Entry and Competition in Concentrated Markets

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This paper proposes an empirical framework for measuring the effects of entry in concentrated markets. Building on models of entry in atomistically competitive markets, we show how the number of producers in an oligopolistic market varies with changes in demand and market competition. These analytical results structure our empirical analysis of competition in five retail and professional industries. Using data on geographically isolated monopolies, duopolies, and oligopolies, we study the relationship between the number of firms in a market, market size, and competition. Our empirical results suggest that competitive conduct changes quickly as the number of incumbents increases. In markets with five or fewer incumbents, almost all variation in competitive conduct occurs with the entry of the second or third firm. Surprisingly, once the market has between three and five firms, the next entrant has little effect on competitive conduct.

I. Introduction

Theoretical models of imperfect competition make diverse predictions about the competitive effects of entry. Contestable market theories, for example, argue that the mere threat of entry curbs market power. By contrast, entry barrier models assign a limited role to potential competitors, arguing instead that only actual entry affects competition (cf. Baumol, Panzar, and Willig 1982; Tirole 1988; Geroski

We thank the National Science Foundation for financial support under grant SES 88-21543 and the Alfred P. Sloan Foundation for providing fellowship support. Clara Jong and Mary Jo Arboleda provided research assistance. Finally, we thank George Stigler and an anonymous referee for their helpful suggestions.

[*Journal of Political Economy*, 1991, vol. 99, no. 5]
 0022-3808/91/9905-0002$01.50

1989; Schmalensee 1989). Between these two extremes lies a range of theories with varying quantitative predictions about the prevalence and consequences of entry. To discriminate among these different theories, we require more detailed empirical models of entry.

Several recent papers have developed detailed econometric models of entry's competitive effects. These include Carlton (1983), Bresnahan and Reiss (1988, 1990), Schary (1988), Berry (1989), Geroski (1989), Lane (1989), and Reiss and Spiller (1989).[1] We extend this research by developing an empirical model of entry for situations in which one does not observe incumbents' or entrants' price-cost margins. Our empirical model builds on Chamberlin's (1933) and Panzar and Rosse's (1987) theoretical description of free-entry competition. In contrast to previous empirical models, firms have U-shaped average costs and entrants may face entry barriers. From this free-entry model we develop the idea of a demand *entry threshold,* a measure of the market size required to support a given number of firms. We show that ratios of entry thresholds provide scale-free measures of entry's effect on market conduct.

The empirical section of our paper estimates entry thresholds for five retail and professional service industries. We obtain these estimates from cross-section data on the number of firms in 202 distinct geographic markets. These markets differ primarily in the number of local residents, a variable we relate to our entry threshold concept. Following Bresnahan and Reiss (1990), we develop ordered probit models of the equilibrium number of market entrants. Structural shifts in these models enable us to estimate the effect of entry on firm profits. Our empirical results suggest that competitive conduct changes quickly as market size and the number of incumbents increase. In markets with five or fewer incumbents, almost all variation in competitive conduct occurs with the entry of the second and third firms. Surprisingly, once a market has between three and five firms, the next entrant has little effect on competitive conduct. We use price data from one of our industries to cross-validate these findings. These data show that prices fall when the second and third firms enter and then level off. We also find that oligopoly prices level off above those in a competitive urban market.

II. Entry and Market Size

Our empirical model provides information about the consequences of entry by relating shifts in market demand to changes in the equilib-

[1] Other empirical studies of entry into concentrated markets examine the decline of dominant firms. See, e.g., Encaoua, Geroski, and Jacquemin (1986) and the references therein.

rium number of firms. We summarize this relationship using the concept of a zero-profit equilibrium level of demand, what we call an "entry threshold." This section defines and interprets entry thresholds. We begin by describing our assumptions about market demand and firms' costs.

A. *Demand, Technology, Competition, and Entry*

Consider a product market in which demand has the form

$$Q = d(\mathbf{Z}, P)S(\mathbf{Y}). \tag{1}$$

Here, $d(\mathbf{Z}, P)$ represents the demand function of a "representative consumer," $S(\mathbf{Y})$ denotes the number of consumers, and the vectors $\mathbf{Y}$ and $\mathbf{Z}$ denote demographic variables affecting market demand. This demand specification presumes that if the number of consumers doubles, total market demand will double at any given price. Put another way, if we moved a consumer to a different size market and kept $\mathbf{Z}$ and P constant, the consumer's tastes would not change. We adopt this demand specification primarily because it simplifies our analysis of entry thresholds. Later we discuss its applicability to our sample of industries.[2]

On the cost side, we assume that firms incur fixed costs of $F(\mathbf{W})$ and have marginal costs of $\mathrm{MC}(q, \mathbf{W})$, where $\mathbf{W}$ represents exogenous variables affecting costs and q is firm output.[3] In Bresnahan and Reiss (1988), we assumed that firms had constant marginal costs. Here we assume that firms have U-shaped average total costs, declining initially because of fixed costs and rising later because of increasing marginal costs. We represent average variable costs by $\mathrm{AVC}(q, \mathbf{W})$.

B. *A Diagrammatic Analysis of Entry Thresholds*

Our empirical analysis draws inferences about the extent of competition by relating the number of entrants, N, to the size of their market, S. To predict how N should vary with S, we begin by considering a homogeneous product market with many identical potential entrants. Each firm has the long-run cost functions displayed in figure 1. The demand curve labeled D_1 depicts the minimal level of demand a single firm needs to break even. At this level of demand, S_1 consumers pay

[2] When market demand increases nonlinearly in S, we obtain more complicated equilibrium relationships between markups and entry thresholds. In our empirical analysis, we perform joint tests of the linear demand specification in (1) and the equilibrium relationships implied by our model of competition.

[3] We do not distinguish between fixed and sunk costs because we cannot separately identify these costs with cross-section data.

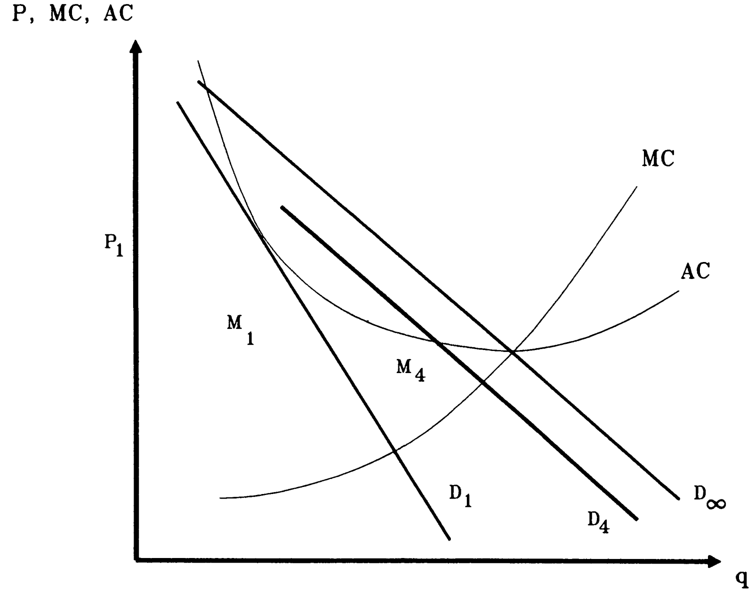

FIG. 1.—Breakeven firm demand and margins

price P_1. Although a monopolist just breaks even at this price, it earns the substantial price-cost margin M_1.

As the size of this market increases, market demand rotates outward. This increase increases the monopolist's profits. It also increases potential entrants' postentry profits. Most oligopoly theories predict that continued demand growth will encourage entry, thereby reducing incumbents' margins. Eventually, as market demand grows large relative to minimum efficient scale, firms' price-cost margins will tend to competitive levels. In figure 1, this occurs when the per firm demand curve D_∞ passes through the bottom of average total cost.

To measure the rate at which oligopoly margins decline toward zero, we would ideally like to observe how quickly the breakeven price-cost margins $M_N = P_N - \mathrm{MC}(q_N)$ fall as N increases from one to two firms, two to three firms, and so on. Because we rarely observe margins, we instead use entry thresholds to draw inferences about margins. To understand what entry thresholds tell us about the effects of entry, we first compare the monopoly and competitive entry thresholds. A monopolist earns zero economic profits when

$$\Pi_1(S_1) = [P_1 - \mathrm{AVC}(q_1, \mathbf{W})]d(\mathbf{Z}, P_1)S_1 - F = 0. \tag{2}$$

This equation shows that

$$S_1 = \frac{F}{[P_1 - \mathrm{AVC}(q_1, \mathbf{W})]d(\mathbf{Z}, P_1)}, \tag{3}$$

the ratio of unobservable fixed costs F to variable profits per customer, $P_1 - \mathrm{AVC}(q_1, \mathbf{W})$. The larger fixed costs or the lower variable profits, the greater the market size needed to support a single entrant.

The competitive analogue of the monopoly entry threshold is the per firm entry threshold, $s_\infty = \lim_{N\to\infty} S_N/N$. This entry threshold equals fixed costs divided by competitive variable profits. The entry threshold ratio s_∞/s_1 measures the fall in variable profits per customer between a monopoly and a competitive market. This scale-free measure of competition is bounded below by unity and increases with a steepening of the monopolist's demand curve. Equivalently, the more efficient a monopolist is at surplus extraction, the greater this ratio.

Between monopoly and perfect competition lies oligopoly. The analysis above suggests that we can use ratios of oligopoly entry thresholds to draw inferences about changes in oligopoly variable profits (and margins). For example, changes in the threshold ratio s_∞/s_N tell us how quickly oligopoly variable profits approach competitive variable profits. To see graphically what changes in entry thresholds measure, return to figure 1. The per firm demand curve D_4 depicts the level of demand required for the fourth entrant to break even. As drawn, entry by the second through fourth entrants has moved M_4 much closer to M_∞ than M_1. Because the breakeven scale for an entrant also increases relatively, s_4 will generally be closer to s_∞ than s_1.

As a practical example of how we plan to compare entry thresholds, suppose that we observe that it takes 2,000 customers to support a monopolist (i.e., $s_1 = 2{,}000$) and that the market becomes perfectly competitive when each firm has 4,000 customers (i.e., $s_\infty = 4{,}000$). These two entry thresholds bracket the range of oligopoly entry thresholds we should observe. If, for instance, the fourth entrant expects to compete in a perfectly competitive market, then we should observe $S_4 = 4 \times 4{,}000 = 16{,}000$ consumers, or $s_\infty/s_4 = 1$. This ratio would tell us that quadropolists earn the same variable profits per customer as competitive firms. Alternatively, suppose that the fourth entrant is part of a cartel; it enters when it covers its fixed costs at the monopoly price, that is, when the market has $4 \times 2{,}000 = 8{,}000$ consumers. In this case, $s_\infty/s_4 = 2$. Extending this logic to degrees of postentry competition between cartels and perfect competition, we would generally expect to observe per firm entry thresholds between 2,000 and 4,000 customers. When we observe s_4 equal to 3,810 customers, for example, we shall usually conclude that the market is nearly competitive. In this case, the ratio s_∞/s_4 equals 1.05, indicating that a quadropolist serves about 5 percent fewer customers than a competitive firm.

To describe more formally the economic information in entry thresholds, we now develop the equilibrium structure of s_N. In a homogeneous industry, the Nth entrant earns profits of

$$\Pi_N = [P_N - \text{AVC}(q_N, \mathbf{W}) - b_N]d_N\frac{S}{N} - F_N - B_N, \tag{4}$$

where $d_N = d(\mathbf{Z}, P_N)$. We include the constants $b_N \geq 0$ and $B_N \geq 0$ in equation (4) to allow for the possibility that later entrants have higher variable or fixed costs. The breakeven condition $\Pi(S_N) = 0$ defines the breakeven level of demand we call the per firm entry threshold. Formally,

$$s_N = \frac{S_N}{N} = \frac{F_N + B_N}{(P_N - \text{AVC}_N - b_N)d_N}. \tag{5}$$

As in equation (3), it equals the ratio of fixed costs to equilibrium variable profits per customer. Holding production and entry costs fixed, we see that s_N decreases with increases in variable profits and margins. The entry threshold s_N also decreases with decreases in fixed costs.

Following our earlier graphical analysis, we use the ratio

$$\frac{s_{N+1}}{s_N} = \frac{F_{N+1} + B_{N+1}}{F_N + B_N}\frac{(P_N - \text{AVC}_N - b_N)d_N}{(P_{N+1} - \text{AVC}_{N+1} - b_{N+1})d_{N+1}} \tag{6}$$

to measure the rate at which markups or variable profits fall with entry. From comparative statics on the first-order conditions for quantities and the zero-profit conditions governing entry, we can show that if firms have the same costs and if entry does not change competitive conduct, then $s_{N+1}/s_N = 1$. Thus departures of successive entry threshold ratios from one measure whether competitive conduct changes as the number of firms increases. Notice that this statistic does not measure the *level* of competition. Instead, it measures how the level *changes* with the number of firms. Consider, for example, the entry threshold ratios one would observe in a cartelized industry in which $b_N = B_N = 0$. A cartel with N firms requires N times a single monopolist's breakeven level of demand. When firms preserve the cartel as N increases, we observe $s_2 = s_1$, $s_3 = s_2$, $s_4 = s_3$, and so on, just as in the competitive case. What one makes of this equivalence depends on what one assumes about the prevalence of competition after several firms have entered. Most oligopoly theories suggest that when the ratio of successive per firm entry thresholds converges to one for large values of N, the market is competitive.[4]

When firms do not have the same costs, ratios of entry thresholds have the form

$$\frac{s_N}{s_M} = \frac{V_M}{V_N} \frac{F_N + B_N}{F_M + B_M}. \tag{7}$$

In this equation, V_M stands for the Mth entrant's breakeven variable profits. These ratios combine information about the decline in firms' postentry profits with information about differences in fixed costs. We interpret this ratio as we did before, only now we draw inferences based on maintained hypotheses about differences in entrants' V's, F's, B's, and b's. For example, if B_N increases with N, then successive entry threshold ratios will remain above one.

So far we have considered entry thresholds under the assumption that one does not observe firms' prices or quantities. Suppose that one does observe prices and quantities. Do entry thresholds provide additional information about competition and firms' technologies? Equation (5) suggests that entry thresholds do. If we have margin and output data, we can estimate V_N. From this estimate, we can calculate $F_N + B_N$ using equation (5). Thus margin and output data allow us to recover information on fixed costs.

In practice, one rarely has both margin and output data. This means that it may not be possible to estimate fixed costs. Even when we do not have complete data, we can still use entry thresholds to provide information on the extent of competition and firms' technologies. Now, however, we must evaluate entry thresholds by making additional assumptions about the unobservables underlying equation (6). For example, by making assumptions about postentry competition, differences among firms' costs, and the shape of market demand, we can predict how fast margins will change with S and how fast s_{N+1}/s_N will converge to one. Table 1 provides an illustration of how price-cost margins and successive entry threshold ratios change for identical Cournot-Nash competitors. To construct the table, we assumed $P = a - b(Q/S)$, and each firm has total costs of $C = F + mq + kq^2$.[5]

Columns 1 and 2 of table 1 present results comparable to those of the constant marginal cost model used in Bresnahan and Reiss (1988). With constant marginal costs, firms' equilibrium profits increase lin-

[4] We note, however, that without price or quantity information, we cannot rule out the possibility that market competition converged to some less competitive norm. Thus in concentrated markets, we shall draw inferences from changes instead of levels. We illustrate this point in Sec. IV.

[5] The calculations in the table assume $a - m = 15$, $F = 5$, and $b = 1$.

TABLE 1

SUCCESSIVE ENTRY THRESHOLD RATIOS FOR A COURNOT OLIGOPOLY MODEL WITH LINEAR DEMAND AND CONSTANT MARGINAL COSTS

	k = 0, MES = ∞		k = 2, MES = 1.58		k = 10, MES = .71	
NUMBER OF FIRMS	s_{N+1}/s_N (1)	$P_N - \mathrm{MC}_N$ (2)	s_{N+1}/s_N (3)	$P_N - \mathrm{MC}_N$ (4)	s_{N+1}/s_N (5)	$P_N - \mathrm{MC}_N$ (6)
1	2.25	7.5	2.17	6.3	2.01	.8
2	1.78	5.0	1.64	3.8	1.52	.4
3	1.56	3.8	1.42	2.7	1.34	.3
4	1.44	3.0	1.31	2.1	1.25	.2
5	1.36	2.5	1.24	1.7	1.20	.2
20	1.10	.8	1.06	.4	1.05	.0
∞	1.00	.0	1.00	.0	1.00	.0

NOTE.—Price minus marginal cost equals $15 - (Q/S) - 2kq$. Fixed costs equal five. MES denotes minimum efficient scale

early in S. Firms' margins, therefore, do not change unless entry occurs.[6] The other columns in the table show how entry threshold ratios change as the slope of marginal costs (controlled by k) increases. Holding k fixed, we see that entry threshold ratios and price-cost margins decline at a decreasing rate as N increases. Increasing k also reduces successive entry threshold ratios, but not by much compared to the rate at which they fall with N.

The entry thresholds in this table exhibit the general pattern that we expect to observe in our data. As entry occurs, competition increases and entry threshold ratios *gradually* decline toward one. Although our example assumes that all firms are the same, one can readily generalize our model to allow for differentiated products and interfirm differences. Consider, for example, what one would observe if later entrants had higher costs, perhaps because they used less efficient technologies or faced entry barriers.[7] From equation (7), we see that when later entrants have higher costs, s_N increases relative to s_1. Consider also how this ratio changes when firms price discriminate. Since a price-discriminating monopolist earns greater profits per customer at any market size, it will have a smaller breakeven level of demand. If, in addition, entry reduces opportunities for price discrimination, then price discrimination will tend to lower s_1 relative to s_N, much in the same way that increased postentry competition raises

[6] By contrast, if we assumed that firms were Bertrand competitors, then this market would have a natural monopoly.

[7] Many recent models define entry barriers as strategic actions that disadvantage an entrant. This definition differs from Bain's (1956) and Stigler's (1968) definitions. Our empirical definition of entry barriers comes closest to Stigler's cost-based definition.

s_N relative to s_1. Finally, similar arguments suggest that when firms can differentiate their products, s_N will fall relative to s_1.

III. Retail and Professional Market Entry Thresholds

To estimate a series of entry thresholds, we require data on demand and the number of firms in a market. Ideally, we would like to observe a single industry in which market demand has fluctuated enough to cause significant firm turnover. Here we instead use a cross section of geographically concentrated markets to conduct the same empirical comparative statics. Firms in these markets face different levels of demand for their products. By carefully prescreening our sample of markets, we can hold constant extraneous differences across markets.

Our sample contains 202 isolated local markets. A typical market in our sample is a county seat in the western United States. These county seats are separated from other towns in the county. Because most of the local population resides in or near the central town, its population provides a reasonable first approximation to $S(\mathbf{Y})$. Figure 2 plots the distribution of our sample markets by ranges of the central town's population. This figure shows that our sample towns cover a wide range of market sizes, making it possible to estimate the population required to support one, two, and more firms.

In an earlier paper, we estimated a market's first two entry thresholds under the assumption that firms had constant marginal costs. Here we extend our analysis to consider U-shaped average costs and entry thresholds for the third, fourth, and fifth firms. We selected our sample of markets and industries using criteria developed in our earlier work (see Bresnahan and Reiss 1988, 1990). Briefly, we located towns or small cities in the continental United States that were at least 20 miles from the nearest town of 1,000 people or more. We eliminated towns that were near large metropolitan areas or were part of a cluster of towns. Our specific criteria exclude, for example, towns within 100 miles of a city of 100,000. We believe, a priori, that these selection criteria ensure that we can identify all relevant competitors. In the next section, we also propose a test of this hypothesis.[8]

We limited our study to industries or occupations in which we could identify all sellers of a narrowly defined product or service. We did not consider grocery and clothing stores, for example, because they sell a range of products. Table 2 lists the products and services that

[8] Some consumers in our markets may drive long distances to visit other markets. To apply our theory, we require that at least some consumers with high reservation prices do not leave the market.

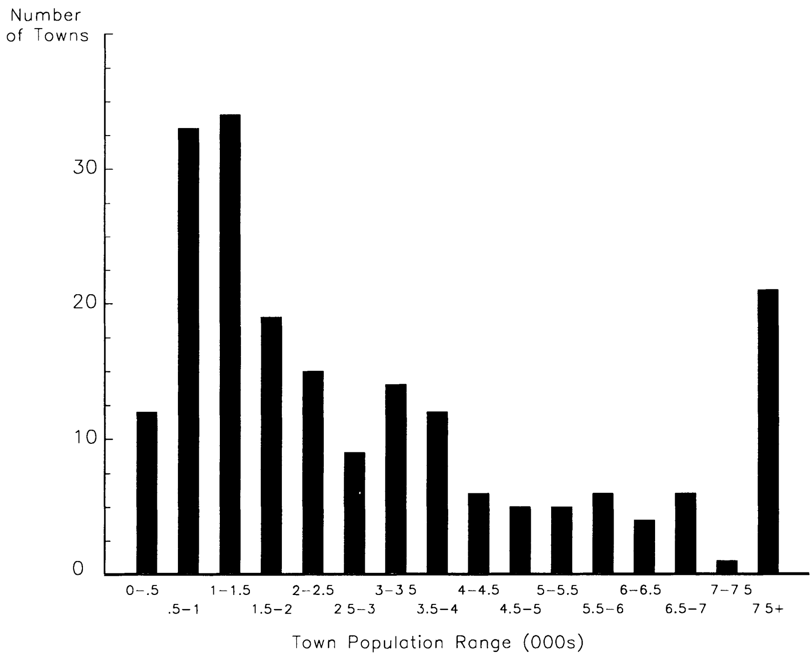

FIG. 2.—Number of towns by town population

we considered initially. Because our econometric procedures require several observations in each market size class, we eliminated all industries that did not have at least 10 observations in each size class (i.e., markets with either $N = 0, \ldots, 4$ or five or more firms). We subsequently dropped beauticians and electricians because we could not reliably estimate S_4 and S_5 for these industries. Our final sample includes the following five industries: doctors, dentists, druggists, plumbers, and tire dealers.[9]

We identified firms in each market using telephone books and trade information. We checked the accuracy of these lists by visiting some of our markets and by matching them to secondary sources. The most difficult practical issue we faced when counting firms was how to treat multiple health service practices at the same address. When these practices had the same phone number, we treated them as part of one multiperson firm. We also estimated the doctor and dentist models treating each physician and dentist as a firm. This convention only slightly changes the estimated entry threshold ratios.

[9] We did not estimate entry thresholds for farm equipment dealers because we had difficulty defining $S(\mathbf{Y})$ in larger markets. We tried county-level variables such as the number of farms, the number of large farms, the land area of farms, and numbers of farm animals.

TABLE 2

Market Counts by Industry and Number of Incumbents

Industry	Number of Firms							
	$N = 0$	$N = 1$	$N = 2$	$N = 3$	$N = 4$	$N = 5$	$N = 6$	$N \geq 7$
Druggists	28	62	68	23	8	6	3	4
Doctors	37	61	36	16	11	7	6	28
Dentists	32	67	39	15	12	12	4	21
Plumbers	71	47	26	21	10	4	6	17
Tire dealers	45	39	39	24	13	15	6	21
Barbers	95	66	23	9	3	6	0	0
Opticians	173	19	5	1	4	0	0	0
Beauticians	10	26	19	24	26	19	11	67
Optometrists	68	85	36	7	3	3	0	0
Electricians	60	54	32	17	10	5	7	17
Veterinarians	53	80	41	21	5	0	1	1
Movie theaters	90	72	25	10	5	0	0	0
Automobile dealers	38	44	54	35	25	2	1	3
Heating contractors	117	40	19	8	4	8	3	3
Cooling contractors	153	30	13	5	1	0	0	0
Farm equipment dealers	90	39	23	19	17	9	1	4

Source.—Authors' tabulations from American Business Lists, Inc.

A. *Predictors of* N

Our theory uses the market size variable $S(\mathbf{Y})$ to predict the number of active firms. The bar charts in figure 3 describe the relationship between our main predictor of S, current town population, and the number of practicing dentists. The two figures report for a given population range the distribution of towns that have zero, one, two, three, four, or five or more dentists. Figure 3*a* summarizes the distribution of towns with no dentist, a monopolist, or two dentists; figure 3*b* summarizes the number of markets with three, four, and five or more dentists. Figure 3*a* suggests that the monopoly dentist entry threshold, S_1, is near 500 people. The duopoly entry threshold, S_2, lies between 1,000 and 2,000 people. Thus if town population alone measured market size, we would conclude that the dentists' duopoly entry threshold ratio, S_2/S_1, is larger than two, suggesting that entry by the second dentist reduces margins.

Although both figures show that the number of dentists increases with current town population, town population imperfectly predicts the number of dentists. Clearly, other factors affect dentists' location decisions. Research summarized in Ernst and Yett (1985), for example, points to such variables as expected future population growth, market demographics, changing economic conditions, consumer incomes, and factor prices. To allow for these differences in markets, we estimated entry thresholds using an econometric model of entrants' long-run discounted profits. Following the discrete choice literature, we model firms' unobserved profits using qualitative information about firm profitability. We know that an industry will have N entrants when $\Pi_N > 0$ *and* $\Pi_{N+1} < 0$. If we assume that profits have additively separable observed and unobserved components, then we can estimate unobserved profits up to an arbitrary normalization. Following the structure of equation (4), we assume that

$$\Pi_N = S(\mathbf{Y}, \lambda)V_N(\mathbf{Z}, \mathbf{W}, \alpha, \beta) - F_N(\mathbf{W}, \gamma) + \epsilon, \tag{8}$$

where λ, α, β, and γ represent profit function parameters, $\mathbf{Y}$ describes market size, $\mathbf{Z}$ and $\mathbf{W}$ shift per capita demand and costs, and the unobserved error term ϵ summarizes profits that we do not observe. To simplify the estimation process, we assume that ϵ has a normal distribution that is independently distributed across markets and is independent of our observables. We also assume that ϵ has zero mean and a constant variance and that each firm within a market has the same profit error. This last assumption presumes that successive entrants' profits differ only through the deterministic variables in (8). In Bresnahan and Reiss (1990), we discuss the economic consequences of these assumptions. (See also Berry's [1989] discussion.) We use these

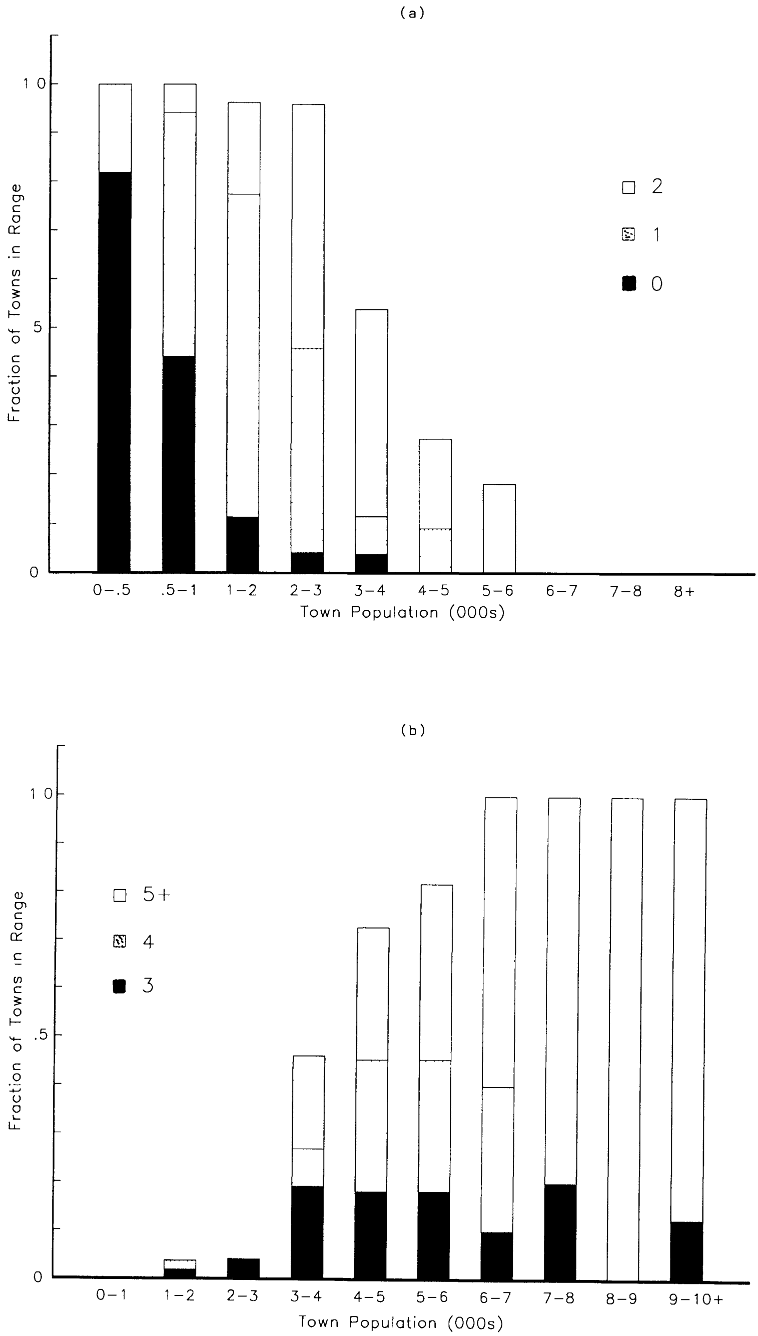

FIG. 3.—Dentists by town population

assumptions here largely because we cannot reject this restricted specification with more general alternatives described in our earlier paper.

The assumption that all firms within a market have the same unobserved profit allows us to use an ordered probit to estimate entry thresholds. These ordered probit models have as their dependent variable the number of firms in the market. We construct the likelihood functions for these ordered probits by calculating probability statements for each type of oligopoly. The probability of observing markets with no firms equals

$$\Pr(\Pi_1 < 0) = 1 - \Phi(\overline{\Pi}_1),$$

where $\Phi(\cdot)$ is the cumulative normal distribution function, and $\Pi_1 = \overline{\Pi}_1 + \epsilon$ equals a monopolist's profits. If $\overline{\Pi}_1 \geq \overline{\Pi}_2 \geq \ldots \geq \overline{\Pi}_5$, the probability of observing N firms in equilibrium ($N = 1, 2, 3$, or 4) equals

$$\Pr(\Pi_N \geq 0 \text{ and } \Pi_{N+1} < 0) = \Phi(\overline{\Pi}_N) - \Phi(\overline{\Pi}_{N+1}).$$

The residual probability of observing five or more firms equals

$$\Pr(\Pi_5 \geq 0) = \Phi(\overline{\Pi}_5).$$

Table 3 summarizes the variables we included in **W**, **Y**, and **Z**; defines our variables; and presents sample descriptive statistics. We model market size as a linear function of population variables. Specifically, we assume that

$$\begin{aligned} S(\mathbf{Y}, \lambda) = {} & \text{town population} + \lambda_1 \text{ nearby population} \\ & + \lambda_2 \text{ positive growth} + \lambda_3 \text{ negative growth} \\ & + \lambda_4 \text{ commuters out of the county}. \end{aligned} \tag{9}$$

We set the coefficient of town population in $S(\mathbf{Y}, \lambda)$ equal to one because V_N contains a constant term. This normalization translates units of market demand into units of current town population. We include population within 10 miles of town, nearby population, to allow the population surrounding a town to increase demand.[10] The growth variables—positive growth and negative growth—represent, respectively, the positive and negative growth in town population from 1970 to 1980. These growth terms capture entrants' asymmetric expectations about future market growth, as well as lags in responses to past growth (see, e.g., Hause and Du Rietz 1984; Dixit 1989). We include the variable commuters out of the county to check our market

[10] In Bresnahan and Reiss (1988), we compared this measure to ones that counted people within 5 miles, 20 miles, and 25 miles of town.

TABLE 3

SAMPLE MARKET DESCRIPTIVE STATISTICS

Variable	Name	Mean	Standard Deviation	Min	Max
Firm counts:					
Doctors	DOCS	3.4	5.4	.0	45.0
Dentists	DENTS	2.6	3.1	.0	17.0
Druggists	DRUG	1.9	1.5	.0	11.0
Plumbers	PLUM	2.2	3.3	.0	25.0
Tire dealers	TIRE	2.6	2.6	.0	13.0
Population variables (in thousands):					
Town population	TPOP	3.74	5.35	.12	45.09
Negative TPOP growth	NGRW	−.06	.14	−1.34	.00
Positive TPOP growth	PGRW	.49	1.05	.00	7.23
Commuters out of the county	OCTY	.32	.69	.00	8.39
Nearby population	OPOP	.41	.74	.01	5.84
Demographic variables:					
Birth ÷ county population	BIRTHS	.02	.01	.01	.04
65 years and older ÷ county population	ELD	.13	.05	.03	.30
Per capita income ($1,000's)	PINC	5.91	1.13	3.16	10.50
Log of heating degree days	LNHDD	8.59	.47	6.83	9.20
Housing units ÷ county population	HUNIT	.46	.11	.29	1.40
Fraction of land in farms	FFRAC	.67	.35	.00	1.27
Value per acre of farmland and buildings ($1,000's)	LANDV	.30	.23	.07	1.64
Median value of owner-occupied houses ($1,000's)	HVAL	32.91	14.29	9.90	106.0

SOURCE.—Firm counts: American Business Lists, Inc.; population variables: U.S. Bureau of the Census (1983) and *Rand McNally Commercial Atlas and Marketing Guide* (annual); demographic variables: U.S. Bureau of the Census (1983).

definition. It represents the Census Bureau's count of county residents who commute to work outside the county. A negative value of λ_4 suggests that commuters purchase goods in nearby markets.

We model firms' per capita variable profits, V_N, as a function of the number of firms, N, and economic variables, $\mathbf{X} = [\mathbf{W}, \mathbf{Z}]$. We assume that this function has the linear form

$$V_N = \alpha_1 + \mathbf{X}\beta - \sum_{n=2}^{N} \alpha_n. \tag{10}$$

The term $V_1 = \alpha_1 + \mathbf{X}\beta$ equals the per capita variable profit of a monopolist. In previous work, we experimented with alternative nonlinear functional forms for V_1 with limited success. (See Reiss and Spiller [1989] for a nonlinear structural model of V_N.) We include **X** in profits to control for differences in monopoly variable profits across markets. Because we do not have town-specific demographic and economic information, our **X** variables come from county-level census data sources. We included per capita income in each industry's specification because consumer income usually affects the demand for goods and services. We included the number of births and the number of elderly residents in both doctors' and dentists' profit functions to control for demographic variation in the demand for and cost of health care services.[11] Because these variables summarize both demand and cost conditions, we do not attempt to draw structural inferences about the signs of their coefficients. Finally, the positive α_n intercepts measure the fall in per capita variable profits when the nth firm enters. Specification (10) assumes that the α_n do not vary across markets. In specifications not reported here, we allowed the α_n to depend on market-specific covariates but found little evidence of intermarket variation in α_n.

The model in Section II implies that S can enter V_N through equilibrium q_N and prices. Below we report specifications that exclude S from (10). We impose this restriction because we could not find significant effects of S on V_N. (When we did include S, the entry thresholds did not change much from those reported below.)

We label terms in (8) that do not include S fixed costs. These costs include both fixed production costs and fixed barriers to entry. In the doctors' specification, for instance, these costs could include the cost of building a patient base and the costs of the doctor's time. Because we do not have detailed information on costs, we assume

$$F_N = \gamma_1 + \gamma_L W_L + \sum_{n=2}^{N} \gamma_n.$$

The term $F_1 = \gamma_1 + \gamma_L W_L$ equals a monopolist's fixed costs. We include the price of agricultural land in it to capture intermarket variation in land costs.[12] The γ_n terms allow later entrants to have higher costs. When we observe γ_n greater than zero, we conclude that later entrants have higher fixed costs. We do not know, however, whether these higher costs mean that the entrant is less efficient (i.e.,

[11] Previous cross-section studies of health care services have found that these variables explain significant variation in levels of service (see Ernst and Yett 1985, chaps. 5, 6; Baumgardner 1988).

[12] Bresnahan and Reiss (1988, 1990) report other specifications with different variables in F, such as the local retail wage. These other variables do not significantly affect the estimates we report here.

the supply curve of entrants is upward sloping) or it faces entry barriers.

B. Baseline Estimates

Table 4 reports a set of ordered probit results. Table 5 reports the entry thresholds implied by these probits. Each industry's probit specification has 19 parameters: four λ's, four β's, five α's, and six γ's. As a practical matter, each specification has too many parameters. We included excess variables in these specifications to encompass several alternative models of entrants' profits. As expected, most specifications contain insignificant demand and cost variable coefficients. For example, the per capita income variable does not explain cross-sectional variation in demand or variable costs. We interpret the insignificance of these coefficients as evidence that our sample selection criteria have already provided us with a homogeneous sample.

In maximizing the sample likelihood functions, we imposed the constraint that later entrants do not have higher profits at the same S; that is, we required $\overline{\Pi}_N \geq \overline{\Pi}_{N+1}$. To ensure that this constraint holds, we imposed the constraints $\alpha_N \geq 0$ and $\gamma_N \geq 0$. When these constraints were violated, we report the constrained specification with the highest likelihood value. In the doctors' ordered probit model, for instance, this criterion led us to choose the likelihood function that set α_3 and α_5 equal to zero. Most of the estimated α's and γ's automatically satisfy our constraints; that is, variable profits per customer fall and fixed costs increase as the number of firms increases. We also see, however, that the data do not always distinguish between changes in variable profits and fixed costs. We return to this point below.

Part A of table 5 reports entry threshold estimates for the specifications in table 4. To calculate these entry thresholds, we used the formula

$$S_N = \frac{\hat{\gamma}_1 + \hat{\gamma}_L \overline{W}_L + \sum_{n=2}^{N} \hat{\gamma}_n}{\hat{\alpha}_1 + \overline{X}\hat{\beta} - \sum_{n=2}^{N} \hat{\alpha}_n}, \tag{11}$$

where a bar over a variable denotes the sample mean and a circumflex denotes the corresponding maximum likelihood estimate reported in table 4.[13] The estimates in table 5 suggest that a monopoly tire dealer

[13] Our estimates do not change by much if we replace the sample means of **X** and **W** by their monopoly market means.

TABLE 4

Baseline Specifications

Variable Name	Doctors	Dentists	Druggists	Plumbers	Tire Dealers
OPOP (λ_1)	1.15	−.46	.08	.27	−.53
	(.85)	(.32)	(.37)	(.60)	(.43)
NGRW (λ_2)	−1.89	.63	−.30	.68	2.25
	(1.60)	(.85)	(.97)	(1.10)	(.75)
PGRW (λ_3)	1.92	−.35	−.24	−.45	.34
	(1.01)	(.41)	(.41)	(.36)	(.59)
OCTY (λ_4)	.80	2.72	.16	−.28	.23
	(1.26)	(.98)	(.34)	(.71)	(.94)
BIRTHS (β_1)	−.59	9.86	11.34		
	(6.57)	(8.29)	(10.10)		
ELD (β_2)	−.11	.22	2.61		−.49
	(.55)	(.74)	(.78)		(.75)
PINC (β_3)	−.00	.04	.02	.05	−.03
	(.00)	(.03)	(.02)	(.03)	(.04)
LNHDD (β_4)	.013	.28	.08	.003	.004
	(.05)	(.07)	(.06)	(.06)	(.06)
HUNIT (β_5)				.51	
				(.46)	
HVAL (β_6)				.42	
				(.03)	
FFRAC (β_7)					−.02
					(.08)
V_1 (α_1)	.63	−1.85	−.13	.06	.86
	(.46)	(.61)	(.58)	(.52)	(.45)
$V_1 - V_2$ (α_2)	.34		.29		.03
	(.17)		(.21)		(.15)
$V_2 - V_3$ (α_3)		.12	.19	.15	.15
		(.14)	(.17)	(.09)	(.10)
$V_3 - V_4$ (α_4)	.07	.20	.25	.07	
	(.05)	(.06)	(.14)	(.08)	
$V_4 - V_5$ (α_5)			.04	.04	.08
			(.12)	(.07)	(.05)
F_1 (γ_1)	.92	1.10	.91	1.28	.53
	(.30)	(.25)	(.29)	(.26)	(.23)
$F_2 - F_1$ (γ_2)	.65	1.84	1.34	1.04	.76
	(.30)	(.19)	(.35)	(.14)	(.21)
$F_3 - F_2$ (γ_3)	.84	1.14	1.77	.32	.46
	(.13)	(.46)	(.54)	(.28)	(.21)
$F_4 - F_3$ (γ_4)	.18		.06	.40	.60
	(.23)		(.70)	(.35)	(.12)
$F_5 - F_4$ (γ_5)	.42	.66	.51	.25	.12
	(.13)	(.60)	(.95)	(.35)	(.20)
LANDV (γ_L)	−1.02	−1.31	−.84	−1.18	−.74
	(.53)	(.37)	(.51)	(.48)	(.34)
Log likelihood	−233.49	−183.20	−195.16	−228.27	−263.09

Note.—Asymptotic standard errors are in parentheses

TABLE 5

A. Entry Threshold Estimates

Profession	Entry Thresholds (000's)					Per Firm Entry Threshold Ratios			
	S_1	S_2	S_3	S_4	S_5	s_2/s_1	s_3/s_2	s_4/s_3	s_5/s_4
Doctors	.88	3.49	5.78	7.72	9.14	1.98	1.10	1.00	.95
Dentists	.71	2.54	4.18	5.43	6.41	1.78	.79	.97	.94
Druggists	.53	2.12	5.04	7.67	9.39	1.99	1.58	1.14	.98
Plumbers	1.43	3.02	4.53	6.20	7.47	1.06	1.00	1.02	.96
Tire dealers	.49	1.78	3.41	4.74	6.10	1.81	1.28	1.04	1.03

B. Likelihood Ratio Tests for Threshold Proportionality

Profession	Test for $s_4 = s_5$	Test for $s_3 = s_4 = s_5$	Test for $s_2 = s_3 = s_4 = s_5$	Test for $s_1 = s_2 = s_3 = s_4 = s_5$
Doctors	1.12 (1)	6.20 (3)	8.33 (4)	45.06* (6)
Dentists	1.59 (1)	12.30* (2)	19.13* (4)	36.67* (5)
Druggists	.43 (2)	7.13 (4)	65.28* (6)	113.92* (8)
Plumbers	1.99 (2)	4.01 (4)	12.07 (6)	15.62* (7)
Tire dealers	3.59 (2)	4.24 (3)	14.52* (5)	20.89* (7)

Note.—Estimates are based on the coefficient estimates in table 4. Numbers in parentheses in pt. B are degrees of freedom.
* Significant at the 5 percent level.

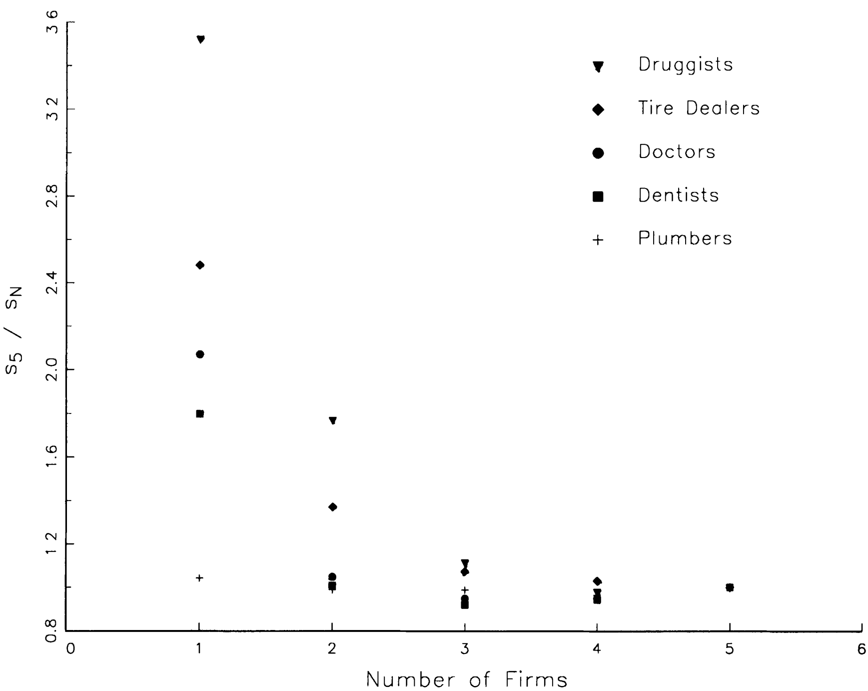

FIG. 4.—Industry ratios of s_5 to s_N by N

or druggist requires about 500 people in town to set up business. A monopoly doctor or dentist needs between 700 and 900 people. Monopoly plumbers require at least twice what monopoly doctors or dentists need to break even.

Part B of table 5 reports ratios of successive per firm entry thresholds. These ratios decline with N. Notice, however, that the decline stops abruptly at $N = 3$ and that s_3 approximately equals s_4 and s_5. Figure 4 illustrates this decline. It plots the ratio of the market size required to support five versus N firms, that is, s_5/s_N. This ratio by definition equals one for $N = 5$. For $N < 5$, it can vary anywhere from one to infinity, depending on the entrants' estimated costs and variable profits (see eq. [11]). Figure 4 shows that these ratios are very near one once the market has more than two firms. In markets with two or fewer firms, however, they may be much greater than one.

Equation (6) suggests several reasons why the first two entry threshold ratios may depart from one. In a homogeneous good industry, the entry threshold ratio increases in the ratio of margins, entry costs, entrant inefficiencies, and the slope of long-run average variable costs. Price discrimination and product differentiation also could cause entry threshold ratios to depart from one. We believe that the doctors, dentists, tire dealers, druggists, and plumbers in our sample compete in relatively homogeneous markets. We also believe that they use similar production technologies and have similar costs.[14] Under the maintained hypothesis of homogeneous entrants, our results suggest that entry does not change margins and costs by much. However, we cannot completely rule out the possibility that offsetting movements in demand and costs could leave entry thresholds constant. For example, one could challenge our maintained assumptions by arguing that product differentiation offsets competitive decreases in margins, thereby leaving entry threshold ratios constant. While such offsetting changes could occur, the patterns exhibited in figure 4 appear to require remarkably coincident changes in margins.

To test whether the different entry threshold ratios in figure 4 reflect systematic differences among entrants, we tested whether entry thresholds remain unchanged as N increases. Column 1 in part B of table 5 reports likelihood ratio test statistics for the null hypothesis that $s_4 = s_5$. To perform this test, we constrained α_5 and γ_5 so that $s_4 = s_5$. Subsequent columns report tests of the hypotheses that $s_3 = s_4 = s_5$, $s_2 = s_3 = s_4 = s_5$, and $s_1 = s_2 = s_3 = s_4 = s_5$. Apart from dentists, we do not reject the null hypothesis that the per firm triopoly entry threshold equals the per firm quadropoly and quintopoly entry thresholds. These tests do, however, reject the equality of the monopoly through quintopoly entry thresholds. Although these individual test statistics are not independent, we believe that they suggest that duopoly and triopoly entry threshold ratios decrease because of competition.

We also explored the robustness of the results in table 5 to our use of five or more firms as a residual category. By using only four or more firms as a residual category, we increase the number of industries we can consider from five to eight. The entry threshold ratios we obtain for our original five industries do not differ much from those in table 5. We also obtained similar patterns of entry threshold ratios for two other industries, heating contractors and barbers. These industries, for example, have ratios of S_4 to S_3 close to $4/3$. Auto dealers provide the sole exception to our previous findings: they have S_4/S_3 well above $4/3$. In principle, this departure reflects differences between the third and fourth dealers as well as increases in competition. One important difference between the third and fourth new-car dealers in our sample is that the fourth entrant is typically a second General Motors dealer, the first intrabrand competitor. Because the

[14] The American Medical Association's *Directory of Physicians* confirms that most of our doctors have general or family practices. The American Dental Association's *Directory of Dentists* suggests that our dentists mostly provide general dentistry services. A casual study of Yellow Page advertisements revealed that firms primarily differentiated themselves by location.

fourth dealer provides a close substitute that intensifies competition, it may require much more demand than the third dealer to break even.

The monopoly and duopoly entry threshold ratios in figure 4 raise several other questions about differences among entrants. What factors, for instance, explain the interindustry differences in these ratios? At one extreme, we observe that plumbers have ratios close to one at all market sizes. Other industries have ratios substantially greater than one. We also observe that the ratios fall at varying rates as N increases. These changes are consistent with theories that predict that competition changes at varying rates as N increases. They are also, however, consistent with theories that say that entrants' costs increase as the number of firms grows. We tend to discount cost-based explanations for our results on a priori grounds. Our dentists, doctors, and druggists, for example, receive comparable professional training. They also use similar equipment. One might explain some variation in our ratios by differences in professionals' opportunity costs and their willingness to relocate. We could, for example, observe high ratios if professionals with low opportunity costs sought out isolated monopolies. We cannot rule out these interpretations without knowing the timing of entry and the identity of entrants. We plan to address these issues with panel data in future work.

Differences in the rate of decline of entry thresholds across industries also raise interesting questions about competition. Most simple explanations for the interindustry differences in tables 4 and 5 provide imperfect explanations of figure 4. One might argue, for instance, that a major difference between monopoly plumbers and doctors is that plumbers have more opportunities for spreading fixed costs. Although our model does not explicitly consider the incremental fixed costs of other businesses, these other opportunities might allow monopolists to enter earlier than if they operated only one business. This suggests that industries with part-time opportunities will have high ratios of s_2/s_1. Of our industries, we believe that plumbers have the best part-time opportunities. Yet they have ratios of s_2/s_1 close to one. Similarly, we believe that druggists have more part-time opportunities than doctors or dentists. Yet the professionals all have similar monopoly and duopoly entry threshold ratios. Thus part-time opportunities provide an imperfect explanation for our monopoly and duopoly results.

C. *Specification Issues*

The coefficient estimates in table 4 and the summary entry threshold ratios in figure 4 appear to show that entry by the third and fourth firms does not substantially change competitive conduct. We now test

TABLE 6

LIKELIHOOD RATIO TESTS FOR EQUAL FIXED COSTS

Profession	Likelihood Value	Test Statistic	Degrees of Freedom	s_2/s_1	s_3/s_2	s_4/s_3	s_5/s_4
Doctors	247.80	28.63*	2	1.56	1.11	1.02	1.08
Dentists	187.84	9.29*	1	1.51	1.10	.98	1.01
Druggists	205.10	19.89*	4	1.68	1.55	1.16	1.09
Plumbers	231.69	6.84	3	.99	.99	1.07	1.08
Tire dealers	266.90	7.61*	2	1.32	1.24	1.07	1.11

* Significant at the 5 percent level.

various hypotheses about why entrants' profits differ. We tested three sets of hypotheses about variable profits. First, we tested for differences in entrants' fixed costs. Second, we tested whether only current town population explains market size. Third, we considered whether variations in local economic conditions explained differences in firms' variable profits. For each of these hypotheses, we report tests of the hypothesis and estimates of the entry thresholds under the maintained hypothesis.

The profit function (8) depends on N through α_N and γ_N. Most of our estimates of α_N and γ_N in table 4 have large standard errors, suggesting that profits do not change significantly with N. When we exclude one of these parameters, however, we usually obtain much smaller standard errors on the other parameter.[15] To test whether only variable profits fall with N, we tested the null hypothesis that all firms had the same fixed costs. Table 6 summarizes our test results and the constrained entry threshold ratios. The likelihood ratio statistics generally reject the null hypothesis of equal fixed costs. Only plumbers appear to have similar fixed costs. While we find evidence that later entrants have higher fixed costs, we cannot say whether these fixed costs represent efficiency differences or entry barriers. We note, however, that whatever the sources of cost differences, the constrained entry threshold ratios do not differ much from the unconstrained estimates.

We next tested our definition of market size, $S(\mathbf{Y})$. We easily reject the null hypothesis that we can exclude all but current town population from $\mathbf{Y}$. We also tested whether we could delete potentially collinear variables from $\mathbf{Y}$. We performed these tests by excluding all variables from $\mathbf{Y}$ that had coefficients less than their estimated standard errors. Table 7 shows that although we can omit these variables from

[15] When we excluded α_2 from the plumbers' specification, for instance, we found that γ_2 had a much smaller standard error than γ_3, γ_4, or γ_5. This situation parallels the problem of multicollinearity in a linear model.

TABLE 7

LIKELIHOOD RATIO EXCLUSION TESTS FOR THE MARKET SIZE REGRESSORS

Profession	Likelihood Value	Test Statistic	Variables Omitted	s_2/s_1	s_3/s_2	s_4/s_3	s_5/s_4
Doctors	236.35	5.74	OPOP, OCTY	2.33	1.11	1.00	.98
Dentists	183.84	1.30	PGRW, NGRW	1.78	1.11	.98	.98
Druggists	195.61	.90	PGRW, OPOP, OCTY	2.08	1.581	1.16	1.03
Plumbers	228.74	.99	NGRW, OPOP, OCTY	1.05	.98	1.12	1.01
Tire dealers	265.27	4.36	NGRW, OCTY	2.10	1.24	1.03	1.06

market size, no single definition of market size applies to all industries.

Our final set of tests examines the sensitivity of the entry threshold ratios to the variables included in V_N. Specifically, we tested whether we could remove all variables from V_N that had coefficients less than their estimated standard errors. Table 8 shows that we can remove most of these variables. The exclusion of them also does not change our entry threshold estimates. Thus, apart from market size and the market structure dummy variables, we find little intermarket variation in V_N.[16]

As a final check of the results reported in table 4, we tested our market definition criteria. If our markets were too close to other markets, then "leakages" of customers might trivially reduce the market power of our oligopolists and reduce entry threshold ratios. Our measure of the number of workers who commute outside the county proxies for one type of local demand leakage. We expect that if our sample selection criteria did not adequately isolate our markets, then these commuters would have a negative effect on market size. The baseline results in table 4 suggest that these commuters have a small effect, if any.

While our econometric specifications allow for demand leakages, the presence of significant alternative sources of supply nearby could confound our demand comparative statics. For example, although our markets are at least 20 miles from other markets, some people may regularly drive more than 40 miles to visit a doctor or buy tires. We explored the adequacy of our distance criterion by first weakening it and then strengthening it. If our initial distance criteria were sufficiently stringent, then a further strengthening of them should have little effect on our estimated entry thresholds. Conversely, a significant weakening of our market separation criterion should reduce the importance of town population and lower our entry threshold estimates.

To test these conjectures, we first constructed a sample of very isolated markets by removing all markets from our original sample that were within 40 miles of the next town of 1,000 people or more.[17] Consumers in this sample have at least an 80-mile round-trip to the next large town. This criterion eliminated 45 markets, leaving a sample of 157 markets. We also constructed a second, less isolated sample of towns by treating as a market each U.S. county with fewer than 10,000 residents in 1980. Roughly half of these counties are in our

[16] We also included all **X** variables in each industry's variable profit function. These additional variables had little effect on our estimated entry thresholds.

[17] We did not change our other sample selection criteria.

TABLE 8

LIKELIHOOD RATIO EXCLUSION TESTS FOR THE VARIABLE PROFITS REGRESSORS

Profession	Likelihood Value	Test Statistic	Variables Omitted	s_2/s_1	s_3/s_2	s_4/s_3	s_5/s_4
Doctors	233.52	.06	BIRTHS, ELD, PINC	1.98	1.10	1.00	.95
Dentists	183.25	.11	ELD	1.76	1.09	.98	.94
Plumbers	228.29	.36	LNHDD	1.06	1.00	1.03	.96
Tire dealers	263.92	1.66	ELD, PINC, LNHDD, LANDV	1.85	1.28	1.04	1.02

NOTE.—The druggists specification did not have the absolute value of any coefficient smaller than its estimated standard error.

TABLE 9

Entry Thresholds for Alternative Market Definitions

Profession	Weaker Distance Criterion				Stronger Distance Criterion			
	s_2/s_1	s_3/s_2	s_4/s_3	s_5/s_4	s_2/s_1	s_3/s_2	s_4/s_3	s_5/s_4
Dentists	1.13	.88	.94	.99	1.82	1.15	1.06	*
Doctors	1.05	1.07	1.10	1.01	1.93	1.02	1.01	*

* Not estimable because of small sample sizes.

original sample. The other half were not because they failed our market definition criteria. To limit data collection costs, we analyzed data only on doctors and dentists.

Table 9 reports baseline profit specifications for the isolated and unisolated samples. For the more isolated markets, we obtain entry threshold ratios similar to those reported in table 5. For the unisolated sample, however, we find much smaller ratios. These estimates suggest that entry by the second and third health care professionals has a much smaller effect on margins. We also find that if we moved towns closer together, the number of firms in any one town increases in proportion to the combined town populations. In a much earlier study, Pashigian (1961) observed a similar pattern for automobile dealers in urban markets. Both his findings and those in table 9 support our procedure for defining markets.

IV. Supplemental Evidence from Tire Prices

While we believe that entry thresholds decline because of increased competition, we cannot rule out the possibility that high entry threshold ratios indicate that entry barriers delay entrants. To draw more precise inferences about entry thresholds, we require data on costs, prices, or outputs. Toward this end, we collected price information from tire dealers in our sample. We focused on tire dealers primarily because they were the most willing to provide us with price quotes over the phone. During the winter of 1990, we placed phone calls to 165 tire dealers in the western United States. This sample includes a subset of our original dealers and dealers from a large urban market. Most of our phone calls went to dealers in our original sample. Because financial constraints prevented us from phoning all the dealers in our original sample, we phoned dealers until we obtained a balanced sample across market size classes.

Because our phone calls postdate our entry data, we used current

Yellow Page listings to contact dealers and determine the structure of their market. We collected our data by having an interviewer ask the dealer for the price of four 175-80-R13 radial tires. (This size fit the car of one of the authors.)[18] The interviewer asked for a price that included mounting and balancing charges and excluded taxes and trade-in rebates. The interviewer also asked for the mileage rating and brand of the tire since these features explain much of the quality variation in tire prices. When dealers could not give us an exact mileage rating, we asked for the National Highway Traffic Safety Administration's (NHTSA) uniform tire quality grade tread wear rating stamped on the tire.[19] If the dealer carried more than one brand of 175-80-R13 radial tire, the interviewer also requested information on those brands.

A. *The Sample*

Table 10 describes our sample. The columns report information on dealers by the number of dealers in the market in 1990. The column labeled 1.5 covers rural monopolies that fail our original market definition criteria. We included these towns as an additional check on our market definition criteria. The column headed urban covers the competitive southern San Francisco Bay Area tire market. This market includes San Jose and northern Santa Clara County. The top section of the table summarizes dealer response rates. The difference between the second and third lines represents dealers who exited between 1986 and 1990, dealers who changed phone numbers, and so on. The difference between the third and fourth lines summarizes the unwillingness of dealers to quote prices or to supply both mounting and balancing services. Overall, the response rates are high, although firms in concentrated markets were slightly less likely to provide usable price quotations. (A usable price response is one in which the dealer supplied a valid mileage rating and brand name. If a dealer's reported mileage rating fell more than 5,000 miles outside the NHTSA rating, we declared the price quotation invalid.)[20]

The second panel of the table tabulates information on the respondents' prices. Dealers in concentrated markets offered between two and three price quotes on average. While our data pertain to a common domestic tire size, we do not know whether variations in the dealers' willingness to quote prices reflect the quality of their service or the types of tires that they supply.

[18] This author reports finding an excellent deal.

[19] See National Highway Traffic Safety Administration (1988). This publication reports the tread wear ratings and other tire information.

[20] For example, one dealer insisted that all his tires were good for 100,000 miles.

TABLE 10

TIRE PRICE SAMPLE DESCRIPTIVE STATISTICS

	NUMBER OF TIRE DEALERS IN THE MARKET						
	1	2	3	4	5	1.5	Urban
Candidate phone listings	39	66	48	64	75	*	200+
Surveyed by us	36	22	19	28	21	20	19
At listed number	32	19	19	24	21	17	18
Would respond	28	19	19	23	20	14	17
Total prices quoted	76	52	50	64	49	36	62
Usable price quotations	42	31	40	57	45	17	59
	Sample Means						
Price	54.9	55.7	54.4	51.6	52.0	53.8	45.6
Tire mileage rating (000)	44.5	47.0	47.7	45.4	43.8	43.0	45.3
	Sample Medians						
Price	53.9	55.0	52.9	50.9	49.8	51.7	43.2
Tire mileage rating (000)	45	45	50	40	40	40	45

* Unknown.

B. *An Analysis of Prices*

The bottom of table 10 reports means and medians of the dealers' price quotations and the tire mileage ratings. The means and medians suggest that the distribution of prices is positively skewed. The monopoly and duopoly median prices do not differ by much. The same is true of quadropoly and quintopoly prices. The triopolies and "1.5" markets fall in between these two groups. Prices in the Bay Area are about 12–15 percent lower than those in these concentrated markets.

To adjust dealers' prices for brand and quality differences, we regressed the price of a tire, P, on a set of zero-one dummy variables for the number of firms in the market, the tire's mileage rating (in thousands of miles), the county retail wage, and zero-one dummy variables for brands. We include the market structure dummy variables to measure how much price falls with N, the number of active dealers in 1990. We include the mileage rating as a measure of product quality and the retail wage to proxy dealer cost differences. The dummy variables for brands remove brand-specific demand and cost differences. Because the prices are skewed and include some outliers, we report both least-squares and least absolute deviations estimates of our price equation.[21]

[21] For the least absolute deviations estimates, we used the approach of Koenker and Bassett (1978) to calculate coefficient standard errors. These estimates use the approximation $[2f(0)]^{-2}(\mathbf{X}'\mathbf{X})^{-1}$, where $f(\cdot)$ represents the density function of the er-

Column 1 of table 11 reports a constrained baseline specification that includes the tire's mileage rating, the county retail wage, and a zero-one dummy variable for whether the tire is a Michelin.[22] At the bottom of the table we report F-statistics for the null hypothesis that the individual market size dummies are equal. These tests confirm that prices fall as N increases. Further, we do not reject the null hypothesis that monopoly prices and duopoly prices are equal, nor do we reject the hypothesis that prices in three-, four-, and five-firm markets are equal. The point estimates also show that prices fall as entry occurs, as suggested by our entry threshold estimates. Between monopolies and quintopolies, price falls by about 8 percent on average. Between quintopolies and the Bay Area, price falls another 20 percent. (Our phone calls suggest that service quality also improves as one moves to larger markets.) The regression in column 2 reports an unconstrained version of the regression in column 1. It also includes more brand dummy variables. Column 3 reports least absolute deviations estimates of the price equation. The results in columns 2 and 3 generally reinforce the results in column 1.

To summarize, our tire price data confirm that entry lowers margins. Markets with three or more dealers have lower prices than monopolists and duopolists. We also find that while prices level off between three and five dealers, they are higher than unconcentrated market prices. Thus it appears that there are other intermediate ranges of concentration in which entry increases competition and lowers prices.

V. Conclusion

Economists know relatively little about the competitive consequences of entry into and exit from oligopolistic markets. This paper showed that when one does not observe firms' prices or costs, one can still draw inferences about the effects of entry. Our econometric estimates of entry thresholds for five different retail and professional industries confirm our initial hypothesis that postentry competition increases at a rate that decreases with the number of incumbents. Figure 4 shows

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rors and $\mathbf{X}$ is the matrix of regressors. We estimated $f(0)$ by the derivative approximation $(\hat{\epsilon}_r - \hat{\epsilon}_s)/[F(\hat{\epsilon}_r) - F(\hat{\epsilon}_s)]$, where $\hat{\epsilon}_r$ equals the fifty-fifth percentile estimated residual, $\hat{\epsilon}_s$ equals the forty-fifth percentile estimated residual, and $F(\cdot)$ equals the empirical distribution function of the residuals. Calculations that used slightly wider percentile intervals produced similar results. We calculated the likelihood ratio test statistics using the procedures outlined in Gonin and Money (1989).

[22] We also estimated a slightly more general specification that included town population. By including it, we test our specification that variable profits do not change with S, say because of rising marginal costs. We did not find any evidence of an effect of S on price.

TABLE 11

TIRE PRICE REGRESSIONS (N = 282)

Variable Name	Ordinary Least Squares (1)	Ordinary Least Squares (2)	Least Absolute Deviations (3)
Constant term	26.4	29.9	29.5
	(4.69)	(4.87)	(4.43)
Monopoly market dummy	1.88	.26	.54
	(2.12)	(2.33)	(2.12)
Duopoly market dummy	1.88	−.62	.96
		(2.42)	(2.30)
Triopoly market dummy	−1.80	−2.60	−2.12
	(2.05)	(2.34)	(2.11)
Quadropoly market dummy	−1.80	−3.36	−2.53
		(2.21)	(2.01)
Quintopoly market dummy	−1.80	−1.99	−2.00
		(2.22)	(2.01)
Urban market dummy	−12.1	−11.0	−11.4
	(2.62)	(2.62)	(2.38)
Mileage rating	.43	.38	.39
	(.05)	(.05)	(.05)
County retail wage	1.00	.62	.74
	(.53)	(.53)	(.49)
Other dummy variables	Michelin brand	11 brands	11 brands
Regression R^2	.43	.51	
F or χ^2 hypothesis tests:			
$\alpha_1 = \alpha_2$	.01	.01	1.1
$\alpha_3 = \alpha_4 = \alpha_5$	.68	.70	2.3
$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5$	2.82*	2.86*	448*

NOTE.—The omitted category is all towns not satisfying our monopoly market definition. The numbers in parentheses are asymptotic standard errors.
* Significant at the 5 percent level.

that most of the increase in competition comes with the entry of the second and third firms.

These results initially surprised us. We expected to find entry threshold ratios that declined more gradually. It instead appears that the competitive effect of entry occurs rapidly, a finding confirmed by our tire price data. Whether this pattern appears in other industries remains an open question. Our results for new-car dealers suggest that they may not always, especially when firms sell differentiated products.

Finally, our entry thresholds offer two primary advantages over previous methods for estimating the competitive consequences of entry. First, one can estimate entry thresholds even when one does not have price or quantity data. Second, although one may disagree with the specific null hypotheses that we (or others) would maintain when interpreting entry thresholds, our models have the advantage of making previously implicit assumptions explicit. Thus our models serve to complement other work that studies the effects of entry with reduced-form regression models or qualitative data (see, e.g., Graham, Kaplan, and Sibley 1983; Weiss 1990). Having noted their advantages, we also note that our models leave several important issues unexplored. When markets overlap, it becomes less clear how one should compute entry thresholds. Our models also do not consider the timing of entry and exit decisions. To address these issues, we must develop richer empirical models of competition and more complete data on entry and exit.

References

Bain, Joe S. *Barriers to New Competition: Their Character and Consequences in Manufacturing Industries.* Cambridge, Mass.: Harvard Univ. Press, 1956.

Baumgardner, James R. "Physicians' Services and the Division of Labor across Local Markets." *J.P.E.* 96 (October 1988): 948–82.

Baumol, William J.; Panzar, John C.; and Willig, Robert D. *Contestable Markets and the Theory of Industrial Structure.* New York: Harcourt Brace Jovanovich, 1982.

Berry, Stephen. "Estimation of a Model of Entry and Exit in Airline City-Pair Markets." Working paper. New Haven, Conn.: Yale Univ., Dept. Econ., 1989.

Bresnahan, Timothy F., and Reiss, Peter C. "Do Entry Conditions Vary across Markets?" *Brookings Papers Econ. Activity,* no. 3 (1988), pp. 833–82.

———. "Entry in Monopoly Markets." *Rev. Econ. Studies* 57 (October 1990): 531–53.

Carlton, Dennis W. "The Location and Employment Choices of New Firms: An Econometric Model with Discrete and Continuous Endogenous Variables." *Rev. Econ. and Statis.* 65 (August 1983): 440–49.

Chamberlin, Edward H. *The Theory of Monopolistic Competition.* Cambridge, Mass.: Harvard Univ. Press, 1933.

Dixit, Avinash. "Entry and Exit Decisions under Uncertainty." *J.P.E.* 97 (June 1989): 620–38.

Encaoua, David; Geroski, Paul; and Jacquemin, Alexis. "Strategic Competition and the Persistence of Dominant Firms: A Survey." In *New Developments in the Analysis of Market Structure,* edited by Joseph E. Stiglitz and G. Frank Mathewson. Cambridge, Mass.: MIT Press (for Internat. Econ. Assoc.), 1986.

Ernst, Richard L., and Yett, Donald E. *Physician Location and Specialty Choice.* Ann Arbor, Mich.: Health Admin. Press, 1985.

Geroski, Paul A. "The Effect of Entry on Profit Margins in the Short and Long Run." *Ann. Econ. et Statis.,* nos. 15–16 (July–December 1989), pp. 333–53.

Gonin, René, and Money, Arthur H. *Nonlinear L_p-Norm Estimation.* New York: Dekker, 1989.

Graham, David R.; Kaplan, Daniel P.; and Sibley, David S. "Efficiency and Competition in the Airline Industry." *Bell J. Econ.* 14 (Spring 1983): 118–38.

Hause, John C., and Du Rietz, Gunnar. "Entry, Industry Growth, and the Microdynamics of Industry Supply." *J.P.E.* 92 (August 1984): 733–57.

Koenker, Roger W., and Bassett, Gilbert, Jr. "Regression Quantiles." *Econometrica* 46 (January 1978): 33–50.

Lane, Sarah J. "Entry and Competition in the ATM Manufacturers' Market." Manuscript. Boston: Boston Univ., School Management, 1989.

National Highway Traffic Safety Administration. *Uniform Tire Quality Grading.* Washington: Government Printing Office, 1988.

Panzar, John C., and Rosse, James N. "Testing for 'Monopoly' Equilibrium." *J. Indus. Econ.* 35 (June 1987): 443–56.

Pashigian, B. Peter. *The Distribution of Automobiles: An Economic Analysis of the Franchise System.* Englewood Cliffs, N.J.: Prentice-Hall, 1961.

Reiss, Peter C., and Spiller, Pablo T. "Competition and Entry in Small Airline Markets." *J. Law and Econ.* 32, no. 2, pt. 2 (October 1989): S179–S202.

Schary, Martha A. "The Probability of Exit." Manuscript. Boston: Boston Univ., School Management, 1988.

Schmalensee, Richard. "Inter-Industry Empirical Analysis." In *The Handbook of Industrial Organization,* vol. 2, edited by Richard Schmalensee and Robert D. Willig. Amsterdam: North-Holland, 1989.

Stigler, George J. *The Organization of Industry.* Homewood, Ill.: Irwin, 1968.

Tirole, Jean. *The Theory of Industrial Organization.* Cambridge, Mass.: MIT Press, 1988.

U.S. Bureau of the Census. *County and City Data Book.* Washington: Government Printing Office, 1983.

Weiss, Leonard W. *Concentration and Price.* Cambridge, Mass.: MIT Press, 1990.