Who thinks about the competition?

Managerial ability and strategic entry in US local telephone markets*

Avi Goldfarb
Rotman School of Management
University of Toronto
105 St. George Street
Toronto, ON M5S 3E6
416-946-9604
agoldfarb@rotman.utoronto.ca

Mo Xiao
Eller College of Management
University of Arizona
1130 E. Helen Street
P.O. Box 210108
Tucson, AZ 85721-0108
520-621-2192
mxiao@eller.arizona.edu

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ABSTRACT

We examine US local telephone markets shortly after the Telecommunications Act of 1996. The data suggest that older, experienced, 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 correctly conjecture competitor behavior. We find that manager characteristics are key determinants in managerial ability. Furthermore, our estimate of ability predicts out-of-sample success. Counterfactuals provide insight into the industry's struggles despite substantial (indirect) subsidies: It is only when the ability to correctly conjecture competitor behavior is high that firms enter empty markets.

Keywords: behavioral industrial organization, cognitive hierarchy, entry games, CLECs, local telephone competition

JEL Classification: D03, L2, L96

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1) Introduction

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 and consequences 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, or CLECs) were aided by implicit subsidies from government and suppliers, and they varied substantially in size, management, and telecommunications experience. New firms run by 35-year-old university dropouts competed alongside decades-old firms with educated, experienced, professional managers. These 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 importantly, and in contrast to many existing models of firm behavior in new industries that emphasize cost and production heterogeneity (e.g., Klepper 2002; Holmes and 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 older, more experienced CEOs and CEOs with degrees in economics or business tended to enter markets with fewer competitors.

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. (Camerer 2003). Since 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., McKelvey and Palfrey 1995), level-k thinking (e.g., Costa-Gomes and Crawford 2006), and cognitive hierarchy (e.g., Camerer, Ho, and 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. 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. Unlike games featuring multiple Nash equilibria with fully rational players, this hierarchy yields a unique solution. In our setting of an entry game, this unique solution enables us to determine the identities of entrants as well as associate entry decisions with manager and firm characteristics. Relying on prior research, we interpret the hierarchy as a measure of strategic ability.[1] This interpretation allows us to examine which firm and CEO characteristics are determinants of strategic ability.

In particular, we estimate the structural model using CLECs' entry decisions into local markets in 1998, when the decision can most reasonably be treated as simultaneous because the industry was new and firms had less time to react to others' decisions. This simultaneity, combined with the lack of established industry norms, make this a particularly appealing application for a hierarchical model of ability.[2] Empirically, the players identified as better at playing the game will be those that choose to enter markets with few competitors and choose not to enter markets with many competitors. We also estimate the model for 2002 and discuss changes in strategic ability after the 2001 shakeout.

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

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[1] Camerer and 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. 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.

[2] Collard-Wexler (2008) discusses the realism of Bayesian Nash equilibrium in applied work and argues that a lack of industry norms and experience, combined with simultaneity, provide an ideal platform for adding behavioral assumptions.

traditional wisdom of reviewing a manager's curriculum vitae works. Older, more experienced, and appropriately educated managers tend to enter markets with fewer competitors. To the extent that our interpretation of this as indicative of manager ability is correct, this suggests that hiring a 35-year old as CEO can be quite risky. Second, comparing results across years, we find that the measured level of ability is substantially higher in 2002 than in 1998. We interpret the increase in measured ability after the shakeout as supporting evidence for an evolution towards the long-run equilibrium outcome assumed in much of the existing simultaneous entry literature (e.g., Greenstein and Mazzeo 2006, p. 337). Third, 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. These three results (combined with several industry facts and the existing laboratory research) suggest internal and external validity for our model in the absence of the ability to directly test against alternatives such as Bayesian Nash.

While a growing literature documents how manager characteristics relate to outcomes (e.g., Bertrand and Schoar 2003; Kaplan, Klebanov, and Sorenson 2008), to the best of our knowledge our paper is the first to structurally examine how these characteristics correlate with firm strategies in a real-world setting. With this structure, we can gain insight into the effects of subsidies in a new industry.

CLECs benefited from implicit subsidies due to government regulation of the incumbent carriers and explicit subsidies of equipment purchases from Nortel and Lucent (Crandall 2005; Goldstein 2005). We conduct counterfactual experiments to evaluate the impact of subsidies on the entry decisions of CLECs. We find that the effectiveness of a subsidy depends critically on the level of strategic ability. When average ability is low, subsidies induce little entry into unsaturated markets. In contrast, when average ability to correctly conjecture competitor behavior is high, subsidies do induce entry into markets that would not otherwise be served. If a goal of government subsidies is to increase the number of markets where the incumbents face competition (i.e., the number of markets served by at least one CLEC), this goal could only be realized if strategic ability is high. Similarly, the low-interest loans from equipment manufacturers would have been more likely to be repaid if high ability CLECs used those loans to open new markets rather than if low ability CLECs used them to enter markets that were already saturated.

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.

2) Background and Literature

In this section, we review four distinct topics that put our study in context. First, we discuss the nature of local telephone competition in the United States and explain why a model that allows for heterogeneity in strategic ability is particularly important here. Second, we discuss behavioral game theory, emphasizing the details of the CH model. Third, we discuss how our research relates to the literature on empirical discrete choice models of firm interactions. Finally, we build a list of potential correlates with strategic ability by discussing a literature that relates firm and CEO characteristics to actions and performance.

Local Telephone Competition

Between the *Kingsbury Commitment of 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 (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 mid-sized US cities.[3] A shakeout followed, and by 2002 just 64 CLECs were operating in 195 locations. Of the CLECs that were licensed to enter these mid-sized markets in 1998, just 41% survived independently through 2002. Thus, while many firms exited, the number of markets served by the remaining firms increased.

Both Goldstein (2005) and Crandall (2005) provide detailed histories of telecommunications competition following the 1996 Act. They describe how a change in government policy (including implicit subsidies through constraints on incumbent carriers), combined with generous loans from equipment manufacturers, led to investments in local telecommunications infrastructure totaling billions of dollars. In addition, 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 correctly 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

[3] We focus on mid-sized cities (with population between 100,000 and 1,000,000) for two reasons. First, smaller places are typically non-urban areas that contain few high-value business customers to attract CLECs. Second, larger cities often encompass several sub-markets, so it is difficult to determine the existence and scope of strategic interactions among entrants. Furthermore, a handful of larger markets had local telephone competition prior to the 1996 Telecom Act.

systematically correlated with manager characteristics. On average, firms run by managers without degrees in economics or business were the only CLECs in the markets they entered 8.8% of the time. In contrast, firms run by managers with such degrees operated as the only CLEC 13.5% of the time. The figure also shows that firms run by older and more experienced managers were more likely to be the only competitors in the markets they entered. We provide descriptive regression analysis supporting this link between manager characteristics and the level of competition after describing the dataset in Section 3.

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.[4]

We conclude the section on local telephone competition by noting that our paper is not the first to examine competition in these markets. Closest to our work is Greenstein and Mazzeo (2006). They examine CLEC entry decisions using a similar underlying structural model to ours, though they do not allow for heterogeneity in managerial ability. Instead, they emphasize another aspect of heterogeneity: heterogeneity in product characteristics defined by differences between national and local CLECs. Our paper therefore complements theirs in that both emphasize the

[4] Of course, we acknowledge that heterogeneity in the ability to correctly conjecture competitor behavior is not the only possible explanation for these correlations. Alternative explanations include: 1) educated and experienced managers have a different attitude to risk and 2) educated and experienced managers have more inside information and are therefore better able to *know* rather than conjecture what competitors will do. Still, we believe our choice of the CH model is more useful in understanding the CLEC industry in 1998 for several reasons. First and most importantly, the anecdotal, descriptive, and historical evidence mentioned above does suggest an inability to conjecture competitor behavior. Second, the CH model has a convenient structure (based on laboratory evidence) that allows us to generate an estimate of ability and simulate the consequences of policy changes. Third, the risk attitudes model cannot simply be that inexperienced managers are less risk-averse because experienced managers enter more markets and because there are no significant differences in market size across manager characteristics. The empirical correlation is that experienced managers enter markets with fewer competitors while *controlling for market size and characteristics*. Thus, inexperienced managers would specifically need to prefer a kind of risk relating to competition. Finally, we have found no evidence that inside information played a role in these decisions or evidence of any illegal leaks on the part of government agencies.

importance of firm-level heterogeneity in understanding the CLEC market. We emphasize ability while Greenstein and Mazzeo emphasize product variation. Other papers on local telephone competition include Economides, Seim, and Viard (2008) on the consumer welfare effects of the increase in local phone competition between 1999 and 2003 in New York state and Mini (2001) and Alexander and Feinberg (2004) on the behavior of incumbent carriers in using non-price levers to restrict entry. Our paper takes a unique perspective on local telephone competition by using behavioral game theory as a framework for understanding interesting patterns in the data.

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. Camerer's (2003) textbook provides a detailed review of behavioral game theory and how it differs from standard game theory. A key difference is that behavioral game theory has used laboratory-based evidence to adjust standard models to account for bounded rationality and personal biases. Of particular relevance to our research are the 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.[5]

Specifically, 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 Goldfarb and Yang 2008). As mentioned

[5] Haile, Hortacsu, and 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. Furthermore, under CH sophisticated players will be those who enter markets with few competitors and avoid markets with many competitors.

earlier, 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. In this model, higher types have what Chong, Camerer, and Ho (2005) call "increasingly rational expectations" in that the absolute total deviation between type k's beliefs and the true frequencies fall as k rises. Therefore, for high enough k, type k and type k+1 players will have approximately the same beliefs. Camerer, Ho, and Chong (2004) show that CH works well in both entry games and "beauty contest" games (Nagel 1995; Ho, Camerer, and Weigelt 1998).[6]

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. Beliefs are therefore not mutually consistent. Instead, each player acts if they can perfectly predict their rivals' actions, leading to a unique outcome. This outcome can be short lived because players may revise their beliefs and have an incentive to deviate once they observe other's actions. This outcome can also be long lasting if changing actions is time-consuming and costly, or noises in the environment delay (or even prevent) players from updating their beliefs. While fully acknowledging the caveats of the CH model, we argue that our focus on a new industry, where naïvety and noise are prevalent, gives us an ideal platform for the application of the CH model.

A small literature has taken this model and examined its consequences for market outcomes. Hossain and Morgan (2007) develop a theoretical model that shows that in a two-

[6] In the standard beauty contest game, players are asked to pick a number between 1 and 100. The winner is the player who chooses the number closest to two-thirds of the average of all the players. Using diverse subject pools, the Nash outcome of all players choosing 1 explains actual choices poorly.

sided market, when players behave according to a CH model rather than a standard equilibrium model, the market often has a unique tipped equilibrium. Goldfarb and Yang (2008) show that strategic ability slows the diffusion of a new product when retailers are strategic. We are not aware of any paper that has explored how manager and firm characteristics correlate with strategic ability as identified by a behavioral game theory model.

Related Structural Models

We apply the CH model to an entry game. There is a rich literature on estimation of entry games in economics starting with Bresnahan and Reiss (1990, 1991). They link population thresholds for entry with changes in firms' competitive conduct by estimating a static entry game from cross-sectional variation in the number of firms and in population. 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 only study the numbers of different types of entrants in an equilibrium (Mazzeo 2002; Greenstein and Mazzeo 2006), to revise certain features of the game such as information structure (Seim 2006), to estimate the game under different equilibria to check robustness (Jia 2008), or to focus on bounds instead of point identification (Ciliberto and Tamer 2007). 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 utilize rich firm-level information in an entry game instead of abstracting the differences away or just focusing on a few categorical variables. Furthermore, by adding a structural parameter of strategic ability to the standard entry models, it is possible to conduct simulations to assess how the impact of subsidies varies with manager ability.

A small number of other papers have explored estimating behavioral biases in games played by real-world firms. Aradillas-Lopez and Tamer (2008) develop a semi-parametric model to estimate rationalizability in entry games but do not take it to data (though Collard-Wexler (2008) gives a simple estimation example). Consistent with the rationalizability literature (e.g., Bernheim 1984), they model level 0 as the set of all possible actions, level 1 as the set of all possible best responses to level 0, level 2 as the set of all best responses to level 1 (that are also best responses to level 0), etc.

In contrast, our approach is parametric, and we impose more structure on the meaning of level 0. This structure allows us to estimate heterogeneity in strategic ability rather than a lower bound on the level of ability in the market. Brown, Camerer, and Lovallo (2007) compare quantal response equilibrium, cursed equilibrium, and CH in the context of movie distributors' decisions to show movies to critics. Hortacsu and Puller (2008) show that older, more experienced firms behave closer to the Nash equilibrium prediction than other firms in electricity auctions. Che, Sudhir, and Seetharaman (2007) and Lim and Ho (2007) also explore the consequences of behavioral assumptions to firms. Finally, Goldfarb and Yang (2008) apply a similar CH-based model to data on 56k modem adoption by Internet Service Providers. Lacking data on manager and firm characteristics, Goldfarb and Yang emphasize the simulation results showing that firms with higher estimated ability were more likely to still be operating 10 years later and that an increase in strategic ability would have slowed the diffusion of 56k modems.

Relating Firm and Manager Characteristics to Actions and Performance

By exploring which firm and manager characteristics correlate with more steps of thinking, we address a growing literature on the link between firm (and manager) characteristics and firm performance. Bloom and Van Reenan (2007) examine the correlation between management practices, management characteristics, and firm performance. They provide evidence of heterogeneity in the ability of managers. They also suggest some potential correlates with decision quality, including whether the firm is privately owned and the level of product market competition. Kaplan, Klebanov, and Sorenson (2008) show correlations between success and specific interpersonal and execution skills. Bertrand and Schoar (2003) track top managers as they move across firms and show robust evidence of heterogeneity in manager ability. Furthermore, they find that older executives tend to be more conservative while managers with an MBA tend to be more aggressive. Chevalier and Ellison (1999) study the relationship between market excess returns and manager characteristics using a cross section of mutual funds managers. They find that managers who attended better undergraduate institutions obtain higher returns even after adjusting for behavior differences and selection biases. Baker, Ruback, and Wurgler's (2007) review article on behavioral corporate finance discusses other papers that address similar themes, including the roles of firm age and ownership structure. Laboratory research also suggests correlations between characteristics and ability. Chong, Camerer, and Ho (2005) show that strategic ability is correlated with education level and quality and with training in game theory. Slonim (2005) shows that ability is correlated with experience.

This literature therefore suggests many possible covariates to include in our assessment of which firm and manager characteristics might be correlated with ability. We include several of these in our analysis.

3) Data and Motivating Analysis

3.1) Data Description

We combine information from several different sources to create a unique dataset which contains details on firms' entry decisions, firm- and manager-level characteristics, and market attributes.

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 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 the incentives and 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.[7] In addition, for a subset of CLECs, we have limited information on revenues (overall and from local phone service) and the number of employees.

[7] Specifically, we use three sources for this alternative definition: 1) 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), 2) Crandall (2005) mentions several bankruptcy-related exits, and 3) newspaper archive searches generate 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.

Second, using the information on CEO names from the NPRG reports, we conducted a thorough search of several publically archived sources to identify CEO characteristics, including education (highest degree, field of study, and school attended), age, and industry experience. 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.[8] In the end, we obtain education information for 75% of the CEOs in our data and age and experience information for 74%. When the data are missing, rather than drop those firms from our sample, we code the values as zero and create "missing data" covariates for experience, age, and education as controls. The coefficients on the missing data covariates have no economic interpretation.[9]

Lastly, we obtain information on location characteristics from the 2000 US Census. The locations in the NPRG reports are best interpreted at the Census "place" level rather than the county or metropolitan statistical area. The Census provides place-level demographic information from the Census of Population but not place-level business information from the Economic Census. We selected the following variables for our analysis: population, household

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[8] Both coauthors and an undergraduate research assistant conducted the search. All information found by the research assistant has been confirmed by one of the coauthors. The search algorithm is as follows: 1) if public, search 10-K reports for biographical information (otherwise skip to Step 2), 2) search company websites for biographical information, 3) search *Who's Who* archives, 4) search news archives for mentions of the company and the individual in the same article (allow for alternative names such as Bob for Robert), 5) search Google for mentions of the company and the individual, 6) 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, 7) have a second person visit each source and confirm. If unsure about the match between the CLEC manager and the individual found in our search, we do not include the data (for example, we found information about a "Karl Douglas" with links to the telecommunications industry but we could not confirm that it was the Karl Douglas from REACH Communications).

[9] This method of dealing with missing data may produce biased estimates in our setting if the missing covariates and other covariates are correlated (e.g. Allison 2002). However, Jones (1996) shows that the signs of coefficients in interest do not change. Further, the combined prediction with the missing values is consistent. Therefore our counterfactuals, which include the missing variables in simulation, will still be valid exercises. We just need to be somewhat cautious in the interpretation of the magnitude of the estimated coefficients.

income, racial composition, median age, number foreign born, household size, and poverty rate.[10]

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.[11]

Tables 1a, 1b, and 1c provide descriptive statistics. Table 1a shows that these firms are generally privately owned (64.5% 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 18 years experience in the industry and are highly educated. Of the firms operating in 1998, 58% of managers have a graduate degree and 78% have at least one degree in economics or business. The table also shows the high turnover rate in the industry. Nearly 60% 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. Table 1c summarizes the data at the firm-market level.

[10] In one robustness check, we include information from the FCC on whether there were any competitive access providers in the place prior to 1995 (Federal Communications Commission 1999).

[11] 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.

3.2 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 older, appropriately educated, experienced managers tend to enter markets with fewer competitors. In particular, we estimate the following probit regression for firm j in market m:

$$Entry_{jm} = \alpha_0 + \alpha_1 \left(\#\,competitors\right)_{\mathrm{m}} + Z_j \alpha_2 + \left(\#\,competitors\right) Z_j \alpha_3 + X_m \alpha_4 + \varepsilon_{jm} \qquad (1)$$

where $Entry_{jm}$ is a binary variable for the entry decisions of firm j in market m; Z_j are manager characteristics including age, experience, and education (economics or business training); X_m are market characteristics including population, household income, racial composition, median age, number foreign born, household size, poverty rate, GTE presence, and Regional Bell Operating Company presence; and ε_{jm} is the error term. Of interest in this regression are the signs of the interaction terms between the number of competitors and manager characteristics (α_3), which measure whether manager background mediates the relationship between competition and entry.[12]

The number of competitors in the above regression is potentially 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.

[12] To address concerns expressed in Ai and Norton (2003), we confirmed that marginal effects at mean values yield the same sign as the interaction terms.

Table 2 shows the results. Columns 1 through 4 use the specification in Equation (1). The negative coefficients on the interaction between number of competitors in the market and manager characteristics show that older, more educated (in business and economics), and more experienced managers are more likely to enter markets with fewer competitors. To ensure that the above results are not washed out once we consider that better managers may choose to enter markets with more favorable characteristics, Column 5 includes interaction terms between manager characteristics and market population and Column 6 includes interaction terms between manager characteristics and all nine market-level controls in the data. While the age and education results disappear in the last column, overall we see this table as suggestive of an intriguing, and perhaps non-standard, relationship between manager characteristics and firm entry decisions. Managers with more education and experience appear to better anticipate competitor decisions that occur at roughly the same time. Since the market-level demographics control for the overall appeal of the market, this is not simply a matter of older, more educated, and more experienced 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. The structure provides insight into manager decisions and policy consequences in a newly forming industry.

4) Model

In this section, we describe how we model heterogeneity in managerial ability in an oligopolistic entry game.[13] 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.

[13] This section builds on the estimation strategy in Goldfarb and Yang (2008).

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 midsized markets took off in 1998. In addition, while companies did announce "planned" market entry, there appears to be little correlation between these plans and actual entry decisions.[14] 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 without any 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. Higher-level players consider their competitors' behavior while evaluating the potential payoffs of each strategy.

More formally, at a given time period, J_m potential entrants are simultaneously deciding whether to enter market m. Market demand is public information except for a firm- and market-specific stochastic term. All firms make decisions based on expected market profitability and expected competition with other firms. However, these firms have different levels of strategic

[14] 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 1998-99 took between six and eighteen months, depending on the market.

ability, type k $\left(k = 0,1,2...\right)$, which is drawn from a Poisson distribution with parameter τ_j $\left(j = 1,2,...,J_m\right)$. τ_j is a deterministic function of firm attributes such as ownership structure and firm age as well as manager characteristics such as manager experience and education. Parametrically, $\tau_j = \exp(\gamma_0 + Z_j\gamma)$ where Z_j is a vector of all the covariates that affect the strategic ability of firm j.[15] Firm j does not observe its competitors' specific types, but all τ_j is public information.

As τ_j increases, firm j is more likely to be a higher type player who has a better perception about the type distributions of its potential competitors. A type k player believes all its competitors have lower types up to $k-1$. Specifically, it believes that a potential competitor i $\left(i \neq j\right)$ is distributed with a Poisson distribution truncated at $k-1$ with parameter τ_i. If the potential competitor i has a high τ_i, firm j will perceive i as more likely to be a higher type.

A potential entrant decides whether the expected discounted value of the future profit stream is sufficiently high to support its entry. Firm j considering entering market m has an expected discounted value of future profits conditioning on its type k, which is specified below:

$$E\left(\Pi_{jm} \mid k\right) = \beta_0 + X_m\beta + \psi E\left(\#entrants \mid X_m, \tau_i, k\right) + \varepsilon_{jm} \qquad (2)$$

We adopt the above reduced-form profit function for its tractability. Equation 2 states that the type-variant expected discounted value of future profits, $E\left(\Pi_{jm} \mid k\right)$, depends on a vector of time-invariant market attributes X_m, a perceived competition variable that will be discussed below, and an idiosyncratic error term with standard normal distribution reflecting unobserved firm- and market-specific heterogeneity in expected profits. The entry decision of firm j is a dichotomous

[15] We use exponential functional form to ensure τ_j is non-negative, as required by the Poisson distribution.

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 $E(\Pi_{jm} \mid k) \geq 0$, and $D_{jm} = 0$ otherwise.

In the above formulation, X_m contains market-level variables 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 X_m include local demographic variables such as race, age, household size, population mobility, household income, poverty rate, and whether the incumbent local telephone company is GTE, a "Baby Bell," or another company.

The focus of this study is each firm's perception about the competition it will encounter upon entry; that is, $E(\#entrants \mid X_m, \tau_i, k)$ in Equation 2. The expectation is conditioned on each firm's own type, all the potential entrants' strategic ability, and market attributes. A type 0 firm, which does not take competitor entry into consideration, has an expected discounted value of future profits of:

$$E(\Pi_{jm} \mid 0) = \beta_0 + X_m \beta + \varepsilon_{jm} \tag{3}$$

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

$$E(\Pi_{jm} \mid 1) = \beta_0 + X_m \beta + \psi E\left(\sum_{i \neq j} D_{im} \mid X_m, Truncated\,Poisson(\tau_i, 0), 1 \right) + \varepsilon_{jm} \tag{4}$$

where $Truncated\,Poisson(\tau_i, 0)$ 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 τ_i and truncated at 0. For a type 1, the assumed distribution is therefore not relevant. The truncation means that the type 1 player assigns 100% probability to its competitor's likelihood of being a type 0. The type 1 then uses the profit function specified in Equation 3 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 $k > 1$, its perceived distribution of its competitor types is drawn from $Truncated\,Poisson(\tau_i, k-1)$. As k increases, the discrepancy between $Truncated\,Poisson(\tau_i, k-1)$ and $Truncated\,Poisson(\tau_i, k)$ gradually disappears and the truncated Poisson gradually approaches the real Poisson distribution. That is, a high type player is able to make decisions based on nearly correct beliefs on its rivals' expected behavior. [16]

The estimated parameters are $\theta = [\beta_0, \beta, \psi, \gamma_0, \gamma]$, where β measures how a firm' expectation about a market's profitability is affected by X_m, ψ measures how the same expectation is affected by the perceived competition, and γ measures how firm- and manager-specific characteristics shift a firm's strategic ability. As econometricians, we do not observe any given firm's type. Therefore, to estimate θ, we need to evaluate each firm's entry probabilities by conditioning on all possible types and integrate these probabilities over the distribution of types to predict the entry probability of this firm. We match the entry probabilities of all firms to the data using a standard maximum likelihood procedure. Specifically:

$$\hat{\theta} = \arg\max \sum_{j,m} \ln\left(prob\left(D_{jm} = 1\right)^{D_{jm}} \; prob\left(D_{jm} = 0\right)^{1-D_{jm}} \right) \qquad (5)$$

To conclude this section, we discuss the identification of this model. We identify the degree to which manager and firm characteristics correlate with the latent ability distribution parameter, τ_j, rather than the exact number of steps of consideration the firms undergo. The

[16] 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 eight or more types.

number of steps of consideration or the type of a firm is the firm's private information, and therefore both the firm's rivals and we the econometricians can only assess of the probability of each possible type given our observation or estimate of τ_j, which is a function of firm- and manager-specific characteristics. Given that we observe firms with different firm- and manager-specific characteristics make systematically different entry decisions in similar markets with the same number of entrants, we identify the relationship between the firm and manager characteristics and τ_j from an exclusion restriction, and we identify the scale of τ_j off of the Poisson and $\tau_j = \exp(\gamma_0 + Z_j\gamma)$ functional forms.

To be more concrete, Table 2 shows that firms with more experienced managers are systematically less likely to enter markets with a large number of competitors. Thus, our model will generate higher τ_j for managers with more experience and therefore an increased likelihood of high types. In order to determine the impact of firm- and manager-specific characteristics on a firm's ability to consider its competition, we need these characteristics to be excluded from the covariates that determine market profitability aside from perceived competition. Therefore, we assume that manager characteristics such as age, education, and experience only affect profitability through their impact on manager decisions. In other words, we identify γ to the extent that a manager's education is not correlated with a firm's propensity to enter markets with few competitors except through strategic decision-making. We feel this is reasonable because customers are unlikely to patronize a company simply because its CEO has an economics degree. This exclusion restriction also implicitly means that the characteristics of the managers of other potential entrants function as instruments for the number of competitors in a market. As discussed earlier, the number of competitors is endogenous: some unobserved market level heterogeneity may drive the entry decisions of *all* potential entrants. In our model, all manager characteristics are determined before the realization of the market level systematic shocks. The characteristics of the managers of a firm's potential competitors therefore only affect the firm's entry decisions through their influence on the potential competitors' actions. 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 number of entrants; that is, they function as implicit instruments.

As a final point on identification, we note that the constant term in τ_j is identified from the functional form of the strategic ability function. While we have explored robustness to alternative functional forms and find largely similar results, we need to be cautious in our interpretation of the overall level of strategic ability in the market. We can, however, compare across markets and across years given that we use the same functional form assumptions throughout.

5) Results

We first present the coefficient estimates for 1998. As discussed above, this was effectively the first year of entry in these mid-sized 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. We then examine the correlation between the estimates of strategic ability and two measures of firm performance: survival and revenue. At the end of this section, we simulate the consequences of a subsidy to show that subsidies are most effective when strategic ability is high.

5.1) What Drives Strategic Ability?

In this sub-section, we examine whether the standard information on a manager's biography relates to strategic ability. We also relate firm characteristics to ability. Table 3 Column 1 shows the main results. The top part of the table shows the coefficients for the strategic ability function and the bottom part of the table shows the coefficients for market attributes used in estimating the latent profitability of entry. Before turning to our analysis of firm- and manager-level characteristics, we note the strong negative relationship between the expected number of competitors and the level of entry (Row 17). This is the most statistically significant result in almost all specifications and shows that firms appear to know, on average, that they should avoid direct competition. Therefore, it is empirically relevant to examine how variation in strategic ability leads to variation in the avoidance of competition.

Rows 1 to 7 show the coefficients for manager-level characteristics in driving measured ability (ln (τ)), and Rows 8 to 11 show coefficients for firm-level characteristics. In discussing the results, we focus on three areas: experience, education, and ownership structure.

Experience: Experience is widely viewed as an asset for managers. It is emphasized in manager bios and on company annual reports. Laboratory research has shown experience is positively correlated with ability in beauty contest games (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 with experience. Specifically, we find that older firms have higher values of τ (Row 8). Older managers also have higher levels of τ, while managers under 40 have especially low levels of τ (Rows 1 and 2). We define age by three dummy variables rather than as a continuous measure in order to starkly test the hypothesis that ability improves with age up to a point, but then decreases for managers more than one standard deviation above the mean. Our results reject the idea that older managers become less sophisticated as they age. Instead, we find that CEOs in their thirties tend to act naïvely about competition, which supports the traditional industry practice of hiring middle-aged CEOs. Furthermore, while not significant in all specifications, a manager's experience in the industry is positively correlated with τ (Row 3).

Education: We examine three different aspects of education: field (Rows 4 and 5), level (Row 6), and quality (Row 7). 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 in either economics or business (where they likely learned about game theory) have higher levels of τ. The quality and level of the degree, however, are not systematically correlated with τ. Managers with graduate degrees and those with degrees from schools in the US News list of top 25 colleges do not have higher levels of measured strategic ability. The latter result is robust to using the top 50 colleges.

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 tend to have lower measured ability (Row 9). We see two possible explanations for this: 1) 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 2) 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 were older and had more years experience than the other CLEC managers in our sample. We find no consistent relationship between measured ability and either private ownership (Row 10) or venture-capital backing (Row 11).

The remainder of Table 3 shows robustness to a number of alternative specifications. Table 3 Column 2 keeps only the four most significant covariates in *Z* from Column 1. Column 3 adds population as a predictor of strategic ability, while Column 4 uses an alternative functional form for τ: $\tau_j = K\Phi\left(\gamma_0 + Z_j\gamma\right)$, where $\Phi\left(.\right)$ is the density function of the standard normal distribution and K is the maximum number of types we allow for estimation. The core results do not change, though the coefficient on manager experience loses significance.

Table 4 shows robustness to alternative samples. Column 1 defines potential entrants only as those 79 firms that did eventually enter the CLEC market rather than all firms licensed to do so. The core results described above are unchanged, though again experience loses significance. Column 2 excludes the few markets that had at least one competitive access provider with rights to a local telephone number (though they may not be operating yet) in the fourth quarter of 1994. Here, experience gains significance, but whether the manager has a degree in economics or business loses significance. Column 3 estimates the model using 2002 data. While many results are robust, we are cautious in interpreting the coefficients from 2002 since the entry decisions can no longer be considered simultaneous. The main purpose of the 2002 estimation is to compare the measured value of strategic ability across years.

5.2) Measured Strategic Ability in 1998 and 2002

In the 1998 data, the average value of τ is 3.13 (Table 3 Column 1 Row 28). This means that 4% of firms are type 0, 14% are type 1, 21% are type 2, 22% are type 3, 17% are type 4, and 22% 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 providing support for the CH model. Given that this is a more important decision than those faced by laboratory subjects, we expect the value of τ to be higher. Still, we want to be cautious in our interpretation of the value of τ because the constant (Row 16) is only identified on the functional form. We are much more comfortable comparing the relative importance of manager and firm characteristics to strategic ability and comparing the value across years using the same functional form than interpreting the level of τ in any absolute sense.

Table 4 Column 3 Row 27 shows that τ increases to 4.82 using 2002 data. The measure of ability requires a different interpretation in this year because firms could observe what competitors 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 shakeout as supporting evidence for an evolution towards the steady equilibrium outcome assumed in much of the existing simultaneous entry literature (e.g., Greenstein and Mazzeo 2006).

At the same time, the variance of τ across firms increases over time. Comparing the minima and maxima of τ across the two years, it seems that the emergence of highly sophisticated firms after the shakeout drove the increased variation. It also indicates that although the industry as a whole increased in sophistication over time, naïvety persisted. Given that this is an industry with a high turnover rate and that we already showed new firms to be less likely to act strategically, this pattern is not surprising. Some questions, however, still 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.

5.3) 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.[17]

Table 5 shows the results. The core independent variable in these regressions is the predicted value of τ for each firm, based on the coefficients in Table 3 Column 1. We find that the predicted τ is positively correlated with four different definitions of success: 1) survival as defined by appearing in the 2002 NPRG reports, 2) survival as defined by not having an accessible public record of exit through failure, 3) revenue (conditional on survival), and 4) local phone service revenue (conditional on survival).

Since we predict the value of τ from a simple log linear 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 firm and manager characteristics drive survival for reasons other than strategic ability. Consistent with the prior literature (e.g., Dunne, Roberts, and Samuelson 1988), we especially suspect that firm age and size have effects on firm survival, independent of τ. Therefore, we include these as controls. The results are robust. While certainly not conclusive, we view these results as providing some external validity for our model.

5.4) Counterfactual Analysis: Subsidies and Strategic Ability

Next, we examine how the impact of a subsidy varies with strategic ability. The CLEC industry was highly subsidized in two ways. First, there was an implicit government subsidy. The 1996 Act forced the incumbents to provide CLECs with access to their facilities and rights

[17] 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.

of way and to allow CLECs to interconnect at any technically feasible point. At the simplest level, this meant that facilities-based CLECs did not have to build their own poles, ducts, and conduits and that their customers could call customers of the incumbent carriers. Both of these saved CLECs considerable expenditures. A number of other regulations gave the CLECs even more generous access to incumbent networks, though the courts overturned many of these by 2006. Second, equipment manufacturers (especially Nortel and Lucent) provided generous loan terms under which CLECs could deploy state-of-the-art telecommunications equipment with little advance payment and low interest rates.[18]

Since we do not have dollar figures in our model, we simulate a subsidy as being equivalent to an increase in the population of a place. We examine the consequences of subsidies equal to increases in population of 20,000 and 50,000 as the average level of ability in the market changes.[19] We aim to illustrate that the impact of subsidies depends on the levels of strategic ability of firms in an industry.

In Figure 2, we examine ex-post regret. By "regret" we mean that firms would have made a different decision had they correctly conjectured competitor behavior. The line showing the results without a subsidy clearly shows that as strategic ability increases, the level of regret falls. This is by construction of the model. Since we define strategic ability as the ability to correctly conjecture competitor behavior, higher ability means less regret. Figure 2 illustrates two findings relating to subsidies and ex-post regret. First, a subsidy seems to inevitably lead to a higher level of regret, meaning that a larger proportion of a CLEC's choices are less profitable than they would have been with a more accurate conjecture of competitor behavior. The reason is that

[18] See Crandall (2005) and Goldstein (2005) for more details. We now know that Nortel's sales to CLECs helped artificially inflate reported profits in the late 1990s.
[19] For each counterfactual experiment, we take 1000 draws from the error distribution and report the average results across the 1000 simulations.

firms with less-than-perfect ability tend to incorrectly gauge the impact of a subsidy on their competitors' entry decisions. Second, the comparison between low and high levels of ability shows that the gap in the level of regret between subsidized and unsubsidized markets narrows as strategic ability rises. When average τ is 2, the gap between regret in markets with high subsidies and markets with no subsidies is seven percentage points. This gap narrows to two percentage points when average τ is 4.5, suggesting that the problem of subsidies leading to more regret is attenuated when average ability is higher. Thus, subsidizing an industry with low average strategic ability may have the unintended consequence of stimulating too much regret, thereby leading to frequent turnover. This hurts the objectives of a government hoping to encourage a thriving industry and of an equipment manufacturer waiting to have its loans repaid.

Figure 3 focuses on markets that would not have any CLEC entrants without the subsidy. It explores whether subsidies reduce the number of un-served markets. For low levels of strategic ability, subsidies have little impact on un-served markets. In contrast, when average ability is high, subsidies substantially reduce the percentage of un-served markets. Thus, subsidies only encourage widespread local phone competition if strategic ability is high. Given that the measured level of ability in our estimates is 3.13, the simulations suggest that the implicit and explicit subsidies to the industry served to increase the competition in markets that were competitive anyway and did little to generate competition in un-served markets.

What explains this? When strategic ability is high, firms correctly infer the markets with the greatest marginal benefit of entry after the injection of a subsidy. These are often the underserved markets, which tend to have smaller populations. The subsidy consequently generates entry into these markets. In contrast, when strategic ability is low, firms incorrectly guess at competitor behavior. As a result, they fail to recognize the existence of many open markets, where the overall appeal of entry is greatly enhanced by the subsidy. Overall, this exercise shows that a subsidy is a weak policy tool in industries with low strategic ability.

6) Conclusions

Overall, our approach provides insights into the incidence of strategic ability in a new market: Local telephone competition following the 1996 Act. We show that firm behavior is related to manager and firm characteristics in a systematic way. Generally, older firms with educated, experienced managers made decisions that suggest they were better able to correctly conjecture competitive behavior. In order to better understand this relationship, we impose a structural model of strategic ability based on the Cognitive Hierarchy model. Based on our estimates of this model, our simulations show that the effects of subsidies depend strongly on the strategic ability of the market participants; subsidies are most effective when the level of ability is high. At the level of ability estimated in our results, subsidies do little to increase the number of markets served by CLECs.

Three aspects of our results suggest considerable validity for our model in this setting. First, the coefficient estimates are suggestive that the strategic ability parameter, τ, is correlated with intelligence and experience. Managers that are trained in economics or business (and therefore are particularly likely to have been exposed to game theory) are estimated to be more sophisticated. Furthermore, managers with more experience (measured by years in the industry and age) are estimated to be more sophisticated. Second, our estimate of τ increases following the shakeout, which suggests that the industry became more sophisticated in its aftermath. Third, 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.

As with any empirical work, this paper has a number of limitations. First, we explore a very specific type of ability: the ability to correctly conjecture competitor behavior. We cannot say anything about the many other dimensions of managerial ability. Second, the analysis is not a test of CH against Nash because the Nash concept is not nested in our model and therefore not directly testable. We use the CH model because it provides a formal structure for the descriptive relationship between manager characteristics and entry decisions. There are other possible explanations that we cannot reject (for example, educated experienced managers may be better able to get inside information about what other firms are doing). Still, as discussed above, we rely on laboratory experiments as support for the framework and argue that our results have both internal and external validity and they are consistent with industry accounts. 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 uneducated, inexperienced CEOs rather than about the CEOs themselves. On a related note, it is possible that the education and experience of CEOs is correlated with the education and experience of the other employees and that we are therefore measuring the overall level of education and experience in the company rather than anything to do with the CEO per se. 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. Our results help explain several aspects of early competition in local telephone markets.

We provide an explanation for why firms run by educated, older, more experienced managers operated in markets with fewer competitors. In addition, our counterfactual analysis helps understand why, despite substantial subsidies, many markets remained un-served by CLECs while demographically similar markets had a large number of entrants.

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Table 1a: Descriptive Statistics by CLEC

	1998		2002	
Variable	**Mean**	**Std Dev**	**Mean**	**Std Dev**
# markets to enter	61.520	66.852	90.312	70.634
# markets entered	4.916	9.362	15.671	16.787
Firm age	7.927	17.899	10.281	14.893
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 1998 (N=82)	3489.0	16608	N/A	
Survive to 2002	0.406	0.494	N/A	
Alternate definition of survive to 2002	0.688	0.466	N/A	
Revenue 2002 (million $, N=48)	535	1550	N/A	
Local phone revenue 2002 (million $, N=46)	150	362	N/A	
Manager characteristics (conditional on being observed)				
Any economics or business degree	0.783	0.415	0.755	0.434
Any graduate degree	0.583	0.496	0.551	0.501
Any engineering or science degree	0.396	0.493	0.372	0.488
Any degree from US News top 25 school	0.400	0.493	0.275	0.450
Age	46.619	9.040	48.297	7.138
Experience	18.436	8.162	19.685	9.683
# of observations (CLECs)	96		64	

Table 1b: Descriptive statistics by market (N=234)

Variable	Mean	Std Dev	Min	Max
Population (in thousands)	224.07	160.84	100.27	951.27
% African American	0.178	0.180	0.003	0.840
Median age	32.80	3.079	22.9	41.8
Household size	2.636	0.418	2.03	4.55
% foreign born	0.156	0.125	0.011	0 .721
Median household income (in $1000)	41.67	11.67	23.48	88.77
% below poverty line	0.145	0.063	0.022	0.356
GTE	0.107	0.310	0	1
RBOC	0.808	0.395	0	1

Table 1c: Descriptive statistics by CLEC-market

	1998		2002	
	Mean	**Std Dev**	**Mean**	**Std Dev**
Entry	0.080	0.271	0.173	0.378
Population (in thousands)	222.40	160.76	229.02	165.73
% African American	0.169	0.170	0.188	0.179
Median Age	32.75	3.13	32.86	3.10
Household Size	2.67	0.440	2.62	0.404
% Foreign Born	0.171	0.131	0.156	0.127
Household Income (in $1000)	42.33	12.16	41.05	11.70
% below poverty line	0.140	0.063	0.149	0.063
GTE	0.118	0.323	0.109	0.312
RBOC	0.802	0.398	0.806	0.395
Privately owned	0.432	0.495	0.439	0.496
Financed by venture capital	0.160	0.367	0.269	0.443
Firm age	13.71	27.26	12.94	21.84
Subsidiary	0.211	0.408	0.182	0.386
Experience	15.54	9.87	17.02	11.33
Age below 40	0.159	0.365	0.067	0.251
Age above 55	0.243	0.429	0.248	0.432
Any graduate degree	0.573	0.494	0.501	0.500
Any economics or business degree	0.553	0.497	0.636	0.481
Any engineering or science Degree	0.225	0.418	0.330	0.470
Any degree from US News top 25	0.409	0.491	0.271	0.445
Experience missing	0.164	0.370	0.122	0.328
Age missing	0.076	0.265	0.148	0.355
Education missing	0.135	0.342	0.033	0.180
# of observations (CLEC-markets)	**5906**		**5780**	

Table 2: Probit regressions of 1998 entry on manager characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
	Controls for manager characteristics and demographics	**Controls for manager characteristics and demographics**	**Controls for manager characteristics and demographics**	**Controls for manager characteristics and demographics**	**Adds interactions of manager characteristics with population**	**Adds interactions of manager characteristics with all place-level data**
# of competitors x	-0.055			-0.046	-0.058	-0.043
1(Manager over 40)	(0.025)**			(0.026)*	(0.026)**	(0.027)
# of competitors x 1(Manager has		-0.028		-0.028	-0.042	0.002
economics or business degree)		(0.015)*		(0.016)*	(0.021)**	(0.025)
# of competitors x			-0.002	-0.002	-0.002	-0.003
Manager experience			(0.001)**	(0.001)**	(0.001)*	(0.001)**
Pseudo-R^2	0.21	0.21	0.20	0.23	0.23	0.25
Log Likelihood	-1295.6	-1307.7	-1320.9	-1270.1	-1261.0	-1239.8
# of markets	234	234	234	234	234	234
# of CLEC-markets	5906	5906	5906	5906	5906	5906

For this table and all following tables, standard errors are reported in parentheses. *significant at 90% confidence level. **significant at 95% confidence level. ***significant at 99% confidence level.
Columns 1, 2, and 3 include Manager has economics or business degree, Manager experience, and Manager age, respectively, along with dummy variables for missing data, controls for population, % population black, median age, household size, % foreign born, average income, poverty rate, GTE presence, RBOC presence, and a control for the number of competitors. Column 4 includes all three manager characteristics and the same controls as columns 1-3. Column 5 adds the manager characteristics interacted with population. Column 6 adds manager characteristics interacted with each of % population black, median age, household size, % foreign born, average income, poverty rate, GTE presence, and RBOC presence. Full set of coefficients given in Appendix Table 1. To address concerns expressed in Ai and Norton (2003), we confirmed that marginal effects at mean values yield the same sign as the interaction terms.

Table 3: Strategic ability and entry coefficients (N=5906)

		Variables	(1) Main	(2) Limited covariates in τ	(3) Allow τ to vary by market size	(4) Alternative functional form $\tau_j = K\Phi(\gamma_0 + Z_j\gamma)$
Coefficients on strategic ability parameter ln(τ)	(1)	**Manager age below 40**	-0.046 (0.021)**	-0.981 (0.201)***	-0.153 (0.051)***	-0.066 (0.023)***
	(2)	**Manager age above 55**	0.019 (0.016)	-0.100 (0.175)	0.053 (0.034)	0.011 (0.018)
	(3)	**Log (manager years of experience in industry)**	0.035 (0.016)**	0.068 (0.189)	0.037 (0.035)	0.017 (0.018)
	(4)	**Manager has degree in economics or business**	0.027 (0.014)**	0.395 (0.198)**	0.062 (0.030)**	0.028 (0.016)*
	(5)	**Manager has degree in engineering or science**	0.017 (0.018)		0.043 (0.037)	0.005 (0.020)
	(6)	**Manager has graduate degree**	-0.005 (0.018)		0.0633 (0.035)*	-0.003 (0.020)
	(7)	**Manager has degree from US News top 25**	-0.016 (0.015)		-0.0626 (0.031)**	-0.013 (0.017)
	(8)	**Log (firm age)**	0.032 (0.007)***	0.742 (0.141)***	0.080 (0.017)***	0.038 (0.008)***
	(9)	**Subsidiary**	-0.057 (0.018)***		-0.142 (0.0401)***	-0.056 (0.020)***
	(10)	**Privately owned**	-0.012 (0.018)		-0.0523 (0.0371)	-0.028 (0.021)
	(11)	**Venture capital**	-0.030 (0.023)		0.0474 (0.048)	-0.017 (0.025)
	(12)	**Place population in millions**			1.055 (0.258)***	
	(13)	**Years of experience missing**	0.131 (0.049)***	-0.419 (0.476)	0.103 (0.110)	0.061 (0.055)
	(14)	**Manager age missing**	-0.109 (0.025)***	0.532 (0.212)**	-0.039 (0.050)	-0.052 (0.028)*
	(15)	**Manager education missing**	-0.028 (0.015)*	0.017 (0.221)	-0.051 (0.032)	-0.027 (0.017)
	(16)	**Constant in τ**	1.108 (0.053)***	0.013 (0.661)	0.588 (0.170)***	-0.273 (0.058)***
Coefficients on entry	(17)	**Expected # of competitors**	-1.22 (0.062)***	-0.394 (0.023)***	-0.691 (0.082)***	-1.152 (0.062)***
	(18)	**Place population in millions**	10.582 (0.658)***	6.655 (0.460)***	6.010 (1.138)***	10.468 (0.644)***
	(19)	**% black**	2.122 (0.824)***	0.752 (0.456)*	2.638 (0.732)***	2.008 (0.802)**
	(20)	**Median age**	0.043 (0.044)	0.010 (0.030)	-0.027 (0.046)	-0.009 (0.040)
	(21)	**Household size**	-1.055 (0.386)***	-1.569 (0.269)***	-0.864 (0.460)*	-0.440 (0.389)
	(22)	**% foreign born**	-0.843 (1.604)	1.811 (0.845)**	3.699 (1.412)***	-1.006 (1.394)
	(23)	**HH income in $1000**	-0.250 (1.224)	-0.247 (0.652)	-0.143 (1.150)	-0.268 (1.110)
	(24)	**% below poverty line**	8.165 (4.99)	7.544 (2.97)**	4.218 (5.115)	5.177 (4.644)
	(25)	**GTE**	1.482 (0.506)***	1.422 (0.339)***	2.196 (0.519)***	0.976 (0.469)**
	(26)	**RBOC**	0.919 (0.390)**	1.031 (0.274)***	1.878 (0.405)***	0.736 (0.373)**
	(27)	**Constant**	-0.227 (5.491)	-0.043 (3.074)	-0.350 (5.379)	0.584 (5.027)
	(28)	**Mean τ**	3.13	3.41	2.91	3.38
	(29)	**Minimum τ**	1.98	2.58	1.66	2.79
	(30)	**Maximum τ**	5.65	3.99	7.65	3.72
	(31)	**Log Likelihood**	-1307.8	-1310.2	-1294.4	-1309.5

Table 4: Alternative Samples

		Variables	(1) Potential entry means entered by end of 2002	(2) Only places without CAPs in Q4 1994	(3) 2002 data
Coefficients on strategic ability parameter ln(τ)	(1)	**Manager age below 40**	-0.052 (0.023)**	-0.122 (0.067)*	-0.331 (0.110)***
	(2)	**Manager age above 55**	0.014 (0.018)	0.006 (0.049)	0.353 (0.141)**
	(3)	**Log (manager years of experience in industry)**	0.016 (0.018)	0.076 (0.045)*	-0.009 (0.060)
	(4)	**Manager has degree in economics or business**	0.032 (0.015)**	0.015 (0.046)	0.161 (0.082)**
	(5)	**Manager has degree in engineering or science**	0.012 (0.020)	-0.028 (0.057)	0.313 (0.107)***
	(6)	**Manager has graduate degree**	0.009 (0.020)	0.093 (0.055)*	0.087 (0.085)
	(7)	**Manager has degree from US News top 25**	-0.027 (0.016)	-0.109 (0.055)**	-0.012 (0.114)
	(8)	**Log (firm age)**	0.039 (0.008)***	0.132 (0.035)***	0.166 (0.066)**
	(9)	**Subsidiary**	-0.0700 (0.020)***	-0.237 (0.065)***	-0.119 (0.080)
	(10)	**Privately owned**	-0.041 (0.021)*	-0.100 (0.056)*	0.067 (0.090)
	(11)	**Venture capital**	-0.002 (0.025)	0.015 (0.065)	0.221 (0.112)**
	(12)	**Years of experience missing**	0.068 (0.054)	0.257 (0.136)*	0.163 (0.188)
	(13)	**Manager age missing**	-0.064 (0.027)**	-0.083 (0.067)	-0.277 (0.125)**
	(14)	**Manager education missing**	-0.022 (0.017)	-0.039 (0.049)	0.242 (0.109)**
	(15)	**Constant in τ**	1.110 (0.061)***	0.750 (0.162)***	0.789 (0.286)***
Coefficients on entry	(16)	**Expected # of competitors**	-1.107 (0.077)***	-0.618 (0.082)***	-0.430 (0.052)***
	(17)	**Place population in millions**	9.381 (0.737)***	7.758 (0.831)***	10.063 (1.044)***
	(18)	**% black**	2.607 (0.843)***	1.822 (0.696)***	3.010 (0.616)***
	(19)	**Median age**	-0.004 (0.043)	0.001 (0.044)	-0.031 (0.031)
	(20)	**Household size**	-0.736 (0.414)*	-2.020 (0.404)***	-0.357 (0.247)
	(21)	**% foreign born**	1.716 (1.564)	2.651 (1.185)**	-0.515 (0.838)
	(22)	**HH income in $1000**	-0.079 (1.260)	0.073 (0.913)	-0.359 (0.604)
	(23)	**% below poverty line**	5.389 (4.864)	9.546 (4.090)**	7.701 (3.159)**
	(24)	**GTE**	1.450 (0.498)***	1.463 (0.498)***	0.412 (0.303)
	(25)	**RBOC**	0.663 (0.405)	1.173 (0.445)***	0.636 (0.247)**
	(26)	**Constant**	-0.077 (5.384)	-0.097 (4.289)	-0.241 (2.928)
	(27)	**Mean τ**	3.31	3.03	4.82
	(28)	**Minimum τ**	2.61	1.64	2.36
	(29)	**Maximum τ**	3.69	4.77	10.75
	(30)	**# of CLECs**	79	95	64
	(31)	**# of CLEC-markets**	5699	5201	6095
	(32)	**Log Likelihood**	-1295.2	-1105.7	-2458.8

Table 5: Firms with a higher τ are more likely to exit the industry early

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Survive in sample to 2002[b]		**Alternative definition of survival to 2002**[b]		**Log revenue in 2002**[c]		**Log local phone revenue in 2002**[c]	
τ [a]	0.158	0.385	0.087	0.237	0.900	1.301	0.752	1.403
	(0.080)**	(0.153)**	(0.075)	(0.137)*	(0.433)**	(0.794)	(0.446)*	(0.787)*
Log(firm age in 1998)		-0.184		-0.103		-0.280		-0.608
		(0.101)*		(0.092)		(0.525)		(0.518)
Log(employees in 1998)		0.002		0.009		0.402		0.496
		(0.025)		(0.024)		(0.150)**		(0.149)***
Constant					15.158	12.134	14.623	10.713
					(1.462)***	(2.082)***	(1.502)***	(2.066)***
# of observations	96	82	96	82	48	43	46	41
R^2	N/A	N/A	N/A	N/A	0.09	0.33	0.06	0.36
Log Likelihood	-62.79	-52.55	-58.93	-48.78	N/A	N/A	N/A	N/A

[a] τ is calculated from the coefficients in Table 3 Column 1. [b] Probit regressions. Marginal effects shown. [c] Linear regressions.
*significant at 90% confidence level. **significant at 95% confidence level. ***significant at 99% confidence level.

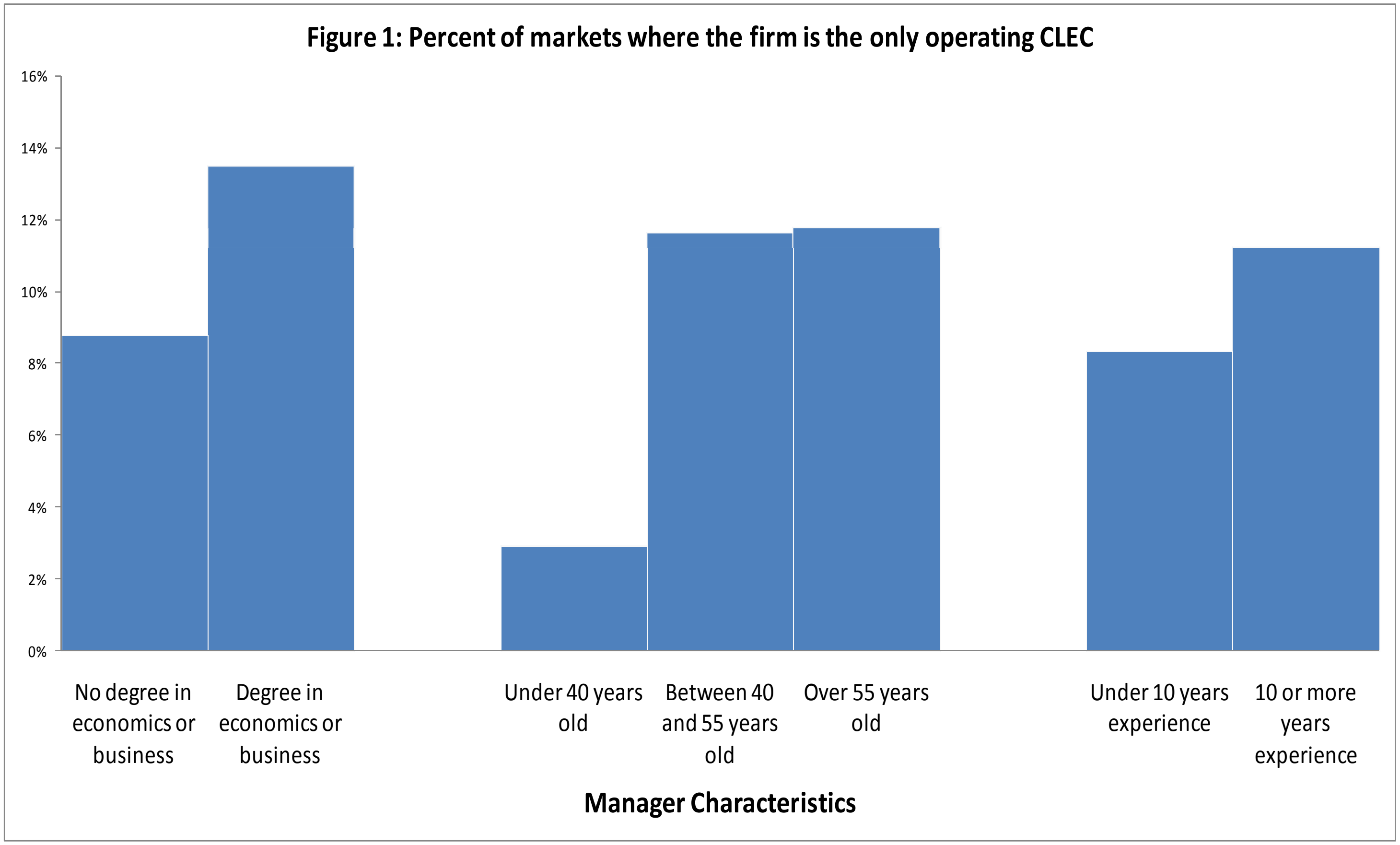
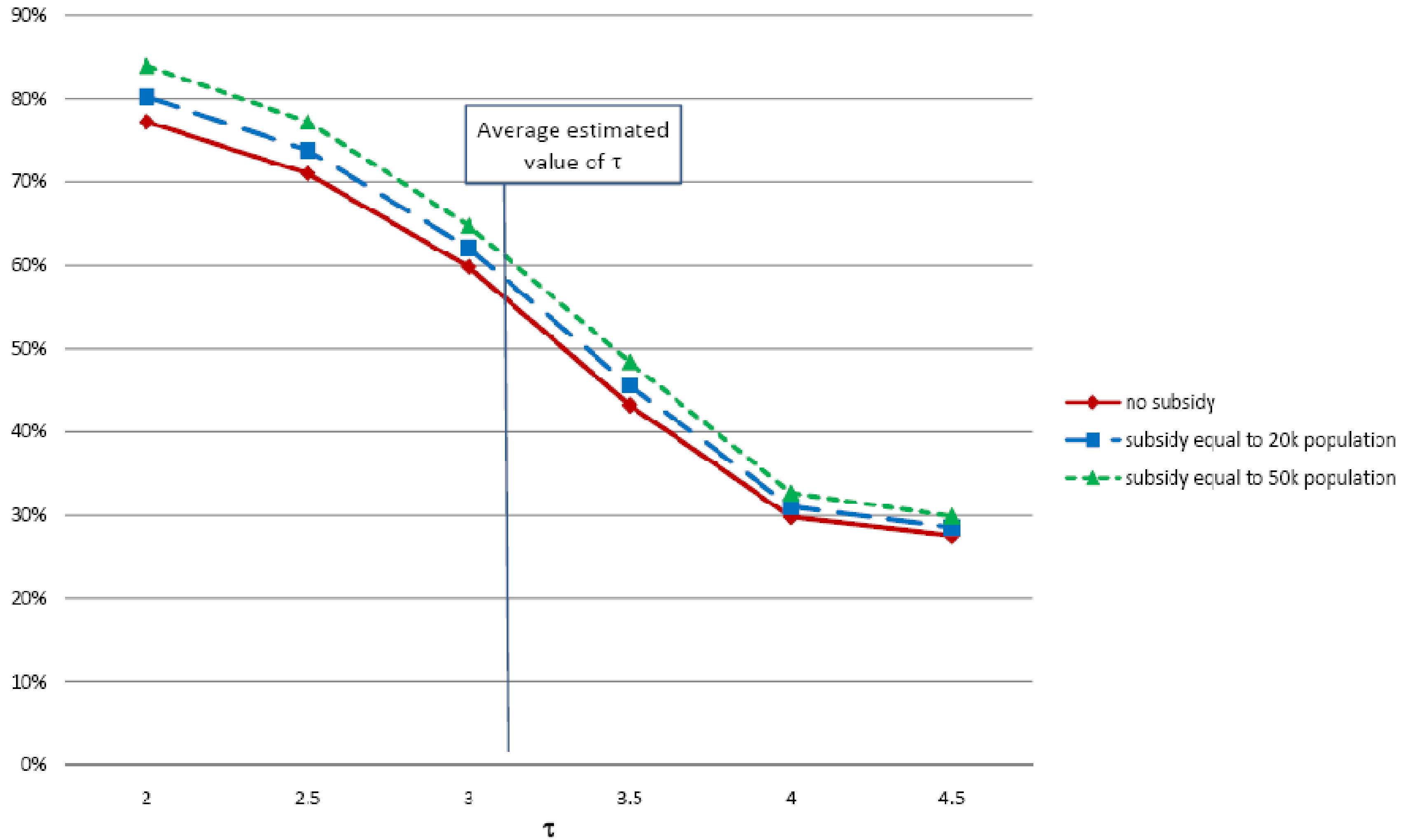


Figure 1: Percent of markets where the firm is the only operating CLEC
16%
14%
12%
10%
8%
6%
4%
2%
0%
No degree in economics or business
Degree in economics or business
Under 40 years old
Between 40 and 55 years old
Over 55 years old
Under 10 years experience
10 or more years experience
Manager Characteristics

Figure 2: Percent of decisions with ex-post regret



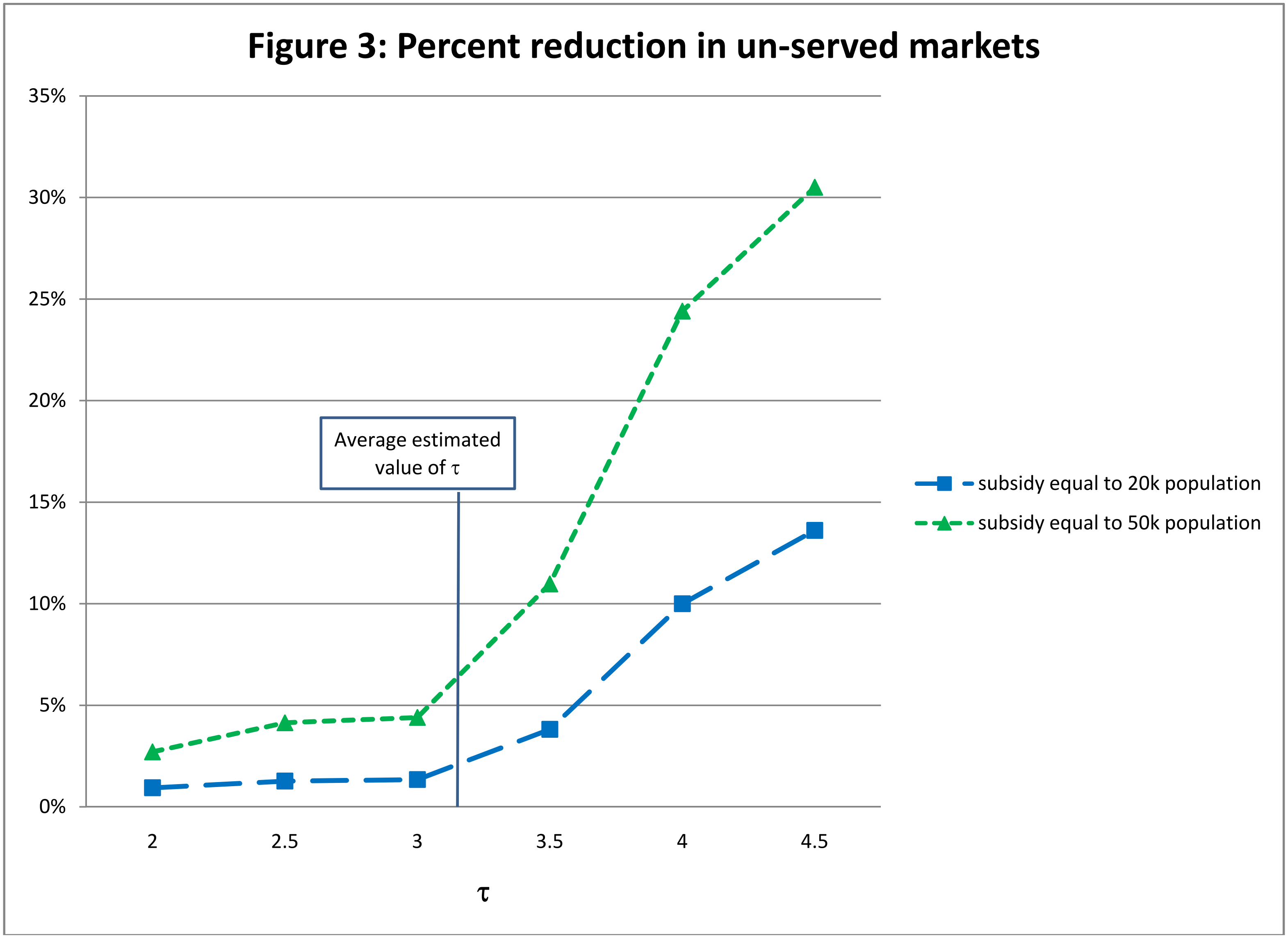


Figure 3: Percent reduction in un-served markets
35%
30%
25%
20%
15%
10%
5%
0%
Average estimated value of τ
2
2.5
3
3.5
4
4.5
τ
subsidy equal to 20k population
subsidy equal to 50k population

ONLINE APPENDIX

Who thinks about the competition?
Managerial ability and strategic entry in US local telephone markets

NOT FOR PUBLICATION

Appendix Table 1: Full set of coefficients from Table 2

	(1)	(2)	(3)	(4)	(5)	(6)
# Competitors × Manager age above 40	-0.0551			-0.0462	-0.0575	-0.0430
	(0.0245)*			(0.0263)+	(0.0263)*	(0.0268)
# Competitors × Manager has economics or business degree		-0.0275		-0.0277	-0.0418	0.0018
		(0.0151)+		(0.0162)+	(0.0207)*	(0.0247)
# Competitors × Manager experience			-0.0019	-0.0018	-0.0020	-0.0027
			(0.0008)*	(0.0009)*	(0.0011)+	(0.0013)*
Manager age above 40	0.8675			0.8794	0.7789	0.5434
	(0.1635)**			(0.1713)**	(0.1720)**	(0.1822)**
Manager age missing	-0.7416			-0.5693	0.0800	0.8636
	(0.1321)**			(0.1441)**	(0.1996)	(0.3114)**
Manager has degree in economics or business		-0.0643		0.0319	0.0042	-2.0620
		(0.0763)		(0.0810)	(0.1040)	(1.5739)
Education information missing		-0.8088		-0.6705	-0.7338	-0.7912
		(0.1193)**		(0.1290)**	(0.1299)**	(0.1338)**
Manager years experience			0.0084	-0.0003	-0.0015	-0.1035
			(0.0045)+	(0.0050)	(0.0063)	(0.0834)
Manager experience missing			-0.4164	-0.2565	-0.3258	-0.4719
			(0.1153)**	(0.1244)*	(0.1260)**	(0.1310)**
Number of competitors	0.0555	0.0781	0.0887	0.1064	0.1190	0.1072
	(0.0117)**	(0.0142)**	(0.0170)**	(0.0197)**	(0.0231)**	(0.0269)**
Population	0.0015	0.0014	0.0015	0.0015	-0.0005	0.0009
	(0.0002)**	(0.0002)**	(0.0002)**	(0.0002)**	(0.0006)	(0.0007)
Percent population black	0.3066	0.2819	0.3565	0.2478	0.2820	-0.0298
	(0.2151)	(0.2136)	(0.2129)+	(0.2175)	(0.2184)	(0.9566)
Median age in place	-0.0259	-0.0240	-0.0263	-0.0255	-0.0271	-0.0685
	(0.0126)*	(0.0125)+	(0.0124)*	(0.0127)*	(0.0127)*	(0.0406)+
Average household size	-0.8920	-0.8348	-0.8618	-0.8719	-0.8667	-1.5502
	(0.1334)**	(0.1313)**	(0.1312)**	(0.1346)**	(0.1350)**	(0.5813)**
Percent foreign born	0.3446	0.3352	0.3748	0.3052	0.3227	2.0930
	(0.3665)	(0.3606)	(0.3608)	(0.3695)	(0.3711)	(1.2805)
Median household income	-0.0085	-0.0087	-0.0089	-0.0088	-0.0094	-0.0383
	(0.0061)	(0.0060)	(0.0060)	(0.0062)	(0.0062)	(0.0263)
Percent under the poverty line	0.7334	0.5207	0.3692	0.7418	0.5838	-3.2814
	(1.1558)	(1.1403)	(1.1421)	(1.1680)	(1.1728)	(4.5602)
GTE dummy	0.4176	0.3965	0.4251	0.4068	0.4122	0.4143
	(0.1547)**	(0.1540)*	(0.1531)**	(0.1568)**	(0.1570)**	(0.8297)
RBC dummy	0.3447	0.3367	0.3519	0.3544	0.3568	0.8482
	(0.1279)**	(0.1277)**	(0.1270)**	(0.1298)**	(0.1299)**	(0.6785)
Age × population					0.0000	0.0000
					(0.0000)**	(0.0000)
Experience × population					-0.0000	0.0000
					(0.0000)	(0.0000)
Manager has degree in economics or business × population					0.0003	0.0000
					(0.0004)	(0.0004)
Age × average household income						0.0005
						(0.0005)
Experience × average household income						0.0002
						(0.0007)
Manager has degree in economics or business × avg household income						-0.0011
						(0.0133)
Age × % population black						0.0140
						(0.0187)
Experience × % population black						-0.0064
						(0.0254)
Manager has degree in economics						-0.4875

or business × % population black						(0.4540)
Age × median age in place						0.0001
						(0.0007)
Experience × median age in place						0.0018
						(0.0014)
Manager has degree in economics						0.0091
or business × median age in place						(0.0265)
Age × average household size						0.0006
						(0.0102)
Experience × average household						0.0072
size						(0.0149)
Manager has degree in economics or						0.8047
business × average household size						(0.2947)**
Age × percent below the poverty						0.0366
line						(0.0814)
Experience × percent below the						0.1758
poverty line						(0.1354)
Manager has degree in economics or						-1.6616
business × % below poverty line						(2.4698)
Age × % foreign born						-0.0120
						(0.0240)
Experience × % foreign born						-0.0379
						(0.0427)
Manager has degree in economics						-0.9476
or business × % foreign born						(0.7839)
Age × GTE dummy						-0.0007
						(0.0169)
Manager has degree in economics						0.3142
or business × GTE dummy						(0.3342)
Experience × GTE dummy						-0.0064
						(0.0202)
Age × RBOC dummy						-0.0075
						(0.0138)
Manager has degree in economics						0.3147
or business × RBOC dummy						(0.2780)
Experience × RBOC dummy						-0.0147
						(0.0173)
Constant	1.0415	0.8758	0.8276	1.0510	1.1376	4.2061
	(0.7355)	(0.7271)	(0.7311)	(0.7505)	(0.7573)	(1.7697)*
# of observations	5906	5906	5906	5906	5906	5906
# of markets	234	234	234	234	234	234
Pseudo-R^2	0.213	0.205	0.197	0.228	0.234	0.246
Log Likelihood	-1295.6	-1307.7	-1320.9	-1270.1	-1261.0	-1239.8