The Effect of the Internet on Product Quality in the Airline Industry*

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Abstract

How did the diffusion of the Internet affect product quality in the airline industry? We argue that the shift to online distribution channels has changed the way airlines compete for customers - from an environment in which airlines compete for space at the top of travel agents' computer screens by scheduling the shortest flights, to an environment where price plays the dominant role in selling tickets. Using flight-level data between 1997 and 2007 and geographical growth patterns in Internet access, we find a positive relationship between Internet access and scheduled flight times. The magnitude of the effect is larger in competitive markets without low-cost carriers and for flights with shortest scheduled times. We also find that despite longer scheduled flight times, flight delays increased as passengers gained Internet access. More generally, these findings suggest that increased Internet access may adversely affect firms' incentives to provide high quality products. (Internet; e-commerce; Search; Air Travel; Product Quality)

I. Introduction

How do improvements in information availability affect markets? Researchers have long emphasized that price information is critical for the efficient functioning of markets. The growth of electronic commerce and Internet marketplaces has been considered as contributing towards market efficiency, because it has enabled consumers to compare prices across hundreds of vendors with much less effort than would be required in the physical world (e.g. Brynjolfsson and Smith 2000; Brown and Goolsbee 2002; Clemons et al. 2002). Indeed, the traditional economic view suggests that the Internet makes markets more competitive, thereby leading firms to reduce prices. But, besides setting lower prices, are there other ways in which firms have responded to the changes in the competitive landscape (Brynjolfsson et al. 2003; Ellison and Ellison 2009)?

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Could more price information also lead firms to offer lower product quality? Could more information change the market equilibrium in ways that deemphasize the importance of product quality (Bakos 1997)? Our paper aims to address these questions by highlighting subtle ways in which the diffusion of the Internet has affected performance and product quality in the airline industry. To our knowledge, this is the first empirical study that has examined the relationship between product quality and Internet access or search costs in general.

The U.S. airline industry provides a natural setting for examining the effect of Internet access on product quality. The distribution of airline tickets has undergone dramatic changes over the past 15 years, as more air passengers have gained Internet access. In 1997 only 0.5% of U.S. domestic airline tickets were purchased online, whereas in 2007 between 50% and 60% of tickets were purchased online (Berry and Jia 2010). Previous research has also shown that Internet usage is strongly associated with lower airfares (Orlov 2011), and that over 35% of traditional brick-and-mortar travel agencies exited their markets between 1997 and 2003 as more air passengers began to use the Internet to purchase airline tickets (Goldmanis et al. 2010).

Like other products, flights have multiple dimensions of quality, such as aircraft cleanliness, food quality, the number of flight attendants and flight safety. Our main measure of flight quality is scheduled elapsed flight time, i.e. the amount of time between the scheduled departure and the scheduled arrival. Figure 1 plots a time series for the mean scheduled flight times between 1990 and 2007. The time series fluctuates in the early 1990s and then shows a strong upward trend starting in the second half of the 1990s. We argue that the shift in airfare distribution channels from traditional travel agencies to online distribution channels can explain about a quarter to a half of this upward trend. In the early 1990s, when brick-and-mortar travel agencies sold over 80% of airline tickets (Borenstein 1992), flights typically appeared on the travel agent's screen in ascending order according to their scheduled durations (GAO 1995). Given that travel agents booked over 80% of flights from the first screen and that the majority of the tickets were sold from the first line of search results, airlines had strong incentives to maintain short scheduled flying times (Guerin-Calvert 1992). This incentive changed as the Internet became the most common channel for purchasing airline tickets, and price became the main criterion to sort flights. In other words, the Internet has changed the way airlines compete for customers, creating a shift from an environment in which airlines compete to appear at the top of travel agents' computer screens by scheduling the shortest flights, to an environment where price plays the dominant role in selling tickets, and scheduled time is not as important.[1] As flight duration times became less important in affecting revenues, airlines could

[1] Consistent with our claim, American Airlines' Capacity Planning managing director said: "[before the Internet] you had to be on the first screen [of the travel agent]. All the booking came off the first screen.

schedule longer flights and reduce costly fuel consumption[2] and other related costs (Forbes et al. 2012).

To substantiate our claim, we investigate the relationship between increases in Internet usage and scheduled elapsed flight times using several sources of flight level data over the years 1997–2007. Our analysis exploits three main sources of variation in the data: (1) differences in Internet penetration over time; (2) differences in Internet penetration across geographical locations; and (3) differences in competition levels across flight segments (*flight segment* refers to a directional non-stop route between two airports). These arguably exogenous sources of variation allow us to (a) use panel data to estimate the marginal effect of Internet penetration on our measures of flight quality, and (b) investigate whether the size of the effect varies across flight segments with different levels of competition. In particular, we expect that the effect of the Internet to be greater in markets where airlines were more likely to use flight scheduled time to compete with other airlines. Our identification strategy also exploits the fact that connecting passengers on a flight from airport A to airport B likely purchased their ticket in a metropolitan area, where they actually began their trip, which may not be the area of airports A or B. Thus, we can compare the effect of the Internet on flights departing from the same airport on the same day but also carry different fractions of passengers who purchased their tickets online. By also incorporating various measures of congestion at the flight and the airport levels and a rich set of fixed effects, we believe that we are able to identify the impact of the Internet on scheduled elapsed flight times.

In our empirical analysis, we find that Internet usage is associated with a significant increase in scheduled elapsed flight times. This effect is particularly large in competitive markets and can explain about one-half of the total increase in scheduled elapsed flight times. We then investigate whether this effect reflects the extent to which airlines were using scheduled elapsed flight times to differentiate themselves from other airlines or differentiate among their own flights. First, we exploit the fact that low-cost carriers did not primarily rely on the traditional computer reservation systems to sell airfares. Accordingly, in markets with low-cost carriers we expect scheduled elapsed flight time to be less important in the first place and the effect of the

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You'd bring your airplanes in as fast as you can and you'd let them go as fast as you can." (see *ATW online* at http://www.nesdb.go.th/specialWork/suvarnabhumi/ceo_talk/No%20Peaking.pdf.). The Wall Street Journal also reports that scheduled time has increased dramatically over the years, sometimes by up to 39% for similar flights. The Middle Seat: Why a Six-Hour Flight Now Takes Seven. Scott McCartney (2010, February 4), *Wall Street Journal* (Eastern Edition), p. D.1. For instance, the scheduled duration time of United Airlines' before-noon flight from San Francisco (SFO) to New York City (JFK) increased from 323 minutes in July 1997 to 347 minutes in July 2007.

[2] Flying at higher altitudes is considered more fuel-efficient but also requires flights to fly longer to reach the higher altitude. See, for example, http://online.wsj.com/article/SB10001424052748704901104575423261677748380.html

Internet on scheduled elapsed flight time to be weaker. Second, we focus on the flights with the shortest scheduled times in their segments. We expect the effect of the Internet to be larger for these flights that previously appeared at the top of traditional travel agents' screens, especially in more competitive segments. Our regression results confirm our expectations.

The rapid growth in Internet usage and the arguably exogenous shift in airlines' incentives to maintain short scheduled elapsed flight times also provide a unique opportunity to study the effect of the Internet on flight delays, another measure of flight quality (see, for example, Forbes 2008, Mazzeo 2003 and Prince and Simon 2009). Theoretical models (e.g. Rogerson 1988; Dranove and Satterthwaite 1992) offer mixed predictions on the effect of lower search costs on product quality. Our findings, however, indicate that flights with higher percentages of passengers who originated from areas with higher Internet penetration experienced longer arrival delays. These flight delays occurred mainly because of longer actual flight times, primarily due to longer departure delays. Taking into account the total effect of the Internet on flight times and delays, our estimates suggest that in competitive markets the increase in Internet access contributed about 5 to 7 additional minutes in arrival delays and actual flight times, respectively.

Our paper contributes to the voluminous literature on the effect of information and communication technologies on productivity and performance (e.g. Brynjolfsson and Hitt 2000; Bloom et al. 2012). Naturally, the existing literature predominantly focuses on the large benefits associated with the adoption of information and communication technologies. Our findings, however, highlight a potentially negative effect of the diffusion of online distribution channels on product quality. Furthermore, although our findings come from the airline industry, we believe that exploring firms' incentives to appear at the top of consumers' search are relevant in many other settings of online search. Indeed, recent theoretical (Arbatskaya 2007) and empirical (Oestreicher-Singer and Sundararajan 2011) papers have shown that the prominence or visibility of a firm product affect firms' performance. Our findings also contribute to a growing literature on the effect of competition on performance and product quality (e.g. Hubbard 2003; Olivares and Cachon 2009; Matsa 2011; Syverson 2011). Unlike most of the existing evidence, our results suggest that effect of Internet access on measures of performance and product quality are negative, particularly in more competitive environments.

II. Data

Our data come from several sources. Data on Internet usage over time come from the Computer Use and Ownership Supplement to the Consumer Population Survey (CPS). We use the CPS to measure Internet penetration for every major metropolitan area. The survey asks about Internet access at home, school, and business. For each of the 243 metropolitan areas, we use sample weights provided by the CPS to compute the percentage of respondents answering "yes" to any of these Internet access questions. Data are available for the years 1997, 1998, 2000, 2001, 2003 and 2007. Table 1 provides descriptive statistics for this variable.

Our primary source of flight-level data is the on-time performance database from the U.S. Bureau of Transportation Statistics. This database reports scheduled and actual flight information for all flights on each airline with at least 1% of U.S. domestic passenger revenues. In particular, the data include measures of scheduled and actual departure and arrival times as well as identifying information for each aircraft and flight. Using these data, we investigate how the Internet affected the scheduled elapsed and actual flight times of the same flights. Table 2 reports the average scheduled flight times and delays for the 9 carriers that reported this information throughout the period we are investigating.

Another data source we use is the Official Airline Guide (OAG), which publishes a complete set of scheduled flights for *all* airlines between all U.S. airports. We use the OAG data to construct the measures of competition for each flight segment in addition to several measures of aircraft operations in each airport and at different times throughout the day. In Section IV we provide further details on these measures. These measures enable us to control for potential changes in the number of flights and congestion patterns over time and across airports. In addition, we use these data to define an airline as a low-cost-carrier[3] as well as to check if using the entire set of scheduled flights produces different results with regard to the effects of Internet access on the shortest scheduled flight times. Figure 2 uses the OAG data and focuses on the flights with the shortest scheduled times to show the large increase in the minimum scheduled elapsed flight time between the years 1997 and 2007.

We supplement these data with additional sources. First, we use the Origin and Destination Survey (DB1B) market database. This database contains data for a 10% sample of all domestic passenger tickets purchased in each quarter for each year of our sample. In some specifications we include the mean airfare which we derive from the DB1B as a control variable,[4] In addition, as we explain hereafter we use the DB1B database to calculate the weights for the Internet penetration variable at the flight level. Importantly, the DB1B database includes the outbound and return portions of round-trip tickets, so we can identify each passenger's home airport (and therefore the associated

[3] The list of low-cost carriers includes Southwest Airlines, AirTran, JetBlue, Frontier, ATA Airlines, Allegiant Air, Skybus Airlines, Spirit Airlines, Sun Country Airlines, ValuJet Airlines, National Airlines, and Independence Air.

[4] The DB1B dataset reports airfares at the itinerary level. We allocate this fare to each of the itinerary's segments proportional to segments' distances. We then compute the average of airfares on each segment.

metropolitan area in which he or she is likely to have purchased the ticket).[5] Simply matching the flight data to the metropolitan area in which each *flight's* origination airport is located is inadequate. A passenger returning home on the return portion of a round-trip ticket, for example, is likely to have purchased his or her ticket at home, i.e., in the metropolitan area in which the flight's destination airport is located. Still other passengers are on the second leg of their outbound itineraries (or the first leg of their return itinerary), so neither the airplane's origination airport nor its destination airport is the airport at which these passengers began their round-trip travel. The distinction is important because our hypothesis is that the share of passengers who buy their tickets online (or have the option of doing so) affects airlines' scheduled elapsed flight times. Therefore, we calculate the following weighted measure of Internet penetration among the passengers on airline *i* serving flight segment *j* in quarter *t*: (1) $\mathrm{IP}_{ijt} = \sum_k \omega_{ijkt} \mathrm{I}_k^m \mathrm{IP}_{mt}$, where ω_{ijkt} is the share of all passengers on the flight who began their travel itinerary in airport *k*, IP_{mt} is the Internet penetration in metropolitan area *m*, and I_k^m is an indicator that is equal to 1 if airport *k* is located in metropolitan area *m* and 0 otherwise.[6,7] Second, we use data from the Bureau of Economic Analysis to construct demographic and economic measures at the metropolitan-area level. These measures control for expected and unexpected demand changes that may be spuriously correlated with Internet penetration. Finally, we use the T100 (Form 41) database from the Bureau of Transportation Statistics to derive a directional carrier–flight-segment load factor variable for each month in our sample.

After matching these datasets, we limit our sample to traffic during one Thursday in each quarter in the years CPS data are available. In what follows, we present estimation results for nine carriers for which data on on-time performance were available for all years between 1997 and 2007. We also limit our analysis to flight segments between the 100 airports with the highest numbers of passengers. This leaves us with 286,004 observations. The results are qualitatively similar if we do not constrain the data.

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[5] Before 2000, Southwest Airlines reported all of its round-trip ticket sales as two one-way tickets, so we cannot identify the home airport for these Southwest passengers, and thus we exclude Southwest Airlines from our analysis prior to 2000.

[6] For example, consider a flight from airport A to airport B. Assume that 40 percent of the passengers are flying round trip from A to B (so they are on the outbound portion of their round-trip itinerary), another 35 percent of the passengers are flying round trip from B to A (so they are on the return portion of their round-trip itinerary), another 15 percent of the passengers are flying round trip from airport C to airport B with a stop each way at airport A (so they are on the second segment of the outbound portion of their round-trip itinerary), and, finally, that the remaining 10 percent are flying round trip from airport A to airport D with a stop each way at airport B (so they are on the first segment of the outbound portion of their round-trip itinerary). The weighted average Internet penetration for passengers on this particular airline's flight from airport A to airport B is equal to (0.40 + 0.10) IP_A + 0.35 IP_B + 0.15 IP_C, where IP_i denotes the Internet penetration in the metropolitan area in which airport *i* is located. See also Dana and Orlov (2010).

[7] In the analysis we use the terms Internet access, Internet and Internet penetration (IP) interchangeably.

III. Identification and Empirical Specification

The explosion of e-commerce in recent years illustrates how the Internet is shaping the way consumers and businesses interact, affecting industry structure, and accelerating diffusion of information across firms and consumers. Nevertheless, identifying causal effects of the Internet on firms' behavior has proved to be difficult. A common research design uses cross-sectional data with the key right-hand-side variable being a measure of Internet usage or Internet access. Such analyses suffer from potentially severe omitted-variable bias, because the Internet variable is likely to be correlated with unobserved characteristics of Internet users. Using panel-data design in this study we can potentially address this concern because we control for both cross-sectional differences correlated with Internet access as well as common changes over time. Identifying the marginal effect of the Internet using a panel-data design may still be difficult if the observed changes in Internet penetration are small. We believe that the airline industry is well-suited to address this concern. Our study focuses on a period in which Internet access grew rapidly, from an average metropolitan-area penetration level of 19.4% in 1997 to an average penetration level of 76.3% in 2007. This change is also reflected in the share of airline tickets sold online, rising from 0.5% in 1997 to 50–60% in 2007. Importantly, substantial variation in changes in Internet penetration across U.S. metropolitan areas over time (see Table 1) provides additional identification power for our results.

Nevertheless, the panel data results may still be biased if areas that experienced faster Internet growth also experienced other changes that resulted in longer flight times. For example, an increase in local Internet usage could lead to lower prices, which may result in more flights operating at the local airport. This additional air traffic may translate into congestion and longer flight times. Thus, our Internet estimates may capture the impact of the Internet on the number of aircraft operations and on airport congestion.

There are two main reasons why we think this concern is mitigated in our study. The main reason is that our data include direct measures of aircraft and airport operations. In the regressions below we include a wide range of flight and airport congestion variables that are supposed to control for changes in the level of operations from each airport. We use the OAG data to construct various measures of the numbers of flights that are scheduled to operate at the origin and destination airports at the same hour on the same day (X^C in the regression below). In particular, we include the following measures: the number of departures and arrivals at the flight's destination airport within an hour of the flight's arrival; the number of departures and arrivals at the flight's origin airport and, separately, at the flight's destination airport on that day; the number of departures and arrivals at the flight's origin airport within an hour of the flight's departure; and the Herfindahl-Hirschman index

(HHI) at the flight's origin airport and at the flight's destination airport. The airport HHI measures should reflect potential situations in which airlines operating in concentrated airports gain advantages in handling flight operations and avoiding delays. Table 3 lists descriptive statistics for several variables included in our analysis.

A second reason concerns the large drop in the volume of domestic flights, up to 15% in certain months, following the 9/11 terrorist attacks. Intuitively, this exogenous drop in the volume of flights can help identify the relationship between the scheduled elapsed flight time and the volume of operations. More importantly, because the level of Internet access did not change after the 9/11 events, the decrease in flight volume can also help separate the effect of the Internet we are interested in from the effect of aircraft operations.

To control for other socio-economic changes at the metropolitan-area level we also include the following demand variables (X^D in the regression below): metropolitan-area population, level of unemployment and average per capita income. These variables are included in order to control for both short- and long-run variations in demand growth across airline segments and thus are constructed from the metropolitan-area data in the same way that the Internet penetration variable is constructed. Importantly, we also include a set of fixed effects that are supposed to capture any unobservable changes along the carrier, regional and time dimensions. Below we further explain how the inclusion of these fixed effects can help us identify the effect of the Internet on scheduled and actual flight times.

A. Main Specification for Scheduled and Actual Flight Time Measures

The basic framework for the analysis is a fixed-effects regression of the form:

(2) $$Y_{fijt} = \beta_1 IP_{ijt} + \beta_2 IP_{ijt} \cdot HHI_{jt} + \beta_3 HHI_{jt} + \beta_D X_{ijt}^D + \beta_C X_{fijt}^C + \alpha_j + \theta_{act} + \delta_{it} + \mu_{ki} + \varepsilon_{fijt},$$

where an observation is a flight *f* of airline *i* on directional segment *j* departing from airport *k* on day *t*. Y_{fijt} is an outcome measure of interest measured in minutes. The primary independent variables are the traffic-weighted measure of metropolitan-area Internet penetration (IP_{ijt}) and the interaction between this measure and the competition level, measured by the HHI for the corresponding flight segment ($IP_{ijt} \times HHI_{jt}$). We also add the segment's HHI, measured based on the share of each carrier flights on a segment, as a separate regressor.

To control for unobservables we include the following set of fixed effects: directional segment, aircraft type, carrier/day and airport/carrier fixed effects. The directional segment fixed effects, α_j, control for time-invariant airport-pair characteristics, such as distance, the flying direction and landing and departing conditions for each segment. The aircraft-type fixed effects, θ_{act}, account for unobservable technical differences among different aircrafts that may allow aircrafts to fly at different speeds and recover lost time differently during flight. By including the carrier/day fixed effects, δ_{it}, we account for seasonal, technological and other trends that may affect airlines' tendency to change their schedules. Importantly, we allow this effect to differ across airlines. Hence, for example, if American Airlines implemented a nationwide change in its schedules whereas United did not implement such a change, then these carrier/day fixed effects should control for that. In the regressions in which we use measures of actual flight times as the dependent variable, these carrier/day fixed effects may also capture unobservable events that have different effects on different airlines on a given day, such as extreme weather conditions that generate ripple effects on a carrier entire network performance. Including the carrier/day fixed effects implies that our cross-sectional variation comes from comparing two flights by the same carrier on the same day. In general, these two flights can depart from the same or different airports.

Still, such a comparison across airports may not be completely accurate. There are many unobserved differences across airports that may affect airlines' incentives to adjust their scheduling decisions. If these factors, such as the number of gates a carrier leases or the scale of operations in a particular airport, are correlated with the growth of Internet usage in the area that the airport serves, then we may actually obtain biased Internet estimates. To control for such bias, in some specifications we also add airport/carrier fixed effects, μ_{ki}, which should capture unobserved differences across carriers that operate in the same airports, such as the number of gates and the location of each carrier's terminals. Hence, in these latter specifications we actually test whether differences in the fraction of passengers who (likely) purchased their flights online affected scheduled elapsed flight times on the same carrier's flights on the same day, on the same type of aircraft, and originating from the same airport.

Two key features of the airline industry allow us to strengthen this identification strategy even further. The first is that airlines face different levels of competitive pressure across different segments originating from the same airport. This implies that the identification of the effect of the Internet on an airline's flights from the same airport and the same day comes at least partially from comparing flights by the same airline that depart from the same airport on the same day but in different competitive environments. As mentioned above, we expect that the effect of the Internet on flight duration will be greater in markets in which airlines were more likely to use duration times as means to sell tickets.

The second feature that can help identify the differential effect of the Internet on an airline's flights (same airport, same day, same aircraft) is that these flights likely carry different fractions of passengers who purchased their tickets online. This occurs because of the hub and spoke network structure of the airline industry. The network structure implies that many of the passengers who, for example, depart on a Delta flight from Atlanta actually began their journeys in different airports in different metropolitan areas. The share of connecting passengers is substantial. Ater (2012) reports that more than 50% of the passengers at the 17 largest U.S. hub airports use these airports to connect to other fights. As we discussed above, our weighted Internet variable reflects this feature of the airline industry and our assumption that passengers who purchase their tickets online do so in the areas where they begin their trips. Consequently, our comparison across an airline's flights from the same airport on the same day does not necessarily imply that we are comparing flights that carry passengers living in the same metropolitan area and who have similar levels of access to the Internet.

B. Presence of Low-Cost Carriers and Business vs. Non-Business Flights

Our main argument is that the Internet changed the way airlines compete, from competing on scheduled elapsed flight times to price competition. Another way to examine this argument is to investigate the relationship between Internet access and scheduled elapsed flight time under alternative competitive market conditions. To do so, we exploit two main characteristics of the airline industry: first, we investigate how scheduled elapsed flight times differ between segments in which low-cost carriers operate and those in which such carriers do not operate. Our conjecture is that legacy airlines are more likely to compete on scheduled elapsed time in segments in which low-cost carriers *do not* offer service. This is both because the presence of low-cost carriers already alters the nature of competition towards price competition (Goolsbee and Syverson 2008) and also because low cost carriers, such as Southwest Airlines, the largest and most successful low-cost carrier, historically have not relied on the traditional computer reservation systems to sell tickets. Specifically, we test whether scheduled elapsed times are longer for flights in segments where a low cost-carrier operates, and whether the magnitude of the effect of the Internet on scheduled elapsed flight times is smaller in these segments. To do so, we estimate again the equation above and add a dummy variable for whether a low-cost carrier operates on a given segment and its interaction with Internet penetration.

Second, in a separate specification we distinguish between flights that are more versus less likely to carry business passengers. Our hypothesis is that airlines are particularly interested in attaining short scheduled flight times when they can increase their sales to business passengers. We consider two alternative definitions for business flights. First, we define business flights as flights that depart between 6 a.m. and 9 a.m., and, second, we consider the flights that connect the 30 largest U.S. cities as business flights (Gerardi and Shapiro 2009). We enhance the base specification presented above by adding a dummy variable for morning flights, a dummy variable for segments from or to airports in the 30 largest cities, and their interactions with the variable for Internet penetration. Adding these two dummy variables, along with the set of fixed effects introduced above, implies that we are now exploiting two additional sources of variation: the distinction between 'morning versus non-morning' flights operated by the same carrier on the same day and the same segment, as well as the distinction between flights heading to 'large versus non-large' cities. We conjecture that before the Internet became highly accessible, morning flights heading to larger cities were likely to be shorter than non-morning flights heading to non-large cities, and that this difference declined once more passengers started using the Internet to purchase airline tickets.

C. Including Price as a Control Variable

In additional specifications we also include as a separate control variable the logarithm of each airline's average airfare on a given flight segment in the corresponding quarter. We expect prices to fall as more passengers gain Internet access, and this fall may lead airlines to offer lower product quality, reflected in longer flight times. By including the airfare variable we aim to isolate the two channels through which the Internet may have affected flight time measures: first, by affecting the mode of competition and second by affecting prices and, indirectly, quality. Adding the airfare raises endogeneity issues. Passengers may care about both price and scheduled elapsed flight times, and an airline may jointly determine the price and elapsed flight time. To address this concern, we adopt an instrumental variable approach exploiting the variation in prices offered by the same airline on markets with similar characteristics. Specifically, we use the airline's average segment fare on all other segments of similar length (we divide segments into five quintiles according to length) and the airline's rivals' average fare on the reverse segment. These instruments are similar in spirit to the instruments adopted by Nevo (2001) and other studies that use data from different geographic markets.[8]

D. Using Flight Delays and Actual Flight Times as Dependent Variables

[8] In the regressions in which we study the relationship between the presence of a low-cost-carrier in scheduled elapsed flight times we modified our definition of instruments: when calculating the airline's average segment fare on all other segments of similar length, we distinguish between segments where low-cost carriers are present and segments where low-cost carriers are not present.

Our analysis above focuses on changes in one measure of product quality: scheduled elapsed flight times. The suggested mechanism implies that the shift towards online travel agencies rendered the use of scheduled elapsed flight times less effective as a means to sort flights. The theoretical models on search costs and product quality, however, focus on a different setting and offer mixed predictions as to whether the lower prices induced by lower search costs have a positive or a negative effect on firms' incentive to invest in product quality (e.g. Rogerson 1988; Dranove and Satterthwaite 1992). On the one hand, airlines may not be able to provide the same level of product quality as prices and margins drop. On the other hand, online customers may find it easier to compare product quality, thereby increasing airlines' incentives to invest in product quality. Furthermore, in the context of this paper, airlines may even find it relatively cheaper to reduce arrival delays, because the constraint against padding their scheduled flight times is largely relaxed. To identify which of these effects dominates we analyze arrival delay, actual flight time and departure delay as the dependent variables in a regression framework similar to the one we used to analyze scheduled elapsed flight time. These dependent variables are measured in minutes, where a delay can be negative if a flight arrives or departs before its scheduled time. In these regressions, we also add the following aircraft–flight–level variable: 1) an aircraft's arrival delay (in minutes) on its previous flight; 2) the scheduled buffer time (in minutes) between a given flight's scheduled departure and the scheduled time of its corresponding aircraft's previous arrival; 3) a variable that represents the number of flights a given flight's aircraft has performed on a given day prior to the flight under consideration; 4) an airline's average load factor — i.e., how full that airline's flights are — on a particular flight segment in the corresponding month. In the instrumental variables regressions in which we use the load factor variable, we control for its potential endogeneity by using the average load factor in segments with similar lengths as instruments, like the airfare instruments. Notably, omitting any or all of these additional variables does not qualitatively affect our results.

E. The Shortest Scheduled Elapsed Flight Times

To buttress the interpretation that the growth of online distribution channels has changed the competition mode in the airline industry, we also analyze the relationship between Internet access and the *shortest* scheduled elapsed flight time on a given segment. The effect of the Internet on scheduled flight times is likely to be greater for the flights with the shortest scheduled times, as these short times were presumably set in an effort to be displayed at the top of the travel agents' screens in the pre-Internet era. Figure 3 shows the time course of the ratio between the shortest scheduled time and the average scheduled time across segments with at least five daily flights. The figure illustrates that changes in the scheduled flight times were larger for the flights with the shortest scheduled times.

This suggests that the change in the form of competition was greater for the flights with the shortest scheduled time. To study the effect on the shortest scheduled elapsed time in a regression framework we estimate the following fixed-effects regression:

$$(3)\ Y_{jt} = \beta_I IP_{jt} + \beta_{I-MS} IP_{jt} \cdot HHI_{jt} + \beta_{MS} HHI_{jt} + \beta_C X_{jt}^C + \beta_D X_{jt}^D + \alpha_j + \delta_t + \varepsilon_{jt}$$

In this specification an observation is a directional segment-day pair, and Y_{jt} is an outcome measure of interest. IP_{jt} is the average of the Internet penetration variables across the flights that operate on segment j on a particular day t. Similarly, the demographic variables, X_{jt}^D, are obtained by taking the average of the demographic variables across the carriers that operate on the segment. The congestion measures X_{jt}^C correspond to the number of flights that depart from and arrive at the origin and destination airports. The fixed effects include segment fixed effects, α_j, and day fixed effects, δ_t. The dependent variable is the shortest scheduled elapsed flight time. In this specification we are also interested in comparing the magnitude of the Internet estimates to the magnitude of estimates using the entire set of flights on the segment. To alleviate concerns regarding the effect of entry or exit into segments with few flights or into segments with longer or shorter flight distance, we restrict the analysis to segments in which at least five flights operated on each day included in our sample.

IV. Results

A. Scheduled Flight Time Measures

We report the results using scheduled flight time as the dependent variable in Table 4. The coefficient of the Internet variable in column 1 is 4.2 and is highly significant, suggesting that airlines scheduled longer flights as Internet access among passengers increased. The HHI variable is positive and significant, consistent with our claim that airlines compete using scheduled elapsed flight times. The coefficient on the interaction term between Internet penetration level and HHI is negative and significant, suggesting that most of the effect of Internet penetration on scheduled elapsed time occurs in competitive markets. This finding lends support to our claim that airlines relied less on scheduled elapsed flight times to differentiate themselves as more passengers used the Internet to purchase airline tickets. Adding the fare variable in column 2 is associated with a small decline in the magnitude of the Internet coefficient estimates, although both variables are statistically significant. We obtain similar results when we control for the potential endogeneity of the price variable in column 3. As expected, in all specifications the coefficients that correspond to the number of flights departing from and arriving at the origin and destination airports within the same hour of the respective flight are positive and statistically significant. For example, our results suggest that the addition of 30 flights that depart within the same hour is associated with nearly 2 additional minutes in scheduled time. In columns 4–6 we present the regression results of similar specifications except that we also include the airport/carrier fixed effects. As seen in Table 4, the magnitude of the Internet coefficient decreases by about 20 percent, but it is still positive and significant. The estimate for the coefficient of the HHI slightly increases, and the magnitude of the coefficient of the Internet and HHI interaction term hardly changes.

B. More on Scheduled Flight Time Measures

Low-Cost Carrier Presence.—Table 5 reports estimation results for the analysis that examines the relationship between Internet access and the scheduled duration of legacy carriers' flights when a low-cost carrier either offer or does not offer service on the same segment. The coefficient of the low-cost carrier dummy variable indicates that flights by legacy carries are more than 2 minutes longer in segments in which low-cost carriers operate than in segments in which low-cost carriers do not operate. According to our interpretation, in these markets legacy carriers focus on the price dimension, and hence their scheduled elapsed flight times are relatively longer than in other flight segments. As passengers gained Internet access and price became more important in all markets, the distinction between the two types of markets disappeared. As in Table 4, columns 1-3 and 4-6, respectively, display the results without and with the origin/carrier fixed effects. The results are similar across the alternative specifications.

"Business" and "Non-business" Flights.—Table 6 reports the estimation results that exploit our proxies for business and non-business flights. The regression results confirm our hypothesis that "business" flights are, *ceteris paribus*, shorter than "non-business" flights (the difference is nearly 1 minute), and that the effect of the Internet on scheduled elapsed time is larger for business flights than for non-business flights. These two effects are statistically different.[9]

Changes in the Shortest Scheduled Flying Time.— Table 7 presents the regression results using the shortest scheduled elapsed flight time on a segment on a particular day as the dependent variable.[10] In column 1 we include only the Internet variable and segment fixed effects. The estimate on the Internet coefficient, 7.34, is large and highly significant. In column 2 we add the HHI variable and its

[9] These and other results hold if instead of Thursdays in each quarter in each year in our sample we consider Mondays or Tuesdays. Although the effect we find on the difference between business and non-business flights is not large, we believe that given the expansive set of fixed effects in our regressions, any effect is indicative of the presence of the relationship.

[10] To be consistent with other regression analyses in this study we used the same sample of flights of nine airlines that consistently reported on-time performance statistics in the period 1997-2007 to determine and analyze the fastest flying times. The regression results remain qualitatively the same if instead we use information on scheduled elapsed flight times of all airlines, using the OAG data.

interaction with the Internet variable. The coefficient on the Internet variable increases and, as before, we find that the effect of the Internet is considerably larger for more competitive segments. The magnitude of the Internet coefficient declines when we add day fixed effects and additional controls in columns 3 and 4, but it is still large and significant. The estimates of the HHI coefficient are positive and large, and their magnitudes are three times larger than those of the HHI coefficients shown in Table 4, in which we use the scheduled elapsed flight time as the dependent variable. The magnitudes of the coefficients in Table 7 suggest that when few passengers had Internet access, the shortest scheduled flight time dropped by 2.5 minutes once the market structure changed from a monopoly to an equal-size duopoly. As Internet access became more available to passengers, however, a similar change in market structure resulted in a considerably smaller effect - roughly 0.5 minutes - on the shortest scheduled flying time.

We also performed similar regression analyses for other measures of flight times on a given segment: 25th percentile, median, and 75th percentile flight times. Consistent with our interpretation, the effect of the Internet on these other measures was smaller for the 25th percentile and median flight times and was not significant for the 75th percentile flight times.

C. Results Using Actual Flight Times as Dependent Variables

Arrival Delays.—Table 8 shows estimation results for flight delays, measured as the (positive or negative) difference in minutes between a flight's actual time of arrival and its scheduled time of arrival at its destination. The estimates for the Internet coefficient are positive and significant in all specifications, suggesting that flight delays have increased as more airline passengers have gained access to the Internet. Our interpretation of this result is that flight quality, measured by flight delays, fell as search costs and prices fell. Notably, delays have increased even though airlines have been scheduling longer flight times. The estimates for HHI coefficients are positive but statistically significant only at the 10 percent significance level or below. This suggests that although airlines maintained shorter scheduled elapsed times on more competitive segments they were still able to achieve shorter delays for these flights. The interaction term between the Internet variable and HHI is negative and highly significant. This finding suggests that, as above, quality fell more in more competitive environments. This presumably occurred because airlines in these markets obtained lower margins and hence chose to save on costly resources, which are needed to ensure on-time performance.

Our results imply that an increase of 0.2 in Internet penetration among the passengers on a given flight, which roughly equals one standard deviation for this variable, is associated with an increase of slightly more than 2 minutes in arrival delays. This represents a 24% increase in arrival delay time compared with its average level. For monopolistic segments, an increase of 0.2 in Internet penetration is associated with an increase of 0.8 minutes in arrival delays.

The coefficients on the numbers of operations at the origin and destination airports are positive and statistically significant, as expected. The coefficients for other variables (not reported in Table 8) are consistent with our expectations: a longer arrival delay for the previous flight on the same aircraft is associated with a longer delay for the given flight, while a longer scheduled time between a given flight's departure and the arrival of the previous flight on the same aircraft is associated with a shorter arrival delay for the given flight. Finally, a flight that takes place later in the day (as measured by the Flight in Day variable) is associated with a longer arrival delay. In addition, the load factor variable is positive and significant, confirming our expectation that delays are affected by the number of passengers on each plane. In column 2 we add the logarithm of a given airline's average fare on a given segment in a given quarter. The coefficient on average fare is negative and statistically significant, supporting theoretical models predicting that decreases in search costs lead to decline in quality. The results do not change qualitatively when we account for potential endogeneity of fares in column 3. The coefficient on the Internet penetration variable is still positive and significant. We obtain similar results in columns 4-6 when we include also the airport/carrier fixed effects.

Actual Flight Time and Departure Delay Measures.—Our results suggest that both scheduled elapsed flight times and flight delays increased as more passengers gained Internet access. This implies that actual flight times also increased. We now investigate this directly. In Table 9, we repeat our analysis using the actual flight time as the dependent variable. We compute this measure as the time elapsed between the scheduled flight departure time and the actual arrival time. In these regressions, the coefficient on the Internet penetration variable is statistically significant and, as expected, is larger in magnitude than the corresponding coefficient in the regressions in which arrival delay is the dependent variable. According to the results from column 1, an increase of 0.2 in Internet penetration is associated with an increase in actual flight time of between 1 and 2.8 minutes, depending on the level of competition. Hence, the overall effect of the Internet amounts to between 2.5 and 7 minutes. In addition, the coefficient on the fare variable is negative and significant, which is consistent with our claim that quality diminishes as prices fall. Controlling for the potential endogeneity of the airfare in column 3 does not qualitatively change our results. The coefficient on the HHI variable is positive and significant. This could imply that in competitive segments airlines are able to compensate for short scheduled elapsed flight times. We also explored whether the increased actual time is driven by longer departure delays, measured as the elapsed time between the actual and scheduled departure times. This additional test is important because airlines are likely to have more control over delays occurring on the ground before departure compared to the flight airtime. In regression results (available upon request) we find that departure delays are significantly higher for flights on segments in which larger shares of passengers have Internet access. This difference is greater in competitive markets. Taking into account the total effect of the Internet on flight times and delays, our estimates suggest that in competitive markets the increase in Internet access contributed about 5 to 7 additional minutes in arrival delays and actual flight times, respectively.

D. Robustness

In addition to several robustness checks mentioned above, we performed the following checks on our results. First, we reran our regressions to include all airlines that reported on-time performance statistics to the U.S. Department of Transportation (instead of including only airlines that reported on-time performance throughout the entire period studied), and the results were qualitatively the same. Second, instead of restricting our analysis to the largest 100 airports, we reran our analysis focusing on the largest 50 U.S. airports, and again we obtained qualitatively similar results. Third, we ran the regressions separately for earlier and later time periods. These regressions suggest that most of the effect of the Internet on scheduled elapsed flight times took place between the years 1998 and 2007. Fourth, we verified that our results remained unchanged when we used flights from other days of the week. Fifth, to alleviate concerns that the results are driven by changes in the weights that are part of our measure of Internet access rather than by changes in Internet penetration at the MSA level, we fixed the weights and reran the regressions with a re-calculated measure of Internet access. The results remained qualitatively and quantitatively the same. An additional concern is that the HHI variable could be endogeneous. Therefore, we also ran instrumental variable regressions where we used lagged HHI values on the same segment as instruments. Again, the regression results remained qualitatively the same. Finally, we verified that our results are not sensitive to the exclusion of the late arrival and the scheduled buffer variables. Inclusion of the late arrival variable might lead to serial correlation in our specification. Furthermore, one might be concerned that the scheduled buffer variable is under the control of the airline, and hence is potentially endogenous. Yet, excluding these variables does not qualitatively change our results. Furthermore, we did not find a significant relationship between our Internet access variable and the scheduled buffer variable. Finally, we verified that the significance of coefficients is not affected when we cluster the standard errors at alternative levels, such as at the carrier/day level.

V. Discussion

Following the deregulation of the U.S. airline industry in 1978, airlines began competing on price at the expense of flight quality. More than twenty years later, the U.S. airline industry experienced another dramatic change as passengers began using the Internet to search for and easily compare prices across airlines. In the search for ways to reduce costs and address the lower margins, legacy carriers considered abandoning their traditional business model in which passengers paid more in return for better service. Our findings suggest that airlines' response involved not only price cuts but also reductions in the quality provided to consumers, especially in more competitive environments. Thus, our results suggest that the advent of the Internet, like the 1978 airline deregulation, led to lower prices and at the same time lower flight quality. The magnitudes of effects we find are in line with findings of other studies that examined the relationship between market structure and airline performance. Mayer and Sinai (2003) provide evidence that flights from and to hub airports are 4.5 to 7.2 minutes longer. Forbes and Lederman (2010) show that departure delays are 2.3 minutes shorter on normal-weather days and 5.6 minutes shorter on rainy days for integrated airlines than non-integrated airlines.

One way to interpret these results is that price and scheduled elapsed flight times are substitute product characteristics that consumers base their search upon. In that sense, by replacing flight times with price, we provide evidence that is consistent with traditional theoretical search cost models. A more general view would also recognize that there are potentially important differences between price and quality measures: First, the choice among price and quality as the main criterion for search can have different welfare effects. Second, airlines can (and actually do) use sophisticated pricing techniques to price-discriminate among passengers on the same flight. In contrast, the scheduled elapsed flight time is the same for all passengers on a given flight which makes it harder for airlines to discriminate among customers. We leave these new directions for future research.

VI. Conclusion

Empirical research and competition policy tend to focus almost exclusively on price setting, making relatively little progress studying the effect of competition and information on non-price attributes. In this paper, we address this gap by examining the effect of the Internet on product quality in the airline industry. Our main measure for product quality is scheduled elapsed flight times. Our empirical analysis provides evidence that increased Internet usage led to longer scheduled elapsed flight times. This increase was most pronounced in flight segments in which legacy carriers competed with one another and among the flights with the shortest scheduled times. We argue that these findings can best be explained by a fundamental shift in the mode of competition in the airline industry - from competition on scheduled flight times to competition on prices. We also examine the effect of increased Internet usage on flight delays, the conventional measure of product quality in the airline industry. Our findings suggest that delays increased, despite the increase in airlines' scheduled elapsed flight times. These results support the theoretical models that predict a positive relationship between product quality and search costs.

This paper makes two main contributions to the literature. First, to the best of our knowledge, it is the first paper that examines whether increased access to information has a predominantly positive or negative effect on product quality. Economic theory has long emphasized the importance of information for the efficient functioning of markets. Nevertheless, previous papers have typically explored how access to information affects prices, and generally have not investigated other ways in which firms respond to these changes. Our findings – that the Internet had a negative effect on product quality – provide one such explanation. More generally, our findings that quality fell, together with previous findings that prices have fallen as Internet usage has increased, could suggest that the effect of the Internet on consumers in the airline industry is ambiguous. Explicitly measuring the effect of the Internet on consumer welfare is left for future research.

Second, our paper contributes to the growing literature that investigates the effect of information and communication technologies on productivity and performance. Not surprisingly, the existing literature focuses on the large benefits associated with the adoption of information and communication technologies. Our findings, however, highlight a potentially negative effect of online distribution channels, which have indirectly reduced the incentives of airlines to compete on product quality. The results of this study are also related to other industries. In particular, in the context of online search, being on top of the consumers' search results is considered important for online vendors as it translates into higher revenues. Our paper offers direct evidence on firms' response to changes in the criterion used to rank products.

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TABLE 1—INTERNET PENETRATION ACROSS METROPOLITAN STATISTICAL AREAS (*N*= 243)

Year	Mean	Std. Dev.	Min	Max
1997	0.194	0.074	0.043	0.489
1998	0.411	0.118	0.094	0.723
2000	0.555	0.110	0.207	0.836
2001	0.662	0.102	0.225	0.911
2003	0.698	0.100	0.323	0.923
2007	0.763	0.085	0.415	0.970

Source: Computer Use and Ownership Supplement to the Consumer Population Survey.

TABLE 2—DIFFERENCES ACROSS AIRLINES

	Average Scheduled Flight Time (mins)	Average Arrival Delay (mins)	Average Departure Delay (mins)
Alaska Airlines	137.0	9.8	9.2
America West	138.3	9.8	9.4
American Airlines	162.4	6.4	8.3
Continental Airlines	159.9	11.3	10.7
Delta Airlines	133.1	9.3	9.1
Northwest Airlines	135.6	8.7	8.5
Southwest Airlines	97.4	7.1	10.6
United Airlines	150.5	11.7	12.2
US Airways	116.7	9.9	9.2

Notes: Each cell contains average values over each airline's directional segments in the sample over 24 days in 24 quarters. US Airways merged with America West in 2005.

TABLE 3—DESCRIPTIVE STATISTICS (286,004 OBSERVATIONS)

Variable	Mean	Std. Dev.	Min	Max
INTERNET	0.6	0.2	0.1	0.9
HHI	0.701	0.255	0.164	1.000
SCHEDULED FLIGHT TIME	135.1	71.2	22.0	660.0
ARRIVAL DELAY	9.1	31.3	-65.0	358.0
DEPARTURE DELAY	9.7	28.0	-50.0	360.0
TOTAL ACTUAL TIME	144.2	77.5	3.0	832.0
Additional Control Variables:				
LOAD FACTOR	0.693	0.117	0.075	0.980
AVG. FARE	138.5	69.7	1.9	658.0
NR DEPARTURES PER HOUR, ORIGIN	33.4	24.0	1.0	122.0
NR DEPARTURES PER HOUR, DEST	28.7	22.8	0.0	122.0
NR ARRIVALS PER HOUR, DEST	32.3	24.4	1.0	171.0
NR ARRIVALS PER HOUR, ORIGIN	29.0	22.6	0.0	1.0
Demand Variables:				
LOG (INCOME PER CAPITA)	10.4	0.1	9.9	10.9
LOG (POPULATION)	15.1	0.6	12.7	16.7
EMPLOYMENT, %	0.60	0.03	0.38	0.73
LATE ARRIVAL	5.8	26.0	-65.0	797.0
SCHEDULED BUFFER	100.8	93.7	-397.0	1406.0
FLIGHT IN DAY	3.2	2.0	1.0	14.0

TABLE 4—REGRESSION RESULTS: SCHEDULED FLIGHT TIME

Dependent Variable:	SCHEDULED ELAPSED FLIGHT TIME, mins					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	OLS	OLS	IV
INTERNET	4.209***	3.865***	3.796***	3.297***	3.114**	3.081**
	(1.300)	(1.281)	(1.284)	(1.230)	(1.221)	(1.225)
HHI	1.288***	1.775***	1.805***	1.546***	1.905***	1.905***
	(.491)	(.493)	(.495)	(.483)	(.483)	(.483)
INTERNET * HHI	-3.115***	-3.296***	-3.293***	-3.085***	-3.228***	-3.215***
	(.669)	(.662)	(.663)	(.663)	(.655)	(.656)
NR DEPARTURES ORIGIN AT FLIGHT'S HOUR	.060***	.060***	.060***	.060***	.060***	.060***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
NR DEPARTURES DESTINATION AT FLIGHT'S HOUR	.026***	.026***	.026***	.025***	.025***	.025***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
NR ARRIVALS DESTINATION AT FLIGHT'S HOUR	.029***	.029***	.029***	.030***	.030***	.030***
	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
NR ARRIVALS ORIGIN AT FLIGHT'S HOUR	.003	.004*	.004*	.006***	.007***	.007***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
LOG (AVG. FARE)		-1.705***	-1.837***		-1.358***	-1.389***
		(.263)	(.279)		(.240)	(.256)
Segment Fixed Effects	Y	Y	Y	Y	Y	Y
Aircraft Fixed Effects	Y	Y	Y	Y	Y	Y
Demographic Controls (X^D)	Y	Y	Y	Y	Y	Y
Addl' Congestion Controls (X^C)	Y	Y	Y	Y	Y	Y
Carrier/Day Fixed Effects	Y	Y	Y	Y	Y	Y
Origin/Carrier Fixed Effects	N	N	N	Y	Y	Y
Observations	286,004	286,004	285,509	286,004	286,004	285,509

Notes: Standard errors are in parentheses. Asterisks denote the significance level of coefficients: *** - 1 percent, ** - 5 percent, * - 10 percent. Standard errors are clustered within a segment. Additional control variables are described in the text.

TABLE 5—REGRESSION RESULTS: SEGMENTS WITH AND WITHOUT LCC PRESENCE

Dependent Variable:	SCHEDULED ELAPSED FLIGHT TIME, mins					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	OLS	OLS	IV
INTERNET	4.852***	4.594***	4.551***	4.431***	4.242***	3.957**
	(1.491)	(1.474)	(1.478)	(1.430)	(1.420)	(1.580)
HHI	2.835***	2.963***	2.966***	2.933***	3.051***	3.049***
	(.514)	(.515)	(.516)	(.509)	(.508)	(.510)
INTERNET * HHI	-4.642***	-4.630***	-4.605***	-4.581***	-4.573***	-4.522***
	(.736)	(.729)	(.730)	(.731)	(.723)	(.751)
LCC	2.384***	2.181***	2.143***	2.406***	2.208***	2.181***
	(.340)	(.345)	(.346)	(.337)	(.342)	(.353)
INTERNET * LCC	-3.520***	-3.263***	-3.228***	-3.512***	-3.268***	-3.205***
	(.722)	(.727)	(.728)	(.720)	(.722)	(.799)
INTERNET * HHI * LCC	.060	-.011	.010	.068	.001	-.034
	(1.003)	(1.004)	(1.005)	(1.016)	(1.017)	(1.060)
LOG (AVG. FARE)		-.902***	-1.007***		-.886***	-.891**
		(.269)	(.289)		(.253)	(.284)
Segment Fixed Effects	Y	Y	Y	Y	Y	Y
Aircraft Fixed Effects	Y	Y	Y	Y	Y	Y
Demographic Controls (X^D)	Y	Y	Y	Y	Y	Y
Congestion Controls (X^C)	Y	Y	Y	Y	Y	Y
Carrier/Day Fixed Effects	Y	Y	Y	Y	Y	Y
Origin/Carrier Fixed Effects	N	N	N	Y	Y	Y
Observations	243,113	243,113	242,605	243,113	243,113	242,605

Notes: Sample excludes Southwest Airlines. Standard errors are in parentheses. Asterisks denote the significance level of coefficients: *** - 1 percent, ** - 5 percent, * - 10 percent. Standard errors are clustered within a segment. Additional control variables are described in the text.

TABLE 6—REGRESSION RESULTS: BUSINESS VS. NON-BUSINESS FLIGHTS

Dependent Variable:	SCHEDULED ELAPSED TIME, mins					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	OLS	OLS	IV
INTERNET	3.369***	2.988**	3.129**	2.457**	2.197*	2.364**
	(1.307)	(1.298)	(1.300)	(1.238)	(1.238)	(1.238)
HHI	1.072**	1.178**	1.617***	1.286***	1.257**	1.670***
	(.499)	(.525)	(.505)	(.491)	(.515)	(.493)
INTERNET * HHI	-2.612***	-2.720***	-2.896***	-2.535***	-2.582***	-2.743***
	(.696)	(.697)	(.693)	(.691)	(.688)	(.686)
MORNING	-1.037***	-1.019***	-1.022***	-.802***	-.802***	-.805***
	(.111)	(.111)	(.111)	(.107)	(.106)	(.107)
INTERNET * MORNING	.723***	.714***	.720***	.650***	.647***	.653***
	(.124)	(.124)	(.124)	(.121)	(.122)	(.122)
INTERNET * LARGE	.981***	.735**	.757**	1.021***	.822**	.857**
	(.374)	(.366)	(.367)	(.365)	(.357)	(.359)
INTERNET * LARGE * MORNING	.093	.089	.081	.179	.174	.166
	(.253)	(.253)	(.253)	(.247)	(.247)	(.247)
LOG (AVG. FARE)		-1.690***	-1.742***		-1.373***	-1.322***
		(.263)	(.276)		(.239)	(.252)
Segment Fixed Effects	Y	Y	Y	Y	Y	Y
Aircraft Fixed Effects	Y	Y	Y	Y	Y	Y
Demographic Controls (X^D)	Y	Y	Y	Y	Y	Y
Congestion Controls (X^C)	Y	Y	Y	Y	Y	Y
Carrier/Day Fixed Effects	Y	Y	Y	Y	Y	Y
Origin/Carrier Fixed Effects	N	N	N	Y	Y	Y
Observations	286,004	286,004	285,509	286,004	286,004	285,509

Notes: Standard errors are in parentheses. Asterisks denote the significance level of coefficients: *** - 1 percent, ** - 5 percent, * - 10 percent. Standard errors are clustered within a segment. Additional control variables are described in the text.

TABLE 7—REGRESSION RESULTS: SHORTEST SCHEDULED ELAPSED TIME

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
INTERNET	7.338***	10.730***	3.318***	3.791***
	(.120)	(.397)	(1.012)	(1.020)
HHI		5.170***	5.230***	5.958***
		(.376)	(.372)	(.373)
INTERNET * HHI		-4.098***	-3.928***	-4.079***
		(.491)	(.484)	(.483)
NR DEPARTURES ORIGIN AT FLIGHT'S HOUR				.060***
				(.010)
NR DEPARTURES DESTINATION AT FLIGHT'S HOUR				-.033***
				(.010)
NR ARRIVALS DESTINATION AT FLIGHT'S HOUR				.039***
				(.010)
NR ARRIVALS ORIGIN AT FLIGHT'S HOUR				-.053***
				(.010)
Segment Fixed Effects	Y	Y	Y	Y
Demographic Controls (X^D)	N	N	N	Y
Day Fixed Effects	N	N	Y	Y
Observations	54,228	54,228	54,228	54,228

Notes: Standard errors are in parentheses. Asterisks denote the significance level of coefficients: *** - 1 percent, ** - 5 percent, * - 10 percent. Standard errors are clustered within a segment. Additional control variables are described in the text.

TABLE 8—REGRESSION RESULTS: ARRIVAL DELAYS

Dependent Variable:	ARRIVAL DELAY, mins					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	OLS	OLS	IV
INTERNET	10.372**	9.807**	9.832**	9.674**	9.366**	9.446**
	(4.254)	(4.206)	(4.210)	(4.309)	(4.273)	(4.279)
HHI	1.414	2.228	2.421	1.952	2.644*	2.816*
	(1.585)	(1.605)	(1.613)	(1.587)	(1.605)	(1.613)
INTERNET * HHI	-6.416***	-6.701***	-6.854***	-6.856***	-7.116***	-7.260***
	(2.252)	(2.250)	(2.254)	(2.257)	(2.255)	(2.259)
NR DEPARTURES ORIGIN AT FLIGHT'S HOUR	0.032***	0.032***	0.033***	0.031***	0.031***	0.031***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
NR DEPARTURES DESTINATION AT FLIGHT'S HOUR	0.012**	0.012**	0.012**	0.011**	0.011**	0.011**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
NR ARRIVALS DESTINATION AT FLIGHT'S HOUR	0.019***	0.018***	0.018***	0.021***	0.020***	0.020***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
NR ARRIVALS ORIGIN AT FLIGHT'S HOUR	0.009*	0.010**	0.010**	0.010**	0.011**	0.011**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
LOG (AVG. FARE)		-2.741***	-3.159***		-2.536***	-2.921***
		(0.745)	(0.811)		(0.775)	(0.852)
Segment Fixed Effects	Y	Y	Y	Y	Y	Y
Aircraft Fixed Effects	Y	Y	Y	Y	Y	Y
Demographic Controls (X^D)	Y	Y	Y	Y	Y	Y
Addl' Congestion Controls (X^C)	Y	Y	Y	Y	Y	Y
Carrier/Day Fixed Effects	Y	Y	Y	Y	Y	Y
Origin/Carrier Fixed Effects	N	N	N	Y	Y	Y
Observations	286,004	286,004	285,509	286,004	286,004	285,509

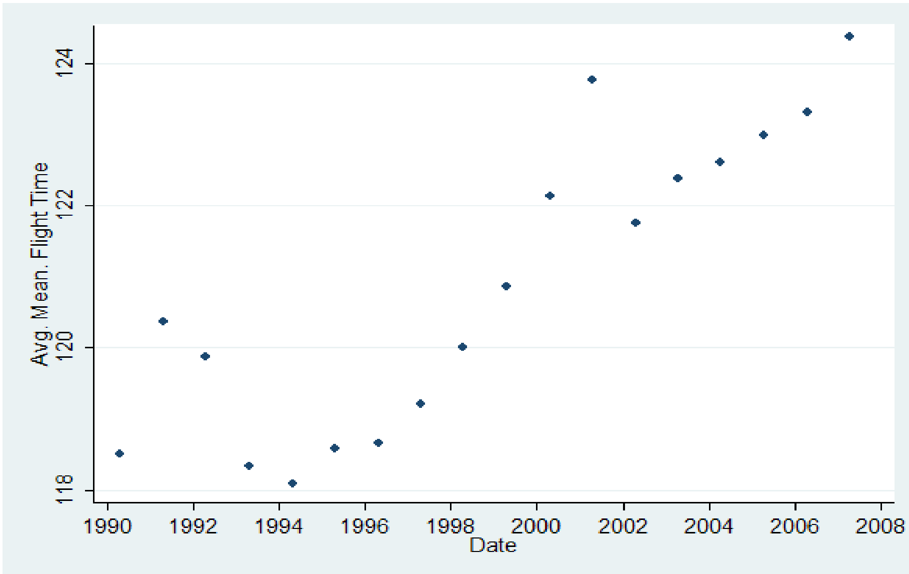
Notes: Standard errors are in parentheses. Asterisks denote the significance level of coefficients: *** - 1 percent, ** - 5 percent, * - 10 percent. Standard errors are clustered within a segment. Additional control variables are described in the text.

TABLE 9—REGRESSION RESULTS: ACTUAL ELAPSED TIME

Dependent Variable:	ACTUAL ELAPSED TIME, mins					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	OLS	OLS	IV
INTERNET	14.546***	13.571***	13.555***	13.027***	12.513***	12.548***
	(4.673)	(4.591)	(4.595)	(4.680)	(4.623)	(4.629)
HHI	2.758	4.163**	4.334**	3.530**	4.682***	4.808***
	(1.722)	(1.739)	(1.749)	(1.710)	(1.719)	(1.726)
INTERNET * HHI	-9.516***	-10.008***	-10.154***	-9.923***	-10.356***	-10.481***
	(2.450)	(2.441)	(2.443)	(2.442)	(2.428)	(2.431)
NR DEPARTURES ORIGIN AT FLIGHT'S HOUR	.092***	.092***	.092***	.090***	.090***	.090***
	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)
NR DEPARTURES DESTINATION AT FLIGHT'S HOUR	.036***	.037***	.036***	.035***	.035***	.035***
	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)
NR ARRIVALS DESTINATION AT FLIGHT'S HOUR	.050***	.049***	.049***	.052***	.051***	.051***
	(.007)	(.007)	(.007)	(.007)	(.007)	(.007)
NR ARRIVALS ORIGIN AT FLIGHT'S HOUR	.012**	.014**	.014**	.016***	.016***	.017***
	(.006)	(.005)	(.006)	(.006)	(.006)	(.006)
LOG (AVG. FARE)		-4.734***	-5.182***		-4.223***	-4.524***
		(.821)	(.894)		(.829)	(.911)
Segment Fixed Effects	Y	Y	Y	Y	Y	Y
Aircraft Fixed Effects	Y	Y	Y	Y	Y	Y
Demographic Controls (X^D)	Y	Y	Y	Y	Y	Y
Addl' Congestion Controls (X^C)	Y	Y	Y	Y	Y	Y
Carrier/Day Fixed Effects	Y	Y	Y	Y	Y	Y
Origin/Carrier Fixed Effects	N	N	N	Y	Y	Y
Observations	286,004	286,004	285,509	286,004	286,004	285,509

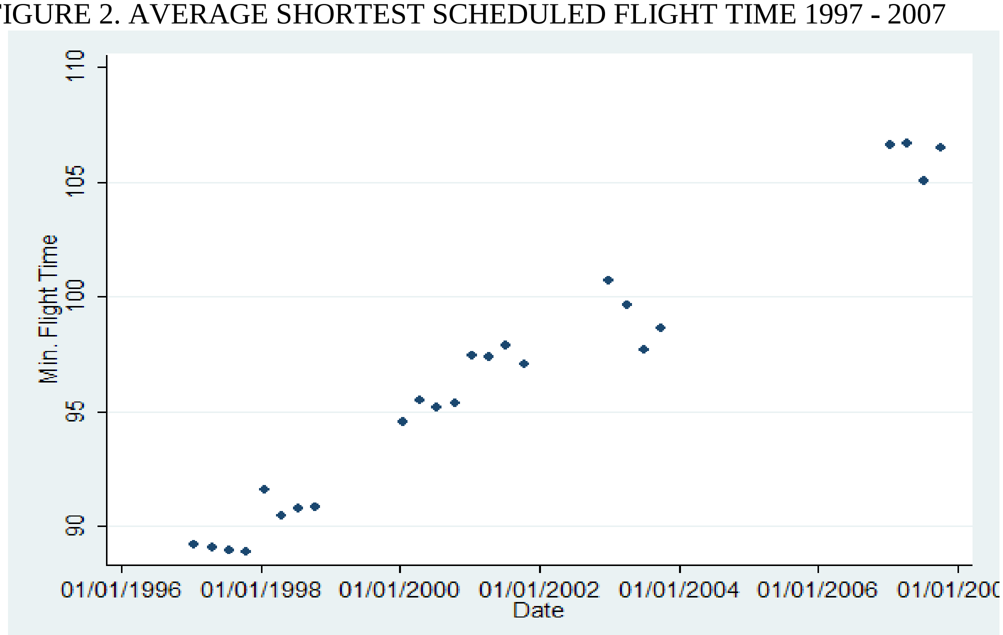
Notes: Standard errors are in parentheses. Asterisks denote the significance level of coefficients: *** - 1 percent, ** - 5 percent, * - 10 percent. Standard errors are clustered within a segment. Additional control variables are described in the text.

FIGURE 1. AVERAGE SCHEDULED FLIGHT TIME 1990 - 2007



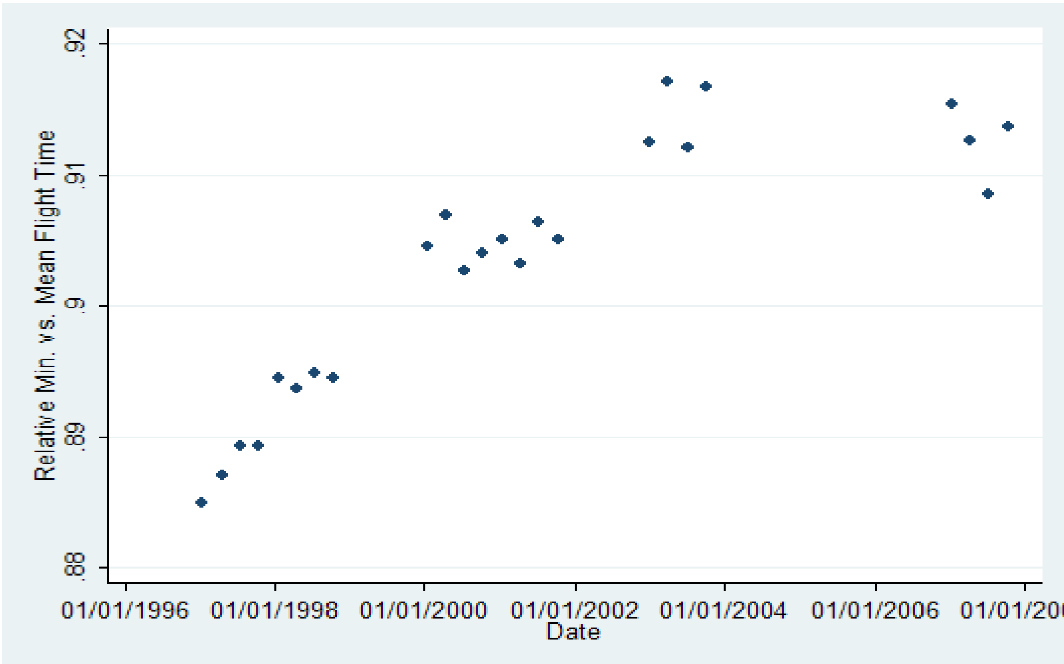
Notes: Average is calculated across directional non-stop segments that had at least five daily flights. Data source: On-Time performance database.

FIGURE 2. AVERAGE SHORTEST SCHEDULED FLIGHT TIME 1997 - 2007



Notes: Average is calculated across directional non-stop segments. Data source: OAG

FIGURE 3. RELATIVE CHANGE IN SHORTEST VS. MEAN SCHEDULED FLYING TIME



Notes: The figure shows the ratio between the shortest and average scheduled flight times. The sample includes directional non-stop segments that had at least five daily flights. The calculation of the average flight time excludes flights with the fastest scheduled times. Data source: OAG database.