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Entry, exit, and the determinants of market structure

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This article estimates a dynamic, structural model of entry and exit for two US service industries: dentists and chiropractors. Entry costs faced by potential entrants, fixed costs faced by incumbent producers, and the toughness of short-run price competition are important determinants of long-run firm values, firm turnover, and market structure. In the dentist industry entry costs were subsidized in geographic markets designated as Health Professional Shortage Areas (HPSA) and the estimated mean entry cost is 11 percent lower in these markets. Using simulations, we find that entry cost subsidies are less expensive per additional firm than fixed cost subsidies.

1. Introduction

■ Adjustment in market supply can occur on both the firm-size margin and the entry-exit margin. When the nature of the technology places limits on firm size, the supply adjustment occurs primarily through the entry and exit of firms. These limits are often present in service industries and are particularly important in some health service industries where the one-on-one nature of the practitioner-patient relationship effectively constrains how much output a doctor can produce. This results in the entry-exit margin being particularly important as the source of supply adjustment in these industries. In this article we estimate a dynamic structural model of entry for two health service industries, dentists and chiropractors, and identify the economic forces determining market supply.

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An empirical model of entry and exit in the service industries must capture three related forces. The first is the toughness of short-run price competition, which captures the idea that an increase in the number of firms in a market lowers the profits that are earned by all. The second feature is the magnitude of the fixed cost faced by producers, which is crucial to the exit decision of incumbent producers. The third feature is the magnitude of the sunk entry cost faced by potential entrants. Together, these three features will determine how many firms choose to serve a particular market. These three components are treated as the primitives of the empirical model, estimated, and used to describe long-run firm profitability and market structure.

A complicating factor in some health industries is that entry subsidies exist. In the US there is a long-term concern that there is "underprovision" of health services in some geographic areas because there are too few doctors, dentists, and mental health professionals in the area. Since 1978, the US Health Resource and Services Administration has identified underserved geographic areas, designated Health Professional Shortage Areas (HPSA), and subsidized the entry costs of primary care physicians, dentists, and mental health professionals that locate there. In 2012, there were over 54 million people living in areas designated as HPSAs for primary care physicians and 43 million for dentists. The empirical model we develop incorporates information on these underserved dental markets and assesses the effect of the entry subsidies on market structure.

We estimate the model with microdata collected as part of the US Census of Service Industries. We measure the number of establishments, the flows of entering and exiting establishments, and the average profit of establishments for more than 400 small geographic markets in the US at five-year intervals over the 1982–2002 period. We use these data to estimate an empirical model that characterizes the determinants of long-run firm values, the entry rate, and the exit rate across markets and over time. By estimating the model separately for two industries we are able to contrast the role of entry costs and the competitive effect of entry on profits between the two industries. We then use the estimated model to analyze the effect of entry subsidies in the dentist industry and contrast the costs and benefits of this policy with an alternative that subsidizes the fixed costs of incumbent firms.

The empirical results show that, for dental practices, the slope of the profit function with respect to the number of firms is negative and statistically significant. In the chiropractor industry there is also a negative effect but the decline is smaller in magnitude and not statistically significant. Estimates of parameters of the distributions of entry costs and fixed costs indicate that they are statistically significant for both industries, with the magnitudes being larger in the dental industry. We also find that entry costs are 11 percent lower in markets that were designated as HPSA markets for dentists. Overall, the estimates indicate that all three primitives of the model are important components of long-run firm values and market structure. As the number of firms in the market increases, the value of continuing in the market and the value of entering the market both decline, the probability of exit rises, and the probability of entry declines. These outcomes also differ substantially across markets due to differences in exogenous cost and demand factors.

Using the model estimates we simulate two alternative policies that subsidize firms in underserved dental markets. One is an entry cost subsidy that mimics the present policy used in HPSA markets and the second is a policy that subsidizes the fixed costs of incumbent producers. The two policies impact firm decisions in very different ways. The entry cost subsidy encourages entry but lowers long-run profits and increases the exit rate from the market whereas the fixed cost subsidy raises long-run profits, lowers the exit rate, and only slightly raises the entry rate. A cost benefit comparison shows that the entry cost subsidy is less expensive in terms of their cost per additional firm.

The next section of this article provides some background on the sources of entry and exit barriers in the dentist and chiropractor industries and summarizes the patterns of turnover observed in our data. The third section summarizes the theoretical model of entry and exit developed by Pakes, Ostrovsky, and Berry (2007) and presents our empirical representation of it. The fourth section summarizes our data focusing on the measurement of entry and exit, profitability, and the number of potential entrants in each geographic market. The fifth section reports the econometric

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estimates of the toughness of competition, entry cost, and fixed cost distributions for each industry. It also reports the results of several counterfactual exercises that reveal the importance of these three factors in generating turnover and the level of long-run profitability.

2. Market structure and turnover: dentists and chiropractors

■ In this article we study the determinants of market structure for two health services industries, dentists (NAICS 621210/SIC 8021) and chiropractors (NAICS 621310/SIC 8041), that are similar in terms of the nature of demand and technology but differ in the level of profits and turnover patterns. They both provide their services in relatively small, local markets, and the decision-making unit is a practice which is usually a small, single-doctor business. The market demand for these services is closely tied to population but the level of demand, and thus revenue and profits, generated by a given population will differ between the two professions. This will lead to different entry flows, exit flows, and number of practitioners in the two professions. The range of products offered is fairly standardized, and services of different practitioners are good substitutes for each other, at least until the population level reaches the point where specialization into different subfields (orthodontia, cosmetic dentistry) occurs. The technology is reasonably standardized across establishments in each industry and the main inputs are office space, capital equipment, office staff, and technical assistants that are combined with the doctor's time to produce output.

One difference between the two professions is the level of entry costs faced by a new practice. In our framework, an entry cost is any cost born by a new establishment in a geographic market that is not born by an existing establishment. The simplest difference arises from the cost of capital equipment and office construction. Dental offices generally require multiple treatment rooms with specialized electrical, plumbing, and X-ray equipment and office space typically requires significant renovation to make it usable. In contrast, the main equipment for a chiropractic office is a specialized chiropractic table in each treatment room. In addition to these setup costs, there is also the cost of attracting a stock of patients. Entry costs can also arise because of entry barriers, such as state licensing restrictions, that slow the geographic mobility of dentists or chiropractors from one market to another.[1]

Beginning in 1978 and continuing to the present day, federal government programs have been used to promote the entry of dentists, physicians, and mental health specialists into geographic areas that are designated as HPSA. In the case of dentists the designation is based on a combination of population-dentist ratio, local poverty level, distance to other markets, and access to fluoridated water. Once a geographic area has been designated as an HPSA, a number of federal and state subsidy programs become available to new physicians and dentists that locate there. The most significant funding comes from a loan repayment program administered by the National Health Service Corps (NHSC). In 2012, the NHSC loan repayment program made 4267 awards totalling \$169 million to physicians and dentists practicing in HPSAs.[2] For dentists, the subsidies are based on a sliding scale ranging from \$30,000 to \$200,000 per dentist depending on the length of time they serve in the HPSA. Typical payments are \$60,000 for a full-time, two-year commitment. In 2012, in addition to the federal program, 32 states had loan repayment programs targeted at new dentists with most being tied to service in an HPSA. In addition to each state's own funding for these programs, the NHSC provided \$9.8 million in funding to the states. In total, NHSC funding supported 1207 practicing dentists in 2011. The use of loan repayment subsidies to encourage physicians and dentists to locate in underserved areas will increase in importance in the future. Under the Affordable Care Act, total funding for all the NHSC programs has been increased to

[1] Professionals in both fields must be licensed to practice. National written exams are given in both fields and dentists must also pass regional or state-level clinical exams. The use of regional examining boards has grown over the last 20 years and made it easier for new dentists to be qualified in multiple states. American Dental Association (2012) and Sandefur and Coulter (1997) provide details on licensing requirements in each profession.

[2] NHSC also administers a scholarship program that supports physicians and dentists that commit to working in an HPSA after graduation. In 2012, there were 222 scholarship awards totalling \$42 million.

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$300 million dollars per year through 2015, compared with $135 million in 2009. The ceiling limit on the annual loan repayment award has been increased from $35,000 to $50,000 and award amounts can vary across HPSA, with a premium for areas with the most severe shortages.

Increasing the entry of new practices is one way to improve access to medical or dental care in a geographic area but reducing exit may be equally important. In 2012, the NHSC reported that, of the physicians and dentists funded under the NHSC programs, 82 percent were serving in underserved markets one year after their obligation was completed, and this fell to 55 percent after 10 years. The retention rate for dentists was 48 percent after 10 years. Using a survey of dentists funded by the NHSC between 1980 and 1997, Mofidi et al. (2002) report that 46 percent of the subjects were working in an underserved area in 1998. However, using a survey of physicians, Pathman et al. (2004) did not find a significant difference in retention rates between rural HPSA markets and rural non-HPSA markets, suggesting that entry was the more important factor determining service coverage in HPSA markets. Holmes (2005) studies the sequential decision of a physician to accept an NHSC scholarship and the type of community to locate in. He estimates that without the NHSC program there would be a 10 percent decline in the number of physicians in moderately- and highly underserved markets, implying the subsidies did increase net entry in these areas.[3]

From an IO perspective these subsidies act like a reduction in entry cost, which is designed to alter market structure and turnover in the HPSAs. We observe differences in market structure and turnover between the two industries and between the HPSA and non-HPSA areas. The data we will analyze in this article are for isolated geographic markets in the US which are observed at five points in time, 1982, 1987, 1992, 1997, and 2002. These markets are all relatively small, with populations that vary between 2,500 and 50,000 people. For dentists we utilize 639 geographic markets that have between 1 and 20 establishments and 59 of these markets are in HPSA designated areas. For chiropractors there are 410 markets with between one and eight establishments. The market-time observations are divided into four quartiles based on population, and Table 1 summarizes the number of establishments, average demand characteristics, and turnover in each quartile.

The first four rows of the table correspond to the non-HPSA markets for dentists. The first row shows that the smallest 25 percent of the markets have an average population of 5.14 thousand people and 3.86 dental practices. The annual average revenue per practice is $148,120. The three demand variables are per-capita income (in thousands of dollars), total federal medical expenditures in the area (in thousands of dollars), and the infant mortality rate (deaths per 1000 infants). The latter two variables are included to control for differences in the access and quality of medical care in the area. The last two columns are the entry proportion (the number of entering practices as a share of the number of practices) and the exit rate. For this smallest quartile of markets .204 of the establishments entered over the previous five years and .185 of the previous establishments exited.

Comparing the change in the number of practices relative to the average size of a practice we observe that supply adjustment comes primarily on the entry-exit margin. As the market size increases from the smallest to largest population quartile the average number of practices increases from 3.86 to 11.90, a 208 percent increase, although the average size of the practice, measured in revenue, increases only 16 percent. These are both good industries in which to study the entry and exit process.

Contrasting the non-HPSA and HPSA markets for dentists we observe differences in market structure. The HPSA designated markets have fewer practices on average in quartiles 2-4 and approximately the same in the smallest quartile. They also have a higher entry proportion and

[3] Although not a policy that subsidizes the entry or operating costs of a dentist, a decision to fluoridate public drinking water supplies can have an impact on the demand for dental services and therefore on long-run market structure. Ho and Neidell (2009) use county-level data on the incidence of fluoridation and estimate that an 8 percentage point increase in exposure to fluoridated water reduced the number of dental practices by 0.6 percent and the number of dental employees by 1.2 percent.

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TABLE 1 Demand and Market Structure Statistics (means across market-time observations)

	Structure		Demand			Dynamics	
Population Quartiles (mean population)[a]	n	Revenue per Practice[b]	Per-capita Income[b]	Fed. Medical Benefits[b]	Infant Mortality[c]	Entry Proportion	Exit Rate
			Dentist — non-HPSA Markets				
Q1 (5.14)	3.86	148.12	9.30	1.38	8.63	.204	.185
Q2 (7.67)	5.65	158.67	9.30	1.99	8.80	.206	.176
Q3 (11.10)	7.84	157.87	9.32	2.02	8.60	.206	.193
Q4 (19.93)	11.90	168.01	9.34	2.57	8.94	.209	.198
			Dentist — HPSA Markets				
Q1 (5.50)	3.92	129.11	9.12	1.30	9.12	.190	.214
Q2 (7.33)	4.57	148.62	9.13	1.51	9.13	.243	.212
Q3 (11.24)	5.16	151.27	9.18	1.47	9.18	.285	.208
Q4 (20.31)	8.55	171.99	9.17	2.02	9.17	.246	.175
			Chiropractors				
Q1 (6.39)	2.00	93.83	9.30	1.63	8.98	.413	.233
Q2 (9.74)	2.53	97.40	9.32	1.84	8.43	.482	.246
Q3 (14.92)	3.06	107.29	9.32	2.41	8.70	.503	.244
Q4 (28.20)	3.84	121.49	9.37	3.56	8.80	.518	.254

[a]thousands of people; [b]thousands of 1983 dollars; [c]deaths per 1000 infants.

a higher exit rate. Some of this may be due to different demand conditions because the HPSA markets tend to have lower per-capita income, lower federal medical benefits, and a higher infant mortality rate, all suggesting less overall health care usage. However, it is likely that the subsidized entry costs also play a role. Lower entry costs will tend to increase both entry and exit rates in a market, and this is consistent with the higher turnover observed in the HPSA markets. Contrasting the non-HPSA and chiropractor markets we observe, on average, a smaller number of practices, lower revenue per practice, and much higher entry and exit rates for chiropractors. The demand shifters, particularly income and infant mortality, tend to be similar across the population categories for the two industries and so the main forces generating the different market structure for chiropractors are likely to be lower per-capita demand, leading to fewer practices, and lower entry and fixed costs, leading to higher turnover. The empirical model we develop in the next section will allow us to identify the differences in profit, entry costs, and fixed costs and assess how they contribute to the differences in market structure and turnover in Table 1.

3. A Model of entry, exit, and profit

□ **Theoretical model.** Beginning with Bresnahan and Reiss (1987, 1991) and Sutton (1991), empirical studies of market structure have relied on a two-period model in which there is short-run competition among a fixed number of firms that determines price, quantity, and profits and long-run entry-exit decisions that determine the number of firms. This framework has relied on the zero-profit condition to specify a relationship between the number of firms and market size and has been estimated using cross-sectional data for geographic markets.[4] Overall, this two-period framework is designed as a model of long-run market structure and it does not distinguish the continuation decision of an incumbent firm from the entry decision of a potential entrant.[5] If there is a difference between the fixed cost an incumbent faces and the sunk entry cost a potential

[4] Other empirical papers in this literature are Berry (1992), Campbell and Hopenhayn (2005), Mazzeo (2002), Syverson (2004), and Seim (2006). Berry and Reiss (2007) provide a detailed summary of this literature.

[5] The exception to this is Berry (1992) which allows the airline's profit on a route to depend on whether they had a presence in one or both endpoint cities in prior years. Longitudinal information, either panel data or an historical measure of market structure, is needed to distinguish the different impacts of incumbents and potential entrants on market structure.

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entrant faces, then these two types of firms will respond differently when market fundamentals change. This limits the usefulness of two-period models in analyzing policies that are aimed only at potential entrants, as is the HPSA policy.

Recently, several authors have developed dynamic models of entry and exit that recognize that the participation decision for an incumbent firm differs from the decision for a potential entrant (Aguirregabiria and Mira, 2007; Bajari, Benkard, and Levin, 2007; Pesendorfer and Schmidt-Dengler, 2003; Pakes, Ostrovsky, and Berry, 2007; Ryan, 2012; and Collard-Wexler, 2013). Empirical papers that have drawn on these methodologies have utilized data on the flows of entering and exiting firms to estimate dynamic structural models of entry and exit in imperfectly competitive markets.

In this section, we outline a dynamic model of entry and exit that is similar to the model developed by Pakes, Ostrovsky, and Berry (hereafter, POB) with some modifications that aid estimation. Let s be a vector of state variables that determine the profit each firm will earn when it operates in the market. Represent the common component of per firm profit as $\pi(s;\theta)$ where θ is a vector of profit function parameters. The state vector $s = (n, z)$ contains two elements: n, the number of incumbent firms in the market at the beginning of the period and z, a set of exogenous profit shifters. The profit shifters in z, which will include variables that shift production costs, such as market-level input prices, and total market demand, such as market population and income, are assumed to evolve exogenously as a finite-state Markov process. The number of firms n will evolve endogenously as the result of the individual firm entry and exit decisions. Given a number of entrants e and exits x, the number of active firms evolves as $n' = n + e - x$. The individual entry and exit decisions will be determined by current and expected future profits and, through their effect on n', will impact future profits. In this specification the profit function $\pi(s;\theta)$ is viewed as a reduced-form profit function and the parameters θ summarize the combined effects of demand parameters, cost parameters, and the nature of short-run competition among the firms in the market.

Incumbent Firm's Decision. In the current period with market state s each incumbent firm earns $\pi(s;\theta)$. At the end of the period they draw a fixed cost λ_i, which is private information to the firm and is treated as an *iid* draw from a common cumulative distribution function G^λ. This fixed cost will be paid in the next period if they choose to continue in operation. Given the market state s and its observed fixed cost for the next period, the firm makes a decision to continue into the next period or to exit. The maximum payoff from the incumbent's current production plus discrete exit/continue decision can be expressed as

$$V(s;\lambda_i,\theta) = \pi(s;\theta) + \max\{\delta VC(s;\theta) - \delta\lambda_i, 0\}, \tag{1}$$

where VC is the expectation of the next period's realized value function for the firms that choose to produce. The firm will choose to exit the market if its fixed cost is larger than the expected future profits. This implies that the probability of exit by firm i is

$$\begin{aligned} p^x(s;\theta) &= \Pr(\lambda_i > VC(s;\theta)) \\ &= 1 - G^\lambda(VC(s;\theta)). \end{aligned} \tag{2}$$

Dropping θ to simplify the notation, the future firm value $VC(s)$ can be defined precisely as:

$$\begin{aligned} VC(s) &= E^c_{s'}\left[\pi(s') + E_{\lambda'}\left(\max\left\{\delta VC(s') - \delta\lambda', 0\right\}\right)\right] \\ &= E^c_{s'}[\pi(s') + \delta(1 - p^x(s'))(VC(s') - E(\lambda'|\lambda' \leq VC(s'))], \end{aligned} \tag{3}$$

where the expectation $E^c_{s'}$ is taken using the continuing firms' perceptions of the future values of the state variables $s = (n, z)$. The second line shows that, for each future state vector s', the firm will earn the current profit $\pi(s')$ and will produce in future periods with probability $(1 - p^x(s'))$. When it produces in future periods it earns the discounted expected future value net of the expected future fixed costs. This last expectation is conditional on the firm choosing to

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produce, so it is a truncated mean over the values of λ' that are less than the expected payoff from producing. This expression can be simplified if the fixed cost λ is distributed as an exponential random variable, $G^{\lambda} = 1 - e^{-(1/\sigma)\lambda}$ with parameter σ. Then the truncated mean fixed cost can be written as:

$$E(\lambda'|\lambda' \leq VC(s')) = \sigma - VC(s')\left[p^{x}(s')/(1 - p^{x}(s'))\right]. \tag{4}$$

Substituting this into equation (3), the continuation value becomes

$$VC(s) = E^{c}_{s'}\left[\pi(s') + \delta VC(s') - \delta\sigma(1 - p^{x}(s'))\right]. \tag{5}$$

Potential Entrant's Decision. Each potential entrant i observes the market state $s = (n, z)$ and also observes a private entry cost κ_i, which is treated as an *iid* draw from a common entry cost distribution G^{κ}. This cost is interpreted as the startup cost plus fixed cost that the firm must pay if it chooses to produce in the next period. The expected profit payoff for a firm that chooses to enter is

$$VE(s) = E^{e}_{s'}[\pi(s') + \delta VC(s') - \delta\sigma(1 - p^{x}(s'))], \tag{6}$$

where the notation $E^{e}_{s'}$ denotes that the expectation of future state values is from the perspective of an entering firm. The potential entrant enters if the discounted value of entry is larger than its private entry cost: $\delta VE(s) \geq \kappa_i$, so that the probability of entry in this model is

$$\begin{aligned} p^{e}(s) &= \Pr(\kappa_i < \delta VE(s)) \\ &= G^{\kappa}(\delta VE(s)). \end{aligned} \tag{7}$$

Equations (2) and (7) provide the basis for an empirical model of the observed entry and exit flows in a market. To implement them it will be necessary to estimate the continuation and entry value, $VC(s)$, and $VE(s)$, across states and model the distributions of fixed costs and entry costs, G^{λ} and G^{κ}.

POB show how to measure the continuation and entry values from market level data on profits, exit rates, and transition rates for the state variables. To simplify notation, define π, $\mathbf{VC}$, and $\mathbf{p}^{x}$ as vectors over the states (n, z) and define $\mathbf{M}_c$ as a matrix giving the incumbent's perceived transition probabilities from each (row) state (s) to every other (column) state (s'). The value of continuation can be written as

$$\mathbf{VC} = [I - \delta\mathbf{M}_c]^{-1}\,\mathbf{M}_c\left[\pi - \delta\sigma(1 - \mathbf{p}^{x})\right]. \tag{8}$$

Given a nonparametric estimate of $\mathbf{M}_c$, which can be constructed from data on the transitions patterns across states, we estimate $\mathbf{VC}$ as a fixed point to equation (8) where $1 - \mathbf{p}^{x} = G^{\lambda}(\mathbf{VC})$. This method has the advantage that the probability of exit is generated consistently with the other parameters of the model but has the disadvantage of requiring that the value of continuation be solved for each state at each parameter vector.[6]

Let $\mathbf{M}_e$ be the perceived state transition matrix from the perspective of the potential entrant, then the value of entry (6) becomes

$$\mathbf{VE} = \mathbf{M}_e[\pi + \delta\mathbf{VC} - \delta\sigma(1 - \mathbf{p}^{x})]. \tag{9}$$

Given estimates of $\mathbf{VC}$, π, and $\mathbf{M}_e$, $\mathbf{VE}$ can be constructed and used with the entry condition equation (7), and entry flow data to estimate the parameters of the entry cost distribution G^{κ}.[7]

[6] POB suggest using nonparametric estimates of both $\mathbf{M}_c$ and $\mathbf{p}^{x}$ in equation (8). This avoids the need to resolve the value of continuation at each parameter vector. In our application, we found that the solution of equation (8) was fast and that the estimates of $\mathbf{VC}$ were very stable.

[7] The main difference between the fixed cost model we use and the scrap value model developed by POB is that the last term $-\delta\sigma(1 - \mathbf{p}^{x})$ in equations (8) and (9) would be replaced by $+\delta\sigma_s\mathbf{p}^{x}$ where σ_s is the parameter of the exponential distribution of scrap values. An increase in the mean scrap value will raise VC and VE, while an increase in the mean fixed cost will lower them. A higher value of VE will lead to a higher estimate of the sunk entry cost. We found that in

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□ **Empirical model.** The goal of the empirical model is to estimate the vector of short-run profit function parameters θ and parameters characterizing the distribution of fixed costs G^{λ} and entry costs G^{κ} where the latter will differ for HPSA and non-HPSA markets. We utilize a panel data set for a cross-section of $m = 639$ geographic markets over $t = 5$ time periods. For each market/year observation, the key endogenous variables are the number of establishments n_{mt}, the number of entering firms e_{mt}, and the number of exiting firms x_{mt}. There is also a set of exogenous demand and cost shifters denoted z_{mt}, one of which is a measure of market size, such as population.

We can contrast this setup with the two-period framework that was developed by Bresnahan and Reiss (1987, 1991). Their insight is that the cross-sectional covariation between the number of firms and exogenous measures of market size can be used to infer the competitive effect on profits of an additional firm in the market.[8] Because their model is static, there is no distinction between short-run profits $\pi(s)$ and long-run firm values $VC(s)$ and $VE(s)$. In the dynamic model in the last section, firms make participation decisions based on long-run firm values given in equations (8) and (9). $VC(s)$ and $VE(s)$ include both the competitive effect of an additional incumbent firm on short-run profits, given by the relationship $\pi(n)$, and the future expected competitive effect due to entry and exit, which is captured by the transition matrices for the states, M_c and M_e. These transition matrices for the number of firms are equilibrium objects that also depend upon both the number of incumbent firms and the number of potential entrants. If firms make their participation decisions in this way, then the empirical relationship between market size and the number of firms will reflect both of these effects but they cannot be separately identified in the static framework. By estimating the dynamic model we will be able to separately measure the effect of the number of firms on both short-run profits π and long-run firm values VC and VE.

Another way in which the dynamic model differs from the static model is that it makes a sharp distinction between fixed costs λ that are paid by incumbents each period and one-time sunk entry costs κ that are paid by potential entrants. The static model relies on the zero-profit condition for entry assuming that there is no systematic cost difference between firms that have operated in the market in prior years and new potential entrants. At a minimum, it is necessary to distinguish these two groups in order to analyze policies that subsidize entry costs such as the HPSA program. Using the dynamic model, we will be able to compare the effects of subsidies on entry costs with subsidies on fixed costs for incumbents.

Finally, the dynamic model predicts that market structure at a point in time depends, not just on the expected future profit stream, but also on the past market structure, that is, the number of incumbents in the previous time period and the number of potential entrants. In the static model, the prior market structure is not relevant. Dunne et al. (2009) estimate reduced-form models for the number of firms and average firm size that are consistent with this dynamic framework and contrast them with the reduced-form models from the static framework. They find that market structure in both the dentist and chiropractor industries depends significantly on the lagged number of firms and the number of potential entrants and that the coefficient on market size differs substantially when the lagged market structure variables are included. At a minimum, their findings indicate that it can be difficult to disentangle the magnitude of the competitive effect of additional firms from the fixed costs and sunk costs driving the participation decisions using the static framework.

Profit function. Since we observe average market-level profits in our data, we are able to recover the parameters of the profit function θ. We specify a profit function that is very flexible with

estimating the scrap value model the estimated entry costs were higher than were reasonable given some indirect evidence we were able to construct on entry costs. We instead chose to develop the model treating the *iid* profitability shock as a fixed cost.

[8] Berry and Reiss (2007) discuss a number of alternative specifications for demand, cost, and short-run competition that can be estimated, fully or in part, using the relationship between the number of firms and market size for a cross-section of markets.

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respect to the state variables. We assume that the average profit function for all practices in market m, year t can be written as

$$\pi_{mt} = \theta_0 + \sum_{k=1}^{5} \theta_k I(n_{mt} = k) + \theta_6 n_{mt} + \theta_7 n_{mt}^2 + h(\theta_z, z_{mt}) + f_m + \varepsilon_{mt}. \tag{10}$$

We include a set of dummy variables $I(n_{mt} = k)$ to distinguish markets with $k = 1, 2, 3, 4, 5$ establishments and would expect the per-establishment profits to decline with discrete increases in n. We also include linear and quadratic terms in n to allow the possibility of a diminishing effect of n on average profits as the number of firms increases beyond five. $h(\theta_z, z_{mt})$ is a quadratic function of the five exogenous state variables that control for differences in cost and demand conditions: the level of population pop_{mt}, the average real wage paid to employees in the industry w_{mt}, real per-capita income, inc_{mt}, county-level real medical benefits paid by the federal government med_{mt}, and infant mortality rate $mort_{mt}$. The latter two variables control for differences in access to medical care facilities in the area. To simplify the discussion below, we will often combine these exogenous variables into the state vector $z_{mt} = \{pop_{mt}, w_{mt}, inc_{mt}, med_{mt}, mort_{mt}\}$.

Despite controlling for these state variables, it is likely that there are unobserved factors that lead to persistent differences in the level of profits across markets. This could include factors such as education differences that could affect the demand for these services, the type of employers in the area, which could lead to differences in the degree of insurance coverage for health-related services, and differences in the availability of substitute products in the same or adjacent geographic markets. To control for potential profit differences across markets arising from these factors we include a market fixed effect f_m in the profit function specification. If there are persistent factors that cause differences in profits across markets and we fail to control for them we expect the coefficients related to the number of firms $\theta_1, \ldots \theta_7$ to be biased toward zero. That is, we will underestimate the competitive (negative) effect of an increase in the number of firms on producer profits. Finally, all other variation is captured with a idiosyncratic shock ε_{mt} that is assumed to be *iid* across markets and time. The inclusion of f_m in the profit function complicates the dynamic aspects of the model because f_m must now be treated as a state variable in the empirical model of entry and exit. We discuss treatment of this in the next section.

Given the assumptions of the theoretical model, the number of firms is uncorrelated with the idiosyncratic shock ε and equation (10) can be estimated with the fixed effects estimator. The key assumption is that all sources of serial correlation in profits have been controlled for with the time-varying state variables, number of firms, and market fixed effect so the idiosyncratic shock does not contain any serially correlated components that the firms use in making entry or exit decisions. Although the profit function parameters could still be consistently estimated if there were instrumental variables available that were correlated with the number of firms n but not the idiosyncratic shock ε, it is difficult to identify good candidates for instruments. In particular, the lagged number of firms in the market n_{mt-1} is not an appropriate instrument because the combination of the dynamic decision process generating n and the serial correlation in ε means that n_{mt-1}will be correlated with ε_{mt}.[9]

State variable transitions. The second step of the estimation method is to estimate the two transition matrices M_c and M_e. POB propose to estimate these objects nonparametrically by discretizing the values of the state variables and calculating the transition frequencies from the market-level panel data for each discrete state. In our case, the number of firms n is already a discrete variable. After estimating the profit function parameters $\hat{\theta}$ we construct a single continuous variable measuring the combined effect of the exogenous variables in z_{mt} as the fitted

[9] Lagged values of the exogenous state variables z are candidates for instruments. We have estimated the profit function model using them as instruments but find that they are not highly correlated with the number of firms after controlling for current values of the exogenous state variables.

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value

$$\hat{z}_{mt} = h(\hat{\theta}_z, z_{mt}), \tag{11}$$

that captures the combined contribution of the demand and cost shifters to profits. We then discretize the values of $\hat{z}_{mt}$ into a small number of categories and use the mean of each category as the discrete set of points for evaluation. Denote these points as z_d. Although the market fixed effects are discrete, there is one for each of the 639 geographic markets in our data set, and this quickly exhausts the data available. To simplify this, we further classify the markets into a small number of categories based on their estimated $\hat{f}_m$. Denote these points as f_d.

The number of discrete states is $n_{\max} \cdot z_d \cdot f_d$, where $n_{\max}$ is the largest number of firms observed in any market, and the number of cells in the transition matrices are $(n_{\max} \cdot z_d \cdot f_d)^2$. To keep the dimensionality of M_c and M_e tractable, we use 10 discrete categories for the exogenous state variable z_d and 3 categories for f_d**.** We exploit the fact that the state variables in z evolve exogenously and that the market fixed effect does not change over time, so that the transition probability used by continuing firms is $M_c(n', z'_d, f_d|n, z_d, f_d) = M_{nc}(n'|n, z_d, f_d) \cdot M_z(z'_d|z_d) \cdot I_{f_d}$. Each of these smaller matrices is estimated separately using the observed transitions in the data. A similar expression for M_e can be written as $M_e = M_{ne}(n'|n, z_d, f_d) \cdot M_z(z'_d|z_d) \cdot I_{f_d}$.

Fixed costs and entry costs. The final stage of the estimation method focuses on the parameters of the fixed cost and entry cost distributions using the data on entry and exit flows in the market. For each market observation mt, the value of continuing is constructed from equation (8) and denoted $\hat{VC}_{mt}(\sigma)$ to indicate that it depends on the parameter σ, which characterizes the fixed cost distribution. Similarly, $\hat{VE}_{mt}(\sigma)$ is constructed from (9) to also indicate it depends on the fixed cost parameter σ. Denoting $G^{\kappa}(\alpha)$ and $G^{\lambda}(\sigma)$ as the cdf's of the entry cost and fixed cost, respectively, then the log of the probability of observing a market with x_{mt} exits and e_{mt} entrants (given p_{mt} potential entrants) is given by

$$\begin{aligned} l(x_{mt}, e_{mt}; \sigma, \alpha) = {} & (n_{mt} - x_{mt}) \log(G^{\lambda}(\hat{VC}_{mt}(\sigma); \sigma)) + (x_{mt}) \log(1 - G^{\lambda}(\hat{VC}_{mt}(\sigma); \sigma)) \\ & \times (e_{mt}) \log(G^{\kappa}(\hat{VE}_{mt}(\sigma); \alpha)) + (p_{mt} - e_{mt}) \log(1 - G^{\kappa}(\hat{VE}_{mt}(\sigma); \alpha)), \end{aligned} \tag{12}$$

where $G^{\kappa}(\alpha)$ is allowed to differ between observations in HPSA and non-HPSA markets.

The log-likelihood for the entry and exit observations is

$$L(\sigma, \alpha) = \sum_m \sum_t l(x_{mt}, e_{mt}; \sigma, \alpha). \tag{13}$$

The final step is to specify the cdf's for the entry cost and fixed cost distribution. Consistent with the theoretical model in the last section, we assume that the firm fixed cost λ is distributed as an exponential random variable with parameter σ, which is the mean fixed cost. For the distribution of firm entry costs, $G^{\kappa}(\alpha)$, we assume it follows a chi-squared distribution and the single parameter α is the unconditional mean.[10] To recognize the impact of the entry subsidy in HPSA markets, we will allow the entry cost distribution G^{κ} to differ between HPSA and non-HPSA markets. Finally, we also estimate this stage of the model using GMM where the moments are the average entry and exit rates across states. POB found that GMM performed better in their simulations when the entry and exit rates were very small because the estimates were less sensitive to measurement error in the continuation value. This is not likely to be an issue in our data because the five-year measurement period leads to entry and exit rates which are generally in the 0.2 to 0.5 range (see Table 1).

[10] We also estimate the model using an exponential distribution for the entry cost and find that over the range of the data the two estimated distributions are indistinguishable.

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4. Data

□ **Definition of the market.** To estimate the model the data set must contain information on the entry flows, exit flows, average firm profits, exogenous profit shifters, number of firms, and potential entrants across multiple markets. The data we use in this analysis come from US Census Bureau's Longitudinal Business Database (LBD) and Census of Service Industries. The LBD contains panel data on the identity of all employers in the United States for each year from 1982 through 2002, while the Census of Service Industries contains information on revenues, costs, and geographic location for each establishment in the service sectors for the years 1982, 1987, 1992, 1997, and 2002. We define geographic markets as incorporated census places, which are basically small to midsized towns and cities in rural or semirural areas. We also identify whether each geographic market is subject to entry subsidies for dentists because it is designated as a HPSA. The HPSA areas vary in size from multiple census tracts to counties and are not identical to the economic census places that we use to define our geographic markets, but we are able to match the HPSA areas to our markets. If all or part of one of our geographic markets falls into the coverage area of an HPSA, then we designate that geographic market as an HPSA market. If the HPSA designation is effective in attracting new dental practices then our observed geographic market should have a higher than expected number of practices, even if only part of the market is in the HPSA area. Overall, 59 of the 639 geographic markets in our data are HPSA areas for at least one of the sample years.

□ **Measuring entry and exit.** As discussed in Jarmin and Miranda (2002), the LBD uses both Census Bureau establishment-level identification numbers and name and address matching algorithms to track continuing establishments over time. An entrant is defined as an establishment that is not present in the market in period t but is producing in the market in period $t + 5$ (the next census year). Similarly, an exit is defined as an establishment that is in a market in period t and is not in that market in period $t + 5$. The focus of our model is on the startup and shutdown decisions that change the number of firms in operation in a market. We do not treat the sale of an ongoing practice as an exit and an entry but rather as a change in ownership which does not affect market structure or profitability. To the extent possible, what we measure in the exit statistics are the number of establishments that actually shut down.

□ **Market level demand and cost variables.** In the profit function we include six exogenous state variables. To control for demand differences we include the population and the real per-capita income of the geographic market. The population estimates for incorporated places in each sample year are constructed from the Census Bureau's Population Estimates Program. The remaining demand variables, real per-capita income, total federal medical payments, and the infant mortality rate, are constructed at the county level. The income and medical payments data is from the Bureau of Economic Analysis deflated by the CPI and a health care price index, respectively. To control for cost differences we measure the average real wage paid to employees in health services industries in the area where the deflator is the national CPI. Because we do not use local price deflators, variation in the wage variable will also reflect price-level differences across geographic markets, which is likely to be important in the cross-section dimension of the data.

□ **Measuring establishment profits.** The empirical model requires a measure of the average profits or net income earned by a dentist or chiropractor from operating the establishment. To construct this, we use information on the establishment's revenue, payroll, and legal form of organization from the Census LBD. We control for other business expenses (licensing fees, costs of supplies and materials, insurance, rent, depreciation charges on capital equipment, and purchased services) using information from the American Dental Association (2002) and the Census Bureau's Business Expenses Survey (BES) (U. S. Census Bureau, 2007) which estimate these expenses as approximately 35 percent of a dentist's office revenues. For the offices of

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chiropractors, we rely on aggregate data from the BES for industry 804 (Offices of Other Health Practitioners) that show that these expenses account for 37 percent of a chiropractor's office revenues.

In constructing a measure of profit we also recognize differences in the establishment's legal form of organization. For sole proprietors and partnerships, firm pretax profits (net income) are revenue minus payroll minus estimated expenses. For incorporated businesses, part of the owner's compensation is typically included in payroll. We use aggregate tax data to measure the share of payroll going to the owners of incorporated firms in each of these industries and adjust payroll and profits of corporations to reflect this. The second correction deals with the fact that the number of owner-practitioners will vary across medical offices and thus the level of firm profits will vary with the number of owner-practitioners.[11] In order to make our profits comparable across offices of different scale, we normalize the profits per office by the average number of owner-practitioners across the LFO types. Thus, our final measure of profit is the net income per owner-practitioner.[12]

□ **Measuring the number of potential entrants.** The empirical model requires that we measure the pool of potential entrants in each geographic market. One option that has been used in the literature is to assume that there is a fixed number of potential entrants in every market and time period. This is not realistic given the large variation in the population and number of firms we observe in our market-level data. Instead, we adopt two definitions of the entry pool that will allow it to vary with the size of each market. The first sets the number of potential entrants for a market-time observation equal to the maximum number of different establishments that appear in the market over time minus the number of establishments already in operation. This assumes that in each geographic market we observe all possible establishments being active at some point in time and the pool of potential entrants in a year is the set of establishments that are not currently active. We will refer to this as the "internal" entry pool because it is constructed using only data that is present in the Census LBD. It will also tend to covary positively with the population of the geographic market and the actual number of entering firms, resulting in an entry rate that is roughly constant across market sizes. The disadvantage of this measure is that, as the number of establishments has increased over time due to exogenous growth in population, it is likely to overestimate the number of potential entrants, and thus underestimate the entry rate, in the early years of the sample.

This internal entry pool definition misses the fact that one of the main sources of entry into these professions is a doctor that breaks away from an existing practice to start a new practice in an area.[13] To capture this feature of the potential entry pool, we exploit additional data from the American Dental Association, Federation of Chiropractic Licensing Boards, and Bureau of Health Professionals to estimate the number of non-owner practitioners in an area. Specifically, we measure the number of dentists that exceed the number of dental offices in the county in which each of the geographic markets is located and in the counties that are contiguous to this county. We will refer to this as the "external" entry pool definition.

The potential entry pools are summarized in Table 2. The table reports the average number of potential entrants for observations with a given number of establishments. The number of potential entrants rises with the number of establishments and, for the "internal" entry pool, is slightly larger

[11] Based on 1997 dentist data, for sole proprietors the ratio of the number of owners to offices is one to one; for partnerships there are roughly 1.8 owner-dentists per partnership; and for professional service organizations there are roughly 1.35 dentists per practice.

[12] Using the census data, we measure the flow of profits in census year t while the entry and exit numbers are flows over the five-year period between censuses. We convert the annual profits to the discounted sum over the five-year interval by $\Pi_{mt} = \sum_{j=0}^{4} \delta^j \pi_{mt}$ and with $\delta = .95$. In effect, we treat the practice as making the decision to exit or enter based on the discounted sum of the five-year flow of profits. In addition, the discount rate used to construct VC and VE is the value at the end of the five-year interval, $.95^5 = .773$.

[13] Industry sources (Weaver, Haden, and Valachovic, 2001) explain that most entry comes from dentists leaving an existing practice to start a new one and that few dental school graduates start new practices on their own right after school.

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TABLE 2 Number of Potential Entrants (mean across market-time observations)

Number of Establishments	Dentists: Number of Potential Entrants — Internal Entry Pool	Dentists: Number of Potential Entrants — External Entry Pool	Chiropractors: Number of Potential Entrants — Internal Entry Pool	Chiropractors: Number of Potential Entrants — External Entry Pool
$n = 1$	2.31	23.55	3.42	1.95
$n = 2$	2.74	25.22	3.78	2.88
$n = 3$	3.48	23.41	4.25	4.21
$n = 4$	4.04	23.05	5.13	5.37
$n = 5$	4.75	23.79	5.61	6.83
$n = 6$	6.03	25.45	6.19	7.74
$n = 7$	6.58	27.83	6.16	9.37
$n = 8$	7.81	29.09	8.75	10.67
$n = 9$	8.53	28.26		
$n = 10,11$	9.66	27.13		
$n = 12,13,14$	11.74	25.89		
$n = 15,16,17$	13.83	27.15		
$n = 18,19,20$	15.95	28.21		

than the number of establishments in the market. The "external" entry pool for dentists is much larger because we identify a fairly large number of dentists in the surrounding counties. In general, this external entry pool will increase with the size of the geographic market, but it is not as closely tied to the number of practices in the market as the internal entry pool. The difference in the number of potential entrants between the two definitions will likely affect the estimated sunk entry cost, with the larger entry pool implying a lower entry rate and correspondingly higher estimated entry costs. As an altervative to these assumptions on the potential entry pool, the Appendix estimates a model where the pool is infinite and entry is modeled as a Poisson process.

5. Empirical results

□ **Estimates of the profit function.** The profit function parameters θ are estimated both with and without market fixed effects and are reported in Table 3. The first column reports estimates for the dentist industry without the market fixed effect. The dummy variable coefficients for markets with one to four firms are positive and decline slightly as n increases but are not significant, although the coefficient for markets with $n = 5$ actually increases and is significant, whereas the coefficients on n and n^2 are small and not significant. If there are persistent, unobserved profit determinants across markets, these coefficients will be biased toward zero. In contrast, after controlling for market fixed effects, the same coefficients in column two indicate a more substantial decline in average profits with an increase in the number of firms. The dummy variable coefficients are larger in magnitude, but still not statistically significant, whereas the coefficients on n and n^2 do indicate a significant negative competitive effect from an increase in the number of firms. The coefficients imply that, relative to a market with five practices, the monopolist will have a profit premium of 69 percent. This premium will decline to 47 percent in a duopoly, 26 percent in a market with three practices, and 10 percent with four firms. The estimates indicate a substantial competitive effect on average profits as the number of practices increases.

The profit function estimates for chiropractors are reported in the last two columns of the table. Because there are at most eight establishments in any market, we use a full set of dummies for the number of firms, and markets with eight firms are the omitted group. As expected, there is a more substantial decline in profits when the fixed effect estimator is used, although none of the coefficients are individually statistically significant. The decline in profits with an increase in the number of firms is much smaller than for dentists. Relative to a market with five practices, the profit premiums are 15 percent, 5 percent, and 3 percent for monopoly, duopoly, and three

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TABLE 3 Profit Function Parameter Estimates (standard deviation in parentheses)

Dentist			Chiropractor		
Variable	No Market Fixed Effect	Market Fixed Effect	Variable	No Market Fixed Effect	Market Fixed Effect
Intercept	−11.543 (4.184)*	−2.561 (4.922)	*Intercept*	−1.215 (8.720)	−23.96 (10.55)*
$I(n=1)$	.0379 (.0240)	.0519 (.0301)	$I(n=1)$	.0200 (.0328)	.0613 (.0373)
$I(n=2)$	.0253 (.0173)	.0342 (.0221)	$I(n=2)$	.0211 (.0324)	.0389 (.0373)
$I(n=3)$	.0113 (.0134)	.0179 (.0163)	$I(n=3)$	.0100 (.0328)	.0338 (.0361)
$I(n=4)$	.0112 (.0100)	.0108 (.0122)	$I(n=4)$	.0046 (.0324)	.0192 (.0355)
$I(n=5)$	.0191 (.0087)*	.0154 (.0088)	$I(n=5)$	.0005 (.0331)	.0266 (.0360)
n	−.0044 (.0045)	−.0238 (.0059)*	$I(n=6)$	−.0021 (.0339)	.0041 (.0362)
n^2	.0001 (.0002)	5.55e-4 (2.45e-4)*	$I(n=7)$	−.0277 (.0353)	−.0205 (.0369)
pop	.0127 (.0196)	.0029 (.0301)	*pop*	−.0097 (.0253)	.0036 (.0403)
pop^2	−6.69e-5 (3.07e-5)*	−1.68e-4 (1.07e-4)	pop^2	−8.92e-5 (2.96e-5)*	−.0001 (.0001)
inc	2.421 (.9027)*	.242 (1.064)	*inc*	.2004 (1.845)	4.994 (2.248)*
inc^2	−.1260 (.0489)*	.0048 (.0577)	inc^2	−.0062 (.0977)	−.2589 (.1200)*
med	−.0299 (.1005)	.2779 (.1310)*	*med*	.3042 (.1360)*	.0634 (.2220)
med^2	−.0007 (.0001)*	−.0009 (.0002)*	med^2	−.0004 (.0004)	−.0007 (.0006)
mort	.1387 (.0397)*	.1134 (.0363)*	*mort*	−.1040 (.0745)	.0184 (.0801)
$mort^2$	−.0002 (.0001)	−7.97e-5 (1.19e-4)	$mort^2$	.0004 (.0003)	7.62e-5 (2.76e-4)
wage	−.1955 (.0577)*	−.0935 (.0554)	*wage*	.1866 (.0687)*	.0867 (.0776)
$wage^2$	−.0013 (.0002)*	−.0008 (.0002)*	$wage^2$	−.0005 (.0001)*	−.0002 (.0001)
$pop * w$	2.55e-5 (1.61e-4)	2.67e-4(1.86e-4)	$pop * w$	7.91e-6 (9.53e-5)	-2.46e-6 (1.14e-4)
$pop * inc$	−.0009 (.0020)	.0019 (.0032)	$pop * inc$	.0015 (.0027)	.0005 (.0043)
$pop * med$	−.0004 (.0002)*	−.0003 (.0004)	$pop * med$	.0004 (.0002)*	.0003 (.0003)
$pop * mort$	4.72e-6 (1.18e-3)	5.97e-5 (1.25e-4)	$pop * mort$	−.0001 (.0001)	−.0004 (.0001)*
$wage * inc$	.0246 (.0062)*	.0119 (.0060)*	$wage * inc$	−.0182 (.0072)	−.0090 (.0082)
$wage * med$	.0029 (.0006)*	.0023 (.0007)*	$wage * med$	.0011 (.0004)*	.0004 (.0005)
$wage * mort$	−2.82e-5 (3.09e-4)	.0002 (.0003)	$wage * mort$	.0003 (.0004)	.0010 (.0004)*
$inc * med$	.0031 (.0107)	−.0267 (.0138)	$inc * med$	−.0326 (.0142)*	−.0071 (.0234)
$inc * mort$	−.0148 (.0042)*	−.0124 (.0038)*	$inc * mort$	.0102 (.0078)	−.0024 (.0084)
$med * mort$	−.0003 (.0005)	−.0008 (.0006)	$med * mort$	−7.52e-4 (7.80e-4)	.0006 (.0010)
obs	2556	2556	obs	1640	1640
F(27,df)	32.03	58.94	F(27,df)	13.47	5.51
p-value	.0000	.0000	p-value	.0000	.0000

*significant at .05 level

or four firm markets, respectively. This can reflect that there are close substitute products for chiropractor services so that the profit premium earned in markets with few practices is limited. As a result, an additional firm has a smaller effect on industry competition and firm profits.

□ **Fixed costs, firm values, and the probability of exit.** The maximum likelihood estimates of the parameters of the fixed cost and sunk entry cost distributions, σ and α, are reported in Table 4. Each of these parameters is the mean of the underlying cost distribution, expressed in millions of 1983 dollars. Because the entry, exit, and profit flow data used in the likelihood function are measured over five-year intervals, the parameters are the costs of operating over a five-year period. Panel A of Table 4 reports maximum likelihood parameter estimates for the dentist industry. The estimate of the mean fixed cost is .37 million dollars for both the internal and external entry pool definitions.[14] It is also unaffected by whether we distinguish HPSA and non-HPSA markets in panel B.

[14] We also estimated σ using only the part of the likelihood function that pertains to the exit and survival flows, ignoring its effect on the value of entry *VE*. This had no effect on the estimate, which implies that the long-run value of the firm can be robustly estimated with or without the data on entry and assumptions on the potential entry pool. Finally, we also use the nonparametric estimator of p^x suggested by POB and find the results are very robust to this alternative.

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TABLE 4 Fixed Cost and Entry Cost Parameter Estimates (standard errors in parentheses)

	Maximum Likelihood Estimator			GMM Estimator		
Panel A. Dentist (all markets)						
Entry Pool	σ	α		σ	α	
Internal	0.373 (0.006)	2.003 (0.013)		0.362 (0.004)	2.073 (0.031)	
External	0.375 (0.006)	3.299 (0.039)		0.362 (0.004)	2.644 (0.067)	
Panel B. Dentist (HPSA versus non-HPSA markets)						
Entry Pool	σ	α (HPSA)	α (non-HPSA)	σ	α (HPSA)	α (non-HPSA)
Internal	0.366 (0.009)	1.797 (0.069)	2.019 (0.041)	0.351 (0.005)	1.877 (0.076)	2.098 (0.032)
External	0.368 (0.008)	3.083 (0.169)	3.376 (0.079)	0.351 (0.005)	1.943 (0.213)	2.695 (0.092)
Panel C. Chiropractor						
Entry Pool	σ	α		σ	α	
Internal	0.275 (0.005)	1.367 (0.015)		0.254 (0.004)	1.337 (0.023)	
External	0.274 (0.005)	1.302 (0.022)		0.254 (0.004)	1.302 (0.028)	

TABLE 5 Predicted Value of Dynamic Benefits VC, VE (evaluated at different values of the state variables) (millions of 1983 dollars)

	VC for Incumbents — Dentist			*VE* for Potential Entrants — Dentist		
	Low(z, f)	Mid(z, f)	High(z, f)	Low(z, f)	Mid(z, f)	High(z, f)
$n = 1$	0.433	0.764	1.286	0.394	0.722	1.247
$n = 2$	.0383	0.714	1.236	0.350	0.678	1.202
$n = 3$	0.331	0.661	1.184	0.304	0.632	1.156
$n = 4$	0.297	0.628	1.150	0.273	0.601	1.126
$n = 5$	0.261	0.591	1.114	0.240	0.568	1.093
$n = 6$	0.236	0.567	1.089	0.218	0.546	1.070
$n = 8$	0.195	0.525	1.048	0.180	0.508	1.032
$n = 12$	0.126	0.457	0.979	0.117	0.445	0.969
$n = 16$	0.089	0.420	0.942	0.083	0.412	0.936
$n = 20$	0.067	0.397	0.920	0.064	0.392	0.916
	VC for Incumbents — Chiro			*VE* for Potential Entrants — Chiro		
$n = 1$	0.178	0.344	0.562	0.170	0.335	0.553
$n = 2$	0.166	0.332	0.551	0.161	0.326	0.544
$n = 3$	0.155	0.321	0.540	0.151	0.316	0.534
$n = 4$	0.148	0.314	0.532	0.144	0.308	0.527
$n = 5$	0.138	0.304	0.522	0.134	0.299	0.517
$n = 6$	0.132	0.298	0.516	0.129	0.294	0.512
$n = 7$	0.127	0.294	0.512	0.126	0.291	0.509
$n = 8$	0.123	0.289	0.508	0.123	0.287	0.506

Given the estimate of $\sigma = .373$, we calculate the value of an incumbent continuing in operation, VC, and the value of entering, VE, for alternative state vectors (n, z, f) and these are reported in the top half of Table 5.[15] The estimate of VC, the discounted sum of expected future net income to the practitioner, varies substantially with the state variables. As we move down each column, increasing the number of firms while holding the exogenous state variables fixed, VC declines. This reflects two forces: the underlying toughness of short-run competition seen in the slope of the profit function and the endogenous impact of entry and exit on the long-run firm payoff. As will be discussed below, this latter effect mitigates the decline in long-run profitability arising from the toughness of short-run competition because an increase in the number of firms leads to less entry and more exit in the industry.

[15] We construct three combinations of the discrete state variables (z_d, f_d) which will generate low, medium, and high values of the profit function.

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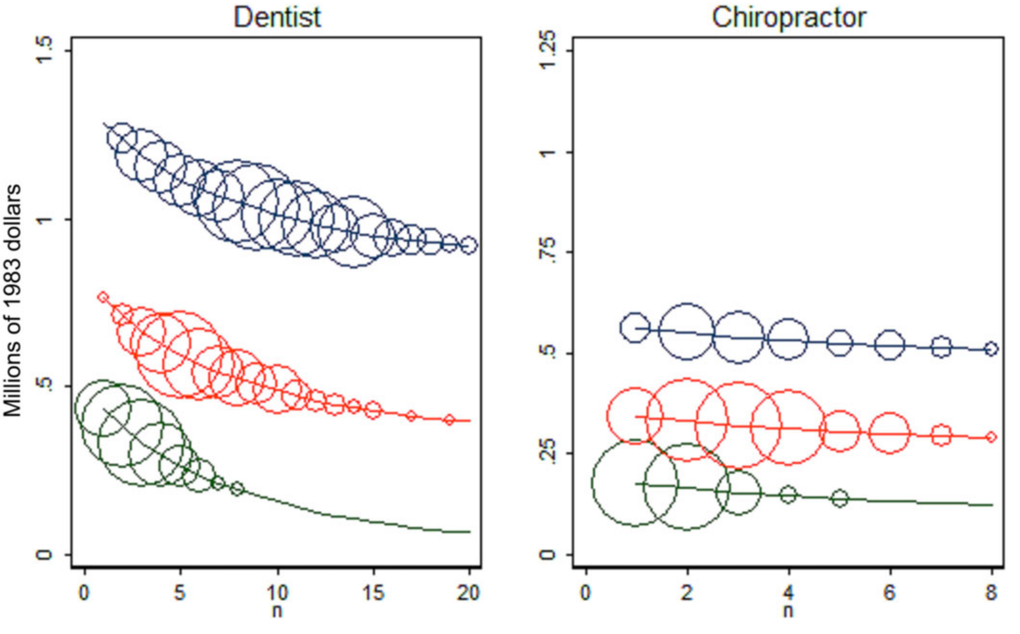
FIGURE 1

VALUE OF CONTINUATION *VC*(n, z, f) LOW, MEDIUM, AND HIGH VALUES OF (z, f)



Holding n fixed and allowing the state variables (z, f) to increase results in substantial increases in VC as shown in Table 5. This indicates that differences across markets in population, wages, income, access to medical care, and the market fixed effect result in significant differences in long-run firm values, even after accounting for the endogenous effect of entry and exit. For example, a monopoly provider in a market with low-profit characteristics, *low*(z, f), would have an estimated long-run value of .433 million dollars, whereas that same monopoly would have a value of 1.286 million dollars in a market with high-profit characteristics. It is clear from comparing the estimates of VC that differences in exogenous characteristics across markets are more important than differences in the number of firms in determining the long-run value of the firm. The value of entering the market, VE, is reported in the last three columns of Table 5 and we observe that, at each state vector, the estimates are similar to the estimate of VC and thus show the same pattern of decline with n and substantial variation with exogenous market characteristics.[16]

To more clearly illustrate the variation in VC across states and the difference in the levels across industries, we graph the values of VC from Table 5 in Figure 1. Each line represents $VC(n)$ holding the other state variables fixed and thus reflects the endogenous relationship between the number of firms and firm values. The upward shifting of the function reflects the difference due to an increase in the exogenous market characteristics (z, f). Finally, to relate the values to the actual data, the size of the circles reflects the number of market/year observations in the data set that have each combination of (n, z, f). It is clear from the figure that markets with low (z, f) values have few firms, while markets with exogenous characteristics that generate higher profits support more firms. However, even in the high profit markets there is wide variation in the number of firms present which implies that some additional source of market heterogeneity, in our case

[16] The difference in VC and VE arises from the difference between incumbents and entrants in the perceived transition probabilities for the state variables, M_c and M_e, in equations (8) and (9). In this application, the estimates of the two transition matrices are very similar so that the estimates of VC and VE are also very similar for each state.

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TABLE 6 Predicted Probabilities of Exit and Entry (evaluated at different values of the state variables)

	Probability of Exit — Dentist			Probability of Entry — Dentist		
	Low(z, f)	Mid(z, f)	High(z, f)	Low(z, f)	Mid(z, f)	High(z, f)
$n = 1$	0.313	0.129	0.032	0.141	0.216	0.382
$n = 2$	0.358	0.148	0.036	0.126	0.204	0.371
$n = 3$	0.412	0.170	0.042	0.110	0.191	0.360
$n = 4$	0.451	0.186	0.046	0.100	0.182	0.352
$n = 5$	0.497	0.205	0.050	0.088	0.173	0.344
$n = 6$	0.531	0.219	0.054	0.080	0.166	0.338
$n = 8$	0.593	0.244	0.060	0.067	0.155	0.328
$n = 12$	0.713	0.294	0.072	0.044	0.136	0.312
$n = 16$	0.787	0.324	0.080	0.032	0.124	0.303
$n = 20$	0.836	0.345	0.085	0.024	0.117	0.297
	Probability of Exit — Chiro			Probability of Entry — Chiro		
$n = 1$	0.524	0.286	0.129	0.133	0.245	0.371
$n = 2$	0.547	0.299	0.135	0.127	0.239	0.367
$n = 3$	0.569	0.311	0.141	0.119	0.233	0.362
$n = 4$	0.585	0.319	0.144	0.114	0.228	0.358
$n = 5$	0.606	0.331	0.150	0.107	0.222	0.352
$n = 6$	0.620	0.339	0.153	0.103	0.219	0.350
$n = 7$	0.629	0.344	0.155	0.101	0.217	0.348
$n = 8$	0.639	0.349	0.158	0.098	0.215	0.346

differences in firm fixed costs, sunk entry costs, and the number of potential entrants, will be needed to explain the differences in market structure across geographic markets.

These fixed cost estimates for dentists in Table 4 can also be compared with the estimates for the chiropractor industry reported in panel C of Table 4. The estimate of the fixed cost parameter σ is .275 and is not affected by the modelling assumptions we make on the entry cost or entry pool. The estimates of VC and VE derived using this value of σ are reported in the bottom half of Table 5. Like the findings for the dentist industry, we see that VC and VE both vary substantially with differences in the exogenous state variables (z, f) and, for a given state, VC and VE are very similar in magnitude. These results differ from the dentist findings in two ways. First, the decline in both values as n increases is not as substantial as the decline for dentists. This partly reflects the earlier finding about the toughness of short-run competition, that an increase in the number of firms has less impact on average profits in this industry, but it will also be affected by how entry and exit respond to the number of firms. Second, the magnitude of VC and VE for the chiropractors is substantially less than for dentists. A monopoly dental firm operating in a market with high-profit characteristics would have a firm value of 1.286 million dollars while a monopoly chiropractor in the same type of market would have a firm value of .562 million. This reflects the overall lower level of per-period profit observed for chiropractors.

Incumbent firms remain in operation if they have a realization of their fixed cost that is less than the value of continuing. Combining equation (2) with the assumption that the fixed cost λ has an exponential distribution, the probability of exit is $p^x(n, z, f) = exp(-VC(n, z, f)/\sigma)$. The first three columns of Table 6 report the estimated probability of exit for different states. Reflecting the underlying variation in VC, the probability of exit rises as the number of firms in the market increases and declines as the exogenous state variables shift toward combinations that result in higher profit states. In the case of dentists, the probability of exit varies from a low of .032 for monopoly markets with high (z, f) to a high of .836 if a market had 20 firms and low (z, f) characteristics. In particular, there is a large reduction in the exit probability as we move from low to high (z, f) states. The exit rate in the high (z, f) states is only one-tenth the magnitude in the low states. The chiropractors have lower values of VC and a lower value of σ than the distribution for dentists. The former effect will generate higher exit probabilities for chiropractors whereas

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the lower σ results in the distribution of fixed costs having more mass on small values, which results in lower exit probabilities. The net effect of these two forces, however, always generates predicted exit probabilities that are larger for the chiropractors than for the dentists. The more favorable fixed cost distribution does not compensate for the lower long-run profits, and thus there is higher exit in the chiropractor industry.

□ **Sunk costs and the probability of entry.** The final parameter of interest characterizes the distribution of sunk entry costs faced by potential entrants. In Table 4, we report estimates of the entry cost parameter for the internal and external entrant pools. In panel A, the estimate is 2.003 using the internal entry pool definition and 3.299 using the external pool definition. This dependence on the entry pool definition is not surprising because, as shown in Table 2, the external pool definition generates much larger potential entrant pools and thus lower entry rates in the data. Given the estimates of *VE*, which do not depend on the entry cost parameter, the lower entry rates observed with the external pool definition imply a higher level for the entry cost. When we divide our geographic markets into underserved markets using the HPSA designation a clear distinction arises in the coefficients reported in panel B of Table 4: in both specifications, the HPSA markets have a lower estimated mean entry cost than the non-HPSA markets. This is consistent with the intent of the policy to encourage practices to locate in these underserved markets. We will explore the implication of this entry cost difference in counterfactual exercises in the next section. For the chiropractor industry, we observe the estimated cost parameter is always smaller than for dentists, regardless of model specification. Comparing the estimates using the internal and external entry pools, the differences are fairly minor: 1.367 for the internal pool and 1.302 for the external pool. This is consistent with the finding in Table 2 that the two definitions do not lead to substantially different measures of the number of the potential entrants.

Using the mean entry cost estimated using the internal entry pool, we calculate the probabilities of entry using equation (7) and report them in the last three columns of Table 6 for different states. The probability rises as (z, f) increases and falls as the number of firms increase, reflecting the variation in *VE*. The interesting comparison is between the two industries. The distribution of entry costs has a higher mean in the dentist industry but the higher values of *VE* lead to a probability of entry that is similar for dentists than chiropractors. For example, the probabilities of entry into a monopoly dentist market are .141, .216, and .382 depending on the level of (z, f) and .133, .245, and .371 for monopoly chiropractor markets. This difference between the two industries does increase as the number of firms increases with the chiropractor market having a higher probability of entry in markets with up to eight firms.

An implication of the model is that the mean entry cost for firms that choose to enter will vary with market state. It is given by $E(\kappa|\kappa \leq \delta VE(s_i))$. Firms will be willing to incur higher entry costs to enter more profitable markets. For monopoly dentist markets, this truncated mean equals \$179,000, \$300,000, and \$462,000 for markets with low, medium, and high (z, f) values, respectively. Osterhaus (2006) reports that the current cost of opening a new dental practice was between \$450,000 and \$500,000. This includes the cost of construction, state-of-the-art equipment, and allowances for working capital and marketing.

To check the sensitivity of the parameter estimates we also estimated the model using GMM, and the estimates are reported in Table 4. The only difference of note is that the entry costs are smaller for the GMM estimates than for the ML estimates when the external entry pool is used for the dentists. There is little difference in the entry cost estimates using the internal entry pool. The external entry pool has a larger number of potential entrants and so generates smaller entry rates in the data. POB (2007) preferred the use of the GMM estimator when entry and exit rates were small and the pattern we observe is consistent with their finding. In the remainder of the article we will focus on the ML estimates using the internal entry pool.

□ **The impact of entry subsidies: comparing HPSA and non-HPSA markets.** The goal of this section is to show how long-run profits, *VC* and *VE*, entry and exit probabilities, and long-run

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TABLE 7 Distribution of the Number of Dental Establishments

	non-HPSA Markets		HPSA Markets	
Number of Establishments	Data	Model	Data	Model
$n = 1$	.018	.043	.034	.059
$n = (2,3)$	.166	.162	.314	.268
$n = (4,5)$	.223	.209	.275	.251
$n = (6,7,8,9,10)$	.376	.382	.305	.340
$n > 10$	.217	.204	.072	.081

TABLE 8 Average Number of Dental Establishments Per Market

	non-HPSA Markets		HPSA Markets	
z Category	Data	Model	Data	Model
1	3.83	3.80	4.13	4.35
2	4.75	4.36	4.29	4.31
3	4.89	5.03	4.71	4.36
4	5.85	5.66	4.79	4.27
5	6.07	5.96	5.25	5.05
6	7.03	6.85	4.58	5.11
7	7.89	7.40	5.63	5.71
8	8.93	8.24	8.71	7.28
9	10.27	9.52	9.17	8.61
10	13.18	11.72	13.09	11.94

market structure in the dentist industry are driven by the magnitude of the underlying entry and fixed costs. Before constructing the counterfactuals to study these effects, we summarize the ability of the model to explain the observed market structure and turnover in the dentist industry. We begin with the observed number of firms in each state in the first year of the data and then use the model to simulate the evolution of market structure over four additional time periods. We repeat the simulations 300 times and compare the average pattern across simulations with the actual patterns observed in the data for those years. Table 7 reports the frequency distribution of the number of firms across markets and years for both the non-HPSA and HPSA markets. The model is able to reproduce the distribution of the number of firms observed in the data. In particular, it is able to reproduce the fact that HPSA markets generally have fewer firms than non-HPSA markets.

Table 8 reports the mean number of firms across the 10 discrete states for the exogenous state variable z. Again, the model reproduces the pattern in the number of firms across states reasonably well. The only deviation is a slight underestimate of the average number of firms in the non-HPSA markets when $z \geq 4$, but the upward trend in the average number of firms as z increases is clearly evident. Finally, the model does a good job of matching the average entry and exit rates in the data. In the non-HPSA markets the mean entry and exit rates in the data are .19 for both and the model estimates are .21 and .20, respectively. In the HPSA markets the mean entry and exit rates in the data are .22 and .21 while the model predictions are .23 and .21.

Using the ML parameter estimates in Table 4, we evaluate predicted changes in the entry and exit flows and number of firms under alternative assumptions about the entry and fixed cost distributions. We focus on the 59 markets which were classified as HPSA markets during our sample period and use the combinations of states (n, z_d, f_d) observed in those markets. The first counterfactual studies the impact of shifting the entry cost distribution from the one characterizing the non-HPSA markets to the one characterizing the HPSA markets.[17] The underlying

[17] Solving the model given alternative values of the entry cost parameter α requires first that the entrant's and incumbent's optimization problems are solved to give the values of $VC(n, z_d, f_d)$ and $VE(n, z_d, f_d)$ at each grid point

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TABLE 9 Reduction in Entry Cost: Impact on Entrants (percentage change in the variable)

	$VE(n, z, f)$			$p^e(n, z, f)$		
Number of Firms	Low (z, f)	Mid (z, f)	High (z, f)	Low (z, f)	Mid (z, f)	High (z, f)
$n = 1$	−5.83	−3.70	−2.10	20.30	15.88	11.87
$n = 2$	−5.60	−3.44	−1.89	21.90	16.79	12.38
$n = 3$	−5.97	−3.47	−1.84	23.12	17.51	12.79
$n = 4$	−5.84	−3.28	−1.70	24.53	18.23	13.17
$n = 5$	−6.09	−3.23	−1.63	25.80	18.89	13.52
$n = 7$	−5.86	−2.92	−1.41	28.44	20.06	14.10
$n = 9$	−5.62	−2.63	−1.22	31.15	21.11	14.59

TABLE 10 Reduction in Entry Cost: Impact on Incumbent Establishments (percentage change in the variable)

	$VC(n, z, f)$			$p^x(n, z, f)$		
Number of Firms	Low (z, f)	Mid (z, f)	High (z, f)	Low (z, f)	Mid (z, f)	High (z, f)
$n = 1$	−6.50	−4.26	−2.50	7.85	9.11	8.99
$n = 2$	−6.26	−3.97	−2.26	6.64	7.89	7.76
$n = 3$	−6.50	−3.91	−2.15	5.93	7.18	7.05
$n = 4$	−6.36	−3.71	−1.98	5.20	6.44	6.31
$n = 5$	−6.62	−3.66	−1.90	4.73	5.97	5.84
$n = 7$	−6.31	−3.28	−1.63	3.69	4.91	4.78
$n = 9$	−6.06	−2.97	−1.42	2.92	4.13	4.01

parameter change is a reduction in the mean of the unconditional entry cost distribution from the value estimated for non-HPSA markets ($\alpha = 2.019$) to the value for subsidized HPSA markets ($\alpha = 1.797$), an 11 percent reduction in mean entry costs. Table 9 reports the percentage changes in firm values for entering firms and the entry rate and Table 10 reports the same numbers for incumbent firms and the exit rate that result from this entry cost reduction. We construct the variables for each state and summarize the changes for low, mid, and high (z, f) markets. In Table 9 we observe that, in the high profit regime, average entry values VE for new firms fall between 2.1 and 1.2 percent across states with the largest declines in the markets with few firms. The effect of the increased competition from potential entrants has the largest effect in monopoly markets and declines as the number of incumbent firms in the market increases. In the low profit regime the reduction in VE is larger, varying from −5.6 to −6.1 percent but is not related to the number of incumbent firms. The table also shows that the percentage increase in the entry rate is large, between 11.9 and 31.1 percent, with the largest impact in the low profit markets. The objective of the subsidy is to increase the number of dentists in underserved markets and the results show that there are the most substantial percentage gains in low (z, f) (i.e., low profit) markets, not necessarily low n markets.

The corresponding numbers for incumbent firms in Table 10 show a similar decline in the value of the incumbent firms VC. It shows that the lower entry costs lead to an increase in the exit rate, from 2.9 to 9.1 percent across states, with the largest percentage increase in firm exit coming in the highest profit markets, those with few firms and high (z, f) values. Markets with few firms are the ones where the oligopoly effect, the decline in average profits as the number of firms increases as seen in Table 3, is most substantial. As expected, a reduction in entry costs acts to increase the competitive pressure from potential entrants, which results in both higher firm turnover and lower firm values. This effect will offset some of the gains due to the increased

(n, z_d, f_d). This involves using the estimated profit function, empirical transition matrix for z, and the estimated mean fixed costs to simultaneously solve equations (1), (3), and (6). POB (2007) provide the formulas for the equilibrium values of a firm's perceptions of the number of entrants and exits for survivors, $p^c(e, x|n, z, f, \chi^c = 1)$ and entrants, $p^e(e, x|n, z, f, \chi^e = 1)$.

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TABLE 11 Cost-Benefit Comparison of Alternative Policies

Impact on Market Structure	Benchmark non-HPSA costs	Entry Cost Reduction	Fixed Cost Reduction	Expand Program
$\Pr(n = 1)$	0.062	0.055	0.056	0.034
$\Pr(n \leq 3)$	0.338	0.313	0.319	0.246
$\Pr(n \leq 5)$	0.592	0.562	0.571	0.475
Average number of entrants/market	1.396	1.657	1.423	2.563
Average number of exits/market	1.029	1.131	0.950	1.477
Net change in establishments/market	0.367	0.526	0.473	1.086
Cost/additional entrant (millions 1983 \$)		0.103		0.075
Cost/additional establishment (millions 1983 \$)		0.170	0.503	0.140

entry rate seen in Table 9. It illustrates an important economic point relevant to entry subsidies: the increased entry will also reduce the profitability of existing producers and increase exit. To evaluate the effect of entry subsidies it is necessary to look at the impact on both entry and exit.

Rather than subsidizing entry costs, an alternative policy to increase the number of dental practices would be to subsidize the costs of operating a practice in the market or provide additional payments to the practice based on the number of patients served. In our model, this operating subsidy can be studied by lowering the estimated fixed costs and simulating the change in firm values, entry, exit, and market structure. In order to make these fixed cost simulations comparable to the entry cost simulations just reported, we choose to reduce the mean fixed cost by 5 percent because this generates a very similar change in the distribution of the number of firms. The adjustment mechanism is very different in the two cases. The reduction in fixed cost acts to raise firm values, VC and VE, in most markets, particularly the markets with few firms. Focusing on markets with three or fewer firms, VC rises, on average, by 0.9, 2.3, and 3.3 percent for the low, mid, and high (z, f) markets, respectively. This lower fixed cost also reduces the exit rate substantially in these markets with the reduction in the exit rate averaging 6.2, 13.6, and 25.2 percent across the (z, f) categories. Finally, in contrast to the policy that subsidizes entry costs, the operating cost subsidy has a small effect on the entry rate in these markets, increasing it between 0.3 and 2.6 percent.

Overall, the two subsidies act in very different ways. The entry cost reduction increases the pressure from potential entrants, lowers firm values, and increases turnover, both entry and exit. The operating cost reduction makes it more profitable to be an incumbent, raises firm values, reduces exit, and leads to a small increase in entry. In both cases we simulate, the 11 percent reduction in entry cost and a 5 percent reduction in operating cost, the ultimate impact on market structure is very similar. Table 11 compares the two subsidies in terms of their impact on market structure and the cost per additional entrant and per additional firm. The first three rows summarize the distribution of market structure across markets, focusing on the probability of having few firms in a market. Both the entry cost and fixed cost reduction lead to a slight reduction in the number of markets with less than five firms, from .592 in the benchmark case (using costs for the non-HPSA markets) to .562 or .571. Rows 4 through 6 show how this increase is accomplished by summarizing the number of entrants, exits, and net change in number of firms on average across markets. The entry cost reduction leads to an increase in the average number of entrants per market from 1.396 to 1.657 while the fixed cost reduction leads to 1.423 entrants per market. The number of exiting firms increases when entry costs are reduced, consistent with the change in exit probabilities in Table 10, and decreases when fixed costs are reduced. The net change in the average number of firms per market is a measure of the overall impact of the cost changes on the number of dental firms. In the case of the 11 percent entry cost reduction there is a net increase of .526 firms per market and, when fixed costs are reduced by 5 percent, there is an increase of .473 firms per market. These absolute changes are small, but when compared with the median number of firms in these markets, three, the impact is more substantial.

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In addition to affecting entry and exit in different ways, the two cost changes lead to different total expenditures. When entry costs are subsidized, only new firms receive the subsidy and the cost of the subsidy is determined by the total number of entrants. Using the benchmark as the base, we estimate that the entry cost subsidy we model would lead to increased entry of 62 dentists across the 59 HPSA markets and four time periods at a total cost of 6.37 million (1983) dollars or $103,000 per additional entrant. However, this does not take into account that some of the entry will be offset by additional exit. When expressed as a cost per additional firm the cost rises to $170,000 per firm. This clearly illustrates the difficulty of using entry cost subsidies to increase the number of firms in a market when exit is also endogenous: some of the new firms receiving subsidies will simply be replacing older firms that are induced to exit.

In contrast, when operating costs are subsidized, all incumbents receive the payment and not just the new firms. Although this increases the number of firms by reducing exit, it means that the subsidy will also be provided to firms that would have remained in operation even without the subsidy. The total cost of the subsidy that reduces fixed costs by 5 percent is $12.6 million and when expressed as a cost per additional firm in the market it rises to just over $500,000. These cost per firm figures illustrate two points: entry subsidies also encourage exit and operating cost subsidies end up being paid to firms that would remain in operation anyway.

Table 11 reports an additional counterfactual we conduct to study the impact of expanding the entry cost subsidy program. The Affordable Care Act has authorized approximately a doubling of total expenditure on the NHSC scholarship and loan subsidy program. To simulate a large program expansion we reduced the entry cost for HPSA markets to 1.3, a 35 percent discount relative to non-HPSA markets. This results in a 215 percent increase in total expenditure on the program. The final column of Table 11 shows the impact of this expanded subsidy program on market structure. It substantially reduces the percentage of markets with few firms. Monopoly markets now account for only 3.4 percent of markets and markets with 5 or fewer firms account for 47.5 percent, compared with 56.2 percent under the smaller entry cost subsidy program. There is a net increase of 1.086 additional firms per market resulting from an increase of 2.563 entrants, which is partially offset by an increase of 1.477 exits.

6. Conclusion

■ Market structure is determined by the entry and exit decisions of individual producers and these are affected by expectations of future profits which, in turn, depend on the nature of competition within the market. In this article we utilize microdata for two US service industries, dentists and chiropractors, over a 20-year period to study the process of entry and exit and how it determines both market structure and long-run firm values. We estimate a dynamic structural model of firm entry and exit decisions in an oligopolistic industry, based on the model of POB (2007) and distinguish the decisions of incumbent firms from potential entrants. We use a panel data set of small geographic markets and data on the average profits of firms and the flows of entering and exiting firms in each market to estimate three underlying structural determinants of entry, exit, and long-run profitability. The first is the toughness of short-run price competition, the second is the magnitude of the sunk entry cost faced by potential entrants, and the third is the magnitude of the fixed cost faced by incumbent producers. These three components are treated as the primitives of the model, estimated, and used to measure the distinct impact of incumbents and potential entrants on long-run profitability and market structure.

The results indicate that average profits decline as the number of firms increases. Relative to a market with five firms, the profit premium for 1, 2, 3, and 4 firm dentist markets are 69, 47, 26, and 10 percent, respectively. The same premiums for chiropractor markets are 15, 5, 3, and 3 percent. Estimates of the distributions of entry costs and fixed costs parameters indicate that they are statistically significant for both industries with the magnitudes being larger in the dental industry. Overall, the estimates indicate that all three primitives of the model are

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important components of long-run firm values and market structure. As the number of firms in the market increases, the value of continuing in the market and the value of entering the market both decline, the probability of exit rises, and the probability of entry declines. These outcomes also differ substantially across markets due to differences in exogenous cost and demand factors.

For the dental industry, we utilize information on a government policy that subsidized entry into underserved markets. In our data, 59 of the geographic markets were designated as underserved markets during our sample period. We estimate that the mean entry cost is effectively 11 percent lower in these markets and counterfactual simulations indicate that this cost reduction will lead to approximately .53 more firms per market, on average. The increase in the number of firms reflects both an increase in the number of entrants but also an increase in the amount of exit and a reduction in long-run profit. The estimated cost of the subsidy is \$170,000 for each long-run increase of one firm. In contrast, a subsidy that targets the fixed cost of incumbent firms has virtually the same effect on long-run market structure but a higher cost, \$503,000 per firm. The mechanism underlying the fixed cost subsidy is very different because it primarily acts to lower the exit margin while raising the average profit of incumbent firms. It is expensive because it requires paying subsidies to firms that would remain in operation even if the subsidy were not in place. The counterfactuals illustrate the difficulty of predicting the impact of policies to increase the number of dental practices in underserved markets when there is both endogenous exit and negative effects of entry on firm profits.

The results reported here also indicate several directions for future research in empirical modelling of entry and exit dynamics. Although the estimates of fixed costs and long-run firm values are not sensitive to modelling assumptions on the pool of potential entrants, the estimates of sunk entry costs are. In this study, we treat the pool of potential entrants as exogenous in each market but it would be desirable to better understand what determines variation in the number of potential entrants across markets. In the Appendix, we provide an alternative model with an infinite entry pool and find that it predicts a similar value of entry to the original model in this case. Incorporating additional sources of market-level heterogeneity in the distributions of fixed costs or entry costs is a second area where the basic model can be extended in a straightforward way given the availability of data that would account for across-market shifts in the cost distributions. A third area for research involves incorporating firm-level heterogeneity in profits, fixed costs, and/or entry costs that is correlated over time for individual firms. This would recognize that, for example, a firm that has low idiosyncratic fixed costs in one time period, and is thus unlikely to exit, may have a similar cost structure in future periods. In the model we estimate in this article, this is less of an issue since our focus is on how entry and exit rates vary across geographic markets with different profit determinants, but it will be important in explaining individual firm patterns of participation or exit.

Appendix

This appendix develops an alternative formulation with a large number of potential entrants. The model in Section 3 assumes that in each market there is a fixed set of potential entrants p_{mt} and we have proposed two ways of measuring this in our empirical model. In practice, this is not something that is easy to measure and most applications in the literature just set it equal to a constant for all observations. An alternative is to treat the pool of potential entrants as infinite and model entry as a Poisson process as proposed in Weintraub, Benkard, and Van Roy (2008). In this case, we will rely on a free-entry condition rather than a firm-specific random entry cost to rationalize the flow of entrants in the data. This model will produce an alternative estimate of $VE(n, z)$ that we can compare with the estimates from Table 5.

Assume there is a very large pool of N^e *ex ante* identical potential entrants. Each potential entrant employs a mixed strategy and enters with probability p_N. The payoff function of one potential entrant when $\tilde{e}$ other potential entrants choose to enter is

$$VE(n, z; \tilde{e}) = E^e_{x,z'}[\pi(n + \tilde{e} + 1 - x, z') + E_{\lambda'}(\max\{\delta VC(n + \tilde{e} + 1 - x, z') - \delta\lambda', 0\})].$$

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TABLE A1 Estimates of the Poisson Regression Model (standard error in parentheses)

Variable	Coefficient	Standard Error
$I(n = 1)$	1.457	(0.422)
$I(n = 2)$	0.885	(0.278)
$I(n = 3)$	0.587	(0.198)
$I(n = 4)$	0.287	(0.152)
$I(n = 5)$	0.172	(0.113)
n	−0.107	(0.057)
n^2	0.001	(0.002)
z	0.492	(0.314)

Assume every potential entrant employs the same strategy, then a mixed strategy Nash Equilibrium will require that the expected value of entry for each potential entrant equals a fixed entry cost $\kappa(n, z)$, which can vary by state.

$$\sum_{\tilde{e}=0}^{N^e-1} \binom{N^e - 1}{\tilde{e}} (p_N)^{\tilde{e}}(1 - p_N)^{N^e-1-\tilde{e}} VE(n, z; \tilde{e}) = \kappa(n, z) \tag{A1}$$

This free-entry condition (A1) must hold for any mixed strategy $p_N(n, z) \in [0, 1]$ given state n, z. The realized number of entrants is $e(n, z) = N^e p_N(n, z)$, which from the perspectives of individual potential entrants, is a *binomial random variable* $B(N^e - 1, p_N(n, z))$. Assume that $N^e \to \infty$ and $p_N(n, z)$ is small enough, then $e(n, z)$ is a Poisson random variable where the mean parameter $\gamma(n, z)$ depends on state n, z. The value of entry, when there is positive entry in the market, can then be expressed as

$$\begin{aligned} VE(n, z) = \sum_{e=1}^{\infty} \frac{\gamma(n, z)^e}{e!} exp(-\gamma(n, z))\{E^e_{x,z'}[\pi(n + e - x, z') \\ + E_{\lambda'}(\max\{\delta VC(n + e - x, z') - \delta\lambda', 0\})]\}. = \kappa(n, z) \end{aligned} \tag{A2}$$

To estimate this variant, note that VC and the transition matrix for (x, z) are not affected by the change in the assumption about the number of potential entrants and so can be constructed using the method in the second subsection of Section 3. The new object to be estimated is $\gamma(n, z)$, the mean of the Poisson random variable characterizing the number of observed entrants. We follow Hausman, Hall, and Griliches (1984) by specifying a Poisson regression model with market fixed effect

$$\begin{aligned} E(e_{mt}|\gamma(n_{mt}, z_{mt}), \gamma_m) &= \gamma_m \gamma(n_{mt}, z_{mt}) \\ &= \gamma_m exp(\gamma_0 + \sum_{k=1}^{5} \gamma_k I(n_{mt} = k) + n_{mt}\gamma_6 + n^2_{mt}\gamma_7 + z_{mt}\gamma_8) \end{aligned} \tag{A3}$$

where γ_m is used to control for other sources of unobserved market heterogeneity that might affect entry.

Let the total number of observed entrants for market m over our sample periods 1982-1997 be denoted as te_m, Hausman, Hall, and Griliches (1984) show that a conditional ML estimator will identify γ_0 to γ_8. The joint distribution of the time-series of entrants for market m, $e_{m1}, \ldots, e_{mt}$, is multinomial $M(te_m, p_{m1}, \ldots, p_{mt})$, where $p_{mt} = \frac{\hat{\gamma}(n_{mt}, z_{mt})}{\sum_{t=1}^{T} \hat{\gamma}(n_{mt}, z_{mt})}$. This allows us to simulate draws of the sequence of e for each market and approximate the value of entry, equation (A2), by averaging over the simulations.

$$VE^S(n_{mt}, z_{mt}) = \frac{1}{S} \sum_{s=1}^{S} \hat{E}_{x,z'}[\pi(n_{mt} + e^s_{mt} - x, z') + E_{\lambda'}(\max\{\delta \hat{VC}(n_{mt} + e^s_{mt} - x, z') - \delta\lambda', 0\})] \tag{A4}$$

Using the free-entry condition, equation (A2), the estimated value of entry is equal to the entry cost $\kappa(n, z)$. This will vary across markets due to variation in n, z.

Comparing this model with the one developed in the main part of the article we see that they differ in the way they treat the pool of potential entrants, the source of randomness in the entry decision, and whether the free-entry condition is strictly binding. The earlier model treats the potential entrant pool as small and fixed for a market, randomness is placed on the private entry cost draw by each potential entrant, the distribution of entry costs is specified parametrically, and the free-entry condition is not utilized. The Poisson model developed here treats the entrant pool as infinite, the entry cost as identical for all entrants to a market, the randomness is placed on the outcome of the firm's mixed entry strategy, the free-entry condition holds, and it is not necessary to specify the entry cost distribution.

The estimated parameters for the Poisson regression model are reported in Table A1. They show that the state variables n and z are significant determinants of the entry flow. Entry is increasing in z and decreasing in n and consistent with the oligopoly effect observed in the estimated profit function. Each model produces an estimate of the value of entry

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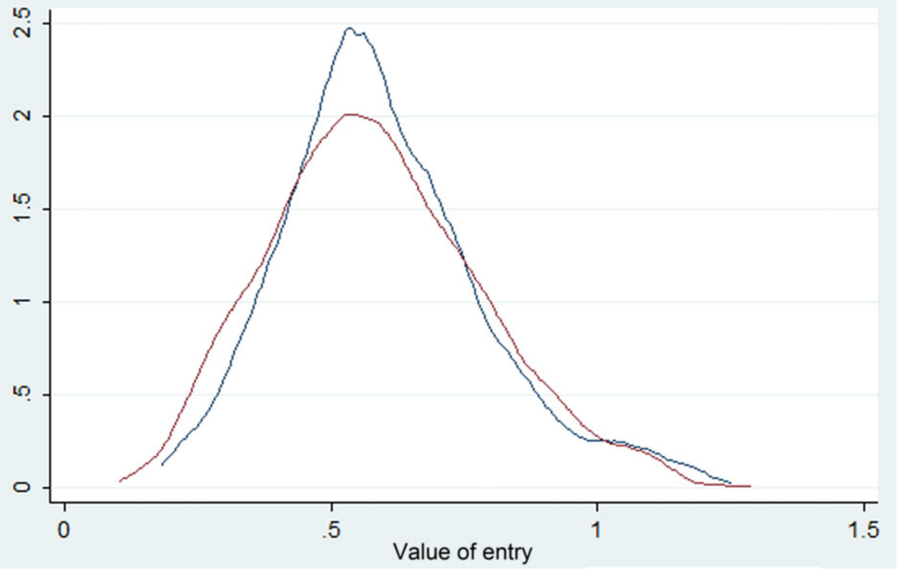
FIGURE A1

KERNAL DENSITY OF $VE(n, z)$ ACROSS MARKETS



Benchmark model and poisson model (millions of 1983 dollars)

$VE(n, z)$. In Figure A1 we plot the kernel densities for $VE(n, z)$ solved from the benchmark model (using equation (9) and the estimates from panel A of Table 4) and the Poisson model (using equation (A4) and the estimated γ parameters). The density for the benchmark model is slightly more peaked but overall they are very similar, which implies that the assumption on the potential entry pool is not affecting the estimates of the long-run payoff to entry. If we are willing to treat the potential entry pool as finite and observable, then we do not need to impose the free-entry condition, and this allows us to also estimate the distribution of entry costs as shown in the main part of the article. On the other hand, imposing the free-entry condition avoids making a parametric assumption on the distribution of entry costs and instead interprets the estimated $VE(n, z)$ as the entry cost distribution.

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