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Timothy Bresnahan
Stanford University

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Peter C. Reiss
Graduate School of Business
and
Timothy F. Bresnahan
Department of Economics

Stanford University

Abstract

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 oligopolies, we find that almost all variation in competitive conduct occurs in monopolies and duopolies. By the time the market has three firms, entry has little additional effect on competitive conduct.

1. Introduction

Theories of imperfect competition provide a rich and sometimes contradictory set of predictions about the effects of entry in concentrated markets. In perfectly contestable markets, for example, we know that the mere threat of entry curbs market power.[1] By contrast, many entry barrier theories assign a limited role to potential competitors, arguing instead that only actual entry affects oligopolistic competition.[2] Between these two extreme views lies a range of entry models. Although many of these models distinguish between potential and actual entrants, they generally do not make specific predictions about the extent to which entry changes oligopolistic conduct.

Recently, economists have begun to study the effects of entry with structural econometric models. (See, for example, Berry (1989), Bresnahan and Reiss (1986; 1988), Carlton (1983), Geroski (1988), Lane (1988), and Schary (1988)).[3] This paper extends this line of research. We propose an empirical model of oligopolistic competition and entry that uses Chamberlain's (1933) and Panzar and Rosse's (1987) description of free-entry competition. This model shows how both technological conditions and competitive forces affect oligopolists' profits. Our model, for example, allows firms to have U-shaped average costs and for entrants to face entry barriers. From our theoretical model, we develop the concept of a demand *entry threshold*. These thresholds measure the size of the market required to support a given number of firms. We show that ratios of these entry thresholds provide a scale-free measure of the extent to which entry changes market conduct.

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[1] See Baumol, Panzar and Willig (1982).

[2] See, for example, Geroski (1988), Tirole (1988), and Schmalensee (1989).

[3] Other empirical studies of entry into concentrated markets have examined such issues as the decline of dominant firms. See Encaoua, Geroski, and Jacquemin (1986) and the references therein.

We use our economic model of entry to estimate entry thresholds for five retail and professional service industries. To reduce the number of extraneous economic variables that could affect our inferences, we collected data on firms in 202 geographically isolated markets. These markets differ mainly in the size of local demand – the key variable we use to perform our empirical comparative statics on the number of firms. Following Bresnahan and Reiss (1986), we use ordered probit models of firms' profits to predict the equilibrium number of firms in a market. 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 in monopolies and duopolies. Surprisingly, when the market has between three and five firms, the next entrant has little effect on competitive conduct.

2. Entry and the Size of the Market

Our empirical model provides information about the consequences of entry by relating shifts in market demand to changes in the equilibrium number of firms. We develop the concept of a zero-profit equilibrium level of demand – what we call an *entry threshold* – to summarize this relationship. This section outlines our assumptions about market demand and firms' costs; it also defines and interprets entry thresholds.

2.1. Demand, Technology, Competition, and Entry

Consider a product market where demand has the form

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

Here, $d(Z,P)$ represents the demand function of a "representative consumer," $S(Y)$ denotes the number of consumers, and the vectors Y and Z denote demographic variables that shift market demand. This particular demand specification presumes that increases in the size of the market, S, proportionately increase demand. Thus, if the number of consumers doubles, total market demand will double at any given price. Put another way, if we moved a consumer from one market to another and kept Z constant, the consumer's tastes would not change. We adopt this particular demand specification because it simplifies our analysis of entry thresholds; below we discuss its applicability to our sample of industries.[4]

In Bresnahan and Reiss (1988) we assumed that firms had constant marginal costs. Here we allow for increasing and decreasing returns by assuming firms' average variable production costs depend on output. Formally, we represent average variable costs by $AVC = AVC(q, W)$. The vector W contains any exogenous variables that affect costs, such as input prices and technological variables. We represent marginal costs by $MC(q, W)$. By definition, $q \times AVC(q, W) = \int_0^q MC(\tau, W) d\tau$. Firms' average total costs, AC, include a fixed cost F, which also depends on W.[5]

2.2. A Diagrammatic Analysis of Entry Thresholds

To see how we propose to draw inferences about competition from changes in the number of firms in a market, consider an industry that produces a homogeneous good. Suppose that all firms in this industry have the long-run marginal and average cost functions depicted in Figure 1. In equilibrium, each firm charges the same price and sells the same amount. Let the de-

[4] One can allow S to affect demand nonlinearly. Such a specification, however, complicates the *equilibrium* relationship between markups and entry thresholds. As an empirical matter, we note that equation (1) allows for sample correlations between individual consumer demands and market size through the economic and demographic variables Z and Y.

[5] In this model we equate sunk costs with fixed costs because we only have cross-section data. In future work we will use panel data to identify these different costs.

mand curve labelled D_1 represent the demand curve of the first firm into the market. Given the structure of marginal costs and the slope of demand, this monopolist earns a substantial margin of $M_1 = P_1 - MC(q_1)$. Notice, however, that at this level of demand the monopolist is indifferent between entering and exiting this market.

Even if we do not observe the monopolist's margin, we can still draw inferences about it from S_1 – the number of consumers necessary for the monopolist to break even. At S_1, the monopolist earns zero economic profit. Using equation (1), we can express monopoly profits at D_1 by

$$\Pi_1(S_1) = V_1 S_1 - F = 0. \tag{2}$$

The monopoly entry threshold, S_1, equals the ratio of two unobservables, i.e., $S_1 = F/V_1$. Hence, if we could estimate the monopolist's entry threshold, we would know the ratio of unobservable fixed costs to per-customer variable profits. We can relate per-customer variable profits to margins by the equation $V_1 = (M_1 + q_1 \partial AVC/\partial q_1) d(Z, P)$. The second term in parentheses, $q\,\partial AVC/\partial q$, equals the area between marginal costs and $MC(q)$ divided by q – a measure of per-unit producer surplus. The monopoly entry threshold thus combines information about margins and costs.

To measure how margins change as entry occurs, consider how the monopoly entry threshold compares to the per-firm entry threshold of a competitive market, i.e., $s_\infty = \lim_{N \to \infty} S_N / N$. In a competitive market, each firm requires at least the (fraction of market) demand given by D_∞ in Figure 1. This demand curve passes through the minimum of long-run average cost, which is the point at which N price-taking firms facing market demand $N * D_\infty$ would break even. By taking the ratio of D_1 to D_∞ at *any given price*, we obtain a measure of the extent to which entry lowers margins. This scale-free measure equals the ratio of entry thresholds, s_1/s_∞, at the given price. Thus, factors that shift break-even levels of demand and margins will also tend to shift ratios of entry thresholds. Figure 1, for example, shows that increases in monopoly market power will increase s_1/s_∞ by increasing margins and thus lowering the monopolist's break-even level of demand.

Between monopoly and perfect competition lies oligopoly. We know that the N-firm oligopoly margin, M_N, lies between M_1 and zero. In what follows we would like to use the sequence of break-even market sizes, $s_1, s_2, ..., s_\infty$ to draw inferences about the effect of entry on margins. In oligopoly markets, entry occurs when demand grows large enough to cover the next entrant's fixed costs. Consider the Nth ($N > 1$) entrant's entry decision. The more this entrant increases market competition, the more customers it requires to break even. To make this intuition precise, consider again our analysis of the extreme entry thresholds s_1 and s_∞. Suppose that it takes 2,000 customers to support a monopolist (i.e., $S_1 = s_1 = 2,000$) and that the market becomes perfectly competitive at 4,000 customers per firm (i.e., $s_\infty = \lim_{N\to\infty} S_N/N = 4,000$). These two entry thresholds bracket the range of oligopoly entry thresholds we could observe. If, for instance, the fourth entrant expects to compete in a perfectly competitive market, then it does not enter until the market has 4 × 4,000 = 16,000 consumers. Alternatively, if the fourth entrant expects to be part of a cartel, then it would enter as soon as the market has 4 × 2,000 = 8,000 consumers. The cartelized market has a lower entry threshold because the firm faces a steeper market demand curve. Extending this logic to intermediate degrees of post-entry competition, we would generally expect to observe the per-firm entry threshold s_4 between 2,000 and 4,000 customers. If, for instance, we observed an entry threshold of 3,800, we would tend to conclude that the market was nearly competitive.

Before proceeding to a formal analysis of the factors determining oligopoly entry threshold ratios (ETRs), we note that our analysis of Figure 1 holds constant many factors that differentiate firms. It presumes, for example, that all firms have the same costs. What if later entrants have higher costs because they use less efficient technologies or face entry barriers?[6] From the figure, we see that when entrants have higher costs, s_N will increase relative to s_1. Thus, if firms' costs differ, entry threshold ratios will reflect these differences. Our analysis of Figure 1 also presumes that firms do not price discriminate. How would the ability of a monopolist to price discriminate affect our entry threshold ratios? A price discriminating monopolist earns greater per-customer profits at any market size. This implies that it will have a smaller break-even level of demand. If, as entry occurs, incumbents lose the ability to price discriminate, then break-even levels of demand for new entrants will tend toward single-price entry thresholds. Price discrimination thus tends to lower s_1 relative to s_N much in the same way that increased post-entry competition raises s_N compared with to s_1. Finally, if firms differentiate their products, this will tend to lower s_N relative to s_1.

2.3. A Further Analysis of Entry Thresholds

To describe relationships among entry thresholds, entry barriers, and margins, we now consider the definition of s_N in more detail. In a homogeneous industry, the Nth firm earns profits of

$$\Pi_N = (P_N - AVC(d_N, W) - b_N)d(P_N, Z)S/N - F_N - B_N. \tag{3}$$

In this equation, we include $b_N > 0$ and $B_N > 0$ so as to allow the marginal

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

entrant to have higher variable or fixed costs. The break-even condition $\Pi(S_N) = 0$ defines the break-even level of market demand we call the per-firm entry threshold. Formally,

$$s_N = S_N/N = \frac{F_N + B_N}{(P_N - AVC_N - b_N)d_N}. \qquad (4)$$

As before, the entry threshold 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 ratios of successive entry thresholds to measure the rate at which markups or variable profits fall with entry. Formally,

$$\frac{s_{N+1}}{s_N} = \frac{F_{N+1} + B_{N+1}}{F_N + B_N} \frac{(P_N - AVC_N - b_N)d_N}{(P_{N+1} - AVC_{N+1} - b_{N+1})d_{N+1}}. \qquad (5)$$

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

$$\frac{s_{N+1}}{s_N} = 1.$$

Thus, departures of the successive entry threshold ratios from 1 provide a measure of the extent to which competitive conduct changes as the number of firms increases. Notice that this statistic does not measure the *level* of competition, rather it measures how the level *changes* with the number of firms. Consider, for example, the threshold ratios one would observe in a cartelized industry where $b_N = B_N = 0$. Absent entry barriers, the $N + 1$ entrant can enter as soon as the market grows to $N + 1$ times a monopolist's output. This implies that for a cartel we should observe $S_2 = 2S_1$, $S_3 = 3/2\,S_2$, $S_4 = 4/3\,S_3$, and so on – just as in the competitive case.[7] What one makes of this equivalence depends on what one assumes about the prevalence of competition after a given number of firms have entered. If this sequence converges to 1 for large values of N, one might reasonably conclude that conduct converged to competition rather than collusion.[8]

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

$$\frac{S_N}{S_M} = \frac{V_M}{V_N}\frac{F_N + B_N}{F_M + B_M}. \tag{6}$$

These ratios combine information about the decline in firms' post-entry profits with information about differences in their fixed costs. To separate changes in variable profits from differences in fixed costs, we must evaluate entry threshold ratios under maintained hypotheses about the unobservables underlying (6). For instance, once we make assumptions about differences in firms' costs, we can draw inferences about changes in variable profits or margins.

3. Estimated Entry Thresholds: Retail and Professional Markets

Our framework for measuring the effects of entry requires us to estimate a series of entry thresholds. Following the logic of our analytical comparative statics, we conduct empirical comparative statics on the number of firms in a market. We propose to do this with a cross-section sample of similar local retail and professional markets. Specifically, we use the expansive geography

[7] The intuition for this condition is straightforward. In a perfectly competitive market where firms have the same U-shaped average cost function, firms operate at minimum long-run average cost. Because a price-taking entrant earns negative profits at any scale other than minimum efficient scale, $s_N = s_{N+1}$.

[8] We note, however, that without price or quantity information, we cannot rule out the possibility that market competition converged to some less competitive norm.

of the U.S. and the geographic specialization of professional and retail services markets to conduct the empirical analogue of our theoretical comparative statics.[9] We chose to study isolated geographic markets because they have several advantages over other types of markets. Specifically, we can easily count firms in these markets; we can also choose our sample of markets so as to change or hold constant various factors that affect entry.

Our data sample consists of 202 isolated local markets. While these markets vary substantially in population, most have only a few firms. The typical market in our sample is a county seat in the western United States. Because much of the population in these western counties resides in or near the county seat, we believe that the central town's population provides a reasonable first approximation to $S(Y)$. Figure 2 provides a histogram of market counts by ranges of central town population.

In an earlier paper, we estimated the first two entry thresholds under the assumption that firms had constant marginal costs. In this paper, we extend our analysis to consider U-shaped average costs and the 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 (1986; 1988)). Briefly, we located towns or small cities in the continental U.S. that were at least 25 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 with 100,000 people.[10] We believe on a priori

[9] One could also use our framework to model time series data. Such a model would, however, have to take into account transitory versus permanent changes in market demand and costs.

[10] Even though some consumers may drive long distances to visit other markets, as long as at least some high reservation price consumers do not leave, the monopolists in our markets will have downward sloping demand curves.

grounds that these selection criteria ensure that we can identify all relevant competitors. In the next section, we also propose a test of this hypothesis.

In selecting industries to study, we chose to study only those industries or occupations where we could identify all sellers of a narrowly defined product or service. This criterion rules out grocery and clothing stores, for example, because they sell a range of products. Table 1 provides a list of the 16 products and services considered in Bresnahan and Reiss (1988). Here we analyze a subset of these industries. We eliminated industries from this list when we could not obtain reliable estimates of the α and γ parameters. This meant we dropped industries that did not have sufficient observations on each market size class (i.e., markets with either $N = 0, 1, 2, ..., 4$, or 5 or more firms). We initially included all industries that had at least ten markets in each size class. When we could not accurately estimate s_4 for either Beauticians or Electricians we dropped them from our analysis.[11] Our final sample includes the following five occupations or trades: Doctors, Dentists, Druggists, Plumbers, and Tire Dealers.

We counted the number of firms in a 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 multi-person firm.[12] Very few

[11] We dropped movie theaters, for example, because it had only 5 quadropolies. We did not estimate entry thresholds for Farm Equipment Dealers because we had difficulty defining $S(Y)$ in larger markets. Our choices for Y included the number of farms, the number of large farms, the amount of land in farms, and the number of farm animals.

[12] 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.

of our markets have multi-person firms (see Bresnahan and Reiss (1988)).

3.1. Predictors of N

Our theory identifies the size of the market, $S(Y)$, as a crucial predictor of the number of active firms. The bar graphs in Figures 3a and 3b describe the relationship between our key predictor of S, current town population, and the number of practicing dentists. Specifically, they show what fraction towns in a given town population range have $0, 1, 2, 3, 4$, or, 5 or more dentists. Figure 3a gives the distribution of towns that have no dentist, a monopoly dentist or a duopoly. Figure 3b summarizes the distribution of markets with three, four, and five or more dentists. Although both figures show a strong relationship between town population and the number of active firms, town population does not perfectly predict the number of firms. From Figure 3a it appears that the monopoly dentist entry threshold equals 500 people; the duopoly entry threshold occurs somewhere between one and two thousand people. Thus, if town population proxies 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.

While we could develop nonparametric estimates of oligopoly entry thresholds from Figures 3a and 3b, these estimates would not hold constant many other economic variables that affect entrant profits. These other variables might explain differences in demand across markets and regional differences in factor prices. To allow for differences in entrants' profits across markets, we estimate a model of entrants' long-run discounted profits. This model treats a firm's profit as a partially observed variable. 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 (3), we assume

$$\Pi_N = S(Y,\lambda)V_N(X,\alpha,\beta) - F_N(X,\gamma) + \epsilon \tag{7}$$

where λ, α, β, and γ represent parameters affecting firms' profits, Y indexes the size of the market, X shifts per-capita demand and costs, and the unobserved error term ϵ summarizes all profit we do not observe. To simplify estimation, we assume that the additive error term ϵ has a normal distribution which is independently distributed across markets and independent of our observables. We also assume that ϵ has zero mean, a constant variance, and that each entrant within a market has the same error. This last assumption presumes that successive entrants' profits differ only through the deterministic variables in (7). In Bresnahan and Reiss (1986), we discuss the economic consequences of this assumption. (See also Berry's (1989) discussion.) We use this assumption here largely because it simplifies estimation and because more general error specifications do not reject this restricted one.

Our 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 constructed 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

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

where $\Phi(\cdot)$ equals the cumulative normal distribution function and $\bar{\Pi}_1 =$

$\bar{\Pi}_1 + \epsilon$ equals a monopolist's profits. Assuming $\bar{\Pi}_1 \geq \bar{\Pi}_2, \ldots \geq \bar{\Pi}_5$, the probability of observing N firms in equilibrium, where $N = 1, 2, 3, 4$, equals

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

The residual probability of observing five or more firms equals

$$Pr\left(\Pi_5 \geq 0\right) = \Phi\left(\bar{\Pi}_5\right).$$

Before describing how we propose to estimate entry threshold ratios from (7), we first discuss our choice of variables for firms' profit functions. Table 2 provides a summary of the variables we include in Y, Z, and W, their sample definitions, and our data sources. Our specification for market size, $S(Y, \lambda)$, has the form

$$\begin{aligned} S(Y,\lambda) = {} & \text{Town Population} + \lambda_1 \text{Nearby Population} + \lambda_2 \text{Pos. Growth} \\ & + \lambda_3 \text{Neg. Growth} + \lambda_4 \text{Outside Commuters}. \end{aligned} \tag{8}$$

We set the coefficient of town population in $S(Y, \lambda)$ equal to one because V_N already contains a constant term. This particular choice of normalization translates units of market demand into units of current town population. We include population within ten miles of town, "Nearby Population," to allow population surrounding town to increase demand.[13] The growth variables "Pos. Growth" and "Neg. Growth" represent respectively the amount of negative and positive growth in town population from 1970 to 1980. These growth terms capture entrants' (possibly asymmetric) expectations about future market growth, as well as lags in responses to past growth. We include

[13] In earlier work (Bresnahan and Reiss (1988)), we compared this measure to others that counted people within five miles, twenty miles and twenty five miles of town.

the variable "Outside Commuters" to check our market definition. It represents the Census' count of county residents who commute to work outside the county. A negative value of λ_4 indicates that commuters purchase goods in nearby markets.

We model firms' per-capita variable profits V as depending on the number of firms, N, and on demographic and economic variables, X. Specifically, we assume the linear relation

$$V_N = \alpha_1 + X\beta - \sum_{n=2}^{N} \alpha_n. \tag{9}$$

The term $\alpha_1 + X\beta$ equals a monopolist's per capita variable profits. We include X so as to allow for differences in monopoly variable profits across markets. Our X variables come from county-level Census data sources. We included per capita income in all specifications 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 variations affecting the demand for and cost of health care.[14] 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 α_n intercepts measure the fall in per capita variable profits when the nth firm enters.[15] Almost all models of entry predict $\alpha_n \geq 0$.

The model in Section 2 implies that S can enter V_N through equilibrium q_N and prices. Below we report specifications that exclude S from (10). We

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

[15] Equation (9) presumes that the α_n do not vary across markets. In other specifications not reported here, we allowed the α_n to depend on market-specific covariates. We found little evidence of intermarket variation in α_N.

impose this restriction because we could not find significant effects of S on V_N. We also found that including S in V_N did not change our entry threshold estimates appreciably.

We interpret the intercept in (7) somewhat loosely as fixed "costs." These costs might either be fixed production costs or barriers to entry. In the doctors' specification, for instance, these costs could represent costs of building a patient base or the opportunity costs of a doctor's time. Because we do not have information on these different types of fixed costs, we only model total fixed costs. We assume,

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

The term $\gamma_1 + \gamma_L W_L$ equals a monopolist's fixed costs. We include the price of agricultural land in the monopolist's fixed costs to capture intermarket variation in the cost of capital.[16] We include the γ_n intercepts because later entrants may have higher costs. If we find $\gamma_n > 0$, we conclude that entrants' fixed costs differ; we do not know, however, whether to infer that the marginal entrant is less efficient (i.e., the supply curve of entrants is upward sloping) or that the marginal entrant faces entry barriers.

3.2. Baseline Estimates

Table 3 reports a set of baseline ordered probit results. Table 4 contains the entry thresholds implied by these results. Each industry's baseline specification has 19 parameters: four λ's, four β's, five α's, and six γ's. As a practical matter, we over-parameterized these baseline specifications so as to nest various hypotheses about variable profits and fixed costs. As expected,

[16] Bresnahan and Reiss (1986; 1988) report other specifications with different variables in F, such as the local retail wage. These other variables did not change our estimates of fixed costs significantly.

most specifications have several insignificant demand and cost variables. For example, variables such as per capita income do not appear to explain cross-sectional variation in demand or variable costs. We generally interpret the insignificance of these variables as evidence that firms face similar economic conditions in these markets.

In maximizing the sample likelihood functions, we imposed the constraint that later entrants do not have greater profits, i.e., $\bar{\Pi}_{N+1} \leq \bar{\Pi}_N$. To impose this constraint, we either set α_N or γ_N equal to zero. For the specifications where we had to impose this constraint, 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 αs and γs automatically satisfy our constraints; that is, per customer variable profits fall and fixed costs increase as the number of firms increases. We also see, however, that the data do not distinguish between changes in variable profits versus fixed costs. We return to this point below.

Table 4 reports entry threshold estimates for the specifications in Table 3. To calculate these entry thresholds, we used the formula

$$S_N = \frac{\gamma_1 + \gamma_L \overline{W}_L + \sum_{n=2}^{N} \gamma_n}{\alpha_1 - \overline{X}\beta + \sum_{n=2}^{N} \alpha_n}, \qquad (10)$$

where a bar over a variable denotes the sample mean.[17] The estimates in Table 4 suggest that a monopoly tire dealer 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 do to break even.

[17] Our estimates do not change by much if we replace the sample means of X and W by their means in the monopoly markets.

The second half of Table 4 reports ratios of successive per-firm entry thresholds. These entry threshold ratios decline with N. Notice, however, that the decline stops abruptly at $N = 3$ and that $s_3 \simeq s_4 \simeq s_5$. Figure 4 illustrates this decline. It plots the ratio of the market size required to support 5 versus N firms, i.e., s_5/s_N. This ratio by definition equals 1 for $N = 5$. For $N < 5$, it can vary anywhere from zero to infinity, depending upon the entrants' estimated costs and variable profits (see equation (10)). 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 (5) 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 slopes of entrants' long-run average cost curves. Price discrimination and product differentiation could also cause entry threshold ratios to depart from one. We believe that the doctors, dentists, tire dealers, druggists, and plumbers in our sample provide approximately the same goods and services. We also believe they use similar production technologies and have the same costs.[18]

Under these maintained hypotheses, our findings for $N > 2$ suggest that entry does not change margins and costs by much. We note, however, that we cannot completely rule out the possibility that offsetting movements in demand and costs could leave entry our thresholds constant. For example, one could challenge our maintained assumptions by arguing that product

[18] 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* also suggests that our dentists mainly provide general dentistry services. Phone book Yellow Page ads reveal little evidence that the other firms in our sample differentiate their products (apart from their choice of location).

differentiation might offset competitive changes 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 these factors.

To explore whether the observed variation in the monopoly entry threshold ratios in Figure 4 reflected more than just sampling variation, we tested whether the entry threshold ratios in Table 4 were equal. The first column in the bottom half of Table 4 reports 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 $s_1 = s_2 = s_3 = s_4 = s_5$. We do not, apart from dentists, reject the null hypothesis that the triopoly entry threshold equals the quintopoly entry threshold. These tests do, however, reject the equality of the monopoly and quintopoly entry thresholds. Thus, we conclude that the observed variation in monopoly and duopoly entry thresholds is not just sampling variation.

We also explored the robustness of our results in Table 4 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 re-estimated entry thresholds for our original five industries do not differ much from those in Table 4. We also obtained similar patterns in entry threshold ratios for two of the remaining 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. Auto dealers have S_4/S_3 well above 4/3. In principle, this departure could reflect many differences between the third and fourth dealers. Of these differences, product differentiation appears to be the most important factor. In our sample, most dealer triopolies involve head-to-head competition among the "Big Three" domestic manufacturers. The fourth entrant typically is another GM dealer, or the first intrabrand competitor. Because the fourth dealer provides a close substitute and thereby 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 additional puzzles. What factors, for instance, explain interindustry differences in these ratios? At one extreme, we observe that the plumbers' entry threshold ratios do not differ much from one. Other entry threshold ratios depart substantially from one. We also observe that the entry threshold ratios fall toward one at varying rates as N increases. These changes are consistent with theories that predict that margins fall as entry occurs. We note, however, that they are also consistent with theories that say entrants' costs change as the number of firms grows. We tend to discount cost-based explanations for our results on a priori grounds. The dentists, doctors, and druggists in our sample come from professional schools that provide similar training. These self-employed professionals also use similar equipment. One might, however, explain some of the variation in our ratios by differences in professionals' opportunity costs and their willingness to relocate. We could, for example, observe high ratios if low opportunity cost professionals sought out isolated monopolies. We cannot rule out interpretations such as these without knowing the timing of entry and the identity of entrants.

Differences in the rate of decline of entry thresholds across industries also raise interesting questions about competition. Most simple explanations for the inter-industry differences in Table 3 and Table 4 provide only partial explanations of Figure 4. One might reason, for instance, that one major difference between monopoly plumbers and monopoly doctors is that plumbers have many more opportunities for spreading fixed costs. Although our model does not explicitly consider the incremental fixed costs of other businesses, these opportunities allow monopolists to enter earlier than they otherwise would. Hence, industries with part-time opportunities should have high monopoly entry threshold ratios. While we would expect plumbers to have the best part-time opportunities, they have monopoly entry threshold ratios close to one. Alternatively, while we expect that druggists would have more part-time opportunities than doctors or dentists, 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.

3.3. Specification Issues

The coefficient estimates in Table 3 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 various hypotheses about the sources of differences in profits across market structures and market types. We tested three sets of hypotheses about variable profits. First, does $\gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$? That is, does Π_N differ from Π_{N-1} only through the variable profit parameters α_N? Second, does only current town population measure the size of the market? Third, do variations in local economic conditions explain differences in firms' variable profits? For each of these hypotheses, we report statistical tests and the new entry threshold estimates.

In the profit function (7), profits depend on N both because $\alpha_N S > 0$ and $\gamma_N > 0$. Most of our α_N and γ_N estimates in Table 3 have large standard errors. Moreover, when we exclude one of these parameters, we usually obtain smaller standard errors on the other parameter.[19] We examined whether our inferences about competition would change if we assumed that all firms had the same fixed costs. That is, we tested the hypothesis that $\gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$. We might reject this null hypothesis because some firms have higher fixed costs or because later entrants face entry barriers. Table 5 summarizes these test results and the new entry threshold ratios.[20] The likelihood ratio statistics (LRs) generally reject the null hypothesis. 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, these costs do not change our estimated entry thresholds by much.

We next tested various restricted definitions of market size. We reject the null hypothesis that we can exclude all but current town population from S. We also tested whether we could delete potentially collinear variables from S. We excluded all variables in S that had coefficients less than their estimated standard errors. Table 6 shows that although we can safely omit these variables from market size, no single definition of market size applies to all industries.

In a final set of tests we examined the sensitivity of our results to our specification of V. Specifically, we tested whether we could remove variables from V that had coefficients less than their estimated standard errors. Table 7 shows that we can remove these variables. Moreover, excluding them does

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

[20] We will provide the parameter estimates upon request. None of these restricted specifications differ dramatically from those in Table 3.

not change our entry threshold estimates by much. Hence, apart from market size and shifts in variable profits with N, we find little intermarket variation in V.[21]

As a final specification check, we also 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. We included the number of people who commute to work outside the county in $S(Y)$ to proxy leakages in local demand. If our sample selection criteria did not adequately separate our markets, then we would expect commuters to have a negative effect on our estimated market sizes. The baseline results in Table 3 suggest that commuters have a small effect. Moreover, this effect often has the wrong sign.

While our theory and specifications allow for at least some leakage of demand, 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 in our original sample that were within 40

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

miles of the next town of 1,000 people or more.[22] Consumers in this new sample have at least an eighty mile round trip to the next large town. This new criterion eliminated 45 markets, leaving a sample of 157 markets. We constructed a sample of unisolated towns by treating each U.S. county with less than 10,000 residents in 1980 as a market. Roughly half of these counties were in our original sample. The other half failed our original distance criteria. To limit data collection costs, we only collected data on doctors and dentists in these counties.

Table 8 contains our re-estimated baseline specifications for these two new samples.[23] The table shows that our more stringent distance criterion does not change our estimated entry threshold ratios by much. On the other hand, the weaker distance criterion changes our entry threshold estimates considerably. In particular, we find that entry by the second and third health care professional 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 would increase in proportion to the combined towns' population. Pashigian (1961) predicted and also found such pattern in his study of urban automobile dealers.

4. Conclusion: Economic Interpretation of the Estimates

Economists know relatively little about the competitive consequences of entry into and exit from oligopolistic markets. This paper showed how one could draw inferences about the effects of entry from entry thresholds. We used our economic analysis of these thresholds to formulate and estimate an econometric model of oligopolistic competition in five retail and professional industries. We reduced the number of measurement problems and

[22] We did not change our other sample selection criteria.
[23] We will make these estimates available upon request.

alternative hypotheses we had to confront by studying only geographically isolated markets. Our econometric models confirm what we observe in simple nonparametric analyses of the data: the extent of post-entry competition increases at a rate that decreases with the number of incumbents. Figure 4 dramatically illustrates this decline. It shows that only the second and third entrants into these local markets significantly change the conditions of competition.

We were initially quite surprised by these results. We expected to find a much more gradual decline in entry thresholds – either because entry only gradually changes margins or because entry barriers only slowly erode. Instead, it appears that most of the effects of entry are felt in highly concentrated markets. Without more information on the timing of entry, and without other data on prices and quantities, we cannot conclude with certainty that our local markets are competitive – only that the conditions of competition do not appear to change by much after three firms have entered. Whether this finding holds for other industries and markets remains an open issue. We do know from our new car dealer results that product differentiation is an important determinant of entry thresholds.

Finally, our approach emphasizes the importance of both technological and strategic factors in entrants' decisions. Although one may take issue with the specific null hypotheses that we (or others) would maintain when interpreting our entry threshold estimates, our framework for studying the effects of entry does 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.[24] Just as other models do, however, our model leaves several

[24] See Weiss' (1986) study. See also Graham, Kaplan and Sibley (1984) for a

important issues unexplored. For instance, when markets overlap, it is less clear how one should treat product differentiation and product lines. Our model of long-run market structure also does 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 short-run entry and exit decisions.

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study of city-pair airline markets.

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Table 1. Distribution of Markets by Industry

Industry	Markets with N Firms							
	N=0	N=1	N=2	N=3	N=4	N=5	N=6	N=7+
Dentists	32	67	39	15	12	12	4	21
Plumbers	71	47	26	21	10	4	6	17
Heating Contractors	117	40	19	8	4	8	3	3
Cooling Contractors	153	30	13	5	1	0	0	0
Electricians	60	54	32	17	10	5	7	17
Beauticians	10	26	19	24	26	19	11	67
Barbers	95	66	23	9	3	6	0	0
Farm Equipment Dealers	90	39	23	19	17	9	1	4
Opticians	173	19	5	1	4	0	0	0
Druggists	28	62	68	23	8	6	3	4
Doctors	37	61	36	16	11	7	6	28
Optometrists	68	85	36	7	3	3	0	0
Tire Dealers	45	39	39	24	13	15	6	21
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

Table 2. Sample Descriptive Statistics

Variable (Units)	Name	Mean	Std Dev	Minimum	Maxi
Firm Counts[a]					
Doctors	DOCS	3.4	5.4	0.0	45.0
Dentists	DENTS	2.6	3.1	0.0	17.0
Druggists	DRUG	1.88	1.5	0.0	11.0
Plumbers	PLUM	2.18	3.3	0.0	25.0
Tire Dealers	TIRE	2.6	2.6	0.0	13.0
Population Variables[bc]					
Population of Town (1000s)	TPOP	3.74	5.35	0.12	45.09
Negative Part of Growth (1000s)	NGRW	-0.06	0.14	-1.34	0.00
Positive Part of Growth (1000s)	PGRW	0.49	1.05	0.00	7.23
Commuters Out of the County (1000s)	OCTY	0.32	0.69	0.00	8.39
Population Near Town (1000s)	OPOP	0.41	0.74	0.01	5.84
Demographic Variables[c]					
Births/County Pop.	BIRTHS	0.02	0.01	0.01	0.04
65 yrs. and Older/County Pop.	ELD	0.13	0.05	0.03	0.30
Per Capita Income ($1000s)	PINC	5.91	1.13	3.16	10.50
Log of Heating Degree Days	LNHDD	8.59	0.47	6.83	9.20
Housing Units/County Pop.	HUNIT	0.46	0.11	0.29	1.40
Fraction of Land in Farms	FFRAC	0.67	0.35	0.00	1.27
Per Acre Value of Farm Land and Buidings ($1000)	LANDV	0.30	0.23	0.07	1.64
Median Value of Owner-Occupied Houses ($1000s)	HVAL	32.91	14.29	9.90	106.0

Sources:

a. *American Business Lists.*
b. *County and City Data Book, 1983.*
c. *Rand McNally Commercial Atlas.*

Table 3. Baseline Specifications

Variable Name		Doctors	Dentists	Druggists	Plumbers	Tire Dealers
OPOP	λ_1	1.15	-0.46	0.08	0.27	-0.53
		(0.85)	(0.32)	(0.37)	(0.60)	(0.43)
NGRW	λ_2	-1.89	0.63	-0.30	0.68	2.25
		(1.60)	(0.85)	(0.97)	(1.10)	(0.75)
PGRW	λ_3	1.92	-0.35	-0.24	-0.45	0.34
		(1.01)	(0.41)	(0.41)	(0.36)	(0.59)
OCTY	λ_4	0.80	2.72	0.16	-0.28	0.23
		(1.26)	(0.98)	(0.34)	(0.71)	(0.94)
BIRTHS	β_1	-0.59	9.86	11.34		
		(6.57)	(8.29)	(10.10)		
ELD	β_2	-0.11	0.22	2.61		-0.49
		(0.55)	(0.74)	(0.78)		(0.75)
PINC	β_3	-0.00	0.04	0.02	0.05	-0.03
		(0.00)	(0.03)	(0.02)	(0.03)	(0.04)
LNHDD	β_4	0.013	0.28	0.08	0.003	0.004
		(0.05)	(0.07)	(0.06)	(0.06)	(0.06)
HUNIT	β_5				0.51	
					(0.46)	
HVAL	β_6				.42	
					(0.03)	
FFRAC	β_7					-0.02
						(0.08)
V_1	α_1	0.63	-1.85	-0.13	0.06	0.86
		(0.46)	(0.61)	(0.58)	(0.52)	(0.45)
$V_1 - V_2$	α_2	0.34		0.29		0.03
		(0.17)		(0.21)		(0.15)
$V_2 - V_3$	α_3		0.12	0.19	0.15	0.15
			(0.14)	(0.17)	(0.09)	(0.10)
$V_3 - V_4$	α_4	0.07	0.20	0.25	0.07	
		(0.05)	(0.06)	(0.14)	(0.08)	
$V_4 - V_5$	α_5			0.04	0.04	0.08
				(0.12)	(0.07)	(0.05)
F_1	γ_1	0.92	1.10	0.91	1.28	0.53
		(0.30)	(0.25)	(0.29)	(0.26)	(0.23)
$F_2 - F_1$	γ_2	0.65	1.84	1.34	1.04	0.76
		(0.30)	(0.19)	(0.35)	(0.14)	(0.21)
$F_3 - F_2$	γ_3	0.84	1.14	1.77	0.32	0.46
		(0.13)	(0.46)	(0.54)	(0.28)	(0.21)
$F_4 - F_3$	γ_4	0.18		0.06	0.40	0.60
		(0.23)		(0.70)	(0.35)	(0.12)
$F_5 - F_4$	γ_5	0.42	0.66	0.51	0.25	0.12
		(0.13)	(0.60)	(0.95)	(0.35)	(0.20)
LANDV	γ_L	-1.02	-1.31	-0.84	-1.18	-0.74
		(0.53)	(0.37)	(0.51)	(0.48)	(0.34)
Ln(Likelihood)		-233.49	-183.20	-195.16	-228.27	-263.09

Asymptotic Standard Errors in Parentheses.

Table 4. Analysis of Entry Thresholds

Profession	Entry Thresholds (1,000s)					Per-Firm ETRs			
	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

Likelihood Ratio Tests for Proportionality*

Profession	LR Test for $s_4 = s_5$	D.F.	LR Test for $s_3 = s_4 = s_5$	D.F.
Doctors	1.12	1	6.20	3
Dentists	1.59	1	12.30*	2
Druggists	0.43	2	7.13	4
Plumbers	1.99	2	4.01	4
Tire Dealers	3.59	2	4.24	3

Profession	LR Test for $s_2 = s_3 = s_4 = s_5$	D.F.	LR Test for $s_1 = s_2 = s_3 = s_4 = s_5$	D.F.
Doctors	8.33	4	45.06*	6
Dentists	19.13*	4	36.67*	5
Druggists	65.28*	6	113.92*	8
Plumbers	12.07	6	15.62*	7
Tire Dealers	14.52*	5	20.89*	7

Notes: The table Table 3 estimates were used to calculate the ETRs. (See equation (10).)

Table 5. Tests for Constant Fixed Costs

Profession	Likelihood Value	LR 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	0.99	0.99	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.

Table 6. Tests of Market Size Variables

Profession	Likelihood Value	LR 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

Table 7. Tests of Market Variables

Profession	Likelihood Value	LR 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	0.95
Dentists	183.25	.11	ELD	1.76	1.09	0.98	0.94
Plumbers	228.29	.36	LNHDD	1.06	1.00	1.03	0.96
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 8. Per-Firm Entry Threshold Ratios for Different Market Definitions

	Weaker Distance Criterion				Stronger Distance Criterion			
Profession	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	NE
Doctors	1.05	1.07	1.10	1.01	1.93	1.02	1.01	NE

NE: Not estimable because of small sample sizes.

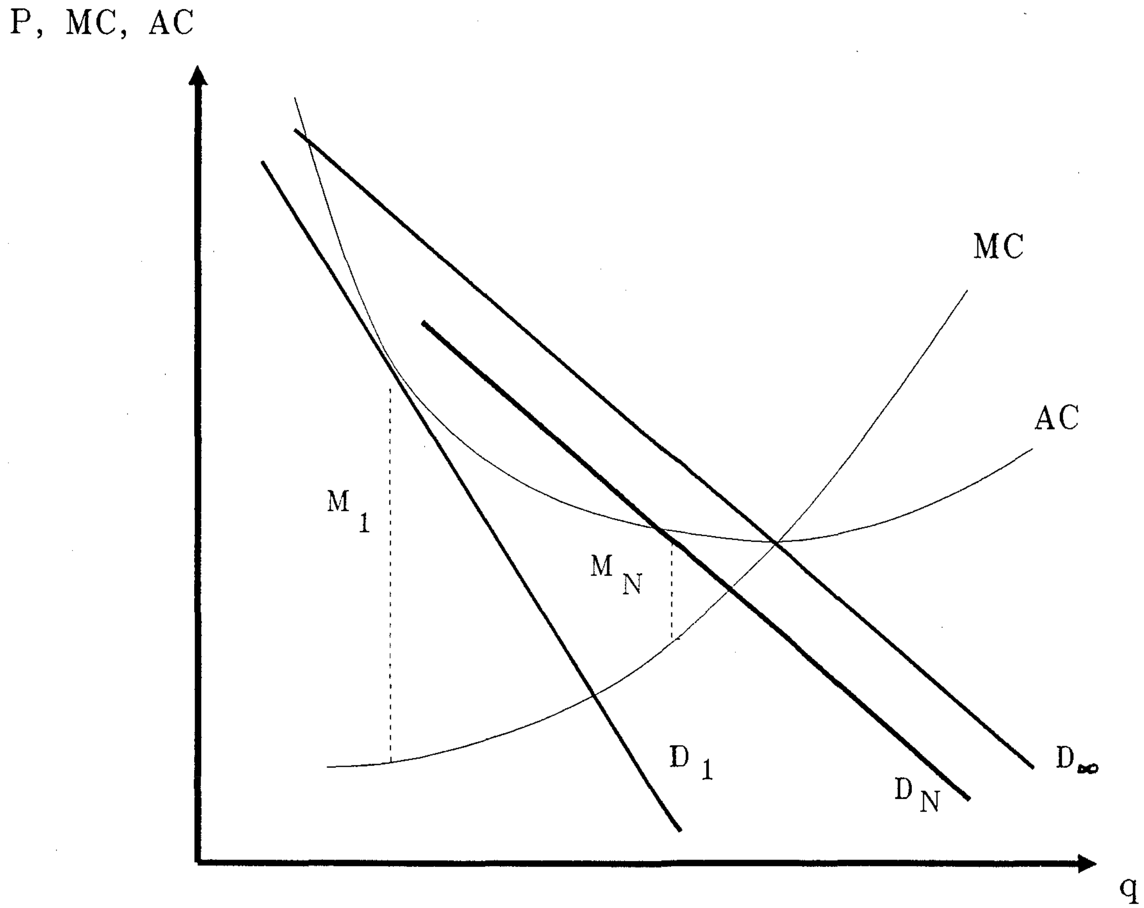

Figure 1. Analysis of Breakeven Demand and Margins

Figure 2. Number of Towns by Town Population

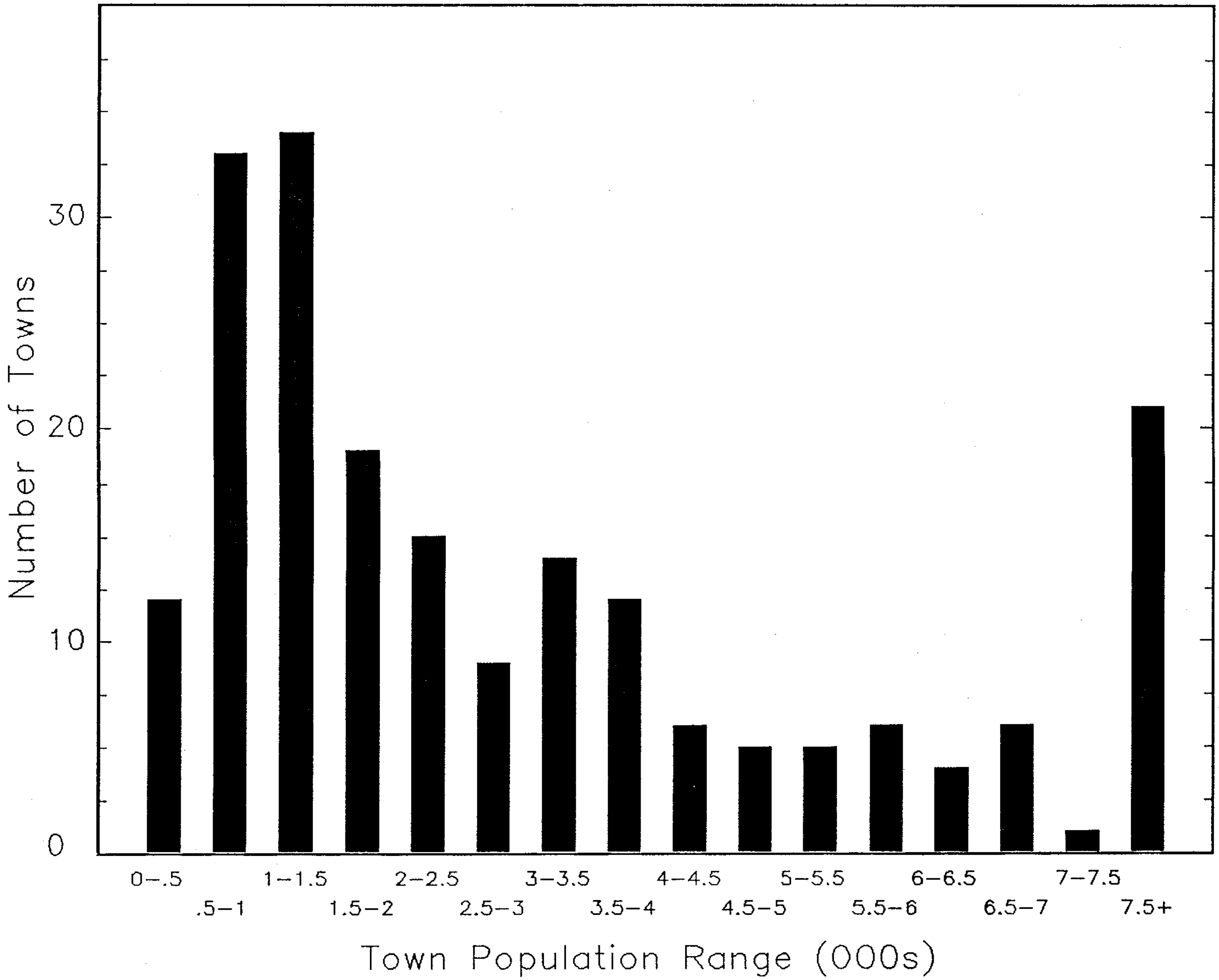

Figure 3a: Dentists by Town Population

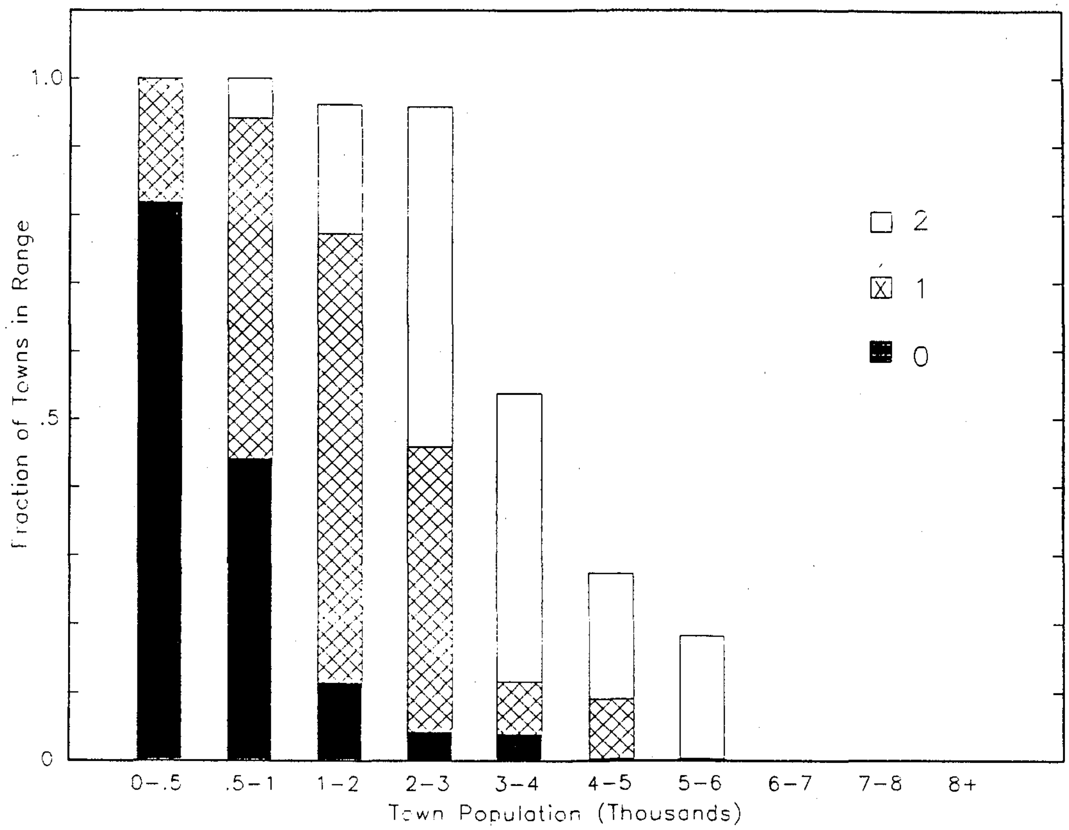

Figure 3b. Dentists by Town Population

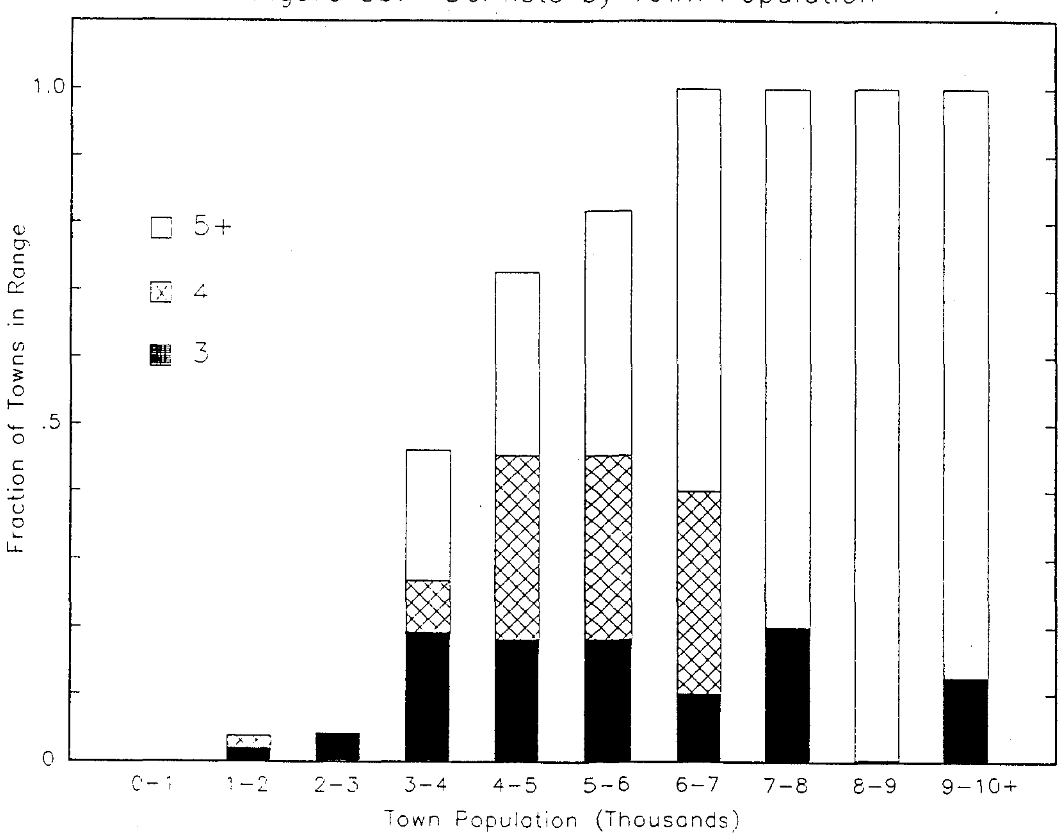

Figure 4. Industry Ratios of s_5 to s_N by N