Competition and Price Dispersion: Consumer Heterogeneity, Product Differentiation and Market Definition *

Myongjin Kim† Leilei Shen‡

July, 2017

Abstract

We analyze the effect of competition on price dispersion in the airline industry and show that the outcome hinges on product differentiation and market definition. Using panel data from 1993 to 2013, an increase in competition has a positive effect on price dispersion in one-way products but a negative effect in round-trip products. This is driven by a bigger (smaller) decrease in the 10th percentile of the price distribution in one-way (round-trip) products within the firm in a route. 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 of a route.

Keywords: Price Dispersion, Competition, Consumer Heterogeneity, Product Differentiation, Market Definition, Airline Industry

JEL codes: D43, L13, L93

*The previous versions of the paper were circulated under the title "Market Structure, Competition, and Price Dispersion in the Airline Industry Revisited" and "Market Definition Changes the Story: Competition and Price Dispersion in the Airline Industry Revisited." We thank the seminar participants at the University of Washington, Indiana University-Purdue University in Indianapolis, Rutgers University, and Byoung Gun Park. We also thank the conference participants at the IIOC, SEA, and EEA for the valuable comments.

†Myongjin Kim is an Assistant Professor in the Economics Department at the University of Oklahoma, Phone: +14053253326; Fax: +14053255842; email: mjkim@ou.edu. web: http://www.myongjinkim.com.

‡Leilei Shen is an Assistant Professor in the Economics Department at the Kansas State University, Phone: +7854775356; email: lshen@ksu.edu. web: https://sites.google.com/site/drleileishen/.

"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 litertature 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 mutal funds, to name a few.[1] Price dispersion can arise for two reasons: search costs and price discrimination. Search costs have been explored in many papers (see, e.g., Salop and Stiglitz 1982; Sorensen 2000). This paper focuses on the effect of competition on price dispersion in the airline industry resulting from price discrimination. 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] An increase in competition leads to an increase in price dispersion in one-way products and a decrease in price dispersion in round-trip products within the firm in a route. This is driven by a bigger (smaller) decrease in the 10th percentile of the price distribution in one-way (round-trip) products. In addition, an increase in income in the origin city increases price dispersion, and this is driven by a bigger increase in the 90th percentile of the price distribution.

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 (1994, hereafter BR) found that a carrier-specific route with higher levels of competition has a greater degree of price dispersion using a cross-section of data from 1986. On the other hand, Gerardi

[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.

and Shapiro (2009, hereafter GS), using a panel from 1993:Q1 to 2006:Q3, found that competition lowers a firm's ability to price discriminate and therefore lowers the price dispersion.

The principal contribution of our study is 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 can offer one-way and round-trip as differentiated products and segment the market based on the direction of a route. A market 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 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 of 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 if they purchase one-way tickets compared to round-trip tickets. In addition, customers who value frequent-flyers rewards program may opt to have at least one leg of their flights from their frequent-flyers rewards program if they are unable to stay loyal to all legs because of price competition from other carriers. In this case, this represents a higher share of customers who are price elastic if they purchase one-way tickets compared to round-trip tickets. In other words, a firm in a route is facing heterogeneous consumers and the distribution of consumers' demand elasticities

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

[4]NY times, 12/3/06

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. Using a panel from 1993-2013, we find that an increase in competition leads to *higher* price dispersion in one-way products within a firm in a route, 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.

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 elastcities is different for each market. If consumers with higher income are more likely to be price inelastic (Frank, 2008; Parkin, Powell, and Matthews, 2002), the distribution of consumers' demand elasticities in the higher income city is first-order stochastically dominant over the distribution of consumers' demand elasticities in the lower income city. Firms then have incentives to segment the market by the direction of a route. 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 an increase in income in the origin city is associated with higher price dispersion within the firm in a directional route and this is driven by a bigger increase in the 90th percentile of the price distribution. In addition, firms 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 lower price dispersion in round-trip products within the firm in a directional route.

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 the 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 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 and leads to omitted variable bias.

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, dropping one direction lowers the overall price dispersion as competition increases. This explains why the effect of competition on price dispersion is biased towards zero when dropping one direction. In addition, the bias is bigger in one-way products than in round-trip products. Therefore, when combining both one-way and round-trip products together, the negative effect of competition on price dispersion in round-trip products tends to dominate the positive effect of competition on price dispersion in one-way products, leading to an overall negative but insignificant effect of competition on price dispersion from 1993 to 2013. Second, the share of round-trip fares dominates before 2007 and is decreasing after 2007, as shown in Figure 1.

[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.

Therefore, if we group one-way and round-trip fares together, the effect of competition in round-trip products dominates before 2007 and this is driving the GS result that higher competition leads to lower price dispersion. After 2007, due to a continuing fall in the share of round-trips in all routes, the effect of competition in one-way products dominates, giving rise to the BR results that higher competition leads to higher price dispersion. 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 airlines are able to cultivate brand loyalty among their high-paying customers perhaps through the airlines' frequent-flyer rewards programs. The positive effect of competition on price dispersion is more evident in recent years, 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 markets. 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's 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 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

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

from increased competition in one-way products. In round-trip products, we find support for GS's theory that more competition leads to lower price dispersion from a bigger decrease in the 90th percentile of the price distribution than that in the 10th percentile of the price distribution.

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) argued that there is a non-monotonic relationship between competition and price dispersion from 1993 to 2008.[7] Stavins (2001) found that as competition increases, price dispersion increases due to restricted tickets. Puller and Taylor (2012) found there is price discrimination depending on the day of the week tickets are purchased. Earlier studies such as Alam, Ross and Sickles (2001) documented that airlines have significant market power in a large number of routes. Busse and Rysman (2001) studied the relation between competition and price discrimination in Yellow page advertisement. Other studies interpret price dispersion in the airline industry as an outcome of peak-load pricing or exogenous shifts in demand (e.g. Cornia, Gerardi and Shapiro (2011), Carlton (1997), Gerstner (1986), and Panzar and Willlig (1981)). Aguirregabiria and Ho (2012), Mantin and Koo (2009), and McAfee and Te Velde (2006) studied competition and pricing dynamics. Siegert and Ulbricht (2014) found intertemporal price discrimination in the airline industry.

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 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

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

[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.

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 Theoretical framework

The central proposition of this study is that a market is not necessarily only bounded geographically, but also in terms of products to be included in it. This concept has been emphasized repeatedly in the introduction of every microeconomics textbook. However, even among empirical work 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 answers to the same research question can be in the opposite ends of the spectrum. In this paper, we propose that airlines offer one-way and round-trip as differentiated products and strategically set prices in the presence of increased competition that lead to an increase in price dispersion in the one-way product and a decrease in price dispersion in the round-trip product within the firm in a route. In addition, we illustrate the role of income in shifting the price distribution in a market defined as a directional route.

2.1 Consumer heterogeneity and product differentiation

Suppose consumers are heterogeneous in their price elasticity of demand. In this section, suppose a firm in a route faces two groups of consumers, A and B, with different distributions of demand elasticity, denoted by cumulative distributions F_A and F_B, respectively. Suppose the distribution F_B is second-order stochastic dominant (SOSD) over F_A. Figure 2A illustrates the probability density functions f_A and f_B for the two distributions, respectively. As shown in Figure 2A, 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 elastic and a higher share of consumers who are very price inelastic. This is, by definition, equivalent to saying that F_A is a mean-preserving spread of F_B. 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 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. A firm facing group B consumers, on the other hand, has smaller share of price-inelastic and price elastic consumers, an increase in competition lowers the firm's ability to price discriminate, and therefore the firm is more likely to reduce the price at the 90th percentile of the price distribution more than the price at the 10th percentile of the price distribution. Hence the price dispersion *within* the firm in a route may decrease from an increase in competition.

In the airline industry, for a route operated by the *same* airline, one-way products and round-trip products maybe 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 the one-way products, consumers may prefer to use different airlines for different legs of their flights because of lower prices, and therefore this represents a higher share of consumers who are very price elastic. 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, and a decrease in price dispersion in round-trip products. Our empirical results support the above prediction that an increase in competition leads to an increase in price dispersion in one-way products within the firm in a route , and a decrease in price dispersion in round-trip products.

2.2 Income and market definition

In this section, we will compare another two groups of consumers, C and D, with their respective distributions of demand elasticity, denoted by F_C and F_D. Suppose distribution F_C is first-order stochastic dominant (FOSD) over F_D, with their respective probability density functions f_C and f_D illustrated in Figure 2B. As shown in Figure 2B, the average demand elasticity is more inelastic in F_C than in F_D. The probability density functions for F_C and F_D can be stated as saying that f_C can be obtained from f_D by shifting f_D to the right. Loosely speaking, consumers in group C are more likely to have more inelastic demand than consumers in group D. A firm facing these two groups of consumers will try to charge higher prices for consumers in group C than for consumers in group D at every percentile of the price distribution, therefore, increasing the price at the 10th and at the 90th percentile of the price distribution. If consumers with higher income are more likely to be price inelastic (Frank, 2008; Parkin, Powell, and Matthews, 2002), direction of a route must be taken into account because the GDP in the origin and destination cities vary over time. For a route between the origin and destination city, the distribution of consumers who have higher income in the origin city may be first-order stochastic dominant than the distribution of consumers who have lower income. This explains our empirical results that when defining a route as a directional route, an increase in GDP, or income, leads to an increase in prices at the 10th and the 90th percentile of the price distribution. Price dispersion will increase if the price increase at the 90th percentile of the price distribution is larger than the price increase at the 10th percentile, and price dispersion will decrease if it is the other way around. We find that in one-way products within a firm in a directional route, an increase in GDP in the origin/destination city leads to an increase in price dispersion, and the effect is only marginally significant in round-trip products. This implies that not only is F_C FOSD over F_D, F_C also has bigger spread than F_D.[9] This means group C consumers has a larger proportion of both relatively elastic and inelastic consumers, and when a firm is going to increase its prices, it will increase its price more at the 90th percentile of the price distribution than at the 10th percentile of the price distribution, leading to an increase in price dispersion from

[9]In other words, if we could shift f_C to the left to have the same mean as f_D, F_D is SOSD over F_C.

an increase in income in the origin/destination city.

3 Data

3.1 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 is almost one third of the world's total air traffic. In terms of volume, the U.S. airlines deliver about 31,000 number of domestic flights per day, and the U.S. commercial airline business takes up about 8% of the U.S. GDP.[10] On top of the large statistical numbers, the U.S. domestic aviation market is famous for more than a handful number of regulations and deregulations placed in turn over the last 8 decades. The biggest turning point of the U.S. aviation market is arguably the Airline Deregulation Act in 1978.

Since the deregulation, many new carriers emerged and as a consequence competition in the U.S. domestic aviation market increased. Low cost carriers started up their business and entered into the competitive and deregulated U.S. airline industry. The low cost carriers' pricing strategy is very aggressive in providing discounts and promotions in ticket fares. To combat the emergence of the low cost carriers, the major big airlines strategically developed alliances through code-sharing and capacity agreements with other airlines and attempted to lower costs (e.g. Gayle (2008) and Brueckner (2003)). Figure 3 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 4 shows that the average number of carriers per route over time is also increasing over time, and this increase is predominantly driven by an increase in LCCs.

[10] 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

3.2 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 Airlines, United, Continental, Delta, TWA, Northwest and US Airways as well as low cost carriers (LCCs), such as Southwest, Jetblue, Spirit and regional carriers.[11] 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 T00 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 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 route 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 route 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 route to include tickets fares from PHL to MCO and back (PHL⇌MCO) if the round-trip indicator is 1, and drop the other direction MCO⇌PHL. Next, we take directions into account. In directional one-way, PHL→MCO and MCO→PHL are considered to be two separate routes and both directions are included in the directional one-way sample. In directional round-trip, PHL⇌MCO and MCO⇌PHL are considered to be two separate routes and both directions are included in the directional round-trip sample.

We also make use of metropolitan area (MA) data from the Bureau of Economic Analysis to

[11] We follow the LCC specification introduced in Ito and Lee (2003). The list of legacy carriers and low cost carriers is presented in the Appendix. Current regional airline list is available upon request.

identify big-city routes as in GS. The big-city route classification relies on the population in a MA. A route is classified as a big-city route if it contains both an origin and a destination airport within the 30 largest MAs in the United States (in terms of MA's population). All results using big-city routes are reported in the Appendix.

Our calculation of 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. Because Gini coefficient is calculated based on ticket fares and number of passengers at each fare level within a firm 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-trips.

3.3 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. 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. Airline carriers' characteristics include if the airline carrier is undergoing mergers or filing bankruptcy.[12] In panel A, we define a route to include both one-way and 1/2*round-trip fares in one direction and calculate the corresponding Gini coefficient and competition measures. 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

[12]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 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.

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 effect 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 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 5a and round-trip in Figure 5b.[13] 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 5a shows a strong and positive relationship between competition and price dispersion based on one-way tickets. As shown, in one-way product for a route from PHL to MCO, an increase in competition is associated with an increase in price dispersion. Similarly, figure 5b 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 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 Airway operating in PHL$\rightarrow$MCO is included and US Airway 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

[13]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.

PHL→MCO is considered a different route than US Airways in MCO→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⇌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.

4 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.[14] The main model specification is:

$$G_{ijt}^{lodd} = \alpha + \beta \ Competition_{jt} + \gamma_{ij} + \kappa \ X_{it} + \delta_t + \varepsilon_{ijt} \tag{4.1}$$

where the Gini coefficient captures the price dispersion of the 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 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.[15] Lastly, we distinguish between the number of legacy and low-cost carriers 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 in merger 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

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

[15] 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.

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.

Due to potential endogeneity concerns for the competition measures, we follow GS and use instrumental variable approach throughout this paper. Specifically we instrument the competition measures with following: the log distance on a route, 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 market share of carriers i on route j at time t.[16]

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

$$p(k)_{ijt} = \alpha + \beta \; Competition_{jt} + \gamma_{ij} + \kappa \; X_{it} + \delta_t + \varepsilon_{ijt} \tag{4.2}$$

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.

[16]We did not include the variable GENSP, i.e. geometric mean ratio of average quarterly enplanements 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.

5 Baseline estimates

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

We begin the analysis by first reporting the estimates of equation (3.1) and (3.2) for routes defined in GS. That is, for example, 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.[17]

Panel A in Table 2 contains estimation results for equation (3.1) using the Gini coefficient as the dependent variable. Panel 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. [18]

Column (1) in Panel A reports the effect of an increase in competition, measured by market concentration $-\ln \widehat{HERF}$, on price dispersion is positive and significant from 2007 to 2013, in support of the results found in BR. However, this effect is negative and significant from 1993 to 2006 in column 4, in support of the results found in GS. When taking all the years together, column 7 shows that the effect on price dispersion is not significantly different from 0.

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 slightly larger than the effect on the 90th percentile of the price distribution. However, the effects are not

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

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

significantly different from each other, and this is driving the result in Panel A that competition *does not* lead to lower price dispersion in 2007-2013. For years 1993-2006, we find in column 4 the effect of competition on the 10th percentile of the price distribution is significantly smaller than the effect on the 90th percentile of the price distribution, leading to the negative effect of competition on price dispersion. When looking at the full panel in column (7), the effects of competition on the 10th and 90th percentile are not significantly different from each other.

Using different measures of competition, including the logarithm of the number of competitors on a given route[19] and the number of LCCs and legacy carriers on a given route,[20] Column 2-3 and 5-6 also present the dichotomous results between the two periods, that the effect of competition on price dispersion is negative and significant from 1993-2006, and the effect is non-negative from 2007-2013. The full panel in column 9 suggests that competition from low-cost and legacy carriers may have different effects on price dispersion on a given route.[21]

The distributions 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 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. Consumers who value flexibility, especially in the case of business travelers who are relatively price inelastic, may prefer one-way tickets. In addition, customers who are relatively price elastic but also value frequent-flyers rewards program may opt to have at least one leg of their flights from their frequent-flyers rewards program if they are unable to stay loyal to all legs because of price competition from other carriers. Therefore, grouping one-way and round-trips together in one market may result in biased estimates. In the next section, we explore the effect of competiton on price dispersion by

[19]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.

[20]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.

[21]GS used the data from 1993 to 2007. We extended the data to include more years and first used year 2007 as the cutoff year. As additional robustness checks, instead of using year 2007 as the cutoff year, we used year 2005 as the cutoff and found similar results. Based on Figure 4, one could also argue that years 2003 to 2007 appear to be undergoing a significant amount of transitioning in terms of airlines offering fewer round-trip tickets. We also tried dropping the transitional years from 2003-2007 and found similar results. Results are available upon request.

defining one-way and round-trip products as differentiated products.

5.2 One-way vs. round-trips

Estimations of Equation (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 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 equation (3.1) and (3.2) for one-way routes using the three competition measures. Column 1, 4, and 7 show that both after 2007 and before 2007, and in the full panel, an increase in competition, measured by the Herfindahl index, leads to more price dispersion.[22] 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. Focusing on Panel B and C, the 10th percentile price falls by approximately twice as much as the 90th percentile price level following an increase in competition for both time periods, 2007-2013 and 1993-2006, respectively. In addition, the decrease in the 10th percentile price level in 2007-2013 is approximately twice as big as the decrease in the 10th percentile price level in 1993-2006, suggesting the effect of competition in the bottom tail of the price distribution is more intense in recent years. In the upper tail of the price distribution, airlines have decreased their prices as well as from an increase in competition, but not as much as they are doing in the bottom tail of the price distribution, lending support to BR theory that airlines are able to cultivate customer loyalty among their high-paying customers, and the new entrants compete more aggressively among the price-conscious customers in the lower tail of the incumbent's price distribution.

Other measures of competition have a positive and significant effect on price dispersion in 2007-2013 that is very consistent with the results in column 1. The results are mixed for the other years. Competition measured in the total number of competitors gives rise to non-negative effect on price dispersion in the years prior to 2007, while competition measured in the number of low-cost carriers has a negative effect on price dispersion in the years prior to 2007.[23]

Table 4 reports the estimation results for equation (3.1) and (3.2) for round-trip routes using the three competition measures. In the 2007-2013 subsample, an increase in competition leads to more price dispersion in all routes in column 1. However, the positive effect is again not robust to other measures of competition. For example, in column 2 and 3, the results are not significantly different from zero when we use the number of competitors and the number of low-cost and legacy carriers to measure competition. These results on the Gini coefficients are driven by the fact that the effect of competition on the 10th and 90th percentile price level in 2007-2013 is not significantly

[22]We would expect to observe larger effects from competition on price dispersion on big-city routes, where we have more price-inelastic consumers. As shown in the appendix, the effect is stronger in big-city routes under each sample period.

[23]Results on big-city routes for the full panel are presented in Appendix A.3-A.6. The effect of competition on price dispersion is stronger in both one-way and round-trip markets, consistent with what GS found in big-city routes compared to all routes.

different from each other. On the other hand, in the 1993-2006 subsample, we find that an increase in competition leads to less price dispersion, and this finding is robust to different measures of competition. Using the full panel, column 7-9 show that an increase in competition leads to less price dispersion in round-trip routes.

In the next section, we further make the distinction based on direction. 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: $A \rightarrow B$ and $B \rightarrow A$. 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 both routes are included in the directional one-way sample. Both routes PHL⇄MCO and MCO⇄ PHL are included in the directional round-trip sample. We use characteristics of the origin and destination city as additional controls for demand in directional one-way and directional round-trip routes.

5.3 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.[24] We control for the characteristics of the origin and destination using origin and destination cities log GDP and estimate the following regressions:

$$G^{lodd}_{ijt,direction} = \alpha + \beta_1 Competition + \theta_1 Origin_{jt} + \theta_2 Destination_{jt} + \gamma_{ij,direction} + \kappa\, X_{it} + \delta_t + \varepsilon_{ijt}. \quad (5.1)$$

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

[24] 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).

and controls for time-invariant directional carrier route characteristics. If θ_2 and θ_3 are positive (negative), higher GDP in the origin and destination cities allow airline carriers to better (less able to) price discriminate.

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

$$p(k)_{ijt,direction} = \alpha + \beta_1 Competition + \theta_1 Origin_{jt} + \theta_2 Destination_{jt} + \gamma_{ij,direction} + \kappa\ X_{it} + \delta_t + \varepsilon_{ijt} \tag{5.2}$$

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 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.

Table 5 reports the results on directional one-way routes using equation (4.1) and (4.2). The sample used for estimating equation (4.1) and (4.2) is smaller than the sample used for estimating (3.1) and (3.2). This is because GDP at the MSA level is only available since early 2000s and is not available for smaller origin/destination cities, this significantly reduces the sample for estimating equation (4.1) and (4.2).[25] Therefore, we focus on the longer panel. An increase in competition leads to more price dispersion for all years using all three measures of competition in Panel A column 1-3.[26] Panel B and C show that this is driven by a larger decrease in the 10th percentile of the price distribution than the decrease in the 90th percentile of the price distribution. The coefficients for origin and destination GDP are positive, suggesting that airlines are able to better

[25] We re-estimate regressions for equation (3.1) and (3.2) for one-way and round-trip producs using the reduced sample in Table 5 and 6, and find the difference between the decrease in the 10th and 90th percentile of the price distribution to be smaller. The direction of the effect of competition on price dispersion is not affected, but the significance level is affected. These results are available upon request. In other words, estimating equation (4.1) and (4.2) improves our estimates on the effect of competition in directional one-way and directional round-trip routes and this is not due to the reduction in sample size.

[26] The effect of competition on price dispersion is similar before and after 2007, however it is less significant due to lack of observations.

discriminate in origin and destination cities with higher GDP. Higher GDP in origin and destination cities are also associated with an increase in price at the 10th and the 90th percentile of the price distribution, and the increase in price at the 90th percentile of the price distribution is larger than the increase in price at the 10th percentile of the price distribution.

Table 6 reports the results on directional round-trip routes using equation (4.1) and (4.2). Panel A shows that an increase in competition, using all three measures, in the full panel, leads to less price dispersion. This is driven by a larger decrease in the 90th percentile of the price distribution than the decrease in the 10th percentile of the price distribution, lending support to GS theory that an increase in competition reduces a firm's ability to price discriminate.

The effect of origin and destination city GDP is positive and significant in columns 1 and 3, again suggesting that airlines are more likely to be able to price discriminate in origin cities with higher GDP. An increase in GDP, or income, leads to an increase in prices at the 10th and the 90th percentile of the price distribution. Price dispersion will increase if the price increase at the 90th percentile of the price distribution is larger than the price increase at the 10th percentile, and price dispersion will decrease if it is the other way around. The effect of income on price dispersion is only significant at 10% level in directional round-trip product markets. One potential explanation for this is because there is a smaller share of both very elastic and very inelastic consumers in round-trip products, when a firm is going to increase its prices, it increases its price more at the 90th percentile of the price distribution, but the increase in 90th percentile of the price distribution is less likely to be statistically significant than the increase in price at the 10th percentile of the price distribution. Therefore, the effect of an increase in income on the price dispersion is only marginally significant.

6 Underlying mechanisms

6.1 Direction

To assess the importance of direction when it comes to studying the effect of competition on price dispersion, we study the effect of competition on the relative price dispersion in directional routes.

The price distribution on a route served by the 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}, $l \in \{\text{one-way, round-trip}\}$, 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:

$$\log GR_{ijt}^{l} = \alpha + \beta\ Competition_{jt} + \gamma_{ij} + \kappa\ X_{it} + \delta_t + \varepsilon_{ijt}. \tag{6.1}$$

By construction, $GR_{ijt}^{l} > 1$. We use the same set of controls as in equation (3.1) 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, dropping one direction lowers the overall price dispersion as competition increases. 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 7 reports the results estimated using equation (5.1). Column 1-3 reports the results using each measure of competition in one-way routes. Column 4-6 reports the results using each measure of competition in round-trip routes. In both one-way and round-trip routes, 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. In addition, the estimated $\hat{\beta}$ is bigger for one-way routes than for round-trip routes.

This implies for the same increase in competition, the price dispersion in one direction is increasing faster than the other direction, and this effect is stronger for the one-way routes than for round-trip routes. Dropping one direction in one-way routes reduces the overall price dispersion form an increase in competition, biasing the estimated effect of competition on price dispersion towards zero. Grouping one-way and round-trip fares together also reduces the overall price dispersion from increased competition. This may explain why grouping one-way and round-trip together and dropping one direction lead to the result that an increase competition leads to lower price dispersion found earlier.

In addition, we 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

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

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

$$\log AvgR_{ijt}^{l} = \alpha + \beta \; Competition_{jt} + \gamma_{ij} + \kappa \; X_{it} + \delta_t + \varepsilon_{ijt} \tag{6.2}$$

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

Table 8 reports the results estimated using equation (5.2). Column 1-3 reports the results using each measure of competition in one-way routes. Column 4-6 reports the results using each measure of competition in round-trip routes. In both one-way and round-trip routes, the effect of competition on the average fare ratio is positive and significant. This confirms the results above that direction matters and higher competition leads to higher average price in one direction compared to the other direction. Dropping one direction lowers the overall price dispersion and leads to biased estimate on the effect of competition on price dispersion.

6.2 Markups

Table 1 summary statistics shows 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:

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

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. $p\,(k)_{jt}^{roud-trip}$ is the roud-trip ticket price at the kth percentile of the distribution. Table 9 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 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 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 BR's original theory that legacy carriers are better at cultivating consumer loyalty through frequent flyer programs among high-paying customers whereas 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.[27]

[27] 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 we control for if the origin/destination city is a hub or not and carrier-route fixed effect 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.

7 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 firm in a route. We find that an increase in competition leads to *higher* price dispersion, 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. However, these results are not very robust to different measures of competition and/or different time period.

Next, we find that arbitrarily dropping one direction tends to underestimate the effect of competition on price dispersion, in both one-way and round-trip products. We address the effect of direction and competition on dispersion by controlling for characteristics of origin and destination on a route. In one-way (round-trip) directional routes, a route from $A \to B$ ($A \rightleftharpoons B$) is considered to be a different market than a route from $B \to A$ ($B \rightleftharpoons A$) within the same firm. Using the full panel, we find that an increase in competition increases price dispersion in directional one-way routes, and lowers price dispersion in directional round-trip routes. In addition, we find that an increase in income increases price dispersion in directional one-way routes by increasing the price at the 90th percentile of the price distribution more than it does at the 10th percentile of the price distribution, but effect is only marginally significant in directional round-trip routes.

We are able to reconcile the results found in BR and GS. The 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 support for GS's theory that more competition leads to lower price dispersion from a bigger decrease in the 90th percentile of the price distribution than that in the 10th percentile of the price distribution.

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. In our directional routes analysis, the effect of origin and destination's GDP on price dispersion is positive. Future studies could use our results to build models to incorporate consumer heterogeneity to allow for regional price discrimination. 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.

References

[1] Aguirregabiria, Victor, and Chun-Yu Ho. 2012. "A dynamic oligopoly game of the US airline industry: Estimation and policy experiments." *Journal of Econometrics*, 168(1): 156–173.

[2] Alam, Ila M Semenick, Leola B Ross, and Robin C Sickles. 2001. "Time series analysis of strategic pricing behavior in the US airline industry." *Journal of Productivity Analysis*, 16(1): 49–62.

[3] Berry, Steven, and Panle Jia. 2008. "Tracing the woes: An empirical analysis of the airline industry." National Bureau of Economic Research.

[4] Borenstein, Severin. 1985. "Price discrimination in free-entry markets." *The RAND Journal of Economics*, 380–397.

[5] Borenstein, Severin. 1991. "The dominant firm advantage in multiproduct industries: evidence from the US airlines." *The Quarterly Journal of Economics*, 1237–1266.

[6] Borenstein, Severin, and Nancy L Rose. 1994. "Competition and price dispersion in the US airline industry." *Journal of Political Economy*, 102(4): 653–683.

[7] Brueckner, JK. 2003. "International airfares in the age of alliances: The effects of codesharing and antitrust immunity." *Review of Economics and Statistics*, 85(1): 105–118.

[8] Busse, Meghan R, and Marc Rysman. 2001. "Competition and price discrimination in yellow pages advertising." *The RAND Journal of Economics*, 36(2): 378–390.

[9] Carlton, Dennis W. 1977. "Peak load pricing with stochastic demand." *The American Economic Review*, 1006–1010.

[10] Cornia, Marco, Kristopher S Gerardi, and Adam Hale Shapiro. 2011. "Price discrimination and business-cycle risk." Working Paper, Federal Reserve Bank of Atlanta.

[11] Dai, Mian, Qihong Liu, and Konstantinos Serfes. 2014. "Is the effect of Competition on Price Dispersion Nonmonotonic? Evidence from the US Airline Industry." *Review of Economics and Statistics*, 96(1): 161–170.

[12] Forbes, Silke J. 2008. "The e effect of air traffic delays on airline prices." *International journal of industrial organization*, 26(5): 1218–1232.

[13] Forbes, Silke J, and Mara Lederman. 2010. "Does vertical integration affect firm performance? Evidence from the airline industry." *The RAND Journal of Economics*, 41(4): 765–790.

[14] Forbes, Silke Januszewski, and Mara Lederman. 2009. "Adaptation and vertical integration in the airline industry." *The American Economic Review*, 99(5): 1831–1849.

[15] Frank, Robert. 2008. *Microeconomics and Behavior*. 7th edition. McGraw-Hill.

[16] FTC, 2016. "Geographic market definition." https://www.ftc.gov/system/files/attachments/us-submissions-oecd-other-international-competition-fora/geographic_market_definition_united_states.pdf.

[17] Gayle, Philip. 2008. "An empirical analysis of the competitive effects of the Delta/Continental/Northwest code-share alliance." *Journal of Law and Economics*, 51(4): 743–766.

[18] Gerardi, Kristopher S, and Adam Hale Shapiro. 2009. "Does competition reduce price dispersion? New evidence from the airline industry." *Journal of Political Economy*, 117(1): 1–37.

[19] Gerstner, Eitan. 1986. "Peak load pricing in competitive markets." *Economic Inquiry*, 24(2): 349–361.

[20] Goolsbee, Austan, and Chad Syverson. 2008. "How do incumbents respond to the threat of entry? Evidence from the major airlines." *Quarterly Journal of Economics*, 123(4): 16111–1633.

[21] Ito, Harumi, and Darin Lee. 2003. "Low cost carrier growth in the US airline industry: past, present, and future." Brown University Department of Economics Paper.

[22] Mantin, Benny, and Bonwoo Koo. 2009. "Dynamic price dispersion in airline markets." *Transportation Research Part E: Logistics and Transportation Review*, 45(6): 1020–1029.

[23] Mayer, Christopher, and Todd Sinai. 2002. "Network effects, congestion externalities, and air traffic delays: Or why all delays are not evil." National Bureau of Economic Research.

[24] Mazzeo, Michael J. 2003. "Competition and service quality in the US airline industry." *Review of industrial Organization*, 22(4): 275{296.

[25] McAfee, R Preston, and Vera Te Velde. 2006. "Dynamic pricing in the airline industry." forthcoming in Handbook on Economics and Information Systems, Ed: TJ Hendershott, Elsevier.

[26] Mueller, Kathrin, and Kai Huschelrath. 2011. "Low Cost Carriers and the Evolution of the US Airline Industry." ZEW-Centre for European Economic Research Discussion Paper, ,

[27] Panzar, John C, and Robert D Willig. 1981. "Economies of scope." *The American Economic Review*, 268–272.

[28] Parkin, Michael, Melanie Powell, and Kent Mathews. 2002. *Economics*. Harlow: Addision-Wesley. pp 77–79.

[29] Pindyck, Robert S., and Daniel L. Rubinfeld. 2013. *Microeconomics*. 8th edition.

[30] Prince, Jeffrey T, and Daniel H Simon. 2014. "Do Incumbents Improve Service Quality in Response to Entry? Evidence from Airlines' On-Time Performance." *Management Science*, 372–390.

[31] Puller, Steven L, and Lisa M Taylor. 2012. "Price discrimination by day-of-week of purchase: Evidence from the US airline industry." *Journal of Economic Behavior & Organization*, 84(3): 801–812.

[32] Roberts, James W, and Andrew Sweeting. 2012. "Airline Mergers and the Potential Entry Defense." Working paper.

[33] Siegert, Caspar, and Robert Ulbricht. 2014. "Dynamic oligopoly pricing: Evidence from the airline industry." Available at SSRN 2413180.

[34] Stavins, Joanna. 2001. "Price discrimination in the airline market: The effect of market concentration." *Review of Economics and Statistics*, 83(1): 200–202.

[35] Wooldridge. 2012. "Econometric analysis of cross-section and panel data." 2nd edition.

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

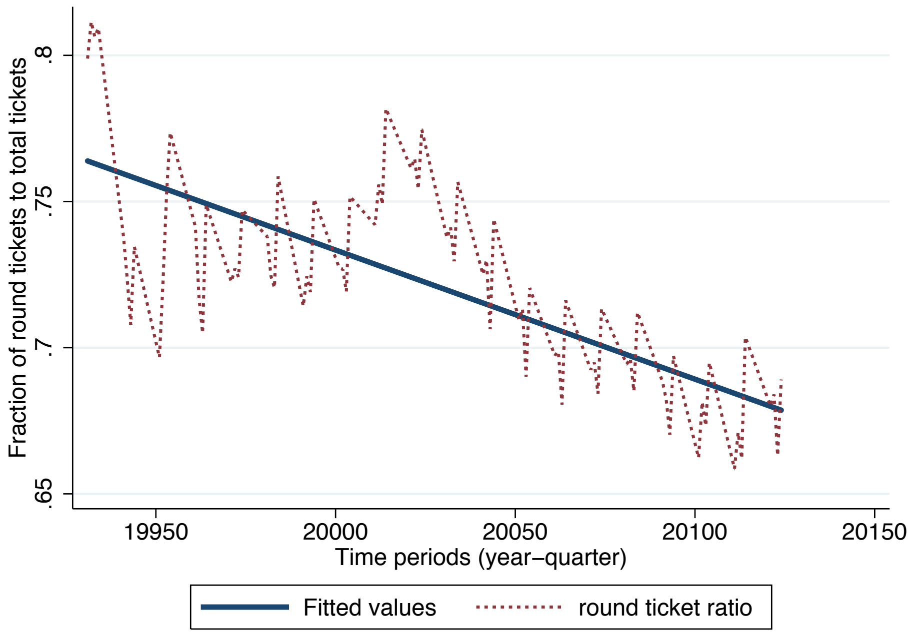


Figure 2: SOSD and FOSD

Figure 1A

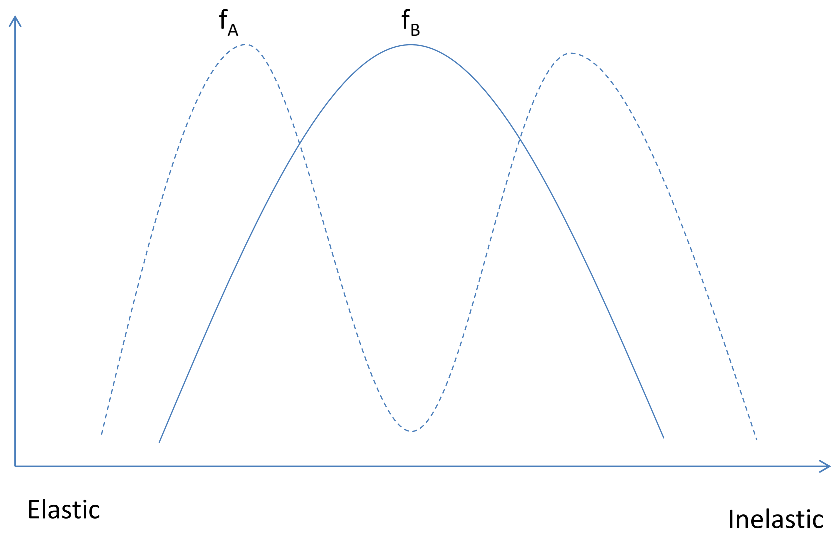
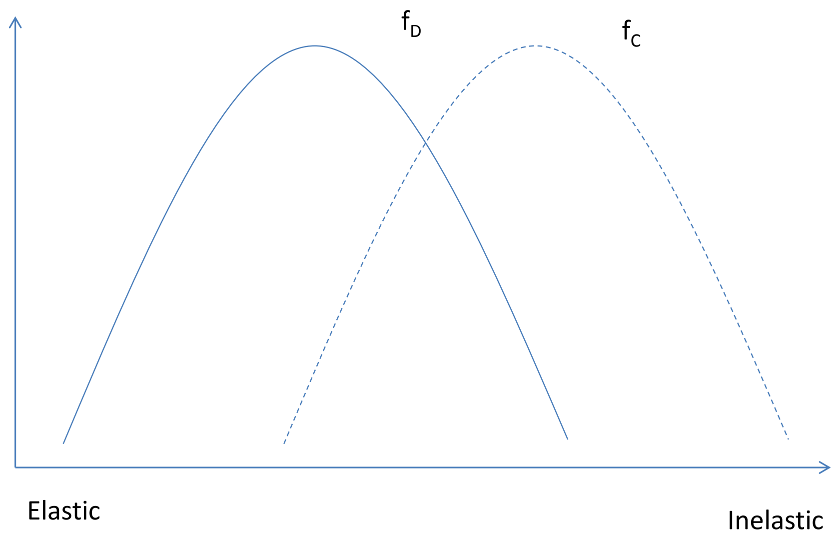


Figure 1B



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.

Figure 3: Weighted average number of low cost airlines per route

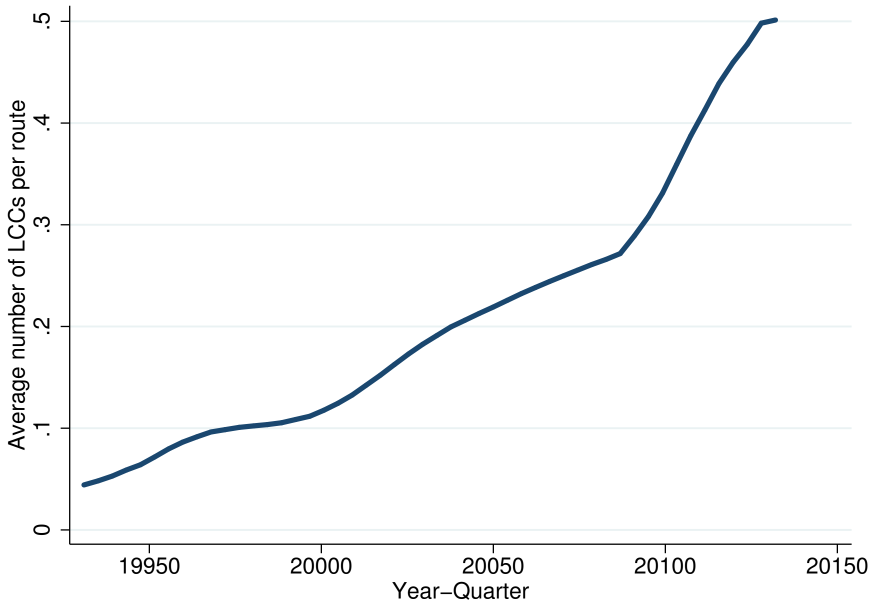


Figure 4: Weighted average number of airlines per route

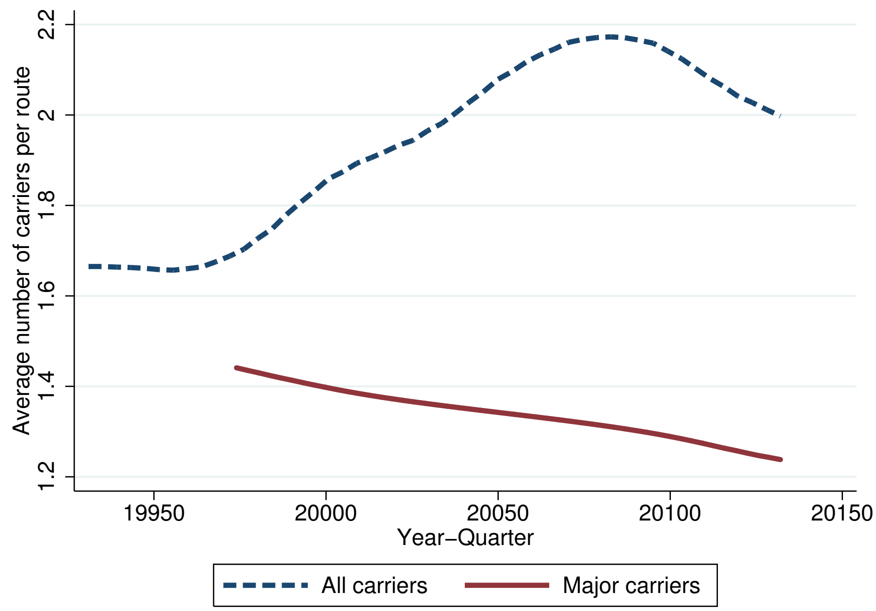
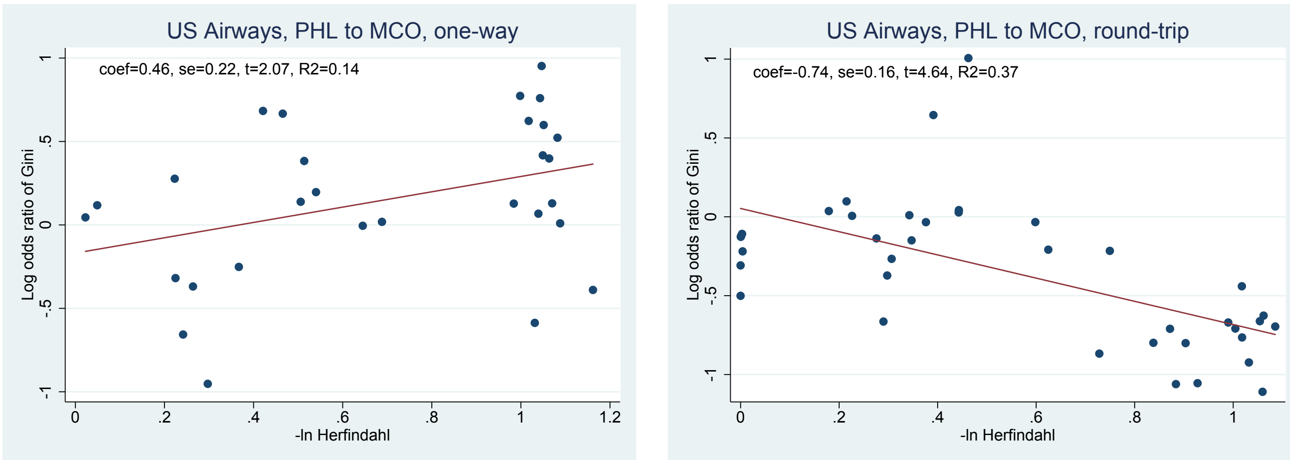


Figure 5. Distinction between one-way and round-trip.



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.

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	1
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-trips

	2007-2013			1993-2006			All Years		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A Gini coefficient									
-ln $\widehat{HERF}$	0.055**			-0.059***			-0.022		
	(0.023)			(0.015)			(0.034)		
ln $\widehat{N}$		0.012			-0.038***			-0.029	
		(0.012)			(0.013)			(0.018)	
N^{LCC}			-0.007			-0.051***			0.206***
			(0.008)			(0.008)			(0.057)
N^{LEG}			0.005			0.005			-0.158***
			(0.008)			(0.005)			(0.058)
R^2	0.74	0.72	0.74	0.79	0.78	0.79			
Panel B 10th percentile									
-ln $\widehat{HERF}$	-0.238***			-0.143***			-0.298***		
	(0.020)			(0.013)			(0.025)		
ln $\widehat{N}$		-0.103***			-0.102***			-0.106***	
		(0.012)			(0.010)			(0.015)	
N^{LCC}			-0.108***			-0.081***			-0.115***
			(0.008)			(0.007)			(0.005)
N^{LEG}			0.007			-0.051***			-0.026***
			(0.006)			(0.005)			(0.004)
R^2	0.89	0.90	0.89	0.84	0.86	0.84			
Panel C 90th percentile									
-ln $\widehat{HERF}$	-0.216***			-0.237***			-0.300***		
	(0.020)			(0.017)			(0.037)		
ln $\widehat{N}$		-0.094***			-0.156***			-0.158***	
		(0.011)			(0.014)			(0.020)	
N^{LCC}			-0.102***			-0.146***			-0.105***
			(0.008)			(0.009)			(0.007)
N^{LEG}			-0.015**			-0.052***			-0.020***
			(0.007)			(0.006)			(0.006)
R^2	0.91	0.91	0.92	0.89	0.89	0.89			
Observations	33,946	15,606	33,946	75,890	33,500	75,890	112,622	55,279	112,622

NOTE: Results for year 2007-2013 are reported in column (1)-(3), 1993-2006 in (4)-(6), and 1993-2013 in (7)-(9). All regressions include carrier-route-specific dummies, time dummies, 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 Trips

	2007-2013			1993-2006			All Years		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Panel A Gini coefficient				
-ln $\widehat{HERF}$	0.136***			0.107***			0.154***		
	(0.030)			(0.030)			(0.040)		
ln $\widehat{N}$		0.065***			0.008			0.043***	
		(0.015)			(0.0166)			(0.014)	
N^{LCC}			0.049***			-0.044***			-0.032***
			(0.011)			(0.013)			(0.008)
N^{LEG}			-0.004			-0.000			0.010
			(0.009)			(0.009)			(0.009)
R^2	0.58	0.54	0.58	0.69	0.64	0.69	0.60	0.54	0.60
					Panel B 10th percentile				
-ln $\widehat{HERF}$	-0.263***			-0.122***			-0.537***		
	(0.024)			(0.012)			(0.034)		
ln $\widehat{N}$		-0.177***			-0.112***			-0.180***	
		(0.014)			(0.014)			(0.012)	
N^{LCC}			-0.108***			-0.128***			-0.136***
			(0.010)			(0.010)			(0.007)
N^{LEG}			0.002			-0.055***			-0.053***
			(0.007)			(0.006)			(0.005)
R^2	0.86	0.86	0.86	0.84	0.84	0.84	0.80	0.83	0.82
					Panel C 90th percentile				
-ln $\widehat{HERF}$	-0.135***			-0.060**			-0.414***		
	(0.021)			(0.029)			(0.046)		
ln $\widehat{N}$		-0.064***			-0.094***			-0.132***	
		(0.011)			(0.015)			(0.018)	
N^{LCC}			-0.059***			-0.170***			-0.153***
			(0.009)			(0.012)			(0.009)
N^{LEG}			-0.016**			-0.067***			-0.061***
			(0.007)			(0.009)			(0.008)
R^2	0.84	0.79	0.85	0.87	0.85	0.87	0.83	0.80	0.84
Observations	29,531	14,398	29,531	40,397	19,452	40,397	64,923	31,820	68,692

NOTE: Results for year 2007-2013 are reported in column (1)-(3), 1993-2006 in (4)-(6), and 1993-2013 in (7)-(9). All regressions include carrier-route-specific dummies, time dummies, 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 Trips

	2007-2013			1993-2006			All Years		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A Gini coefficient									
-ln $\widehat{HERF}$	0.060***			-0.060***			-0.105***		
	(0.022)			(0.015)			(0.021)		
ln $\widehat{N}$		0.010			-0.035***			-0.041***	
		(0.012)			(0.012)			(0.013)	
N^{LCC}			0.004			-0.051***			-0.050***
			(0.008)			(0.008)			(0.006)
N^{LEG}			-0.004			0.003			0.005
			(0.008)			(0.005)			(0.005)
R^2	0.75	0.72	0.75	0.79	0.78	0.79	0.74	0.73	0.74
Panel B 10th percentile									
-ln $\widehat{HERF}$	-0.239***			-0.141***			-0.391***		
	(0.020)			(0.013)			(0.020)		
ln $\widehat{N}$		-0.101***			-0.100***			-0.174***	
		(0.012)			(0.010)			(0.012)	
N^{LCC}			-0.105***			-0.079***			-0.107***
			(0.008)			(0.007)			(0.005)
N^{LEG}			0.006			-0.051***			-0.030***
			(0.006)			(0.005)			(0.004)
R^2	0.89	0.90	0.89	0.83	0.86	0.84	0.82	0.85	0.83
Panel C 90th percentile									
-ln $\widehat{HERF}$	-0.221***				-0.236***		0.537***		
	(0.021)				(0.017)		(0.026)		
ln $\widehat{N}$		-0.099***			-0.153***			-0.233***	
		(0.011)			(0.015)			(0.015)	
N^{LCC}			-0.105***			-0.146***			-0.165***
			(0.009)			(0.009)			(0.008)
N^{LEG}			-0.013*			-0.052***			-0.032***
			(0.007)			(0.006)			(0.006)
R^2	0.92	0.91	0.92	0.89	0.88	0.89	0.85	0.85	0.85
Observations	33,946	15,606	33,946	75,890	33,500	75,890	104,569	46,833	108,727

NOTE: Results for year 2007-2013 are reported in column (1)-(3), 1993-2006 in (4)-(6), and 1993-2013 in (7)-(9). All regressions include carrier-route-specific dummies, time dummies, 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. Directional one-way

	All Years		
	(1)	(2)	(3)
	Panel A Gini coefficient		
-ln $\widehat{HERF}$	0.195**		
	(0.090)		
ln $\widehat{N}$		0.142***	
		(0.044)	
N^{LCC}			0.065***
			(0.020)
N^{LEG}			0.023
			(0.015)
Origin GDP	0.295***	0.508***	0.293***
	(0.081)	(0.139)	(0.080)
Dest GDP	0.216**	0.414***	0.214**
	(0.086)	(0.145)	(0.085)
R^2	0.56	0.46	0.56
	Panel B 10th percentile		
-ln $\widehat{HERF}$	-0.714***		
	(0.087)		
ln $\widehat{N}$		-0.207***	
		(0.039)	
N^{LCC}			-0.184***
			(0.019)
N^{LEG}			-0.035***
			(0.012)
Origin GDP	0.109**	0.020	0.124**
	(0.054)	(0.078)	(0.053)
Dest GDP	0.090	-0.000	0.109**
	(0.055)	(0.082)	(0.055)
R^2	0.80	0.77	0.81
	Panel C 90th percentile		
-ln $\widehat{HERF}$	-0.566***		
	(0.063)		
ln $\widehat{N}$		-0.087***	
		(0.032)	
N^{LCC}			-0.133***
			(0.016)
N^{LEG}			-0.042***
			(0.012)
Origin GDP	0.224***	0.209*	0.234***
	(0.070)	(0.118)	(0.071)
Dest GDP	0.199***	0.145	0.214***
	(0.072)	(0.126)	(0.073)
R^2	0.83	0.70	0.83
Observations	17,018	7,553	17,018

NOTE: All regressions include carrier-route-direction-specific dummies, time dummies, a bankruptcy dummy, and a merger dummy. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. A directional one-way route is defined as follows: a route from $A \rightarrow B$ is different from $B \rightarrow A$. Price dispersion and competition measures are calculated for each route. *** denotes significance at 1%. ** denotes significance at 5% and * denotes significance at 10%.

Table 6. Directional round-trip

	All Years		
	(1)	(2)	(3)
	Panel A Gini coefficient		
-ln $\widehat{HERF}$	-0.170***		
	(0.039)		
ln $\widehat{N}$		-0.066***	
		(0.023)	
N^{LCC}			-0.077***
			(0.014)
N^{LEG}			0.009
			(0.011)
Origin GDP	0.095*	0.010	0.099*
	(0.054)	(0.082)	(0.053)
Dest GDP	0.073	0.049	0.077
	(0.053)	(0.082)	(0.052)
R^2	0.79	0.72	0.79
	Panel B 10th percentile		
-ln $\widehat{HERF}$	-0.602***		
	(0.043)		
ln $\widehat{N}$		-0.234***	
		(0.028)	
N^{LCC}			-0.178***
			(0.012)
N^{LEG}			-0.014
			(0.010)
Origin GDP	0.182***	0.103	0.198***
	(0.044)	(0.064)	(0.042)
Dest GDP	0.184***	0.117*	0.202***
	(0.044)	(0.066)	(0.043)
R^2	0.83	0.84	0.88
	Panel C 90th percentile		
-ln $\widehat{HERF}$	-0.823***		
	(0.046)		
ln $\widehat{N}$		-0.304***	
		(0.030)	
N^{LCC}			-0.254***
			(0.014)
N^{LEG}			-0.019
			(0.013)
Origin GDP	0.230***	0.054	0.250***
	(0.052)	(0.086)	(0.046)
Dest GDP	0.213***	0.096	0.236***
	(0.052)	(0.089)	(0.047)
R^2	0.88	0.85	0.89
Observations	29,151	12,148	29,151

NOTE: All regressions include carrier-route-direction-specific dummies, time dummies, a bankruptcy dummy, and a merger dummy. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. Column (1) is for all routes. Column (2) is for big-city routes only. A directional round-trip route is defined as follows: a route from $A \rightleftharpoons B$ is different from $B \rightleftharpoons A$. Price dispersion and competition measures are calculated for each route. *** denotes significance at 1%. ** denotes significance at 5% and * denotes significance at 10%.

Table 7. Gini ratio on directional routes

	One-way			Round-trip		
	(1)	(2)	(3)	(4)	(5)	(6)
-ln $\widehat{HERF}$	0.134***			0.041***		
	(0.016)			(0.008)		
ln $\widehat{N}$		0.013**			0.022***	
		(0.005)			(0.005)	
N^{LCC}			0.004			0.009***
			(0.003)			(0.002)
N^{LEG}			0.006*			0.010***
			(0.003)			(0.002)
R^2	0.22	0.24	0.23	0.26	0.28	0.26
Observations	64,920	31,820	68,688	104,569	46,833	108,727

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 carrier-route-specific dummies, time dummies, a bankruptcy dummy, and a merger dummy. 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 8. Average fares ratio

	One-way			Round-trip		
	(1)	(2)	(3)	(4)	(5)	(6)
-ln $\widehat{HERF}$	0.383***			0.389***		
	(0.090)			(0.061)		
ln $\widehat{N}$		0.003			0.246***	
		(0.035)			(0.037)	
N^{LCC}			-0.019			0.045**
			(0.021)			(0.019)
N^{LEG}			-0.003			0.069***
			(0.020)			(0.016)
R^2	0.25	0.24	0.24	0.24	0.27	0.25
Observations	64,699	31,714	68,470	104,567	46,832	108,726

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 carrier-route-specific dummies, time dummies, a bankruptcy dummy, and a merger dummy. 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 9 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 sume 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 Additional tables and figures

Table A1. Legacy and low cost carriers

Legacy	LCC
United Airline	Accessair Holdings
US Airways	Air South Inc.
American Airline	AirTran Airways Corporation
Northwest Airline	American Trans Air Inc.
Delta Airline	Eastwind Airlines Inc.
TWA	Frontier Airlines Inc.
Continental	Frontier Flying Service
	JetBlue Airways
	Kiwi International
	Morris Air Corporation
	National Airlines
	Pro Air Inc.
	Reno Air Inc.
	Southwest Airlines Co.
	Spirit Air Lines
	Sun Country Airlines
	Valujet Airlines Inc.
	Vanguard Airlines Inc.
	Western Pacific Airlines
	Allegiant Air

NOTES: This is a list of legacy and low-cost carriers in the data set. The list of historical/current regional airlines is available upon request.

Table A2. 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.

Table A.3. Big-city routes 1993-2013: one-way and round-trip

	One-way			Round-trip		
	(1)	(2)	(3)	(1)	(2)	(3)
	Panel A Gini coefficient					
-ln $\widehat{HERF}$	0.217***			-0.143***		
	(0.063)			(0.035)		
ln $\widehat{N}$		0.044**			-0.057***	
		(0.021)			(0.018)	
N^{LCC}			-0.023*			-0.063***
			(0.014)			(0.009)
N^{LEG}			0.021			0.006
			(0.014)			(0.008)
R^2	0.49	0.48	0.49	0.72	0.72	0.72
	Panel B 10th percentile					
-ln $\widehat{HERF}$	-0.589***			-0.430***		
	(0.050)			(0.031)		
ln $\widehat{N}$		-0.195***			-0.178***	
		(0.015)			(0.015)	
N^{LCC}			-0.143***			-0.090***
			(0.010)			(0.008)
N^{LEG}			-0.054***			-0.035***
			(0.008)			(0.006)
R^2	0.80	0.84	0.81	0.83	0.85	0.84
	Panel C 90th percentile					
-ln $\widehat{HERF}$	-0.472***			-0.637***		
	(0.067)			(0.044)		
ln $\widehat{N}$		-0.159***			-0.258***	
		(0.026)			(0.020)	
N^{LCC}			-0.154***			-0.162***
			(0.011)			(0.012)
N^{LEG}			-0.064***			-0.036***
			(0.011)			(0.009)
R^2	0.81	0.79	0.82	0.84	0.85	0.85
Observations	29,076	18,029	29,076	44,535	26,831	44,535

NOTE: All regressions include carrier-route-specific dummies, time dummies, 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-way only uses one direction of one-way tickets and round-trip only uses one direction of round-trip tickets 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 A.4. Big-city routes 1993-2013: directional one-way and directional round-trip

	Directional one-way			Directional round-trip		
	(1)	(2)	(3)	(1)	(2)	(3)
	Panel A Gini coefficient					
-ln $\widehat{HERF}$	0.427***			-0.181***		
	(0.138)			(0.066)		
ln $\widehat{N}$		0.155***			-0.044	
		(0.048)			(0.035)	
N^{LCC}			0.086***			-0.073***
			(0.028)			(0.022)
N^{LEG}			0.049***			-0.004
			(0.018)			(0.017)
Origin GDP	0.731***	1.242***	0.726***	-0.075	-0.162	-0.079
	(0.178)	(0.275)	(0.183)	(0.094)	(0.130)	(0.094)
Dest GDP	0.641***	1.032***	0.625***	-0.067	-0.101	-0.072
	(0.181)	(0.258)	(0.184)	(0.091)	(0.129)	(0.091)
R^2	0.45	0.43	0.45	0.76	0.71	0.76
	Panel B 10th percentile					
-ln $\widehat{HERF}$	-0.891***			-0.640***		
	(0.127)			(0.069)		
ln $\widehat{N}$		-0.215***			-0.242***	
		(0.044)			(0.036)	
N^{LCC}			-0.188***			-0.153***
			(0.024)			(0.016)
N^{LEG}			-0.052***			-0.032***
			(0.014)			(0.011)
Origin GDP	-0.214**	-0.281*	-0.197**	0.118*	0.075	0.112*
	(0.104)	(0.147)	(0.099)	(0.069)	(0.099)	(0.066)
Dest GDP	-0.271**	-0.309**	-0.232**	0.132*	0.133	0.123*
	(0.105)	(0.145)	(0.100)	(0.068)	(0.100)	(0.065)
R^2	0.77	0.78	0.80	0.82	0.84	0.83
	Panel C 90th percentile					
-ln $\widehat{HERF}$	-0.625***			-0.895***		
	(0.090)			(0.064)		
ln $\widehat{N}$		-0.083**			-0.294***	
		(0.033)			(0.034)	
N^{LCC}			-0.117***			-0.221***
			(0.023)			(0.018)
N^{LEG}			-0.053***			-0.049**
			(0.017)			(0.020)
Origin GDP	0.239*	0.429**	0.249*	0.066	-0.138	0.057
	(0.140)	(0.206)	(0.133)	(0.097)	(0.132)	(0.090)
Dest GDP	0.201	0.397*	0.228	0.075	-0.052	0.062
	(0.156)	(0.228)	(0.144)	(0.099)	(0.136)	(0.092)
R^2	0.80	0.68	0.80	0.86	0.85	0.87
Observations	7,007	4,343	7,007	11,487	6,849	11,487

NOTE: All regressions include carrier-route-direction-specific dummies, time dummies, a bankruptcy dummy, and a merger dummy. Standard errors are in parentheses and are clustered by route. Hats indicate that instrumental variables are used. A directional one-way route is defined as follows: a route from $A \rightarrow B$ is different from $B \rightarrow A$. Similarly for directional round-trip: a route from $A \rightleftharpoons B$ is different from $B \rightleftharpoons A$. Price dispersion and competition measures are calculated for each route. *** denotes significance at 1%. ** denotes significance at 5% and * denotes significance at 10%.

Table A.5. Big-city routes: Gini ratio on directional routes

	One-way			Round-trip		
	(1)	(2)	(3)	(4)	(5)	(6)
-ln $\widehat{HERF}$	0.124***			0.051***		
	(0.020)			(0.011)		
ln $\widehat{N}$		0.013**			0.021***	
		(0.006)			(0.007)	
N^{LCC}			0.007			0.009***
			(0.005)			(0.003)
N^{LEG}			0.008*			0.012***
			(0.004)			(0.002)
R^2	0.19	0.22	0.20	0.26	0.28	0.26
Observations	29,076	18,029	29,076	44,535	26,831	44,535

NOTE: The dependent variable is log GR_{ijt}^{l} for carrier i at time t for one-way or round-trip route j. All regressions include carrier-route-specific dummies, time dummies, a bankruptcy dummy, and a merger dummy. 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 A.6. Big-city routes: Average fares ratio

	One-way			Round-trip		
	(1)	(2)	(3)	(4)	(5)	(6)
-ln $\widehat{HERF}$	0.287**			0.396***		
	(0.129)			(0.094)		
ln $\widehat{N}$		-0.041			0.224***	
		(0.043)			(0.048)	
N^{LCC}			-0.019			-0.005
			(0.029)			(0.027)
N^{LEG}			0.014			0.106***
			(0.028)			(0.023)
R^2	0.23	0.24	0.23	0.25	0.28	0.25
Observations	28,965	17,970	28,965	44,534	26,830	44,534

NOTE: All regressions include carrier-route-specific dummies, time dummies, a bankruptcy dummy, and a merger dummy. 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%.

B Instrumental variables

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

ln Distance$_j$: The logarithm of nonstop distance in miles between endpoint airports of route j.

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.

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.