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Product choice and oligopoly market structure

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I propose an empirical model to analyze product differentiation and oligopoly market structure. The model endogenizes firms' product-type decisions, measures how effects of competitors differ depending on their product types, and can incorporate alternative specifications for the product choice game. I estimate using data from oligopoly motel markets along U.S. interstate highways; motel establishments are characterized by their quality choice. The results demonstrate a strong incentive for firms to differentiate. The effects of demand characteristics on product choice are also significant. Game specification is of minor importance, although differences in the games analyzed do affect equilibrium market structure predictions in some cases.

1. Introduction

■ Understanding the causes and consequences of concentrated industry structure continues to pose a formidable challenge for industrial organization economists. Markets in which firms can differentiate their products are especially complex, as each individual firm's product choice affects its own profitability, and the extent of product differentiation influences the intensity of competition for all market participants. This article addresses one particularly difficult question: What drives the product-type decisions of firms in oligopoly markets? The empirical model estimated here endogenizes firm product choice and can be used to evaluate competing explanations for the patterns of product differentiation observed in markets.

Numerous game-theoretic models have addressed firms' product-type choices and made equilibrium predictions about the extent of product differentiation in markets. The framework introduced in Hotelling's (1929) classic article sets up the underlying tradeoff firms face: competition among firms may be less intense if they offer products that consumers find less substitutable, but firms may have an opposing incentive to select an undifferentiated product for which demand is strong. Subsequent models have experimented with various factors that can influence this tradeoff and the resulting array of product types offered by firms in equilibrium. For example, players may choose their product types simultaneously or in some sequence. They may be committed to their choice or have the option to change in response to the decisions of other firms. In each

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case, product choice and market structure predictions depend critically on the assumptions and specifications of the particular model in question.[1]

This article empirically analyzes the structure of differentiated product markets by estimating an equilibrium model that predicts the number of firms operating in a market and the product types each firm has chosen. Endogenizing product choice extends the equilibrium entry models estimated by Bresnahan and Reiss (1991b) and Berry (1992).[2] Firms enter the market if their margins are high enough to cover fixed costs and select the profit-maximizing product type, knowing that margins fall with the entry of additional firms and may depend on the relative product space location of competitors. The empirical strategy is to draw inferences from a single cross-section of market structure observations by making an assumption about the nature of the entry process. The framework can be adapted to incorporate and compare alternative equilibrium concepts. No attempt is made to directly analyze the inherently dynamic process of firms entering a market by, for example, iteratively computing Markov-perfect equilibria for a time-series of market structure observations.[3]

I estimate the model using a new dataset consisting of firm and market information for 492 small motel markets located along U.S. interstate highways. The structure of these local markets can be readily approximated by categorizing each operating motel firm according to the quality of services that it offers. The empirical results indicate that motel firms earn substantially more by choosing differentiated products. However, the effects of demand characteristics, represented by demographic variables, are also significant. These effects can be large enough to outweigh the incentive to differentiate in some cases, generating a market outcome with little or no differentiation. Changing the assumptions about the game's equilibrium concept has a negligible impact; instead, the incentives to reduce competition through differentiation and to choose a product type with strong demand are critical.

The article is organized as follows. Section 2 presents the endogenous product choice equilibrium model in detail. Section 3 contains information about the motel industry and the dataset that I have constructed, describing why they are particularly appropriate for pursuing the agenda proposed above. Parameter estimates appear in Section 4, along with some policy experiments. Section 5 offers some conclusions.

2. Endogenous product choice equilibrium model

■ Two related mechanisms determine equilibrium market structure in a differentiated product oligopoly: each firm's entry and product-type decision and how these choices affect the other firms in the market. Firms make their product choice by comparing payoffs to operating under each product-type alternative. Meanwhile, the number of competing firms and their product types will affect the toughness of price competition and, ultimately, the payoffs for firms under each possible product choice. Since every firm's behavior affects the product choice of all its competitors, the entry and product-type decisions of all market participants should be estimated simultaneously. The model endogenizes product choice by treating the number of extant firms of each product type as the dependent variable. Based on a game-theoretic competition assumption, each of the possible equilibrium product-type configurations implies a set of relationships regarding firm payoffs under the various product choice alternatives.

This proposed framework fits into the growing series of multiple-agent qualitative-response models.[4] These models describe the preferences and choices of interacting agents and are partic-

[1] Commentators on this literature (Fisher, 1989; Peltzman, 1991; and Sutton, 1990, 1998) have noted that although theory models could describe the conditions and assumptions under which almost any market structure could be supported, they did little to address which assumptions were most appropriate.

[2] Reiss and Spiller (1989) estimated the relative competitive effects of perfect and imperfect substitutes in the context of predicting whether the imperfect substitute enters the market. Berry and Waldfogel (1999) analyze entry into heterogeneous product markets, but they do not allow the effects of competitors to vary by product type.

[3] Ericson and Pakes (1995) propose a framework for addressing entry and market structure within a model that explicitly incorporates firm and industry dynamics.

[4] Reiss (1996) provides an outline of the modelling strategy in his review of this literature.

ularly useful for incorporating a game-theoretic behavioral model to analyze equilibrium market structure outcomes. Bresnahan and Reiss (1991b) and Berry (1992) have applied the multiple-agent qualitative-response setup to analyze entry in oligopoly markets. The observed number of market participants is the dependent variable; it is the equilibrium outcome of a game in which firms choose whether to enter the market. In both articles, a reduced-form profit function describes the resulting payoffs in terms of market conditions and the (fixed) number of operating firms. They enforce a Nash equilibrium solution concept, so no profitable deviations from the observed equilibrium outcome are permitted. Operating firms make positive profits, but firms not operating—which would face one more competitor than the extant firms face if they were to enter the market—would make negative profits if they did operate. Additional competitors negatively affect firms' profits in the postentry stage of the game; this particular additional competitor reduces profits to below zero for firms in that market.[5] Along with a market-specific error (representing unobserved payoffs to operating in the market), a probability is assigned to each outcome (number of operating firms) based on the equilibrium concept. Maximum likelihood selects parameters of the payoff function that maximize the probability of the observed outcomes.

□ **Payoff function.** The model estimated here endogenizes each firm's product choice as well as its entry decision. If two distinct product types are defined, the dependent variable is an ordered pair indicating the number of market participants of each type. This equilibrium outcome represents the combination of each market participant's decision on both whether to operate and which of the possible product types to choose.[6] Acknowledging that same-type competitors may affect payoffs more than different-type competitors, the model posits a separate payoff function for each product type. The number of competitors and their product types appear as arguments—for any firm operating as quality type T in market m the following reduced-form profit function is specified:[7]

$$\pi_{Tm} = X_m \beta_T + g(\theta_T; \vec{N}) + \varepsilon_{Tm}.$$

The first term represents market demand characteristics that affect firm payoffs (note that the effect of X_m varies by type). The $g(\theta_T; \vec{N})$ portion of the payoff function captures the effects of competitors, with the vector $\vec{N}$ representing the number of competing firms of each type that the firm faces. Parameters in the function distinguish between the effects of same-type and different-type firms on payoffs, and they capture the incremental effects of additional firms of each type.[8] The parameter vector θ also varies across T, so that the competitive effects may differ by type. The unobserved part of payoffs, ε_{Tm}, is assumed to be different for each product type at a given market.[9]

□ **Equilibrium concepts.** Following Sutton (1998), consider firms in each market to be playing a generic two-stage game. In the initial "investment" stage, firms decide whether to enter and choose to offer either low-quality or high-quality services. Once firms have made their entry and

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[5] "Positive" and "negative" profits should be interpreted somewhat loosely here. Toivanen and Waterson (2001), in their entry/exit study of fast food establishments, acknowledge that entrants' profits must exceed entry costs and that unprofitable firms may nonetheless operate if variable costs are met. Firms must have identical entry costs to attribute profit differences exclusively to competition.

[6] In an extension (described below) to the model, three product types are defined, and an ordered triple represents each market's outcome.

[7] This profit function specification was chosen primarily to make the estimation tractable. Following Berry (1992) and Bresnahan and Reiss (1991b), it can be interpreted as the log of a demand (market-size) term multiplied by a variable-profits term that depends on the number (and product types) of market competitors. There are no firm-specific factors in the profit function.

[8] Note that this specification measures the same competitive effect for all values of the X variables. While this does not allow the competitive effects to vary according to values of the demand regressors, it keeps the number of parameters to estimate manageable.

[9] The error term represents unobserved payoffs from operating as a particular type in a given market. It is assumed to be additively separable, independent of the observables (including the number of market competitors), and identical for each firm of the same type in a given market.

product-type decisions, a "competition" stage ensues in which payoffs are determined. Assume that the infinite number of potential entrants in each market are identical; that is, for a given market structure, the same product-type choice yields the same profits for every firm. However, profits may differ for the different product types within the market. Firms that do not enter earn a payoff of zero; firms that do enter market m earn $\pi_{Tm}(\vec{N})$, where T is the product type chosen and $\vec{N}$ represents the number and product types of all the competitors that have entered by the time the investment stage ends and the competition stage begins.[10]

I consider two distinct assumptions for how the investment stage proceeds.[11] The first is a Stackelberg game—firms play sequentially and make irrevocable decisions about entry and product type before the next firm plays. Firms do anticipate that subsequent firms will have the opportunity to make decisions about entry and product type once they have committed to their choice. The last firm of each product type finds entry profitable and prefers the chosen product type to the alternatives. Additional entry, in either product type, is not profitable. Therefore, a Nash equilibrium can be represented by an ordered pair (L, H) for which the following inequalities hold:

$$\begin{array}{lll} \pi_L(L-1, H) > 0 & \pi_L(L, H) < 0 & \pi_L(L-1, H) > \pi_H(L-1, H) \\ \pi_H(L, H-1) > 0 & \pi_H(L, H) < 0 & \pi_H(L, H-1) > \pi_L(L, H-1). \end{array}$$

Under the assumptions that an additional market participant always decreases profits and that the decrease is larger if the market participant is of the same product type, such an equilibrium exists.[12]

As an alternative, we can assume that the investment stage proceeds in two substages—firms choose whether to enter in the first substage and are committed to these entry decisions. Firms do not select their product types at the time they enter; therefore, the number of firms that enter is the maximum $(L + H)$ for which there is some (L, H) configuration where both π_L and π_H are profitable. Product types are selected simultaneously in the second substage. Because only entry is initially sunk, this game involves considerably less commitment on the part of firms. A proof that a unique equilibrium exists under the same assumptions on the profit function for this two-substage version of the game is provided in Appendix A.[13]

These two equilibrium concepts make different predictions for some values of the profit functions. For example, consider the case where the following inequalities hold:

$$\pi_H(L, H) > 0 \qquad \pi_L(L-1, H+1) < 0 \qquad \pi_L(L-1, H) > \pi_H(L-1, H).$$

In the Stackelberg version of the game, the Lth low-type firm will not enter the market (despite the third inequality), because once the $H + 1$th high-type firm follows it will be unprofitable to operate as a low-type firm. Thus, the outcome $(L - 1, H + 1)$ obtains. In the two-substage version, only $L + H$ firms enter, because it is not possible to operate as a low-type firm in the $(L, H + 1)$ configuration (though it is profitable for the high type). With the number of firms fixed at $L + H$, the $L + H$th firm prefers to operate as a low type, and (L, H) is the resulting configuration.

Extending the model beyond two product types requires a slight modification to the second equilibrium concept. Suppose, for example, firms could offer low-, medium-, or high-quality services. With an additional potential action available to firms, no (pure-strategy) Nash equilibrium exists for the two-stage version of the game. As an alternative, I propose an equilibrium concept

[10] $\vec{N}$ can be thought of as the market structure without the firm whose payoff is in question. For example, if (2, 1) is the observed market structure, $\vec{N} = (1, 1)$ for π_L and $\vec{N} = (2, 0)$ for π_H.

[11] The conditions under which a unique equilibrium exists in a simultaneous-move game with these three available actions (two product types and "no entry") are quite restrictive. See Bresnahan and Reiss (1991a) and Mazzeo (1998).

[12] Formally, the first assumption implies that $\pi_T(L, H) > \pi_T(L + 1, H)$ and $\pi_T(L, H) > \pi_T(L, H + 1)$, and the second implies that $\pi_L(L, H) - \pi_L(L + 1, H) > \pi_L(L, H) - \pi_L(L, H + 1)$ and $\pi_H(L, H) - \pi_H(L, H + 1) > \pi_H(L, H) - \pi_H(L + 1, H)$.

[13] This game is motivated by the fact that in the motel industry, entering a market is relatively more difficult than switching product types. Switching product types can be accomplished by upgrading or downgrading current facilities, or merely by affiliating with a different national chain in some cases.

in which firms play the investment stage in three separate substages. They decide on entry in the first substage; as before, the Nth firm enters only if there is a configuration with N firms in which all the product types make positive profits. In the second substage, firms that have entered again have two choices: they can either operate as a low-quality motel or not. Finally, there is a third substage in which firms that did not choose the low product type decide between medium and high quality. The critical feature of this structure is that at each substage firms have no more than two options. Although firms cannot change their previous decisions in later substages, there is less commitment than in the Stackelberg version of the investment stage. As in the two-product-type version, there are some values of the profit function for which the two equilibrium concepts predict different market structure outcomes.

□ **Estimation.** As mentioned above, the parameters of the profit function will be estimated using a model that predicts the equilibrium product-type configuration across markets. Allowing for two product types and as many as three firms of each product type in the market, the dependent variable can take on one of 15 possible values. Under the assumptions defined above, each equilibrium concept assigns a particular product-type configuration based on the data for the market in question and values for the payoff function pararmeters, for every realization of $(\varepsilon_L, \varepsilon_H)$. Assuming a distribution for the error term, a predicted probability for each of the 15 possible outcomes is calculated by integrating $f(\varepsilon_L, \varepsilon_H)$ over the region of the $\{\varepsilon_L, \varepsilon_H\}$ space corresponding to that outcome.[14,15]

The boundaries of each region are somewhat complicated and correspond to the profit function inequalities that imply each outcome. This is illustrated in Figure 1, in which boundaries corresponding to product-type configuration outcomes (L, H) and $(L-1, H+1)$ are graphed. The rectangular regions of the $\{\varepsilon_L, \varepsilon_H\}$ space implied by the entry conditions for these two outcomes overlap—for some values of $(\varepsilon_L, \varepsilon_H)$ at most $L + H$ firms can profitably enter, and the inequalities $\pi_L(L-1, H) > 0$, $\pi_H(L, H-1) > 0$, $\pi_L(L-2, H+1) > 0$, and $\pi_H(L-1, H) > 0$ all hold. The diagonal line comparing the value of $\pi_L(L-1, H)$ and $\pi_H(L-1, H)$ bisects the overlapping regions—for $(\varepsilon_L, \varepsilon_H)$ such that $\pi_L(L-1, H) > \pi_H(L-1, H)$, the outcome is (L, H), and $(L-1, H+1)$ is assigned where $\pi_L(L-1, H) < \pi_H(L-1, H)$.[16]

Finally, note that an adjustment to this configuration assignment mechanism may need to be made based on the equilibrium concept of the game. The triangle in Figure 1 defined by the lines $\pi_L(L-1, H) = 0$, $\pi_L(L-1, H) = 0$, and $\pi_L(L-1, H) > \pi_H(L-1, H)$ corresponds to the set of inequalities described above for which the two game specifications imply different equilibrium predictions. As such, the density under this triangle contributes to the outcome $(L-1, H+1)$ in the Stackelberg version of investment stage and to the probability of the (L, H) outcome in the two-stage version.

Since the equilibrium is unique, the sum of the probabilities for all market configurations always equals one. Maximum likelihood selects the profit function parameters that maximize the probability of the observed market configurations across the dataset. The likelihood function is

$$L = \prod_{m=1}^{492} \text{Prob}\left[(L, H)_m^O\right],$$

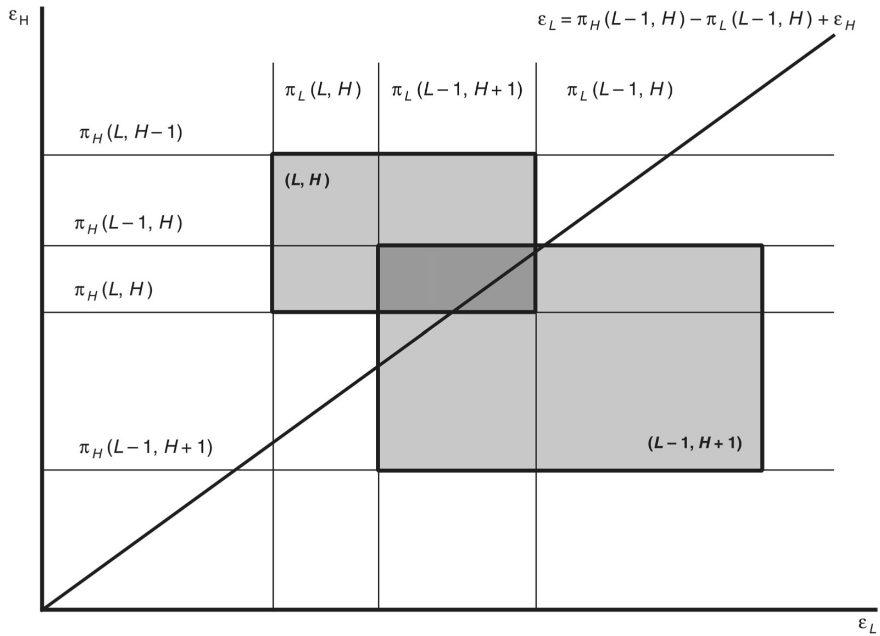
where $(L, H)_m^O$ is the observed configuration of firms in market m—its probability is a function of the solution concept, the parameters, and the data for market m. For example, if $(L, H)^O = (1, 1)$ for market m, the contribution to the likelihood function for market m is Prob[(1, 1)].

[14] In the estimation, markets are constrained to have no fewer than zero and no more than three firms of either product type. Since there are no (0, 0) markets included in the dataset, the computed probabilities are conditional on $\{\varepsilon_L, \varepsilon_H\}$ such that $\pi_L(0, 0)$ and $\pi_H(0, 0)$ are not simultaneously less than zero.

[15] I assume that the distribution of $(\varepsilon_L, \varepsilon_H)$ is bivariate normal, with a correlation coefficient of zero. It is possible to write down a likelihood function that includes ρ as a parameter to be estimated; instead, I ran versions with various values of ρ specified. There was little change in the estimated parameters.

[16] By symmetry, the same adjustment is made between the outcomes (L, H) and $(L+1, H-1)$.

FIGURE 1
PARTITIONING FOR EQUILIBRIUM OUTCOMES



It is worth noting that since the two equilibrium concepts assign the same set of payoff function values to different outcomes in some cases, their corresponding likelihood functions are not the same. For identical parameter values, the two games contribute different values for the probability of the observed configuration. By incorporating the alternative versions of the solution concept directly into the estimation, I can explicitly compare the empirical implications of assumptions that theorists have exploited to construct games that alter the predicted market structure outcomes. This constitutes an initial step in measuring how important strategic considerations are in determining the equilibrium industry concentration ultimately observed in markets.

When we move to three product types, specifying the appropriate limits of integration is exceedingly complex, and directly calculating the probability of the observed product-type configuration is not feasible. As an alternative, I use a frequency simulation approach to estimate the payoff function parameters in the three-product-type case. I take a series of random draws from a trivariate normal $f(\varepsilon_L, \varepsilon_M, \varepsilon_H)$ distribution—along with the data and a set of parameter values, each draw corresponds to a particular product-type configuration. As the number of draws approaches infinity, the share of these simulated draws that match the observed product-type configuration approaches the probability of the observed outcome. Parameter values are selected to maximize the number of times that the simulated configuration is the same as the observed configuration across all the markets in the dataset. More details on the three-product-type estimation procedure can be found in Appendix B.

3. Industry and dataset

■ To estimate the endogenous product choice equilibrium model, I have constructed a dataset that consists of information from all the motel establishments operating in 492 oligopoly markets located along interstate highways throughout the United States. The motel segment of the lodging industry caters to automobile travellers, with properties typically located along highways. Motels began to prosper during the first half of the 20th century: as Americans purchased automobiles in larger numbers, it became popular to criss-cross the country on vacations and to travel from town to town for business. The motel industry was buoyed further by the establishment of the National

System of Interstate and Defense Highways, a 42,500-mile network of freeways conceived in 1956 and constructed in the years since that spans nearly all the nation's large cities. Business establishments providing services for travellers have flourished along interstate highways, even in remote areas where little demand for such services would otherwise exist.

In the early years, most motel properties were independent—often a single family designed, built, managed, and operated the motel. Over the last several decades, however, more motel owners have affiliated themselves with regional and national franchises and chains.[17] This organizational form evolved in part to address a quality-commitment problem between firms and consumers: since travellers often stay in a particular location only once, an establishment does not have a "repeat business" incentive to provide quality accommodations. Consumers were attracted to chain-affiliated motels, known to have a consistent and predictable level of quality.[18]

Although all motels provide the same basic services, they differ in the level of service quality they have chosen to supply. A single-index representation of differentiation based on quality has traditionally been applied to establishments in the roadside motel class of properties.[19] In fact, a proliferation of different quality "levels" of lodging products has become standard strategy in the motel industry. Firms attempt to create niches of market power by offering unique price/quality combinations that appeal to a particular subset of consumers.[20] Effectively conveying quality information to their targeted niche is important for firms, and chains transmit this information through advertising, reputation, and repeat business.[21] Travel organizations like the American Automobile Association (AAA) have established ratings systems to provide consumers with accurate information about the quality of motel services. The measure of quality I use to classify product choice in my sample is based largely on the AAA rating for each motel.

Though franchising and chain affiliation are widespread, independent entrepreneurs still make the product-type decisions for individual properties—particularly in smaller rural markets, where individual franchisees choose their quality by selecting a chain to represent, and independent motels remain quite common.[22] This is crucially important in the empirical model, which fundamentally assumes that each characteristic of each establishment represents the choice that maximizes profits for that establishment. The individual franchisees or independent motel operators represented in my dataset almost certainly behave in this manner, whereas establishment-level optimization would not be ideal in cases where franchisors make decisions for multiple outlets and the maximized franchise profit is not equal to the sum of the maximized profits for each individual establishment.[23]

The nature of demand for highway motel services complicates the selection and definition of markets to analyze empirically. Highway motels serve both visitors of residents and businesses in

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[17] Belasco (1979) is an excellent history of the early motel industry in the United States. Recent trends and the current state of the industry are chronicled by Jakle, Sculle, and Rogers (1996). Today, chains actively promote franchise opportunities and often provide financial assistance to potential franchisees, increasing the pool of potential entrants at all quality levels.

[18] Ingram (1996) lays out this argument in greater detail and presents empirical implications.

[19] It might be argued that certain classes of hotels differentiate themselves by the types of services they offer. Hartman (1989) has applied hedonic techniques to study demand for luxury and specialty hotels using amenities such as free parking, business/meeting services, and airport shuttles.

[20] Choice Hotel International, for example, promotes franchising opportunities in seven different motel chains, each designed to cater to a different clientele. Dahl (1993) attributes Choice's success to recognizing and exploiting market segmentation opportunities. Other companies that own multiple brand names in different quality segments include Hospitality Franchise Systems and Marriott.

[21] Jones (1995) reports that motel chains have recently redoubled their efforts to maintain consistency in quality throughout their affiliates. For example, Holiday Inn recently directed its franchisees to spend $1 billion to renovate their properties (Harris, 1997).

[22] Although several chains own and manage some outlets themselves, it is well documented that the company-owned establishments are more often located in urban areas (Brickley and Dark, 1987; Lafontaine, 1992). Nearly 45% of the rural highway motels in the dataset are not affiliated with a chain or franchise.

[23] Jakle, Sculle, and Rogers (1996) also report that individual establishments change their chain affiliation quite frequently, which provides some motivation for the two-substage specification of the entry/product choice game described in Section 2.

the town nearby each exit, as well as long-distance travellers, resting between legs of a multiday road trip. These mobile consumers may choose their destination market, as well as the particular motel they patronize. We observe geographically isolated clusters of motels along most interstates, however, which practically limits the extent to which motels at one exit compete with motels at other exits.[24] Therefore, I define a market as the cluster of motels located adjacent to an individual interstate highway exit. In so doing, I implicitly assume that competition among the motels at an exit is much stronger than between a motel at that exit and one at a nearby exit or in a town close to the exit (but away from the highway). This definition also abstracts from issues related to location strategy and whether geographic clustering provides benefits to firms. To partially account for intermarket effects, I use the distance to the closest exits with motels to help determine market size, as described below.

To avoid markets that are not oligopolies and maintain a degree of homogeneity among the markets, I collected data only from small, rural exits. Each market in the dataset is located along one of the 30 U.S. Interstate Highways in Table 1.[25] Of all the eligible exits along these highways, 492 contained at least one motel.[26] I was able to assemble an exhaustive list of motel establishments at each market exit—necessary to describe the equilibrium at the market accurately—by consulting AAA's *TourBooks,* chain-affiliated motel directories, the American Hotel and Motel Association's (AHMA) *Directory of Hotel and Motel Companies*, and telephone listings for each town. A total of 1,817 firms were identified at the 492 markets. The top panel of Table 2 breaks down these markets by the number of operating motels in each. Nearly 80% of the markets in the sample have five or fewer properties; only 3% have more than ten firms. The bottom panel of Table 2 displays the number of motels identified from each data source. The AAA *TourBooks*® were the most common source, but many establishments would not have been identified without the telephone-listing search.[27]

I assembled detailed information about each motel, including its chain affiliation, capacity (number of rooms), and price. Table 3 lists the chains most often chosen by franchisees—properties affiliated with Best Western®, Super 8®, and Days Inn® make up more than one-quarter of all the motels, and 45% are not affiliated with any regional or national chain. I also assigned each motel in the dataset to one of three quality "types": low, medium, or high. For properties listed in AAA, I used their quality rating of between one and four "diamonds" to make this assignment. Motels with a one-diamond rating were put into the low category, two diamonds in medium, and three or four diamonds in high. Chain-affiliated motels not listed in AAA were put into the category most populated by the members of the same chain that are in AAA. Because AAA has minimum quality standards for inclusion in its *TourBooks,* independents that AAA does not list were placed in the low-quality category. Table 3 also provides a breakdown of the motels' assigned quality levels. This quality level represents the product choice made by the firm; I examine competition among firms within and across these categories.[28]

To complete the dataset, I appended to the motel information several demographic and geographic variables describing conditions at each market. From the U.S. Census, I obtained the

[24] Bresnahan and Reiss (1987, 1991b) defined markets as geographically isolated towns. Solomon (1994) and Bleakley (1995) provide interesting anecdotes on intermarket competition among motels.

[25] Three-digit interstates and several one- and two-digit interstates that do not cross a state boundary (e.g., 4 in Florida, 27 in Texas, and 97 in Maryland) or predominantly covered metropolitan areas (e.g., 84E, 91, and 93) were not included. Mileage data are computed using maps from AAA.

[26] Exits located within metropolitan statistical areas (MSAs) or in counties with more than 15 motels listed in *County Business Patterns* ("big motel counties") were excluded. Exits with no motels, which typically intersect sparsely travelled secondary roads far from any small town, were not included in the analysis. The econometric model reflects the fact that the markets contain at least one motel.

[27] The data sources were searched in the order listed in the table. Subsequent sources added new properties and were used to verify the validity of previously checked sources. Phone calls were made to clear up discrepancies among the data sources.

[28] A discrete quality space facilitates the estimation of competitive effects in an equilibrium model by limiting the number of different competitive interactions to be measured—three product types imply nine different competitive interactions. Product heterogeneity within quality types may explain why motels remain profitable, even when they have same-type competitors.

TABLE 1 Interstate Highways and Motel Markets Included in the Dataset

Interstate	Endpoint #1	Endpoint #2	Total Miles	Counties Traversed	Counties in MSAs	"Big Market" Counties	Motel Markets
5	Whatcom Cty, WA	San Diego, CA	1,382	34	23	7	6
10	Los Angeles, CA	Jacksonville, FL	2,460	71	40	1	27
15	Toole Cty, MT	San Diego, CA	1,431	29	10	6	9
20	Reeves Cty, TX	Florence Cty, SC	1,537	64	33	2	24
24	Johnson Cty, IL	Marion Cty, TN	317	17	7	1	5
25	Weld Cty, CO	Dona Ana Cty, NM	1,061	25	15	2	8
26	Haywood Cty, NC	Charleston, SC	261	13	7	2	3
29	Pembina Cty, ND	Platte Cty, MO	752	27	6	0	11
30	Dallas, TX	Pulaski Cty, AR	337	15	7	0	7
35	St. Louis Cty, MN	Webb Cty, TX	1,572	63	30	3	29
40	San Bernadino Cty, CA	New Hanover Cty, NC	2,458	81	33	7	34
44	Oklahoma Cty, OK	St. Louis, MO	485	20	11	1	9
55	Chicago, IL	St. Charles Cty, LA	944	28	15	0	23
57	Chicago, IL	Mississippi Cty, MO	381	20	4	0	12
59	Dade Cty, GA	St. Tammany Cty, LA	444	15	6	2	6
64	St. Clair Cty, IL	York Cty, VA	929	43	23	1	10
65	Lake Cty, IN	Mobile, AL	887	45	25	1	18
70	Millard Cty, UT	Baltimore, MD	2,181	76	34	5	36
71	Cleveland, OH	Jefferson Cty, KY	346	20	14	1	3
75	Chippewa Cty, MI	Broward Cty, FL	1,742	76	46	7	24
76	Denver, CO	Deuel Cty, NE	147	6	3	0	4
77	Cleveland, OH	Lexington Cty, SC	598	25	11	0	15
79	Erie Cty, PA	Kanawha Cty, WV	344	16	6	2	6
80	San Francisco, CA	Bergen Cty, NJ	2,909	97	46	13	46
81	Jefferson Cty, NY	Jefferson Cty, TN	856	30	43	2	17
84 (West)	Portland, OR	Summit Cty, UT	765	23	4	2	17
85	Dinwiddie Cty, VA	Mobile, AL	668	42	24	0	11
90	Seattle, WA	Boston, MA	3,088	100	46	14	38
94	Yellowstone Cty, MT	Detroit, MI	1,607	54	27	3	20
95	Aroostook Cty, ME	Miami, FL	1,757	83	61	9	14

population and per-capita income of both the market's nearest town and the market's county. The annual average daily traffic that passes each market's exit along the interstate, which is monitored by the Federal Highway Administration (FHWA), is also included. I consulted a battery of AAA maps to determine the distance from each market to its nearest motel competition along the

TABLE 2 Identification of Motels at Dataset Markets

Number of Motels per Market—Frequency Table

Number of Motels	Number of Markets	Percent of Total (%)
1	128	26.0
2	96	19.5
3	73	14.8
4	60	12.2
5	32	6.5
6	22	4.5
7	20	4.1
8	17	3.5
9	13	2.6
10	16	3.3
11	2	.4
12	4	.8
13	4	.8
14	4	.8
15	1	.2
Total	492	

Sources of Information for Motel Identification

Information Source	Number of Motels	Percent of Total (%)
AAA *TourBooks*	913	50.2
Chain directories	265	14.6
AHMA directory	21	1.2
Telephone survey	618	34.0
Total	1,817	

highway, noting whether the adjacent markets are also in the dataset or the reason why they were not included. These variables are used to help determine the demand for motels at each market, as described below.

4. Estimation results

■ The endogenous product choice equilibrium model presented in the previous section provides a framework for analyzing the entry and product-type decisions of oligopolists. Game-theoretic models have demonstrated that firms' optimal product choices may depend on the specification of consumer demand and commitment strategies, as well as the ability to soften competition through product space isolation. This empirical model analyzes observed differentiation patterns to evaluate the relative importance of these factors. To start, I present results from the two-product-type version of the model, in which potential actions for firms include operating as a low-quality or a high-quality motel and not operating.[29] This classification produces a total of 15 possible

[29] Firms previously categorized as medium-quality are placed in the high-quality category. Combining the medium- and high-quality categories was somewhat arbitrary, but among simple reclassification schemes, this one results in the lowest amount of within-type product heterogeneity for the two-product-type case.

TABLE 3 **Motel Chains and Quality Assignments**

	Number of Motels				
Chain Affiliation	Low Quality	Medium Quality	High Quality	Total	Percent of Total (%)
Budget Host	20	15	2	37	2.0
Best Western	1	36	138	175	9.6
Comfort Inn	0	28	70	98	5.4
Days Inn	16	98	31	145	8.0
Econolodge	5	60	5	70	3.9
Hampton Inn	0	0	17	17	.9
Holiday Inn	0	0	82	82	4.5
Holiday Inn Express	0	3	9	12	.7
Howard Johnson	2	13	0	15	.8
HoJo Inn	3	6	1	10	.6
Motel 6	27	0	0	27	1.5
Quality Inn	0	3	13	16	.9
Ramada Inn	0	0	25	25	1.4
Scottish Inn	12	2	0	14	.8
Super 8	4	142	2	148	8.1
Travelodge	2	4	1	7	.4
Other chains	23	51	30	104	5.7
Independents	658	98	59	815	44.9
Totals	773	559	485	1,817	
Percent of total (%)	42.5	30.8	26.7		

market configurations; the observed number of markets with each configuration is displayed in Table 4.[30] The table shows that differentiated configurations are more common (for example, there are more (1, 1) markets than either (2, 0) markets or (0, 2) markets), but that some unbalanced configurations (the (1, 3) configuration, for example) also occur frequently. The results from the three-type version follow.

□ **Payoff function parameterization.** Parameterizing the payoff function is the next critical step in the empirical analysis. The X variables should be ones that affect demand for motel rooms at that exit (correlated with profits, all else equal); parameter estimates indicate the effects of consumer demand on the returns to each product choice.[31] The following regressors are included in the payoff function:

[30] I assume that the incremental competitive effects die out beyond the third same-type firm; therefore, markets with three or more firms of a type are treated the same. Since the dataset contains no (0, 0) configurations, the probability of the observed configuration is conditional on at least one motel operating.

[31] That is, given a motel's minimum efficient scale, higher demand would allow more firms to operate profitably. As such, variables representing the costs of operating motels could also qualify as X variables, but none had a meaningful effect on the estimation.

TABLE 4 **Observed Market Configurations for the Two-Product-Type Models**

Market Configuration	Number of Markets	Percent of Total (%)
(1, 0)	61	12.4
(0, 1)	67	13.6
(2, 0)	26	5.3
(1, 1)	40	8.1
(0, 2)	30	6.1
(3, 0)	10	2.0
(2, 1)	22	4.5
(1, 2)	30	6.1
(0, 3)	33	6.7
(3, 1)	13	2.6
(2, 2)	17	3.5
(1, 3)	35	7.1
(3, 2)	20	4.1
(2, 3)	30	6.1
(3, 3)	58	11.8
Total	492	

(i) *PLACEPOP*. The population of the town nearest the highway exit—should be positively correlated with motel demand, since a larger town has more people and businesses that highway travellers would want to visit.

(ii) *TRAFFIC*. The FHWA's measure of the annual average daily traffic that passes by the market's exit—should also be positively correlated with motel demand, since more-travelled stretches of highway have more consumers looking to stay at a motel.

(iii) *SPACING*. The distance in miles from the market exit to the closest exits along the highway with motels (the sum of the distance to the closest competitors on either side). I expect a positive correlation between SPACING and demand—a location is more popular if the closest alternatives are further away.

(iv) *WEST*. A dummy variable indicating markets located in the western region of the United States—its distinctive geography suggests that the *WEST* region may attract a group of travellers with different preferences for motel quality.

Table 5 provides summary statistics. Also note that except for the dummy variable *WEST*, the data for the X variables are transformed as follows for use in the estimations:

$$PLACEPOP_m^* = \ln\left[\frac{PLACEPOP_m}{\frac{1}{492}\sum_{m=1}^{492} PLACEPOP_m}\right].$$

Consequently, a value of *PLACEPOP* equal to the mean in the dataset is transformed to zero; a value above the mean becomes positive, and a value below the mean becomes negative. Analogous

TABLE 5 Summary Statistics of X Variables

		Mean	Standard Deviation	Minimum	Maximum
X variables in the payoff function					
PLACEPOP	Population of town closest to the market	5,802.3	6,408.8	100	38,705
TRAFFIC	Average annual daily traffic on interstate at market exit	16,506.6	8,754.4	2,040	68,103
SPACING	Sum of miles from market exit to adjacent markets along highway	53.1	29.9	10	224
WEST	Dummy variable; equals one if market is in west region	.18	.39	0	1

X variable transformation

$$X_m^* = \ln\left[\frac{X_m}{\frac{1}{492}\sum_{m=1}^{492} X_m}\right]$$

X_m	X_m^*
Sample mean	0
Half the sample mean	$\ln(.5) = -.693$
Twice the sample mean	$\ln(2) = .693$

transformations are done on the *TRAFFIC* and *SPACING* variables.[32] No modification is made for the *WEST* dummy—it equals one for *WEST* region markets.

As described in detail in Section 2, the $g(\theta_T; \vec{N})$ portion of the payoff function captures the effects of competitors on product choice. For each $\vec{N}$, a set of dummy variables is defined, and the corresponding θ-parameters represent the incremental effects of additional competitors. The estimates reported reflect the following specification of the competitive-effect dummy variables:[33]

$$\begin{aligned}
g_{LOW} = {} & \theta_{LL1} * \text{presence of first low competitor} \\
& + \theta_{LL2} * \text{presence of second low competitor} \\
& + \theta_{L0H1} * \text{presence of first high competitor (no low competitors)} \\
& + \theta_{L0HA} * \text{number of additional high competitors (no low competitors)} \\
& + \theta_{L1H} * \text{number of high competitors (one low competitor)} \\
& + \theta_{L2H} * \text{number of high competitors (two low competitors)} \\
g_{HIGH} = {} & \theta_{HH1} * \text{presence of first high competitor} \\
& + \theta_{HH2} * \text{presence of second high competitor} \\
& + \theta_{H0L1} * \text{presence of first low competitor (no high competitors)} \\
& + \theta_{H0LA} * \text{number of additional low competitors (no high competitors)} \\
& + \theta_{H1L} * \text{number of low competitors (one high competitor)} \\
& + \theta_{H2L} * \text{number of low competitors (two high competitors).}
\end{aligned}$$

[32] These transformations facilitate estimation of the model—the optimization routine performs better when the variables are scaled so that the range of the data is narrower and more similar across the variables in the model.

[33] The goal is to make the specification of the competitive effects through $g(\theta_T; \vec{N})$ as flexible as possible, while maintaining estimation feasibility. For example, in the cases where the data indicate the "number" of competitors, I implicitly assume that the incremental effect of each additional competitor is the same.

TABLE 6 Estimated Parameters: Two-Product-Type Models

Parameter		Two-Substage Version		Stackelberg Version	
		Estimate	Standard Error	Estimate	Standard Error
Effect on low-type payoffs					
Constant	C_L	1.6254	.9450	1.5420	.9192
Low competitor #1	θ_{LL1}	−1.7744	.9229	−1.6954	.8931
Low competitor #2	θ_{LL2}	−.6497	.0927	−.6460	.0922
High competitor #1 (0 lows)	θ_{L0H1}	−.8552	.9449	−.7975	.9258
Additional high competitors (0 lows)	θ_{L0HA}	−.1247	.0982	−.1023	.0857
Number of high competitors (1 low)	θ_{L1H}	−.0122	.1407	−.0154	.0444
Number of high competitors (2 lows)	θ_{L2H}	−.0000	.0000	−1.12E-6	.0001
PLACEPOP	β_{L-P}	.2711	.0550	.2688	.0554
TRAFFIC	β_{L-T}	−.0616	.1070	−.0621	.1069
SPACING	β_{L-S}	.3724	.1271	.3700	.1271
WEST	β_{L-W}	.5281	.1515	.5246	.1511
Effect on high-type payoffs					
Constant	C_H	2.5252	.9395	2.5303	.8925
High competitor #1	θ_{HH1}	−2.0270	.9280	−2.0346	.8810
High competitor #2	θ_{HH2}	−.6841	.0627	−.6841	.0627
Low competitor #1 (0 highs)	θ_{H0L1}	−1.2261	.9314	−1.2176	.8841
Additional low competitors (0 highs)	θ_{H0LA}	−5.25E-6	.0006	−.0000	.0000
Number of low competitors (1 high)	θ_{H1L}	−2.82E-7	.0001	.0000	.0001
Number of low competitors (2 high)	θ_{H2L}	−.0000	.0000	−5.34E-6	.0003
PLACEPOP	β_{H-P}	.6768	.0551	.6801	.0570
TRAFFIC	β_{H-T}	.2419	.1137	.2419	.1142
SPACING	β_{H-S}	.5157	.1332	.5159	.1328
WEST	β_{H-W}	.2562	.1585	.2588	.1592
Log-likelihood		−1143.01		−1143.12	

□ **Results.** Table 6 displays the payoff function estimates from the two versions of the two-product-type models. I first discuss the results from the two substage version of the model, which are in the left-hand columns of the table. Later in this section, I shall return to the Stackelberg version estimates from the right-hand columns. The parameters for the payoff function of low-quality firms are in the top panel of the table; the high-type payoff function estimates are in the bottom panel.

The estimated parameters indicate the relative payoffs to operating as either a low-type or a high-type firm under different market conditions and in different product-type configurations. For example, the relative value of the constants indicates that, at markets with similar values for the X variables and in which there are no competing firms, operating a high-quality motel is on average more profitable than operating a low-quality motel ($C_H = 2.5252$ versus $C_L = 1.6254$).[34]

[34] All the figures presented in this section represent predicted payoffs and assume that the unobservable part of profits for both types are at their mean—zero. Evaluating the probability that one type's payoffs exceed the other's requires the standard errors of the parameters, and an assumption about the error-term variances.

Factoring in market conditions, however, can change this relationship. For example, suppose that in market m, *PLACEPOP* is one-tenth the sample mean, the other X variables are at their sample means, and the market is outside the *WEST* region. With no competitors, the payoffs to operating a low-quality motel are on average higher ($\pi_L = 1.6254 + (-2.303) * (.2711) = 1.001$) than those to to operating a high-quality motel ($\pi_H = 2.5252 + (-2.303) * (0.6768) = .9668$).[35]

Next, consider the competitive effects on product choice, as captured by the θ-parameters. The large difference between the parameters representing the effects of the first same-type competitor and the first different-type competitor is striking. For low-quality firms, the first low-type competitor ($\theta_{LL1} = -1.7744$) has more than twice the (negative) effect on payoffs as the first high-type competitor ($\theta_{L0H1} = -.8552$). For high-quality firms, the effect of the first competitor is 65% greater if it is also a high type ($\theta_{HH1} = -2.0270$ versus $\theta_{H0L1} = -1.2261$). The effect of the first same-type competitor is significantly greater than that of the first different-type competitor in both cases.[36]

The large difference in these parameters provides strong evidence that differentiation is a profitable product choice strategy for firms. To illustrate, consider a firm choosing whether to operate a low- or high-quality motel when there is one high-type competitor. If this market is not in the *WEST* region and has values of the other X variables equal to their sample means, low payoffs are $\pi_L = 1.6254 + (-.8552) = .7702$, while high payoffs are $\pi_H = 2.5252 + (-2.0270) = .4982$. The relative difference between the competitive effect of same and different-type firms outweighs the baseline preference for offering high quality; on average, when there is one high-quality competitor, the low-quality option yields higher payoffs.

The remaining θ-parameters represent the incremental effects of additional competing firms. These effects are smaller than the impact of the first competing firm. For example, the effect of the second high-type competitor on high-type payoffs is about one-third the effect of the first high-type competitor ($\theta_{HH1} = -2.0270$ versus $\theta_{HH2} = -.6841$). High-type payoffs are reduced by the sum of the two coefficients when there are two high-type competitors: $-2.0270 + -.6841 = -2.7111$. Note that since this sum exceeds (in absolute value) the estimated high-type constant, a third high-quality firm would not be profitable on average at a market with the sample mean values of the X variables. In this case, not operating would be preferred over operating a high-quality motel.

While the estimated θ-parameters indicate powerful incentives for firms to offer differentiated products, the demand effects are large enough to predict undifferentiated product-type configurations in some cases. For example, population has a positive and significant effect on payoffs of both product types, but the relative size of the coefficients indicates that firms in markets with population above the sample mean tend to choose high quality, while low quality is more attractive in below-average population markets. Consider once again the product choice at a non-*WEST* market with one high-type competitor. Let *TRAFFIC* and *SPACING* be at their sample mean, but suppose *PLACEPOP* is twice its sample mean at this market. In this case, the firm will, on average, earn more by choosing the high quality product choice: $\pi_H = 2.5252 + (-2.0270) + (.6931) * (.6768) = .9673$, while $\pi_L = 1.6254 + (-.8552) + (.6931) * (.2711) = .9567$.[37] This empirical finding demonstrates how particular preferences—consumers at markets with larger population are more willing to pay for higher quality—can cause the benefits of product space isolation to be outweighed by the benefits of offering a product type with greater demand.

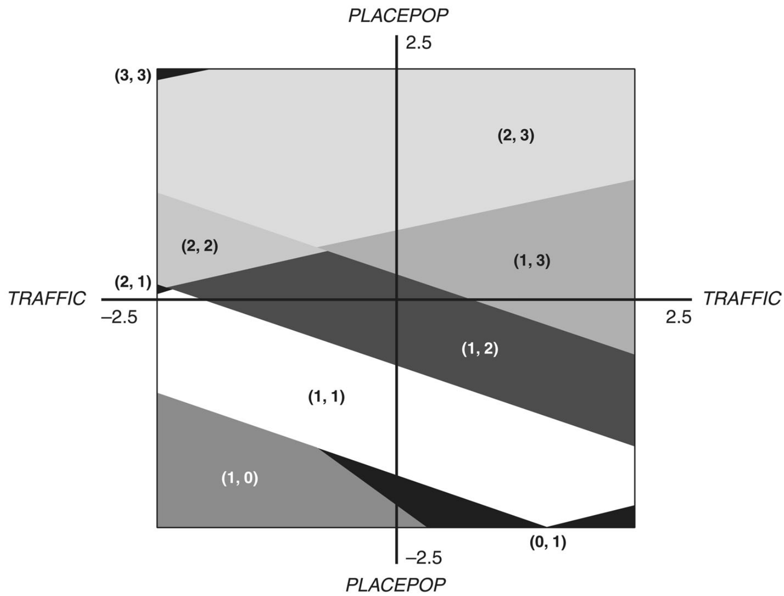
□ **Predictions and policy experiments.** By calculating and comparing predicted payoffs of operating as either product type and not operating for each possible configuration of competitors,

[35] Since *PLACEPOP* is one-tenth the sample mean, the parameter estimate for *PLACEPOP* is multiplied by ln(.1) = (−2.303) to compute the predicted payoffs. The transformed value of an X variable at its sample mean is zero; therefore, the other variables do not contribute to the predicted payoffs.

[36] The negative effect of the first same-type firm is significantly different from zero, while the first different-type effect is negative but not significant. The correlation between the parameter estimates is fairly high; therefore, the difference between the parameter estimates is statistically significant at the 5% level.

[37] In this case, 69 markets in the dataset (14 %) have *PLACEPOP* at least twice the mean.

FIGURE 2
EQUILIBRIUM OUTCOME PREDICTIONS: TWO-SUBSTAGE VERSION



the estimated parameters can be converted into predicted values of the equilibrium market structures for a given set of market conditions. Figure 2 illustrates how the predicted equilibrium varies with different values of the *PLACEPOP* and *TRAFFIC* variables. Markets depicted in the figure are outside the *WEST* region and have the sample mean value of *SPACING*. The graph plots the equilibrium market configuration prediction generated by the estimated parameters (for the two-substage version of the game) as a market's values for *PLACEPOP* (vertical axis) and *TRAFFIC* (horizontal axis) vary from −2.5 to 2.5.[38] For the market with sample mean values for *PLACEPOP* and *TRAFFIC*, plotted at the origin of Figure 2, the estimated model predicts an equilibrium configuration with one low-type firm and two high-type firms operating.

These results could potentially be used by firms to inform decisions about entry and product choice. For example, consider a potential entrant to a market where the values of *PLACEPOP* and *TRAFFIC* equal the sample mean. This firm could compute the amount of additional population needed for the market to support one more firm. Here, a third high-quality motel becomes profitable if the population of the market increases by 31%.[39] By contrast, *TRAFFIC* would have to more than double to support an additional entrant.

The estimates could also suggest optimal product choice in response to a demographic shock. At a low population market (one-tenth the sample mean) with an average level of *TRAFFIC*, only one motel can operate profitably. As described above, the model predicts that the firm would choose to offer low quality, since $\pi_L > \pi_H$ under these conditions. However, if *TRAFFIC* passing by the exit were to double (due to a closure elsewhere in the interstate system, for example) it would be more profitable for the firm to offer high quality.[40] Depending on the costs of upgrading, it may be profitable for the proprietor to convert this motel from low to high quality or to enter into a franchising agreement with a higher-quality chain.

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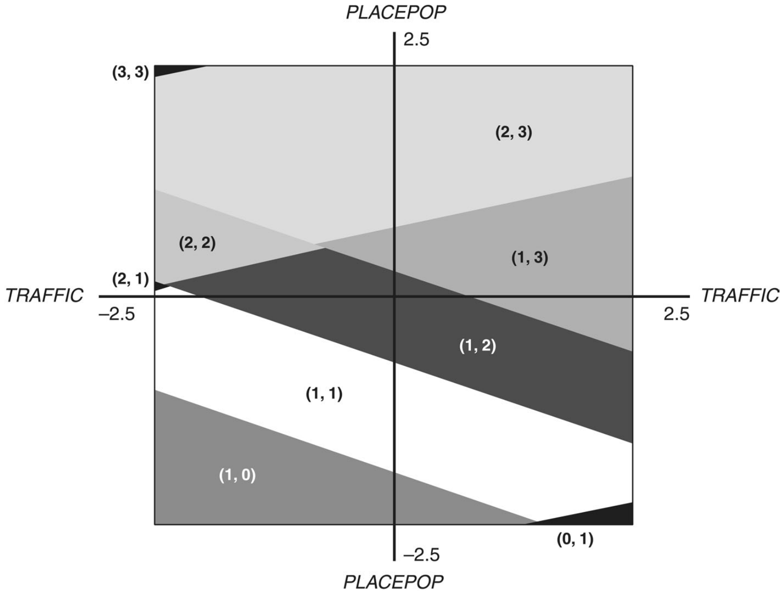
[38] Recall that the X variables are transformed (Table 5); a value of zero indicates that an X variable is at its sample mean, and a value of 2.5 is about 12 times its sample mean.

[39] The potential entrant would solve the equation $2.5252 - 2.0270 - .6841 + \ln(x/5802) = 0$. A population increase of 1,800 individuals would correspond to the high-quality firms in a (1, 3) market earning positive profits.

[40] With the increased *TRAFFIC*, $\pi_L = 1.083$ and $\pi_H = 1.134$.

FIGURE 3
EQUILIBRIUM OUTCOME PREDICTIONS: STACKELBERG VERSION



Finally, we return to the right-hand columns of Table 6, which contain the parameter estimates from the Stackelberg version of the model. Recall from Section 2 that the likelihood functions used to estimate the two versions of the model vary, corresponding to differences in how the two games assign equilibrium market structure outcomes under particular circumstances. Despite this, the estimated parameters are strikingly similar. Between the two sets of columns, there is only a small difference in the competitive effects and almost no difference in the demand effects. The equilibrium product-type configurations predicted in the two versions of the model are also quite similar. Figure 3 displays the predictions for the Stackelberg version of the model (compare Figure 2 for the two-substage version), and Figure 4 plots the few values of the market-characteristics variables for which the two estimated games predict different market structure outcomes. The specification of the model changes the equilibrium prediction in fewer than 3% of the cases tested.[41]

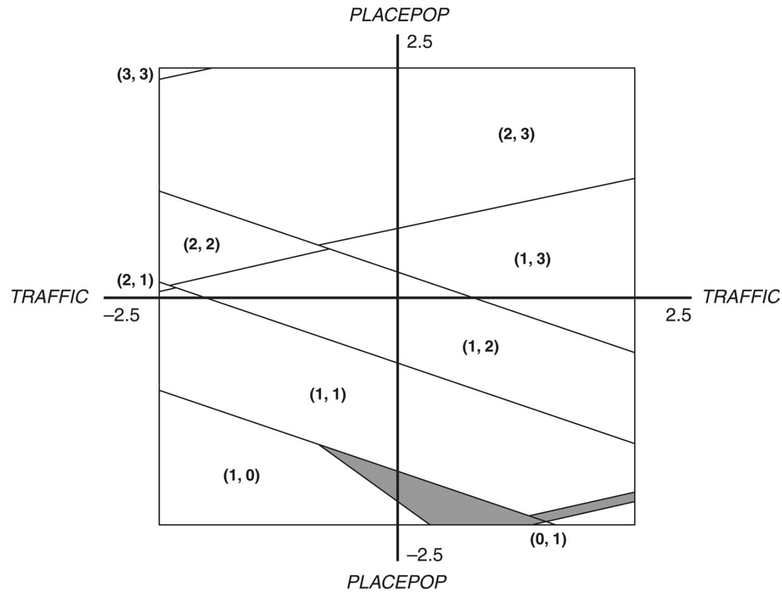
□ **Three-product-type model.** To facilitate the estimation, the payoff function parameterization is leaner in the model where firms can choose among three product types. *PLACEPOP* and *SPACING* are the only X variables included and the θ parameters are further collapsed, as suggested in Section 2. There is a θ parameter representing the effect of a same-type competitor for each of the three product types. In addition, two separate parameters capture the impact of different-type competitors—θ_{CN} for the effects of competitors that are one type removed in product space, and θ_{CF} for the effects of competitors two types away. The following specification for the portion of the three payoff functions results:

$$\begin{aligned} g_{LOW} = \theta_{LL} &* \text{number of low competitors} \\ + \theta_{CN} &* \text{number of medium competitors} \\ + \theta_{CF} &* \text{number of high competitors} \end{aligned}$$

[41] The log-likelihood values for the two versions of the model are also very similar: −1143.12 for Stackelberg and −1143.01 for the two-substage version. In addition, Vuong's (1989) test for evaluating nonnested models indicates no difference between the two-substage and Stackelberg specifications.

FIGURE 4

PREDICTION DIFFERENCES: STACKELBERG AND TWO-SUBSTAGE VERSIONS



$$g_{MED} = \theta_{MM} * \text{number of medium competitors}$$
$$+ \theta_{CN} * (\text{number of low competitors} + \text{number of high competitors})$$
$$g_{HIGH} = \theta_{HH} * \text{number of high competitors}$$
$$+ \theta_{CF} * \text{number of low competitors}$$
$$+ \theta_{CN} * \text{number of medium competitors.}$$

With this parameterization, the estimates reveal the contrast between the "same-type" effects ($\theta_{LL}, \theta_{MM}, \theta_{HH}$) and the "cross" effects (θ_{CN}, θ_{CF}), and they distinguish the "near cross" effects (θ_{CN}) from the "far cross" effects (θ_{CF}).[42]

Table 7 presents estimates from the three-substage version of the three-product-type model. Again, there is strong evidence that the (negative) effect on payoffs is greater for same-type competitors than for different-type competitors. The difference between the same-type and different-type effects is much larger than in the two-product-type case; in fact, the relative size of the cross-effects makes them almost negligible compared to the same-type effects. There is also little difference between the impact of close and far different-type competitors—both are much smaller than the same-type effects. Adding a quality category reduces firm heterogeneity within product types; the reclassification makes the average same-type competitor a closer substitute and its relative (to competitors in other product types) effects on profits greater. As a result of the more distinct quality submarkets, the benefits of product differentiation appear much stronger in the three-product-type case.

The estimates of the demand effects differ for each product type, again indicating that market conditions can increase the proclivity for firms to choose a particular product type. In more extreme cases for *PLACEPOP* and *SPACING*, a product type might be selected even if its only competitor is the same type. For example, suppose there is one medium-quality competitor operating at a market in which the values of *PLACEPOP* and *SPACING* are at the sample mean. Payoffs to

[42] An alternative parameterization revealed no differences between the cross-effects specified separately to capture the effects of particular competitors on each product type (e.g., breaking θ_{CF} down into θ_{LH} for the effect of a high-quality competitor on low-type profits and θ_{HL} for the effect of low on high).

TABLE 7 Estimated Parameters: Three-Product-Type Models

Parameter	Estimate	Standard Error
Constants		
Low	1.1937	.0582
Medium	1.4938	.0512
High	1.0311	.0542
"Same" effects		
Effect of low on low—θ_{LL}	−1.1881	.0513
Effect of med. on med.—θ_{MM}	−1.4939	.0473
Effect of high on high—θ_{HH}	−1.6779	.0469
"Cross" effects		
"One type away" effect—θ_{CN}	−.0243	.0212
"Two types away" effect—θ_{CF}	−.0227	.0057
***X* variables**		
PLACEPOP		
Low	.1127	.0238
Medium	.7681	.0586
High	.2603	.0254
SPACING		
Low	.0120	.0565
Medium	.6145	.0244
High	.2901	.0629

operating as a medium type (π_M = 1.4938 − 1.4939 = −.0001) are less on average than for operating as a low type (π_L = 1.1937 − .0243 = 1.1694) or a high type (π_H = 1.0311 − .0243 = 1.0068). However, if the market is larger than average, say with a transformed *PLACEPOP* value of two, the predicted payoff associated with choosing medium quality is highest among the three.[43] As in the two-product-type case, the effects of demand characteristics can outweigh the competitive effects and help explain some undifferentiated configurations.

Finally, the two versions of the game can again be used to evaluate the role of the specification of competition in the context of the three-product-type model. I calculate and compare the equilibrium product-type configurations that the three-substage and the Stackelberg versions of the game predict, using one set of estimated parameters and different values of the *X* variables and the error term. The predicted equilibria in two alternative versions of the game differ less than 1% of the time.[44] Once again, the results of altering the structure of the game indicate that the importance of the specification of competition is much smaller empirically than the theoretical literature has suggested.

5. Conclusion

■ This article empirically examines the oligopoly market structure implications of endogenous product choice by firms. The theoretical literature demonstrates the difficulty of analyzing this problem, in which there are costs and benefits of all the product choice strategies available to firms. Game theory models can predict an equilibrium market structure in the presence of these

[43] In this case, π_M = 1.4938 − 1.4939 + 2 ∗ (.7681) = 1.5361, π_L = 1.1937 − .0243 + 2 ∗ (.1127) = 1.3948, and π_H = 1.0311 − .0243 + 2 ∗ (.2603) = 1.5274.

[44] I made the above calculation in lieu of estimating this alternative likelihood function, since the three-product-type model is difficult to estimate. Given the result, the parameters that would maximize the value of the simulated likelihood functions in the two versions of the model would probably be very similar.

opposing forces, but the predictions often depend critically on the way the entry and product-type decisions are modelled. In this article, empirical investigation of product choice behavior attempts to establish regularities where theory provides only stylized results.

A methodological advance is necessary to undertake an empirical analysis of product choice and market competition. An appropriate empirical model of oligopoly market structure must estimate simultaneously the decisions of all market participants. Previous analyses of product-differentiated markets did not incorporate the fact that the product types chosen by competitors affect all firms' payoffs and, thus, their product choices. The endogenous product choice equilibrium model developed in this article captures this simultaneity by extending the multiple-agent qualitative-response model literature to study the game played by product-differentiated oligopolists. The model can accommodate different specifications of this game, to investigate the importance of modelling assumptions on equilibrium outcomes.

Three main conclusions follow from the estimated parameters of the endogenous product choice equilibrium models. First, the empirical evidence from oligopoly motel markets strongly supports the product choice theories that predict firms will offer products unlike those of their competitors. The negative effect that a competitor has on firm payoffs is up to twice as large if that competitor is the same product type. Second, the results demonstrate that demographic variables representing the influence of demand factors help predict both how many firms can operate profitably in a market and the firms' product-type decisions. The effects of demand characteristics can be large enough in some cases to outweigh the relative difference in the competitive effects, resulting in an undifferentiated market configuration. Finally, varying the degree of commitment that firms make to entry and product choice has minimal effect—the Stackelberg and two-substage versions of the model predict extremely similar values for both competitive and demand effects on payoffs and equilibrium product-type configuration outcomes. Whereas theory models demonstrate that there are scenarios under which different assumptions about entry and product choice commitment can lead to alternative equilibrium market structure predictions in some cases, the empirical results indicate that the incidence and influence of such scenarios are quite small. In this analysis, the effects of game specification were empirically negligible. By focusing on particularizing results, the theory literature has overemphasized the role of strategic firm behavior in predicting equilibrium product-type outcomes. Evidence from this industry suggests that the simpler forces, as described by Hotelling, dominate.

Appendix A

■ **Proof of existence/uniqueness of equilibrium in the two-substage version of the entry and product choice game.** Suppose $N^* = L + H$ firms entered the market in the first substage. Therefore, some $(L, N^* - L)$ configuration must exist such that $\pi_L(L-1, N^*-L) > 0$ and $\pi_H(L, N^*-L-1) > 0$. Such configurations are candidates for possible equilibria. Start by considering any of the (L, N^*-L) configurations for which these inequalities hold. Such a configuration is an equilibrium unless

$$\pi_H(L, N^*-L-1) < \pi_L(L, N^*-L-1) \tag{A1}$$

or

$$\pi_L(L-1, N^*-L) < \pi_H(L-1, N^*-L). \tag{A2}$$

Note that (A1) and (A2) cannot simultaneously be true.

If (A1) holds, then $\pi_L(L, N^*-L-1) > 0$, since $\pi_H(L, N^*-L-1) > 0$ and $\pi_H(L+1, N^*-L-2) > 0$ since $\pi_H(L, N^*-L-1) > 0$. So, $(L+1, N^*-L-1)$ satisfies the requirements to be an equilibrium unless

$$\pi_H(L+1, N^*-L-2) < \pi_L(L+1, N^*-L-2), \tag{A3}$$

which would imply a new potential equilibrium of $(L+2, N^*-L-2)$.

This process continues until we get to evaluating the potential equilibrium of $(N^*, 0)$. Since we only have low product types in this configuration, $\pi_L(N^*-1, 0) > \pi_H(N^*-1, 0)$ is enough to guarantee an equilibrium. If this inequality does not hold, the configuration $(N^* - 1, 1)$ satisfies the equilibrium requirements. The case where inequality (A2) holds rather than (A1) would be symmetric. Therefore, at least some equilibrium configuration must exist.

For uniqueness, suppose a generic (L, H) is an equilibrium, implying that the following inequalities hold:

$$\pi_L(L - 1, H) > \pi_H(L - 1, H) \tag{A4}$$

and

$$\pi_H(L, H - 1) > \pi_L(L, H - 1). \tag{A5}$$

An alternative equilibrium with $(L+H)$ firms might be $(L-1, H+1)$, but that would require $\pi_H(L-1, H) > \pi_L(L-1, H)$, which is ruled out by (A4). Similarly, an equilibrium $(L + 1, H - 1)$ would be ruled out by (A5).

Another possibility would be an equilibrium with $(L - 2, H + 2)$ firms, which implies $\pi_H(L - 1, H + 1) > \pi_L(L - 2, H + 1)$. This is ruled out because of (A4) and the maintained assumption that an additional same-type competitor reduces profits more than an additional different-type competitor; thus, $\pi_L(L - 1, H) < \pi_L(L - 2, H + 1)$. Again, a similar argument rules out the $(L + 2, H - 2)$ configuration.

Appendix B

■ **Frequency simulator for the three-product-type likelihood function.** This Appendix describes the frequency simulation approach used to estimate the likelihood function for the three-product-type model. Simulation is employed because the complexity of the limits of integration make direct computation of the probability of the possible configuration infeasible. For the problem outlined in Section 2, the procedure works as follows: take a large number, K, of random draws from the assumed (trivariate normal) distribution. For each random draw k, a unique simulated equilibrium product-type configuration is generated for each market m based on the data for that market, the payoff function parameters, and the value of the random draw. I count the number of times P out of K for which the simulated equilibrium equals the observed configuration: $(L, M, H)^S_{mk} = (L, M, H)^O_m$, where $(L, M, H)^S_{mk}$ is the simulated equilibrium configuration at market m for draw k and $(L, M, H)^O_m$ is the observed configuration for market m. The corresponding likelihood function is written as

$$L = \prod_{m=1}^{492} \frac{P_m(\beta, \theta)}{K},$$

where $P_m(\beta, \theta) = \sum_{k=1}^{K} I[(L, M, H)^S_{mk} = (L, M, H)^O_m]$. As K approaches infinity, this ratio provides a consistent estimate of the probability of the observed outcome.[45]

The discrete nature of the dependent variable makes the simulated likelihood function difficult to optimize. There are naturally long flat sections where parameters change but the value of the indicator (and thus the likelihood function) does not, as well as discontinuous jumps when the parameter value moves enough to switch the indicator. For this problem, the indicator function described above is, in fact, the product of a series of indicator functions representing each of the profit function inequalities that must hold for a particular product-type configuration. The simulated likelihood function estimated here is smoothed by replacing each individual profit function inequality indicator $I[\pi_A(\vec{N}_A) > \pi_B(\vec{N}_B)]$ with $\Phi([\pi_A(\vec{N}_A) - \pi_B(\vec{N}_B)]/h)$, where Φ represents the cumulative normal distribution function. For the estimates reported in the last subsection of Section 4, $h = .1$ and $K = 100$ were used.[46]

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[45] This simulated maximum-likelihood approach generates consistent parameter estimates only as K approaches infinity. A simulated method-of-moments estimator (McFadden,1989; Pakes and Pollard, 1989) was applied to equilibrium entry models by Berry (1992) and Davis (2000), but quantifying distance between predicted and observed market structures is not feasible with multiple product types.

[46] Alternative smoothing procedures are discussed by Stern (1992), again in the context of simulated method-of-moments estimation.

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