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Competition and Entry in Small Airline Markets

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COMPETITION AND ENTRY IN SMALL AIRLINE MARKETS

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Abstract: This paper develops an econometric model of airline entry and price competition in small airline markets. The paper departs from previous work on entry in several ways. First, it specifies a structural revenue model that includes threshold conditions recognizing the discreteness of entry and exit. Second, the model distinguishes between direct and indirect service decision, and analyzes how competition in one type of service affects entry and exit in the other. Third, the paper develops econometric specifications of competition conduct within and across service segments, taking into account selectivity biases induced by entry. We find fixed costs do not vary substantially across city-pairs and are on average small. Direct and indirect travel are not perfect substituted, however, they also are not independent in demand. Finally, we find evidence that the presence of a direct firm tends to increase indirect service competition.

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1. Introduction

Empirical studies of deregulated airline markets have been concerned with two general questions. First, did airline deregulation make city-pair markets competitive? Second, should recent mergers and the rise of hub and spoke systems raise antitrust concerns? Many recent empirical analyses of airline deregulation have concluded that city-pair markets are not perfectly contestable.[1] Several studies also conclude that potential competition is not strong enough to promote price competition.[2] These conclusions are, with few exceptions, drawn from regressions that find a positive correlation between average market fares and market or airport concentration.[3] While the observed correlations do raise questions about whether airline markets are *perfectly contestable*, conclusions about potential competition rest on the appropriateness of price-concentration regressions as a means for assessing market power.

An important limitation of the price-concentration regression framework is that it does not distinguish between technological and strategic explanations for relations between fares and market structure. Consider, for example, the finding that airports with dominant carriers tend to have higher fares. This outcome could reflect the ability of dominant carriers to erect airport entry barriers, thereby raising the costs of potential entrants. Alternatively, it could reflect both economies from concentrating operations at airports and regional efficiency differences among airlines. These two explanations have very different implications for antitrust policy toward this industry. In the absence of more complete structural models of entry, however, it is unclear what existing regression models tell us about strategic pricing behavior.

Recent empirical models of competitive conduct have emphasized that market concentration and prices are endogenously determined.[4] While some empirical pricing

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[1] See, for example, Bailey, Graham, and Kaplan (1985), Graham, Kaplan, and Sibley (1983), Moore (1986), Morrison and Winston (1987), Peteraf (1987), Borenstein (1987) and Berry (1988).

[2] Graham, Kaplan and Sibley (1983), p. 137.

[3] Exceptions include Morrison and Winston (1987) and Berry (1988).

[4] For a general discussion of this point see Bresnahan's (1988) survey.

models have recognized this, and have used instrumental variables for concentration measures, more complete empirical models are needed to justify the variables that separately identify market concentration and fare equations. Such models would explain entry in addition to fares. This paper develops a model where direct entry and fares are simultaneously determined. It is a first step toward understanding how turnover in city-pair markets affects competition.

Our model departs from previous work on entry in two major ways. First, we specify a structural pricing model that includes threshold conditions recognizing the discreteness of entry and exit. In contrast to previous work, this model distinguishes between direct and indirect service decisions. It clarifies how competition in one type of service affects entry and exit in the other. It also shows how entry in a differentiated product market introduces a selection bias in equations explaining prices or quantities.[5] Second, the paper develops an econometric specification that measures competitive conduct within and across service segments. This specification takes into account selectivity bias induced by entry. In addition to providing estimates of elasticities and cross-elasticities of direct and indirect service, fixed costs, and firm conjectures, it makes explicit the economic assumptions needed to estimate endogenous market structure models. A key feature of the model is its treatment of unobservable fixed costs. Following Bresnahan and Reiss (1987), the magnitude of fixed costs is determined from information on the number of firms in the market.

While our models have advantages, they also have practical limitations. They pose significant computational burdens because of the discrete/continuous modelling of the number of firms and prices. The distinction between direct and indirect service also introduces additional computational demands. At present, these complications require us to restrict the generality of our empirical specifications and our data sample. Like Bresnahan and Reiss (1987), we reduce the complexity of the entry threshold

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[5] Direct service is defined as service with no change of planes. It includes nonstop service as well as service with stops but no change of plane. Indirect service involves at least one stop with a change of plane.

equations by only using data on small markets. These markets have at most one firm offering direct service, but can have any number offering indirect service. While the limitation of the sample to small direct markets simplifies the estimation considerably, it also introduces a form of sample selection bias. We discuss this problem when interpreting our results in Section 4.

2. A Model of Direct and Indirect Service

Not all airline service is the same. Passengers can fly first class rather than coach, leave at peak versus off-peak times, and fly direct instead of indirect. A number of studies have documented that consumers are willing to pay for these conveniences. In particular, at the same price, consumers seem to prefer direct over indirect service.[6] Similarly, firms too have preferences over service offerings. In general, indirect flights have a number of advantages over direct flights. These include greater scheduling flexibility and fleet utilization. On the other hand, indirect flights tend to be less profitable because of consumer tastes. We now consider how these tradeoffs affect fares and firms' decisions to serve routes.

2.1. Service Provision

Firms generally enter markets when their perceived profits are positive. Firms' service incentives are easily assessed when economic profits are observable. Unfortunately, both firms' perceptions of profits and economic profits are unobservable. Inferences about them must be drawn from limited information, such as who provides service and the level of fares. To model service decisions, assume that firms' decisions are the discrete outcomes of a simultaneous-move game. Let D be equal to 1 if direct service is provided and 0 otherwise, and let I be 1 if indirect service is offered and 0 otherwise. A set of service offerings is a pure strategy Nash equilibrium when no firm wishes to make a unilateral change in its service. This necessary condition

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[6] For a study of preferences between single and multiple airline service, see Carlton, Landes and Posner (1980).

can be expressed as a series of threshold conditions on firms' (unobserved) profits. These conditions relate unobservable profits to observed qualitative entry decisions. Denoting firm i's variable profits during a post-entry period by VP_i, and fixed costs by F_i, these threshold conditions are:

$$\begin{array}{lcllcl}
(D_i, I_i) = (0,0) & \iff & \mathrm{VP}_i^D < F_i^D & \text{and} & \mathrm{VP}_i^I < F_i^I \\
(D_i, I_i) = (0,1) & \iff & \mathrm{VP}_i^D < F_i^D & \text{and} & \mathrm{VP}_i^I \geq F_i^I \\
(D_i, I_i) = (1,0) & \iff & \mathrm{VP}_i^D \geq F_i^D & \text{and} & \mathrm{VP}_i^I < F_i^I \\
(D_i, I_i) = (1,1) & \iff & \mathrm{VP}_i^D \geq F_i^D & \text{and} & \mathrm{VP}_i^I \geq F_i^I .
\end{array} \tag{1}$$

These threshold conditions are similar in appearance to standard discrete choice conditions. As noted in Bresnahan and Reiss (1986), however, they are complicated by the dependence of each firm's variable profits on the equilibrium actions of firms in *both* segments. For example, direct variable profits, VP_i^D, depend on the quantity strategies of the direct firms and, because consumers view direct and indirect flights as substitutes, on the quantity strategies of indirect firms. Thus, if there are M firms that could potentially offer direct service and N that could potentially offer indirect service, $\mathrm{VP}_i^D = \mathrm{VP}_i^D(q_1^D, ..., q_M^D, q_1^I, ..., q_N^I)$.

The dependence of each firm's profits on its own actions and those of other potential competitors leads to very complicated models of market structure, particularly in this industry where firms offer differentiated products. This paper takes a first step toward developing such models by considering how simultaneity affects the entry and fare decisions in a special case: one where there is at most one firm offering direct service and N firms offering indirect service. We restrict attention to this case for two reasons. First, it is empirically tractable. Second, although our analysis is specialized, it illustrates how potential entrants affect the specification of empirical models of fares and market structure. Specifically, we shall see how the existence of a potential entrant in direct service affects the pricing behavior of indirect firms, and how in turn this behavior affects the likelihood that the direct firm will enter. This simple empirical model of inter-service competition provides a number of insights about competition in networks.

We begin by developing the assumptions necessary to recover demand, cost, and competitive conjecture parameters from observations on whether or not direct service is offered.

2.2. Demand and Cost Conditions

The demand system for travel on a particular city pair route is assumed to be linear and symmetric. That is,

$$\begin{aligned} P^D &= a^D - b^D Q^D - c\,Q^I \\ P^I &= a^I - b^I Q^I - c\,Q^D. \end{aligned} \tag{2}$$

The prices P^D and P^I are respectively the prices of a one-way direct and a one-way indirect trip between the two cities. The quantities Q^D and Q^I are the total number of passengers flying direct and indirect. The demand parameters a^D, a^I, b^D, b^I, and c are positive constants that we are interested in estimating. The common cross-price term c is used to reduce the computational complexity of the model. Estimates of c provide some indication of whether consumers view direct and indirect flights as close substitutes (e.g. $b^D = b^I = c$ would imply perfect substitutes).

Firms' costs have fixed and variable components. Unit variable costs per passenger are assumed constant. This assumption allows us to subtract marginal costs from the demand intercepts with little loss in generality. Firms' fixed costs include all fixed service costs for the route plus any change in network fixed costs. Because these fixed costs are difficult to measure, even with the best of accounting data, we treat fixed costs as unobserved random variables.

2.3. The Competitive Environment

Firms' conjectures about rivals' reactions to their decisions figure prominently in the conditions that determine fares, service levels, and ultimately profits. One problem with allowing each firm to have a set of conjectures is that this introduces too many conjectural parameters. Here we adopt a stylized model of competition that is empirically tractable and yet retains some of the more important features of cross-service competition. Our most important simplifying assumption is that firms choose to offer only one type of service. In addition, we examine markets which have at most one firm offering direct service. No limit is placed on the number of firms offering indirect service. Indirect firms are, however, assumed to be identical and their number given. While these are highly stylized assumptions, they do allow us to model cross-service conjectures in a computationally tractable way. Later we discuss how these assumptions affect our results.

Following recent work on estimating market power, the extent of competition between firms is measured using conjectural variation parameters.[7] As there is more than one type of service, more than one conjectural parameter is required to characterize competition.[8] Some of the more important conjectures are: indirect firm's perceptions of indirect quantity responses; and direct and indirect firms' perceptions of cross-service quantity responses. Denote an indirect firm's perception of how indirect service responds to changes in its service by $\theta = \partial Q^I/\partial q^I$, the direct firm's perception of indirect firms' responses to changes in direct service by $\xi^D = \partial Q^I/\partial Q^D$, and indirect firms' conjecture by $(\partial Q^D/\partial Q^I)(\partial Q^I/\partial q^I) = \xi^I\theta$. Estimates of ξ^D, ξ^I, and θ provide a sense of how firms compete among themselves and across segments. Several special cases are of interest. For Cournot-Nash noncooperative competition in both segements, $\xi = 0$ and $\theta = 1$. For Bertrand competition in both segments, $\xi < 0$ and $\theta = 0$.[9] Other competitive regimes are obtained by allowing these parameters to differ from 0 and 1. For example, more cooperative outcomes typically have $\xi > 0$ and $\theta > 1$.

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[7] See Bresnahan (1988) for a discussion both of econometric models of market power and the meaning of conjectural variations.

[8] For a discussion of multi-product conjectural parameters see Gelfand and Spiller (1987).

[9] Specifically, $\xi^I = -c/b^D$ and $\xi^D = -c/b^I$.

Estimates of the conjectural parameters can be recovered from the threshold conditions (1) using information about firms' optimizing behavior. To see this, consider the solution to an oligopoly quantity game played among N symmetric indirect carriers and one direct competitor. An indirect firm's quantity strategy and price are

$$q^I = \frac{[a^I(2b^D + c\xi^D) - c\,a^D]}{(2b^D + c\xi^D)[b^I(N+\theta) + \theta c\xi^I] - Nc^2} = \frac{\Delta^{QI}}{\Delta} \tag{3}$$

$$P^I = \frac{\theta(b^I + c\xi^I)(a^I(2b^D + c\xi^D) - c\,a^D)}{(2b^D + c\xi^D)[b^I(N+\theta) + \theta c\xi^I] - Nc^2} = \frac{\Delta^{PI}}{\Delta}. \tag{4}$$

The direct firm's output strategy and price are

$$Q^D = \frac{a^D(b^I(N+\theta) + c\theta\xi^I) - Nca^I}{(2b^D + c\xi^D)[b^I(N+\theta) + \theta c\xi^I] - Nc^2} = \frac{\Delta^{QD}}{\Delta} \tag{5}$$

$$P^D = \frac{(b^D + c\xi^D)(b^I(N+\theta) + c\theta\xi^I - Nca^I)}{(2b^D + c\xi^D)[b^I(N+\theta) + \theta c\xi^I] - Nc^2} = \frac{\Delta^{PD}}{\Delta}. \tag{6}$$

Notice that both price and quantity depend on the number of firms offering indirect service, as well as on demand and conjectural variation parameters. Since we have data on prices and quantities of direct and indirect service, we could estimate the demand and conjectural parameters by adding errors and jointly estimating this system of equations. Notice, however, that such an approach contains two important assumptions. First, it assumes that the event "The direct firm has entered" is given. Second, and somewhat less important, it assumes that N is given.

Since direct and indirect airline markets are linked through demand and costs, the entry of the direct firm introduces a sample selection problem. To understand this problem, consider the quantity equation for indirect service, equation (3). When there is no direct firm, equation (3) is inappropriate. Instead, the indirect firm's quantity strategy switches as follows

$$q^I = \begin{cases} \Delta^{QI}/\Delta & \text{if } \mathrm{VP}^D \geq F^D \\ a^I/(b^I(N+\theta)) & \text{if } \mathrm{VP}^D < F^D \end{cases} \tag{7}$$

where the second line is indirect quantity when there are no direct competitors. This equation shows how direct entry affects the specification of indirect price or quantity equations. It also suggests that indirect entry will create selection effects in direct price or quantity equations.

Since not all the variables and parameters in profits are observed by us, the shift in regime in equation (7) raises an unobserved selection bias. Recall that the direct firm enters when its variable profits exceed fixed costs, or in logarithms

$$\ln \Delta^{QD} + \ln \Delta^{PD} - 2 \ln \Delta \geq \ln F^{D}. \tag{8}$$

As demand parameters and fixed costs are unknown, which regime is realized in equation (7) depends on the distribution of unobserved fixed costs and demand conditions. Since these unobservables are likely correlated across types of service, the fare equations are subject to an endogenous sample selection problem. (See Heckman (1978, 1979) and Bresnahan and Reiss (1986).)[10] For example, there may be unobserved demand conditions in a market that simultaneously increase direct and indirect demand. These unobservables may encourage entry in both markets and thereby change the relationship between fares and market structure. To understand the statistical implications of this selection problem, we now develop a more complete stochastic specification for profits.

2.4. Stochastic Assumptions

Because profits on which firms base entry decisions are not observed, the logarithmic threshold conditions (8) and (9) must be estimated by treating profits as latent or unobservable random variables (See Bresnahan and Reiss (1986, 1987)). Conventional logit and probit approaches to estimating threshold models add a logistic or normally distributed error to profits. Such an additive error specification can be justified by

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[10] Endogenous sample selection is involved because there are also entry conditions for the indirect firms. For example, indirect entry implies

$$\ln(P^I Q^I) = \ln \Delta^{QI} + \ln \Delta^{PI} - 2 \ln \Delta \geq \ln F^{I}. \tag{9}$$

Yet, this condition depends on the direct firm being in the market.

assuming that fixed costs are known up to a multiplicative unobservable random error, i.e. $FC^j = F^j \exp(\epsilon^j)$ where $j = I$ or D. The error in fixed costs represents network or route-specific cost differences that cannot be captured by observables. These costs include the opportunity cost of allocating a plane to the route and the fixed costs of having dedicated gate facilities.[11] For simplicity, the natural logarithm of these costs are assumed to be normally distributed with mean zero and variances σ_D^2 and σ_I^2.

An additive structure on the logarithmic threshold conditions (8) and (9) can also be justified by assuming that both demand intercepts are estimable up to a common unobservable, μ, that does not differ across markets. Specifically, we model the the demand intercepts as $\tilde{a}^D = a^D\mu$ and $\tilde{a}^I = a^I\mu$. With nonzero marginal costs, our assumption is that the difference between the demand intercept and marginal cost is multiplied by the common unobservable μ.[12] To make the econometric model tractable and to keep prices positive at small levels of service, it is assumed that μ is lognormally distributed, or equivalently that $2\ln(\mu)$ is normally distributed with mean zero and variance σ_μ^2.

The joint distribution of the unobservables μ, ϵ^D, and ϵ^I determines the probability of entry. Substituting the fixed cost and demand errors into the threshold conditions (8) and (9), service is offered when

$$\ln(P^D Q^D) \geq \ln F^D + \epsilon^D \tag{10}$$

and

$$\ln(P^I Q^I) \geq \ln F^I + \epsilon^I \tag{11}$$

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[11] Fixed costs are likely to include the costs of maintaining a gate, overhead service personnel, and prorated costs of the plane. Currently, the cost of renting a Boeing 757 passenger airliner for a day are in the neighborhood of \$15,000. (See *San Francisco Chronicle*, Section C, Monday, June 27, 1988.)

[12] If the unobservable demand effects differed between indirect and direct service, then the additively separable structure of the error term would no longer be preserved.

The probability that the direct firm enters conditional on there being N indirect firms is

$$\Pr(D = 1|N \geq 1) = \Phi[(\ln \Delta^{QD} + \ln \Delta^{PD} + 2\ln(\mu) - 2\ln \Delta - \ln(F^D))/\sigma_D] \qquad (12)$$

where $\Phi(\cdot)$ is the cumulative normal distribution function. Conditional on entry, we observe the direct firm's total revenue, $P^D Q^D$. Observed and predicted total direct revenue are related by the equation

$$\ln(P^D Q^D) = \ln \Delta^{QD} + \ln \Delta^{PD} + 2\ln(\mu) - 2\ln \Delta.$$

Whether or not the direct firm enters, we observe total indirect revenue for all firms on the route. That is, we observe $P^I Q^I = N q^I P^I$.

To derive the likelihood function for whether or not there is direct service given that there are N indirect firms, we relate the stochastic structure of the observables to the two events. For markets with direct service

$$\epsilon^D \leq \ln P^D Q^D - \ln F^D$$

and

$$2\ln \mu_1 = (\ln P^D Q^D + \ln P^I Q^I - \ln \Delta^{QD} - \ln \Delta^{PD} - \ln \Delta^{QI} - \ln \Delta^{PI} + 4\ln \Delta)/2.$$

Assuming that ϵ^D and $\ln \mu$ are independently distributed, the likelihood contribution of a market with direct service is

$$\phi(2\ln \mu_1/\sigma_\mu) Pr(D = 1|N \geq 1) \qquad (13)$$

where ϕ is the standard normal density and $Pr(D = 1|N \geq 1)$ is defined in (12). For markets without direct service we know

$$\epsilon^D > \ln P^D Q^D - \ln F^D$$

and

$$2 \ln \mu_2 = \ln P^I Q^I - \ln \Delta^{QI} - \ln \Delta^{PI} + 2 \ln \Delta.$$

The likelihood contribution of a market with no direct service is

$$\phi(2 \ln \mu_2 / \sigma_\mu) Pr(D = 0 | N \geq 1) \tag{14}$$

where $Pr(D = 0|N \geq 1) = 1 - Pr(D = 1|N \geq 1)$.

The likelihood function consisting of regimes (13) and (14) has a form that is similar to censored regression models with unobservable stochastic thresholds. (See for example Maddala (1983).) In these models, the assumption that the threshold (ϵ^D) error and the censored error ($\ln \mu$) are independent is necessary for identification of the parameters. The demand and conjectural parameters of our model are estimated by maximum likelihood using this normalization. An important assumption underlying our likelihood function is that it is conditional on N, the number of indirect firms. This assumption constrains the equilibrium conditions in (1), since it does not allow the number of indirect firms to vary with the number of direct firms. While in principle more general models are desirable, we have been unable to formulate an empirically tractable version of such a model. The main difficulty is that the likelihood function for the number of entrants is not be well-defined unless unobservable payoffs satisfy certain economic restrictions that make the entry outcomes unique. (See Bresnahan and Reiss (1986).) In our model with entry in two types of service and continuous observables, these conditions are quite complicated.

3. The Data and Empirical Specifications

The data used in this paper are drawn from the Department of Transportation's Origin and Destination Survey, Data Bank IA.[13] These data cover domestic carrier operations on U.S. routes during the first quarter of 1982. They are based on a 10

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[13] These data are based on Boeing Computer Services processed version of the original Origin and Destination Survey.

percent sample of all purchased tickets. The data include the average number of passengers flown daily between an origin and destination, and average fares for direct and indirect routings.

This paper uses two different samples, one with 113 observations and a second with an additional 687 observations. Both samples were selected using the same criteria. From an alphabetical list of city-pairs, routes were chosen whenever they: had no more than one direct firm, had indirect service, and had price and quantity information available for all firms. To make routes comparable, we excluded routes with Hawaiian or Alaskan cities. The smaller sample of 113 markets is based on a screening of the first 200 markets. It was used extensively to develop our initial specifications. The larger sample is based upon a screening of the top 2500 city-pair markets in 1982 to obtain a sample of 800. Because the computational demands of our model increase dramatically with the sample size, this larger sample was used primarily as a hold-out sample on which we could check the findings from the smaller sample.

While dealing with small direct markets simplifies the estimation process considerably, this selection criterion non-randomly censors the sample. This censoring operates in two ways. First, it affects the probability model for entry based on the threshold conditions (1). In particular, holding the observables fixed, we truncate outcomes where the unobservables would support two direct firms. This sample selection problem is likely to bias estimates of fixed costs, since they are important determinants of the threshold conditions. It may also bias estimates of the demand parameters. One way to oversome this censoring bias is to model entry of the second, third, and subsequent direct firms. This model is beyond the scope of this paper and is left for further work. A second potential truncation problem is that we do not have many observations where there is only direct service. Thus, we are unable to model similar initial selection problems caused by the entry of indirect firms. In future work we also hope to treat the entry decisions of indirect entrants.

3.1. The Demand Specification

Previous studies of airline demand (e.g. Brown and Watkins (1968), Abrahams (1980), and Ippolito (1981)) have found that a variety of demographic variables are useful in explaining total market demand for service. Few studies have, however, separated total market demand into its direct and indirect service components. Our demand specifications include variables used in previous demand studies, as well as variables that help explain the relative demands for direct versus indirect service. The demand intercepts are assumed to be of the form[14]

$$a^j = \exp(a_0^j + a_1^j * \text{MINPOP} + a_2^j * \text{ATEMP} + a_3^j * \text{XDIST}).$$

The own slope parameters are assumed constant, and the cross-effect specification is

$$c = \exp(c_0 + c_1 * \text{DISTDIFF} + c_2 * \text{ATEMP}).$$

In these equations, j represents direct or indirect, MINPOP is the minimum population of the two cities, ATEMP is the absolute value of the difference in the cities' average January temperature (divided by 100), XDIST is a variable equal to 1 if the distance between the two cities is more than 1,000 miles, and 100*DISTDIFF is the difference between DISTLH, the shortest Great Circle routing between the origin and destination cities that passes over a large hub, and DISTANCE, the Great Circle distance between the origin and destination.

The variable MINPOP measures the size of the market. Previous studies have used alternative measures, such as the sum or product of both cities' populations. Our use of MINPOP is motivated by the following example. There is much more travel between San Francisco and New York City than there is between San Francisco and Champaign, Illinois. Further, relative to their total populations, there is not much of a difference in travel between Champaign and San Francisco, and Champaign

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[14] These exponential forms assure that the parameters are positive as required by the theory.

and New York. In trying to predict travel demands for each of these pairings, it seems that it is the people of Champaign and their propensity to travel (or have visitors) that largely determines the size of the market. Indeed, when compared to the other measures mentioned above, MINPOP was always economically and statistically more significant. Of course, population is not the only determinant of demand. The variable ATEMP is used as an indicator of potential tourist demand for warmer (and sometimes colder climates). We expect that demand is greater the larger the difference in climates, and that $a_2^I > a_2^D$ because vacationers are more willing to change planes. The variable XDIST is included to take into account the availability of substitute modes of transport. We expect that the longer the distance between cities, the greater is consumers' willingness to pay for plane trips.

The cross-price parameter c depends on both city characteristics and routing considerations. The variable DISTDIFF measures the extra miles that a passenger has to travel to go through a large hub. Since most indirect flights connect through a large hub, the time cost of an indirect flight is increasing in DISTDIFF. Large values of DISTDIFF should therefore make indirect and direct flights less close substitutes. That is, c_1 should be negative. The degree of substitutability between the two types of service should also depend on whether the route is a tourist route. We include ATEMP, as above, to proxy the amount of tourist travel. Because tourists are more likely to view the two services as close substitutes, we expect $c_2 > 0$.

3.2. The Fixed Costs Specification

Fixed costs are difficult to measure directly. As an alternative, we parameterize fixed costs as a linear function of observables. These variables capture some of the route and network-related fixed costs affecting entry. The remainder are part of the fixed cost error. We use the following specification for the non-random component of fixed costs of direct service

$$F^D = \exp(F_0 + F_1 * \text{CONGEST} + F_2 * \text{LARGEHUB} + F_3 * \text{DISTANCE}).$$

The variable CONGEST is a dummy variable equal to 1 for the congested cities Los Angeles, Chicago, Washington and New York. These cities have been singled out in previous work as being congested during this time period.[15] Terminal and fixed maintenance costs are known to be substantially higher in these cities, as are the opportunity costs of slots. The variable LARGEHUB is included to measure the relative increase or decrease in fixed costs from operating out of a major airport. This variable is equal to one if at least one of the airports meets the Department of Transportation's definition of a large hub.[16] We expect that F_1 should be greater than zero. The sign of F_2 is ambiguous a priori. Finally, DISTANCE is included to allow for the possibility that entry may be more costly the longer the direct flight. In essence, DISTANCE measures any disadvantages that a regional airline faces in spreading its operations. This disadvantage could reflect either increased operation or equipment costs from geographical dispersion.

4. Results

Table 1 reports sample averages of the variables in our data set for markets with and without direct service. Roughly seventy percent of the markets in both samples have a direct firm. These markets are on average twice as large as markets without a direct firm and they have slightly fewer firms overall. Markets with only indirect service tend to be longer haul markets and they are less likely to have a large hub as an endpoint. Markets with direct service have average market fares in the range of 20 to 25 cents per mile. These yields (i.e. fare per mile) are roughly comparable to those reported in other studies (e.g. Bailey and Panzar (1981) and Borenstein (1988)). Not too much can be made of the lower average fares in the indirect-only markets, since yields are known to decline with distance.[17] According to our tourism index ATEMP, the markets without direct service are more likely to carry tourist

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[15] For example, Bailey, Grahan, and Kaplan (1985).

[16] See for example the Department of Transportation's *Airport Activity Statistics*.

[17] See for example Bailey, Grahan, and Kaplan (1985).

traffic. Finally, there is little difference between the markets in terms of our market size measure MINPOP.

Table 2 reports two sets of estimates of the direct service model based on the smaller sample. Both specifications allow indirect firms to have arbitrary conjectures about indirect competition (i.e. θ is estimated). The specifications differ by whether cross-service competition is assumed to be Cournot (i.e. $\xi^D = \xi^I = 0$) or Bertrand.[18] We limited our attention to these two regimes because of the difficulty in maximizing the likelihood function when the conjectures were unconstrained. The estimates of the demand parameters are roughly similar across the two specifications. The effect of various variables can be evaluated using values of the exogenous variables. Estimates of the market demand parameters are summarized in Table 8. These estimates are for the average market in our sample. The slope coefficients indicate that direct demand is more steeply sloped than indirect demand. If direct and indirect service were perfect substitutes, then we would expect $b^I = b^D = c$. At the sample means, we can reject this hypothesis for the direct coefficient, but not for the indirect coefficient. As expected, increasing the distance required to fly through a large hub reduces the degree of substitutability c. Routes that have more tourists, according to ATEMP, appear to encourage less substitution between direct and indirect service.

Of the individual intercept coefficients, minimum population has a positive effect on both demands and is statistically significant.[19] Holding prices constant, at the sample means a doubling of the minimum population will increase direct demand by 2.5 percent and indirect demand by over 30 percent. The tourism index ATEMP has the correct sign for indirect but appears to reduce direct demand. It is, however, generally insignificant. The long distance dummy XDIST is only marginally significant in indirect, indicating that demand does not increase significantly with distance.

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[18] See footnote 9 for the Bertrand conditions.

[19] It is worth repeating that the intercept estimates in the table are the demand intercepts minus marginal cost. The comparative statics on the demand parameters assume that marginal costs do not depend on demand variables.

Among the variables used to explain fixed costs, only DISTANCE of the flight is significant. Although the effect of DISTANCE is statistically significant, it does not have a large economic effect. For example, increasing the distance of the flight from 1000 to 1500 miles adds approximately \$ 50 - \$ 75 to fixed costs. Both congested airports and large hubs have higher fixed costs.[20] The fixed cost estimates from both models are similar but seem unusually low. The expected (daily) fixed costs for direct service for a non-hub, uncongested city pair located 1000 miles apart are respectively \$ 146 and \$ 169 for the Cournot and Bertrand models. For congested large hubs these figures are \$242 and \$266. Finally, the variance of the fixed cost unobservables is relatively modest. For the calculations above, the standard deviation of fixed costs is roughly between \$ 100 and \$ 150.

The two models provide slightly different estimates of the indirect solution concept θ. The cross-market Cournot estimate in the first column indicates θ is slightly above, but not significantly different from, the indirect Cournot value of 1. The Bertrand specification estimate is close to the symmetric perfect cartel value N.[21] Since the other estimated parameters are roughly comparable, there is little reason to prefer one specification over another except on the basis of overall fit. Comparing the two models using the Akaike Information Criterion suggests that the Bertrand model is the preferred model.[22]

Tables 3 and 4 report restricted versions of the model estimated in Table 2. Both tables again use the smaller sample of markets. Table 3 reports Cournot and Bertrand

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[20] See Spiller (1988) for an efficiency explanation of this finding based on capacity constraints at large hubs. Borenstein (1988) provides a noncompetitive explanation for this finding.

[21] The point estimate of 2.1 is close to the 2.4 average number of indirect suppliers. It should be noted, however, that if market shares are not identical then θ can exceed N when firms perfectly collude. We thank Margaret Slade for pointing this out.

[22] The AIC is given by ln(likelihood) - K, where K is the number of parameters. See Akaike (1973). Since the two specifications have the same number of parameters and observations, the criterion suggests choosing the model with the higher likelihood value.

cross-service models under the assumption that there is a perfect cartel in the indirect market. That is, $N = 1$ and consequently $\theta = 1$. Table 4 assumes that the N indirect firms offering indirect maintain Cournot conjectures. The parameter estimates in these two tables do not differ substantially from those in Table 2. It appears therefore that the demand and cost parameter estimates are relatively insensitive to the within indirect service conjecture θ. Perhaps the most important difference between Tables 3 and 4 is the smaller slope coefficient estimates obtained for the Bertrand assumption in Table 3. These estimates suggest that for the average market in our sample, direct and indirect flights are not perfect substitutes. There is, however, still substantial substitution. Another difference is that the likelihood values in Table 3 suggest that the Cournot model of cross-service competition is to be preferred to the Bertrand model.

Table 5 explores the robustness of our results to the size of the sample. It reports estimates of the Table 3 perfect cartel specification based on the larger sample of 800 markets. Comparing the Cournot estimates in the first column of Tables 3 and 5 we find that there are a few differences in the estimates. Tourism appears to be a less important determinant of demand for the larger sample. Estimated fixed costs are roughly the same, although the estimated standard deviation of unobserved fixed costs is higher in the larger sample. The most important differences between Table 3 and 5 are in the Bertrand models. In particular, in the larger sample, estimated fixed costs are substantial. For an uncongested, non-large hub route the estimated fixed costs are \$13,302, as compared to \$108 for the Cournot model. These fixed costs are more in line with the rental cost of a plane.[23]

The differences between the Cournot and Bertrand models is Table 5 may reflect real differences in the way direct and indirect and direct firms react to each other. Alternatively, they may reflect changes in the indirect firms' conjectures about each others' behavior (θ) based on the presence or absence of the direct firm. Table 6

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[23] See footnote 11.

explores this latter possibility. Table 6 presents estimates of a model that allows θ to vary by whether or not there is direct service. Conjectures are θ_0 when there is direct service and θ_1 when there is no indirect service. The point estimates of the θ's in Table 6 differ slightly across the Cournot and Bertrand specifications. Conjectures are uniformly lower when there is direct service, with the estimated θ_0 being insignificantly different from the noncooperative Cournot value of 1. When there is no direct service, the indirect firms appear to behave more cooperatively, with the estimated conjecture being close to the value implied by a symmetric cartel, namely the average number of indirect firms.

Table 7 examines the hypothesis that in the absence of direct service the indirect firms perfectly collude. We test this hypothesis by assuming θ_1=N=1. That is, θ_1 is set equal to the number of indirect firms when there is no direct service. We let N take its actual value when there is direct service. Both models in Table 7 give similar parameter estimates. The Cournot model, however, has an estimated θ_0 less than that estimated under Bertrand cross-service conjectures. The Akaike Information Criteria for these models and their counterparts from the previous table are very similar, suggesting that the cartel assumption introduced in Table 7 is not rejected.

To summarize the results in Tables 2 through 7, most of the demand and cost parameters are relatively stable across the different specifications. First, the demand for direct service is usually estimated to be less elastic than that of indirect. The direct service slope estimates are very large if it is assumed that the marginal costs of service are zero. Evidence in Table 5, however, indicates that this conclusion is sensitive to the sample size. There is also some evidence that the demand estimates are sensitive to the functional form of the model. For a single direct firm with zero marginal costs, the equilibrium direct demand elasticity must be 1. Our estimates based upon sample average prices and quantities generally imply a demand elasticity lower than 1. If, however, demand elasticities are calculated using predicted quantities and prices, the predicted demand elasticity is one. One possible explanation for this phenomenon is selectivity bias in the sample. That is, direct firms may enter only when they have a higher than average demand shock (i.e.large $\ln \mu$). At a given quantity, observed prices will therefore tend to be higher than those predicted for the average market in our sample.

A second consistent finding in the tables is that observable fixed costs are small and there is little apparent variation in unobserved fixed costs. The estimates of the Bertrand model in Table 5, however, suggest that this finding may be sensitive to the sample of markets and the conjectures made by direct and indirect firms. Some of the variables used to proxy fixed costs have effects that are consistent with several recent empirical studies. In particular, for the large sample, direct service from large hubs has higher fixed costs than from smaller hubs. This may explain in part recent efforts by airlines to develop hubs in smaller uncongested airports (e.g. Piedmont's development of the Charlotte, Dayton, and Syracuse hubs). Whether this is because of gate and capacity constraints, or because of some inherent disadvantage of smaller carriers, cannot be answered here.

5. Conclusions

Many empirical studies of airline prices draw conclusions about market power from regressions of fares on market structure variables. These studies document relations between fares and concentration measures. They do not, however, distinguish between market power and technological determinants of fares. Such distinctions require more complete models of airline service. The model in this paper takes a step in this direction by modelling consumer demand for direct and indirect service. It also emphasizes that statements about price competition require models of entry. For example, statements that firms have long-run market power imply that potential competition and entry are ineffective. There are a variety of reasons why entry could be ineffective, such as high entry barriers. To disentangle entry barriers from normal cost differences, a model of entry in the presence of fixed entry costs is required. Such a model must explain how strategic behavior affects entry.

The stylized model in this paper indicates that this task is difficult, as entry introduces a selectivity bias in equations explaining fares or quantities. This problem arises because the observable and unobservable variables determining entry are related to unobservables affecting demand and costs. Interdependencies in firms' entry and price or quantity decisions also create selection problems. Our model begins to analyze these selection problems by considering how direct entry affects indirect revenues and competition. Our estimates of demand, cost and competitive parameters yield several findings worth future study. Fixed costs do not vary substantially across city-pairs and they are not very large. The estimated standard deviation of unobserved fixed costs is also small, suggesting that that unobserved fixed costs (e.g. airport specific costs) are likely small. Direct and indirect travel are not perfect substitutes, nor, however, are they independent in demand. Finally, our specifications of competitive conjectures do not provide definitive evidence that cross-service conjectures are perfectly competitive or perfectly collusive. We do find, however, that the presence of a direct firm does tend to increase competition within the indirect segment.

Our model and findings begin the process of understanding the richness of airlines' products and the ways in which airlines compete. As discussed above, much remains to be done to improve our models and understanding of the data. For example, several important specification problems in our model remain. First, we need to model the endogeneity of the number of indirect firms. Second, the model needs to be extended to allow all firms to endogenously choose whether to serve one or both segments. Finally, and perhaps most important, the model and the data need to be extended to allow more than one direct firm. Progress on each of these topics should prove important in understanding how to measure market power not only in this industry, but also in other concentrated, differentiated product markets.

TABLE 1

SAMPLE AVERAGES

Variable	N = 113 Direct Service	 No Direct Service	N = 800 Direct Service	 No Direct Service
Total Passengers (Daily)	39.1	14.4	35.6	17.7
Direct Passengers (Daily)	24.8	N.A.	19.5	N.A.
Total Number Of Firms	2.14	2.94	2.55	2.64
Fare Per Mile (In Cents)	23.45	13.67	21.24	15.01
DISTANCE (In Miles)	719	1333	898	1342
DISTDIFF	99.8	7.6	61.5	23.0
Large Hub (In Percent)	70	54	72	71
MINPOP (In Millions)	.56	.64	.66	.64
ATEMP	12.7	18.8	15.5	18.6
Markets	78	35	509	291

TABLE 2
MAXIMUM LIKELIHOOD MODEL
OLIGOPOLY IN INDIRECT
Estimation of θ

	VARIABLE	Cournot Cross-Service Competition	Bertrand Cross-Service Competition
a_O^D	CONSTANT	5.88	6.36
		(12.82)	(13.67)
a_1^D	MINPOP	.32	.33
		(2.87)	(3.21)
a_2^D	ATEMP	-.82	-.59
		(-.91)	(-.68)
a_3^D	XDIST	.05	.09
		(.45)	(1.05)
a_O^I	CONSTANT	5.68	5.86
		(12.60)	(12.02)
a_1^I	MINPOP	.23	.29
		(2.08)	(2.47)
a_2^I	ATEMP	.27	.28
		(.66)	(.74)
a_3^I	XDIST	.22	.19
		(1.96)	(1.79)
b^D		4.38	4.45
		(5.03)	(4.57)
b^I		2.34	2.79
		(2.72)	(2.79)
c_0	CONSTANT	2.03	2.90
		(2.82)	(4.12)
c_1	DISTDIFF	-.79	-.26
		(-1.97)	(-1.60)
c_2	ATEMP	-1.18	-.81
		(-.46)	(-.76)
F_0^D	CONSTANT	4.21	4.46
		(10.44)	(11.37)
F_1^D	CONGEST	.44	.34
		(1.12)	(.95)
F_2^D	LARGEHUB	.07	.11
		(.34)	(.63)
F_3^D	DISTANCE	.72D-3	.62D-3
		(3.44)	(3.24)
θ		1.46	2.12
		(3.82)	(3.24)
σ_D		.32	.26
		(2.68)	(2.98)
σ		.72	.73
		(11.49)	(11.70)
	Log Likelihood	-143.52	-140.81
N		113	113

Asymptotic t-statistics in parentheses.

TABLE 3
MAXIMUM LIKELIHOOD MODEL
PERFECT CARTEL IN INDIRECT
$(\theta = 1, N = 1)$

	VARIABLE	Cournot Cross-Service Competition	Bertrand Cross-Service Competition
a_0^D	CONSTANT	6.06	5.66
		(13.99)	(9.38)
a_1^D	MINPOP	.31	.33
		(3.03)	(3.48)
a_2^D	ATEMP	-2.16	-.52
		(-2.15)	(-.68)
a_3^D	XDIST	.07	.09
		(.39)	(1.12)
a_O^I	CONSTANT	5.40	5.34
		(12.57)	(12.37)
a_1^I	MINPOP	.28	.28
		(2.65)	(2.84)
a_2^I	ATEMP	.16	.30
		(.39)	(.74)
a_3^I	XDIST	.14	.16
		(1.29)	(1.80)
b^D		2.99	2.81
		(3.37)	(3.07)
b^I		1.83	1.77
		(2.04)	(2.84)
c_0	CONSTANT	3.13	1.71
		(5.18)	(2.84)
c_1	DISTDIFF	-.19	-.19
		(-1.06)	(-.68)
c_2	ATEMP	-3.96	-.66
		(-2.51)	(-.84)
F_0^D	CONSTANT	4.69	4.54
		(11.09)	(7.01)
F_1^D	CONGEST	.40	.37
		(1.02)	(.50)
F_2^D	LARGEHUB	.04	.09
		(.18)	(.50)
F_3^D	DISTANCE	.57D-3	.66D-3
		(2.37)	(2.85)
σ_D		.28	.27
		(2.58)	(3.03)
σ		.72	.74
		(11.63)	(12.99)
	Log Likelihood	-140.53	-142.33
N		113	113

Asymptotic t-statistics in parentheses.

TABLE 4
MAXIMUM LIKELIHOOD MODEL
COURNOT IN INDIRECT
$(\theta = 1)$

	VARIABLE	Cournot Cross-Service Competition	Bertrand Cross-Service Competition
a_O^D	CONSTANT	5.90 (14.72)	6.31 (13.44)
a_1^D	MINPOP	.31 (2.81)	.30 (2.90)
a_2^D	ATEMP	-.55 (-.77)	-.52 (-.69)
a_3^D	XDIST	.10 (.98)	.13 (1.48)
a_O^I	CONSTANT	6.07 (13.70)	6.02 (14.69)
a_1^I	MINPOP	.20 (1.76)	.24 (1.82)
a_2^I	ATEMP	.22 (2.56)	.24 (2.63)
a_3^I	XDIST	.24 (2.56)	.25 (2.63)
b^D		4.42 (5.21)	4.61 (5.51)
b^I		2.95 (3.63)	2.87 (3.61)
c_0	CONSTANT	2.32 (4.79)	2.77 (4.48)
c_1	DISTDIFF	-.67 (-1.97)	-.36 (-1.47)
c_2	ATEMP	-.56 (-.37)	-.75 (-.71)
F_0^D	CONSTANT	4.13 (12.95)	4.28 (11.55)
F_1^D	CONGEST	.33 (.93)	.25 (.66)
F_2^D	LARGEHUB	.14 (.78)	.16 (.86)
F_3^D	DISTANCE	.70D-3 (3.20)	.62D-3 (2.83)
σ_D		.29 (6.81)	.26 (3.20)
σ		.74 (13.35)	.75 (12.54)
	Log Likelihood	-144.07	-143.22
N		113	113

Asymptotic t-statistics in parentheses.

TABLE 5
MAXIMUM LIKELIHOOD MODEL
PERFECT CARTEL IN INDIRECT
$(\theta = 1, N = 1)$

	VARIABLE	Cournot Cross-Service Competition	Bertrand Cross-Service Competition
a_0^D	CONSTANT	6.09	6.55
		(18.92)	(24.56)
a_1^D	MINPOP	.36	.18
		(11.02)	(5.52)
a_2^D	ATEMP	-.98	-.28
		(-1.55)	(-1.57)
a_3^D	XDIST	.08	.04
		(2.08)	(1.12)
a_0^I	CONSTANT	5.26	5.49
		(16.21)	(14.58)
a_1^I	MINPOP	.36	.22
		(10.18)	(7.02)
a_2^I	ATEMP	.06	-.22
		(.41)	(-1.15)
a_3^I	XDIST	.07	.04
		(1.77)	(1.26)
b^D		3.14	1.55
		(4.88)	(2.36)
b^I		1.26	1.30
		(1.92)	(1.73)
c_0	CONSTANT	2.72	.88
		(28.02)	(4.15)
c_1	DISTDIFF	-.03	-.00
		(-1.36)	(-2.01)
c_2	ATEMP	-1.16	.38D-2
		(-1.66)	(.13)
F_0^D	CONSTANT	3.78	8.73
		(26.84)	(18.87)
F_1^D	CONGEST	-.04	.18
		(-.29)	(1.52)
F_2^D	LARGEHUB	.22	.23
		(2.46)	(2.88)
F_3^D	DISTANCE	.86D-3	.72D-3
		(8.97)	(9.42)
σ_D		.63	.51
		(9.77)	(10.06)
σ		.85	.89
		(31.29)	(29.42)
	Log Likelihood	-1287.97	-1278.22
N		800	800

Asymptotic t-statistics in parentheses.

TABLE 6
MAXIMUM LIKELIHOOD MODEL
OLIGOPOLY IN INDIRECT WITH REGIME CHANGE
Estimation of θ_0 and θ_1

	VARIABLE	Cournot Cross-Service Competition	Bertrand Cross-Service Competition
a_0^D	CONSTANT	6.32	6.12
		(13.74)	(13.93)
a_1^D	MINPOP	.34	.36
		(3.26)	(3.40)
a_2^D	ATEMP	-.94	-.74
		(-1.65)	(-.98)
a_3^D	XDIST	.11	.10
		(1.01)	(1.09)
a_0^I	CONSTANT	5.93	5.59
		(12.83)	(13.21)
a_1^I	MINPOP	.28	.33
		(2.47)	(2.85)
a_2^I	ATEMP	.34	.30
		(.88)	(.70)
a_3^I	XDIST	.20	.14
		(1.99)	(1.37)
b^D		4.68	3.50
		(4.98)	(4.00)
b^I		2.98	2.21
		(3.362)	(2.437)
c_0	CONSTANT	2.81	2.37
		(4.46)	(3.88)
c_1	DISTDIFF	-.70	-.17
		(-1.70)	(-1.39)
c_2	ATEMP	-1.57	-.94
		(-1.20)	(-1.17)
F_0^D	CONSTANT	4.58	4.55
		(8.41)	(10.61)
F_1^D	CONGEST	.43	.44
		(1.18)	(1.23)
F_2^D	LARGEHUB	.02	.00
		(.12)	(.02)
F_3^D	DISTANCE	.92D-3	.86D-3
		(3.61)	(3.09)
θ_0		.53	1.18
		(1.26)	(2.22)
θ_1		2.58	4.26
		(2.49)	(1.87)
σ_D		.29	.25
		(3.45)	(2.81)
σ		.72	.72
		(12.23)	(11.91)
	Log Likelihood	-141.78	-139.01
N		113	113

Asymptotic t-statistics in parentheses.

TABLE 7
MAXIMUM LIKELIHOOD MODEL
OLIGOPOLY IN INDIRECT
$\theta_1 = N = 1$ and θ_0 Estimated

	VARIABLE	Cournot Cross-Service Competition	Bertrand Cross-Service Competition
a_0^D	CONSTANT	6.01	6.10
		(11.86)	(12.87)
a_1^D	MINPOP	.34	.34
		(3.10)	(3.20)
a_2^D	ATEMP	-.84	-.81
		(-.78)	(-1.22)
a_3^D	XDIST	.12	.11
		(1.18)	(1.21)
a_0^I	CONSTANT	5.76	5.70
		(12.60)	(13.12)
a_1^I	MINPOP	.25	.26
		(2.27)	(2.40)
a_2^I	ATEMP	.34	.29
		(.87)	(.73)
a_3^I	XDIST	.19	.18
		(1.80)	(1.67)
b^D		3.98	3.76
		(4.39)	(4.49)
b^I		2.67	2.59
		(3.10)	(3.01)
c_0	CONSTANT	2.41	2.51
		(3.20)	(4.13)
c_1	DISTDIFF	-.67	-.28
		(-1.58)	(-1.23)
c_2	ATEMP	-1.31	-1.14
		(-.48)	(-1.23)
F_0^D	CONSTANT	4.62	4.54
		(7.35)	(10.90)
F_1^D	CONGEST	.43	.37
		(1.22)	(1.02)
F_2^D	LARGEHUB	.01	.04
		(.05)	(.24)
F_3^D	DISTANCE	.94D-3	.81D-3
		(3.84)	(3.40)
θ_0		.53	1.12
		(1.29)	(2.29)
σ_D		.28	.25
		(2.97)	(2.68)
σ		.73	.73
		(11.65)	(11.82)
	Log Likelihood	-141.88	-140.04
N		113	113

Asymptotic t-statistics in parentheses.

TABLE 8
ESTIMATES OF THE DEMAND PARAMETERS EVALUATED AT SAMPLE AVERAGES

Cournot Cross-Service Competition	Table 2	Table 3	Table 4	Table 5	Table 6	Table 7
a^D	395.4	394.8	425.2	501.0	624.2	464.7
a^I	383.0	286.6	556.5	259.3	506.4	420.9
c	4.6	12.0	6.9	11.5	9.7	6.7
b^D	80.3	19.8	82.7	23.0	107.6	53.4
b^I	10.4	6.3	19.1	3.5	19.7	14.4

Bertrand Cross-Service Competition	Table 2	Table 3	Table 4	Table 5	Table 6	Table 7
a^D	674.9	338.7	664.7	772.6	528.0	607.3
a^I	470.8	275.0	532.9	275.7	364.1	393.0
c	13.8	4.5	11.7	2.4	8.4	8.8
b^D	85.3	16.6	100.4	4.7	33.0	43.0
b^I	16.3	5.9	17.6	3.7	9.1	12.2

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