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ABSTRACT

Market structure is determined by the entry and exit decisions of individual producers. These decisions are driven by expectations of future profits which, in turn, depend on the nature of competition within the market. In this paper we estimate a dynamic, structural model of entry and exit in an oligopolistic industry and use it to quantify the determinants of market structure and long-run firm values for two U.S. service industries, dentists and chiropractors. We find that entry costs faced by potential entrants, fixed costs faced by incumbent producers, and the toughness of short-run price competition are all important determinants 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. The magnitude of these effects differ substantially across markets due to differences in exogenous cost and demand factors and across the dentist and chiropractor industries. Simulations using the estimated model for the dentist industry show that pressure from both potential entrants and incumbent firms discipline long-run profits. We calculate that a seven percent reduction in the mean sunk entry cost would reduce a monopolist's long-run profits by the same amount as if the firm operated in a duopoly.¸

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1 Introduction

The relationship between market structure and the competitiveness of market outcomes has played a major role in anti-trust enforcement, regulatory proceedings, and industrial organization research. While the effect of market structure, the number and relative size of producers, on firm and industry pricing, markups, and profits is generally the focus of interest, it has long been recognized that market structure cannot be viewed as exogenous to the competitive process.[1] 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.

A simple two-stage model of entry and competition has provided a unifying framework for analyzing the relationship between market structure and the competitiveness of market outcomes and has been used as the basis for a number of empirical studies (see Bresnahan and Reiss (1987, 1991), Berry (1992), Sutton (1991), and Berry and Reiss (2007)). In the short run, the number of firms n is fixed, firms compete through price or quantity choice, and this generates profits π for each incumbent as a function of the market structure. This short-run relationship is captured by a function $\pi(n)$ which Sutton (1991) terms "the toughness of competition." This function reflects product, demand, and cost factors that determine how competition occurs in the market. These can include the degree of product differentiation across firms, the geographic segmentation of the market, the level of transportation costs, whether firms compete in prices or quantities, structural factors that could facilitate collusion, cost heterogeneity, or capacity differences across firm. This function will differ across industries.

In the long run, the number of firms is endogenous and results from a group of potential entrants each making a decision to enter the market given knowledge of $\pi(n)$. The key structural equation at this stage is a zero-profit condition that guarantees that each entrant covers all fixed costs. Overall, this framework endogenizes market structure and the level of firm profits. Empirical studies based on this two-period framework, beginning with Bresnahan and Reiss (1987, 1991), have relied on the zero-profit condition and cross-sectional data for different-

[1] See Sutton (1991) Chapter 1, for a summary and discussion of the historical treatment of market structure in the industrial organization literature.

sized geographic markets. By estimating the relationship between the number of firms and an exogenous profit shifter, such as market population, they are able to draw some inferences about the toughness of price competition $\pi(n)$ for a product or industry.[2]

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.[3] If there is a difference between the fixed cost an incumbent faces and the sunk entry cost a potential entrant faces then these two types of firms will not behave the same. Without this source of firm heterogeneity, the two-period model cannot produce simultaneous flows of entering or exiting firms, something that is commonly observed in market-level data. In this paper we estimate a dynamic structural model of firm entry and exit decisions in an oligopolistic industry 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 key structural determinants of entry, exit and long-run profitability. The first is the toughness of short-run price competition $\pi(n)$, 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. Pesendorfer and Schmidt-Dengler (2003), Bajari, Benkard, and Levin (2007), Pakes, Ostrovsky and Berry (2007), and Aguirregabiria and Mira (2007) have recently developed dynamic models of entry and exit in imperfectly competitive markets that can be used to describe the evolution of market structure and the competitiveness of market outcomes. In this paper we estimate a variant of the model developed by Pakes,

[2]Other papers in this literature include Berry (1992), Campbell and Hopenhayn (2005), Mazzeo (2002), Syverson (2004), and Seim (2006). Berry and Reiss (2007) discuss the conditions under which this type of data can be used to empirically distinguish the toughness of price competition from the fixed cost of entry and different sources of firm heterogeneity. Sutton (1991) uses the framework to identify a robust relationship between market size, the level of sunk entry costs, and market concentration for homogenous goods industries where the level of entry cost is determined by the production technology and is exogenous to the entrant.

[3]The exception to this is Berry (1992). In modeling the choice of an airline to fly between two cities, A and B, in a year he allows the airline's profit function to depend on whether or not they had a presence in city A or B or both in prior years. Longitudinal information, either panel data or an historical measure of market structure, are needed to distinguish the different impacts of incumbents and potential entrants on market structure and competition.

Ostrovsky, and Berry (2007).

We use the empirical model to analyze the entry and exit patterns of establishments in two medical-related service industries: dentists and chiropractors. Using micro data collected as part of the U.S. Census of Service Industries, we measure the number of establishments and the flows of entering and exiting establishments for more than 400 small geographic markets in the U.S. at five-year intervals over the 1977-2002 period. We are also able to measure the average profits of establishments in each geographic market and year. We use this data to estimate an empirical model that characterizes the toughness of competition, the rate of entry, and the rate of exit across markets and over time.

The results indicate that the toughness of price competition increases with n. For dental practices the slope of the function $\pi(n)$ is negative, statistically significant, and particularly large as the number of establishments increases from 1 to 4. In the chiropractor industry the decline is smaller in magnitude but still statistically significant for monopoly markets. 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 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. Simulations using the estimated model for the dentist industry show that pressure from both potential entrants and incumbent firms discipline long-run profits. We calculate that a seven percent reduction in the mean sunk entry cost would reduce a monopolist's long-run profits by the same amount as if the firm operated in a duopoly.

The next section of this paper reviews the recent literature on structural models of entry and exit. The third section 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 fourth section summarizes the theoretical model of entry and exit developed by Pakes, Ostrovsky, and Berry (2007) and presents our empirical representation of it. The fifth section summarizes our data focusing on the measurement of entry and exit, profitability, and the number of potential entrants in each geographic market. The sixth section reports the econometric 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 Literature Review

The theoretical and empirical literature on firm turnover has developed in parallel over the last two decades. Broad descriptions of the empirical entry and exit flows have been produced for different countries, industries, and time periods.[4] A common finding is that many industries are characterized by the simultaneous entry and exit of firms so that, while some producers are finding it unprofitable to remain in the industry, others are finding it profitable to enter. This leads immediately to interest in sources of heterogeneity in profits, entry costs, or fixed costs across firms in the same industry or market.[5] A second finding is that the level of turnover varies across industries and is correlated with the capital intensity of the industry. This leads to interest in the level of entry costs, how they act as a barrier to entry and exit, and how they vary across industries.[6]

Related to these empirical findings, and often building on them, is a theoretical literature that characterizes equilibrium in an industry populated by heterogenous firms with entrants that face sunk costs of entry. The dynamic models of Jovanovic (1982), Lambson (1991), Hopenhayn (1992), Dixit and Pindyck (1994), Ericson and Pakes (1995), and Asplund and Nocke (2006) all share the feature that the participation decision for an incumbent firm differs from the decision for a potential entrant. When deciding to remain in operation, incumbents

[4] For example, Dunne, Roberts, and Samuelson (1988) measure entry and exit flows for the U.S. manufacturing sector and Jarmin, Klimek, and Miranda (2008) provide similar evidence for the U.S. retail sector. Bartelsman, Haltiwanger, and Scarpetta (2008) provide a cross-country comparison of firm turnover patterns. See Caves (1998) for a summary of the earlier empirical evidence on firm turnover.

[5] A large empirical literature has developed that relates entry and exit patterns to underlying differences in firm productivity. For example, see Bailey, Hulten and Campbell (1992), Foster, Haltiwanger, and Krizan (2001), and Aw, Chen, and Roberts (2001).

[6] See Dunne and Roberts (1991) for evidence on the correlation between turnover and capital intensity in U.S. manufacturing industries. In Sutton's (1991) model for exogenous sunk cost industries, one of the key determinants of market structure is the sunk cost needed to construct a plant of minimum efficient size. This will obviously vary across industries with the capital intensity of the technology.

compare the expected sum of discounted future profits with the fixed costs they must cover to remain in operation, while potential entrants compare it with the sunk entry cost they must incur at the time of entry. The same future payoff can thus lead to different participation decisions by an incumbent and a potential entrant and this has implications for the way that market structure responds to changes in expected future profits. In this environment, unlike in the two period models of market structure, an industry's market structure at a point in time depends, not just on the expected future profit stream, but also on the past market structure. In Dunne, Klimek, Roberts, and Xu (2009) we find that market structure in the dentist and chiropractor industries depends on the lagged number of firms and the number of potential entrants in the market as implied by these dynamic theoretical models

Another insight from the theoretical literature is that the level of entry costs affects the magnitude of the flows of entry and exit. For example, in both Hopenhayn's (1992) competitive framework and Asplund and Nocke's (2006) imperfectly competitive framework, markets with high sunk entry costs are characterized by low rates of producer turnover. The sunk cost of entry acts as a barrier to entry that insulates the existing firms from competitive pressure. Industry profit and average firm value can also increase when entry costs are large.[7]

Recently, several empirical papers have utilized data on the flows of entering and exiting firms to estimate dynamic structural models of entry and exit in imperfectly competitive markets. Aguirregabiria and Mira (2007) and Collard-Wexler (2006) implement a discrete choice model of entry and exit and are able to estimate parameters measuring both the toughness of competition and entry costs (where each is expressed relative to the variance of unobserved shocks to profits). Ryan (2006) studies market structure in the cement kiln industry By modeling both the demand and cost curves in the industry and treating plant capacity as a dynamic choice variable, he is able to characterize markups and capital adjustment costs as well as entry costs in the industry. In this paper we exploit data on average firm profits and entry and exit flows to estimate a variant of the model of Pakes, Ostrovsky, and Berry (2007). Although we cannot estimate the level of markups we are able to measure the toughness of

[7] There is also a selection effect which depends on the level of the entry cost. When entry costs are high, more low-profit firms will survive and this will tend to reduce industry profit and average firm value. As long as this selection effect is not too strong, the industry profitability will be positively correlated with the magnitude of sunk entry costs.

short run competition as well as entry costs, fixed costs, and long-run firm values in dollars.

3 Turnover in the Market for Dentists and Chiropractors

3.1 Institutional Differences in Entry and Exit Costs

In this paper we study the determinants of market structure for two health services industries, dentists (NAICS 621210) and chiropractors (NAICS 621310), that are similar in terms of the nature of demand and technology but differ in the level of profits and turnover patterns.[8] They both provide their services in relatively small local markets and the decision-making unit is a practice. Although there are several choices for the legal form of organization, sole proprietorship, partnership, or corporation, many of the practices are small, single doctor businesses. The market demand for these services is closely tied to population. Other characteristics of the market that affect the level of total demand include income, demographics, and prevalence of insurance. 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. These are combined with the doctor's time to produce output.[9]

The two professions differ in the level of demand generated by a given population. This leads to differences in the level of revenue and profits, and thus entry flows, exit flows and number of practitioners in the two professions for a given market size. A second area of difference 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. In addition to the cost of renovating office space and installing capital equipment, there is also the cost of attracting a stock of patients. Further, entry costs can arise because of entry barriers, such as state licensing restrictions, that slow the geographic mobility of dentists or chiropractors from one market to another. The entry costs vary between the

[8] Prior to 1997, dentists are SIC industry 8021 and chiropractors are SIC 8041.

[9] There is some room for substitution among the inputs and the importance of technician assistants, particular in dental offices, has increased over time.

two industries for a number of reasons. The simplest difference arises from the cost of capital equipment and office construction. Dental offices generally require multiple treatment rooms with x-ray and dental equipment. The kind of physical infrastructure, electrical, plumbing, and support structures for x-ray equipment, tend to be very specialized and typical office space requires significant renovation to make it usable.[10] In contrast, the main equipment for a chiropractic office is a specialized chiropractic table in each treatment room. For both dentists and chiropractors it is possible to lease the necessary equipment which can reduce the size of the initial investment.

Another source of difference in entry conditions between the two professions involves licensing requirements.[11] Professionals in both fields must be licensed to practice in a state. Professional schools are typically four years in both fields, although tuition at dental schools is higher. Also, dental students typically have a bachelors degree before they enter while a significant fraction of chiropractic students do not have a bachelors degree. At the end of schooling, national written exams are given in both fields. Dentists must also pass clinical exams that are administered regionally or by individual states. The acceptance of results across states varies by state but is not uncommon. The use of regional examining boards has grown over the last 20 years and this has made it easier for new dentists to be qualified for a license in multiple states. For chiropractors there is a national exam that covers clinical skills, but some states require additional state exams. Besides the licensing process by examination, by which most new graduates are licensed, there is a separate licensing process for experienced practitioners that want to relocate to a new state. Referred to as licensing by credentials, this requires a dentist to show evidence of practice experience, often five or more years of continuous practice. A gap in the practice period or disciplinary actions may disqualify an experienced dentist from obtaining a license by credentials. This can help reduce mobility of dentists.[12] For chiro-

[10] Osterhaus (2006) reports that the current cost of opening a new dental practice in Arizona is between $450,000 and $550,000. This includes the cost of construction, state-of-the-art equipment, and allowances for working capital and marketing.

[11] See American Dental Association (2001) and Sandefur and Coulter (1997) for further details on licensing requirements in each profession.

[12] The state of Ohio reports that, of the 1046 licenses issued between 1999 and 2004, only 45 were issued by credentials. In order to increase the number of dentists in the state, the Texas legislature recently passed legislation to reduce the hurdles faced by dentists using the credentials process, specifically reducing the number of years of experience required and requiring the State Board of Dental Examiners to consider the acceptance of

practors, licensing by credentials appears to be a simpler process where the required time in continuous practice is often less and waivers are more readily granted.

On the exit side, we will model the shut down decision as depending on fixed costs that the firm must pay to remain in operation. Because of the differences in capital equipment and office space discussed above the fixed costs are likely to be higher for the dentist industry. One final factor that is important to recognize is that our focus is on the number of firms in operation in a market, not the identities of the doctor owning the firm. We are interested in modeling the startup and shutdown decisions of a practice that can change the number of firms in operation, not the sale of a ongoing practice that simply changes the identity of the owner. In our data, we do not treat the sale of a 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.

3.2 The Patterns of Market Structure and Market Dynamics

In this section we summarize market structure and magnitudes of firm turnover for these two industries. The data correspond to isolated geographic markets in the U.S. which are observed at five-year intervals beginning in 1977 and ending in 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 at least one but not more than 20 establishments. For chiropractors we use 410 markets that have between one and eight practices.. The data is described in detail in Section 5 below but here we discuss the counts of establishments present in each of the years and the count of the entering and exiting establishments between each pair of years.

Table 1 aggregates the market-year observations into categories based on the number of establishments (n) in year t and provides the mean number of entrants and exits from t to $t+1$. Several patterns are important to recognize. First, as we move down the table to markets with a larger number of incumbents (which also reflects larger populations), the average entry and exit flows increase. Not surprisingly, there is more turnover in larger markets. When expressed

other regional clinical exams.

as a proportion of n, the entry and exit patterns are more stable across market sizes. In the case of dentists, the entry proportion in Column 3 declines monotonically with n until n=8, but once the market has 5 incumbents the entry flow is between .21 and .24 with no pattern across larger markets. Similarly, with chiropractors there is an initial decline in the entry proportion as n increases, but beyond n=3 there is no systematic pattern as the entry proportion varies from .32 to .39. The exit flow, expressed as a proportion of n shows little variation for dentists. With the exception of the markets with only one establishment, the exit rate lies between .19 and .21. Similarly, for the chiropractors there is no systematic pattern in the exit rate as n increases. One possible explanation is that in small markets the expected profits change systematically with changes in the number of firms or market size but this effect diminishes or disappears in larger markets. Entry and exit in larger markets are thus determined primarily by heterogeneity in entry costs and fixed costs.

The second pattern is that the entry and exit flows, for a given level of n, are always larger for chiropractors than dentists. This holds in both absolute magnitudes and proportional to the number of firms. This suggests differences in underlying entry costs between the two industries. Finally, there is simultaneous entry and exit in many markets for both industries. The fifth column of Table 1 reports the percentage of market-year observations that have simultaneous entry and exit. The statistics indicate that simultaneous entry and exit are common, even in many markets with only a few firms. This indicates that the empirical model must recognize and allow for some form of heterogeneity in expected profitability across firms.

Overall, the entry and exit statistics suggest that a combination of competitive and technological factors interact to produce the market-level outcomes we observe and the importance of each factor differs between the two industries. In smaller markets, those with 1 to 5 firms for dentists and 1 to 3 firms for chiropractors, there is a pattern in entry and exit rates that could reflect both systematic market-level effects on profits as well as underlying firm heterogeneity. To isolate these effects we will need to estimate the profit function for producers in each industry, where there is a role for both the number of firms in the market and overall market size to affect profits. The turnover statistics suggest substantial within-market turnover in both industries but a higher degree of turnover among chiropractors. One explanation for this difference is that dentists face higher sunk entry costs in establishing a business.. The model developed in the next section will allow us to estimate these entry costs for each industry. Finally, the flows of simultaneous entry and exit indicate that heterogeneity exists across producers within the same market. This heterogeneity in outcomes could result from differences in fixed costs or entry costs across producers. Section 6 reports econometric results that isolate these separate effects.

4 A Model of Entry, Exit, and Profit

4.1 Theoretical Model

In this section we outline the dynamic model of entry and exit. It is very similar to the model developed by Pakes, Ostrovsky, and Berry (2007) with some modifications that aid estimation. We begin with a description of incumbent producer i's decision to exit or remain in operation. Let s be a vector of state variables that determine the profit each firm will earn when it operates in the market. Represent the 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, 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 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.[13] Given the market state s and

[13] The primary difference between this model and the one developed in Pakes, Ostrovsky, and Berry (2007) is that they model λ_i as a scrap value that the firm earns in the next period if it chooses to close. The models are similar in that they assume the realized profits of the firm in each period are composed of a common short-run

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 more precisely as:

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

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 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:

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

payoff $\pi(s,\theta)$ and a firm-specific component λ_i that is treated as an *iid* shock.

Substituting this into equation 3 the continuation value becomes:

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

A market is also characterized by a pool of potential entrants where each observes the current market state $s = (n, z)$ and makes a decision to enter at the start of the next period. Each potential entrant i 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 payoff from entering depends on the evolution of the state variables (n, z) and the expectation of future state variables is taken from the perspective of a firm that chooses to enter. 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 expectation $E^e_{s'}$ 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 values, $VC(s)$ and $VE(s)$, across states and model the distributions of fixed costs and entry costs G^λ and G^κ.

Pakes, Ostrovsky and Berry (2007) 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 $\boldsymbol{\pi}, \mathbf{VC}$ 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:

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

This equation can be solved for $\mathbf{VC}$ as a function of $\boldsymbol{\pi}, \mathbf{p}^x$, and $\mathbf{M}_c$:

$$\mathbf{VC} = \left[I - \delta \mathbf{M}_c \right]^{-1} \mathbf{M}_c \left[\boldsymbol{\pi} - \delta\sigma(1 - \mathbf{p}^x) \right] \tag{9}$$

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. Pakes, Ostrovsky, and Berry (2007) identify an alternative method that is computationally simpler. They suggest utilizing nonparametric estimates of both $\mathbf{M}_c$ and $\mathbf{p}^x$ and substitute them into equation(9) to construct $\mathbf{VC}$. 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 and chose to use the first method.

Finally the value of entry, equation (6), can also written in matrix notation. Let $\mathbf{M}_e$ be the perceived state transition matrix from the perspective of the potential entrant then the value of entry becomes:

$$\mathbf{VE} = \mathbf{M}_e[\boldsymbol{\pi} + \delta \mathbf{VC} - \delta\sigma(1 - \mathbf{p}^x)]. \tag{10}$$

Given estimates of $\mathbf{VC}, \boldsymbol{\pi}$, 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.[14]

[14] The main difference between the fixed cost model we use and the scrap value model developed by Pakes, Ostrovsky, and Berry (2007) is that the last term $-\delta\sigma(1-\mathbf{p}^x)$ in both equations (9) and (10) 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. An higher value of VE will lead to a higher estimate of the sunk entry cost. We found that in 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.

4.2 Empirical Model

The goal of the empirical model is to estimate the vector of profit function parameters θ and parameters characterizing the distribution of fixed costs G^{λ} and entry costs G^{κ} for both the dentist and chiropractor industries. We will utilize a panel data set for a cross-section of $m =$ 639 geographic markets over t= 5 time periods, for dentists and $m = 410$ geographic markets over t= 5 time periods for chiropractors. In the empirical application to each industry, for each market/year observation, there is one endogenous state variable, the number of establishments n_{mt}, and three exogenous state variables, the level of population pop_{mt}, the average real wage paid to employees in the industry w_{mt}, and real per-capita income, inc_{mt}. These are the primary demand and cost shifters in these health care industries. To simplify the discussion below we will often combine these three exogenous variables into the state vector $z_{mt} = \{pop_{mt}, w_{mt}, income_{mt}\}$.

4.2.1 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 respect to the number of firms, population, wage rate, and income. We assume that the average profit function for all dentist practices in market m, year t can be written as:

$$\begin{aligned} \pi_{mt} \quad = \quad & \theta_0 + \sum_{k=1}^{5} \theta_k I(n_{mt} = k) + \theta_6 n_{mt} + \theta_7 n_{mt}^2 + \\ & \theta_8 pop_{mt} + \theta_9 pop_{mt}^2 + \theta_{10} w_{mt} + \theta_{11} w_{mt}^2 + \\ & \theta_{12} inc_{mt} + \theta_{13} inc_{mt}^2 + \theta_{14}(pop_{mt} * w_{mt}) + \\ & \theta_{15}(pop_{mt} * inc_{mt}) + \theta_{16}(inc_{mt} * w_{mt}) + f_m + \varepsilon_{mt} \end{aligned} \tag{11}$$

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 5. For the chiropractor industry the maximum number of establishments we observe is n=8, so we simply replace n_{mt}

and n_{mt}^2 with two additional dummy variables to distinguish markets with 6 or 7 establishments. To control for the three exogenous state variables we include a quadratic specification in *pop*, w, and *inc*.

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 like 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 $\theta_1, ...\theta_7$ 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.[15]

Given the assumptions of the theoretical model, the number of firms is uncorrelated with the idiosyncratic shock ε and equation (11) 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. If ε does contain them, then it should be treated as an additional, unobserved, state variable in the model, substantially complicating the specification of the dynamic decisions.[16] While 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

[15] Ackerberg, Benkard, Berry, and Pakes (2007) discuss this as one way to correct for serial correlation in the market-level profit data that arises from unobserved market-specific factors.

[16] Das, Roberts, and Tybout (2007) estimate a dynamic entry model for a monopolistically competitive industry in which profit shocks are treated as serially-correlated state variables that are unobserved by the econometrician.

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}.[17]

4.2.2 State Variable Transitions and the Probability of Exit

The second step of the estimation method is to estimate the two transition matrices M_c and M_e which can then be used to estimate VC and VE for each state using equations (8) and (10). Pakes, Ostrovsky, and Berry (2007) 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. We construct a single continuous variable measuring the combined effect of the exogenous variables in $z_{mt} = \{pop_{mt}, w_{mt}, income_{mt}\}$ using the estimates of the profit function from stage 1. After estimating the profit function parameter vector $\hat{\theta}$ we define a single exogenous aggregated state variable:

$$\begin{aligned} \hat{z}_{mt} &= \hat{\theta}_8 pop_{mt} + \hat{\theta}_9 pop_{mt}^2 + \hat{\theta}_{10} w_{mt} + \hat{\theta}_{11} w_{mt}^2 + \hat{\theta}_{12} inc_{mt} + \\ &\quad \hat{\theta}_{13} inc_{mt}^2 + \hat{\theta}_{14}(pop_{mt} * w_{mt}) + \hat{\theta}_{15}(pop_{mt} * inc_{mt}) + \hat{\theta}_{16}(inc_{mt} * w_{mt}) \end{aligned} \tag{12}$$

that captures the combined contribution of income, population, and wages 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. While the market fixed effects are discrete, there is one for each of the geographic markets in our data set, 639 for dentists and 410 for chiropractors, 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 size of the estimated M_c and M_e transition matrices depends on the number of discrete categories in n, z_d, and f_d. The number of discrete states is $n_{\max} \cdot z_d \cdot f_d$, where n_{max} is the largest

[17] 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 values of the state variables. Given the complications arising from treating ε as an unobserved state variable we have chosen to limit the exogenous state variables to z and f_m.

number of firms observed in any market, and the number of cells in the transition matrices are $(n \cdot z_d \cdot f_d)^2$. Given that in our data set n_{max} is 20 for dentists and 8 for chiropractors, the number of cells exceeds the number of market observations even for small values of $z_d \cdot f_d$. To make the nonparametric estimation 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. To reduce the dimensionality of the transition matrices further 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 can be estimated separately. A similar expression for M_e can be written as $M_e = M_{ne}(n'|n, z_d, f_d) \cdot M_z(z'_d|z_d) \cdot I_{f_d}$.

To estimate these transition matrices, define the set of market-year observations observed in the discrete state (n, z_d, f_d) as $T(n, z_d, f_d) = \{mt : (n_{mt}, z_{mt}, f_m) = (n, z_d, f_d)\}$. The transition rate among states that is perceived by continuing incumbent firms in a market beginning in state (n, z_d, f_d) contains the matrix $M_{nc}(n'|n, z_d, f_d)$ which is estimated as:

$$\hat{M}_{nc}(n'|n, z_d, f_d) = \frac{\sum_{mt \in T(n,z_d,f_d)}(n - x_{mt})I\left[n_{mt+1} = n'\right]}{\sum_{mt \in T(n,z_d,f_d)}(n - x_{mt})} \tag{13}$$

In this case I is a dummy variable equal to one if the period $t+1$ state is n'. This equation describes an incumbent's probability of transiting from state (n, z_d, f_d) to state (n', z_d, f_d), conditional on not exiting.

The transition rate among states that is perceived by entering firms in a market beginning in state (n, z_d, f_d) depends on M_{ne} which is estimated as:

$$\hat{M}_{ne}(n'|n, z_d, f_d) = \frac{\sum_{mt \in T(n,z_d,f_d)}(e_{mt})I\left[n_{mt+1} = n'\right]}{\sum_{mt \in T(n,z_d,f_d)}(e_{mt})} \tag{14}$$

This describes a potential entrant's probability of transiting from state (n, z_d, f_d) to state (n', z_d, f_d), conditional on entering in state (n, z_d, f_d).

Finally, the transition pattern for the exogenous state variables in z is estimated as:

$$\hat{M}_z(z'_d|, z_d) = \frac{\sum_{mt \in T(z_d)} I\left[(z_{mt+1}) = z'_d\right]}{\sum_{mt \in T(z_d)} I\left[(z_{mt}) = z_d\right]} \tag{15}$$

The estimators in equations (13), (14), and (15) allow us to construct estimates of M_c and M_e which are components of the value of continuing or entering the market.

4.2.3 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 market m at time t, each of the n_{mt} incumbent firms makes a decision to continue or exit based on its private fixed cost and the value of continuing. Using the estimates from the first two stages, an estimate of $VC(n, z_d, f_d)$ can be constructed for each state up to the parameter σ which characterizes the fixed cost distribution G^{λ}. 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. Similarly, each of the p_{mt} potential entrants makes a decision to enter or stay out based on its private entry cost, and the value of entering. Denote this as $\hat{VE}_{mt}(\sigma)$ 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 is given by:

$$\begin{aligned} l(x_{mt}, e_{mt}; \sigma, \alpha) = & \qquad (16) \\ & (n_{mt} - x_{mt}) \log(G^{\lambda}(\hat{VC}_{mt}(\sigma); \sigma)) + (x_{mt}) \log(1 - G^{\lambda}(\hat{VC}_{mt}(\sigma); \sigma)) \\ & (e_{mt}) \log(G^{\kappa}(\hat{VE}_{mt}(\sigma); \alpha)) + (p_{mt} - e_{mt}) \log(1 - G^{\kappa}(\hat{VE}_{mt}(\sigma); \alpha)) \end{aligned}$$

The log-likelihood for the entry and exit observations is

$$L(\sigma, \alpha) = \sum_m \sum_t l(x_{mt}, e_{mt}; \sigma, \alpha). \qquad (17)$$

To implement this, we need to make assumptions about 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.[18] For the distribution of firm entry costs, $G^{\kappa}(\alpha)$, we have more flexibility to specify the shape of the distribution and will estimate the model under two different distributional assumptions. One is that it follows a chi-square distribution and the second is that it follows an exponential distribution. In each case, there is a single parameter α to estimate and this parameter is the unconditional mean of the entry cost distribution.

5 Data

5.1 Definition of the Market

To estimate the model the data set must contain information on the entry flows, exit flows, average firm profits, exogenous profits shifters (*pop*, *inc*, and w), 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 1977 through 2002, while the Census of Service Industries contains detailed information on revenues, costs, and geographic location for each establishment in the service sectors for the years 1977, 1982, 1987, 1992, 1997, and 2002. Similar to the approach taken by Bresnahan and Reiss (1991, 1994), we focus on relatively isolated geographic markets that are away from large population centers. We are able to construct the necessary data for more than 700 incorporated census places, which are basically small to mid-sized towns and cities in rural or semi-rural areas. The markets have populations that vary from 2,534 to 49,750 people, which are larger than the range of market sizes studied by Bresnahan and Reiss. Of these markets 639 had at least one dental practice in every year and never had more than 20 practices. For the chiropractors, we limit the analysis to 410 geographic areas that had between 1 and 8 practices in every year.[19]

[18] It is possible to extend this framework to allow heterogeneity in the fixed cost distribution across markets and time by modeling σ as function of some observable market-year characteristic. The empirical difficulty is that this new characteristic must be treated as another state variable in addition to n and z. We will report some results of this extension below.

[19] There were very few markets which met our population criteria and had more than 20 dentist or 8 chiropractor practices.

5.2 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 in a market 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 geographic market in period t and is not in that market in period $t+5$. For each market, we construct the numbers of entering, exiting, and continuing establishments.

It is important to emphasize that we would like to eliminate the sale of an ongoing practice from the entry and exit statistics and have done this to the extent possible. This is in keeping with the assumptions of the model, which views the number of independent decision makers (n) as the endogenous state variable affecting profits and the entry and exit decision as reflecting a change in the number of decision makers. In practice, however, the LBD is constructed based on following establishments at a specific location over time, but some of the linking relies on matching the name and address of the establishment across years. If the sale of a practice results in a name change, then it may not be recognized as an ongoing establishment and this will lead to an upward bias in the entry and exit rates we construct.[20]

5.3 Market Level Demand and Cost Variables

In the profit function we include three exogenous state variables to capture differences in the evolution of profits across markets. To control for demand differences we include the population and the real per-capita income of the geographic market. Population estimates for incorporated places in each sample year are constructed from data collected in the Census Bureau's Population Estimates Program and are augmented by interpolations from the decennial

[20] In longitudinal Census data, errors in the linkage for an establishment over time will appear as a simultaneous entry and exit. We have compared our entry rates for dental practices with independent information on new licenses reported by the licensing boards in several states. While not comprehensive, in cases where we can make comparisons with the census markets, it suggests that the rate of entry we measure is approximately 5 percentage points higher (20 percent versus 15 percent, on average), but the cross-state patterns are similar and the 5 percentage point differential is similar across states. The higher rate in the census data could reflect errors in following existing practices over time or the movement of dentists into new geographic markets. While these two data sources have different units of measurement, establishments versus individuals, it is encouraging that the cross-sectional ranking of high and low entry states is similar.

population censuses for the earlier sample years. Real per-capita income is constructed at the county level using data from the Bureau of Economic Analysis and deflated by the CPI. To control for cost differences we measure the average real wage paid to employees in health services industries in the area. This is then deflated by 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.

5.4 Measuring Establishment Profits

The empirical model requires a measure of the average profits earned by establishments in each geographic market and time period. The relevant measure of profits in this industry is the net income earned by the dentist or chiropractor from operating the establishment. To construct this measure, we use information on revenue, payroll, and legal form of organization from the Census LBD and information on other business expenses from the American Dental Association (ADA) and the Census Bureau's Business Expenses Survey (BES). These expenses include licensing fees, costs of supplies and materials, insurance, rent, depreciation charges on capital equipment, and purchased services among other things. They capture market level differences in variable and some fixed costs.[21] These data sources report that expenses other than payroll are approximately 35% of a dentist's office revenues. For the offices of chiropractors, we rely on aggregate data from the BES for industry 804 (Offices of Other Health Practitioners) that contains chiropractors. Based on the BES data, we estimate that other expenses account for 37% of a chiropractor's office revenues.

In constructing a measure of profit, two other important features of the industries must be accounted for. First, the tax status of a firm will affect how key data items are reported. For sole proprietors and partnerships, the owner receives compensation as net income and not as payroll. For these legal forms of organization (LFO), firm pre-tax profits (net income) are revenue minus payroll minus estimated expenses. For professional service organizations (corporations), the owning dentist(s)/chiropractors are typically paid part of their compensation as a component

[21] As developed in the theoretical model section, we will also incorporate a firm-specific fixed cost shock which will generate profit heterogeneity across firms within each market.

of 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 corporation 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.[22] In order to make our profits comparable across offices of different scale, we normalize the profits per office by the average number of practitioner-owners across the LFO types. Thus, our final measure of profit is the net income per owner-practitioner.[23]

5.5 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 definition sets the number of potential entrants into a geographic market in a time-period equal to the maximum number of different establishments that appear in the market over time minus the number of establishments already in operation. The rationale behind this definition is that in each geographic market we observe all potential entrants being active at some point in time. In each time period the pool of potential entrants 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 it is affected by the overall growth in market size and the

[22] 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.

[23] A final modification is made to the profit figures to standardize the profit flow with the entry and exit flows. Using the Census data we have measured the flow of profits in census year t while the entry and exit numbers represent flows over the 5 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 in equations (9) and (10) is the value at the end of the five year interval, $.95^5 = .773$.

number of establishments over time. Since the number of establishments has increased over time due to exogenous growth in population, this measure 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.[24] To capture this feature of the potential entry pool, we exploit additional data from the ADA, Federation of Chiropractic Licensing Boards (FCLB) and Bureau of Health Professionals (BHP) 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 use this number as our estimate of the pool of potential entrants for a market. We will refer to this as the "external" entry pool definition. In the case of chiropractors, we use much cruder information from the FCLB and BHP on the ratio of the number of licensed chiropractors to the number of chiropractors' offices to construct the excess pool of entrants available to start new businesses. This correction does not vary across geographic markets. We also adjust the chiropractor pool for new graduates, since they are a more important source of new entrants than in the case of dentists.

The potential entry pools are summarized in Table 2. The table reports the average number of potential entrants across all observations with a given number of establishments. In all cases the number of potential entrants rises with the size of the market. For both industries, the "internal" entry pool gives a number of potential entrants that is slightly larger than the number of establishments in the market. This is also true of the "external" entry pool for the chiropractors. The main difference is between the internal and external pools for the dentist industry. In general, since there can be many adjoining counties for each market, we identify a fairly large number of dentists in those surrounding areas and it is the size of the dentist pool in these surrounding areas that determines the number of potential entrants. In general, this external entry pool will increase with the size of the geographic market but it is not as

[24] 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.

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. We will discuss the impact of this definition on the estimated parameters in the next section

6 Empirical Results

6.1 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. If there are persistent unobserved profit determinants across markets, then in this specification the coefficients on n will be biased toward zero so that we underestimate the toughness of competition. The dummy variable coefficients for markets with one to five firms are positive and decline as n increases and the coefficients on n and n^2 also imply a declining effect of n on profits, but none of the coefficients are statistically significant. In contrast, after controlling for market fixed effects, the same coefficients in column two indicate a significant competitive effect from an increase in n. The coefficient on n is larger in absolute value and there are significantly higher average profits in monopoly and duopoly. markets. The function representing the toughness of competition is summarized in Figure 1 for each of the two sets of parameter estimates. This plots the fitted value from the profit function regressions against n, holding other variables fixed at the sample means. The steeper line for the dentist industry shows the function when market fixed effects are controlled for and the attenuation bias that occurs when the fixed effects are eliminated is obvious. The slope of this function summarizes the impact of market structure on market performance in the short-run. When market fixed effects are incorporated, the mean predicted firm profit drops from 78.7 thousand dollars for a monopoly to 64.8 thousand for a duopoly to 46.8 thousand for a market with five firms, a 40.5 percent decline from monopoly markets to markets with 5 firms.

In the profit function with fixed effects, several of the other state variables have statistically significant coefficients. When evaluated at the sample means of the variables, the marginal effect of each of the three variables, population, income, and wages, are all positive. The first two effects are consistent with demand increases as market size and income increase. The wage effect is counter to what is expected if it is a cost shifter and is likely capturing an effect of cost-of-living differences across geographic markets. The most substantial effect comes from changes in income and, when expressed as an elasticity, the impact of an increase in income on profits is 1.20. This can reflect both increased use of dental services and use of more advanced services that are likely to have higher profit margins in higher-income areas.

The profit function parameters for the chiropractor industry are reported in column 3 (without market fixed effect) and column 4 (with fixed effect) of Table 3. Because the number of firms in our sample varies from one to eight across markets, we use a full set of dummy variables to model the effect of n on average profit, with the base group being the markets with eight firms. The fixed effects estimates indicate that an increase in n reduces average profits. The coefficient for the monopoly market is statistically significant but the coefficients for the other values of n are not significant. When evaluated at the mean of the other state variables, a market with one firm will have average annual profits of 59.7 thousand dollars, a duopoly will have 57.7 thousand, and a market with five firms 53.0 thousand, an overall decline of 11.2 percent as the market moves from monopoly to five firms. The estimated functions summarizing the toughness of competition are also graphed in Figure 1 and the attenuation bias in the estimates when we do not control for the market fixed effect is also present. The effect of the other three state variables are all positive when evaluated at the means. Interestingly, the profit elasticity with respect to income is .654, which is less than in the dentist industry. Demand and profits increase as market income rises but the lower elasticity might reflect substitution into other forms of medical care as income rises.

Comparing the estimated toughness of competition function between the two industries we see that, while it declines with n for both, it is much steeper for dentistry. This will reflect the nature of short-run competition among firms and the demand and cost characteristics that determine short-run profitability. What the estimated patterns suggest is that the actual entry of an additional firm will have a larger adverse impact on current firm profits in the dentist industry. Among other things, this could reflect the availability of substitute products outside of the industry. If alternatives for dental care are more limited than for chiropractor services, then existing firms enjoy a higher degree of short-run market power which is then reduced as the number of providers increases.

6.2 Fixed Costs, Firm Values, and the Probability of Exit

The parameters of the fixed cost and sunk entry cost distributions, σ and α, were estimated with maximum likelihood using the likelihood function for the entry and exit rates in equation (17). Each of these parameters is the mean of the underlying cost distribution the firms face, expressed in millions of 1983 dollars. Since 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. Table 4 reports parameter estimates for several specifications of the model including two assumptions about the shape of the entry cost distribution (chi-square and exponential) and two assumptions about the pool of potential entrants (the internal and external pools as defined in section 5.5).

Panel A of Table 4 reports parameter estimates for the dentist industry. The estimate of the mean fixed cost varies from .307 to .309 million dollars across different specifications on the entry pool and entry cost distribution.[25] Obviously, this parameter estimate is completely insensitive to alternative assumptions on the entry dimensions.[26] Given this estimate of σ, 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.[27] The estimate of VC, the discounted sum of expected future net income to the practitioner, varies

[25] We also estimated the parameter σ using only the part of the likelihood function that pertains to the exit and survival flows. In this way the parameter σ is not used to help fit the entry data (through the estimate of VE). The estimates of σ were not affected by this change so the fixed cost estimates and the long-run value of the firm can be robustly estimated with or without the data on entry and the potential entry pool. Finally, we also use the nonparametric estimator of p^x suggested by Pakes, Ostrovsky, and Berry (2007) and find the results are very robust to this alternative.

[26] We also estimated an extension of the model in which the mean of the fixed cost distribution was allowed to vary across markets with differences in the proportion of dentists in the market over age 55. The idea was to see if markets with older dental practices had lower mean fixed costs because their capital equipment had depreciated. The effect was significant and when evaluated at the average value of the age variable produced an estimate of the mean fixed cost identical to the estimate of .308 in Table 4, Panel A. With access to better data on some factors that lead to shifts in the fixed cost distribution across markets it is possible to extend the model to allow for this additional source of market-level heterogeneity.

[27] 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.

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 in Figure 1 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.

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, 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 .374 million dollars, while that same monopoly would have a value of 1.058 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.[28].

These estimates can be contrasted with the estimates for the chiropractor industry reported in Panel B of Table 4. The estimate of the fixed cost parameter σ is .258 and is not affected by the modeling 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

[28]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 9 and 10. These, in turn, differ across the two types of firms because they condition on their own choice. In our application, the estimates of $\hat{M}_{nc}$ and $\hat{M}_{ne}$ from equations 13 and 14 are similar, so that the estimates of VC and VE are also very similar for each state.

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 1.058 million dollars while a monopoly chiropractor in the same type of market would have a firm value of .599 million. This reflects the overall lower level of per period profit observed for chiropractors.

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 2. 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 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.

Given estimates of the long-run benefits of operating in a geographic market with a given state, and the fixed cost distribution faced by incumbents, we can estimate the probability of exit and the mean fixed cost faced by surviving firms. 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 each of the 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 .774 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 while 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.

The mean level of fixed costs incurred by surviving firms depends on both the parameter σ and the truncation point $VC(n, z, f)$ as shown in equation (4). The first three columns of Table 7 report values of this truncated mean across different states. For example, in the monopoly markets for dentists, if there are low (z, f) characteristics the monopolist would spend, on average, .150 million dollars on fixed costs and still remain in operation but in high (z, f) markets spending would average .272 million for the monopoly dentist that remained open. Notice that this occurs, even though the distribution of fixed costs the firms face is identical across all markets, because the amount that operating firms are willing to spend in fixed costs varies with the long-run profitability of the market. Comparing across states, there is more variation in the fixed costs across low, medium, and high (z, f) markets than across markets with different numbers of firms. Comparing the two industries the fixed costs that firms would be willing to incur are larger for dentists than chiropractors.

6.3 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 under different assumptions about the shape of the cost distribution and the nature of the potential entrant pool. In Panel A, when we assume that the entry cost distribution is chi-square we get parameter estimates of 1.674 using the internal entry pool definition and 2.786 using the external pool definition. When the entry distribution is exponential the parameter estimates are 1.410 and 5.309 with the internal and external pool definitions, respectively. 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. Focusing on the internal entry pool, the estimated entry cost parameters, 1.674 for the chi-square and 1.41 for the exponential, imply virtually identical entry cost distributions. When the distributions are plotted there is no practical distinction between them. With the external entry pool, the estimates are sensitive to the distributional assumption. When using the exponential distribution there is a higher mean, with less mass on low entry costs and a fatter tail for high entry costs. This sensitivity increases our concerns about the use of the external entry pool definition. 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: 1.495 for the internal pool and 1.338 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. The estimate using the exponential distribution, 1.078, is lower than the model using the chi-square assumption but, as was seen for the dentists, plots of the two cost distributions are virtually identical.

Given these estimates, 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. Even though the distribution of entry costs has a higher mean in the dentist industry, the higher values of VE lead to a probability of entry that is larger for dentists than chiropractors. For example, the probabilities of entry into a monopoly dentist market are .176, .296, and .432 depending on the level of (z, f) but slightly lower, .106, .194, and .346, for monopoly chiropractor markets. Using the exponential distribution for the entry cost, we also calculate the mean entry cost incurred by the firm's that choose to enter as $E(\kappa|\kappa < \delta VE) = \alpha - \delta VE(1-p^e)/p^e$ and these are reported in the last three columns of Table 7.[29] The mean cost varies across states due to variation in both VE and p^e. Two patterns are of interest. In high-profit markets, firms will be willing to expend more money to enter. Both the marginal and average entrant into a market will depend on the market characteristics which, in our framework, are the market structure and exogenous profit determinants. Second, the mean realized entry costs are higher in the dentist industry. For example, on average, entrants into the monopoly dentist markets will have sunk costs of .132, .233, or .361 million dollars depending on whether it is a low or high profit market. The entrants into monopoly markets for chiropractors will have average entry costs of .059, .112, and .213 million dollars.[30]

Comparing the long-run earnings net of the relevant fixed or sunk costs between the surviving incumbents and the actual entrants provides an estimate of the barrier to entry faced by actual entrants. In a market in state (n, z, f), each surviving incumbent will have expected earnings in the next period net of fixed costs of $\delta(VC - E(\lambda|\lambda < VC))$, while each firm that chooses to enter will have an expected next period payoff net of entry costs of $\delta VE - E(\kappa|\kappa < \delta VE)$. The difference between these two future payoffs is a measure of the barrier to entry faced by a potential entrant relative to an incumbent. We define the barrier to entry as $BTE(n, z, f) = \delta(VC - VE) - \delta E(\lambda|\lambda < VC) - E(\kappa|\kappa < \delta VE)$ which is the difference in expected future returns net of costs between an incumbent and an entrant. From the results in Table 5, VC and VE are approximately equal for any state, so the difference in mean fixed costs and mean sunk costs will be the major source of advantage for the incumbent. In the case of monopoly markets for dentists, the $BTE(n = 1, z, f)$ is .032 .081, and .172 million dollars depending on the level of (z, f) This means that, in a high-profit market, the long-run net payoff to an incumbent dentist from remaining in the industry is approximately .172 million dollars more

[29] The Table 7 estimates use the internal entry pool definition since this is defined in the same way for both industries.

[30] These truncated means are not substantially different if we model entry costs using the chi-square distribution. In this case, the corresponding means for the three profit states for the dentist industry are .121, .213, and .337 and for the chiropractor industry are .051, .098, and .186 million dollars.

than the payoff to an entrant. The difference declines as the number of firms in the market increases but, even when there are 20 firms in a high profit market, the net benefit to an incumbent is still .092 million dollars higher than the net benefit to an entrant. The difference is smaller in the chiropractor industry. In the case of monopoly markets it equals $69,400 in high-profit states and this declines to .058 million dollars as the number of firms increases to 8.

6.4 Evaluating changes in the toughness of competition and entry costs

The focus of this section is to illustrate how market structure n and long-run profits, VC and VE, in the dentist industry are driven by the underlying structural features of the industry, specifically: the toughness of short-run competition, the magnitude of the entry cost, and the size of the pool of potential entrants. This allows us to assess the separate impact of entry conditions (entry costs and the size of the entry pool) from current profit conditions on long-run profits and market structure. We evaluate changes in the toughness of short-run competition by changing the parameter on n in the estimated profit function We evaluate changes in the entry cost by altering α, the mean of the entry cost distribution, and we evaluate changes in the number of potential entrants by scaling the size of the pool of potential entrants in each market. Solving the model for these alternative parameter values 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 (n, z_d, f_d). Using the estimated profit function, equation (11), the empirical transition matrix for z, equation (15), the estimated mean fixed costs and entry cost, and the internal entry pool for the number of potential entrants in each market with n firms, equations (1), (3), and (6) are solved simultaneously.[31]

Tables 8, 9, and 10 report results of the model solution for the dentist industry, focusing on one set of parameter changes at a time. We construct the proportional changes in VC, VE, p_x and p_e for each state and summarize them in the tables with regressions on dummy variables for n, z_d, and f_d. Table 8 summarizes the effect of lowering the current profit premium earned in markets with small numbers of firms. We do this by eliminating the profit premium in markets

[31] Pakes, Ostrovsky and Berry (2007) provide the formulas for the equilbrium 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, $p^e(e, x|n, z, f, \chi^e = 1)$.

with 1 to 5 firms by setting the coefficients on the dummy variables $I(n = 1)$ to $I(n = 5)$ equal to zero. This still allows for a negative, diminishing effect of n on short-run profit through the coefficients on n and n^2 but removes the additional premium earned in markets with $n \leq 5$. In this counterfactual, we observe that firm values decline, exit rates increase, and entry rates decrease in markets with 5 or fewer firms, but there is very little impact on markets with more than 5 firms. For example, the first line of the table shows that, by eliminating this premium in monopoly markets, VC and VE would decline by 8.0 percent and 5.6 percent, respectively while the exit rate would rise by 17.6 percent and the entry rate decline by 4.8 percent. The direction of these effects remains the same but the magnitudes of the effects are greatly diminished as n increases. The combination of lower long-run profits, higher exit rates, and lower entry rates generates a leftward shift in the across-market distribution of the number of firms.[32] The probability that a market has three or fewer firms rises from .370 to .387 and the probability a market has five or fewer firms rises from .669 to .679. Thus the elimination of the short-run profit premium in markets with few firms would result in higher concentration levels across markets. This is consistent with the two-stage model of Sutton (1991) for exogenous sunk cost industries: more vigorous post-entry competition leads to more concentrated markets.

Alternatively we can evaluate the effects of changes in the entry mechanism, measured by both the level of sunk entry costs and the number of potential entrants. Table 9 reports the change in firm values and turnover if the mean of the unconditional entry cost distribution falls by 25 percent. Average firm values for both incumbents and entrants fall between 2.5 and 6.4 percent with the larger reductions in markets with a small number of firms. As shown in the first row of the table, in monopoly markets the firm values for the incumbent and entry groups fall by 6.4 and 5.3 percent, respectively, as a result of this increased pressure from potential entrants. The entry and exit rates both rise substantially as a result of the decrease in entry

[32] To construct the across-market distribution of firms for each conterfactual we first specify the initial market conditions for a set of 639 markets using independent draws on n, z_d, and f_d. The values of n are drawn from the empirical distribution of n and the values of z and f are drawn uniformly from the grid points z_d and f_d. Second, the equilbrium number of entrants (e) and exits (x) for each market is generated by drawing an entry cost for each potential entrant and a fixed cost for each incumbent from their underlying distributions and comparing them with the value of VC and VE for that market. This process is then repeated for five time periods, updating the state variables n and z each period, to create a simulated data set with the same number of market/time observations as our original data set. Finally, this process is repeated thirty times and the average values for the resulting across-market distibution of the number of firms are reported.

costs. In monopoly markets the entry rate rises by 21.1 percent and the exit rate rises by 15.3 percent. The reduction in entry costs contributes to both higher turnover and lower firm values. It also contributes to an increase in market concentration. The probability of observing a market with three or fewer firms rises from .370 to .392 and the probability a market has five or fewer firms rises from .669 to .691. As seen in the first experiment, a parameter shift that reduces long-run firm values also results in a more concentrated market structure.

The final experiment we perform analyzes the effects of an exogenous increase in the pool of potential entrants. Table 10 reports changes when there is a 50 percent increase in this pool. In this case there is a substantial reduction in the firm values VC and VE, over 10 percent in monopoly and duopoly markets and still more than 4.0 percent when there are 20 firms in the market. The exit probability rises substantially and the entry probability falls. The latter effect needs to be weighed against the increase in the size of the entry pool and, in this case, the large increase in the entry pool actually generates an increase in the number of entering firms. This increase leads to an overall decline in market concentration, in contrast to the previous experiment where we lowered the entry cost. In this case, the probability that the market has three or fewer firms falls from .370 to .296 and the probability of five or fewer firms falls from .669 to .567. In this case, the reduction in long-run profits is accompanied by a rightward shift in the equilibrium distribution of the number of firms and thus lower market concentration. Together the three experiments illustrate the complexity of the adjustments in response to changes in the underlying industry conditions. While all three experiments lowered long-run firm values, they have different effects on the entry and exit rates and thus on the equilibrium market structure. An increase in the pool of potential entrants leads to more firms and fewer concentrated markets while the reductions in both short-run profit premiums and entry costs lead to higher market concentration.

As a final step we assess the relative impact of competitive pressure from existing firms with the pressure from potential competitors through the entry process. To do this we compute the reduction in VC that will occur if the short-run profit premiums are removed and then calculate the reduction in the mean entry cost that will generate the same reduction in VC. In the case of the monopoly markets, if we reduce the premium in the short-run profit function from the monopoly to the duopoly level, the reduction in VC is the same magnitude as what would occur if the mean entry cost was lowered by 7 percent. In other words, a seven percent reduction in the mean entry cost, which equals approximately $100,000, will reduce the incumbent firm's continuation value by the same amount as if the market shifted from a monopoly to a duopoly. Continuing this comparison, an increase in the number of firms from two to three will have the same impact on VC as an eight percent reduction in the entry cost. Finally, an increase from three to four firms will lower the continuation value in the three firm market to the same magnitude as a six percent reduction in the entry cost. Overall, in the case where there are a small number of firms in the market, pressure from potential entrants as well as existing firms has a disciplining effect on long-run profits.

7 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 paper we utilize micro data for two U.S. service industries, dentists and chiropractors, over a 25 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 Pakes, Ostrovsky and Berry (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 the toughness of price competition increases with the number of firms. For dental practices the slope of the function $\pi(n)$ is negative, statistically significant, and particularly large as the number of establishments increases from 1 to 4. In the chiropractor industry the decline is smaller in magnitude but still statistically significant between monopoly and duopoly markets. 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 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. Counterfactuals using the estimated model for the dentist industry show that pressure from both potential entrants and incumbent firms discipline long-run profits. We calculate that a seven percent reduction in the mean sunk entry cost would reduce a monopolist's long-run profits by the same amount as if the firm operated in a duopoly.

The results reported here also indicate several directions for future research in empirical modeling of entry and exit dynamics. While the estimates of fixed costs and the toughness of short-run competition are not sensitive to modeling assumptions on the pool of potential entrants, the estimates of sunk entry costs are. In one of the counterfactual exercises, the size of the pool of potential entrants is found to have a significant effect on long-run firm values and turnover rates. 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. 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 paper, 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.

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Table 1: Entry and Exit Statistics

(mean across market-time observations)

Number Estabs	Number Entrants	Number Exits	Entry Proportion	Exit Rate	% of obs with E,X>0
Dentist					
n =1	.612	.284	.612	.284	.149
n =2	.655	.349	.328	.175	.224
n =3	.843	.554	.281	.185	.332
n =4	1.00	.729	.251	.182	.388
n =5	1.21	.963	.242	.193	.466
n =6	1.41	1.16	.235	.193	.529
n =7	1.55	1.48	.222	.211	.651
n =8	1.73	1.57	.216	.196	.678
n =9	2.07	1.87	.230	.207	.785
n =10,11	2.29	2.24	.218	.214	.806
n =12,13,14	2.86	2.60	.220	.199	.870
n =15,16,17	3.20	3.20	.200	.200	.915
n =18,19,20	3.44	4.46	.181	.235	.972
Chiropractor					
n =1	.841	.223	.841	.223	.202
n =2	.908	.479	.454	.240	.295
n =3	1.03	.761	.345	.254	.424
n =4	1.40	1.07	.351	.267	.542
n =5	1.58	1.38	.317	.276	.664
n =6	1.90	1.82	.317	.303	.761
n =7	2.05	2.26	.292	.322	.744
n =8	3.25	2.92	.406	.365	.917

Table 2: Number of Potential Entrants

(mean across market-time observations)

Number of Estabs	Dentists Number of Potential Entrants internal entry pool	 external entry pool	Chiropractors Number of Potential Entrants internal entry pool	 external entry pool
n=1	2.58	22.49	3.85	2.06
n=2	2.94	25.36	4.17	3.39
n=3	3.72	21.79	4.57	4.61
n=4	4.41	22.36	5.32	5.61
n=5	5.19	22.94	5.63	6.98
n=6	6.46	24.63	6.27	7.83
n=7	7.08	27.38	6.16	9.37
n=8	8.02	28.23	8.75	10.67
n=9	9.07	27.28		
n=10,11	10.20	26.68		
n=12,13,14	12.18	25.01		
n=15,16,17	14.12	27.19		
n=18,19,20	16.24	28.45		

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	-1.719 (3.775)	5.465 (3.453)	*Intercept*	-12.784* (5.217)	-28.836** (6.367)
$I(n=1)$	.0495 (.0318)	.0847** (.0269)	$I(n=1)$	.0202 (.0164)	.0690* (.0347)
$I(n=2)$	.0208 (.0148)	.0395* (.0197)	$I(n=2)$	.0199 (.0160)	.0514 (.0342)
$I(n=3)$	.0139 (.0107)	.0180 (.0148)	$I(n=3)$	.0083 (.0155)	.0392 (.0338)
$I(n=4)$	.0130 (.0088)	.0128 (.0112)	$I(n=4)$	.0036 (.0151)	.0255 (.0336)
$I(n=5)$	.0137 (.0071)	.0075 (.0082)	$I(n=5)$	-.0021 (.0162)	.0303 (.0344)
n	-.0046 (.0034)	-.0191** (.0053)	$I(n=6)$	.0026 (.0172)	.0100 (.0347)
n^2	.0001 (.0001)	.0004 (.0002)	$I(n=7)$	-.0238 (.0163)	-.0117 (.0357)
pop	-.0091 (.0146)	-.0385 (.0217)	*pop*	-.0068 (.0177)	-.0682** (.0242)
pop^2	-.0001** (2.62e-5)	-.0002* (8.9e-5)	pop^2	-4.5e-5 (2.6e-5)	-8.9e-5 8.7e-5
inc	.4429 (.8210)	-1.347 (.7550)	*inc*	2.676* (1.142)	6.160** (1.382)
inc^2	-.0270 (.0448)	.0829* (.0414)	inc^2	-.1393* (.0626)	-.3285** (.0751)
w	-.1690** (.0501)	-.0828* (.0391)	w	.0934 (.0767)	.0593 (.0503)
w^2	-.0012** (.0002)	-.0007** (.0001)	w^2	-.0003 (.0003)	-.0001 (.0001)
$pop \cdot w$	.0001 (.0001)	4.9e-6 (.0001)	$pop \cdot w$	-.0002 (.0002)	-.0002* (9.2e-5)
$pop \cdot inc$	.0014 (.0016)	.0061** (.0023)	$pop \cdot inc$	.0011 (.0019)	.0081** (.0026)
$inc \cdot w$	.0220** (.0055)	.0112** (.0043)	$inc \cdot w$	-.0076 (.0083)	-.0048 (.0055)
number obs	3195	3195	number obs	2050	2050

** significant at the .01 level, * significant at .05 level

Table 4: Fixed Cost and Entry Cost Parameter Estimates

(standard errors in parentheses)

	Chi-Square Entry Costs		**Exponential Entry Costs**	
Panel A. Dentist				
Entry pool	Fixed Cost σ	Entry Cost α	Fixed Cost σ	Entry Cost α
internal	0.308 (.004)	1.674 (.027)	0.307 (.003)	1.410 (.046)
external	0.309 (.004)	2.786 (.028)	0.307 (.003)	5.309 (.102)
Panel B. Chiropractor				
Entry pool	Fixed Cost σ	Entry Cost α	Fixed Cost σ	Entry Cost α
internal	0.258 (.006)	1.495 (.040)	0.258 (.006)	1.078 (.057)
external	0.257 (.006)	1.338 (.035)	0.258 (.006)	0.874 (.041)

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	.374	.665	1.058	.352	.641	1.029
n=2	.285	.575	.969	.264	.553	.942
n=3	.255	.546	.939	.245	.534	.923
n=4	.236	.527	.920	.228	.517	.906
n=5	.219	.509	.903	.209	.497	.886
n=6	.182	.473	.866	.179	.467	.856
n=7	.170	.461	.854	.167	.456	.848
n=8	.164	.455	.848	.161	.450	.839
n=10	.147	.438	.831	.149	.438	.827
n=12	.130	.421	.814	.132	.421	.810
n=16	.099	.390	.783	.102	.390	.779
n=20	.078	.369	.763	.082	.370	.759
	VC for Incumbents - Chiro			VE for Potential Entrants - Chiro		
n=1	.156	.303	.599	.155	.300	.592
n=2	.153	.299	.595	.153	.298	.590
n=3	.151	.297	.593	.150	.295	.586
n=4	.148	.294	.591	.147	.292	.583
n=5	.148	.294	.591	.147	.292	.583
n=6	.137	.283	.580	.136	.282	.573
n=7	.115	.261	.558	.118	.263	.554
n=8	.114	.260	.557	.120	.265	.557

Table 6: Predicted Probabilities of Exit and Entry

(evaluated at different values of the state variables)

(millions of 1983 dollars)

	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	.296	.115	.032	.176	.296	.432
n=2	.396	.153	.043	.135	.262	.404
n=3	.435	.169	.047	.126	.254	.397
n=4	.463	.180	.050	.118	.247	.392
n=5	.491	.190	.053	.108	.239	.385
n=6	.553	.215	.060	.094	.226	.375
n=7	.575	.223	.062	.088	.221	.371
n=8	.586	.227	.063	.084	.219	.369
n=10	.620	.240	.067	.079	.214	.365
n=12	.655	.254	.071	.070	.206	.359
n=16	.724	.281	.078	.054	.193	.348
n=20	.774	.301	.083	.044	.183	.341
	Probability of Exit - Chiro			Probability of Entry - Chiro		
n=1	.544	.309	.098	.106	.194	.346
n=2	.553	.314	.099	.104	.193	.345
n=3	.557	.316	.100	.102	.191	.344
n=4	.563	.320	.101	.100	.189	.342
n=5	.563	.320	.101	.100	.189	.342
n=6	.587	.333	.105	.094	.183	.337
n=7	.640	.363	.115	.081	.172	.329
n=8	.642	.364	.115	.083	.173	.329

Table 7: Estimated Fixed and Sunk Costs

(evaluated at different values of the state variables)

(millions of 1983 dollars)

	Mean Fixed Cost for Survivors - Dentist			Mean Sunk Cost for Entrants - Dentist		
	low(z,f)	mid(z,f)	high(z,f)	low(z,f)	mid(z,f)	high(z,f)
n=1	.150	.221	.272	.132	.233	.361
n=2	.121	.203	.264	.100	.203	.333
n=3	.110	.196	.261	.093	.196	.327
n=4	.103	.192	.259	.087	.191	.322
n=5	.096	.187	.257	.079	.184	.315
n=6	.082	.178	.252	.068	.173	.305
n=7	.077	.175	.251	.064	.169	.301
n=8	.075	.173	.250	.062	.167	.300
n=10	.068	.168	.248	.057	.162	.296
n=12	.060	.164	.245	.051	.157	.290
n=16	.047	.155	.241	.039	.146	.280
n=20	.038	.148	.238	.031	.138	.273
	Mean Fixed Cost for Survivors - Chiro			Mean Sunk Cost for Entrants - Chiro		
n=1	.070	.122	.193	.059	.112	.213
n=2	.069	.121	.192	.058	.111	.212
n=3	.068	.121	.192	.057	.110	.211
n=4	.067	.120	.192	.056	.109	.210
n=5	.067	.120	.191	.056	.109	.210
n=6	.063	.116	.189	.052	.105	.207
n=7	.053	.109	.185	.045	.099	.200
n=8	.053	.109	.185	.046	.099	.201

Table 8: Counterfactual 1 - Eliminate Profit Premium when n = 1,...5

Number of Firms	Proportional Change in VC	VE	p^x	p^e
$n = 1$	-.080	-.056	.176	-.048
$n = 2$	-.053	-.038	.105	-.033
$n = 3$	-.034	-.024	.059	-.021
$n = 4$	-.023	-.016	.039	-.014
$n = 5$	-.014	-.009	.023	-.008
$n = 6$	-.009	-.006	.016	-.005
$n = 7$	-.006	-.003	.011	-.003
$n = 8$	-.003	-.001	.008	-.001
$n = 10$	.000	.001	.004	.001
$n = 12$	.002	.003	.002	.003
$n = 16$	.004	.004	.000	.004
$n = 20$	.004	.004	.000	.004

Table 9: Counterfactual 2 - 25% Reduction in Entry Costs

Number of Firms	Proportional Change in			
	VC	VE	p^x	p^e
$n = 1$	-.064	-.053	.153	.211
$n = 2$	-.056	-.048	.125	.219
$n = 3$	-.054	-.047	.110	.223
$n = 4$	-.050	-.044	.097	.229
$n = 5$	-.049	-.043	.088	.232
$n = 6$	-.046	-.041	.080	.236
$n = 7$	-.044	-.039	.073	.239
$n = 8$	-.042	-.037	.067	.242
$n = 10$	-.039	-.035	.058	.247
$n = 12$	-.038	-.034	.051	.251
$n = 16$	-.032	-.029	.037	.259
$n = 20$	-.028	-.025	.027	.265

Table 10: Counterfactual 3 - Increase Potential Entry Pool by 50%

Number of Firms	Proportional Change in			
	VC	VE	p^x	p^e
$n = 1$	-.117	-.107	.304	-.091
$n = 2$	-.104	-.098	.246	-.083
$n = 3$	-.092	-.088	.197	-.076
$n = 4$	-.086	-.082	.173	-.071
$n = 5$	-.088	-.084	.166	-.073
$n = 6$	-.082	-.079	.149	-.070
$n = 7$	-.078	-.075	.134	-.066
$n = 8$	-.074	-.071	.121	-.063
$n = 10$	-.065	-.063	.096	-.056
$n = 12$	-.062	-.060	.087	-.054
$n = 16$	-.054	-.052	.060	-.047
$n = 20$	-.044	-.043	.042	-.039

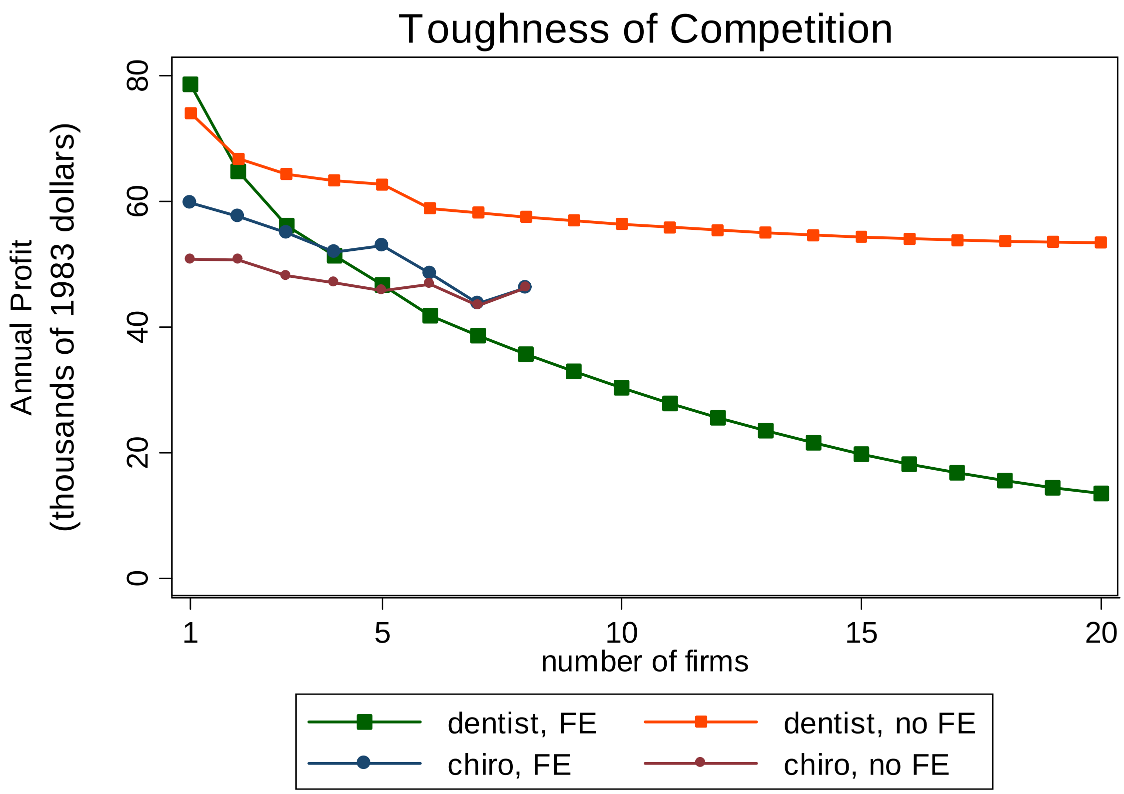
Toughness of Competition
Annual Profit
(thousands of 1983 dollars)
0
20
40
60
80
1
5
10
15
20
number of firms
dentist, FE
dentist, no FE
chiro, FE
chiro, no FE

Figure 1

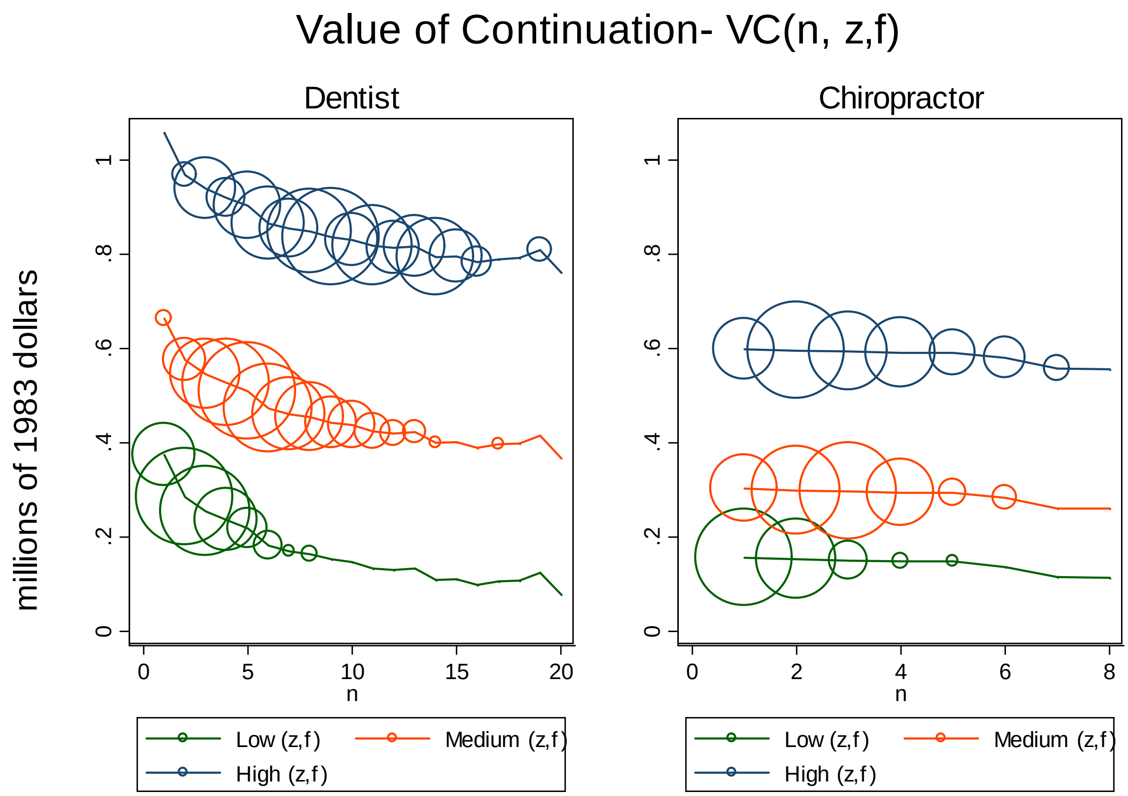
Value of Continuation- VC(n, z,f)
Dentist
Chiropractor
millions of 1983 dollars
0
.2
.4
.6
.8
1
0
5
10
15
20
n
0
2
4
6
8
n
Low (z,f)
Medium (z,f)
High (z,f)
Low (z,f)
Medium (z,f)
High (z,f)

Figure 2