper, we propose that airlines offer one-way and round-trip as differentiated products and airlines strategically set their prices such that in an increase in competition leads to an increase in price dispersion in one-way products and no effect in price dispersion in round-trip products.

Suppose consumers are heterogeneous in their price elasticity of demand. Suppose a firm in a

[30] It is possible that LCCs tend to be point-to-point carriers as compared to hub-and-spoke. Therefore, it is possible that it is this network design that lends itself more to one-way tickets, rather than high markups on one-way fares, that LCCs are offering many one-way tickets. Although carrier-route fixed effects absorb the main effects of whether end point cities are hub or not in our main regressions, we further divide the sample into four subsamples: one-way hub-and-spoke, one-way non-hub-and-spoke, round-trip hub-and-spoke, and round-trip non-hub-and-spoke. The effects of competition on price dispersion in one-way vs. round-trip are robust. Results are available upon request.

route faces two groups of consumers, A and B, with different distributions of demand elasticity, denoted by the cumulative distributions F_A and F_B, respectively. Suppose the distribution F_B is second-order stochastic dominant (SOSD) over F_A. Figure 5A illustrates the probability density functions f_A and f_B for the two distributions, respectively. As shown in Figure 5A, the average demand elasticity is the same in F_A and F_B. However, F_A has a higher share of consumers who are very price inelastic and a higher share of consumers who are very price elastic. This is, by definition, equivalent to saying that F_A is a mean-preserving spread of F_B in terms of consumers' price elasticity of demand. A firm in a route has incentive to offer differentiated products for group A and group B consumers so it can change its price dispersion differently in the presence of increased competition in the same route. An increase in competition leads to lower prices. However, a firm in a route facing group A consumers has the incentive to lower prices at the bottom 10th percentile of the price distribution a lot more than it does at the 90th percentile of the price distribution. This is because if the firm has to lower prices, it should lower the prices for the group of price-sensitive (elastic) consumers, as opposed to lowering the prices for the group of price-insensitive (inelastic) consumers. This leads to an increase in price dispersion *within* the firm in a route from an increase in competition if the firm is facing group A consumers.

In the airline industry, for a route operated by the *same* airline, one-way products and round-trip products may be tailored to meet the needs of different groups of consumers. The distribution of consumer's demand elasticity in the round-trip products may be SOSD over the distribution of consumer's demand elasticity in the one-way products for the following reasons. Consumers may prefer one-way tickets if they do not know the return date of their trip and prefer to book without a return flight to avoid incurring additional ticket change costs. Consumers may also prefer to fly to multiple destinations and therefore return to their origin city through a third location. For these reasons, these consumers may be willing to pay a higher premium for one-way tickets. This represents a higher share of consumers who are price inelastic compared to consumers who prefer to purchase round-trip tickets. In addition, price elastic consumers may prefer to "mix and match" airlines to minimize their spendings on a trip, and this may involve purchasing one-way tickets from different airlines as opposed to purchasing one round-trip ticket from the same airline. To summarize, if consumers are heterogeneous and the distribution of consumer's demand elasticity in round-trip products is SOSD over that in the one-way products, an increase in competition leads to an increase in price dispersion in one-way products. Our empirical results lend support to the above prediction that an increase in competition leads to an increase in price dispersion in one-way products within a firm in a route.

6 Conclusion

This paper shows that product differentiation and market definition play important roles in the presence of heterogeneous consumers in order to study the effect of competition on price dispersion. In the case of airline industry, counting both one-way and round-trip tickets in a route is problematic when it comes to calculating price dispersion in a market. We first distinguish between one-way and round-trip products within a ticketing carrier in a route. We find that an increase in competition leads to *higher* price dispersion in one-way products, and this is driven by a smaller decrease in price in the upper tail of the price distribution than that in the lower tail of the price distribution. In round-trip products, an increase in competition leads to lower price dispersion and this is driven by a bigger decrease in price in the upper tail of the price distribution than that in the lower tail of the price distribution, however, the results for round-trip products are not robust to the inclusion of carrier-time fixed effects.

Next, we find that arbitrarily dropping one direction tends to underestimate the effect of competition on price dispersion in one-way products. In one-way (round-trip) directional routes, a route from $A \rightarrow B$ ($A \rightleftharpoons B$) is considered to be a different market than a route from $B \rightarrow A$ ($B \rightleftharpoons A$) within the same carrier. Using the full panel, we find that an increase in competition increases price dispersion in directional one-way products, and has no significant effect on round-trip products.

Our results in one-way products lend support to BR's original theory that airlines are able to cultivate brand loyalty among their high-paying customers perhaps through the airlines' frequent-flyer rewards programs. First, airlines compete more aggressively in the bottom tail of the price distribution from disproportionate entry of LCCs in one-way products. Second, mergers of legacy carriers allow them to cover even larger networks and increase the value of their frequent flyer programs, especially to business travelers. Low cost carriers (LCCs), on the other hand, have much smaller and much less attractive frequent flyer programs. Consequently, legacy carriers after mergers derive higher market power and maintain the ability to charge high fares to their frequent flier customers. More aggressive competition in the bottom tail of the price distribution, coupled with airlines' ability to cultivate brand loyalty among their high-paying customers, lead to higher price dispersion from increased competition in one-way products. In round-trip products, we find the effect of competition to be negative on price dispersion, however this result is not robust after controlling for carrier-time fixed effects and weather variables that could affect demand on a route over time.

Our paper contributes to the literature on the airline industry and the literature on price discrimination. Competition affects price dispersion differently in one-way and round-trip products. Future studies could use our empirical results to build models to allow firms to strategically differentiate their products in a market in the presence of heterogeneous consumers and to shed new light on the impact of market structure on consumer welfare. Lastly, market definition is very important for public policy decisions. The decision to allow or deny mergers or acquisitions depends on the effect of that merger or acquisition on future competition and prices, but the first step is properly defining a market.

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Figure 1: Industry Features: round-trip ratio (e.g. SW has increased one-way/round tickets)

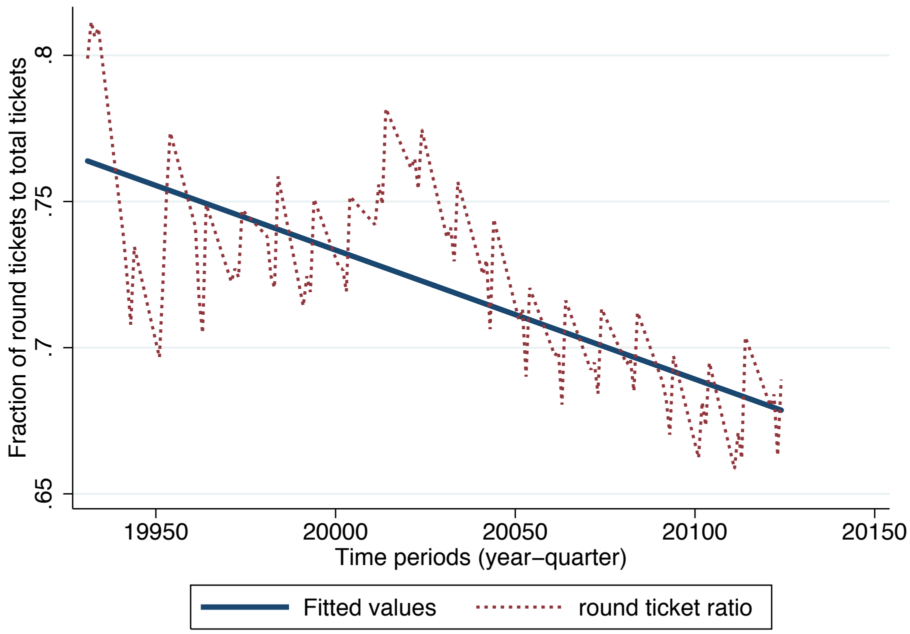


Figure 2: Weighted average number of low cost airlines per route

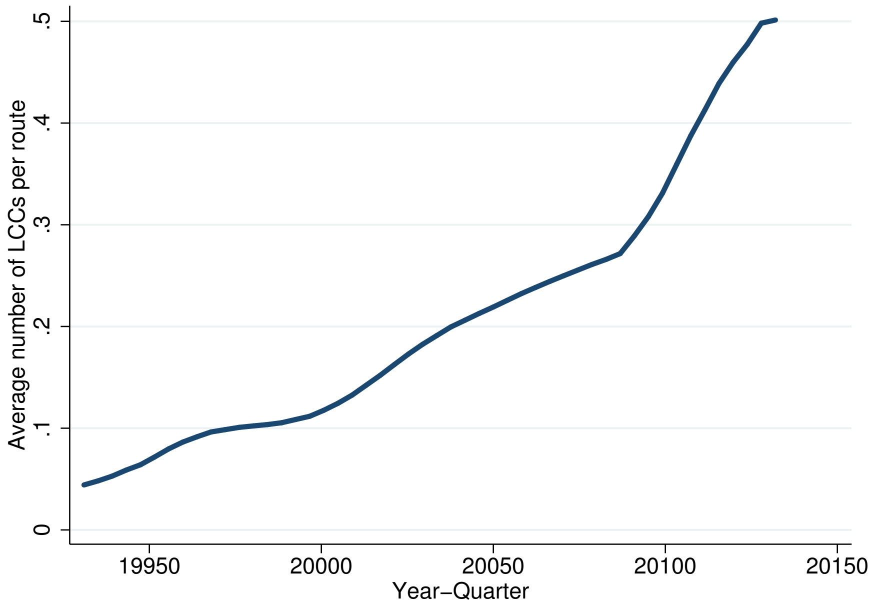


Figure 3: Weighted average number of airlines per route

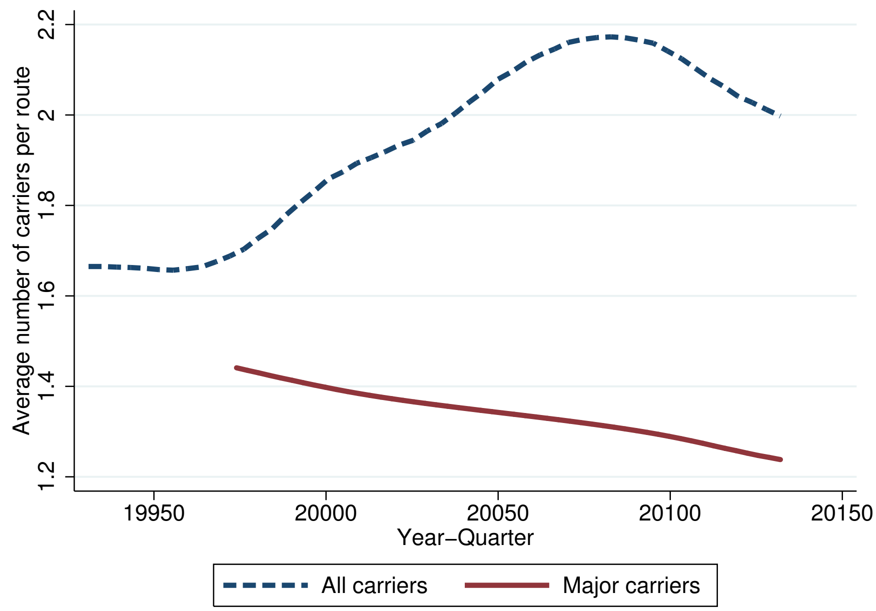
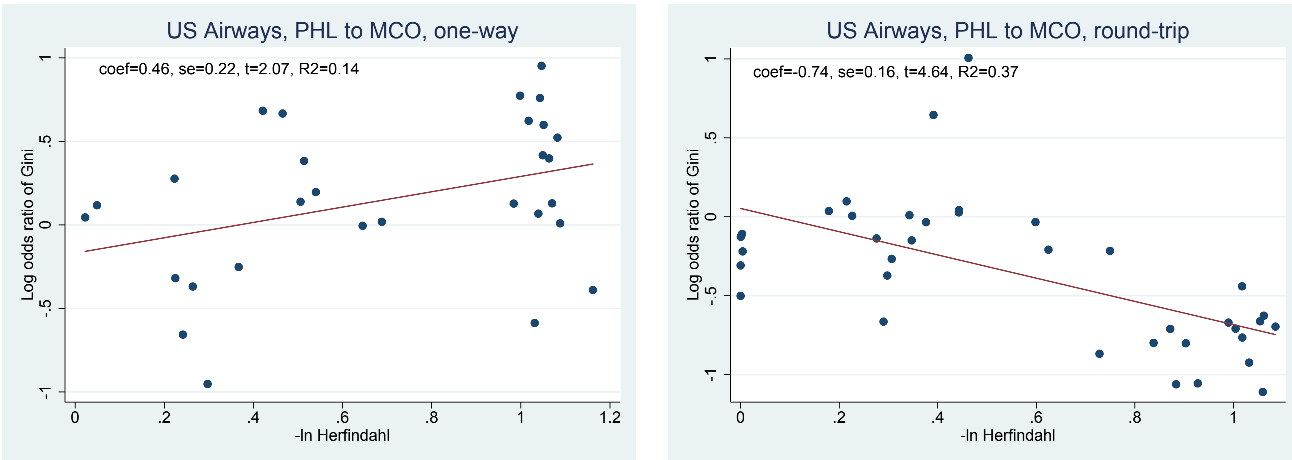
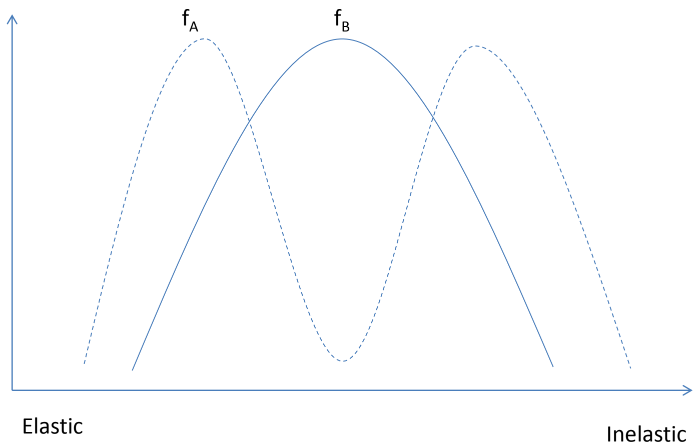


Figure 4. Distinction between one-way and round-trip.



NOTE: The Y-axis is log odds ratio of Gini coefficient, and the X-axis is - ln Herfindahl Index. An increase in competition increases - ln Herfindahl Index. The figures look very similar without taking logs, i.e. with Gini coefficient on the Y-axis, and - Herfindahl Index on the X-axis.

Figure 5. Second Order Stochastic Dominance



NOTE: The X-axis is the price elasticity of demand. An increase along the X-axis denotes the price elasticity of demand is more inelastic. f_A denotes the distribution of heterogeneous demand elasticity for one-way products, and f_B denotes the distribution of heterogeneous demand elasticity for round-trip products.

Table 1. Summary of main variables

Variable	Mean	Std. Dev.	Min	Max
	Panel A. Both one-way and round-trip routes			
Gini_{ijt}	0.269	0.080	0	0.947
Herfindahl_{jt}	0.753	0.249	0.145	1
N_{jt}	0,654	0.873	0	7
N_{jt}^{LCC}	0.504	0.611	0	3
N_{jt}^{LEG}	0.970	0.830	0	6
Bankruptcy_{it}	0.008	0.088	0	1
Merger_{it}	0.006	0.077	0	1
	Panel B. One-way			
Gini_{ijt}	0.276	0.093	0	0.949
Herfindahl_{jt}	0.699	0.258	0.152	1
N_{jt}	0.689	0.856	0	7
N_{jt}^{LCC}	0.751	0.606	0	3
N_{jt}^{LEG}	0.740	0.818	0	4
	Panel C. Round-trip			
Gini_{ijt}	0.245	0.074	0	0.883
Herfindahl_{jt}	0.758	0.246	0.123	1
N_{jt}	0.618	0.828	0	6
N_{jt}^{LCC}	0.468	0.591	0	3
N_{jt}^{LEG}	0.758	0.246	0	6

NOTE: Table 1 reports the summary statistics of routes defined as both one-way and round-trip, one-way only, and round-trip only using routes in one direction, and the other direction is dropped. i denotes carrier, j denotes route, and t denotes time.

Table 2. Both One-way and Round-trip products

	1993-2013			1993-2006		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A Gini coefficient					
-ln $\widehat{HERF}$	-0.022			-0.059***		
	(0.034)			(0.015)		
ln $\widehat{N}$		-0.029			-0.038***	
		(0.018)			(0.013)	
N^{LCC}			0.206***			-0.051***
			(0.057)			(0.008)
N^{LEG}			-0.158***			0.005
			(0.058)			(0.005)
	Panel B 10th percentile					
-ln $\widehat{HERF}$	-0.298***			-0.143***		
	(0.025)			(0.013)		
ln $\widehat{N}$		-0.106***			-0.102***	
		(0.015)			(0.010)	
N^{LCC}			-0.115***			-0.081***
			(0.005)			(0.007)
N^{LEG}			-0.026***			-0.051***
			(0.004)			(0.005)
	Panel C 90th percentile					
-ln $\widehat{HERF}$	-0.300***			-0.237***		
	(0.037)			(0.017)		
ln $\widehat{N}$		-0.158***			-0.156***	
		(0.020)			(0.014)	
N^{LCC}			-0.105***			-0.146***
			(0.007)			(0.009)
N^{LEG}			-0.020***			-0.052***
			(0.006)			(0.006)
Observations	112,622	55,279	112,622	75,890	33,500	75,890

NOTE: Results for years 1993-2013 are reported in columns (1)-(3) and 1993-2006 in (4)-(6). All regressions include carrier-route FE, time FE, a bankruptcy dummy, and a merger dummy. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, one direction of round-trip fares (divided by two) and one-way fares are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution, as in GS. *** denotes significance at 1%. ** denotes significance at 5% and * denotes significance at 10%.

Table 3. One-way Products

	1993-2013			1993-2006		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A Gini coefficient					
-ln $\widehat{HERF}$	0.154***			0.107***		
	(0.040)			(0.030)		
ln $\widehat{N}$		0.043***			0.008	
		(0.014)			(0.0166)	
N^{LCC}			-0.032***			-0.044***
			(0.008)			(0.013)
N^{LEG}			0.010			-0.000
			(0.009)			(0.009)
	Panel B 10th percentile					
-ln $\widehat{HERF}$	-0.537***			-0.122***		
	(0.034)			(0.012)		
ln $\widehat{N}$		-0.180***			-0.112***	
		(0.012)			(0.014)	
N^{LCC}			-0.136***			-0.128***
			(0.007)			(0.010)
N^{LEG}			-0.053***			-0.055***
			(0.005)			(0.006)
	Panel C 90th percentile					
-ln $\widehat{HERF}$	-0.414***			-0.060**		
	(0.046)			(0.029)		
ln $\widehat{N}$		-0.132***			-0.094***	
		(0.018)			(0.015)	
N^{LCC}			-0.153***			-0.170***
			(0.009)			(0.012)
N^{LEG}			-0.061***			-0.067***
			(0.008)			(0.009)
Observations	64,923	31,820	68,692	40,397	19,452	40,397

NOTE: Results for years 1993-2013 are reported in columns (1)-(3) and 1993-2006 in (4)-(6). All regressions include carrier-route FE, time FE, a bankruptcy dummy, and a merger dummy. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, the one-way ticket prices for only one direction are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution. *** denotes significance at 1%. ** at 5% and * at 10%.

Table 4. Round Products

	1993-2013			1993-2006		
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A Gini coefficient			
-ln $\widehat{HERF}$	-0.105***			-0.060***		
	(0.021)			(0.015)		
ln $\widehat{N}$		-0.041***			-0.035***	
		(0.013)			(0.012)	
N^{LCC}			-0.050***			-0.051***
			(0.006)			(0.008)
N^{LEG}			0.005			0.003
			(0.005)			(0.005)
			Panel B 10th percentile			
-ln $\widehat{HERF}$	-0.391***			-0.141***		
	(0.020)			(0.013)		
ln $\widehat{N}$		-0.174***			-0.100***	
		(0.012)			(0.010)	
N^{LCC}			-0.107***			-0.079***
			(0.005)			(0.007)
N^{LEG}			-0.030***			-0.051***
			(0.004)			(0.005)
			Panel C 90th percentile			
-ln $\widehat{HERF}$	-0.537***			-0.236***		
	(0.026)			(0.017)		
ln $\widehat{N}$		-0.233***			-0.153***	
		(0.015)			(0.015)	
N^{LCC}			-0.165***			-0.146***
			(0.008)			(0.009)
N^{LEG}			-0.032***			-0.052***
			(0.006)			(0.006)
Observations	104,569	46,833	108,727	75,890	33,500	75,890

NOTE: Results for years 1993-2013 are reported in columns (1)-(3) and 1993-2006 in (4)-(6). All regressions include carrier-route FE, time FE, a bankruptcy dummy, and a merger dummy. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, round-trip ticket prices divided by two are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution. *** denotes significance at 1%. ** at 5% and * at 10%.

Table 5. Robustness: GDP and BLP-style Enplanement IV

	One-way Trips						Round-trips					
		1993-2013			1993-2006			1993-2013			1993-2006	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A Gini coefficient											
-ln $\widehat{HERF}$	0.195**			0.431***			-0.170***			-0.084***		
	(0.090)			(0.066)			(0.039)			(0.024)		
ln $\widehat{N}$		0.141***			0.012			-0.066***			-0.029*	
		(0.044)			(0.019)			(0.023)			(0.016)	
N^{LCC}			-0.065***			-0.043***			-0.077***			-0.054***
			(0.020)			(0.012)			(0.000)			(0.007)
N^{LEG}			0.022			-0.002			0.009			0.002
			(0.015)			(0.009)			(0.010)			(0.005)
	Panel B 10th percentile											
-ln $\widehat{HERF}$	-0.714***			-0.451***			-0.602***			-0.353***		
	(0.087)			(0.044)			(0.043)			(0.025)		
ln $\widehat{N}$		-0.207***			-0.147***			-0.234***			-0.166***	
		(0.038)			(0.016)			(0.028)			(0.016)	
N^{LCC}			-0.184***			-0.128***			-0.178***			-0.080***
			(0.018)			(0.009)			(0.011)			(0.006)
N^{LEG}			-0.035***			-0.056***			-0.014			-0.050***
			(0.012)			(0.006)			(0.010)			(0.005)
	Panel C 90th percentile											
-ln $\widehat{HERF}$	-0.566***			-0.161***			-0.822***			-0.478***		
	(0.063)			(0.061)			(0.046)			(0.027)		
ln $\widehat{N}$		-0.087***			-0.125***			-0.304***			-0.210***	
		(0.031)			(0.019)			(0.029)			(0.016)	
N^{LCC}			-0.133***			-0.167***			-0.254***			-0.146***
			(0.016)			(0.011)			(0.013)			(0.008)
N^{LEG}			-0.042***			-0.072***			-0.019			-0.052***
			(0.012)			(0.009)			(0.013)			(0.006)
Observations	64,923	31,820	68,692	37,283	18,182	39,309	104,569	46,833	108,727	72,546	31,939	75,017

NOTE: All controls from Tables 3 and 4 are used. Results for one-way trips are reported in columns (1)-(6) and round trips in columns (7)-(12). All regressions control for changes in each route (geographic market) over time using GDP of origin and destination city, carrier-route FE, time FE, a bankruptcy dummy, and a merger dummy. In addition, instead of enplaned passengers on route j as one of the instruments for competition on route j, we use the BLP-style instrument: the average enplaned passengers on routes other than j. All regressions include Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, round-trip ticket prices divided by two are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution. *** denotes significance at 1%. ** at 5% and * at 10%.

Table 6. Robustness: Dropping Regional Carriers

	One-way Trips						Round-trips					
		1993-2013			1993-2006			1993-2013			1993-2006	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A Gini coefficient											
-ln $\widehat{HERF}$	0.137***			0.382***			-0.105***			-0.072***		
	(0.040)			(0.062)			(0.022)			(0.027)		
ln $\widehat{N}$		0.032**			-0.012			-0.042***			-0.029	
		(0.015)			(0.021)			(0.015)			(0.020)	
N^{LCC}			-0.039***			-0.051***			-0.049***			-0.048***
			(0.008)			(0.011)			(0.007)			(0.008)
N^{LEG}			0.002			-0.014			-0.002			-0.004
			(0.009)			(0.010)			(0.006)			(0.005)
	Panel B 10th percentile											
-ln $\widehat{HERF}$	-0.519***			-0.410***			-0.412***			-0.385***		
	(0.033)			(0.041)			(0.020)			(0.025)		
ln $\widehat{N}$		-0.180***			-0.143***			-0.178***			-0.172***	
		(0.012)			(0.017)			(0.012)			(0.016)	
N^{LCC}			-0.136***			-0.130***			-0.117***			-0.094***
			(0.007)			(0.009)			(0.005)			(0.006)
N^{LEG}			-0.055***			-0.056***			-0.032***			-0.051***
			(0.006)			(0.006)			(0.004)			(0.005)
	Panel C 90th percentile											
-ln $\widehat{HERF}$	-0.411***			-0.167***			-0.561***			-0.507***		
	(0.046)			(0.059)			(0.027)			(0.028)		
ln $\widehat{N}$		-0.140***			-0.141***			-0.243***			-0.224***	
		(0.019)			(0.020)			(0.016)			(0.016)	
N^{LCC}			-0.157***			-0.176***			-0.174***			-0.158***
			(0.009)			(0.011)			(0.008)			(0.009)
N^{LEG}			-0.069***			-0.081***			-0.042***			-0.060***
			(0.008)			(0.009)			(0.007)			(0.006)
Observations	61,035	29,665	63,506	34,928	16,526	36,208	99,575	43,838	102,906	68,632	29,458	70,646

NOTE: The sample is restricted to legacy and low-cost carriers. Competition measures are recalculated using only legacy and low-cost carriers. All controls from the previous table are used. Results for one-way trips are reported in columns (1)-(6) and round trips in columns (7)-(12). All regressions control for changes in each route (geographic market) over time using GDP of origin and destination city, carrier-route FE, time FE, a bankruptcy dummy, and a merger dummy. In addition, instead of enplaned passengers on route j as one of the instruments for competition on route j, we use the average enplaned passengers on routes other than j. All regressions include Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, round-trip ticket prices divided by two are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution. *** denotes significance at 1%. ** at 5% and * at 10%.

Table 7. Robustness: Controlling for Carrier-Time FE

			One-way Trips						Round-trips			
		1993-2013			1993-2006			1993-2013			1993-2006	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Panel A Gini coefficient						
-ln $\widehat{HERF}$	0.101***			-0.095**			0.008			-0.065**		
	(0.030)			(0.043)			(0.021)			(0.027)		
ln $\widehat{N}$		0.038***			-0.017			0.010			-0.021	
		(0.014)			(0.018)			(0.016)			(0.020)	
N^{LCC}			0.040***			0.017**			-0.009			-0.044***
			(0.006)			(0.008)			(0.006)			(0.008)
N^{LEG}			0.009			-0.000			-0.011**			-0.004
			(0.006)			(0.007)			(0.004)			(0.005)
						Panel B 10th percentile						
-ln $\widehat{HERF}$	-0.448***			-0.425***			-0.404***			-0.409***		
	(0.025)			(0.035)			(0.020)			(0.026)		
ln $\widehat{N}$		-0.131***			-0.112***			-0.159***			-0.165***	
		(0.009)			(0.013)			(0.012)			(0.016)	
N^{LCC}			-0.104***			-0.107***			-0.106***			-0.093***
			(0.005)			(0.008)			(0.005)			(0.006)
N^{LEG}			-0.043***			-0.049***			-0.041***			-0.054***
			(0.005)			(0.005)			(0.004)			(0.005)
						Panel C 90th percentile						
-ln $\widehat{HERF}$	-0.395***			-0.539***			-0.453***			-0.515***		
	(0.038)			(0.044)			(0.025)			(0.029)		
ln $\widehat{N}$		-0.087***			-0.119***			-0.173***			-0.199***	
		(0.019)			(0.015)			(0.015)			(0.015)	
N^{LCC}			-0.071***			-0.103***			-0.125***			-0.145***
			(0.007)			(0.008)			(0.007)			(0.009)
N^{LEG}			-0.055***			-0.065***			-0.059***			-0.065***
			(0.005)			(0.006)			(0.005)			(0.005)
Observations	61,024	29,634	63,497	34,917	16,496	36,198	99,565	43,812	102,896	68,623	29,434	70,637

NOTE: Controlling for carrier-time FE absorbs the bankruptcy and merger dummies that vary at carrier-time level and time FE that vary at time level. All controls from the previous table are used. Note that the sample is restricted to legacy and low-cost carriers. Competition measures are recalculated using only legacy and low-cost carriers. Results for one-way trips are reported in columns (1)-(6) and round trips in columns (7)-(12). All regressions control for changes in each route (geographic market) over time using GDP of origin and destination city, carrier-time FE, and carrier-route FE. In addition, instead of enplaned passengers on route j as one of the instruments for competition on route j, we use the average enplaned passengers on routes other than j. All regressions include Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, round-trip ticket prices divided by two are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution. *** denotes significance at 1%. ** at 5% and * at 10%.

Table 8. Robustness: Controlling for Weather Variables to Account for Other Changes on A Route Over Time.

	One-way Trips						Round-trips					
		1993-2013			1993-2006			1993-2013			1993-2006	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A Gini coefficient											
-ln $\widehat{HERF}$	0.141***			-0.070			0.019			-0.048		
	(0.037)			(0.050)			(0.025)			(0.032)		
ln $\widehat{N}$		0.045***			-0.009			0.017			-0.011	
		(0.015)			(0.018)			(0.017)			(0.022)	
N^{LCC}			0.038***			0.014			-0.007			-0.041***
			(0.006)			(0.009)			(0.007)			(0.009)
N^{LEG}			0.010			-0.000			-0.015***			-0.005
			(0.006)			(0.008)			(0.005)			(0.005)
	Panel B 10th percentile											
-ln $\widehat{HERF}$	-0.505***			-0.498***			-0.421***			-0.437***		
	(0.031)			(0.045)			(0.024)			(0.031)		
ln $\widehat{N}$		-0.129***			-0.109***			-0.162***			-0.175***	
		(0.009)			(0.014)			(0.013)			(0.018)	
N^{LCC}			-0.105***			-0.108***			-0.103***			-0.092***
			(0.006)			(0.010)			(0.005)			(0.007)
N^{LEG}			-0.048***			-0.054***			-0.041***			-0.053***
			(0.005)			(0.006)			(0.004)			(0.006)
	Panel C 90th percentile											
-ln $\widehat{HERF}$	-0.425***			-0.596***			-0.462***			-0.529***		
	(0.044)			(0.053)			(0.029)			(0.033)		
ln $\widehat{N}$		-0.078***			-0.108***			-0.174***			-0.208***	
		(0.019)			(0.015)			(0.016)			(0.017)	
N^{LCC}			-0.073***			-0.105***			-0.118***			-0.140***
			(0.008)			(0.010)			(0.008)			(0.010)
N^{LEG}			-0.064***			-0.074***			-0.063***			-0.068***
			(0.006)			(0.007)			(0.006)			(0.006)
Observations	40,720	23,820	41,846	22,784	12,840	23,335	70,385	36,029	72,059	48,698	23,923	49,745

NOTE: We also control for weather variables, such as precipitation, snowfall, max and min temperature, to control for other changes on a route over time that could affect demand and therefore the price dispersion. The weather variables could also as proxies for cost shifters that affect operational costs over time on a route. All controls from the previous table are used. Note that controlling for carrier-time FE absorbs the bankruptcy and merger dummies that vary at carrier-time level and time FE that vary at time level. The sample is restricted to legacy and low-cost carriers. Competition measures are recalculated using only legacy and low-cost carriers. Results for one-way trips are reported in columns (1)-(6) and round trips in columns (7)-(12). All regressions control for changes in each route (geographic market) over time using GDP of origin and destination city, carrier-time FE, and carrier-route FE. In addition, instead of enplaned passengers on route j as one of the instruments for competition on route j, we use the average enplaned passengers on routes other than j. All regressions include Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, round-trip ticket prices divided by two are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution. *** denotes significance at 1%. ** at 5% and * at 10%.

Table 9. Directional One-way Trips and Directional Round Products

	Directional One-way Trips						Directional Round-trips					
		1993-2013			1993-2006			1993-2013			1993-2006	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel A Gini coefficient											
-ln $\widehat{HERF}$	0.229***			0.066			0.075			0.098		
	(0.078)			(0.146)			(0.047)			(0.072)		
ln $\widehat{N}$		0.075***			0.087*			0.052**			0.056	
		(0.024)			(0.048)			(0.023)			(0.046)	
N^{LCC}			0.047***			0.031			-0.010			-0.001
			(0.015)			(0.031)			(0.015)			(0.021)
N^{LEG}			0.014			-0.003			-0.005			-0.024*
			(0.011)			(0.016)			(0.011)			(0.013)
	Panel B 10th percentile											
-ln $\widehat{HERF}$	-0.550***			-0.528***			-0.504***			-0.560***		
	(0.064)			(0.125)			(0.044)			(0.071)		
ln $\widehat{N}$		-0.104***			-0.126**			-0.182***			-0.241***	
		(0.020)			(0.049)			(0.026)			(0.046)	
N^{LCC}			-0.108***			-0.132***			-0.130***			-0.141***
			(0.013)			(0.027)			(0.011)			(0.016)
N^{LEG}			-0.034***			-0.015			-0.029***			-0.040***
			(0.009)			(0.014)			(0.009)			(0.009)
	Panel C 90th percentile											
-ln $\widehat{HERF}$	-0.418***			-0.578***			-0.538***			-0.554***		
	(0.078)			(0.128)			(0.045)			(0.062)		
ln $\widehat{N}$		-0.037			-0.059*			-0.156***			-0.194***	
		(0.029)			(0.035)			(0.021)			(0.039)	
N^{LCC}			-0.077***			-0.149***			-0.155***			-0.158***
			(0.018)			(0.025)			(0.013)			(0.020)
N^{LEG}			-0.045***			-0.022			-0.040***			-0.063***
			(0.014)			(0.018)			(0.012)			(0.013)
Observations	10,763	5,954	10,763	4,196	2,251	4,196	19,813	9,723	19,813	10,346	4,797	10,346

NOTE: All controls from the previous table are used. We control for weather variables, such as precipitation, snowfall, max and min temperature, to control for other changes on a route over time that could affect demand and therefore the price dispersion. The weather variables could also as proxies for cost shifters that affect operational costs over time on a route. Note that controlling for carrier-time FE absorbs the bankruptcy and merger dummies that vary at carrier-time level and time FE that vary at time level. The sample is restricted to legacy and low-cost carriers. Competition measures are recalculated using only legacy and low-cost carriers. Results for directional one-way trips are reported in columns (1)-(6) and directional round trips in columns (7)-(12). All regressions control for changes in each route (geographic market) over time using GDP of origin and destination city, carrier-time FE, and carrier-route FE. In addition, instead of enplaned passengers on route j as one of the instruments for competition on route j, we use the average enplaned passengers on routes other than j. All regressions include Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. For a given route j for carrier i at time t, round-trip ticket prices divided by two are used to calculate the Gini coefficient, the 10th and 90th percentile in the price distribution. *** denotes significance at 1%. ** at 5% and * at 10%.

Table 10. Gini Ratio

	One-way			Round-trip		
	(1)	(2)	(3)	(4)	(5)	(6)
-ln $\widehat{HERF}$	0.042**			0.052***		
	(0.017)			(0.009)		
ln $\widehat{N}$		0.008			0.023***	
		(0.006)			(0.006)	
N^{LCC}			0.005			0.008***
			(0.003)			(0.002)
N^{LEG}			0.010***			0.009***
			(0.003)			(0.002)
Observations	40,720	23,820	41,846	70,385	36,029	72,059

NOTE: The dependent variable is log GR^{l}_{ijt} for carrier i at time t for one-way or round-trip route j. All regressions include controls in the previous table. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used.*** denotes significance at 1%. ** denotes significance at 5% and * denotes significance at 10%.

Table 11. Average Fares Ratio

	One-way			Round-trip		
	(1)	(2)	(3)	(4)	(5)	(6)
-ln $\widehat{HERF}$	0.166			0.500***		
	(0.105)			(0.075)		
ln $\widehat{N}$		-0.024			0.301***	
		(0.037)			(0.043)	
N^{LCC}			0.049**			0.063***
			(0.023)			(0.022)
N^{LEG}			0.035*			0.074***
			(0.020)			(0.018)
Observations	40,658	23,771	41,784	70,384	36,028	72,058

NOTE: The dependent variable is log $AvgR^l_{ijt}$ for carrier i at time t for one-way or round-trip route j. All regressions include controls in the previous table. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. *** denotes significance at 1%. ** denotes significance at 5% and * denotes significance at 10%.

Table 12 Markups

	10th	90th
one-way markup	1.13***	1.56***
	(0.002)	(0.003)
R^2	0.90	0.87
Observations	33,958	33,958

NOTE: For each route j at time t, the dependent variable is the price at the kth percentile of round-trip cost constructed based on the sum of one-way tickets, and the independent variable is the price at the kth percentile of round-trip price distribution. *** denotes significance at 1%. ** denotes significance at 5% and * denotes significance at 10%.

A Appendix

Table A.1. U.S. Airline Bankruptcies History 1993-2013

COMPANY	START	ASSETS
United Air Lines	Dec. 2002	$22,800,000,000
Delta Air Lines	Sep. 2005	$21,561,000,000
Northwest Airlines	Sep. 2005	$14,352,000,000
US Airways, Inc.	Sep. 2004	$8,600,458,000
US Airways, Inc.	August 2002	$8,025,000,000
December 1990	$7,656,140,000	
March 1989	$4,037,000,000	
Trans World Airlines, Inc.	June 1995	$2,495,210,000
	January 1991	$2,440,830,000
Trans World Airlines, Inc.	January 2001	$2,137,180,000
	November 1989	$1,034,580,000
Evergreen International Aviation	September 1993	$761,040,000
Resorts International, Inc.	March 1994	$575,790,000
Midway Airlines, Inc.	March 1991	$468,470,000
Pan Am Corp.	February 1998	$26,550,000
	October 1989	$25,440,000
	July 1990	$25,420,000
	January 1988	$17,050,000
WorldCorp, Inc.	February 1999	$16,830,000
Florida West Airlines, Inc.	October 1994	$16,060,000
Sun Country Airlines	January, 2002	
Sun Country Airlines	October 6, 2008	
Primaris Airlines	October 15, 2008	
Mesa Airlines	January 5, 2010	
Arrow Air	July 1, 2010	
American Airlines	November 29, 2011	
Pinnacle Airlines	April 2, 2012	
FLYi Inc's Independence Air	November 2005	$378,500,000
Tower Air, Inc.	February 2000	$350,760,000
Midway Airlines Corp.	August 2001	$349,000,000
Fine Air Services Corp.	September 2000	$303,030,000
Krystal Company, Inc. (The)	December 1995	$130,790,000
Western Pacific Airlines, Inc.	October 1997	$119,690,000
Aloha Airgroup, Inc.	December 2004	$100,000,000
Hawaiian Airlines	March 2003	$100,000,000
HAL, Inc.	September 1993	$105,740,000
Rocky Mt. Helicopters	October 1993	$95,040,000
Crescent Airways Corp.	February 2005	$40,630,000
Vanguard Airlines, Inc.	July 2002	$39,724,302
Kiwi International Air Lines	September 1996	$36,070,000
International Total Services	September 2001	$31,500,000
Flight International Group, Inc.	February 1994	$28,950,000
Conquest Industries, Inc.	January 1996	$27,440,000
	September 1987	$27,000,000
Frontier	April 2008	
Aloha	March 2008	
ATA	April 2008	
Skybus	April 2008	
Kitty Hawk, Inc.	May 2000	
Aloha	January 2005	

NOTES: Source: FOXBusiness & OKC.com.

B Data Construction

In this section, we discuss our methods involved in constructing the data from the DB1B and T-100 Domestic Segment databases. We closely follow the approach in Gerardi and Shapiro (2009). To construct the price dispersion measure, we use only domestic, coach-class itineraries and keep only tickets containing direct flights. The BTS includes a variable, dollar cred, that describes the reliability of each ticket price. Dollar credit is zero if the ticket fare is of questionable magnitude, and one if it is credible. We drop all tickets for which dollar cred is equal to zero. DB1B does not indicate if fares are from frequent-flyer tickets, we follow the approach in the literature and drop all fares less than or equal to \$50 for round-trip tickets (\$25 for one-way tickets). Fares less than \$50 (\$25 for one-way) account for less than 1% of the tickets in the data. We also drop tickets if the operating and ticket carriers are different due to code-sharing arrangements. Code sharing is when a flight operated by an airline is jointly marketed as a flight for one or more other arilines. We drop these tickets because we don't know the actual airline that is setting the price schedule in a code-sharing arrangment.

After filtering the tickets explained in the previous paragraph, we combine tickets and collapse the data into airline-route observations for 84 quarters from 1993 to 2013. We merge the airline-route data from DB1B with T-100 Segment Data. DB1B does not distinguish between nonstop, direct ticket and a ticket that involves a stop without a plane change. Merging with T-100 drops those flights identified as direct in DB1B but are actually with stops because T-100 does not have the corresponding segment information.

Following GS, to eliminate possible coding errors, we drop airline-route obervations that do not have at least 100 passengers in the DB1B. We keep the observation if the number of passengers on an airline-route in a given quarter drops bellow 25% of its mean over time in both DB1B and T-100, but if it is below 25% in one of these two databases and not the other, we drop the observation on the account that the difference in value is mostly due to measurement error.

Our sample based on both one-way and round-trip of a route in one direction contains 52 different carriers with 4900 distinct carrier-route observation in 2470 distinct routes over the 84 quarters between 1993 and 2013. In one-way markets, there are 49 carriers with 3226 distinct carrier-route observations in 1662 routes in one direction. For example, US Airways operating in PHL$\rightarrow$MCO is included and US Airways in MCO$\rightarrow$PHL is dropped. There are 48 carriers, 4232 carrier-routes, and 2098 routes in the round-trip sample. In directional one-way sample, there are 49 carriers, 6416 carrier-routes, and 2280 routes where a route operated by US Airways in PHL$\rightarrow$MCO is considered a different route than US Airways in MCO$\rightarrow$PHL, and both directions are included. In directional round-trip sample, there are 48 carriers, 8433 carrier-routes, and 3324 routes where a route operated by US Airways in PHL$\rightleftharpoons$MCO is considered a different route than US Airways in MCO$\rightleftharpoons$PHL.

C Instrumental variables

We follow BR and GS and use the following instrumental variables:

AMEANPOP: The arithmetic mean of the metropolitan population of end-point cities taken from the 2000 U.S. Census.

GMEANPOP: The geometric mean of the metropolitan popoulation of end-point cities taken from the 2000 U.S. Census.

ln PASSRTE$_{jt}$: The logarithm of total enplaned passengers on route j in period t from the

T-100 Domstic Segment Databank.

ln BLP Enplanement$_{-jt}$ in place of ln PASSRTE$_{jt}$: The logarithm of the average enplaned passengers on route other than j in period t.

IRUTHERF: This instrument is identical to the one used by BR and GS. This variable is the square of the fitted value for MKTSHARE$_{ijt}$ from its first-stage regression, plus the rescaled sum of the squares of all other carrier's shares. See BR for a more detailed explanation. It is equal to

$$\hat{S}_{ijt}^2 + \frac{HERF_{jt} - S_{ijt}^2}{(1 - \hat{S}_{ijt})^2} \cdot (1 - \hat{S}_{ijt})^2,$$

where $\hat{S}_{ijt}^2$ is the fitted value for market share for carrier i on route j at time t.