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Article

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An Empirical Study of the Effect of the Internet on Fares in the U.S. Airline Industry

By HWA RYUNG LEE*

A reduction in search costs is generally believed to make markets more competitive. However, the effect may be mitigated or amplified if consumers must pay costs for switching products. This paper investigates how search costs affect prices in the presence of switching costs using U.S. domestic airfare data for 2000–2010. The airline industry experienced a dramatic decrease in search costs with increasing Internet use in the 2000s. At the same time, the industry is known for its frequent flyer programs (FFPs), which increase switching costs for consumers. We use the average network size of airlines in a market as a proxy for switching costs related to FFPs and Internet usage as a proxy for (the inverse of) search costs. The results show that increasing Internet usage lowers airfares but that the effect is smaller for markets with a larger average network size.

Key Word: Search costs, Switching costs, Internet, Frequent Flyer Program, Airline industry

JEL Code: D1, L1, L93, M3

I. Introduction

Search costs are dramatically reduced in the Internet era, as consumers can easily and quickly compare products on the web. Firms have feared whether the decrease in search costs associated with increasing Internet use would intensify competition. The airline industry is one of the industries greatly affected by the rapidly increasing use of the Internet, and previous research has found that Internet use has led to lower airfares (Brunger 2010, Orlov 2011, Verlinda and Lane 2004). However, the industry is also known for successful loyalty programs called frequent flyer programs (FFPs), which create artificial switching costs. When consumers incur costs when switching products, the effect of the search cost reduction on prices may be smaller. This paper discusses theoretical ambiguities in relation to this and assesses this problem empirically in the context of the effect of the Internet on airfares.

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The presence of switching costs offers less flexibility to consumers and renders market power to firms. Search costs have similar effects in that consumers become less responsive to prices. Accordingly, it appears natural to expect that a decrease in search costs will intensify price competition but that switching costs will hinder the competition arising from the reduced search costs.

In a dynamic setting, however, the effect of search and switching costs can be more complicated. Given that switching costs provide firms with market power over locked-in customers, the equilibrium price will be driven by two opposing forces: exploiting the existing customer base with high prices (“harvest”) or winning market share with low prices in anticipation of ripping off those customers later (“invest”). Similarly, if consumers tend to seek out the products they previously purchased before searching for other products,¹ search costs give firms additional power to lock in customers and present a contrast between investing and harvesting incentives. In sum, it is ambiguous as to whether switching costs would raise prices, whether a reduction in search costs would lower prices, and whether switching costs would mitigate or amplify the effect of search cost reduction.

We use U.S. domestic airfare data for 2000–2010 to assess the price effects of search and switching costs empirically. The average Internet usage in the endpoint cities of a route is used as a proxy for (the inverse of) search costs in the market (i.e., the route).² We measure the size of the route network in three different ways and use those measures as proxies for switching costs related to FFPs.³ This is motivated by the fact that the value of an FFP is highly dependent on the size of an airline’s route network; the more destinations an airline has, the easier it is for customers to accumulate mileage and use it to get where they want to go.

A regression analysis of market average fares suggests that switching costs reduce the price competition arising from a decrease in search costs. Specifically, we find that fares decrease with Internet use but that the fare reduction is less with a larger average network size of competing airlines on a route. This result suggests that switching costs allow firms to stay in a less competitive pricing regime when search costs decrease.

The results have implications on potential policies. Although this work implicitly takes search and switching costs as exogenously given, firms may be able to affect those costs strategically. For example, as a response to declining search costs with the increasing use of the Internet, firms may attempt to increase switching costs to stifle competition arising from declining search costs. A policy aiming to reduce one of the costs may also evoke reactions by firms to offset the effect of the cost decrease. Thus, the dynamic interaction between the two costs and the potential reactions of firms should be considered to improve the effectiveness of policies.

The rest of this paper is organized as follows. Section 2 provides an overview of related literature. Section 3 discusses the ambiguity related to the combined effect of search and switching costs. Section 4 describes the empirical model and data.

¹Alternatively, we can think of the case in which consumers are better-informed about the products they previously purchased and need to incur extra costs to get information about the other products.

²Throughout this paper, we use “route” and “market” interchangeably.

³Borenstein (1989) noted the presence of a hub premium related to FFPs and Lederman (2007) disentangled the value of FFPs from the advantages of being a dominant firm. They attribute the price premium to switching costs arising from FFPs.

Section 5 discusses the estimation results. Concluding remarks are given in Section 6.

II. Literature Review

This paper is related to three streams of literature: studies on switching costs; studies on search costs, especially in the context of the effect of the Internet on competition; and studies on airline competition in the Internet era. There is a large body of literature on both search costs and switching costs. Empirical studies have noted that many industries exhibit some type of switching costs. In the market for bank loans, consumers who switch lose the value of the relationship with a bank arising from information asymmetry (Kim, Kliger, and Vale 2003); in the market for toll-free services, prices fell as 800-numbers became portable (Viard 2007); in the markets for refrigerated orange juice and margarine, consumers behave as if they obtain additional utility from purchasing products they previously purchased or, equivalently, they suffer psychological costs when switching brands (Dubé, Hitsch, and Rossi 2010); and so on.⁴

A large body of theoretical literature on switching costs contrasts the opposing incentives in a dynamic setting, including the incentive to win new customers by lowering prices and the incentive to exploit locked-in customers by raising prices. In these studies, predictions of the relationship between switching costs and competition are ambiguous. Klemperer (1987) and Beggs and Klemperer (1992) demonstrate that markets are generally less competitive with rather than without switching costs, as forward-looking consumers expect that switching costs will make them less flexible in the future and that firms will exploit them by charging high prices. As a result, consumers become less sensitive to current prices; thus, the investment incentive dominates. On the other hand, Cabral and Villas-Boas (2005) demonstrate that switching costs can make markets more competitive, as the strategic effect (that is, competition to win market share) outweighs the direct effect (that is, price increases to exploit existing customers) of switching costs as an example of the “Bertrand Supertrap.” Dubé, Hirsch, and Rossi (2009) establish a U-shaped relationship between price and switching costs using the infinite-horizon model, in which the lock-in factor is allowed to be imperfect. Shin and Sudhir (2009) and Cabral (2009) came up with simpler models that produce some empirical implications given by Dubé, Hirsch and Rossi (2009). Shin and Sudhir (2009) recover the U-shaped relationship between price and switching costs using a two-period Hotelling model when firms cannot discriminate between locked-in and non-locked-in consumers. Meanwhile, Cabral (2009) highlights the result from Cabral (2008), which showed that price is decreasing in switching costs when switching costs are low. Cabral (2008, 2009) allows for price discrimination and determines whether the investing effect or the harvesting effect dominates. Farrell and Klemperer (2007) conduct an extensive survey on switching costs.

The literature on search costs is mostly interested in their relationship with price

⁴There are numerous other industry studies that identify switching costs or the effect of switching costs. For example, see Borenstein (1991) for the market for gasoline, Greenstein (1993) for mainframe computers, Elzinga and Mills (1998) for cigarettes, Shy (2002) for the bank deposit industry and the wireless industry, and Honka (2014) for the auto insurance industry.

dispersion.⁵ In terms of price levels, theories on search costs generally predict a positive relationship between search costs and prices in a static setting. Important exceptions include Lal and Sarvary (1999), who demonstrate that a search cost reduction can raise prices as consumers can identify the characteristics of products better in a vertically differentiated market. There are numerous empirical works that examine competition in the Internet era, in which the increasing use of the Internet is generally interpreted as a decrease in search costs. The literature mostly examines the effect of the Internet on price levels and price dispersions, or the price differential between online and offline stores. For example, in the airline industry, Brunger (2010) finds that “clearly leisure”⁶ travelers pay lower average fares when purchasing a ticket through internet-based online travel agencies as compared to offline travel agencies. Orlov (2011) examines U.S. airline data and finds that, with Internet use, airfares decrease and the degree of intrafirm fare dispersion increases, whereas the degree of interfirm fare dispersion is unaffected. Verlinda and Lane (2004) investigate the effect of search costs on price dispersion characteristics from the angle of price discrimination using U.S. airfare data. They find evidence that the Internet toughens competition and increases the price dispersion between restricted and unrestricted tickets, which is consistent with price discrimination through brand differentiation. However, the airline industry can also be characterized by switching costs arising from FFPs (Borenstein 1989, Lederman 2007). This paper assesses the effect of the Internet on airfares with a focus on the interaction between search and switching costs.

Given the vast literature on both search costs and switching costs and the similar characteristics of the two costs as types of market friction, there have been relatively few attempts to include search and switching costs in one framework. Knittle (1997) includes both search and switching costs to explain why competition arising from the divestiture of AT&T has not lowered the rates of long distance calls, finding supporting evidence that the presence of those costs are major sources of market power. In the theory section of the paper, he considered both costs and showed that they can result in higher prices in a simple static setting. Wilson (2009) offers a unified analysis of search and switching costs in one theoretical framework, also in a static setting.

Farrell and Klemperer (2007) note that researchers often do not distinguish between search and switching costs and that search costs can be modelled in a manner similar to that of switching costs. Some empirical works note the potential dynamic effect of search costs as an alternative explanation of switching costs in creating consumer inertia. Moshkin and Shachar (2000) show that both search and switching costs can result in persistent market share in a dynamic setting and suggest how the two costs can be distinguished from each other empirically. They assume a consumer may incur one of the two costs, but not both. In their model, past consumption can affect current purchase decisions through either switching costs or search costs. Dubé, Hitsch, and Rossi (2010) attempt to identify the reason for consumer inertia by testing predictions considering the three different factors of

⁵See Baye, Morgan, and Scholten (2005) for a survey on search costs and price dispersion.

⁶Travelers are defined as “Clearly Leisure” if their travel characteristics correspond to leisure rather than business travel, in particular, if tickets were purchased more than 14 days before departure, and their itinerary included an extended stay over a weekend.

switching costs, search costs, and learning. They find evidence consistent with consumer behavior in the presence of switching costs rather than search costs or learning. Honka (2014) includes both types of cost in her model to quantify search and switching costs using data from the U.S. auto insurance industry. However, these prior works do not consider the interaction between search and switching costs in determining prices. Here, in contrast, the interaction between the two costs is the main interest. The price effect of a reduction in search costs in the presence of switching costs is theoretically ambiguous and becomes an empirical question.

III. Conceptual Framework

Search costs and switching costs are types of market friction that work in a similar fashion. In a static setting, the two costs make demand less elastic. In a dynamic setting, firms are faced with two opposing forces - investing incentives and harvesting incentives - in the presence of switching costs. A similar dynamic effect arises with search costs if previous purchases induce consumers to seek out the same products again before other products, as consumers are better informed about products they previously purchased. Search costs are distinguished from switching costs, as they affect even consumers not locked into any product.

It is also important to note that search costs and switching costs can influence both search and switching behavior. To switch, consumers would need to search for other products. If consumers are unlikely to switch, they would not search, even with low search costs. Search costs and switching costs jointly shape consumer behavior and determine market prices. In sum, the effect of search costs on firms' pricing decisions in the presence of switching costs would differ depending on which incentive, investment or harvesting, overwhelms.

Suppose that switching costs are so large that no one switches. Locked-in consumers who would never switch would never search for other products in the first place. Any search cost reduction is then irrelevant to those locked-in consumers, and the dynamic, lock-in effect of search costs can thus be ignored.

On the other hand, a decrease in search costs would make firms act more aggressively to win those consumers without purchase histories, that is, those who are not locked into any product. Firms have a strong incentive to lure non-locked-in consumers as, once consumers buy their products, those consumers will be fully locked in to them in the future and the firms will enjoy a monopolist position. This effect will be greater in the presence of larger switching costs, as the monopolist profit a firm can extract from locked-in consumers increases with switching costs. Thus, a decrease in search costs will make markets even tougher in the presence of larger switching costs.

Now suppose that consumers do not incur any costs when switching. Consumers may still be locked into the product they purchased previously if they have to pay costs to become informed about other products. Consumers would not search and switch if the search is a costly process. As in the presence of switching costs, firms will then be faced with the incentive to exploit their customer base as well as the incentive to invest in market share. In addition, search costs make demand less elastic and so may curb the incentive to earn customers by cutting prices. In sum, a

decrease in search costs undermines firms' abilities to harvest, while it has an ambiguous effect on the investing incentive.

The price effect of a reduction in the search cost is complicated by the presence of switching costs. Unless switching costs are high enough to guarantee full lock-in, switching costs and search costs jointly determine the degree of lock-in. Let us suppose that switching costs are relatively low such that consumers may actually switch from one product to another, for example, to seek a better match with their tastes. As long as the combination of search and switching costs creates enough friction to lock consumers into the product previously purchased, firms will be able to sustain a monopolist position over those locked-in consumers. Thus, while search costs are declining, firms are more likely to sustain their lock-in power in the presence of larger switching costs. At the same time, however, both the harvesting incentive and the investing incentive will be enhanced by switching costs, as the extent to which firms can exploit locked-in consumers increases with switching costs.

The market price will be determined as a result of the balance between the incentive to exploit locked-in consumers and the incentive to retain the customer base and poach rivals' customers. As discussed previously, which incentive would overwhelm depends on the respective sizes and the combined size of the search costs and switching costs. The overall effect of a search cost reduction in the presence of switching costs is theoretically ambiguous and becomes an empirical question, as noted earlier.

IV. Empirical Specification and Data

A. Empirical Specification

The previous section discussed the ambiguity of the price effect of a search cost reduction in the presence of switching costs. The airline industry is particularly suitable for assessing this effect. The airline industry experienced a dramatic decrease in search costs with increasing Internet use in the 2000s. Consumers can sort tickets by prices or other ticket characteristics and find attractive alternatives with only a few clicks. They can also check out other travel agency websites, price comparison sites, and airline websites for better deals quickly and easily. The increase in Internet use is an external shock to the industry that reduces search costs and is unrelated to the level of switching costs. We use the average Internet use at the endpoint airports of a route as a proxy for search costs (as measured inversely). Internet use may not reduce the total time spent on searching, as the Internet may idle people. Here, we may interpret search costs as the minimum time and effort needed to find relevant information. As consumers are better informed, their consideration sets will be widened and they will become more flexible.

The airline industry is also characterized by the presence of significant switching costs. Major airlines have FFPs that encourage repeated purchases. These have been regarded as one of the most successful marketing strategies. FFPs reward a consumer who accumulates mileage to a certain level with a bonus ticket. In other words, a consumer has to forgo the opportunity to gain a bonus ticket when buying

from another airline. Those switching costs arising from FFPs are proportional to the extensiveness of the route network, as consumers would find it easier to accumulate and redeem mileage when an airline serves more destinations. In this sense, we use different measures of the average network size of airlines on a route as a proxy for switching costs in the market.

Markets are defined as a trip from an origin airport to a destination airport. The data used in this analysis presents both cross-sectional and over-time variations in Internet use and in the airline network size. This allows us to identify the effects of search costs, switching costs, and the interaction between the two costs on the average market fare.

In particular, we estimate the following fixed-effect model:

$$\log(\text{Fare}_{rt}) = \alpha + X_{rt}\beta + \gamma_1 \text{Internet}_{rt} + \gamma_2 \text{Network}_{rt} + \gamma_3 \text{Internet}_{rt} \cdot \text{Network}_{rt} + \delta_{rq} + \delta_t + \epsilon_{rt}$$

Here, Fare_{rt} denotes the number-of-passengers weighted-average fare in market r at time t ; Network_{rt} is the average network size of the airlines competing in market r at time t , measured in a number of different ways; Internet_{rt} is the average internet penetration rate in the two endpoint regions of market r at time t ; X_{rt} is a set of control variables; δ_{rq} is a fixed effect for the pair of market r and quarter q of time t ; δ_t is a fixed effect for time t ; and ϵ_{rt} is a random error with zero mean.

Market-quarter fixed effects (δ_{rq}) are included to control for the unobserved, time-invariant component of a route and route-specific seasonality; and time-fixed effects (δ_t) are included to account for time-specific components - common demand/supply shocks - unobserved by researchers.

Specifically, the Internet penetration rate in the region where an airport is located is measured by the proportion of people having Internet access in the region. The Internet penetration rate differs across regions and over time. *Internet* denotes the average Internet penetration rate in the two endpoint regions of a given market, i.e.,

$$\text{Internet}_{rt} = (\text{Internet}_{ot} + \text{Internet}_{dt})/2,$$

where $\text{Internet}_{ot}(\text{Internet}_{dt})$ is the proportion of people having Internet access at time t in the region where the origin (destination) airport of market r is located.

An airline's network size at an airport is measured by the number of destinations that the airline serves originating from the airport, and the airline's network size in a market is measured by the average network size of the airline at the endpoint airports of the market. In particular, we devise a network size variable, Network_{rt} , by taking the average of the direct network size of airlines. Specifically, we first compute the simple average of the number of destinations to which a carrier operates a direct flight at each of the two endpoint airports of a given market, after which we take the average of the values across all airlines serving the market multiplied by the number-of-passengers weights, i.e.,

$$\text{Network}_{rt} = \sum_{c \in C} (S_{crt} \cdot \frac{1}{2} (Y_{crt}^{\text{origin}} + Y_{crt}^{\text{dest}}))/2,$$

where S_{crt} is the market share of carrier c in market r at time t ; C is the set of carriers competing in market r at time t ; and $Y_{crt}^{origin}(Y_{crt}^{dest})$ is the number of destinations to which carrier c operates a direct flight from the origin (destination) airport of market r at time t .

As robustness checks, two alternative measures of network size are considered with different variables for Y_{crt}^{origin} and Y_{crt}^{dest} . First, consumers may consider the number of destinations they can reach regardless of the identity of an operating airline and whether they can take a direct flight or not. To reflect this point, we additionally consider the destinations served by only connecting flights and code-sharing flights. In this case, Y_{crt}^{origin} represents the number of destinations that carrier c serves from the origin (destination) airport of market r at time t . Second, consumers may care about the frequency of flights rather than the number of destinations when evaluating FFPs because it would be easier for them to accumulate and use mileages when there are more flights. We consider this by constructing an alternative measure of *Network* based on the number of direct flights operated by an airline from the endpoint airports.⁷ Specifically, Y_{crt}^{origin} is the number of direct flights of carrier c from the origin (destination) airport of market r at time t .

X_{rt} is a set of control variables that accounts for the average product characteristics and market structure. Suppressing the market and time notations (r , t), the average product characteristics include the fraction of direct flights among all itineraries (*Direct*); the fraction of round-trip tickets among all itineraries (*Round*); and the average extra miles flown of all itineraries (*ExtraMiles*). *ExtraMiles* is zero if an itinerary is served by a non-stop, direct flight. For connecting flights, the variable is measured by taking the difference between the actual flown miles and the non-stop miles flown. Variables of the market structure include whether a low-cost carrier (LCC) serves market r at time t ($LCCin_{rt}$); the number of LCCs serving market r at time t ($NumLCC_{rt}$); and the market concentration as measured by the Herfindahl-Hirschman Index (HHI) in market r at time t (HHI_{rt}). LCC-related variables are included because LCCs tend to have a smaller network size and offer less expensive tickets than legacy carriers; LCC entry can result in a spurious positive relationship between the average network size and the average fare in a market.

B. Data

There are two main data sources for the empirical analysis. First, the airline data is obtained from the Bureau of Transportation Statistics of the U.S. Department of Transportation (DOT). The Airline Origin and Destination (O&D) Survey Data Bank 1B (DB1B) is a 10% random sample of tickets used during each quarter and

⁷We do not know the total number of flights that a carrier serves from an origin airport to a destination airport because capacity data is available only for direct flights.

contains information on fares and other ticket characteristics, such as origins, destinations, ticketing carriers, numbers of passengers, numbers of connections (i.e., the number of coupons used in an itinerary), whether a ticket is a round-trip ticket, and so on, at the itinerary level. Capacity data such as the number of available seats and the number of flights are obtained from the T-100 database. Unlike the O&D data, only direct flights are counted in the capacity data. Second, data on Internet use is obtained from various supplements to the Current Population Survey (CPS) of the U.S. Census Bureau. This survey has asked questions about Internet use sporadically since 1997.

This paper examines air travel between airports in the 50 most populated Metropolitan Statistical Areas (MSAs) during the 2000s, when Internet use increased rapidly. The list of MSAs ranked by population as of 2000 is available from the U.S. Census Bureau. All major airports in the MSAs and any minor airports within a 75-mile radius of the major airports are included. Data on Internet use is available for six years between 2000 and 2010 (2000, 2001, 2003, 2007, 2009, and 2010). The surveys asked whether anyone in a household had Internet access at any location. The Internet penetration rate is computed as the fraction of people answering “yes” to this question. In addition, for 2001 and 2003, the surveys also asked whether the respondent searched for a product online. Internet use varies across MSAs and over time. As a robustness check, we measure the proportion of people who engaged in online searches for products instead of the proportion of people having Internet access. We restrict our attention to six years in the 2000s, specifically 2000, 2001, 2003, 2007, 2009 and 2010.

The selection criteria are not related to the level or the change in search and switching costs, and the sample is large enough to cover over 70% of passengers in a quarter. Figure 1 shows that, over time, the average Internet use increases and the average fare decreases, whereas the average network size does not change much. Summary statistics of the variables used in the empirical analysis are shown in Table 1.

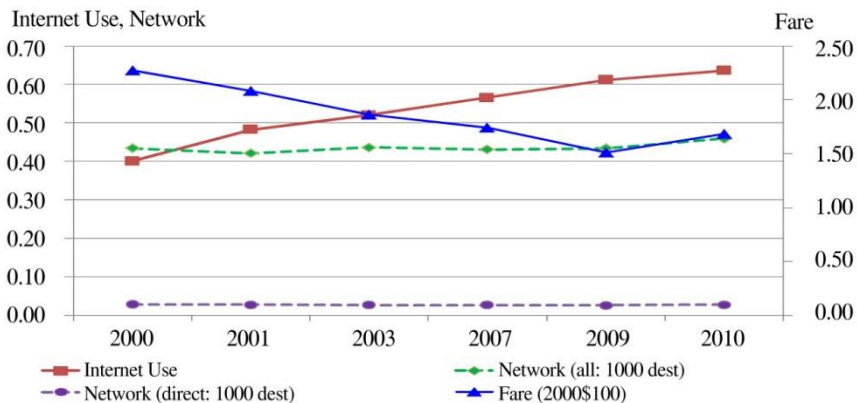


FIGURE 1. INTERNET PENETRATION RATES, NETWORK SIZES, AND FARES OVER TIME

Notes: Internet Use is the Internet penetration rate, Network (direct) is the average number of destinations of airlines served by a direct flight, and Network (all) is the average number of destinations of airlines served by any flight (including connecting services). Details about the variables are given in Section IV.A.

TABLE 1—SUMMARY STATISTICS

	Variable	Mean	SD	Min.	Max.	No. obs
	Fare (2000\$100)	1.86	0.73	0.22	18.39	114,727
	Internet	0.54	0.09	0.30	0.73	
	Network (100 destinations)	0.10	0.08	0.00	0.51	
	Internet·Network	0.05	0.04	0.00	0.28	
Average product characteristics	ExtraMiles (1000 miles)	0.08	0.09	0.00	2.31	
	Direct	0.37	0.39	0.00	1.00	
	Round	0.74	0.16	0.00	1.00	
Market Structure	LCCin	0.59	0.49	0.00	1.00	
	NumLCC	0.83	0.84	0.00	6.00	
	HHI	0.53	0.26	0.05	1.00	
	Distance (1000 miles)	1.17	0.70	0.02	2.72	
	Distance_sqrd	1.86	1.93	0.00	7.42	
Alternative measures of network size						
Total No. of destinations (both direct/connecting flights)	Network (100 destinations)	0.44	0.09	0.01	0.68	
	Network (1000 flights)	0.38	0.37	0.00	2.69	
Different measures of internet use						
	OnlineSearch	0.34	0.04	0.24	0.50	38,577
	OnlineSearch·Network	0.15	0.04	0.00	0.28	

V. Results and Discussion

Main regression results are presented in Table 2. We estimate different specifications regarding the inclusion of network and Internet variables. All specifications include market-quarter fixed effects and time fixed effects, although the related estimates are not reported in the table.

In specification (1), we see the effect of Internet penetration rates, excluding the average network size. The average fare is found to be significantly and negatively associated with the average Internet penetration rate; a 10 percentage point increase in the average Internet penetration rate is associated with a lower average fare by approximately 4.4%.

In specification (2), we disregard Internet penetration rates and note the effect of the average network size. The result shows that the route-average fare is significantly higher with a larger average network size of airlines on a route. When all competing airlines on a route serve ten more destinations with direct flights (that is, Network increases by 0.1), the average fare is expected to increase by 8.2%, holding all other factors constant.

TABLE 2—MAIN REGRESSION RESULTS

Specification		(1)	(2)	(3)	(4)
Variable		Dependent variable: Log (Fare)			
Average product characteristics (No. of passengers weighted)	Network (100 destinations)		0.816*** (0.0310)	0.811*** (0.0309)	0.232*** (0.0762)
	Internet	-0.441*** (0.0339)		-0.427*** (0.0338)	-0.506*** (0.0361)
	Internet·Network				1.156*** (0.135)
	ExtraMiles (1000 miles)	0.119*** (0.0245)	0.102*** (0.0243)	0.102*** (0.0243)	0.115*** (0.0243)
Market structure	Direct	-0.126*** (0.00833)	-0.197*** (0.00839)	-0.197*** (0.00838)	-0.198*** (0.00837)
	Round	-0.241*** (0.0121)	-0.229*** (0.0121)	-0.233*** (0.0121)	-0.242*** (0.0122)
	LCCin	-0.106*** (0.00402)	-0.109*** (0.00398)	-0.109*** (0.00397)	-0.109*** (0.00397)
Market structure	NumLCC	-0.0424*** (0.00185)	-0.0402*** (0.00181)	-0.0402*** (0.00181)	-0.0392*** (0.00182)
	HHI	0.151*** (0.00847)	0.108*** (0.00868)	0.111*** (0.00869)	0.109*** (0.00870)
	Constant	1.152*** (0.0183)	0.932*** (0.0121)	1.105*** (0.0183)	1.156*** (0.0202)
	Observations	114,727	114,727	114,727	114,727
R-squared		0.351	0.358	0.360	0.361
Number of market-quarter pairs		19,981	19,981	19,981	19,981

Notes: Robust standard errors in parentheses; year-quarter dummies included

*** significant at the 1 percent level.

** significant at the 5 percent level.

* significant at the 10 percent level.

In specification (3), we include both *Internet* and *Network* in one specification. The result shows that the respective coefficient estimates on the two variables are unaffected, implying that *Internet* and *Network* are uncorrelated.

Lastly, in specification (4), we add an interaction term between the Internet penetration rate and the network size. The coefficient estimate of *Network* becomes much smaller. Meanwhile, the estimate of the effect of the Internet is greater (that is, more negative) and the interaction term (*Internet·Network*) is positive and significant. When evaluated at the mean value of *Internet*, an increase in *Network* by 0.1 corresponds to an increase in the average fare by 8.5%.⁸ A large fraction of the positive impact of the network size on fares seems to come from the moderation of the negative impact of the Internet. When evaluated at the mean value of *Network*, an increase in *Internet* by 0.1 (that is, an increase of 10 percentage points) corresponds to a decrease in the average fare by 3.9%. The result implies that the pure Internet effect is likely to be underestimated when the network size is not taken into account.

⁸This value is computed as “Estimated coefficient on Network+estimated coefficient on Internet·Network× mean value of Internet.”

Recall that the average Internet penetration rate is used to capture search costs (as measured inversely) and that the average network size of all airlines on a route is used as a proxy for switching costs. We then interpret the regression results in the context of the price effects of search and switching costs. We find that prices tend to increase with search costs and switching costs. When the interaction between search costs and switching costs is considered, a search cost reduction is found to have a greater, negative impact on prices. The significant and positive effect of the interaction term implies that switching costs lessen the negative effect of the search cost reduction on prices.

The results imply that switching costs are not high enough to lock in consumers fully. If people never switch due to high switching costs, reduced search costs should only increase the investing incentive, while the harvesting incentive would remain unaffected. Considering that the investing incentive increases with the switching cost, decreasing search costs will lead to a deeper price cut in the presence of larger switching costs. We then expect to find a negative coefficient for *Internet · Network*, which is not the case in this empirical analysis.

We interpret the positive relationship between fares and the interaction term as an indication that (1) switching costs are not substantial such that switching may take place; (2) switching costs still allow firms to sustain their lock-in power longer and thus maintain higher prices while search costs are declining; and (3) the investing incentive enhanced by switching costs does not outweigh the increased harvesting incentive. In sum, the empirical results support the general belief that the reduction in search costs associated with increasing Internet use would intensify competition, but switching costs would moderate the impact.

The other estimates appear reasonable. With more actual miles flown, fares are higher on average (see *ExtraMiles*). This may arise because it is more costly to operate a flight or because the competitive pressure is generally low when consumers have to offset a longer distance with connecting flights on average. A higher proportion of direct-flight or round-trip tickets is negatively associated with the route-average fare (see *Direct* and *Round*), which reflects that direct flights and round-trip tickets are generally offered to consumers at the same or lower prices as compared to connecting flights and one-way tickets respectively. The signs of the estimated coefficients on market-structure variables are as predicted: the presence of LCCs tends to lower the average fare (see *LCCin* and *NumLCC*); and the average fare tends to be higher in a more concentrated market (see *HHi*).

At this stage, we determine if there are other explanations for the results. First, consumers may exhibit different degrees of lock-in. For example, business travelers fly more frequently, and they also tend to be less price-sensitive as compared to leisure travelers. The value of FFPs (here, the network size) will be more relevant to business travelers. Thus, the positive relationship between *Network* and fares could indicate price discrimination. If airlines tend to provide a more extensive network in a market with more business travelers, the positive coefficient on the interaction term between *Network* and *Internet* may be driven by the fact that business travelers are not heavily affected by the Internet (as they are less price-sensitive). We control for consumer heterogeneity across markets by adding route-quarter fixed effects. By doing so, we address consumer heterogeneity to the extent to which it varies across markets but is constant over time. Aggregate

shocks to consumer heterogeneity are taken into account by including year dummies.

Table 3 presents the estimation results with additional variables to consider other factors that may be related to the interaction between *Internet* and *Network*.

Specification (A1) adds a linear time trend (Time) and an interaction term between the linear time trend and the average network size (*Network* · *Time*) to the main specification. In the 2000s, legacy network carriers' market power weakened and fares decreased, whereas the Internet penetration rate increased. Thus, the negative effect of the Internet may be capturing the trend of decreasing fares, and the negative effect of the interaction term between Internet use and the average network size may be a spurious relationship arising from the decreasing market power of legacy carriers. We include time-trend variables to account for

TABLE 3—ROBUSTNESS CHECKS - TIME TREND AND LCC PRESENCE

Specification Variables	Main	(A1) Time trend	(A2) LCC presence
Network (100 destinations)	0.232*** (0.076)	-0.221** (0.109)	0.202*** (0.077)
Internet	-0.506*** (0.036)	-0.614*** (0.043)	-0.617*** (0.039)
Internet · Network	1.156*** (0.135)	2.236*** (0.237)	1.028*** (0.134)
ExtraMiles (1000 miles)	0.115*** (0.024)	0.113*** (0.024)	0.120*** (0.024)
Direct	-0.198*** (0.008)	-0.198*** (0.008)	-0.192*** (0.008)
Round	-0.242*** (0.012)	-0.239*** (0.012)	-0.237*** (0.012)
LCCin	-0.109*** (0.004)	-0.109*** (0.004)	-0.278*** (0.018)
NumLCC	-0.039*** (0.002)	-0.039*** (0.002)	-0.005 (0.009)
HHI	0.109*** (0.009)	0.110*** (0.009)	0.110*** (0.009)
Time		-0.019*** (0.001)	
Network · Time		-0.026*** (0.006)	
LCCin · Internet			0.317*** (0.033)
NumLCC · Internet			-0.065*** (0.016)
Market-quarter FE	included	included	included
Observations	114,727	114,727	114,727
R-squared	0.361	0.361	0.362

Notes: Robust standard errors in parentheses; year-quarter dummies included

*** significant at the 1 percent level.

** significant at the 5 percent level.

* significant at the 10 percent level.

this potential problem. Indeed *Time* and *Network · Time* are negatively associated with the average fare, but including time-trend variables does not change the main finding that the fare decrease associated with increasing Internet use is lessened by high switching costs.

Specification (A2) includes the interaction between the Internet and the variables related to the presence of LCCs. *Network* is negatively associated with the presence of LCCs, and so *Internet · Network* may capture the Internet effect in the presence of LCCs. On the one hand, consumers may be able to find the inexpensive products of LCCs more easily using the Internet; thus, the effect of the Internet on prices may be more prominent when LCCs are present. On the other hand, because the products of LCCs are generally known to be inexpensive, consumers may search for the price information of LCCs anyway and thus the Internet may have less of an impact on consumer search behavior in the presence of LCCs. These factors can potentially lead to biased estimations of the effects of the interaction term; it will be overestimated in the former case and underestimated in the latter case. The result shows that the effect of Internet use tends to be smaller in the presence of LCCs. However, as the number of LCCs increases, Internet use appears to drive down prices. After allowing for different effects of Internet in the presence of LCCs, we still have similar estimates of the effects of Internet, *Network*, and the interaction between those variables, finding that the Internet lowers prices but that the price drop is smaller when the average network size is larger.

The regression results are dependent on the measure of the network size and on the measure of Internet use. We used different measures of these variables in the robustness checks, and these results are presented in Table 4. As a proxy for switching costs in relation to FFPs (*Network*), we also use the average number of destinations served by airlines by any flight - direct, indirect, and code-sharing flights - (Specifications (B1) and (B2)) and the average number of direct flights at the endpoint airports (Specifications (B3) and (B4)). Details are given in Section IV.A. The difference in the estimates of the Internet with and without *Internet · Network* is much larger, and the estimate of *Network* is insignificant when we take into account all destinations (as compared to main results (3) and (4) in Table 2). Unlike the measure based on the direct network size, this measure (based on all destinations) is likely to capture the pro-competitive effects of code-sharing and a hub-and-spoke system as well. Firms may achieve major cost reductions through code-sharing, and code-sharing on complementary routes may resolve the double marginalization problem. In this sense, this result suggests that network size including all destinations (through direct, indirect, or code-sharing flights) captures more of the effect of double marginalization, while the effect of inhibiting the competitive effect of the Internet remains. The main finding is also confirmed when the number of direct flights is used (Specifications (B3) and (B4)).

We use the proportion of people having Internet access as a proxy for low search costs. For 2001 and 2003, however, we have extra information regarding Internet use. The survey additionally asks if the respondent searched for a product online to purchase at any point over the past year. We use the average of the proportion of people engaging in an online search in the regions in which the endpoint airports of a market are located as a proxy for low search costs (Specifications (B5)~(B8)).

TABLE 4—ROBUSTNESS CHECK - DIFFERENT MEASURES OF *Network* OR *Internet*

Specification	(B1)	(B2)	(B3)	(B4)	(B5)	(B6)	(B7)	(B8)
Variables	All destinations (100 destinations)		Flight frequency (1000 flights)		Online search			
Dependent variable: Log (Average Fare)								
Network	0.583*** (0.022)	0.029 (0.067)	0.139*** (0.007)	0.069*** (0.015)		0.296*** (0.108)	0.332*** (0.108)	-0.438* (0.244)
Internet	-0.449*** (0.034)	-0.877*** (0.063)	-0.424*** (0.034)	-0.466*** (0.036)				
Internet ·Network		1.067*** (0.126)		0.149*** (0.028)				
OnlineSearch					-0.399*** (0.118)		-0.443*** (0.118)	-0.655*** (0.134)
OnlineSearch ·Network								2.286*** (0.695)
ExtraMiles (1000 miles)	0.123*** (0.024)	0.134*** (0.024)	0.107*** (0.024)	0.114*** (0.024)	0.143** (0.064)	0.141** (0.063)	0.137** (0.063)	0.141** (0.063)
Direct	-0.089*** (0.008)	-0.081*** (0.008)	-0.169*** (0.008)	-0.170*** (0.008)	-0.184*** (0.025)	-0.203*** (0.024)	-0.205*** (0.024)	-0.206*** (0.024)
Round	-0.279*** (0.012)	-0.285*** (0.012)	-0.233*** (0.012)	-0.238*** (0.012)	-0.570*** (0.023)	-0.573*** (0.023)	-0.572*** (0.023)	-0.572*** (0.023)
LCCin	-0.097*** (0.004)	-0.098*** (0.004)	-0.109*** (0.004)	-0.109*** (0.004)	-0.149*** (0.010)	-0.148*** (0.010)	-0.149*** (0.010)	-0.148*** (0.010)
NumLCC	-0.035*** (0.002)	-0.034*** (0.002)	-0.039*** (0.002)	-0.038*** (0.002)	-0.028*** (0.005)	-0.028*** (0.005)	-0.027*** (0.005)	-0.027*** (0.005)
HHI	0.104*** (0.008)	0.104*** (0.008)	0.117*** (0.009)	0.115*** (0.009)	0.128*** (0.020)	0.116*** (0.021)	0.115*** (0.021)	0.113*** (0.021)
Constant	0.935*** (0.020)	1.162*** (0.034)	1.112*** (0.018)	1.138*** (0.020)	1.432*** (0.045)	1.287*** (0.025)	1.429*** (0.045)	1.500*** (0.050)
Observations	114,727	114,727	114,727	114,727	38,577	38,577	38,577	38,577
R-squared	0.363	0.364	0.357	0.357	0.272	0.272	0.272	0.273
No. of market- quarters	19,981	19,981	19,981	19,981	4,975	4,975	4,975	4,975

Notes: Robust standard errors in parentheses; year-quarter dummies included

*** significant at the 1 percent level.

** significant at the 5 percent level.

* significant at the 10 percent level.

Suppressing a time notation, we compute

$$OnlineSearch_r = \frac{1}{2} (Online_r^{origin} + Online_r^{dest}),$$

where $Online_r^{origin}$ ($Online_r^{dest}$) denotes the proportion of people who search online in the region in which the origin (destination) airport of market r is located. The number of observations is reduced, as we cover only two years for which data about online searches is available. Although the estimate of *Network* is negative, the interaction term $OnlineSearch \cdot Network$ is much larger and positive, as is the network effect evaluated at any value of Internet in the sample. The effect of *Internet* is negative and the estimated coefficient of *OnlineSearch* is

significantly more negative when *OnlineSearch · Network* is included (Specification (B8) as compared to Specification (B7)). Overall, the main findings are robust to this alternative measure and the use of a subsample.

The results have academic as well as practical implications. First, the comparison between the estimated coefficients of *Internet* with and without the interaction term, *Internet · Network* (that is, specifications (1) and (3) vs. specification (4)) suggests that estimation of the search cost effect ignoring the interaction with switching costs in determining the market price may be biased. Specifically, in the airline industry, we see that the negative effect of a search cost reduction on prices is underestimated when the interaction with switching costs is omitted.

Second, we take search and switching costs as exogenously given when interpreting empirical results in this paper. In some industries, however, firms may be able to affect these costs. In particular, Internet use is believed to have lowered consumers' search costs dramatically, and firms have feared that this would intensify competition. Firms may respond to the decrease in search costs by increasing switching costs. By doing so, firms will be more likely to maintain high prices, and the potential price cut from the decrease in search costs will not be fully realized.

In this sense, policymakers would need to take into account the possibility that the effectiveness of a policy affecting one of the costs can be undermined by firms' responses, altering the size of the other cost. In the context of the airline industry, switching costs are the product of firms' marketing strategies and are rather out of the reach of policymakers. Given this policy restriction, policymakers would find it easier to alter search costs. Let us suppose that policymakers attempt to lower search costs and that the search cost reduction is comparable to 10%p increase in the average Internet penetration rate. Taking the estimates from the main empirical result, we can compute the number of destinations firms need to add to offset the effect of the lowered search costs. As mentioned earlier, a 10%p increase in Internet use corresponds to a 3.9% fare cut. Roughly speaking, firms can offset the fare decrease by raising switching costs by an amount that is comparable to the addition of 4.6 more destinations.⁹ This implies that the policy can be rather easily nullified by firms.

VI. Concluding Remarks

This paper investigates the price effect of reduced search costs in the presence of switching costs in the context of the effect of the Internet on airfares. How a decrease in search costs would affect prices and whether switching costs would amplify or mitigate the effect are theoretically unclear. Results with U.S. domestic airfares show that decreased search costs associated with increasing Internet usage has led to more competition, but switching costs measured in terms of the average

⁹This value is computed as "Estimated coefficient on Internet + estimated coefficient on Internet · Network × mean value of Network" × change in Internet use (here, 10%p) divided by "Estimated coefficient on Network + estimated coefficient on Internet · Network × mean value of Internet".

network size have moderated this effect. When the airline industry was deregulated in 1978, industry experts argued that network sizes would be the key strength of incumbent airlines to survive. This still applies to struggling legacy airlines in the current periods. In the Internet era, the empirical result suggests that their networks would help airlines to weather the storm.

The results of this paper suggest that search and switching costs work in a similar fashion and when combined, they determine prices. In this case, one of the costs can influence the price effect of the other cost. If we do not consider both costs when estimating the magnitude or significance of each cost or when predicting the effects of changes in these costs, the empirical results would likely be biased.

It is also suggested that policymakers give serious consideration to the interaction between search and switching costs when designing and implementing policies which affect one of these costs. Firms' reactions to offset the policy effect should be taken into account. Otherwise, the policy may become ineffective or have unexpected consequences.

We need to note that the interpretation of the empirical result was based on the assumption that search and switching costs are exogenously given. It would be easy to justify exogenous search costs related to the Internet. However, FFPs are endogenously determined by airlines, and their values are dependent on consumer usage. That is, airlines decide how many benefits to give (or not) to consumers based on their past usage. In this case, the literature shows that equilibrium prices decline over time (see Caminal and Matutes (1990) and Rhee (2014)). That is, consumers experience fare decreases throughout the consumption cycle as they accumulate miles and use them to earn free tickets. In this sense, the empirical result in this paper does not mean that consumer welfare will decrease, as the fare cuts associated with reduced search costs may not be fully realized in the presence of switching costs. The impact on consumer welfare is rather ambiguous when switching costs are endogenously determined.

This paper does not provide a formal theory. A formal theory that includes both search costs and switching costs in one framework will be useful to generate specific predictions of the price effects of search and switching costs. Whether and how a price effect of a search cost reduction will be affected by switching costs will become clearer. Moreover, a formal theoretical framework will enable us to conduct more robust empirical studies regarding this relationship.

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