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## Who Thinks about the Competition? Managerial Ability and Strategic Entry in US Local Telephone Markets<sup>†</sup>

By AVI GOLDFARB AND MO XIAO\*

*We examine US local telephone markets shortly after the Telecommunications Act of 1996. The data suggest that more experienced, better-educated managers tend to enter markets with fewer competitors. This motivates a structural econometric model based on behavioral game theory that allows heterogeneity in managers' ability to conjecture competitor behavior. We find that manager characteristics are key determinants in managerial ability. This estimate of ability predicts out-of-sample success. Also, the measured level of ability rises following a shakeout, suggesting that our behavioral assumptions may be most relevant early in the industry's life cycle. (JEL L96, L98, M10)*

Managers make decisions. Sometimes these decisions are made without full information, sometimes they are short-sighted, and sometimes they are brilliant. But all in all, the success of a company chiefly lies in the quality of decisions made by its management. This is why CEO succession is a common *Wall Street Journal* headline. Thus far, however, most empirical economic models have treated firms as black boxes that make purely rational decisions. While empirical models allow heterogeneity in consumer preferences, firm attributes, costs, and market characteristics, they have generally failed to recognize variance in managers' abilities to understand rival firms' strategic behavior.

The aim of this project is to understand the incidence of heterogeneity in management ability in a new industry. The passage of the Telecommunications Act of 1996 opened the competitive local telecommunications industry in the United States. Prior to this act, the market had been dominated by the incumbent local exchange carriers, or "Baby Bells." While widespread competition is still not the norm, the 1996 Act led to substantial entry. The entrants (known as competitive local exchange carriers,

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or CLECs) varied substantially in size, management, and telecommunications experience. Their managers chose which cities and towns the firms should enter following the opening of the market.

The early years of this industry provide an ideal setting for exploring heterogeneity in the strategic ability of managers. Manager experience was heterogeneous, the industry had not yet experienced a shakeout of the lower-quality firms, and industry norms were still developing. More important, and in contrast to many existing models of firm behavior in new industries that emphasize cost and production heterogeneity (e.g., Steven Klepper 2002; Thomas J. Holmes and James A. Schmitz 1995), our data suggest a strong correlation between manager characteristics and competitive considerations. Our descriptive analysis, which characterizes the entry decisions of facilities-based CLECs in 234 midsize US markets with populations between 100,000 and 1,000,000 as of the 2000 census, reveals that experienced CEOs, CEOs with an economics or business education, and CEOs who attended the most selective undergraduate institutions tended to enter markets with fewer competitors.<sup>1</sup>

We develop a model that puts a useful structure on this correlation. The model we use draws on laboratory evidence of iterated decision making in simultaneous games. In particular, numerous laboratory experiments show that people are heterogeneous in the strategies they use to play games. Simply, some people are better at playing games than others. While “better” has several dimensions, much of the laboratory research emphasizes heterogeneity in the ability of players to correctly conjecture competitor behavior. This heterogeneity does not appear to be random; rather, the observed behavior is consistent with an iterative decision process in which some participants do not consider the other players, others consider the other players but do not consider that the other players will consider them, etc. (Colin F. Camerer 2003). Because a key application of game theory in economics is to understand the behavior of firms in competitive situations, the experimental evidence suggests that some managers may be better at making conjectures about competitor behavior than others.

Several related models allow for heterogeneity in the ability of players to correctly conjecture competitor behavior in entry games, including quantal response equilibrium (e.g., Richard D. McKelvey and Thomas R. Palfrey 1995), level- $k$  thinking (e.g., Miguel A. Costa-Gomes and Vincent P. Crawford 2006), and cognitive hierarchy (e.g., Camerer, Teck-Hua Ho, and Juin-Kuan Chong 2004). For our purposes, cognitive hierarchy (henceforth CH) models the heterogeneity in an especially useful way because it includes a parameter that unambiguously identifies players as being better at playing the game. This parameter generates a type distribution for strategic ability. In particular, players have types 0 to  $K$ . A type 0 player does not consider the competition. A type 1 player acts as if all other players are type 0. A type 2 player acts as if all other players are distributed between type 0 and type 1. And a type  $k$  player acts as if all other players are distributed between type 0 and type  $k - 1$ . Therefore, higher types are better able to conjecture competitor behavior and consequently are less likely, on average, to regret their decisions once all decisions are observed. Unlike games featuring multiple Nash equilibria with fully rational players, this hierarchy yields a unique solution.

<sup>1</sup> As a shorthand, we will sometimes refer to the CEOs with an economics or business degree and the CEOs who attended selective undergraduate institutions as “better educated.”

This unique solution enables us to determine the identities of entrants as well as to associate entry decisions with manager and firm characteristics. Relying on prior research, we interpret the hierarchy as a measure of strategic ability.<sup>2</sup> This interpretation allows us to examine which CEO characteristics are determinants of strategic ability. Empirically, the players identified as better at playing the game will be those who choose to enter markets with few competitors and choose not to enter markets with many competitors.

Our estimates yield three core results. First, although journalists like to play up unobservable characteristics such as charisma and leadership as driving CEO success, the traditional wisdom of reviewing a manager's curriculum vitae works. Experienced, better-educated managers tend to enter markets with fewer competitors. Second, our measure of strategic ability predicts outcomes outside our estimation window: firms with managers of higher estimated ability are more likely to stay in business and, conditional on survival, have higher revenue. In short, smarter firms make smarter moves and succeed. Third, comparing results across years, we find that the measured level of ability is substantially higher in 2002 than in 1998. Given that there was a shakeout in 2001, we interpret this as supporting evidence for an evolution toward the long-run equilibrium outcome assumed in much of the existing simultaneous entry literature (e.g., Shane Greenstein and Michael Mazzeo 2006, p. 337). Combined with several industry facts and the existing laboratory research, these three results suggest internal and external validity for the application of a "behavioral" model to our empirical setting.

Next, we provide details of the CLEC environment that motivate our choice to apply the CH model and discuss the relevant literature. The data, model, and results follow. We conclude with a discussion of limitations and the general implications of our results.

## I. Background and Literature

In this section, we review four distinct topics that put our study in context.

### A. Local Telephone Competition

Between the Kingsbury Commitment in 1913 and the Telecommunications Act of 1996, there was little competition in local telecommunications in the United States. The 1996 Act opened up local competition, primarily by barring state regulators from denying entrants the right to compete, by forcing incumbent carriers to allow competitors to interconnect, and by forcing incumbent carriers to allow entrants access to many of their facilities and rights-of-way (Robert W. Crandall 2005). It took until 1998 for entry to be observed on any scale, and by 2000 there were 98 CLECs operating in a total of 190 different midsize US cities.<sup>3</sup> A shakeout followed,

<sup>2</sup>Camerer and Eric J. Johnson (2004) track how long subjects looked at competitor payoffs and find that measured strategic ability is positively correlated with time spent looking at competitor payoffs. Antoni Bosch-Domenech et al. (2002) ask subjects in a beauty contest game to explain their choices and find that people explain their actions with logic based on thinking steps.

<sup>3</sup>We focus on midsize cities (with population between 100,000 and 1,000,000) for three reasons. First, smaller places are typically nonurban areas that contain too few customers to attract CLECs. Second, larger cities often

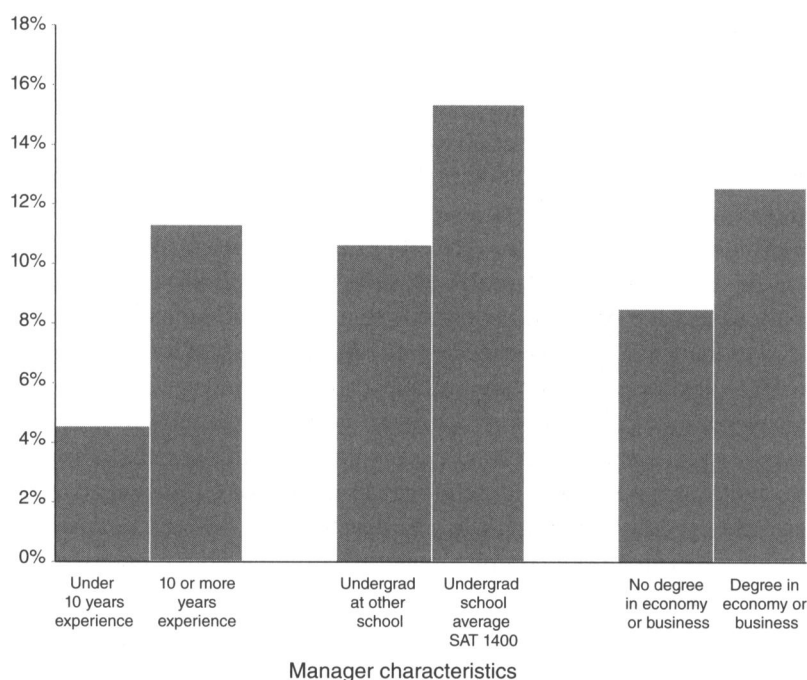


FIGURE 1. PERCENT MARKETS WHERE THE FIRM IS THE ONLY OPERATING CLEC

and at the nadir 64 CLECs were operating in 195 locations. Of the CLECs that were licensed to enter these midsize markets in 1998, just 42 percent survived independently through 2002. Thus, while many firms exited, the number of markets served by the remaining firms increased.

Both Fred R. Goldstein (2005) and Crandall (2005) provide detailed histories of telecommunications competition following the 1996 Act. Both emphasize that many CLECs entered the same markets and ended up competing fiercely with each other. For example, Goldstein (2005, p. 116) writes that it is “likely that the CAPs [CLECs] did not count on each other’s dividing the take” and that this led to lower than expected revenues and large losses. Crandall (2005, p. 39) notes that “a major problem for the new competitors is their proliferation in a given market.” Their assessments suggest that the ability to conjecture the number of competitors that will enter a market is an important determinant of success.

In addition to this anecdotal support for our modeling framework, our data suggest an intriguing link between considering the competition and management characteristics. Figure 1 presents data from 1998 and shows that being the only player in the market appeared to be systematically correlated with a manager’s experience, undergraduate institution quality, and degree field. We provide descriptive regression analysis supporting this link between manager characteristics and the level of competition after describing the dataset in Section III.

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encompass several submarkets, so it is difficult to determine the existence and scope of strategic interactions among entrants. Finally, a handful of larger markets had local telephone competition prior to the 1996 Telecommunications Act.

This evidence suggests that managers with different personal backgrounds tend to act differently and that the difference is consistent with more able managers being better at guessing competitor behavior. Therefore, we apply a model of heterogeneity in ability that matches manager characteristics to strategic entry decisions.<sup>4</sup>

We conclude this subsection by noting that our paper is not the first to examine local telephone competition. For example, Nicholas Economides, Katja Seim, and V. Brian Viard (2008) measure consumer welfare effects of the increase in local phone competition between 1999 and 2003; Daniel A. Akerberg et al. (2008) examine low-income subsidies after the 1996 Act; and Federico Mini (2001) and Donald L. Alexander and Robert M. Feinberg (2004) examine incumbent attempts to restrict entry. Markus Mobius (2001) also discusses behavioral biases in this industry (in the early twentieth century) by arguing that myopic consumer behavior (in the presence of network externalities) explains patterns in local telephone competition. Closest to our work is Greenstein and Mazzeo's (2006) structural examination of CLEC entry decisions. We emphasize heterogeneity in ability, while Greenstein and Mazzeo emphasize product variation. Our paper therefore complements theirs in that both emphasize the importance of firm-level heterogeneity in understanding the CLEC market.

### B. Behavioral Game Theory and the CH Model

The first step in building an entry model that links managerial ability with strategic actions is to select an estimable model that fits our real world oligopolistic setting. There are several behavioral models of play in simultaneous games, including quantal response equilibrium, level- $k$  thinking, and cognitive hierarchy (CH). We focus on CH for its clarity and parsimony in our context. Specifically, CH includes a single parameter that unambiguously identifies players as being better at playing the game.<sup>5</sup>

CH theory posits a hierarchy of rationality. Type 0 players do not consider their competitors; they either pick randomly (as in Camerer, Ho, and Chong 2004) or they act as if the competition is not relevant to their decision (as in Avi Goldfarb and Botao Yang 2009). Type 1 players assume all other players are type 0, type 2 players assume all other players are a combination of types 0 and 1, and type  $k$  players assume all other players are distributed between types 0 and  $k - 1$ . A Poisson distribution effectively describes the distribution of types in lab experiments, and the model assumes that a type  $k$  player assumes all other players are distributed with a truncated (between type 0 and type  $k - 1$ ) version of the same Poisson distribution. Therefore, for high enough  $k$ , type  $k$  and type  $k + 1$  players will have approximately the same beliefs, and these beliefs will match the true frequencies. Camerer, Ho, and Chong (2004) show that CH works well in both entry games and beauty contest games.

The most distinctive feature of the CH model lies in the limited rationality of all players, who fail to recognize the existence of other equally (if not more) strategic players.

<sup>4</sup>Of course, we acknowledge that heterogeneity in the ability to conjecture competitor behavior is not the only possible explanation for these correlations. We discuss alternative explanations below and argue that a model of heterogeneous strategic ability is most consistent with our data.

<sup>5</sup>Philip A. Haile, Ali Hortaçsu, and Grigory Kosenok (2008) show that quantal response equilibrium is not separately identified from a perfect Bayesian equilibrium with noise, and therefore strategic ability is not identified at all.  $K$ -step models other than CH allow for players to be too sophisticated in that they may overestimate the ability of their competitors and end up performing worse. The CH model is useful here because it defines sophisticated players as those who *better* conjecture competitor behavior.

Beliefs are therefore not mutually consistent. Instead, players act if they can perfectly predict their rivals' actions. The outcome can be short lived because players may revise their beliefs and have an incentive to deviate once they observe others' actions. The outcome can also be long lasting if changing actions is time-consuming and costly, or if noise in the environment delays players from updating their beliefs. While acknowledging several caveats, we argue that our focus on a new industry, where naivety and noise are prevalent, gives us an ideal platform for the application of the CH model.

### *C. Related Models*

We apply the CH model to an entry game. There is a rich literature on estimation of entry games in economics starting with Timothy F. Bresnahan and Peter C. Reiss (1990, 1991). The numerous papers that extend the Bresnahan and Reiss framework to other settings try to better accommodate firm-level heterogeneity into the model. The main challenge in modeling heterogeneous firms' strategic entry in a simultaneous setting is that multiple equilibria almost always arise. Previous researchers have had to forgo firm-level information and focus on the numbers of different types of entrants in an equilibrium (Mazzeo 2002), to revise certain features of the game such as information structure (Seim 2006), to estimate the game under different equilibria to check robustness (Panle Jia 2008), or to focus on bounds instead of point identification (Federico Ciliberto and Elie Tamer 2009). Our paper provides a solution to this problem from an alternative angle. By revising the behavioral assumption from complete to limited rationality, we are able to pin down a unique outcome and are therefore able to use rich firm-level information in an entry game.

Andres Aradillas-Lopez and Tamer (2008) discuss the identification problem in games with an alternative behavioral assumption based on the concept of rationalizability (e.g., B. Douglas Bernheim 1984). Allan Collard-Wexler (2008) takes their model to data. Their goal is to relax the assumption of Nash equilibrium behavior but the players in their games are still rational as they play strategies that are consistent with a set of proper beliefs. In contrast, our goal is to relax the assumption of rational players using a structure that is consistent with laboratory evidence in order to understand the correlation between manager characteristics and firm-level entry decisions.

A growing literature in "behavioral industrial organization" has mostly focused on understanding how behavioral biases in consumers affect firm behavior and market outcomes. Stefano DellaVigna and Ulrike Malmendier (2004, 2006) and Sharon Oster and Fiona Scott Morton (2005) show how firms develop pricing strategies in the presence of nonrational consumers. Tanjim Hossain and John Morgan (2006) and Uri Simonsohn and Dan Ariely (2008) document biases in buyer behavior on eBay. On the seller side, David Genesove and Christopher Mayer (2001) document loss aversion in the housing market. Hortaçsu and Steven L. Puller (2008) show that older, more experienced firms behave closer to the Nash equilibrium prediction than other firms in electricity auctions.<sup>6</sup> Much of the recent theory literature has focused

<sup>6</sup>Our contribution is distinct from Hortaçsu and Puller (2008) in three important ways. First, we focus on manager characteristics rather than firm characteristics. Second, our structure draws from behavioral game theory to provide a plausible theoretical mechanism for the deviations from Nash. Third, our results help understand how Nash equilibrium behavior may change over time.

on how behavioral biases can persist in equilibrium (Ran Spiegler 2006; Xavier Gabaix and David Laibson 2006; Ignacio Esponda 2008). Reviews of this literature can be found in sections of Glenn Ellison (2006) and DellaVigna (2009).

A small number of other papers have used structural estimation to understand behavioral biases in firms (Alexander L. Brown, Camerer, and Don Lovallo 2009; Hai Che, K. Sudhir, and P. B. Seetharaman 2007; Noah Lim and Ho 2007; Simonsohn 2010), consumers (Michael Conlin, Ted O'Donoghue, and Timothy J. Vogelsang 2007; Laibson, Andrea Repetto, and Jeremy Tobacman forthcoming), and workers (Daniele Paserman 2008). More closely related to the present study, Goldfarb and Yang (2009) apply a similar CH-based model to data on 56k modem adoption by Internet service providers. Lacking data on manager or firm characteristics, Goldfarb and Yang emphasize simulation results showing that firms with higher estimated ability were more likely to still be operating ten years later and that an increase in strategic ability would have slowed the diffusion of 56k modems. Our research builds on this paper by adding manager-specific data, by fully clarifying the identification given this data, and by comparing results before and after a shakeout.

#### *D. Relating Manager Characteristics to Actions and Performance*

In exploring which manager characteristics correlate with more steps of thinking, we address a growing literature on the role of managers in firm performance. This work has examined how success relates to management practices and characteristics (Nicholas Bloom and John Van Reenen 2007), interpersonal and execution skills (Steven N. Kaplan, Mark M. Klebanov, and Morten Sorenson 2008), overconfidence (Malmendier and Geoffrey Tate 2005, 2008), and manager education and experience (Marianne Bertrand and Antoinette Schoar 2003; Judith Chevalier and Ellison 1999; Camerer et al. 1997). Malcolm Baker, Richard Ruback, and Jeffrey Wurgler (2007) review a related literature in behavioral corporate finance.

## **II. Data and Motivating Analysis**

### *A. Data Description*

We combine information from several sources to create a unique dataset of firms' entry decisions, firm and manager attributes, and location characteristics.

First, we use the 1998 and 2002 CLEC annual reports from the New Paradigm Resources Group, Inc. (NPRG). These reports contain information on the universe of facilities-based CLECs in the United States since the passage of the Telecommunications Act of 1996. NPRG provides a detailed profile of every CLEC on its history, management, ownership and organization, and state certification. From the profiles, we know all local voice markets a CLEC served and the exact year of the entry. We define entry as whether the CLEC provided dial-tone service over a landline in the market. We define potential entry as whether the CLEC was licensed to operate in the state (even if the CLEC was not yet operating at any location in the state). We have firm attributes such as the year the company was founded, whether it is public or private, whether it is venture-capital backed, and whether it is a wholly owned subsidiary of a larger communications company (which affects



incentives and the influence of managers over company decisions). We also construct two measures of firm survival. The first defines survivors as the set of firms from the 1998 data that are also in the 2002 NPRG data. The second, broader measure defines survivors as the set of firms for which we could not find evidence of exit because of bankruptcy or firm-acknowledged failure.<sup>7</sup> In addition, for a subset of CLECs, we have limited information on revenues (overall and from local phone service) and the number of employees.

Second, using the information on CEO names from the NPRG reports, we conducted a thorough search of several publicly archived sources to identify CEO characteristics, including industry experience and education (highest degree, field of study, and school attended). From the education data, we construct measures of whether the manager has a degree in economics or business, whether the manager has a degree in engineering or science, whether the manager attended an undergraduate institution with an average SAT score of at least 1400,<sup>8</sup> and whether the manager has a graduate degree. For public companies, this information is typically available in the Form 10-K annual business and financial report. For private companies (and to fill out the remaining gaps for managers of the public companies), we used a variety of public sources including Who's Who directories, news archives, company websites, and other Internet sources.<sup>9</sup> In the end, we have education information for 90 percent of the CEOs in our data and experience information for 97 percent.

As discussed in Zvi Griliches (1986), there are two standard approaches to missing data in the literature: (i) drop the missing data, and (ii) impute values using other covariates (based on a linear prediction). In our context, dropping the missing data is not possible because we need to know the full set of CLECs that are potential entrants in a market. Therefore, we impute the missing manager-level data using four firm-level characteristics: firm age, whether the CLEC is a subsidiary of a larger communications company, whether the CLEC is privately owned, and whether the CLEC is venture backed. Our results are robust to including the non-missing manager characteristics in the imputation and to treating the missing values nonparametrically with a "data-missing" dummy.<sup>10</sup>

<sup>7</sup>Specifically, we use three sources for this alternative definition: (i) the NPRG reports mention some reasons for exit (the firms that disappear from the 2002 NPRG report without explanation are not counted as exits under this definition), (ii) Crandall (2005) mentions several bankruptcy-related exits, and (iii) newspaper archive searches showed more exits due to failure. This definition is broader because it separates survivors from clear failures. Some firms may disappear from the NPRG report (and thus from the CLEC industry) but continue to operate in other industries. Other small CLECs may go out of business without any mention of why in the NPRG report or the press. Therefore, they would disappear from the NPRG report but we would lack evidence of a clear failure.

<sup>8</sup>The results on the SAT-based measure of school quality are robust to using *US News* rankings, QS World rankings, and a lower SAT thresholds. We focus on the SAT measure with a high threshold because a small but nontrivial fraction of our CEOs attended schools outside the United States. For the very top schools, there is information about SAT requirements for US students. By using a high threshold, we can use the same metric for CEOs who attended US and foreign institutions.

<sup>9</sup>Both coauthors and an undergraduate research assistant conducted the search. The search algorithm is as follows: (i) if public, search 10-K reports for biographical information (otherwise skip to step (ii)), (ii) search company websites for biographical information, (iii) search *Who's Who* archives, (iv) search news archives for mentions of the company and the individual in the same article (allow for alternative names such as Bob for Robert), (v) search Google for mentions of the company and the individual, (vi) search news archives and Google for mentions of the individual; then confirm that it is the correct individual by triangulating with other sources on the individual's career path, (vii) search public profiles on social networking websites, and (viii) have a second person visit each source and confirm.

<sup>10</sup>The statistics literature has shown that imputation leads to consistent estimates, even in nonlinear models (Paul Allison 2002). In contrast, "data-missing" dummies can lead to biased coefficients (though the signs do not change,

Finally, we obtain information on location characteristics from the 2000 US census, from the 1997 US economic census, and from the Federal Communications Commission. The locations in the NPRG reports are best interpreted at the census “place” level rather than the county or metropolitan statistical area. From the population census we selected the following variables for our analysis: population, household income, racial composition, median age, number foreign born, household size, and poverty rate. From the economic census, we use place-level information on the number of establishments, the number of employees per establishment, and the fraction of firms in manufacturing.<sup>11</sup> We include controls for both business and residences because CLECs catered to both business and residential customers. From the Federal Communications Commission, we use data on the incumbent local exchange carrier (GTE, Regional Bell Operating Company (RBOC), etc.). In one robustness check, we use information from the FCC on whether there were any competitive access providers in the place prior to 1995 (Federal Communications Commission 1999).

This combination of NPRG data, manager characteristics data, and census data has several appealing features. We have information on all entry by all firms from the effective start of the industry. We can match this to rich data on firm and manager characteristics, including information on manager education and experience, and to measures of the demographic appeal of each market. Finally, a feature of the local telephone industry enables us to identify a set of potential entrants in each market without assuming that all firms can operate everywhere. Specifically, CLECs must first be approved by state regulators before they can operate in a given state. Once approved, the CLEC can operate anywhere it chooses within the state. Therefore, we identify potential entrants as the set of CLECs approved to operate in the state.<sup>12</sup> In the analysis that follows, we cannot separate firm decisions from manager decisions because, in the first year of the industry, firms and managers are observationally equivalent. Therefore the unit of observation is the firm-place (or equivalently, the manager-place).

Tables 1A, 1B, and 1C provide descriptive statistics. Table 1A shows that these firms are generally privately owned (64.5 percent in 1998) and have a high variance in age (the standard deviation is over twice the mean of 7.9 years in 1998). The managers average 17.7 years of experience in the industry and are highly educated. Of the firms operating in 1998, 55 percent of managers have a graduate degree and 73 percent have at least one degree in economics or business. The table also shows the high turnover rate in the industry. Nearly 60 percent of the firms that operated in 1998 were no longer operating as CLECs in 2002. Table 1B describes the 234 mid-size cities that we use in our analysis. The average market has 2 CLECs operating out of 25 potential entrants (who are licensed to operate in the state). The number of

at least in linear models). The weakness of imputation is that it overstates the precision of the coefficient estimates by assuming the imputed value is known rather than estimated.

<sup>11</sup>This information is available only for the following two-digit NAICS industries: manufacturing (31–33), wholesale trade (42), retail trade (44–45), real estate and rental housing (53), management and remediation (56), educational services (61), health care (62), arts, entertainment, and recreation (71), accommodation and food (72) and other services (81). Therefore, the variables are compiled based on these industries only. This information was missing for six of the places in our data. For these places, we used county-level data and used the population-proportionate values for the business statistics.

<sup>12</sup>It is important to note that while regulatory approval is necessary for entry, it is not sufficient. Among the 96 CLECs approved to operate in 1998, just 56 actually entered at least one market in that year and only 79 had entered by 2002. Based on the NPRG reports, we believe that our definition of potential entrants is both simple and realistic. We check the robustness of our definition by excluding CLECs that had not entered anywhere by 2002.

TABLE 1A—DESCRIPTIVE STATISTICS BY CLEC

Variable	1998		2002	
	Mean	SD	Mean	SD
Number of markets to enter	61.5	66.9	90.3	70.6
Number of markets entered	4.9	9.4	15.7	16.8
Firm age	7.9	17.9	10.3	14.9
Subsidiary	0.312	0.465	0.218	0.416
Privately owned	0.645	0.480	0.625	0.487
Financed by venture capital	0.177	0.383	0.296	0.460
Employees (in thousands) 1998 ( $N = 81$ )	3.517	16.71	N/A	
Survive to 2002	0.427	0.497	N/A	
Alternate definition of survive to 2002	0.667	0.474	N/A	
Revenue 2002 (million \$, $N = 48$ )	535	1550	N/A	
Local phone revenue 2002 (million \$, $N = 46$ )	150	362	N/A	
Manager characteristics (with imputations)				
Experience	17.7	9.3	20.3	11.3
Undergraduate school average SAT $\geq 1400$	0.094	0.293	0.096	0.297
Any graduate degree	0.554	0.475	0.501	0.469
Any economics or business degree	0.733	0.445	0.682	0.433
Any engineering or science degree	0.364	0.463	0.339	0.443
Observations (CLECs)	96		83	

entrants ranges from 0 to 18 while the number of potential entrants ranges from 8 to 35. Table 1C summarizes the data at the firm-market level.

### B. Motivating Analysis

In this section, we present descriptive evidence of a systematic relationship between manager characteristics and firm actions. Consistent with Figure 1, we show that firms with more experienced and better-educated managers tend to enter markets with fewer competitors. In particular, we estimate the following linear probability regression for firm  $j$  in market  $m$ :

$$(1) \quad \text{Entry}_{jm} = \alpha_0 + \alpha_1(\# \text{competitors})_m + \mathbf{Z}_j \alpha_2 \\ + (\# \text{competitors})_m \mathbf{Z}_j \alpha_3 + \mathbf{X}_m \alpha_4 + \varepsilon_{jm},$$

where  $\text{Entry}_{jm}$  is a binary variable for the entry decisions of firm  $j$  in market  $m$ ;  $\mathbf{Z}_j$  are manager characteristics (experience, whether the manager has a degree from an institution with an average SAT above 1400, and whether the manager has a degree in economics or business),  $\mathbf{X}_m$  are market characteristics (population, household income, racial composition, median age, percentage foreign born, household size, poverty rate, number of business establishments, average number of employees per establishment, and the percentage of establishments that are in manufacturing), and  $\varepsilon_{jm}$  is the heteroskedasticity-robust error term (clustered at the city level). In some specifications, we also include controls for firm characteristics (firm age, whether the firm is a subsidiary of a larger communications company, whether the firm is venture-backed, and whether the firm is privately held). Of interest in this

TABLE 1B—DESCRIPTIVE STATISTICS BY MARKET

Variable	Mean	SD	Min	Max
Population (in thousands)	224.1	160.8	100.3	951.3
Median household income (in \$1,000)	41.7	11.7	23.5	88.8
Median age	32.8	3.1	22.9	41.8
Household size	2.6	0.418	2.03	4.55
Percent foreign born	15.6	12.5	1.1	72.1
Percent African American	17.8	18.0	0.3	84.0
Percent below poverty line	14.5	6.3	2.2	35.6
GTE	0.107	0.310	0	1
RBOC	0.808	0.395	0	1
Number of establishments in thousands	4.7	3.8	0.661	24.5
Average number of employees/establishment	16.9	5.0	8.18	58.0
Percent establishments in manufacturing	18.1	10.3	0.001	60.36
Number of operating CLECs	2.02	2.9	0	18
Number of potential entrants	25.2	7.2	8	35
Observations	234			

regression are the signs of the interaction terms between the number of competitors and manager characteristics ( $\alpha_3$ ), which measure whether manager background mediates the relationship between competition and entry.

The number of competitors in the regression above is an endogenous variable which may be correlated with unobserved market-level heterogeneity. In this descriptive analysis, we rely on demographic controls to address this issue and emphasize that the purpose of this subsection is to document an intriguing relationship between manager characteristics and firm entry decisions. In the main analysis that follows, the structure of the model uses the characteristics of the managers of other potential entrants as implicit instruments for the number of competitors.

Table 2A shows the results. The negative coefficients in the first three rows show that more experienced managers, managers with undergraduate degrees from top schools, and managers with degrees in economics or business are more likely to enter markets with fewer competitors. Columns 1 through 4 use variants of the specification in equation (1) and document that the results are robust to including the manager characteristics separately or together.

Column 5 shows that including an interaction between experience and having an economics or business degree has a large impact on coefficient size. We interpret the positive sign on the interaction as suggestive evidence that experience and an economics or business degree are substitutes. If a manager has enough experience, the relationship between having an economics degree and the entry decisions is weak. Because this relationship is so strong in the descriptive analysis, we include the interaction term in the structural specification.<sup>13</sup>

Columns 6 and 7 show robustness to controls for firm characteristics. Table 2B includes two regressions with interaction terms between manager characteristics and the demographic controls related to demand potential. The results are generally robust though, with so many covariates in column 2, we lose some significance.

<sup>13</sup> For consistency, we also tried other interactions and found they did not matter.

TABLE 1C—DESCRIPTIVE STATISTICS BY CLEC-MARKET

	1998		2002	
	Mean	SD	Mean	SD
Entry	0.080	0.271	0.173	0.378
Population (in thousands)	222.4	160.8	229.0	165.7
Household income (in \$1,000)	42.3	12.2	41.1	11.7
Median age	32.8	3.1	32.9	3.1
Household size	2.67	0.440	2.62	0.404
Percent foreign born	17.1	13.1	15.6	12.7
Percent African American	16.9	17.0	18.8	17.9
Percent below poverty line	14.0	6.3	14.9	6.3
GTE	0.118	0.323	0.109	0.312
RBOC	0.802	0.398	0.806	0.395
Number of establishments in thousands	4.62	3.83	4.87	3.89
Average number of employees/establishment	16.7	5.2	16.8	4.8
Percent establishments in manufacturing	18.0	10.5	18.1	10.5
Privately owned	0.432	0.495	0.439	0.496
Financed by venture capital	0.160	0.367	0.269	0.443
Firm age	13.7	27.3	12.9	21.8
Subsidiary	0.211	0.408	0.182	0.386
Experience	17.9	8.5	18.9	10.1
Undergraduate school average SAT $\geq$ 1400	0.075	0.119	0.106	0.308
Any graduate degree	0.670	0.459	0.479	0.491
Any economics or business degree	0.726	0.438	0.723	0.439
Any engineering or science Degree	0.301	0.447	0.354	0.469
Observations (CLEC markets)	5,906		6,095	

Overall we see these results as suggestive of an intriguing, and perhaps non-standard, relationship between manager characteristics and firm entry decisions. Experienced and better-educated managers appear to be better at anticipating competitor decisions that occur at roughly the same time. Because the market-level demographics control for the overall appeal of the market, this is not simply a matter of experienced, better-educated managers entering markets with lower populations. It is that they somehow enter markets that others choose not to enter. Next, we develop a model that puts a useful structure on this relationship.

### III. Model and Identification

#### A. Model

In this section, we describe how we model heterogeneity in managerial ability in an oligopolistic entry game.<sup>14</sup> The model we use assumes simultaneous decision making. While no real world entry decisions are truly simultaneous, we believe simultaneity is a reasonable assumption in the CLEC industry in 1998. The industry was new and implementation took time. While a handful of CLECs operated (as competitive access providers, or CAPs) in large metropolitan areas prior to the Act, the NPRG reports suggest most CLECs became operational in 1997 and entry into midsize markets took off in 1998. In addition, while companies did announce “planned” market entry, there appears to be little correlation between these plans and

<sup>14</sup>This section builds on the model in Goldfarb and Yang (2009).

TABLE 2A—OLS REGRESSIONS OF 1998 ENTRY ON MANAGER CHARACTERISTICS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) No. of competitors $\times$ log(experience)	-0.007 (0.002)***			-0.007 (0.002)***	-0.022 (0.009)**	-0.007 (0.002)***	-0.022 (0.009)**
(2) No. of competitors $\times$ manager attended school with SAT score above 1400		-0.018 (0.007)***		-0.016 (0.007)**	-0.016 (0.007)**	-0.017 (0.007)**	-0.016 (0.007)**
(3) No. of competitors $\times$ manager has degree in economics or business			-0.010 (0.003)***	-0.008 (0.004)**	-0.061 (0.031)*	-0.008 (0.004)**	-0.059 (0.030)*
(4) No. of competitors $\times$ log(experience) $\times$ manager has econ./business degree					0.019 (0.011)*		0.018 (0.010)*
(5) Log(experience)	0.022 (0.005)***			0.025 (0.005)***	0.069 (0.022)***	0.023 (0.005)***	0.087 (0.022)***
(6) Manager attended school with SAT score above 1400		0.045 (0.013)***		0.052 (0.014)***	0.051 (0.014)***	0.067 (0.014)***	0.067 (0.014)***
(7) Manager has degree in economics or business			-0.005 (0.007)	-0.013 (0.007)*	0.135 (0.066)**	0.002 (0.008)	0.21 (0.065)***
(8) Log(experience) $\times$ manager has econ./business degree					-0.053 (0.024)**		-0.076 (0.024)***
(9) Log (firm age)						0.022 (0.004)***	0.022 (0.004)***
(10) Subsidiary						-0.055 (0.009)***	-0.056 (0.009)***
(11) Privately owned						-0.050 (0.008)***	-0.048 (0.008)***
(12) Venture capital						-0.008 (0.009)	-0.015 (0.008)*
(13) No. of competitors	0.036 (0.007)***	0.018 (0.004)***	0.024 (0.005)***	0.042 (0.008)***	0.085 (0.026)***	0.045 (0.008)***	0.086 (0.026)***
(14) Place population in millions	0.074 (0.053)	0.073 (0.053)	0.075 (0.053)	0.071 (0.053)	0.073 (0.053)	0.073 (0.051)	0.076 (0.051)
(15) HH income in \$1,000	-0.003 (0.005)	-0.003 (0.005)	-0.003 (0.005)	-0.003 (0.005)	-0.003 (0.005)	-0.001 (0.005)	-0.001 (0.005)
(16) Median age	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)
(17) Household size	-0.007 (0.014)	-0.007 (0.014)	-0.007 (0.014)	-0.006 (0.014)	-0.006 (0.014)	-0.008 (0.013)	-0.008 (0.013)
(18) Percent foreign born	-0.027 (0.031)	-0.027 (0.031)	-0.024 (0.031)	-0.032 (0.031)	-0.032 (0.031)	-0.025 (0.029)	-0.022 (0.029)
(19) Percent black	0.096 (0.031)***	0.096 (0.031)***	0.090 (0.031)***	0.087 (0.031)***	0.088 (0.031)***	0.089 (0.029)***	0.088 (0.029)***
(20) Percent below poverty line	-0.005 (0.107)	-0.002 (0.107)	-0.007 (0.107)	-0.002 (0.106)	-0.002 (0.106)	0.018 (0.099)	0.019 (0.099)
(21) GTE	0.014 (0.012)	0.014 (0.012)	0.014 (0.012)	0.013 (0.012)	0.013 (0.012)	0.015 (0.011)	0.015 (0.011)
(22) RBOC	0.019 (0.010)*	0.019 (0.010)*	0.019 (0.010)*	0.019 (0.010)*	0.019 (0.010)*	0.020 (0.009)**	0.020 (0.009)**
(23) Log(no. of establishments)	0.049 (0.010)***	0.049 (0.010)***	0.048 (0.010)***	0.049 (0.010)***	0.048 (0.010)***	0.046 (0.009)***	0.045 (0.009)***
(24) Average no. of employees per establishment	0.001 (0.001)*	0.001 (0.001)*	0.001 (0.001)*	0.001 (0.001)*	0.001 (0.001)*	0.001 (0.001)*	0.001 (0.001)*
(25) Percent establishments in manufacturing	-0.109 (0.033)***	-0.109 (0.034)***	-0.108 (0.033)***	-0.109 (0.033)***	-0.109 (0.033)***	-0.103 (0.031)***	-0.104 (0.031)***
(26) Constant	-0.366 (0.113)***	-0.307 (0.111)***	-0.291 (0.109)***	-0.368 (0.112)***	-0.489 (0.130)***	-0.371 (0.105)***	-0.545 (0.124)***
(27) Observations	5,906	5,906	5,906	5,906	5,906	5,906	5,906
(28) $R^2$	0.13	0.13	0.13	0.14	0.14	0.16	0.16

Note: Standard errors are reported in parentheses.

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

TABLE 2B—OLS REGRESSIONS OF 1998 ENTRY ON MANAGER CHARACTERISTICS WITH LARGE SET OF INTERACTIONS

	(1)	(2)	(2)
(1) No. of competitors $\times$ log(experience)	-0.021 (0.009)**	-0.029 (0.009)***	HH income $\times$ manager has degree in economics or business 0.006 (0.009)
(2) No. of competitors $\times$ manager attended school with SAT score above 1400	-0.017 (0.009)*	-0.036 (0.010)***	Age $\times$ log(experience) -0.002 (0.002)
(3) No. of competitors $\times$ manager has degree in economics or business	-0.056 (0.029)*	-0.040 (0.028)	Age $\times$ manager attended school with SAT score above 1400 0.009 (0.006)
(4) No. of competitors $\times$ log(experience) $\times$ manager has econ./business degree	0.018 (0.010)*	0.016 (0.010)	Age $\times$ manager has degree in economics or business 0.005 (0.003)
(5) Log(experience)	0.090 (0.023)***	-0.357 (0.157)**	HH size $\times$ log(experience) 0.023 (0.018)
(6) Manager attended school with SAT score above 1400	0.066 (0.024)***	-1.148 (0.382)***	HH size $\times$ manager attended school with SAT score above 1400 0.115 (0.041)***
(7) Manager has degree in economics or business	0.227 (0.067)***	0.318 (0.265)	HH size $\times$ manager has degree in economics or business 0.033 (0.029)
(8) Log(experience) $\times$ manager has econ./business degree	-0.075 (0.024)***	-0.060 (0.022)***	Percent foreign $\times$ log(experience) -0.150 (0.047)***
(9) Log (firm age)	0.022 (0.004)***	0.020 (0.004)***	Percent foreign $\times$ manager attended school with SAT score above 1400 -0.261 (0.129)**
(10) Subsidiary	-0.056 (0.009)***	-0.053 (0.009)***	Percent foreign $\times$ manager has degree in economics or business -0.073 (0.069)
(11) Privately owned	-0.048 (0.008)***	-0.049 (0.008)***	Percent black $\times$ log(experience) 0.080 (0.039)**
(12) Venture capital	-0.014 (0.008)*	-0.019 (0.008)**	Percent black $\times$ manager attended school with SAT score above 1400 0.516 (0.122)***
(13) No. of competitors	0.082 (0.026)***	0.097 (0.026)***	Percent black $\times$ manager has degree in economics or business -0.210 (0.064)***
(14) Place population in millions	0.185 (0.175)	0.555 (0.224)**	Percent poverty $\times$ log(experience) -0.014 (0.145)
(15) HH income in \$1000	-0.001 (0.005)	0.019 (0.018)	Percent poverty $\times$ manager attended school with SAT score above 1400 -0.202 (0.434)

(Continued)

actual entry decisions in midsize markets.<sup>15</sup> In the end, the simultaneity assumption, though often just a convenient way to limit manager information sets about competitor actions in the literature, works well in our setting where the opening of a new industry meant high volatility and uncertainty.

Our empirical model contains two significant deviations from the one used in laboratory experiments. First, we incorporate market- and firm-level covariates in order to allow entry incentives to vary across markets and managerial ability to vary across firms. In the laboratory, the controlled environment means this is not necessary. Second, type 0 players in our model choose whether to enter based on the expected profitability of the market if they face no competitors rather than choosing randomly, as in Camerer, Ho, and Chong (2004). This is a more reasonable assumption in a real world setting because it is unlikely firms are unaware of public information or deliberately ignore the fact that larger markets have more potential customers.

<sup>15</sup>Many planned entries never happened, and many observed entries were never listed as “planned.” One possible explanation for this is that planned entries were cheap talk meant to appease regulators. Our data also suggest there is considerable time spent building a facilities-based network. For example, Teligent’s deployments in 1998–1999 took between 6 and 18 months, depending on the market.

TABLE 2B—OLS REGRESSIONS OF 1998 ENTRY ON MANAGER CHARACTERISTICS WITH LARGE SET OF INTERACTIONS  
(Continued)

	(1)	(2)		(2)
(16) Median age	−0.002 (0.001)	0.000 (0.006)	Percent poverty × manager has degree in economics or business	0.217 (0.256)
(17) Household size	−0.008 (0.013)	−0.105 (0.047)**	Log(no. estab.) × log(experience)	0.065 (0.014)***
(18) Percent foreign born	−0.022 (0.029)	0.482 (0.136)***	Log(no. estab.) × manager attended school with SAT score above 1400	0.078 (0.030)**
(19) Percent African American	0.087 (0.029)***	−0.031 (0.118)	Log(no. estab.) × manager has degree in economics or business	−0.057 (0.023)**
(20) Percent below poverty line	0.019 (0.098)	−0.068 (0.430)	No. employees × log(experience)	0.001 (0.001)
(21) GTE	0.015 (0.011)	−0.053 (0.056)	No. employees × manager attended school with SAT score above 1400	0.003 (0.002)*
(22) RBOC	0.020 (0.009)**	−0.057 (0.042)	No. employees × manager has degree in economics or business	0.000 (0.001)
(23) Log(no. of establishments)	0.045 (0.009)***	−0.107 (0.039)***	Percent manufacturing × log(experience)	−0.113 (0.053)**
(24) Average no. of employees per establishment	0.001 (0.001)*	−0.001 (0.003)	Percent manufacturing × manager attended school with SAT score above 1400	−0.066 (0.105)
(25) Percent establishments in manufacturing	−0.103 (0.031)***	0.238 (0.136)*	Percent manufacturing × manager has degree in economics or business	−0.006 (0.060)
(26) Population × log(experience)	−0.019 (0.057)	−0.174 (0.076)**	GTE × log(experience)	0.024 (0.023)
(27) Population × manager attended school with SAT score above 1400	0.007 (0.144)	−0.142 (0.168)	GTE × manager attended school with SAT score above 1400	0.116 (0.047)**
(28) Population × manager has degree in economics or business	−0.081 (0.074)	0.045 (0.102)	GTE × manager has degree in economics or business	−0.017 (0.030)
(29) HH income × log(experience)		−0.008 (0.006)	RBOC × log(experience)	0.020 (0.015)
(30) HH income × manager attended school with SAT score above 1400		−0.020 (0.016)	RBOC × manager attended school with SAT score above 1400	0.083 (0.033)**
(31) Constant	−0.563 (0.129)***	0.698 (0.436)	RBOC × manager has degree in economics or business	0.017 (0.022)
(32) $R^2$	0.16	0.17		

Note: Standard errors are reported in parentheses.

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

More formally, let  $j$  ( $j = 1, 2, \dots, J$ ) index the firm (or, equivalently in our data, the manager of the firm), and  $m$  ( $m = 1, 2, \dots, M$ ) index the market. At a given time period,  $Jm$ , potential entrants are simultaneously deciding whether to enter market  $m$ . Market-level demand and cost factors are public information except for a firm- and market-specific stochastic term. All firms make decisions based on these market-level factors and the expected competition from other firms. Firms have heterogeneous ability, however, in inferring the potential level of competition. In each market, each firm draws its type,  $k$  ( $k = 0, 1, 2, \dots, K$ ), from a Poisson distribution with a firm-specific parameter  $\tau_j$ . In notation,  $k \sim \text{Poisson}(\tau_j)$ . This  $\tau_j$  ( $\tau_j > 0$ ) is a deterministic function of firm and manager characteristics.<sup>16</sup> Parametrically,

<sup>16</sup>We do not include an error term in  $\tau_j$  for two reasons. First, there is already randomness in generating types through the Poisson mapping from  $\tau_j$  to any specific type  $k$ . Second, the variance of the error in the  $\tau_j$  function would



$\tau_j = \exp(\gamma_0 + \mathbf{Z}_j\gamma)$ , where  $\mathbf{Z}_j$  is a vector of all the covariates that affect the strategic ability of firm  $j$ .<sup>17</sup> Each  $\tau_j$  is public information.

Firm  $j$  knows its own type but does not observe its competitors' specific types. Therefore, in each market, each firm makes an inference about its competitors' types based on its own type and public information on the firm and manager characteristics of its competitors. A type  $k$  firm believes all its competitors have lower types up to  $k - 1$ . Specifically, it believes that a potential competitor  $i$  ( $i \neq j$ ) has a type drawn from a Poisson distribution with parameter  $\tau_i$ , truncated at  $k - 1$ . In notation, we express this truncated Poisson distribution with an extra parameter:  $\text{Poisson}(\tau_i, k - 1)$ . If the potential competitor has a high  $\tau_i$ , firm  $j$  will perceive  $i$  as more likely to be a higher type. Firm  $j$ 's guesses about this competitor are effectively truncated, however, by how strategic she is herself. If she is a higher type, she is subject to less truncation in her conjecture and thus able to guess the competitors' types more accurately. As described here, every player in this game has limited rationality, as each systematically underestimates the types of its competitors, though the extent of this underestimation varies.

A potential entrant decides whether the expected discounted value of the future profit stream is sufficiently high to support its entry. Upon actual entry, firm  $j$ 's payoff in market  $m$  is given by the following formulation:

$$(2) \quad \Pi_{jm} = \beta_0 + \mathbf{X}_m\beta + \psi(\# \text{ competitors})_m + \xi_m + \varepsilon_{jm}.$$

We adopt the reduced-form profit function above for its tractability. Equation (2) states that the firm's actual payoff of entry depends on a vector of time-invariant market attributes  $\mathbf{X}_m$ , the competition it will encounter upon entry, a market-specific random term  $\xi_m$ , and an idiosyncratic error term  $\varepsilon_{jm}$  with a standard normal distribution reflecting unobserved firm- and market-specific heterogeneity in expected profits. In the formulation above,  $\mathbf{X}_m$  contains market-level observables that might affect the profitability of market  $m$ . Market size, as measured by population, is a key element, as in Bresnahan and Reiss (1990, 1991) and the literature that follows. In the local telephone market, other plausible elements of  $\mathbf{X}_m$  include local demographic variables such as age profiles and income levels, local business activity variables such as the total number of business establishments, and whether the incumbent local telephone company is GTE, a "Baby Bell," or another company. Still, it is likely that these controls do not capture all factors that affect profitability of market  $m$  that the firms observe before they make entry decisions. Therefore, we introduce a market-level random term  $\xi_m$  to capture unobservable exogenous heterogeneity across markets. We assume  $\xi_m \sim N(0, \sigma_\xi)$ , that is,  $\xi_m$  has a normal distribution with standard deviation  $\sigma_\xi$ . The magnitude of  $\sigma_\xi$  informs us about the degree of correlation of entry decisions by different firms into the same market. We assume that  $\xi_m$  is public information observed by all firms (but not by the econometricians), while  $\varepsilon_{jm}$  is private information of firm  $j$ .

be a loose parameter that could not be identified without further strong parametric assumptions. We allow firms to draw a separate type in each market to ensure computational tractability.

<sup>17</sup> We use exponential functional form to ensure  $\tau_j$  is nonnegative, as required by the Poisson distribution.

In our model, each potential entrant acts upon her own type-variant expected discounted value of future profits,  $E(\Pi_{jm}|k)$ , instead of the actual payoff.<sup>18</sup> Based on the type of the manager of the firm in the market, equation (2) becomes

$$(3) \quad E(\Pi_{jm}|k) = \beta_0 + \mathbf{X}_m\beta + \psi E[(\# \text{ competitors})_m | \mathbf{X}_m, \xi_m, \tau, k] + \xi_m + \varepsilon_{jm} \\ = E(\bar{\Pi}_{jm}|k) + \varepsilon_{jm}.$$

The entry decision of firm  $j$  is a dichotomous variable  $D_{jm} \in \{0, 1\}$ , where  $D_{jm} = 1$  if firm  $j$  enters market  $m$  and  $D_{jm} = 0$ , otherwise. Firm  $j$  will enter the local market if the expected discounted value of future profits is positive; that is,  $D_{jm} = 1$  if  $E(\Pi_{jm}|k) \geq 0$ , and  $D_{jm} = 0$  otherwise.

The novelty of this framework is the variation in firms' perceptions about the expected level of competition in each market; that is,  $E[(\# \text{ competitors})_m | \mathbf{X}_m, \xi_m, \tau, k]$  in equation (3). The expectation is conditioned on market attributes  $\mathbf{X}_m$ , market-level random term  $\xi_m$  (observed by firms but not by econometricians), all the potential entrants' strategic ability parameter  $\tau$ , and each firm's own type  $k$ . A type 0 firm, which does not take competitor entry into consideration, has an expected discounted value of future profits of

$$(4) \quad E(\Pi_{jm}|0) = \beta_0 + \mathbf{X}_m\beta + \xi_m + \varepsilon_{jm}.$$

A type 1 firm, which perceives all its potential competitors as type 0 players, has an expected discounted value of future profits of

$$(5) \quad E(\Pi_{jm}|1) = \beta_0 + \mathbf{X}_m\beta + \psi E \left[ \sum_{i=1, \dots, J_m}^{i \neq j} D_{im} | \mathbf{X}_m, \xi_m, \text{Poisson}(\tau_i, 0), 1 \right] \\ + \xi_m + \varepsilon_{jm},$$

where  $\text{Poisson}(\tau_i, 0)$  means that firm  $j$ , as a type 1 player, perceives any of its potential competitor  $i$ 's type to be drawn from a Poisson distribution with parameter  $\tau_i$  and truncated at zero. The truncation means that the type 1 player assigns 100 percent probability to its competitor's likelihood of being a type 0. For a type 1, the assumed distribution is therefore not relevant. The type 1 then uses the profit function specified in equation (4) to figure out expected number of entrants. We can iterate using the same logic and write down any type's expected discounted value of future profits. For a firm of type  $k \geq 2$ , its perceived distribution of any competitor  $i$ 's type is drawn from  $\text{Poisson}(\tau_i, k - 1)$ . As  $k$  increases, the discrepancy between  $\text{Poisson}(\tau_i, k - 1)$  and  $\text{Poisson}(\tau_i, k)$  gradually disappears and the truncated Poisson gradually approaches the real Poisson distribution.<sup>19</sup> That is, a very high type player is able to make decisions

<sup>18</sup> A potential entrant's expected profit is conditional on her own type  $k$ , market demographics  $\mathbf{X}_m$ , market-level random term  $\xi_m$ , and the characteristics of all other potential entrants in the same market. We use  $E(\Pi_{jm}|k)$  to simplify notation.

<sup>19</sup> In estimation, we need to pick a maximum number of types because it is impossible to derive entry likelihood for an infinite number of types. We do this by increasing the number of types and repeating the estimation until the results no longer change. In our analysis, the results are stable at nine or more types.

based on nearly correct beliefs on its rivals' expected behavior. With more correct beliefs, higher types are less likely to make decisions that will generate ex post regret after they observe the actual entry decisions of their competitors. As entering saturated markets and not entering unsaturated markets both cause ex post regret, a higher type means a higher ability to avoid both types of entry-related errors.

A crucial feature of the iterative process above is that each firm acts if she can predict her competitors' entry probabilities (the only exception is the naïve type 0, who completely ignores competitors). A type 1 player perceives every other player in the game to be type 0, and acts upon this belief. A type 2 player perceives every other player to be either type 0 or 1 according to a truncated Poisson distribution with a known parameter, and she then calculates the entry probabilities of any competitor. A player of any type in this game, due to her own limited rationality, best responds to the perceived actions of her competitors, even though the perception can be incorrect. As a result, the entry game we have specified generates a unique outcome by eliminating the "double-guessing" nature of a game in which players are equally rational. In other words, there will not be multiple equilibria in our model, as each player in this game only has one action to follow based on its (incorrect) beliefs.

The estimated parameters are  $\theta = [\beta_0, \beta, \psi, \gamma_0, \gamma, \sigma_\varepsilon]$ . Of these parameters,  $\beta$  measures how a firm's expectation about a market's profitability is affected by  $\mathbf{X}_m$ ,  $\psi$  measures how the same expectation is affected by the perceived competition,  $\gamma$  measures how firm- and manager-specific characteristics shift a firm's strategic ability, and  $\sigma_\varepsilon$  measures the importance of unobserved market-level heterogeneity. As econometricians, we identify the degree to which manager and firm characteristics correlate with the latent ability distribution parameter,  $\tau_j$ , rather than the exact number of steps of consideration the firms undergo in each market. The number of steps of consideration is the firm's private information, and therefore both the firm's rivals and we the econometricians can only assess the probability of each possible type given our knowledge or estimate of  $\tau_j$ , which is a function of firm- and manager-specific characteristics. Therefore, to estimate  $\theta$ , we need to evaluate each firm's entry probabilities by conditioning on all possible types in each market and integrate these probabilities over the distribution of types to predict the entry probability of this firm unconditional on types. We match the entry probabilities of all firms to the data using a standard method of maximum simulated likelihood procedure. Specifically, we maximize the simulated log likelihood

$$(6) \ln L_{\text{simulated}} = \left[ \sum_{m=1, \dots, M} \ln \left\{ \frac{1}{R} \sum_{r=1}^R \left[ \prod_{j=1}^{J_m} (\text{prob}(D_{jm}^r = 1)^{D_{jm}^r} \text{prob}(D_{jm}^r = 0)^{1-D_{jm}^r}) \right] \right\} \right].$$

In (6),  $R$  denotes the number of simulation draws—20—we use for the market-level random term  $\xi_m$ , and  $D_{jm}^r$  denotes the simulated entry decision under an individual simulation draw  $r$ . The full likelihood function is provided in the online Appendix.

### B. Identification of Model Parameters

Assuming our model is the true model underlying the data-generating process, next we discuss the identification of the parameters  $[\beta, \psi, \gamma_0, \gamma]$  in the model. Our model examines the association between firms' entry behavior and market and

firm (manager) characteristics. In the data, we observe variation in (i) the probability of entry by the same firm across different markets and (ii) the probability of entry by different firms into the same markets. To account for these variations, we observe the following explanatory variables: (iii) market characteristics (population demographics and business presence), (iv) the number of potential entrants in each market, and (v) firm and manager characteristics. The identification of  $\beta$  is straightforward—the association between market characteristics as in (iii) and entry probability variation across markets as in (i) allows us to identify the coefficients for market demographics ( $\beta$ ). Here, we focus on the separate identification between the competition effect  $\psi$  and the level of manager ability  $\tau$  (determined by  $\gamma_0$  if there are no covariates for firm and manager characteristics).

As we have two structural parameters to be separately identified, we need to develop at least two sets of restrictions from data to uniquely determine them. The first restriction is from the association between the residual entry probability across markets—what is left to be explained in (i) after  $\beta$  is identified—and the variation in the number of potential entrants as in (iv). Clearly, the competition effect  $\psi$  helps to explain this association because the number of potential entrants enters the profit function only as a determinant of the number of actual entrants. For example, if entry probability drops going from a market with a small number of potential entrants to an otherwise identical market with a large number of potential entrants, we know that the impact of competition ( $\psi$ ) is negative and the magnitude of the drop in entry probability gives us information about the magnitude of this negative competition effect. This magnitude is confounded, however, with the strategic level of players in the market. For example, the same entry probability can be attributed to a combination of a small competition effect and a high level of strategic ability, or to a large competition effect and a low level of strategic ability.

The second restriction from data is the *variance* across firms in propensity to enter the same market (ii). From our model we know that, conditional on market-level variables and the competition effect  $\psi$ , a type 0 has a very high entry probability, a type 1 has a very low entry probability, and a type  $k$  ( $k \geq 2$ ) is in the middle with some oscillation across types. This means that conditional on market-level variables and the competition effect  $\psi$ , the average entry probability can be in the middle because the market is evenly distributed between type 0 and type 1, or because the market is populated mostly with higher types. If there is a large proportion of type 0s and 1s, however, which correspond to low level of  $\tau$ , we will see large variation in entry probability across firms. In contrast, when the market is comprised mostly of higher types, we will see small variation in entry probabilities across firms. With the two restrictions, we should be able to separate  $\psi$  from  $\tau$  in general. That is, we use both the first (average entry probability of the same firm entering different markets) and the second moment (variance in probability of different firms to enter the same markets) to identify  $\tau$  and  $\psi$  through deviation from what would appear to be average behavior given  $\beta$ .<sup>20</sup>

<sup>20</sup> As the variance in probability of different firms to enter the same markets is not necessarily monotonically decreasing for the entire range of  $\tau$  (for example, the variance converges to zero as  $\tau$  goes to zero), we may need to use higher moments (more than two restrictions) to separate  $\tau$  and  $\psi$ . Our likelihood estimator enables us to use information provided by all moments in firms' entry probabilities.

Finally, the matching between firm or manager characteristics as in (v) and variation in entry probability across firms as in (ii) helps identify the coefficients  $\gamma$  for the covariates in the  $\tau$  function. For example, if firms with more experienced managers are systematically less likely to enter markets with a large number of potential competitors, our model will generate higher  $\tau$  and therefore an increased likelihood of high types for managers with more experience. The firm or manager characteristics serve the additional role of implicitly instrumenting for the endogenous expected number of competitors. As discussed in the earlier descriptive analysis, the expected number of competitors is endogenous: unobserved market-level heterogeneity may drive the entry decisions of *all* potential entrants and, in turn, drive the expectation on potential competition. As with standard instrumenting techniques, we need to find variables that affect the expected number of competitors that potential entrant  $j$  faces but do not otherwise affect the entry decisions of potential entrant  $j$ . The characteristics of the other potential entrants in the same markets serve this role.<sup>21</sup> They affect only the formation of the expectation of the number of competitors, and they are determined independently from the realization of the market-level unobserved heterogeneity. In our iterated steps to construct the likelihood of entry for each firm into each market, we use these excluded exogenous variables to predict the expected number of competitors; that is, they function as implicit instruments.

### C. Validity of Underlying Modeling Assumptions

Now, we turn to the validity of the underlying modeling assumptions, which state that a manager's ability (measured by experience and education quality) affects only expected profitability of entry through the ability to conjecture the number of competitors. For identification of the role of managerial ability, we need this assumption to hold for our focal manager characteristics. This means that we need these characteristics to play no role in other drivers of success such as assessing market potential, reducing costs, pricing, exercising quality control, etc. Otherwise, managers will choose markets based on their own and their competitors' ability, but not for the reason assumed in our model. For example, rather than the ability to correctly conjecture competitor behavior, better-managed firms may be in less competitive markets because other firms choose not to compete with them.

Clearly, the exclusion assumption we have made above is a strong assumption. We will not argue for its universal validity. Instead, we will provide evidence suggesting that this assumption is reasonable in our particular setting.

First, to alleviate the concern that manager characteristics may drive post-entry decision quality, we show that manager education (measured by a degree in economics or business and undergraduate institution average SAT score) and experience are uncorrelated with survival (a measure of realized profits) conditional on entry. We establish this fact in order to demonstrate that some manager characteristics appear to affect expected profits through entry decisions, not through postentry decisions.

<sup>21</sup> In fact, for exact identification we need only one such characteristic.

To express this idea more formally, following the notation we have developed above we can write the identification assumption as

$$(7) \quad E(\Pi_{jm} | D_{jm} = 1, \mathbf{X}_m, (\# \text{ competitors})_m) \\ = E[(\Pi_{jm} | D_{jm} = 1, \mathbf{X}_m, (\# \text{ competitors})_m, \text{subset}(\mathbf{Z}_j))],$$

which states that, conditional on entry ( $D_{jm} = 1$ ), market characteristics, and the number of competitors of the market, the manager characteristics  $\mathbf{Z}_j$  do not affect expected realized profits  $\Pi_{jm}$ . As we do not directly observe realized profits at the firm-market level but observe a function of realized profits at the firm level, such as survival, the assumption above leads to

$$(8) \quad E(f(\Pi_{jm}) | D_{jm} = 1, \mathbf{X}_m, (\# \text{ competitors})_m) \\ = E[f(\Pi_{jm}) | D_{jm} = 1, \mathbf{X}_m, (\# \text{ competitors})_m, \text{subset}(\mathbf{Z}_j)],$$

and this equation serves as the basis of the regression we run for identification:

$$(9) \quad f(\Pi_{jm}) = \delta_0 + \mathbf{Z}_j \delta_1 + \mathbf{X}_m \delta_2 + \delta_3 (\# \text{ competitors})_m + \varepsilon_{jm} \quad \text{for } D_{jm} = 1.$$

Our identifying assumption implies the null hypothesis:  $H_0 : \delta_1 = 0$ .

Table 3 presents results from the regressions above, where we use survival as our proxy for realized profits. The first two rows of columns 1 and 2 show the manager characteristics (experience and two measures of education) are not positively related to survival conditional on entry. In contrast, they are significant and positively correlated with survival in the unconditional regressions in columns 3 and 4. The results are consistent with our identifying assumption that manager characteristics relate to profits primarily through entry.

Second, to address the concern that manager characteristics are related to an ability to estimate market potential prior to entry, we show that the number of competitors mediates the correlation between manager characteristics and entry decisions more strongly than demographic characteristics such as population. Table 2B—described earlier to show that better-educated, older managers enter markets with fewer competitors—shows that there is no clear relationship between manager characteristics, demographic characteristics, and entry. While the interaction of the number of competitors with our manager ability covariates displays a consistent negative relationship with entry, we find no consistent relationship with demographic characteristics. For example, in column 1, rows 26 to 28, show insignificant coefficients on the interactions of population and the manager characteristics. Column 2 shows mostly insignificant coefficients on the interactions between demographics and our covariates for ability. When there is significance, the signs vary across measures of manager ability. Overall, we see no systematic pattern suggesting that experienced and better-educated managers make different estimates

TABLE 3—DESCRIPTIVE OLS REGRESSIONS OF SURVIVAL ON MANAGER CHARACTERISTICS

	Conditional on entry		All observations	
	(1)	(2)	(3)	(4)
(1) Log(experience)	−0.068 (0.130)	−0.084 (0.133)	0.170 (0.037)***	0.186 (0.037)***
(2) Manager attended school with SAT score above 1400	−0.156 (0.076)**	−0.158 (0.080)**	0.258 (0.024)***	0.251 (0.024)***
(3) Manager has degree in economics or business	−0.269 (0.424)	−0.320 (0.433)	0.412 (0.117)***	0.481 (0.116)***
(4) Log(experience) × manager has degree in economics or business	−0.027 (0.149)	−0.007 (0.152)	−0.247 (0.041)***	−0.271 (0.041)***
(5) Log (firm age)	0.200 (0.023)***	0.206 (0.023)***	0.120 (0.006)***	0.123 (0.006)***
(6) Subsidiary	0.126 (0.068)*	0.116 (0.069)*	−0.096 (0.016)***	−0.100 (0.016)***
(7) Privately owned	−0.145 (0.063)**	−0.132 (0.065)**	−0.164 (0.015)***	−0.160 (0.015)***
(8) Venture capital	0.327 (0.097)***	0.315 (0.099)***	0.224 (0.021)***	0.212 (0.021)***
(9) Number of competitors	−0.002 (0.005)	0.003 (0.009)	−0.001 (0.002)	0.005 (0.003)
(10) Market attributes controlled	No	Yes	No	Yes
(11) Observations	472	472	5,906	5,906
(12) $R^2$	0.29	0.30	0.18	0.19

Note: Standard errors are reported in parentheses.

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

of market potential (or that they pick markets with different observable characteristics) than other managers. While this is not a definitive test, it is suggestive that the relationship between manager characteristics and the number of competitors is particularly important in our setting.

In this section we have provided evidence to suggest: (i) entry decisions drive the correlation between success and the CEO's experience and education; and (ii) it is the number of competitors (instead of, for example, managers' ability to measure market potential) that drives the correlation between entry decisions and manager characteristics. As such, we argue that our identification strategy, which relies on correlation between manager characteristics and strategic entry considerations, is reasonable in our context.

#### IV. Results

We first present the coefficient estimates for 1998. As discussed above, this was effectively the first year of entry in these midsize markets. Therefore, the entry decisions in this period are more likely to be truly simultaneous. After discussing coefficient estimates and their robustness, we show that the measured level of strategic thinking increased from 1998 to 2002. Finally, we demonstrate a positive correlation between the estimates of strategic ability and two measures of firm performance: survival and revenue.

TABLE 4—STRATEGIC ABILITY AND ENTRY COEFFICIENTS ( $N = 5,906$ )

Variables	Main (1)	No covariates in Z (2)	Only manager characteristics (3)	Alternative treatment of missing variables (4)	No random effects (5)
<i>Coefficients on strategic ability parameter <math>\log(\tau)</math></i>					
(1) Log(experience)	0.161 (0.061)***		0.180 (0.053)***	0.147 (0.057)***	0.235 (0.080)***
(2) Manager attended school with SAT score above 1400	0.069 (0.039)*		0.041 (0.034)	0.062 (0.038)	0.117 (0.052)**
(3) Manager has degree in economics or business	0.396 (0.215)*		0.358 (0.162)**	0.375 (0.193)*	0.558 (0.253)**
(4) Log(experience) $\times$ Manager has econ/business degree	-0.165 (0.076)**		-0.160 (0.057)***	-0.157 (0.068)**	-0.234 (0.089)***
(5) Manager has degree in engineering or science	-0.078 (0.026)***		-0.136 (0.027)***	-0.075 (0.028)***	-0.119 (0.038)***
(6) Manager has graduate degree	0.029 (0.027)		0.098 (0.023)***	0.028 (0.027)	0.024 (0.034)
(7) Log (firm age)	0.045 (0.013)***			0.042 (0.013)***	0.066 (0.018)***
(8) Subsidiary	-0.138 (0.035)***			-0.132 (0.035)***	-0.215 (0.052)***
(9) Privately owned	-0.129 (0.030)***			-0.130 (0.033)***	-0.173 (0.047)***
(10) Venture capital	-0.005 (0.054)			-0.006 (0.052)	-0.021 (0.060)
(11) Constant in $\tau$	0.601 (0.184)***	1.066 (0.043)***	0.592 (0.1600)***	0.648 (0.175)***	0.351 (0.249)
(12) Missing data dummy				0.025 (0.110)	
<i>Coefficients on entry</i>					
(13) Expected number of competitors	-0.655 (0.074)***	-0.652 (0.067)***	-0.685 (0.076)***	-0.655 (0.075)***	-0.545 (0.051)***
(14) Place population in millions	2.059 (1.267)	1.933 (1.253)	2.309 (1.310)*	2.000 (1.277)	1.815 (0.868)**

(Continued)

### A. What Drives Strategic Ability?

In this subsection, we examine whether the standard information on a manager's biography relates to strategic ability. Table 4, column 1, shows the main estimates. The top part of the table shows the coefficients for the strategic ability function and the bottom part shows the coefficients for market attributes used in estimating the latent profitability of entry. Before turning to our analysis of manager- and firm-level characteristics, we note the strong negative relationship between the expected number of competitors and the level of entry (row 13). This is the most statistically significant result in almost all specifications and shows that firms appear, on average, to avoid direct competition. Therefore, it is empirically relevant to examine how variation in strategic ability leads to variation in the avoidance of competition.



TABLE 4—STRATEGIC ABILITY AND ENTRY COEFFICIENTS ( $N = 5,906$ ) (Continued)

(15) HH income in \$1,000	−0.005 (0.027)	−0.016 (0.024)	−0.013 (0.025)	−0.006 (0.027)	−0.007 (0.018)
(16) Median age	−0.109 (0.061)*	−0.103 (0.055)*	−0.109 (0.058)*	−0.114 (0.060)*	−0.117 (0.040)***
(17) Household size	−2.346 (0.600)***	−2.020 (0.576)***	−2.386 (0.599)***	−2.363 (0.598)***	−2.269 (0.434)***
(18) Percent foreign born	4.115 (1.885)**	4.071 (1.744)**	4.115 (1.781)**	4.279 (1.906)**	4.208 (1.232)***
(19) Percent African American	2.577 (1.013)**	2.623 (0.947)***	2.834 (1.017)***	2.615 (1.016)**	2.190 (0.605)***
(20) Percent below poverty line	7.235 (5.084)	5.619 (4.575)	5.398 (4.761)	6.877 (5.090)	5.466 (3.183)*
(21) GTE	1.964 (0.660)***	1.945 (0.622)**	2.035 (0.636)***	1.962 (0.662)***	1.806 (0.441)***
(22) RBOC	1.196 (0.576)**	1.239 (0.547)**	1.366 (0.577)**	1.176 (0.580)**	1.193 (0.365)***
(23) Log(number of establishments)	1.982 (0.359)***	2.040 (0.344)***	1.970 (0.345)***	1.990 (0.359)***	1.649 (0.240)***
(24) Average number of employees per establishment	0.047 (0.036)	0.049 (0.028)*	0.044 (0.033)	0.046 (0.036)	0.042 (0.020)**
(25) Percent establishments in manufacturing	−3.478 (1.511)**	−3.922 (1.293)***	−3.750 (1.422)***	−3.512 (1.504)**	−2.687 (0.861)***
(26) Std. dev. of the market-specific unobservable	0.796 (0.194)***	0.638 (0.192)***	0.714 (0.196)***	0.792 (0.195)***	
(27) Constant	3.330 (3.368)	2.920 (3.001)	3.957 (3.186)	3.681 (3.359)	4.001 (2.372)*
(28) Mean $\tau$	2.59	2.90	2.83	2.59	2.36
(29) Minimum $\tau$	1.96	2.90	2.23	1.66	1.57
(30) Maximum $\tau$	3.41	2.90	3.38	3.41	3.48
(31) Log likelihood	−1,206.8	−1,292.9	−1,253.8	−1,202.6	−1,215.6

Note: Standard errors are reported in parentheses.

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

Rows 1 to 6 show the coefficients for manager-level characteristics in driving measured ability, and rows 7 to 10 show coefficients for firm-level characteristics. In discussing the results, we focus on three areas: experience, education, and ownership structure. The exponential specification of  $\tau$  function means that coefficients in rows 1 to 10 can be interpreted as the percentage change in  $\tau$  responding to a change in the covariate. Therefore, a positive coefficient 0. $x$  means that the (discrete) type is drawn from a distribution with a (continuous) Poisson parameter that is  $x$  percent higher and the manager will, therefore, on average, be of higher ability.

*Experience.*—Experience is widely viewed as an asset for managers. It is emphasized in manager biographies and in company annual reports. Laboratory research has shown experience is positively correlated with ability in beauty contest games (Robert L. Slonim 2005), and other research has documented a relationship between experience (measured at the firm or manager level) and behavior. Our results support

the idea that ability is positively correlated experience. More experienced managers have higher values of  $\tau$  (row 1). This effect is large: some basic algebra implies that moving from one year of experience to five years of experience is associated with a 26 percent increase in  $\tau$ . We also find that older firms have higher values of  $\tau$  (row 7).

*Education.*—We examine three different aspects of education: quality (row 2), field (rows 3 and 5), and level (row 6). Whether education provides value or merely functions as a signal of ability, we would expect it to correlate with the ability of managers. Managers with a degree from a top-level undergraduate institution (with an incoming class average SAT above 1400) have 6.9 percent higher levels of  $\tau$ . Managers with a degree in economics or business (but little experience) have 39.6 percent higher levels of  $\tau$ . Furthermore, managers with a degree in economics or business have a significantly higher level of  $\tau$  than managers with a degree in engineering or science. Whether managers have a graduate degree, however, is not systematically correlated with  $\tau$ .

*Substitution between Education and Experience.*—Consistent with the descriptive analysis above, our results suggest that having a degree in economics or business is particularly correlated with measured ability for inexperienced managers. The results suggest that having a degree in economics or business is a strong substitute for industry experience in terms of the ability to conjecture competitor behavior. This suggests that the economics or business degree can partially substitute for business experience, perhaps partially justifying the use of such claims in business school promotional literature (e.g., John S. Hammond 1980).

*Ownership Structure.*—Ownership structure may be systematically related to manager ability because of incentives and experience. We find that CLECs that were subsidiaries of larger telecommunications companies have lower measured ability (row 8). We see two possible explanations for this: (i) these managers had fewer incentives to be careful in entry decisions because they would be rewarded based on how fast their units grew and their loss could be covered by the mother company, or (ii) these managers were chosen to run a subsidiary business because they were either less skilled or less experienced than the others. We believe the former is more likely because the managers of subsidiaries had more years of experience than the other CLEC managers in our sample. We also find that privately owned firms have lower levels of measured ability (row 9). We find no consistent relationship between measured ability and venture-capital backing (row 10).

The remainder of Table 4 shows robustness to a number of alternative specifications of the covariates included in the regressions. Column 2 drops all covariates on  $\tau$  and shows that the covariates have identifying power in the sense that they increase the log likelihood substantially from column 2 to column 1. Column 3 shows robustness to focusing on manager characteristics and column 4 shows robustness to an alternative treatment of the missing variables: rather than imputation, it sets the value to zero and includes a dummy if the data are missing. Column 5 drops the random effects and, as expected, statistical significance is increased.

The first three columns of Table 5 show further robustness. Column 1 uses an alternative functional form for  $\tau$ :  $\tau_j = K\Phi(\gamma_0 + \mathbf{Z}_j\gamma)$ , where  $\Phi(\cdot)$  is the density

TABLE 5—STRATEGIC ABILITY AND ENTRY COEFFICIENTS: ALTERNATIVE DATA AND FUNCTIONAL FORM SPECIFICATIONS

Variables	Alternative functional form $\tau_j = K\Phi(\gamma_0 + \mathbf{Z}_j\gamma)$ (1)	Potential entry means entered by end of 2002 (2)	Only places without CAPs in 1994:IV (3)	Data from 2002 (4)
<i>Coefficients on strategic ability parameter <math>\log(\tau)</math></i>				
(1) Log(experience)	0.145 (0.054)***	0.166 (0.061)***	0.172 (0.059)***	-0.010 (0.678)
(2) Manager attended school with SAT score above 1400	0.061 (0.035)*	0.064 (0.039)*	0.038 (0.044)	0.640 (0.273)**
(3) Manager has degree in economics or business	0.354 (0.191)*	0.414 (0.215)*	0.420 (0.205)**	0.212 (2.405)
(4) Log(experience) $\times$ manager has econ./business degree	-0.148 (0.067)**	-0.172 (0.076)**	-0.172 (0.074)**	-0.291 (0.662)
(5) Manager has degree in engineering or science	-0.069 (0.023)***	-0.077 (0.027)***	-0.076 (0.026)***	0.550 (0.301)*
(6) Manager has graduate degree	0.032 (0.024)	0.022 (0.028)	0.016 (0.026)	0.080 (0.142)
(7) Log (firm age)	0.045 (0.012)***	0.041 (0.013)***	0.033 (0.013)**	0.466 (0.229)**
(8) Subsidiary	-0.119 (0.0310)***	-0.124 (0.036)***	-0.119 (0.037)***	-0.757 (0.302)**
(9) Privately owned	-0.115 (0.026)***	-0.132 (0.032)***	-0.121 (0.031)***	-0.008 (0.202)
(10) Venture capital	-0.004 (0.048)	-0.010 (0.055)	-0.010 (0.048)	0.058 (0.271)
(11) Constant in $\tau$	-0.774 (0.164)***	0.588 (0.183)***	0.633 (0.183)***	0.588 (2.490)

(Continued)

function of the standard normal distribution and  $K$  is the maximum number of types we allow for estimation. Column 2 defines potential entrants only as those 79 firms that did eventually enter the CLEC market rather than all firms licensed to do so. And column 3 excludes the few markets that had at least one competitive access provider with rights to a local telephone number in the fourth quarter of 1994 (though many were not yet operating). The qualitative results are robust across specifications.

### B. Measured Strategic Ability in 1998 and 2002

The main specification in Table 4, column 1, shows an average estimated level of  $\tau$  of 2.59 (row 28). The various robustness checks using this 1998 data all provide similar estimates (between 2.36 and 2.90). At  $mean(\tau) = 2.59$ , this means that 7.5 percent of firms are type 0, 19.4 percent are type 1, 25.2 percent are type 2, 21.7 percent are type 3, 14.1 percent are type 4, and 12.1 percent are type 5 or higher. The average value is at the high end of the range found in Camerer, Ho, and Chong (2004), although it is well below their maximum of 4.9. We view this as supportive of the CH model. We expect the value of  $\tau$  to be relatively high because this is a more important decision than those faced by laboratory subjects.

Using the 2002 data,  $mean(\tau)$  increases to 4.35. The measure of ability requires a different interpretation in this year because firms could observe what competitors

TABLE 5—STRATEGIC ABILITY AND ENTRY COEFFICIENTS: ALTERNATIVE DATA AND FUNCTIONAL FORM SPECIFICATIONS (*Continued*)

<i>Coefficients on entry</i>				
(12) Expected number of competitors	-0.670 (0.078)***	-0.665 (0.0797)***	-0.718 (0.085)***	-0.205 (0.039)***
(13) Place population in millions	2.037 (1.293)	2.069 (1.270)	2.028 (1.560)	-0.291 (0.684)
(14) HH income in \$1,000	-0.004 (0.027)	-0.004 (0.027)	0.004 (0.030)	0.005 (0.009)
(15) Median age	-0.109 (0.061)*	-0.110 (0.061)*	-0.115 (0.068)*	-0.051 (0.028)*
(16) Household size	-2.328 (0.612)***	-2.364 (0.600)***	-2.297 (0.718)***	-0.541 (0.274)**
(17) Percent foreign born	4.115 (1.921)**	4.198 (1.868)**	3.884 (2.017)*	0.823 (0.671)
(18) Percent African American	2.641 (1.0340)**	2.636 (1.038)**	3.066 (1.098)***	2.331 (0.641)***
(19) Percent below poverty line	7.207 (5.170)	7.060 (5.180)	5.545 (5.448)	3.976 (2.194)*
(20) GTE	1.973 (0.671)***	1.848 (0.648)***	1.836 (0.668)***	0.474 (0.394)
(21) RBOC	1.205 (0.585)**	1.060 (0.567)*	1.081 (0.600)*	0.300 (0.298)
(22) Log(number of establishments)	2.025 (0.370)***	2.035 (0.362)***	2.033 (0.410)***	1.626 (0.227)***
(23) Average number of employees per establishment	0.048 (0.036)	0.044 (0.037)	0.041 (0.038)	-0.019 (0.024)
(24) Percent establishments in manufacturing	-3.569 (1.535)**	-3.636 (1.521)**	-4.063 (1.634)**	0.114 (0.815)
(25) SD of the market-specific unobservable	0.806 (0.196)***	0.789 (0.191)***	0.725 (0.193)***	0.555 (0.089)***
(26) Constant	3.258 (3.419)	3.566 (3.378)	3.672 (3.909)	-0.494 (1.533)
(27) Mean $\tau$	2.61	2.60	2.71	4.35
(28) Minimum $\tau$	1.93	1.97	2.14	0.76
(29) Maximum $\tau$	3.41	3.33	3.44	9.99
(30) Log Likelihood	-1208.2	-1195.4	-1062.7	-2278.2
(31) Number of Observations	5,906	5,699	5,201	6,095
(33) Number of CLECs	96	79	95	83

Note: Standard errors are reported in parentheses.

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

did in the prior periods. Therefore, a simultaneous entry game is less appropriate in this setting. We interpret the increase in measured ability after the 2001 shake-out as supporting evidence for an evolution toward the steady equilibrium outcome assumed in much of the existing simultaneous entry literature (e.g., Greenstein and Mazzeo 2006; Seim 2006). Furthermore, the manager characteristics no longer predict  $\tau$  well in the 2002 data, suggesting that over time competitive pressures or other factors may reduce the informativeness of these characteristics.

Although the industry as a whole increased in sophistication over time, the minimum value in the 2002 data suggests that some naivety persisted. Given that this is

TABLE 6—FIRMS WITH A HIGHER  $\tau$  ARE MORE LIKELY TO EXIT THE INDUSTRY EARLY

	Survive in sample to 2002		Alternative definition of survival to 2002		Log revenue in 2002		Log local phone revenue in 2002	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau^a$	0.345 (0.184)*	0.417 (0.233)*	0.294 (0.160)*	0.416 (0.199)**	2.496 (1.251)*	1.778 (1.171)	2.422 (1.245)*	2.003 (1.308)
Log(firm age in 1998)		-0.0050 (0.074)		-0.037 (0.063)		-0.208 (0.405)		-0.461 (0.369)
Log(employees in 1998)		-0.017 (0.023)		-0.005 (0.021)		0.493 (0.150)***		0.549 (0.134)***
Constant	-0.467 (0.447)	-0.538 (0.550)	-0.096 (0.401)	-0.299 (0.494)	11.536 (3.008)***	11.199 (2.686)***	10.719 (3.106)***	9.752 (3.092)***
Observations	96	90	96	90	48	46	46	44
$R^2$	0.05	0.07	0.04	0.06	0.14	0.34	0.13	0.40

Notes: All columns use linear regression. Heteroskedasticity-robust standard errors in parentheses.

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

<sup>a</sup>  $\tau$  is a generated regressor calculated from the coefficients in Table 4 column 1. We follow procedures outlined in Jeffrey M. Wooldridge (2002) to adjust standard error bias due to uncertainty in the estimate of  $\tau$ .

an industry with a high turnover rate and that we showed new firms to be less likely to act strategically, this is perhaps unsurprising. Some questions, however, follow: Do the smart get smarter, while the less strategic firms exit? Or does the entire industry learn over time? And do firms learn from past successes and failures? The dynamic implications of these questions, although beyond the scope of this project, warrant future research.

### C. Do More Strategic Firms Do Better?

Next, we examine whether the CLECs that we estimate to be more sophisticated were in fact more successful. Given that such a large percentage of firms failed, especially after telecommunications stocks crashed in 2001, we use survival to 2002 as our primary measure of success. We also show results using 2002 revenue as another measure of success.<sup>22</sup>

Table 6 shows the results. The key independent variable in these regressions is the predicted value of  $\tau$  for each firm, based on the coefficients in Table 4, column 1. We find that the predicted  $\tau$  is positively correlated with four different definitions of success: (i) survival as defined by appearing in the 2002 NPRG reports, (ii) survival as defined by not having an accessible public record of exit through failure, (iii) revenue (conditional on survival), and (iv) local phone service revenue (conditional on survival).

Because we predict the value of  $\tau$  from a simple exponential function of firm and manager characteristics, it is important to be cautious in this interpretation. The results will be a consequence of spurious correlation to the extent that these characteristics drive survival for reasons other than strategic ability. Consistent with the

<sup>22</sup> Ideally, we would have a measure of long-term profits. Unfortunately, we do not have profit data and therefore focus on survival and revenue as crude but distinct measures of success.

prior literature (e.g., Timothy Dunne, Mark J. Roberts, and Larry Samuelson 1988), we especially suspect that firm age and size have effects on firm survival, independent of  $\tau$ . Therefore, we show robustness to including these as controls. While not conclusive, we view these results as providing some external validity for our model.

## V. Conclusions

Overall, our approach provides insight into the incidence of strategic ability in a new market: local telephone competition following the 1996 Telecommunications Act. We show that firm behavior is related to manager and firm characteristics in a systematic way. Generally, firms with experienced, better-educated managers made decisions that suggest they were better able to conjecture competitive behavior. In order to better understand this relationship, we impose a structural model of strategic ability based on the Cognitive Hierarchy model.

Several aspects of our results suggest validity for our model in this setting. First, the coefficient estimates are suggestive that the strategic ability parameter,  $\tau$ , is correlated with education and experience. Managers trained in economics or business, those who attended better undergraduate institutions, and those with more experience are estimated to be more sophisticated. Second, our strategic ability parameter correlates with out-of-sample success: those firms estimated to be more strategic in 1998 were more likely to survive and have high revenues conditional on survival. Third, our estimate of average  $\tau$  increases following the shakeout. This suggests that the industry became more sophisticated in its aftermath. While this result is directly informative of only the CLEC industry, it does suggest that allowing for heterogeneous ability in empirical models may be most important in the first years of an industry, prior to a shakeout. This is consistent with laboratory (Chong, Camerer, and Ho 2005; Slonim 2005) and field (John A. List 2003; Robert Ostling et al. 2010) evidence suggesting that repeated play leads to higher rationality.

As with any empirical work, this paper has a number of limitations. First, and perhaps most critically, our model assumes that experienced and better-educated managers are better able to conjecture competitor behavior but they are not better at making decisions in other aspects of their firms' operations. While we provide some corroborating evidence that this assumption captures much of the observed variation in our data, we cannot definitively prove its validity. Second, we cannot do a nested test against Nash equilibrium models, and there are other possible models that we cannot reject (for example, educated experienced managers may be better able to get inside information about what other firms are doing). As discussed above, we rely on lab experiments as support for the framework and argue that our results have both internal and external validity. They are also consistent with industry accounts and the underlying patterns in our data. Third, we do not model the decision of the firm owners to hire CEOs. Therefore, our results could be interpreted as saying something about the kinds of firms that hire less experienced, less educated CEOs rather than about the CEOs themselves. On a related note, it is possible that the experience and education of CEOs is correlated with the experience and education of the other employees, and that we are therefore measuring the overall level of experience and education in the company rather than anything to do with the CEO per se. Fourth, we explore a very specific type of ability: the ability to conjecture competitor behavior.

We cannot say anything about other dimensions of managerial ability. Finally, the empirical setting may differ from the model in ways that may affect the results. For example, while we observe the industry very close to its inception, the game is not truly simultaneous and the extent to which actions are observable may bias our results toward a higher level of ability.

Notwithstanding these limitations, we have provided a structural framework for estimating strategic ability using revealed preference in a real-world setting. The unique solution to this structural model means that we can include manager and firm characteristics in our analysis in a computationally convenient way. Our results help explain aspects of early competition in local telephone markets: why we see variation in the number of competitors in what appear to be similar markets, and why firms run by experienced, better-educated managers operated in markets with fewer competitors.

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