ECONOMIC ANALYSIS GROUP

DISCUSSION PAPER

Do Low-Quality Products Affect High-Quality Entry? Multiproduct Firms and Nonstop Entry in Airline Markets

by

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Abstract

This paper studies the effect of product ownership and quality on nonstop entry in the airline industry. Specifically, this paper empirically examines the decision of an airline to offer high quality nonstop service between cities given that the airline may or may not be offering lower quality one-stop service. I find that airlines that offer one-stop service through a hub are less likely to enter that same market with nonstop service than those that do not. In addition, the quality of the one-stop service is an important determinant of entry. Airlines are more likely to enter a market with nonstop service if their own or their rival's one-stop service in the market are of lower quality. Estimates suggest that the entry of a rival nonstop carrier diminishes the probability a carrier enters the market with nonstop service. However, airlines offering one-stop service respond differently to nonstop rivals. In particular, relative to other carriers, those offering one-stop service are more likely to enter markets if there are nonstop rivals, suggesting that cannibalization effects are diminished in the presence of nonstop competition.

1 Introduction

From breakfast cereals to computers to airline flights there are many differentiated product industries in which firms offer multiple products in the same market. However, there are relatively few empirical papers that examine the entry decision of multiproduct firms. This paper studies the effect of product ownership and quality on the decision to enter a market in the airline industry. The market considered in this paper is transportation services between two cities. I consider two types of services in the city pair market: nonstop service and one-stop service that stops in a hub before reaching the destination city. This paper empirically examines the decision of an airline to offer high quality nonstop service between cities given that the airline may be offering lower quality one-stop service in that market.

In this paper I consider nonstop and one-stop flights to be vertically differentiated services. The nonstop service is a higher quality than the one-stop service in terms of travel time. Several demand studies show that consumers prefer more direct flights.[2] One-stop services also vary in quality. I proxy for the relative quality of the one-stop service using a measure of the directness of the one-stop flight.

I will use a simple example and the diagram below to illustrate the type of strategic situation analyzed in this paper.

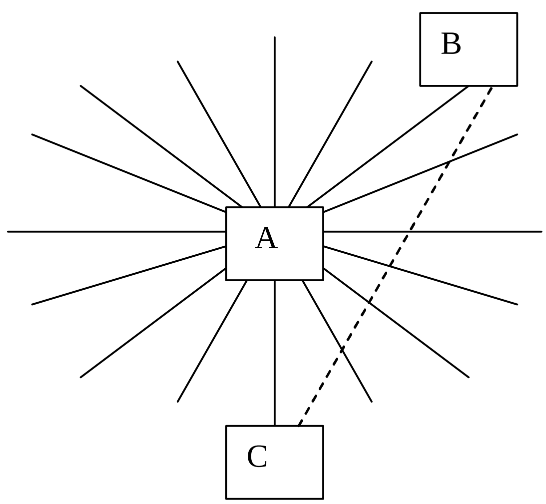

Figure 1: Hub Competition

[2]For example, the demand study by Berry et al (1997) finds that passengers prefer direct flights relative to indirect flights. Direct flight includes all nonstop flights and flights in which there is a stop but passengers do not change planes. An indirect flight is a flight in which a passenger changes planes. Borenstein (1989) finds that each on-plane stop implies a discount of 3 percent to 13 percent in price and 3 to 8 percent discount for each plane change made.

Suppose we have just two airlines, X and Y. Suppose that airline X is a hub carrier that has a hub at A and offers one-stop service in the B to C market through the hub. Airline Y does not have a hub and does not have any existing service in the market. The entry game considered in this paper is the decision of airline X and airline Y to enter the B to C market with nonstop service. I view the one-stop service as affecting nonstop entry through both cannibalization and business stealing effects. The business stealing effect is the effect that competing rival one-stop service has on the profits of the entering nonstop service. On the other hand, for airlines that own one-stop services, offering nonstop service cannibalizes demand for their existing one-stop service. Relative to airlines that have no services in the market, airlines that offer one-stop service have lower incremental profits from offering nonstop service. In the above example, airline Y considers the business stealing effect from competing with the one-stop service in the market. Airline X considers cannibalization of its own one-stop service that acts as a disincentive for entering the market. One might expect that both cannibalization and business stealing effects increase as the quality of the one-stop service in the market increases. The model in this paper also considers competition between nonstop services. One might expect profits to decrease when rival airlines enter the market with competing nonstop services. Finally, if airline$Y$ enters the market, this may reduce profits on airline X's one-stop service. If the profitability of the one-stop service is reduced then this also reduces the cannibalization effect for airline X, which may increase the likelihood that it enters with nonstop service.

This paper models nonstop entry of airlines as a noncooperative entry game, which allows for an economic interpretation of the estimated coefficients. The basic empirical approach of this paper is similar to Berry (1992) and uses a simulation estimator to recover the reduced-form incremental profit from offering nonstop service. The model differs from previous work in airline entry in two important ways. First, I focus on the nonstop entry decision while most other research aggregates across one-stop and nonstop entry. This may be important since Reiss and Spiller (1989) find that the type of services in airline markets (i.e. number of firms offering direct flights or indirect flights) is an important determinant of the level of competition in the market, not just the number of airlines in the market. They argue that aggregating across service segments may lead to incorrect inference about the profitability from entering a market. A second important difference from previous empirical work is that I allow the ownership of one-stop service through a hub to affect the incremental profitability of nonstop entry.

Examining the multiproduct entry decision in airline markets became more relevant as many major network carriers began operating low-cost divisions in the 1990s.[3] The low-cost divisions of major carriers operating during the period of my sample include Metrojet (US Airways), Delta Express, Continental Express and United Shuttle. The low-cost divisions were started in an attempt by major carriers to cut costs and compete with Southwest and other low-cost carriers. This strategy has been called the "airline-wihin-an-airline" strategy because the operations of the low-cost divisions differ from those of the rest of the airline. The low-cost divisions cut back on passenger amenities and shifted emphasis from hub-and-spoke to point-to-point route strategies. In many cases this involved carriers expanding nonstop service to markets outside of their hubs. It is often the case that major

[3]The major network carriers in my sample are American Airlines, Continental, Delta, United Airlines, US Airways, Northwest Airlines and TWA. I refer to these carriers as major "network" carriers to differentiate them from Southwest which is one of the larger carriers, but operates more like a low-cost carrier.

network carriers offer nonstop service in markets in which it also operates one-stop service through a hub. Some examples of new entry of this type in 2000 include: the Boston to Myrtle Beach market where Delta offered both a nonstop flight and a one-stop flight through Atlanta; the Las Vegas to Tulsa market where Delta offered both nonstop service and one-stop service through Salt Lake City; and the Boston to Raleigh market where US Airways offered a nonstop flight and a one-stop flight through Charlotte.

The issues raised in some informal complaints presented to the Department of Transportation (DOT) suggest that this paper may be of interest to policy makers.[4] Several low-cost carriers presented complaints to the DOT because major network carriers began offering competing nonstop service in markets that are also served with one-stop service through a hub. A primary reason for these complaints was that it is relatively unusual for major network carriers to enter these types of markets. In 1995 ValuJet complained when US Airways began offering competing nonstop service from Dulles to Boston and Dulles to Hartford. ValuJet argued that US Airways, in the prior 10 years, had not operated any service through Dulles that was not a major hub and that entry by US Air was anticompetitive. In 1996 Air South complained that Continental had attempted to overlay its new service in three markets: Charleston-Newark, Columbia-Newark, and Myrtle Beach-Newark. The DOT suggests that these types of strategic entry decisions are difficult to explain as nonpredatory. This paper provides some insight into the types of markets that an airline may choose to offer both one-stop and nonstop flights and why both these services may be offered.

As theory would suggest I find evidence that both cannibalization and business stealing are important in shaping nonstop entry of airlines. I also find that the quality of the one-stop services in the market determines the size of the cannibalization and business stealing effects. The amount of competition in a market increases with the number of nonstop rivals. However, a nonstop rival may have a second effect on firms that have an existing one-stop product in the market because nonstop entry reduces profits on the existing one-stop flights, which, in turn, reduces the cannibalization effect. This suggests that nonstop rivals may have less of an impact on carriers with an existing one-stop service in the market relative to carriers without one-stop service. These findings suggest that in certain circumstances nonstop entry decisions by hub carriers that might appear to be predatory, may in fact be consistent with competitors attempting to match the quality of rivals.[5]

The structure of this paper is as follows: Section 2 discusses some of the related literature in airline entry, Section 3 examines the development and structure of airline networks, Section 4 explains the data and variables used in the analysis, Section 5 describes the econometric model, Section 6 discusses the estimates and predictions of the model, and the final section concludes.

[4] The complaints to the DOT were discussed in chapter 2 of a report entitled *Entry and Competition in the U.S. Airline Industry: Issues and Opportunities* (1999) (http://books.nap.edu/html/airline_dereg/pdf/)

[5] This result is consitent with Mazzeo (2003) that shows that additional competition on a route typically leads to improved quality of service as measured by on-time performance.

2 Literature Review

There are many studies that look at entry in the airline industry, but few of them incorporate a structural model of competition. Since many studies have found that competition is an important determinant of entry in airline markets, a structural model of entry should do a better job of predicting the behavior of airlines than a more naive model. In this section I review some structural airline entry papers including Reiss and Spiller (1989), Berry (1992), and Ciliberto and Tamer (2004).[6]

Reiss and Spiller (1989) model the competition between differentiated direct and indirect services. Note that direct service includes all nonstop flights and also includes all flights in which there is no change of planes. Indirect service means a passenger changes planes. They incorporate both entry and price competition in a structural model and examine how direct entry affects price competition in the indirect and direct service market. They find that the indirect service category is significantly more competitive if a direct competitor is also in the market. They also find that within a route there can be large differences in direct and indirect competition. This last point suggests that different service types should not be aggregated, adding support to the approach taken in this paper. There are two key differences between Reiss and Spiller's work and this paper. First, the Reiss and Spiller paper only examines markets with one or fewer direct entrants, while my paper considers markets in which there may be several airlines offering nonstop flights. Second, Reiss and Spiller (1989) assume carriers do not own both a direct and indirect flight in the same market, while this paper is explicitly interested in service ownership.

Berry (1992) examines the role of market presence in both endpoint airports and its effect on entry. He aggregates across service types when defining entry, and allows for multiple entrants. He assumes that entry affects the profitability of all airlines symmetrically. This assumption implies that whether Southwest or American Airlines enters a market they have the same effect on the profitability of other airlines in the market such as Delta or Continental. However, Berry's model allows airlines to have both observed and unobserved heterogeneity in fixed costs. He finds that the heterogeneity in airline presence at both endpoint airports is an important determinant of entry. Berry also finds that his structural model of airline competition produces more realistic predictions of airline entry behavior than more simple entry models.

Cilberto and Tamer (2006) relax the assumption that entry affects the profitability of competing airlines symmetrically. Allowing asymmetric competitive effects between airlines makes the model sufficiently flexible to allow for Southwest to compete differently with American than with Delta. In fact, their model allows for a very general profit function specification so that different carriers may have entirely different profit functions. They find that there is significant heterogeneity in competition between airlines.

Although Ciliberto and Tamer capture an important aspect of airline heterogeneity, similar to Berry they also aggregate across nonstop and one-stop service types. Because they aggregate across service types it is difficult

[6] Another important structural model of airline entry is by Armantier and Richard (2003). They focus on the duopoly competition between American Airlines and United Airlines at the Chicago hub. Armantier and Richard examine both the entry and quantity choices of these airlines under the assumption of incomplete information, while my paper and the papers reviewed here assume that airlines play a complete information entry game.

to determine whether the asymmetry in competition in their model arises because of the different service types being offered by different airlines (i.e. nonstop or one-stop), or if airlines actually price compete differently with each other. One might expect that large network carriers like Delta and American that enter many markets with one-stop service have less of an impact on the profits of carriers like Southwest that enter many markets with nonstop service. In fact, this is what their results tend to suggest. They find that American and Delta have limited effects on the profits of other carriers relative to Southwest. While several papers have shown that Southwest has large competitive effects on rival carriers, the Ciliberto and Tamer model is unable to decompose the impact on competitor profitability due to Southwest rivalry and the type of service chosen by Southwest.[7] In my paper, I assume that there is symmetry in nonstop competition, but allow for asymmetry in competition between the types of services offered. That is, in this paper the defining characteristic of a carrier on a route is its network, not the brand of the carrier.

The current entry paper is also related to the entry model of Mazzeo (2002). Mazzeo examines a game of product differentiation and entry in motel markets. His model extends previous entry models by endogenizing product-type decisions (e.g. low-quality motel or high-quality motel). He then measures the effects of competition between the different product types. My paper also allows for different product-types to affect nonstop entry. However, I treat one product type as fixed, the one-stop service, and I examine the entry decision of offering nonstop service. One advantage of treating one-stop service as fixed is that I can examine continuous measures of product quality in the one-stop service affecting nonstop entry, while Mazzeo's model captures discrete differences in product quality. Justification for treating one-stop service through a hub as fixed is given in the next section of the paper.

3 Hub-and-spoke System and Airline Networks

Before discussing the econometric model, it is important to have some understanding of the structure of airline networks. After deregulation of airlines in 1978, airlines quickly shifted to a hub-and-spoke system which remains the predominant structure in the industry today.[8] A hub-and-spoke system brings passengers from "spoke" cities into a "hub" city where passengers transfer planes and fly to destination "spoke" cities. There are both efficiency and strategic advantages for operating hub-and-spoke networks.

The efficiency of the hub-and-spoke system has been thoroughly studied both empirically and theoretically. The hub-and-spoke system creates high density along spoke routes, which leads to lower costs per passenger. By channelling passengers into a hub, the network is able to generate greater density along all the spokes of the hub. Therefore, hubs allow for more efficient use of facilities and aircraft. Empirical studies by Caves et al (1984) and later Brueckner and Spiller (1994) estimate significant cost savings from economies of density, which suggest that this is a key factor motivating the restructuring of the industry following deregulation. Brueckner et al (1992) examine the structure of the hub network directly and show that there is a relationship between higher traffic

[7] Both Morrison (2001) and Goolsbee and Syverson (2004) show the impact of Southwest entry on fares set by rival airlines.

[8] See Graham Kaplan and Sibley (1983) for a description of key changes after regulation.

density across the network and lower fares. Hendricks et al (1995) provide a formal theoretical model to explain economies of spoke density, and how hub-and-spoke networks arise from basic assumptions about cost savings from economies of density.

Other reasons airlines form hub-and-spoke networks involve strategic advantages. Hendricks et al (1997) explain why it is generally a dominant strategy for hub airlines not to exit a hub-spoke market. They argue that the hub-spoke market produces complementarities in flights that connect in the hub. A monopoly hub that faces competition from a regional carrier along a spoke can credibly remain in the market under price competition because exiting a spoke causes losses in its complementary markets. This credible threat keeps potential entrants out of spoke markets. A hub carrier offering frequent flyer miles also has a strategic advantage. Passengers that use frequent flyer miles value the hub carrier's frequent flyer miles more than other carriers because the hub serves a greater variety of destinations.[9] Hence, passengers that use frequent flyer plans may be more likely to choose the hub carrier. In the remainder of this paper I refer to the combined efficiency and strategic effects of airline networks as network effects.

If the network effects are sufficiently large, then after a hub-and-spoke network is formed, hub carriers will not find it profitable exit spoke routes. Therefore, nonstop routes out of a hub are essentially fixed. A fixed hub network implies that one-stop routes made through the hub are also fixed because passengers can typically connect in a hub. An example using the figure 1 from the introduction helps to illustrate this point. Suppose there are 17 cities and 16 spoke routes connected directly through hub city A. Assume that all connecting flights through A are offered. Now consider the marginal decision to offer nonstop service between two spoke cities B and C as shown by a dotted line in the above figure. The decision to serve the market between B and C with nonstop service is exogenous to the decision to serve the market B to C through the hub if the entry decision in the A to C and A to B markets is unaffected. Because A is a hub exiting a spoke market A to C or A to B implies exiting 15 connecting markets. The same factors that make it unlikely for a carrier to exit a spoke route of a hub also have implications for hub carriers entering spoke routes. The entry decision of a hub carrier will be less affected by competitive factors on a particular route and will primarily be determined as a joint decision to serve the spoke market and many other markets through its hub.

To see that large hub-spoke networks are relatively fixed, I examine the entry and exit rates between all city pairs in a sample of the 50 largest cities. Table 1 in the appendix shows the number of nonstop entry and exits from the second quarter of 1996 to the second quarter of 2000. I find that entry and exit rates are much lower for hub carriers in their hub-and-spoke markets relative to entry and exit rates in markets where no carrier operates a hub.[10] From 1996 to 2000 the hub carriers at their hub had an exit rate of 1.33 percent in their spoke markets, compared to an exit rate of 19.45 percent in nonhub markets in which no carrier operates a hub. The entry rate in hub markets is also much lower for hub carriers at their hub relative to entry rates in non-hub markets. The entry and exit rates provide strong evidence in support of treating hub markets as fixed.

[9] See Borenstein (1989) for a discussion of frequent flyer marketing strategy and empirical work supporting this strategy.

[10] Exit (Entry) rates are computed as the fraction of carriers observed Entering (Exiting) from 1996 to 2000 out of the total number of nonstop flights offered in 1996.

4 Data

The primary data source used are the second quarter data from 2000 of the Official Airline Guide (OAG). The OAG data are a weekly schedule of all nonstop flights operated by domestic and international carriers. Each observation in the database represents a particular flight by a carrier in a quarter and includes information on the identities of the carrier, the origin and destination airports and the days of the week in which the flight operates. The OAG data are used to determine which carriers offer nonstop service.

A secondary source is from the U.S. Department of Transportation's "Origin and Destination" survey. The Origin and Destination survey is a 10 percent random sample of all flight coupons by domestic carriers in the US. The version of the data used are the second quarter data from 2000 from the Data Bank 1A (DB1A). The DB1A data contains a list of fares and the number of passengers traveling in each direction on a route. Route information includes the origin and destination airports, the stops where passengers changed planes, and whether the trip was one-way or round-trip. It also includes the great circle distance of each route. To supplement the information from the above data sets I use 1999 MSA population estimates taken from the U.S. Census Bureau.

I consider a carrier to be offering nonstop service between two cities if they provide 52 or more nonstop flights a quarter (approx 4 a week). To check the accuracy of the OAG data, I also require that I observe at least 500 passengers (50 passengers in the 10 percent sample) flying directly between the origin and destination cities in the DB1A sample.

Using the DB1A data I chose the top 188 cities with the largest number of passenger enplanements in the second quarter of 2000.[11] I then construct a data set that includes all nonstop travel between 188 cities in the second quarter of 2000. I define a city as the MSA. Included in this sample are cities with multiple airports. For example, I count entry in the Portland to Oakland market as entry in the Portland to San Francisco Area market. There is clearly a trade-off between selecting a city pair as the relevant market rather than an airport pair. An argument for using airport pair markets is that business travelers often have a strong preference for flying out of major airports. This is the view taken in Ciliberto and Tamer (2006). However, by looking at the city pair market my estimates capture an important aspect of competition between major network carriers and low-cost carriers operating in secondary airports in the same city. For instance, Southwest operates out of Oakland in the San Fransisco bay area and competes with United Airlines that operates out of the San Fransisco Airport. Both Reiss and Spiller (1989) and Berry (1992) view airline markets as city pairs.

I define an airline as having a hub in a city if the features of the airline network in that city satisfy two selection rules. First, using DB1A data, I select cities in which a single carrier transports more than 300,000 passengers that make a single connection through the hub to one of the 188 selected cities mentioned above. The first rule eliminates all but 20 possible hubs. The second rule requires that 30 or more nonstop routes are offered out of the hub. Applying the second rule leaves 18 selected hubs. These 18 hubs account for 81.4 percent of all one-stop

[11] The188 cities include 200 airports. This number of cities was chosen because it was sufficient to capture a vast majority of domestic passenger travel.

traffic.[12]

To show that these selected hubs vary significantly from other airport operations, I contrast characteristics of the selected hubs with the next 18 potential hubs with the highest number of stopping passengers. See table 8 for detailed list of the selected hubs and the next 18 potential hubs. Table 8 contains detailed information about the operations at each hub and is sorted by the number of stopping passengers. The next 18 potential hubs account for only 12.5 percent of all one-stop traffic. The selected hubs differ from the next 18 is in the percent of the passengers using the hub that are changing planes. I compare the average percent of passengers that change planes in the 18 selected hubs with the next 18 potential hubs. The average airport in one of the selected hubs has 44.14 percent of passengers changing planes, while the average airport in the next 18 potential hubs has only 14.6 percent of passengers changing planes. The types of carriers operating in the next 18 potential hubs are also distinct from those in the 18 selected hubs. Nine of the next 18 hubs are operated by Southwest, and four others are operated by other low-cost carriers. The other carriers in the group of the next 18 include United Airlines at San Francisco, Continental at New York , United Airlines at Los Angeles, and United Airlines at Washington DC.

The next step in constructing the data is defining one-stop service through a hub. The networks of large airlines allow them to serve the same route in a number of different ways. For purposes of this paper, I am interested in the one-stop route that is the closest substitute with nonstop service. Therefore, I select the most direct route passing through a major hub. By a "most direct" route, I mean the total distance of the trip is the shortest. I use the nonstop entry information out of hubs and the location of the hubs to select the most direct one-stop flight through the network. To illustrate this construction, consider Continental Airline's Austin to New York market. The data shows nonstop service from Continental's hub in Houston to both Austin and New York. Next, I examine whether this is the most direct one-stop flight that Continental offers. I find that although they have a hub in Cleveland, the one-stop flight through Houston is a more direct route. Hence, I assume that the relevant service is the one-stop service being offered is through Houston.[13]

In defining one-stop service I exclude very low quality one-stop services offered through hubs. I determine criteria for what one-stop service may be considered "low-quality" by looking at the directness of one-stop flights that passengers usually fly as observed in the DB1A data. Typically, I did not observe one-stop passengers on routes in which the distance is more than twice the distance as the crow flies between two cities. I do not consider an airline as offering one-stop service if the distance along the two segments of the one-stop service is more than twice the distance between the city pairs.

In selecting the subsample of city pair markets, I begin by following Berry (1992) by choosing all city pair

[12] I calculate this statistic as (total number of indirect passengers changing plans at the airport)/(tot passengers changing planes at the airport+total passengers originating from the airport+total passengers destined for the airport)

[13] I checked this example on Expedia on March 3, 2005, and found that Continental offered both nonstop and one-stop service between Austin and New York where the one-stop service is offered through Houston. In constructing the one-stop routes, I do not use information on where passengers are observed traveling. The problem with using the observed routes taken by passengers is that it is endogenous because it depends on the quality of the other services in the market and the pricing decision after entry.

combinations between the 50 most populated cities. The most populated cities are used because these are also cities that are more likely to have nonstop entry. An additional reason for using the 50 most populated cities is that the assumption of hub networks being fixed is more plausible in larger markets where the number of passengers in the network would diminish by a greater amount if the spoke route is exited. Recall that the descriptive statistics regarding entry and exit at hubs were based on the 50 largest cities. Next, I eliminate city pair markets based on two selection rules. First, markets in which any carrier operates a major hub are eliminated. As argued before, because of the strong complementarities in hub markets, I treat nonstop entry out of hubs as fixed. Modeling this entry decision while treating it as fixed in other markets would be logically inconsistent. The second type of market that is eliminated are city pair markets for which the distance between the cities is less than 300 miles. These markets are eliminated because I want to focus on markets where nonstop and one-stop services are likely to compete. In short distance routes the closest substitute to nonstop entry may be car travel and not a one-stop flight. After applying these selection rules I am left with 511 city pair markets.

4.1 Variables

The variables used in this paper include market variables and airline specific variables. The market variables include both population and distance variables. The population variable is constructed from the 1999 U.S. Census Data measured as the geometric mean of the population in the two cities in millions.[14] The distance variable is the great circle distance between the two cities in hundreds of miles.[15]

The airline specific variables capture the network effects of an airline and the characteristics of the one-stop services in the market. Although the larger hubs are removed from the sample, the network effects that are present in the remaining cities are still important determinants of entry. For example, Southwest has no major hubs, but it has a significant presence in a number of cities. To capture network effects I use the variable $NetworkEffect$ which is the number of markets entered nonstop out of the two endpoint cities to the 188 cities in the large sample, but excluding the nonstop route on the city being considered. For example, consider the entry decision between city A and city B. Consider calculating the network variable for airline X. Excluding the A to B entry decision, if airline X has 4 nonstop routes out of city A and 5 nonstop routes out of B then the $NetworkEffect$ variable is $4 + 5 = 9$.

The variable $One - stop$ is a dummy variable which is one if an airline offers a one-stop service through a hub and is equal to zero otherwise. This variable captures the cannibalization of an airlines existing service. The effect of this variable on the non-stop entry of an airline is expected to be negative. The variable $OneOthStop$ equals one if there is another airline in the market offering one-stop service. The variable $NumOthStop$ equals the number of additional rival airlines offering one-stop service in the market.

I measure quality of the one-stop service as the total distance flown on the one-stop flight minus the distance

[14] In the A to B city pair market the population variable is $Pop = \sqrt{(PopulationinCityA/1million) * (PopulationinCityB/1million)}$. A similar measure is used by Berry (1992)

[15] In the case where there are multiple airports in a city, I take the average distance between airports in the city.

as the crow flies between two cities. For instance, the quality of the one-stop flight in the Austin to Portland market with a stop in Houston may be calculated taking the following steps: calculate the distance from Austin to Houston, add the distance from Houston to Portland, and then subtract the distance crow flying distance between Portland and Austin. I call this variable *CircDist*.[16] A similar measure is used by Reiss and Spiller (1989) and Borenstein (1989).[17] As this variable increases the quality of the one-stop service is lower. The variable *OwnCircDist* is the *CircDist* variable of an airline's own one-stop service in the market. If an airline does not have a one-stop product in the market then *OwnCircDist* equals zero. The variable *RivalCircDist* is the quality of the highest quality rival airline in the market. If no airline is in the market then *RivalCircDist* equals zero.

The model in this paper estimates a game of competition between entrants. I consider an airline as a potential entrant in this model if the airline has some presence in both cities of the city pair market in the second quarter of 2000.[18] This definition may be justified if one views nonstop entry as actually occurring in two stages: first airlines decide which cities they will enter, and second they decide which routes will be entered nonstop out of the city. The game analyzed in this paper takes the first stage of entry in a city as given and then analyzes the decision to enter nonstop in a particular city pair market. The reasons for using this definition of entry is that it focuses the entry game on the most likely set of entrants. This definition of a potential entrant differs from that used in Berry (1992) which defines an airline as a potential entrant if they have some presence at either endpoint city. I find that the definition used by Berry includes many firms as potential entrants that are not likely to enter a market.

4.2 Descriptive Statistics

Before describing the full empirical model, I examine some descriptive tables that provide some insights into the determinants of nonstop entry. Table 2 tabulates descriptive statistics by the number of airlines offering nonstop service. The first column lists the number of nonstop entrants and the second column shows the frequency in which that number of nonstop entrants are observed in the data. The frequencies show that in most of the markets in the sample there is no airline offering nonstop service. The third through sixth columns show the mean of the population variables, distance, number of one-stop services and the most direct one-stop service in the market. I find that distance is typically greater in markets in which no carrier offers nonstop service. This may reflect the success of low-cost carriers in entering short distance nonstop routes. The table also shows that nonstop services increase with population. In a markets with fewer nonstop services offered the highest quality one-stop service is greater.

[16] It should also be noted that *CircDist* relates to the cost of providing one-stop service. The greater the *CircDist* variable, the creater the cost of providing transportation services through a hub.

[17] One could argue that a more accurate measure of quality may be total time of a flight or some on-time performance measure at a hub. Although these measures may be a more accurate reflection of consumer preferences, it is not clear that these measure of quality are exogenous to competition. Mazzeo (2003) finds that the on-time performance of a carrier improves with increased competition in the market suggesting that on-time performance may be chosen by carriers.

[18] By "presence" I mean that there is are some passengers observed flying in or out of the city.

Table 3 shows the number of markets entered by each airline and the average value of $NetworkEffect$ for each airline. There are two points to note in this table. First, Southwest enters more markets than any other airline in the sample. This is not surprising given Southwest's strategy of avoiding direct competition with major hubs and their focus on entering markets with nonstop service. Second, there appears to be a strong association between the network effect variable and the number of markets a carrier enters with nonstop service, suggesting that this is likely to be an important explanatory variable. For instance, Southwest that has entered the greatest number of markets in the sample, also has the highest average for the $NetworkEffect$ variable.

Table 4 shows some basic statistics of the $CircDist$ quality measure including the mean, standard deviaion, minimum and maximum. These basic statistics provided in order of their quality ranking in the market, from highest quality (least circuitus) to lowest quality (most circuitus). Note that the average circular distance of the most direct one-stop flight in the market is about 25 miles. This distance reflects the strategic placement of hubs in central locations in the country, and centrally located hubs can offer more direct service to more destinations. This suggests that for most cities there is a major hub that offers fairly direct service. The average $CircDist$ for the second highest quality firm is more than three times greater than the highest quality. The average circular distance variable across all markets and all airlines is 2 (i.e. 200 additional miles are flown).

5 Econometric Model of Entry

I model airlines as playing a complete information entry game. At the beginning of the game, each potential entrant knows its own and its rivals' post-entry incremental profits. Incremental profits for offering nonstop service depend on existing one-stop services in the market through a hub, network features in the city pair, observed and unobserved demand and cost factors, and the number of rivals entering with nonstop service. Given this information, airlines enter the market with nonstop service if their incremental profits are positive, otherwise they do not. I will begin by describing an econometric entry model that is similar to the model presented in Berry (1992).[19]

I assume the following functional form for the reduced-form incremental profit function for offering nonstop service:

$$\pi^*_{ik}(N_i) = x_i^{Market}\beta_{Market} + x_{ik}^{Network}\beta_{Network} + x_{ik}^{OneStop}\beta_{OS} - \delta N_i + \sigma\epsilon_i + \sqrt{1-\sigma^2}\epsilon_{ik} \quad (1)$$

The variables $x_{ik}^{Network}$ capture the network effects of firm k in market i. The variables x_i are market specific variables capturing observed market specific demand and cost factors. The variables $x_{ik}^{OneStop}$ capture the influence of airline k's own one-stop service and the one-stop services of its rivals. I also allow for both market and firm specific unobserved profits ϵ_i and ϵ_{ik}. The parameters to be estimated are $\beta_{Market}, \beta_{Network}, \beta_{OneStop}$ and σ.

[19] The static results provide an estimate of the expected future profitability of the airline for being in the market. This static expected profitability may be different from the actual profitability. For instance, in the observed sample a firms profits may actually be negative, but the airline expects future profitability may be positive.

The variable N_i is the number of airlines that enter in the city pair market, which is the dependent variable in the above model. I assume that additional entry causes profit loss to other airlines in the market so $\delta \geq 0$.

The number of airlines that enter in a pure strategy Nash equilibrium equals the maximum number of airlines that can profitably enter a market. Formally, the equilibrium number of airlines that enter in market i is:

$$N_i^* = \max_{0 \leq n \leq K_i} \{n : \pi_{ik}^*(n) > 0\} \tag{2}$$

where K_i is the number of potential entrants in market i. The number of airlines that enter in equilibrium is unique. To see this, suppose it is not unique, then there is an equilibrium number of airlines $N_i \neq N_i^*$. If $N_i > N_i^*$ this implies that some airline must be making negative profits, and if $N_i < N_i^*$ then there exists a airline that could profitably enter the market but chooses not to enter.[20]

The identity of entering airlines in an equilibrium of the above game is not unique. Consider the simple example of a market with two potential entrants that each find it profitable to enter as a monopolist, $\pi_{ik}^*(1) > 0$, but do not find it profitable to enter in a duopoly market $\pi_{ik}^*(2) < 0$. The above model implies that $N_i^* = 1$, but it is unclear which of the two airlines enters. To use information on the identity of airlines I follow Berry (1992) by assuming that airlines enter in the order of post entry profitability. This assumption can be justified by airlines playing a post-entry war of attrition that would instantly eliminate less profitable airlines if more than N_i^* enter as in Judd (1985). Under the "most-profitable firm enters first" selection rule, let I_{ik}^* be an indicator of entry by airline k in market i. The function I_{ik}^* is 1 if firm k in market i is one of the N_i^* most profitable airlines in the market, and 0 otherwise.

The above model does not allow for nonstop rivals to affect one-stop profits. It may be the case that a nonstop rival may reduce profits on one-stop service, which may induce nonstop entry by a carrier offering one-stop service. The following is an alternative reduced-form profit function that allows nonstop competition to have a different effect on hub carriers and nonhub carriers:

$$\pi_{ik}^*(N_i) = x_i^{Market}\beta_{Market} + x_{ik}^{Network}\beta_{Network} + x_{ik}^{OneStop}\beta_{OS} - \delta(N_i) + \alpha(N_i)x_{ik}^{OneStop} + \sigma\epsilon_i + \sqrt{1-\sigma^2}\epsilon_{ik} \tag{3}$$

The incremental profit function above differs from the other model because it includes the parameter α that accounts for the impact of a nonstop competitor on one-stop profits for carriers offering one-stop service. Theory would suggest that α should be positive because additional competition in the nonstop market will erode profits in the one-stop market, reducing cannibalization effects, and making it hub carriers less responsive to the entry of nonstop rivals.

The inclusion of the additional coefficient, α, complicates the model because it introduces the possibility of multiple equilibria. The multiple equilibria may arise because the impact of rival entry on profitability differs for one-stop and nonstop competitors. For instance, suppose that in the above equation the value of α is greater than δ and both α and δ are positive. Then for a market with two hub firms there could be two equilibria, one where they both enter and another where neither enters. To address the potential problem of multiple equilibria, I select a unique equilibrium to estimate the above model. Specifically, I choose the Nash equilibrium with the

[20] This follows directly from Berry (1992)

greatest number of firms entering the market, so the equilibrium selection rule remains identical to (2) above. This selection rule is again consistent with the war of attrition game where the most profitable firms remain in the market.[21]

5.1 Method of Simulated Moments Estimator

The econometric model above is estimated using a Method of Simulated Moments (MSM) estimator (McFadden (1989) and Pakes and Pollard (1989)).[22] I employ a frequency simulator in my analysis. I start by taking R simulation draws. For a given set of parameter values b and simulation draw $r \in (1...R)$ I evaluate the profit function for all potential airlines in the market and I solve for the Nash equilibrium number of firms in each market $N_{ir}(b)$. I also use the ordering assumption to determine the identities of the $N_{ir}(b)$ firms in the market, where the entry prediction for market i for airline k and simulation draw r is $I_{ikr}(b)$.

An unbiased estimator of the number of airlines that enter market i is found by averaging over the predictions for each simulation draw. That is, the predicted number of airlines entering in market i is $\hat{N}_i(b) = \frac{1}{R}\sum_{r=1}^{R} N_{ir}(b)$. To obtain an unbiased estimator of the entry of individual airlines, I average over the individual entry predictions for each carrier. The unbiased prediction of entering for airline k in market i is $\hat{I}_{ik}(b) = \frac{1}{R}\sum_{r=1}^{R} I_{ikr}(b)$.

Let the observed number of airlines entering in market i be N_i^*, and let the observed entry decision of airline k in market i be I_{ik}^*. I specify the prediction error in the number of airlines for market i as $u_i(b) = N_i^* - \hat{N}_i(b)$. I specify the prediction error in the identity of airline k in market i as $u_{ik}(b) = I_I^* - \hat{I}_i(b)$. The number of potential entrants varies in each market. For this reason, I choose the two potential entrants in the market with the highest network effect variable. The vector of prediction errors is then $v_i(b) = u_i, u_{i1}, u_{i2}$.

From these predictions errors I construct moments. Let $f(Z_i, Z_{i1}, Z_{i2})$ be an L dimensional function of the market i exogenous data Z_i and airline k exogenous data Z_{ik}. Then given M markets and that $v_i(b)$ is uncorrelated with $f(Z_i, Z_{i1}, Z_{i2})$ implies

$$g(b) = \frac{1}{M}\sum_i v_i(b) \bigotimes f(Z_i, Z_{i1}, Z_{i2}) = \frac{1}{M}\sum_i g_i(b)$$

The value $g(b)$ is a vector of size L and the true b satisfies $E[g(b)] = 0$. The MSM-estimator $\hat{b}$ is defined as the minimizer of weighted distance between observed and simulated moments, such that, $\hat{b}$ solves

$$\arg\min_b g'(b)\Omega g(b)$$

where the Ω is a weight matrix. I estimate this model in two stages. In the first stage I set Ω equal to the identity matrix to get a consistent estimate of b. In the second stage I calculate the optimal weight matrix $\Omega = E\left(g(b)\ g'(b)\right)$ by using estimates of b from the first stage. Finally, I solve the above equation again using the new weight matrix to obtain my final estimates. I use simulated annealing to solve for the minimum of the objective function.

[21] The approach of selecting a unique equilibrium to estimate a structural entry model is also applied in Mazzeo (2002).

[22] This section closely follows Berry (1992).

I employ different instruments depending on the specification of the model. The instruments used are discussed along with the each specification in the next section. The standard errors are computed using the formula in Pakes and Pollard (1989) where the asymptotic distribution of $\sqrt{M}(\hat{b} - b)$ is normal with variance-covariance matrix $(1 + \frac{1}{R})\left(E(\frac{\partial g'}{\partial b})\Omega E(\frac{\partial g}{\partial b})\right)^{-1}$.

6 Estimates

Before estimating the full model, it may be useful to analyze a simpler probit model that excludes competition from the analysis. Although the probit model ignores competition between nonstop rivals, it provides a basic approach to look at the impact of one-stop services on nonstop entry. If competition with other nonstop entrants is not an important determinant of entry, then a simple probit model will accurately capture an airlines decision to enter a market. Table 5 shows two simple probit estimates of entry for all potential entrants in each market. Model 1 only includes an airline's own one-stop service, while model 2 includes features of both an airline's own one-stop service and the service of its rivals. Focusing on model 2, the probit estimate shows that ownership of a one-stop service reduces the probability of entry. This reflects cannibalization of an airline's own service. An increase in the circular distance of an airline's own one stop service increases the probability of entry. A reason for this is that cannibalization effects are reduced as the quality of one's own service are lower. Recall that the *CircDist* variable captures the additional distance flown on a route and proxies for the time cost for the customer. As an alternative, one could use the additional distance flown relative to the total direct distance by dividing the *CircDist* variable by the distance between the origin and destination cities and proxies for the relative time costs. I find that the results of the simple probit model estimated below do not qualitatively change if I use either quality measure. If there is a one-stop rival in the market then the probability of entry declines which is consistent with business stealing effects. An increase in the circular distance of a rival airline's service increases the probability of entry suggesting that business stealing effects are less for lower quality rival services. For each additional one-stop entrant the probability of entering increases. This last result is not consistent with the view that competition is greater as the number of one-stop entrants increases. Although the probit captures many of the effects of interest, it is difficult to know how important nonstop competition is between carriers until looking at estimates from the full model.

Now I look at four specifications of the structural model that incorporates competition with other nonstop entrants. These estimates are shown in table 6. The first model is a benchmark model that excludes information on one-stop service in the market. The model is similar to that in Berry (1992), but applied to nonstop entry. In this benchmark model there are 19 moment conditions.[23] Most of the results of the benchmark model follow

[23] The instruments Z_i for the market specific error term u_i include the exogenous covariates of population and distance. It also includes a count of the number of potential entrants, the number of firms with the network effect variable greater than 5, the number of firms with the network variable greater than 10, and the sum of the squared share of nonstop services offered out of the city. The instruments for the firm specific error terms u_{i1}, and u_{i2} include all the covariates for the individual firm. In addition, I also use the number of firms in the market with network variable greater than 10 and the number of potential entrants as additional instruments in the individual

expectations. The larger the population in the cities the more likely airlines are to enter because of the greater demand in the market. The longer the distance the lower the demand and the higher the cost for offering nonstop service. The greater the network effect the more likely airlines are to enter. There are two results that are surprising in these estimates. First, the coefficient on the number of rival nonstop entrants in the market is statistically insignificant. This is unexpected given that the structural studies by Berry (1992) and Ciliberto and Tamer (2006) that find competition has a statistical significant effect on the entry of other carriers. The second surprising result is that the market specific unobservable is insignificant. Since there are many market specific demand factors that are unobserved one might have expected this term to be positive and significant. Examples of route specific unobservables include number of business travelers, vacation traffic, or any other unobserved factor affecting the amount of travel between two cities. It is possible that these market specific unobservable profits are not present, but it may also be the case that we have not isolated the firm specific heterogeneity.

The second specification adds to the benchmark model by incorporating each airlines' own one-stop entry and the circular distance of the service. In estimating this model I include 8 additional moment restrictions to identify the additional parameters.[24] These estimates show that an airline having one-stop service of high quality reduces their profits from offering nonstop service. The estimates also show that as the circular distance of an airline's own one-stop service increases, incremental profits from entering also increase. Both of these results are consistent with airlines reacting to cannibalization effects. The result contrasts with the benchmark model because it shows that competition with other nonstop services has a significant and negative effect on profits. These estimates imply that capturing the heterogeneity of airline service ownership in the market may be important for accurately capturing nonstop competition between airlines. In other words, it seems that the benchmark model may suffer from omitted variable bias. The magnitudes of the estimated coefficients imply that owning a high quality one stop product with an $OwnCircDist_{ik}$ variable near zero is similar in magnitude to having an additional nonstop rival in the market. This suggests that the magnitude of the cannibalization effects are large in relative terms.

The last three estimates are full models that include both an airline's own one-stop service and the one-stop service of rival airlines. The results of full model 1 are similar to the results of the second probit model. The results are consistent with one's own product having cannibalization effects and rival one-stop and nonstop products having business stealing effects. The business stealing effects from rival one-stop entrants are slightly different than those of the probit model. In particular, the coefficient on the number of one-stop entrants variable $NumOthOne-Stop$ was significant in the probit model, but is insignificant in these full-model specifications. The insignificance of the $NumOthOne-Stop$ variable in the full models suggests that only the first one-stop competitor has an affect on the profits of nonstop rivals and that subsequent one-stop entrants do not have a significant impact on nonstop entry.

The columns showing results from full model 2 and full model 3 include the vector of coefficients α from

firms error.

[24] The additional market specific instruments include a dummy of whether there is at least one one-stop service in the market, the total number of one-stop services, and the circular distances of the two most direct one-stop services in the market. Airline specific moment restrictions include the two additional instruments for each error term.

specification (3) above. Full models 2 and 3 differ from full model 1 by allowing for nonstop competitors to have a different impact on hub carriers offering one-stop service and those not offering one-stop service. Many of the results are similar to the results found in the models discussed above, so I will focus on the key differences. Full model 2 includes an interation between the number of nonstop rivals and carriers offering one-stop service, and we find that this coefficient is positive and statistically significant as we had predicted. The result suggests that the hub carriers are less responsive to nonstop entry relative to other carriers. In fact, it appears hub carriers actually have a positive response to rival entry. One interpretation of this result is that hub carriers are matching quality of rivals by entering the market with nonstop service as the profitability of their one-stop service declines. Full model 3 extends the specification of full model 2 by including an interaction of the number of nonstop rivals with the $OwnCircDist_{ik}$ variable. In this specification, the $OwnCircDist_{ik}$ variable is now insignificant and so is the coefficient on the interaction between the $One-stop$ variable and the number of nonstop rivals, but the interaction between the number of nonstop rivals and $OwnCircDist_{ik}$ is positive and statistically significant. The results from full model 3 suggest that the effect of an additional nonstop rival on the entry of a hub carrier will largely be determined by the quality of the hub carriers product. In particular, the results suggest that the higher quality firms will be less likely to enter with nonstop service relative to low quality firms that are more likely to react by matching the quality of rivals in the market. Since the average value of the $OwnCircDist_{ik}$ variable is 2, the results imply that nonstop entry will have little impact on carriers offering an average quality one-stop service because the additional competition from a nonstop competitor is offset by an incentive to match quality.

For both the full model 2 and full model 3 results, the market specific error term σ is positive and statistically significant, while it is not significantly different from zero in other specifications. Finding that σ is positive and statistically significant in these specification suggests that this model may capture some important firm-specific heterogeneity that helps isolate the market specific unobservable.

The models estimated above include a linear competitive effect of $\delta\ (N)$ rather than a term that assumes a decline in competition with additional entrants, such as $\delta\ \log(N)$. The linear functional form assumption was used because this paper is unlike traditional entry models because the model incorporates product ownership. A priori, it wasn't clear how this might affect the estimates, so a linear functional form was chosen. However, estimating full model 3 with the functional form $\delta\ \log(N)$, I find that the model is robust to this alternative specification.

6.1 Predictions and Analysis

This section compares the predictions made by the models estimated in this paper. I compare the full models to the second probit model to evaluate the importance of structurally modeling competition. I also compare the full model 1 and full model 3 to the baseline structural model to check the importance of incorporating information on one-stop service. The results suggest that full model 3 provides the best prediction of the number of entrants, but that the probit produces the most accurate prediction on the identities of entering carriers. However, the full models appear to provide more reasonable out-of-sample predictions

Table 7 shows the prediction for each of the four models. The first row of table 7 shows the estimated number of airlines predicted to enter, the next set of rows shows the measurements of the in-sample predictive accuracy of each model. The predictive accuracy of each model is measured using the mean squared error to predict the number of airlines that enter. The table shows that full model 3 performs the best, followed by the probit. The simple probit model seems to perform better than the other two models in predicting individual firm entry. A potential reason for the predictive accuracy of the probit model is that in many markets it is unlikely that multiple nonstop carriers will compete, so the probit model is likely to perform. In addition, the "full model" only uses information on the two airlines with the greatest market presence, while the probit uses all individual airline entry decisions, so it is not surprising that the probit performs better for predicting individual entry. However, in-sample predictive accuracy is not the only criterion that should be used in determining the usefulness of a model. Reasonable out-of-sample predictions should also be considered. In table 7 I look at 5 different types of changes to exogenous variables and how these changes affect the predicted number of entrants.

In experiment 1, I look at a change in the population variable. The probit model results in a much smaller increase in the total number of entering firms relative to all of the structural models. An increase in the network variable of each potential entrant by 10, more than doubles the number of predicted entrants in the probit model to 824.8, but increases the full model (1) and (3) to less than 700. The reason for the high number of firms predicted in the probit model is that it does not account for the increased competition in the market as more airlines enter.

Next I examine the effect of changing circular distance in the market. In experiment 4 I hold constant the rival services, and I increase each airlines own circular distance by 200 miles. In both the probit and the full model 1 there is only a slight increase in the number of entering firms. In full model 3, the effect is more dramatic because as the quality of the airline's one-stop service falls, the ability to remain competitive with nonstop rivals is diminished, so there is additional incentive to enter the market. It should be noted that the prediction of full model 3 is quite different from that of full model 1. Full model 1 suggests that the incentive to enter increases as the *OwnCircDist* increases in ALL markets, while the results in full model 3 reject this broad effect and suggest that the incentives are isolated to markets facing nonstop competition.

In experiment 5, I hold constant each firms own circular distance and increase the rival circular distance by 200 miles. This increases the number of predicted firms entering to 434.1 in full model 1 and 462.7 in full model 3, while the probit model predicts 558.2 airlines entering. Again, the reason for the difference in predictions is that the probit model does not account for competition in the market.

In the final experiment I evaluate the total effect of cannibalization from one-stop services by holding constant the rival services in the market and examine the effect on entry if no firm owned a one-stop service (i.e. assuming that the coefficient on $One-Stop$=0 and the coefficient on $OwnCircDist$=0). With the full model I find evidence that when cannibalization effects are removed the average number of nonstop services in the market increases to 417.2.

While the in-sample fit varies considerably across the models, the results from this section suggest that the probit estimates may be less reliable for making out-of-sample forecasts, and models that explicitly account for competition in the marketplace appear to produce more reasonable predictions.

7 Conclusion

Empirical studies of entry have largely ignored the role of product ownership in shaping new product entry decisions. This paper explicitly looks at the role of product ownership and its affect on nonstop entry in the airline industry. The results from this paper confirm many prior expectations. I find evidence that cannibalization of an airline's own one-stop service reduce the probability that an airline enters a market. As the quality of an airline's own one-stop service falls, this cannibalization effect diminishes. Competition with rival one-stop services is also an important determinant of nonstop entry. The presence of a rival offering one-stop service in the market reduces the probability of entry, which is consistent with competition between one-stop and nonstop service types. In addition, I find that higher quality one-stop products reduce the probability of nonstop entry by a greater amount than lower quality one-stop products.

I find that competition between nonstop entrants is also an important determinant of nonstop entry. The results suggest that incremental profits tend to decline as the number of nonstop rivals in the market increase. I also find that the effect of an additional nonstop carrier in the market reduces the probability of nonstop entry by more for carriers not offering one-stop service in the market relative to those that offer one-stop service. This is consistent with hub carriers profits being impacted by multiple factors. Specifically, an additional nonstop competitor tends to reduce profits for all airlines in the market, but there is also an incentive for the hub carrier to match quality of nonstop rivals as profits on its one-stop service diminish with the entry of nonstop rivals. I find that the incentive to match quality is greatest for one-stop carriers offering lower quality one-stop service.

More generally, the results in this paper provide some insight into what we might expect to find in other vertically differentiated product markets with multiproduct firms. The decision to enter a market with a high-quality product depends on whether the firm or one of its rivals already offers low-quality service in the market. Cannibalization effects may shape the entry decision of firms because owning a low quality product makes it less likely that a firm will enter a market with a high-quality product. However, if a high-quality rival enters the market this reduces the cannibalization effects from entry.

The results in this paper may also be useful for policymakers. The DOT mentioned several instances where low cost carriers have complained about major hub carriers entering markets with nonstop service, even though hub carriers offer one-stop service through a hub. The results from this paper suggest that this type of response is not unusual, especially in markets where the hub carrier's one-stop service is particularly low.

An important extension of this model may be to structurally identify marginal cost, fixed cost and demand factors affecting entry decisions. These components of a firms profit function may be identified using additional information on prices and passenger travel.

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8 Appendix

Table 1: **Market Entry and Exit Rates**

	Tot. # Mkts. Served in 1996	# Entered	**Entry Rate**	# Exited	**Exit Rate**
Non-hub markets	293	144	49.15%	57	19.45%
Hub Carriers at their hub	601	36	5.99%	8	1.33%

Notes:
Sample includes all city pair combinations between the largest 50 U.S. cities with distances over 300 mi
Excludes airlines that stopped operating over this time period
Tot. Nonstop in 2000 in Non-hub markets: 380
Tot. Nonstop in 2000 by hub carrier at their hub: 629

Table 2: **Summary Statistics**

# of Nonstop	Frequency	Distance (100s of miles)	Pop.	Number of One-stops	Quality One-Stop (in Miles)
0	319	13.78	1.71	5.69	17.97
1	92	11.02	2.27	5.82	32.18
2	52	11.40	3.16	5.62	35.19
3	29	11.43	3.84	5.66	41.48
4	8	8.95	4.64	3.38	130.43
5	7	13.38	8.37	4.71	17.40
6	1	10.35	4.60	7.00	10.00
8	3	10.17	7.00	7.00	8.33

Table 3: **Airline Entry and Network Effects**

Carrier	# Mkts entered	# Mkts Potential Entrant	avg. network effect
American Airlines	45	511	11.22
Continental	23	511	8.09
Delta	44	511	13.79
Northwest	0	511	4.66
United Airlines	37	511	9.83
TWA	9	426	3.60
US Airways	44	359	16.12
Southwest	95	301	23.34
America West	20	213	6.85
Midwest Express Airline	20	170	5.75
Midway Airlines Inc.	14	109	3.66
Alaska	11	70	6.01
Sun Country Airlines	3	70	1.47
American Trans Air	5	69	3.03
Frontier Airlines	0	49	1.63
Airtran	0	43	2.84
National Airlines	3	9	1.67
Spirit Air Lines	4	9	3.44
Pro Air Services	0	9	2.00
Jet Blue	3	6	0.67
Legend	0	2	0.00
Vanguard	0	1	6.00

Table 4: **One-Stop Circular Distance (in Miles)**

Quality Rank High to Low	Mean	Median	s.d.	Min	Max
1st	24.96	6	59.91	0	610
2nd	85.48	43.00	107.00	0	582
3rd	145.14	80.00	157.37	0	932
4th	203.09	161.50	172.67	1	775
5th	297.44	252.00	226.96	4	1047

Table 5: **Probit Estimates***

Variables	Model 1	Model 2
Constant	-2.163	-1.709
	(24.25)	(10.52)
distance (100's miles)	-0.048	-0.061
	(7.63)	(7.14)
Population	0.117	0.101
	(7.40)	(6.19)
One-stop	-0.619	-0.561
	(6.58)	(5.84)
Own Circ Dist (100s miles)	0.050	0.054
	(2.23)	(2.38)
Rival Circ Dist (100s miles)		0.236
		(5.03)
Rival One-Stop		-1.274
		(5.43)
Num Oth One-Stop		0.156
		(4.69)
Network Effects	0.088	0.088
	(26.02)	(25.52)
log likelihood	-667.486	-648.233

* Asy-Z statistics in parenthasis

Table 6: **Main Results***

Variable	Model 1	Model 2	Full Model (1)	Full Model (2)	Full Model (3)
Constant	-2.483	-2.281	-1.625	-1.193	-1.425
	(30.80)	(24.57)	(5.78)	(4.99)	(3.12)
distance (100's miles)	-0.104	-0.114	-0.128	-0.069	-0.090
	(6.80)	(7.66)	(7.42)	(5.47)	(6.02)
Population	0.261	0.408	0.415	0.196	0.268
	(3.41)	(3.78)	(3.88)	(4.50)	(4.00)
One-stop		-0.694	-0.647	-1.431	-0.786
		(4.06)	(4.58)	(7.25)	(3.65)
Own Circ Dist (100s miles)		0.090	0.080	0.069	-0.074
		(2.13)	(1.93)	(1.16)	(0.82)
Rival Circ Dist (100s miles)			0.178	0.216	0.252
			(2.72)	(3.58)	(4.91)
Rival One-Stop			-0.829	-1.569	-1.625
			(2.49)	(5.69)	(4.14)
Num Oth One-Stop			0.070	-0.065	0.076
			(1.55)	(1.28)	(1.41)
Network Effects	0.107	0.102	0.103	0.131	0.121
	(18.15)	(15.20)	(16.71)	(13.92)	(14.57)
Number nonstop rivals (delta)	-0.195	-0.437	-0.522	-0.464	-0.411
	(1.33)	(3.23)	(3.27)	(16.50)	(2.53)
# Nonstop Rivals * One-stop (alpha_1)				0.898	-0.036
				(24.40)	(0.21)
# Nonstop Rivals * Own Circ Dist (alpha_2)					0.173
					(4.09)
Market Correlation	0.077	0.050	0.010	0.695	0.645
	(.34)	(0.18)	(0.12)	(2.21)	(1.61)
# Observations	511	511	511	511	511
Moments	19	27	34	34	34
Simulation Draws	12	12	12	12	12
OBJ Function	62.76	70.19	64.61	70.51	69.55

Table 7: **Predictions and Analysis**

Actual # of Entrants =380

	Probit Model 2	Baseline Model	Full Model (1)	Full Model (3)
Predicted # of Entrants:				
	371.7	355.9	358.0	355.3
Mean Squared Error:				
# of Firms Prediction	0.416	0.502	0.486	0.393
Individual Firm Prediction	0.0432	0.0452	0.0441	0.0465
Entry Impact Analysis:				
1. Change in Pop. (Pop+1)	407.9	427.2	453.0	412.8
2. Change in Network +10	824.8	741.4	632.6	684.7
3. 200m Increase in Own Circ Di	389.9		374.6	416.8
4. 200m Increase in Rival Circ Di	558.2		434.1	462.7
5. No firm owns one-stop product	492.5		417.2	392.0

Table 8: **Selected & Potential Hubs**

Selected Hubs

	City	# Nonstop Routes out of Airport	Tot. Passengers Originating or Destined for Airport	Tot. # of Stopping Passengers	% of Passengers changing planes
Delta	Atlanta	104	4,015,240	3,986,290	49.8%
American Airlines	Dallas	92	2,604,720	2,007,650	43.5%
TWA	St.Louis	71	1,245,540	1,867,920	60.0%
US Airways	Charlotte	66	881,050	1,597,110	64.4%
Delta	Cincinnati	92	871,010	1,594,810	64.7%
United Airlines	Chicago	79	2,802,650	1,333,870	32.2%
United Airlines	Denver	62	1,882,570	1,327,200	41.3%
Continental	Houston	84	1,622,740	1,255,920	43.6%
US Airways	Pitsburgh	71	1,025,440	1,179,500	53.5%
Northwest Airlines	Detroit	80	2,040,140	1,147,380	36.0%
America West	Phoenix	42	1,263,610	1,092,680	46.4%
Northwest Airlines	Minneapolis	76	1,952,670	1,078,920	35.6%
American Airlines	Chicago	73	2,009,650	923,320	31.5%
US Airways	Philadelphia	62	1,560,850	648,910	29.4%
Delta	Dallas	45	838,950	571,820	40.5%
Delta	Salt Lake City	37	970,060	563,320	36.7%
Northwest Airlines	Memphis	46	406,510	555,560	57.7%
Continental	Cleveland	65	891,190	340,240	27.6%

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Airtran	Atlanta	26	964,690	363,900	27.4%
Southwest	Phoenix	30	1,566,270	308,430	16.5%
US Airways	Washington DC	46	2,531,650	243,870	8.8%
Southwest	Houston	22	1,234,640	229,580	15.7%
United Airlines	San Fransisco	28	2,745,580	225,570	7.6%
Continental	New York	61	2,613,140	222,670	7.9%
United Airlines	Los Angeles	26	2,386,720	220,030	8.4%
Midway Airlines	Raleigh	20	365,320	197,270	35.1%
United Airlines	Washington DC	25	1,322,200	194,380	12.8%
Southwest	Las Vegas	35	1,987,470	179,770	8.3%
Southwest	Nashville	26	675,240	173,760	20.5%
Southwest	Washington DC	24	1,195,510	166,900	12.3%
Southwest	Dallas	12	1,240,750	166,070	11.8%
Southwest	Chicago	25	1,230,330	162,730	11.7%
America West	Las Vegas	31	968,950	148,750	13.3%
American Trans Air	Chicago	21	790,170	120,370	13.2%
Southwest	Kansas City	22	586,770	116,470	16.6%
Southwest	St. Louis	21	607,650	113,480	15.7%