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HOW DOES THE INTERNET INFLUENCE PRICE DISPERSION? EVIDENCE FROM THE AIRLINE INDUSTRY*

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I estimate the Internet's effect on the level and dispersion of airline fares on a given route within and across firms. The results suggest that increases in Internet penetration reduce average price and lead to higher intrafirm price dispersion, while increases in Internet penetration do not affect interfirm price dispersion on a given route. Internet penetration affects average fares most in competitive markets. These results suggest that the Internet has significantly but subtlely influenced domestic airline competition. The effect of the Internet on prices and price dispersion is larger on direct flights.

I. INTRODUCTION

THE PERSISTENCE OF PRICE DISPERSION IN HOMOGENOUS GOODS MARKETS is a thoroughly examined phenomenon in economics. Theoretical studies show that when consumers have incomplete information about the good, price dispersion can arise from search-cost differences among them. Furthermore, this literature generally predicts that as consumers become more informed about prices and as search costs decline, both prices and price dispersion will decrease (see Burdett and Judd [1983]; Salop and Stiglitz [1977]; Stahl [1989]; Stigler [1961). Indeed, if all consumers were to know every firm's prices, everyone would buy from the firm offering the lowest price; thus, all firms would offer the same price.

Empirical studies on the relationship between search costs and price dispersion are rare given the lack of clear-cut natural experiments involving changes in consumers' search costs (see Dahlby and West [1986], and Sorensen [2000]). Fortunately, over the last several years, price comparison Web sites on the Internet have presented a unique opportunity for investigation by significantly reducing search costs associated with interfirm

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price comparisons (see Baye, Morgan and Scholten [2006]; Brynjolfsson and Smith [2000]; Clay *et al.* [2002]; Iyer and Pazgal [2003]; Smith and Brynjolfsson [2001). Despite this development, however, measuring the Internet's effect on price dispersion poses some challenges. Most goods and services sold on the Internet also are available offline, for example; the total effect of the Internet therefore will depend on this technology's influence on both online and offline pricing and purchasing. Furthermore, price dispersion for many products occurs not only across firms but also within firms and it is important to distinguish the two of them because the Internet may affect them differently.

This paper confronts these challenges by offering a novel approach for estimating the Internet's effect on price distribution. More specifically, my method draws from the significant differences in Internet adoption rate across geographic locations to assess the Internet's influence on domestic airline fare distribution. The airline industry is particularly suited for an investigation of the Internet's influence on pricing. First, data are available for the full distribution of fares, including those purchased online and offline. Furthermore, the airline industry's traditionally high price dispersion allows us to measure the Internet's effect on price dispersion both between and within firms.

The existing theoretical literature lacks a precise prediction about the effect of lower search costs on intrafirm price dispersion. Informal claims, which build on predictions regarding price dispersion across firms, propose that search-cost decreases facilitate competition among firms and lead to an overall decline in price dispersion both within and across firms. As this paper shows, however, the economics of search costs is more complicated than these claims suggest. Two major issues determine the consequences of changes in search costs: which portion of consumers the search costs affect and to what degree. Indeed, variations in search-cost changes can make the economic environment more competitive for some consumers and less competitive for others.

To investigate the Internet's influence on domestic airline fares, I consulted a variety of data sources. The Current Population Survey (CPS) provided data on Internet penetration over time and across geographical locations, and data on airfares originated from the Department of Transportation. I supplemented these records with flight schedule information from the Official Airlines Guide.

The results of my analysis indicate lower average fares in areas where a higher proportion of consumers have Internet access. However, the Internet's influence on intra- and interfirm price dispersion differs: indeed, when consumers' Internet access increases price dispersion increases within firms, whereas it does not change significantly between firms. Thus, the Internet improves firms' ability to price discriminate among its own customers. Furthermore, increases in intrafirm price dispersion stemming from increases in Internet penetration cast doubt upon claims that the Internet 'levels the playing field' for all consumers. The results are consistent between a sample of direct flights and the full sample that includes both direct and connecting flights; the effect of the Internet is larger in a sample of direct flights. Finally, results show that the Internet mostly affects the price dispersion of major carriers.

This paper contributes to the growing literature on price dispersion in the airline industry. In a previous exploration of this topic, Borenstein and Rose [1994] attempt to separate the effect of price discrimination from the effect of cost differences on price dispersion. They use a cross-section of data and conclude that although cost differences are partially responsible for some price dispersion, they cannot fully explain this phenomenon. They show that routes with more competition and lower flight density tend to have higher price dispersion than other routes (see Stavins [2001], and Gerardi and Shapiro [2009] for extensions).

Despite travel's status as the most popular product sold online, few economists have analyzed the Internet's effect on prices in the airline industry. Granted, Clemons, Hann and Hitt [2002] study the competition between online travel agents in 1997 and document persistent price dispersion online, which they explain through product differentiation, heterogeneity among consumers and inefficiencies in pricing. Chen [2002] supports these conclusions with more recent data on the online prices posted to airlines' Web sites and online travel agents. Two recent papers that directly analyze the effect of the Internet on airline pricing are Verlinda and Lane [2004], and Sengupta and Wiggins [2006]. The authors of the first paper investigate interfirm price dispersion and, contrary to results in this paper, they find evidence that the differences between restricted and unrestricted fares on a route increase as the number of people with Internet access increases. The results in Sengupta and Wiggins [2006] support my findings regarding price levels, but not regarding price dispersion, which was measured differently. Both papers, however, use time periods and employ empirical strategies different from mine; I discuss these differences below.

This paper is the first study to link the Internet to the overall distribution of purchased airline fares and to identify this technology's marginal effect by exploiting geographic variation in Internet adoption rates. To accomplish these tasks, the discussion proceeds as follows: Section II discusses how the airline ticket distribution system has changed over the last decade. Section III describes the data. Section IV discusses identification issues and the empirical approach. Section V presents and interprets the results of my analysis, and Section VI offers conclusions.

II. INDUSTRY BACKGROUND AND INSTITUTIONAL DETAILS

Before the mid-1990's, travel agencies sold most airline tickets. These agencies received ticket information from global distribution systems

(GDS), computer systems that airlines introduced in the 1970's to automate and control ticket distribution. GDS technology expedited work for travel agents, but all carriers were required to pay not only booking fees for each GDS-sold segment of travel but also commissions to travel agents. Taken together, the share of distribution and sales-force expenses accounted for 15–20 per cent of airlines' total expenditures in the 1990's.

Although airlines sometimes sold tickets through their own call centers, travel agencies were more efficient ticket distributors. Consumers preferred using travel agents to avoid having to call different airlines to find the lowest fares. Furthermore, airlines tended to provide incentives for travel agents who sold enough of the airline's tickets to surpass a given threshold level – typically, a level above the airline's market share in the corresponding market. Given these factors, approximately 80 per cent of all airline tickets were sold through travel agencies by the mid-1990's.

The rapid development of the Internet in the late 1990's changed this pattern. On the supply side, airlines now can develop their own Web sites and sell tickets cheaply online. Because this avenue allows airlines to avoid paying fees and commissions, airlines claim they can offer cheaper fares online than through the GDS. Another reason behind lower-priced online fares is airlines' efforts to 'lock-in' loyal customers (e.g., through frequent-flier programs), a strategy that grants airlines some control over ticket distribution.[1]

Despite the Internet's introduction, brick-and-mortar travel agencies booked about 50 per cent of all airline reservations in the late 1990's. Indeed, their expertise and travel knowledge often were necessary for coordinating nontraditional (e.g., open-jaw), international and themed travel. Because travel agents depended on GDS's, however, they could not access some of the low fares posted exclusively on airlines' Web sites, nor could they match many cheap fares available through online travel agencies, which often negotiated special arrangements with airlines.[2]

On the demand side, travelers with Internet access now could compare airline fares by searching through online travel agency or airline Web sites. Besides providing cheaper fares than those available through traditional travel agencies, these Web sites also offered frequent-flier bonuses for online booking. These factors have diminished demand for traditional travel agents' services. Indeed, people purchasing simple tickets now easily can find low fares online, reap incentives and avoid paying commissions to travel agents.[3]

[1] In addition to airlines' Web sites, several online travel agencies (e.g., *Expedia.com* and *Travelocity.com*) allow consumers to compare fares easily across different airlines.

[2] The contractual agreements between travel agents and GDS feature a productivity clause, and the fares travel agents purchase online for their clients do not count toward this requirement.

[3] In an attempt to decrease their dependence on travel agents and cut costs, airlines started reducing their commissions to travel agents in the mid-1990's, completely eliminating them in 2002. As a result, travel agents started charging consumers service fees.

The complex relationship among airlines, GDS, travel agencies and consumers suggests that, as a channel of distribution, the Internet likely will significantly affect both short and long-run airline fares. This paper focuses on the Internet's short-run influence on price level and price dispersion in the airline industry.[4]

In particular, I relate consumer access to the Internet to consumer search costs. This allows me to utilize search costs theory and use changes in search costs as one of the explanations for changes in airline price levels and price dispersion. More importantly, this paper makes a distinction between airline pricing at the interfirm level and pricing at the intrafirm level. The existing literature primarily analyzes price dispersion as an equilibrium phenomenon at the interfirm level and predicts that search cost reductions generally will spark decreases in average prices and price dispersion across firms. In contrast, it is easy to present a simple theoretical example showing that information changes have an uncertain influence on within-firm price dispersion, and thus, the effect of search costs on within-firm price dispersion remains an empirical question.[5]

III. DATA SOURCES AND DESCRIPTION

I employ three data sources. The data on airline fares come from the Department of Transportation's Origin and Destination (O&D) Survey. This is a 10 per cent random sample of all airline itineraries within the United States. Each entry includes information on the origin, destination and change-of-plane airports; carrier; distance; fare class; exact fare paid; and number of passengers paying that fare. All flights are aggregated at the quarter level. Each entry represents a directional, one-way trip and indicates the airport of purchase. When the itinerary is part of a round trip, reported fares equal half of the round-trip ticket price. Knowing the airport of purchase not only allows me to separate consumers traveling in opposite directions (e.g., Chicago-Boston-Chicago travelers from Boston-Chicago-Boston travelers) but also creates two entries per traveler. To avoid double counting, I drop return portions of round-trip tickets. The Appendix provides details on data construction. A drawback of the data is the

[4] I consider a time period with considerable temporal and geographic changes in Internet penetration. Internet adoption slowed and leveled off by the end of my sample's time period. This is one of the major differences from Sengupta and Wiggins [2006], who study how the Internet affected airline pricing at the end of 2004.

[5] Note that the decrease in consumers' search costs as reflected by changes in Internet penetration is not the only possible explanation for observed changes in fares. For instance, because airlines can pass differences in the marginal cost of ticket distribution for offline and online changes on to consumers, lower average fares can arise. I return to this issue in the empirical section.

TABLE I
INTERNET PENETRATION ACROSS LOCATIONS

Year	1997	1998	1999	2000	2001	2002	2003
All areas in the sample	.199	.425	.492	.559	.660	.679	.698
Areas with highest changes in Internet penetration in five years (N = 47)	.184	.450	.516	.582	.687	.721	.756
Area with moderate changes (N = 46)	.206	.422	.492	.563	.660	.681	.702
Areas with lowest changes in Internet penetration in five years (N = 46)	.208	.402	.467	.531	.633	.634	.635

difficulty in distinguishing direct, nonstop flights from direct flights featuring a stopover.

My second data source is the Official Airline Guide, which lists all scheduled direct flights between all U.S. airports. This information allows me to assess differences in a given route's airlines flight schedules over time. Finally, the Computer Use and Ownership Supplement to the CPS provides Internet penetration levels across metropolitan statistical areas (MSA's). The survey asks about Internet access at home, school, and business. For each MSA I compute the fraction of respondents answering yes to any of these Internet access questions using sample weights provided by the CPS. The data are available for the years 1997, 1998, 2000, 2001, and 2003, and I interpolate the penetration for years 1999 and 2002. My sample covers 1997 through 2003 excluding the second quarter of 2001, however, which allows me to avoid the structural changes in the airline industry and the economic slump of the second half of 2001. Table I presents the average level of Internet penetration for three groups of MSA's over the sample's time period: areas with the highest changes in Internet penetration, areas with moderate changes in Internet penetration, and areas with the lowest changes in Internet penetration over the period of study.

For my final sample, I consider the top twenty airlines by number of passengers across all years. As previous literature has argued, major and low-cost carriers can employ different pricing strategies. I therefore distinguish six low-cost carriers.[6] The final 26-quarter sample comprises top the 5,000 routes by number of passengers, which cover 645,000 observations; an observation corresponds to a carrier's direct or indirect flight on a directional route in a quarter. (The distinction between direct and indirect flights helps account for a flight's convenience.[7]) Out of these, 159,000 observations correspond to direct flights. When I aggregate airline-route level data to the route level by combining all airlines' flights

[6] The low-cost carriers are Airtran, ATA, Frontier, JetBlue, Southwest and Spirit.
[7] By aggregating all indirect flights into one category, I implicitly ignore differences in the convenience of connections via different airports. This issue is left for future research.

on a route, including both direct and connecting flights, I arrive at 121,400 route-quarter observations. Including only direct flights yields 54,200 observations.

IV. EMPIRICAL APPROACH

IV(i). *Identification Issues*

In the following analysis, I assume that variation in Internet penetration over time and across locations is exogenous to airline pricing strategies.[8] If the Internet's influence on prices and price dispersion were the only effects of interest, then, assuming the exogeneity of changes in Internet penetration, I could identify the effect from the cross-section of routes and airlines. Due to the O&D data limitations, the observed price dispersion is calculated across tickets with different qualities.[9] Differences in the types of tickets across routes are irrelevant to the analysis, however, as these differences will be subsumed in the error term, which by assumption is not correlated with Internet adoption.

Nevertheless, the Internet's effect on airline pricing is important to study in the context of varying market structure on a route. Because a route's market structure likely correlates with unobservable route characteristics, an endogeneity issue could arise. For instance, if monopoly routes tend to have more business travelers than duopoly and competitive routes, a positive coefficient on the interaction between a monopoly dummy variable and Internet penetration can reflect the differential effect on prices for business travelers and not on prices in monopoly routes. A cross-section of observations therefore will not suffice for the identification.[10]

Given these circumstances, I employ the differences-in-differences strategy. This approach allows me to isolate the effect of unobservable determinants of prices and price dispersion that do not differ over time or across routes. First, the route-level regressions, which I use to study between-firm price dispersion, include two sets of fixed effects: directional route fixed effects and quarter fixed effects. Route fixed effects capture route-specific price factors that remain constant across airlines over time. For instance, if an airport of origin lies in an area with a high concentration of businesses and all airlines price their flights accordingly, fixed effects will capture this pattern, assuming that business

[8] This assumption seems to reflect reality, as other factors mainly affect consumers' decisions to adopt the Internet. On the other hand, to account for the fact that Internet adoption may depend on local economic and demographic factors, which correlate with airline demand and pricing, my regressions include these factors.

[9] Note that because all passengers receive roughly the same 'physical' quality on a flight within a travel class, the quality differences stem solely from ticket restrictions and related inconveniences.

[10] This is the second major difference of this paper from Sengupta and Wiggins [2006], who only have data for one quarter in 2004. Even though the authors have detailed information on ticket restrictions, they cannot effectively study how changes in the Internet affect airline pricing in markets with different market structure.

concentration does not change over time.[11] On the other hand, quarter fixed effects control for changes in time-specific variables. For instance, quarter fixed effects capture the result of (uniform) gasoline price increases.

For the airline-route-level regressions, which I use to study intrafirm pricing, I introduce airline-quarter fixed effects. These fixed effects flexibly capture unobservable changes in fare structure that are airline-specific across all routes in a given quarter (e.g., the effect of Delta's decision to eliminate length-of-stay restrictions on pricing). I also employ airline-route fixed effects, which account for airline-route-specific effects on fares that remain constant over time. These airline-route fixed effects not only incorporate route fixed effects but also account for other temporally constant factors related to an airline's dominance in origin or destination airports.

The O&D data do not allow for separating different flights on the same route operated by the same carrier. This restriction creates a problem because associated fixed costs can fluctuate by flight within a day given the different opportunity costs that arise during peak flight times. The differences-in-differences approach would alleviate the problem of unobservable flight-specific costs under the strong assumption that an airline's number of flights and flight schedule on a route within a day remain constant over time. To manage this assumption, in my regressions I control for the percentage of an airline's flights departing during peak times on a given route.

Similarly, we can negate the problem of unobservable ticket qualities by assuming constant airline yield management strategies over time and across markets; indeed, if a change in strategy applies to all routes, quarter fixed effects will capture the change's effect on pricing. Granted, this assumption is another strong one and I cannot manage it directly.

IV(ii). *Specification and Variables*

The empirical analysis consists of two parts: First, I study the effect of the Internet on the level of prices and price dispersion at the airline-route level; second, I study these effects at the (directional) route level. Previous literature on price dispersion in the airline industry (e.g., Borenstein and Rose [1994], and Gerardi and Shapiro [2009]) analyzed price dispersion only on direct flights. I additionally consider pricing on all flights, both direct and connecting.

At the airline-route level, I consider prices within each airline i on a given route j at a given quarter t. The estimated model is:

$$\begin{aligned} LOG(Y_{ijt}) = {} & \alpha_1 \cdot MKT_{jt} + \gamma_1 \cdot MKT_{jt} \cdot LOG(INTERNET_{jt}) \\ & + \delta_1 \cdot W_{ijt} + \lambda_{it} + \zeta_{ij} + u_{ijt}, \end{aligned} \tag{1}$$

[11] The same logic applies to any demographic-related price factors. For instance, airlines' prices can be higher for routes originating in wealthier areas and lower in low-income areas. Airline-route fixed effects would account for such effects.

where the dependent variable (*AvFARE* or *GINI*) is measured at the airline-route level, and λ_{it} and ζ_{ij} denote airline-quarter and airline-route fixed effects, respectively.

The variables of interest are $INTERNET_{jt}$ (the level of Internet penetration in the origin city of market *j* at time *t*, measured as the percentage of consumers with Internet access) and MKT_{jt}, a vector of market structure variables. The latter vector includes dummy variables indicating whether carrier(s) on a route form a monopoly (*MONOPOLY*), a duopoly (*DUOPOLY*) or a competitive environment (COMPETE). Monopoly routes are routes where a single airline carries more than 90 per cent of passengers, whereas duopoly routes are routes where either (a) the two largest airlines carry 90 per cent of passengers or (b) they carry 80 per cent of passengers and the third-largest carrier transfers less than 10 per cent of all passengers. All other routes are defined as competitive.

Vector W_{ijt} includes a dummy variable for Southwest Airlines' presence (*SOUTHWEST*), a dummy variable for direct flights (*DIRECT*) and a fraction of an airline's direct flights in a given quarter that depart from the base airport during peak times (*PEAK*) (i.e., between 8–10 a.m. or 4–6 p.m.). Also, as a measure of an airline's presence on a given route, I add the airline's market share on the route, measured as the fraction of passengers the airline carried within a given quarter on a directional route (*MktSHARE*).

At the route level, I aggregate all airlines on a route *j* in a given quarter *t* and estimate the following log-linear model:

$$(2)\qquad LOG(GINI\,BW_{jt}) = \alpha \cdot MKT_{jt} + \gamma \cdot MKT_{jt} \cdot LOG(INTERNET_{jt}) + \delta \cdot Z_{jt} + \mu_j + \theta_t + \varepsilon_{jt},$$

where $GINI\,BW_{jt}$ is defined as the difference between overall price dispersion on route *j* in quarter *t* and the average of individual airlines' intrafirm price dispersions on route *j* in quarter *t* weighted by each airline's number of passengers,[12]

$$GINI\,BW_{jt} = GINI_{jt} - \sum_{i=1}^{I_j} n_{ijt} GINI_{ijt}.$$

In (2), MKT_{jt} includes the same variables as before and μ_j and θ_t denote market and quarter fixed effects. The set of control variables Z_{jt} includes a dummy variable for the presence of Southwest Airlines in the market (*SOUTHWEST*),[13] the fraction of passengers traveling on direct flights on the

[12] This is a standard approach to define interfirm price dispersion (see, e.g., Juhn, Murphy and Pierce [1993]).

[13] Given the differences-in-differences nature of the regression, the coefficient on *SOUTHWEST* is identified from the facts of the Southwest Airlines' entry and exit on the route.

TABLE II
SUMMARY STATISTICS

	Direct Flights		All Flights	
	Mean	Std. Dev.	Mean	Std. Dev.
A. Airline-Route Level				
GINI	0.243	0.087	0.244	0.086
AvFARE	163.218	82.220	169.186	81.328
INTERNET	0.550	0.171	0.550	0.172
MONOPOLY	0.203	0.403	0.161	0.368
DUOPOLY	0.565	0.496	0.514	0.500
COMPETE	0.232	0.422	0.324	0.468
MktSHARE	0.634	0.256	0.547	0.295
SOUTHWEST	0.282	0.450	0.305	0.461
DIRECT	1.000	0.000	0.769	0.422
MAJOR	0.746	0.436	0.776	0.417
PEAK	0.315	0.044	0.318	0.045
Observations	159123		645225	
B. Route Level				
GINI BW	0.008	0.012	0.015	0.015
INTERNET	0.549	0.173	0.549	0.173
MONOPOLY	0.071	0.257	0.149	0.356
DUOPOLY	0.643	0.479	0.519	0.500
COMPETE	0.286	0.452	0.331	0.471
SOUTHWEST	0.267	0.442	0.308	0.462
% DIRECT	1.000	0.000	0.766	0.304
% MAJOR	0.782	0.311	0.776	0.320
Observations	54202		121414	

Notes: Weighted by the number of passengers. Fares are in 2000 dollars and are reported for half of the round-trip fare.

route (*% DIRECT*) and the fraction of passengers using major airlines on the route (*% MAJOR*). Table II presents summary statistics for all variables.

IV(iii). *Econometric Issues*

There are two econometric issues my approach must address: endogeneity and the correct calculation of standard errors. First, in specifications (1) and (2), the market structure variables are potentially endogenous, as they can correlate to unobserved price factors that cannot be accounted for explicitly. Indeed, endogeneity tests do not reject the joint endogeneity of market structure variables.

Unfortunately, finding good instruments is a common difficulty with the differences-in-differences approach. The tradeoff inherent in this method is straightforward: a rich set of fixed effects provides stronger identification of the effects of interest, but it eliminates much of the variation in instruments. I tried to use standard instruments (see, for instance, Borenstein [1989]), but the first-stage regression indicates little variation over time. I therefore do not present the instrumental variables estimation results. Instead, below I present the results of the differences-in-differences estimation and discuss what they might mean, and offer both causal and alternative interpretations.

Second, in both specifications (1) and (2), I account for potential unobservable route-specific shocks to cope with the problem of correlation among error terms. To this end, I adjust standard errors assuming positive correlation for observations within the same (directional) route and independence across observations from different routes.[14]

V. EMPIRICAL RESULTS

V(i). *Airline-Route Level*

The first two columns of Table III present the estimation results for average fare on direct flights. I first consider a simple specification with the vector of regressors including Internet penetration, market structure dummy variables and other controls. Results indicate that the Internet's overall effect is negative and statistically significant. As expected, average prices are higher on more concentrated routes. Column 2 shows estimates for the specification (1), which includes interactions of market structure dummy variables and Internet penetration. The interaction effects are negative and significant both economically and statistically with the exception of the coefficient for monopoly routes. The effect of the Internet on average fare is the strongest in competitive markets, followed by duopoly and then monopoly markets, with all three effects being statistically significant from each other.

Columns 3 and 4 repeat the analysis for the full sample that includes both direct and connecting flights. The results are consistent with the estimates for a direct flights sample, although the effect of the Internet is smaller. At the same time, the effect of all other control variables on average price is stronger. Prices are, on average, significantly lower on routes where Southwest is a competitor. Such lower prices also characterize direct flights versus connecting flights. Finally, as expected, the prices are higher for carriers that have higher percentage of flights departing at peak times.

Columns 5 through 8 indicate that price dispersion rises at the airline-route level when Internet penetration increases. This result represents this paper's main finding because it shows that the data refute the common-sense notion that predicts a decrease in price dispersion. As evidenced from Column 6, this result is present in markets with different market structures. The effect of the Internet on price dispersion is the largest on monopoly, followed by duopoly and competitive routes although all three estimated coefficients are not statistically different from each other. Price dispersion is lower on routes where Southwest Airlines is a competitor; it is lower on

[14] Clustering at different levels (e.g., airline-route or airport-airline) did not alter standard errors significantly.

TABLE III
REGRESSION RESULTS FOR AVERAGE FARE AND PRICE DISPERSION AT THE AIRLINE-ROUTE LEVEL

	LOG(AvFARE)				LOG(GINI)			
Dependent Variable:	Direct Flights		All Flights		Direct Flights		All Flights	
LOG(INTERNET)	−.054***		−.028**		.061***		.048***	
	(.020)		(.014)		(.021)		(.014)	
LOG(INTERNET) * COMPETITIVE		−.080***		−.060***		.056**		.046***
		(.021)		(.015)		(.022)		(.015)
LOG(INTERNET) * DUOPOLY		−.063***		−.027*		.060***		.047***
		(.021)		(.015)		(.021)		(.015)
LOG(INTERNET) * MONOPOLY		−.016		.015		.067***		.054***
		(.021)		(.015)		(.021)		(.015)
DUOPOLY	.016***	.025***	.019***	.040***	.001	.004	.003	.003
	(.005)	(.008)	(.004)	(.006)	(.005)	(.007)	(.004)	(.005)
MONOPOLY	.047***	.089***	.057***	.110***	−.011	−.004	.005	.010
	(.009)	(.013)	(.008)	(.011)	(.010)	(.014)	(.008)	(.012)
MktSHARE	−.022	−.013	−.100***	−.091***	−.040**	−.038**	−.079***	−.079***
	(.020)	(.020)	(.014)	(.014)	(.017)	(.017)	(.012)	(.012)
SOUTHWEST	−.018*	−.018*	−.047***	−.042***	−.038***	−.038***	−.020***	−.020***
	(.009)	(.009)	(.006)	(.006)	(.010)	(.010)	(.005)	(.005)
DIRECT			−.107***	−.107***			−.041***	−.041***
			(.003)	(.003)			(.003)	(.003)
PEAK	.046	.052	.072***	.078***	−.045	−.044	−.057**	−.056**
	(.034)	(.033)	(.024)	(.024)	(.038)	(.038)	(.027)	(.027)
Observations	159123	159123	645225	645225	159123	159123	645225	645225

Notes: Weighted by the number of passengers. All regressions contain airline-route and airline-quarter fixed effects. Standard errors are in parentheses. Stars denote the significance level of coefficients: ***- 1 percent, **- 5 percent, *- 10 percent.

direct flights and also lower for carriers that have higher percentage of flights departing at peak times.

In Table IV, I investigate whether changes in Internet penetration affect fares differently across major and low-cost carriers. For this purpose, I consider the interaction terms for Internet penetration, market structure dummy variables and airline type dummy variables. The results indicate that higher Internet penetration leads to lower average fares for both low-cost and major carriers on monopoly and duopoly routes, and does not have a significant effect on fares on monopoly routes. The results for average fares are consistent across two types of carriers: the effect is the strongest in competitive, followed by duopoly and monopoly markets. The observed three effects across markets with different market structure are statistically different from each other for major carriers, while the effects in monopoly and duopoly markets for low-cost carriers are not statistically different from each other.

The results in Columns 3 and 4 of Table IV indicate that higher Internet penetration leads to higher price dispersion for both major and low-cost carriers; however, the effect is not statistically significant for low-cost carriers. For major carriers, the effect is the largest in monopoly, followed by duopoly and competitive routes.

TABLE IV
DIFFERENCES BETWEEN NETWORK AND LOW-COST CARRIERS

	LOG(AvFARE)		LOG(GINI)	
Dependent Variable:	Direct Flights	All Flights	Direct Flights	All Flights
LOG(INTERNET) * COMPETITIVE * MAJOR	− .077***	− .054***	.058**	.046***
	(.024)	(.016)	(.023)	(.015)
LOG(INTERNET) * COMPETITIVE * LCC	− .082***	− .092***	.037	.041
	(.029)	(.024)	(.073)	(.061)
LOG(INTERNET) * DUOPOLY * MAJOR	− .059**	− .020	.063***	.048***
	(.024)	(.016)	(.022)	(.015)
LOG(INTERNET) * DUOPOLY * LCC	− .079***	− .072***	.020	.019
	(.025)	(.022)	(.067)	(.057)
LOG(INTERNET) * MONOPOLY * MAJOR	− .012	.023	.070***	.054***
	(.024)	(.017)	(.022)	(.015)
LOG(INTERNET) * MONOPOLY * LCC	− .038	− .039*	.068	.068
	(.024)	(.022)	(.066)	(.058)
Observations	159123	645225	159123	645225

Notes: Weighted by the number of passengers. All regressions contain airline-route and airline-quarter fixed effects and controls as in Table 3. Standard errors are in parentheses. Stars denote the significance level of coefficients: ***- 1 percent, **- 5 percent, *- 10 percent.

V(ii). *Route Level*

Table V presents estimation results for the effect of the Internet on interfirm price dispersion.[15] The effect is negative on direct flights and positive for the full sample of direct and connecting flights. In both cases, however, the effect is not statistically significant. Columns 2 and 4 show estimates for interactions of market structure dummy variables and Internet penetration; again none of the coefficients is statistically significant.

V(iii). *Discussion*

The results of the estimation show that an increase in Internet penetration leads to lower fares, but no change in interfirm price dispersion. Note from Table II that the average interfirm price dispersion is small; it is therefore not entirely surprising that the Internet has not had a significant effect. At the same time, this result does not contradict this paper's main finding: A rise in price dispersion occurs in response to changes in Internet adoption within each airline on a route.

Thus, this paper's findings only partially support theories involving search costs, which predict that lower search costs lead to decreases in interfirm

[15] I do not present estimation results for effect of the Internet on average fares at the route level, but by virtue of weighting these results are consistent with the effect at the airline-route level.

TABLE V
REGRESSION RESULTS FOR PRICE DISPERSION AT THE ROUTE LEVEL

	LOG(GINI BW)			
Dependent Variable:	Direct Flights		All Flights	
LOG(INTERNET)	– .194 (.168)		.059 (.062)	
LOG(INTERNET) * COMPETITIVE		– .192 (.173)		.034 (.064)
LOG(INTERNET) * DUOPOLY		– .202 (.170)		.059 (.064)
LOG(INTERNET) * MONOPOLY		– .155 (.191)		.100 (.069)
DUOPOLY	– .507*** (.040)	– .514*** (.053)	– .270*** (.020)	– .254*** (.025)
MONOPOLY	– 2.128*** (.087)	– 2.099*** (.121)	– .927*** (.037)	– .879*** (.047)
SOUTHWEST	.063 (.081)	.062 (.081)	– .061** (.029)	– .059** (.029)
% DIRECT			– .687*** (.050)	– .682*** (.051)
% MAJOR	– .956*** (.144)	– .951*** (.143)	– .463*** (.070)	– .456*** (.070)
Observations	54202	54202	121414	121414

Notes: Weighted by the number of passengers. All regression include route and time fixed effects. Standard errors are in parentheses. Stars denote the significance level of coefficients: ***- 1 percent, **- 5 percent, *- 10 percent.

prices and price dispersion.[16] I find the support for the former effect but not the latter.

There are, of course, other explanations for the uncovered patterns for the effect of the Internet on airline pricing. In Section 2, I mentioned that airlines used to justify cheaper Web fares by citing the online channel's lower costs of distribution as compared to fares from travel agencies. If it is cheaper for airlines to sell tickets through the Internet, we would expect fares to drop for Internet users as airlines pass these cost savings on to consumers. The regression results for average fares are consistent with the theory prediction that the pass through is larger in competitive markets. Nevertheless, it does not seem a compelling explanation for observed effects of the Internet on price dispersion along the dimension of market structure, particularly on monopoly routes. Therefore, while future research should try separating two

[16] As mentioned above, this conclusion contradicts that of Verlinda and Lane [2004]. Looking at interfirm price dispersion, they find evidence that the differences between restricted and unrestricted fares on a route increase as the number of people with Internet access increases. Nevertheless, they have only aggregate data for Internet penetration and these data are at the national level; thus, they estimate the Internet's effect only along the time-series dimension. Also, because the authors consider only average fares on a route, they unwillingly ignore structural differences in pricing strategies between major and low-cost carriers. In addition, they overlook the effect of the September 11, 2001, events on the airline industry.

explanations, it is doubtful that the differences in the marginal costs of distribution can fully explain the observed patterns by themselves.

Another alternative explanation for my results is that the observed fare decreases could reflect changes in the associated airlines' opportunity costs. I partially address this issue in previous regressions by using a rich set of fixed effects, which subsumes changes in airline-specific or route-specific costs over time and by controlling for the fraction of flights that depart in peak times, a variable that indirectly accounts for differences in opportunity costs across airlines' flights during a day.[17]

The expansion of low-cost carriers may have been another important factor that contributed to changes in price dispersion.[18] My regression results indicate that controlling for Southwest's presence, the effect of the Internet on price dispersion is positive for both low-cost and major carriers. In addition, to partially address the issue of separating the effect of low-cost carrier expansion from the effect of the Internet, I also studied airline-route level regression for a subsample of markets with no low-cost carrier presence. The effect of the Internet on price dispersion was significant both economically and statistically. Thus, low-cost carriers' expansion cannot be a single factor explaining changes in price dispersion at the end of 1990's.

VI. CONCLUSION

This paper argues that the decrease in search costs associated with the Internet may increase within-firm price dispersion while lowering prices and reducing inter-firm price dispersion. I apply this idea to the data on airline ticket fares, the full distribution of which is available, including purchases online and offline. I base my estimation strategy on the significant difference in the rate of increase of Internet adoption across geographic locations. Additionally, I consider that the Internet's effect on pricing also depends on each route's market structure. The results of my analysis indicate that higher Internet penetration among consumers leads to lower average fares on a given route. This conclusion supports the conjecture that the Internet facilitates competition, thereby creating downward pressure on prices. Furthermore, even though price dispersion is not significantly affected at the interfirm level, it increases at the within-firm level. In summary, this paper's main result shows that within-firm price dispersion increases with Internet penetration; this finding highlights the shortcomings of common-sense notions about search costs' effects on intrafirm price dispersion.

[17] To account for changes in airport-specific costs, which potentially can affect fares, I repeated my analysis for the more constrained airline-route level specification with airport-quarter fixed effects. The results of the estimation are similar to the results from the less constrained specification reported in the paper.

[18] I want to thank a referee for suggesting this explanation.

APPENDIX

In this appendix, I outline how the data was used in my analysis. The data from this survey are of three different sorts: market, coupon and ticket data. I combine these three parts and exclude itineraries with more than one stop, itineraries marked as bulk or containing non-credible fares, itineraries involving flights on carriers with missing names or unknown carriers, itineraries that involve Southwest flying through Dallas-Ft. Worth airport. I only keep round-trip and one-way itineraries involving travel within fifty states and the District of Columbia. I exclude itineraries involving Southwest Airlines before 1999 because all of their itineraries are recorded as one-way trips in the O&D data with the base airport listed as the point of purchase.

I eliminate trips that involve business class and first class tickets, trips that involve more than one carrier and itineraries with fares (in 2000 dollars) below $25 or higher than five times the SIFL (standard industry fare level as quarterly determined by the Department of Transportation) for long-haul trips and six times the SIFL for short-haul trips. Finally, I consider only routes with more than 100 travelers during a quarter and airline/route combinations that carried more than 50 travelers during a quarter.

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