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Preliminary. Comments Welcome.

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Abstract

Past empirical literature provides strong evidence that competition increases when new firms enter a market. However, rarely have economists been able to examine how competition changes with the threat of entry. This paper uses the evolution of the zip code level market structure of facilities-based broadband providers from 1999 to 2004 to investigate how a firm adjusts its entry strategy when facing the threat of additional entrants. We identify the potential n^{th} entrant into a local market as threatened when a neighboring market houses more than n firms providing broadband services. We first document that such a market is more likely to accommodate more than n firms in the long run. Taking account of endogeneity of entry into neighboring markets, we find that the first 1 to 3 entrants significantly delay their entrance into an open local market facing entry threat. We do not find evidence of delayed entry for firms following the 3rd entrant. The evidence suggests that the mere threat of entry may curb market power associated with oligopolistic market structure.

JEL codes: L13 (Oligopoly and Other Imperfect Markets), L8 (Industry Studies: Services)
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1 INTRODUCTION

Economists tend to believe that incumbents behave more competitively with the entry of a competitor and that market power diminishes with the number of rival firms in a market. However, unresolved on theoretical and empirical grounds is whether incumbents respond to the *threat* of entry as well as to the actual entry.[1] Although several recent empirical papers find that incumbents lower prices or expand output significantly to deter or accommodate potential entrants (Ellison & Ellison, 2000; Dafny, 2005; Goolsbee & Syverson, 2006), evidence remains sparse on the causes and impacts of such strategic behavior.

This paper investigates entry threat and entry deterrence from an alternative angle. Imagine a growing market where firms enter sequentially as demand grows gradually. If the prospective 1st entrant expects that the market will soon develop into a competitive market structure, it will discount future flows of profits and find entry less appealing. Even if entry can be deterred, the 1st firm will need to consider the implications on future profitability of having to fight off potential future entrants by engaging in price cuts, output expansion, or advertising campaigns. These entry deterring strategies will lower future profit flows for the prospective 1st entrant, again leading the firm to delay entry. Consequently, the prospective 1st entrant may choose to enter a market with lower demand but also a lower probability of future rivalry. In other words, this 1st entrant can be "deterred" by the concern of a more competitive market structure in the future. A previous line of research on contestable markets initiated by Baumol and colleagues (1982) posits that the local monopolist or oligopolists may behave similarly as highly competitive firms when facing credible threat of entry. If true, potentially contestable markets may delay the prospective monopolist from entering the market in the first place.

[1] Traditional insight argues that incumbents' responses to entry threat are not sub-game perfect, or these responses should be postponed until actual entry occurs. More recent theoretic literature, however, offers rationale such as capacity building, learning or experience, signaling, switching costs for incumbents' preemptive behavior (Dixit, 1979; Spence, 1981; Milgrom and Roberts, 1982; Klemperer, 1987; Farrell and Klemperer, 2004). For a review on strategic models of entry deterrence, see Wilson (1992).

To our knowledge, this alternative question has not been explored empirically because of the difficulty of distinguishing between markets that do and that do not face credible entry threats. We propose that the timing of entry into local broadband service markets offers an opportunity for identifying such a threat. The Federal Communication Commission reports data on the evolution of the market structure of the facilities-based broadband providers at the zip code level from 1999 to 2004. Examining the data, we can identify the n^{th} potential entrant into a local market as threatened when a neighboring market houses more than n providers of broadband services. We then use the timing of the n^{th} potential entrant into the local broadband market to investigate how this entrant adjusts its entry strategy when facing the threat of future entrants.

Two major econometric complications arise from our analysis of this problem. First, there will be contemporaneous correlation in entry decisions across markets because of likely correlated unobserved heterogeneity among adjacent markets. Second, if a prospective entrant into a market considers the market structures of neighboring markets when deciding whether to enter, it must be true that entrants into neighboring markets have engaged in a parallel exercise that incorporates their expectations of what the first firm plans to do. Consequently, the number of incumbent firms in neighboring markets, which serves as a proxy for entry threat, is an endogenous variable in the potential entrants' decision to enter the threatened market.

We develop a discrete choice empirical model in which a firm decides whether to enter a local market in a certain period based on its expectation of future profits flows. Expected profits are determined by market demographics, current market structure, and the entry threat posed by other firms in neighboring markets. We allow markets close to each other to have spatially correlated error terms and we treat the entry threat as endogenous. A GMM framework with instrumental variables yields consistent estimates of the model parameters which yield inferences regarding the impact of entry threat.

We first establish an empirical measure of the entry threat from neighboring markets. We argue that entry threat is credible when it significantly increases the likelihood that a market with an n^{th}

potential entrant will accommodate more than n firms in the (relative) long run. When faced with such a credible entry threat, the 1st set of entrants significantly delay entry, presumably because these first entrants form a lower expectation about future profitability due to the concern over a more competitive market structure in the near future. However, the 4th and later entrants do not display similar strategic behavior. Because firms should only react to the threat of entry if the addition of firms changes the competitive conduct of the market, this finding suggests that the competitive conduct of the local market changes little after the 4th firm enters. The mere threat of entry may curb market power associated with oligopolistic market structure, as theory on contestable markets has pointed out. In the era of telecommunication deregulation, our results on the impact of entry threat suggest that the 1996 Telecommunications Act that aimed to encourage new entrants may have more complicated competitive effects than originally designed.

The paper is structured as follows. Section 2 describes our entry model and our method to deal with the econometric complication in a discrete choice model with spatial correlations and endogenous independent variable. Section 3 introduces the broadband market and the data we use. Section 4 presents our empirical results. Section 5 concludes.

2 METHODOLOGY

2.1 An Illustration about Entry Threat and Entry Deterrence

Before we lay down a detailed econometric framework, we would like to use a simple example to illustrate how a firm's concern over more entry in the long run will reduce its incentive to enter in the short run. Imagine a potential entrant (firm 1) is considering entering an open market in the first or second period. In the first period, firm 1 is the only potential entrant. Another potential entrant (firm 2) identical to firm 1 will arrive in the second period. Such a scenario can arise if firm 2 has prohibitive fixed costs or much inferior technology in the first period so that entry in the first period is never an option for firm 2. However, in the second period firm 2 catches up to become an equal competitor with firm 1.[2]

In the first period, market demand is deterministic. Firm 1 will receive a monopoly profit of $\pi^M - FC$ by entering the market, where π^M denotes monopoly variable profits and FC denotes fixed costs. In the second period, the market demand has grown by a constant with a stochastic component ε. Specifically, either firm will receive $\pi^M + 2a - FC + \varepsilon$ ($a > 0$) if it's the only firm operating, or $\pi^D + a - FC + \varepsilon$ if both firms enter and compete against each other. Here π^D denotes duopoly variable profits with $\pi^M \geq \pi^D$. We assume $\pi^M < FC < \pi^D + a$ so that firm 1 entering in the first period is not a sure event and its option value of waiting until the second period is positive. The standard normally distributed stochastic profit ε cannot be observed by either firm until the start of the second period. *Ex-ante* common knowledge includes π^M, π^D, FC, a and the distribution of ε. For simplicity, we assume the discount factor is 1 and there are no entry or exit costs.

Firm 1, when considering whether to enter the market in the first period, takes into consideration the profit flows in both periods. In the first period, firm 1 receives $\pi^M - FC$ if it enters. In the second period, market structure may change. If ε is low enough, the market may not be able to support any firm. If ε is high enough, the market may be profitable to support one or both firms. The likelihood of having two firms in the second period depends on π^D, FC, a and ε. Specifically, if $\pi^D + a - FC + \varepsilon > 0$, or equivalently, $\varepsilon > FC - \pi^D - a$, both firms will enter in the second period. Firm 1's *ex ante* expectation that both firms will enter can be denoted as $P^2 = \Phi\left(\pi^D + a - FC\right)$, where $\Phi(.)$ is the cumulative density function of a standard normal distribution. Similarly, the probability of no firms entering in the second period is $P^0 = 1 - \Phi\left(\pi^M + 2a - FC\right)$. Using these probabilities, firm 1's expected discounted value of future profits of entering the market in the first period is,

[2] For instance, in the broadband market incumbent local exchange carriers (ILECs) and cable companies seem to always enter markets earlier than competitive local exchange carriers (CLECs).

$$E\Pi_1^{enter} = \pi^M - FC + \left(1 - P^0 - P^2\right)\left(\pi^M + 2a - FC\right) + P^2\left(\pi^D + a - FC\right).$$

If firm 1 chooses not to enter in the first period, it still has the option value of entering in the second period. However, firm 1 loses the advantage of being the incumbent. In a symmetric equilibrium, the two firms should have equal likelihood of becoming the only firm operating when the market is only able to support a single firm. That is, when $FC - \pi^M - a < \varepsilon < FC - \pi^D - a$, either firm has ½ of probability of receiving $\pi^M + a - FC$ in the second period. Thus, firm 1's expected discounted value of future profits of not entering the market in the first period is,

$$E\Pi_1^{not\_enter} = \frac{\left(1 - P^0 - P^2\right)}{2}\left(\pi^M + 2a - FC\right) + P^2\left(\pi^D + a - FC\right)$$

Therefore firm 1 will enter in the first period if and only if $E\Pi_1^{enter} > E\Pi_1^{not\_enter} > 0$, or equivalently, $\pi^M - FC + \frac{\left(1 - P^0 - P^2\right)}{2}\left(\pi^M + 2a - FC\right) > 0$.[3] If P^2 increases (say an exogenous shock results in a higher π^D), then the left hand side of the inequality will decrease, which means firm 1 has a weaker incentive to enter the market in the first period as it is less likely to maintain its monopoly in the second period. In other words, the concern over more entry in the future "deters" firm 1 from entering in the first period. Empirically, if there is a cross section of such markets, we will observe less entry in the first period in those markets with higher likelihood of firm 2 entering in the second period.

2.2 *Empirically Modeling the n^{th} Firm's Entry Decision*

In the section we first describe the environment in which firms enter a market. Then we consider the decision of the n^{th} firm to enter a local market m at time period t, which houses less than n ($1 \le n \le N$, N being the number of all potential entrants) firms at time period $t-1$. Firms are ranked 1st to the N^{th} on the basis of their efficiency levels. We assume that these firms enter the market sequentially and that the more efficient firm always enters earlier than the less efficient ones. This setup ensures that

[3] By assumptions $FC < \pi^D + a$ and $\pi^M \ge \pi^D$, we know that $E\Pi_1^{not\_enter} > 0$.

there will be only one potential entrant, which we label as the n^{th} potential entrant (or interchangeably, the n^{th} firm), when market profitability has grown just enough to induce the next entrant.[4] Market profitability grows over time with a stochastic component.

At the beginning of each time period t, the n^{th} potential entrant decides whether the expected discounted value of the future profit stream is sufficiently high to support entry. The expected profitability is based upon current and anticipated future market demand, available technology, and current and anticipated future market structure. Specifically, this potential entrant forms an expectation about market m's future structure based on the structures of neighboring markets. If at least one rivaling firm operates in a neighboring market but not yet in market m, this n^{th} entrant considers itself threatened by the potential entry of at least one rivaling firm into market m. This can be easily understood in the context of the broadband market. Because of the economic scale of building network facilities, an incumbent broadband provider will find it easier to spillover to an adjacent market as opposed to a more distant alternative.

The n^{th} potential entrant considering entering market m at time t has an expected discounted value of future profits as specified below:

$$\Pi_{mt}^{n} = \alpha_{t}^{n} + X_{m}\beta_{t}^{n} + \gamma_{t}^{n} EntryThreat_{mt}^{n} + u_{mt}^{n} \qquad (1)$$

We adopt the above reduced form profit function for its tractability. The specification is based on the nature of the data for this study (details in section 3). Equation (1) states that the expected discounted value of future profits, Π_{mt}^{n}, depends on a vector of time-invariant market attributes X_m, an entry threat variable that will be specified and discussed below, the impact of having n firms in the market as reflected by the intercept term α_{t}^{n}, and an error term reflecting unobserved market- and time- specific heterogeneity in expected profits. The n superscript indicates that variables or parameters vary with the order of entry. For example, the 1st entrant is threatened when a 2nd firm is likely to enter the market while

[4] It is possible that multiple entrants enter at the same time period, but their entrance still follows the order of their efficiency levels. Later entrants observe earlier entry, but early entrants only form expectations about later entry.

4th entrant is threatened when a 5th firm is likely to enter; or the 1st entrant may have different expectation about the impact of population (or entry threat) on future profitability than the 4th entrant does.

For a given market m at period t, the n^{th} firm's entry decision is a dichotomous variable D_{mt}^{n}. Let $D_{mt}^{n} \in \{0,1\}$ denote the n^{th} potential entrant's entry decision: $D_{mt}^{n} = 1$ if the n^{th} potential entrant enters market m at time t; $D_{mt}^{n} = 0$ otherwise. This firm will enter the local market if expected discounted value of future profits is positive, that is, $D_{mt}^{n} = 1$ if $\Pi_{mt}^{n} \geq 0$, and $D_{mt}^{n} = 0$ otherwise.

In the above formulation, X_m contains market-level variables that might affect each firm's variable profits and fixed operating costs. Market size as measured by population is a key element, as in the Bresnahan and Reiss study (1990, 1991) and their follow-ups. In the broadband market, other plausible elements of X_m include local demographic variables such as gender, race, age and education level composition. Local income levels, commuting patterns, and business activities are also plausible demand shifters. β_t^n measures how the n^{th} firm's time-varying expectations about a market's profitability are determined by X_m. For example, in 1999 a market with 1000 people might not be expected to generate sufficient demand for a single provider of high-speed Internet; in 2004 the same 1000 people might be able to support one or even more. Time-varying β_t^n capture changes over time in consumer taste and/or technology improvements. α_t^n is the intercept term, which reflects the (expected and realized) effect on per-firm variable profits of the n^{th} firm entering the market at time t. If market power diminishes with additional entrants, then α_t^n will decrease as n increases.

The n^{th} firm's entry decision depends on a strategic factor, which is the threat of entry from other firms in neighboring markets. This is the focus of this study. We define $EntryThreat_{mt}^{n} = 1$ if any market within a radius of R miles of market m has at least one firm which is not the n^{th} firm and which has not entered market m at period $t-1$. Because we do not observe firm identities, our empirical work will only be able to identify situations where entry threat exists when there are more than n firms in the neighboring markets.[5] Ideally, we intend γ_t^n to capture the n^{th} firm's concern over a more competitive market structure in the future. However, this entry threat variable reflects not only entry threat from competing firms, but also the possibility of geographic spillover because it is possible that the n^{th} firm itself is one of the incumbents in a neighboring market. Absent any entry threat effect, the coefficient γ_t^n captures the "spillover" effect. That is, the magnitude of a positive γ_t^n indicates the strength of technology advantage for an incumbent firm to spillover to a neighboring market. With the entry threat effect, which theory dictate should be non-positive, γ_t^n captures two counterbalancing effects ---- the spillover and the entry threat effects. We will not be able to separate these two effects out. We suppose the spillover effects always exist as the entry threat effects are established based on the hypothesis that an incumbent is more likely to enter a neighboring market. Therefore, a significantly negative γ_t^n indicates the (negative) entry threat effects dominate the (positive) spillover effects.

The error term u_{mt}^n are market- and time-specific shocks affecting the firm's expected discounted value of entry. To simplify notation, we suppress superscript n and subscript t temporarily. Letting u denote a column vector $[u_m]\ \forall m$ and ε denote a column vector $[\varepsilon_m]\ \forall m$, we formulate the structure of the error term as:

$$u = \psi W u + \varepsilon \qquad (2)$$

This structure reflects the correlation of unobserved profit potential across adjacent markets.[6] Let M denote the total number of local markets. $W = [w_{ij}]$ is an exogenously specified $M * M$ matrix with $w_{ij} = 1$ if $i \neq j$ and market j is within R miles of market i; and otherwise $w_{ij} = 0$.[7] The correlation in the errors is determined by a time-varying scalar ψ. If $\psi = 0$, there is no spatial correlation in unobserved profitability of neighboring markets. If $\psi \neq 0$, then spatial correlation exists. This correlation

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[5] Details on definitions of neighboring markets and entry threat can be found in section 3.4 and 4.1.

[6] This is a standard formulation of spatially correlated errors for cross-section data. For a detailed review on spatial models, see Anselin (1988).

[7] Notice in equation (2), we will never have the same u_i on both sides of the equation because $w_{ii} = 0$.

may be caused by correlated unobserved market attributes or by entrants deciding to enter a group of neighboring markets simultaneously. The disturbance term ε is identically and independently distributed with: $\varepsilon \sim N(0, I_M)$, where I_M is the identity matrix with dimension M.[8]

The variance-covariance matrix of u is $V(u) = \left[\left(I_M - \psi W\right)^T \left(I_M - \psi W\right) \right]^{-1}$, which is heteroskedastic if $\psi \neq 0$. In this case, Probit estimation of equation (1) will be inconsistent even if all right hand variables are exogenous.[9]

2.3 A Discrete Choice Econometric Model with Spatial Correlation

The above formulation gives rise to a discrete choice econometric model with potential spatially correlated error terms. Due to the heteroskedastic error terms, maximum likelihood estimates will be inconsistent. To get consistent estimates of this model, we use the generalized-method-of-moments (GMM) approach developed by Pinske and Slade (1998).[10]

First, we need to test the null hypothesis that $\psi = 0$. We follow the test designed by Pinkse and Slade (1998).[11] The basic idea is as follows: under the null hypothesis, GMM estimation of equation (1) produces consistent estimates $\hat{\theta}_{\psi=0}$ and the residual $u(\hat{\theta}_{\psi=0})$ is a vector of uncorrelated elements. Under the alternative, in contrast, the residual $u(\hat{\theta}_{\psi=0})$ is not a vector of uncorrelated elements. Therefore, $u^T(\hat{\theta}_{\psi=0}) W u(\hat{\theta}_{\psi=0})$, generated by using the actual data, tends to be larger than its counterpart using the data simulated under the restriction $\psi = 0$. If the null hypothesis is rejected, we proceed with GMM estimation with unrestricted ψ. The parameter vector is $\theta = [\alpha, \beta, \gamma, \psi]$. Again superscripts and

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8 The variance of ε is the identity matrix by normalization .
9 See Pinske and Slade (1998), p. 130.
10 They propose a method to handle spatial correlation in the contracts between oil companies and their retail outlets. They allow spatial correlation to be determined by the physical distance between service stations, where distance is viewed alternatively by Euclidean distance, by location along the same street, or by location with in the same geographic boundary.
11 The test is described in detailed in Pinkse and Slade (1998), p130-131.

subscripts are suppressed for notation simplification and we actually estimate a separate set of parameters for each time period t and each n.

The generalized error is defined as:

$$\tilde{u}_m(\theta) \equiv E\left[u_m \mid D_m;\theta\right] = \left\{D_m - \Phi\left[G_m(\theta)\right]\right\} \frac{\phi\left[G_m(\theta)\right]}{\Phi\left[G_m(\theta)\right]\left\{1-\Phi\left[G_m(\theta)\right]\right\}} \tag{3}$$

where $G_m(\theta) = \left(\alpha + X_m\beta + \gamma EntryThreat_m\right)/v_m(\psi)$, and $v_m(\psi)$ is the square root of the m^{th} element on the diagonal of $V(u)$, where $V(u) = \left[\left(I_M - \psi W\right)^T \left(I_M - \psi W\right)\right]^{-1}$. $\phi(.)$ and $\Phi(.)$ are the density and cumulative function of a standard normal distribution respectively.

With this generalized error defined, we form the moment conditions with instruments Z: $E(Z^T\tilde{u}) = 0$. The dimension of Z is $M \times L$, where L is equal or greater than the dimension of the parameter vector.[12] The sample analogue of the moment is $S(\theta) = \frac{Z^T\tilde{u}}{M}$. When there is over-identification, $\hat{\theta} = \arg\min_{\theta} S^T(\theta)\Omega S(\theta)$, where Ω is a $L*L$ positive definite weighting matrix.[13]

If $\psi \neq 0$, $\hat{\theta}$ is consistent and asymptotically normal. We estimate the covariance matrix of $\hat{\theta}$ by using the following property of $\hat{\theta}$:

$$\sqrt{M}(\hat{\theta}-\theta) \sim N(0,\left[B_2(\theta)\right]^{-1}\frac{\partial S^T(\theta)}{\partial\theta}\Omega B_1(\theta)\Omega\frac{\partial S(\theta)}{\partial\theta^T}\left[B_2(\theta)\right]^{-1})$$

where $B_1(\theta) = M \times E(S(\theta)S^T(\theta))$ and $B_2(\theta) = \frac{\partial S^T(\theta)}{\partial\theta}\Omega\frac{\partial S(\theta)}{\partial\theta^T}$.

[12] Note that even when all the right hand side variables are exogenous, we still need one extra instrument besides all the exogenous right hand side variables to identify ψ.

[13] We use optimal weight matrix Ω by following the steps below: first, we get consistent GMM estimate $\hat{\theta}_1$ by using identity weighting matrix: $\Omega = I_M$; second, we construct $\widehat{\Omega} = ME(S(\hat{\theta}_1)S^T(\hat{\theta}_1))$.

2.4 *Endogenous Entry Threat*

The entry threat variable is exogenous if the number of incumbents in neighboring markets is unaffected by the unobservables in market m. However, the assumption of exogenous entry threat does not hold if unobservables across markets are correlated, that is, if $\psi \neq 0$. To illustrate this endogeneity problem, let's note that, at some time period $t' < t$, the process governing the $n+1^{th}$ entry into a neighboring market, call it m', is the same as that governing entry into market m.

$$\begin{aligned} &\Pi_{m't'}^{n+1} = \alpha_{t'}^{n+1} + X_{m'}\beta_{t'}^{n+1} + \gamma_{t'}^{n+1} EntryThreat_{m't'}^{n+1} + u_{m't'}^{n+1} \\ &D_{m't'}^{n+1} = 1 \qquad iff\ \Pi_{m't'}^{n+1} \geq 0; = 0\ otherwise \end{aligned} \tag{4}$$

When some neighboring market m' has at least $n+1$ firms at some time period $t' < t$, we have $EntryThreat_{mt} = 1$. That is, the occurrence of $D_{m't'}^{n+1} = 1$ means $EntryThreat_{mt}^{n} = 1$. $EntryThreat_{mt}^{n}$ is then an endogenous variable in equation (1) because the time-invariant part of error terms in (1) and (4) are spatially correlated, being governed by the process $u = \psi Wu + \varepsilon$. In addition, if prospective entrants are considering the structures of neighboring markets when deciding whether to enter a market m, it must be true that entrants into *m*'s neighboring markets have engaged in a parallel exercise. In principle, one could embed all entry decisions into a simultaneous structural model explaining entry into all markets at all time periods, but identification and estimation would quickly become intractable. Instead, we use a method that first considers a reduced form entry threat equation and then embeds the instrumented entry threat into equation (1).

To correctly identify the effects of entry threat on the n^{th} firm's entry decision into market *m*, valid instruments are essential. A widely used strategy in the empirical industrial organization literature is to instrument the endogenous variable (for example, the price variable in a demand system) by exogenous characteristics of rival products (Berry, Levinsohn & Pakes, 1995; Nevo, 2001), or exogenous market attributes from rival markets (Pinkse and Slade, 1998; Pinkse, Slade, & Brett, 2002). Since we have no product level information, we decide to follow the Pinkse and Slade strategy of applying the averages of the exogenous market attributes of all of market *m*'s neighbors as instruments. This requires a certain degree of naiveté on the part of the market m 's potential entrant in that only market m 's characteristics are considered in the entry decision but not those of neighboring markets. Wouldn't this entrant learn from its neighbors' strategies of geographical expansion and look into the profitability of the neighboring markets and their attributes in formulating plans for future expansion? Clearly, for our instruments to work, the answer has to be no.

We propose two admittedly imperfect solutions to this problem. The first assumes that firms can only consider entry into a single market at a time without developing future plans for entry. Information on the future profitability in neighboring markets is too noisy to influence current decisions. As a consequence, the entrant will consider expansion into markets neighboring *m* only after becoming an incumbent in market *m*. Successive application of this assumption means that potential entrants and neighboring incumbents are symmetrically naïve. The potential entrant is aware that its neighbors are considering expanding into market *m*, but it does not consider how its own entry into *m* will be affecting its own or its neighbors' future expansion decisions. The neighboring incumbents are similarly considering expansion into market *m* but they also only incorporate their's and their neighbor's current expansion plans into their decision to enter market *m.* This conceptual restriction, which often finds its application in the real world where firms are not perfectly forward looking, enables us to use the Pinske-Slade instruments suggested above. An additional instrument is the number of neighboring markets which directly affects the likelihood of spillover and the entry threat.

Our second approach relaxes the restriction of our first approach, but it is still built on the concept that firms are not perfectly forward-looking: they can only look a few steps ahead. Let's suppose they look two steps ahead. In the first step, a potential entrant considers entry into market m, fully aware of its potential expansion into the neighboring markets in the second step. Therefore, the neighboring markets' characteristics, as well as the number of such markets, enter this entrant's expectation about the future profitability of market m. We do not include them in equation (1) for a parsimonious specification, but they should all enter the residual term u. Therefore, the instruments we proposed for our first approach lose their validity. The contemporaneous entry decisions of an incumbent in a neighboring market m' will be based on the profitability of market m' and all its neighbors. If the neighbors of market m' do not entirely overlap with those of market m, then we can use the number and average characteristics of these non-overlapping neighbors markets as instruments. We could repeat the exercise for market entry decisions 3, 4, …, n steps ahead. As long as firms are not infinitesimal forward looking, we can always develop similar instruments. For the length of the current paper, we cut off the entry plan at two steps ahead and then compare results to the one-step-ahead assumption to assess the robustness of results. As we will see, our results are not sensitive to the choice of instrument sets.

3 THE BROADBAND MARKET AND DATA

3.1 The Rollout of Broadband: 1999 to 2004

The broadband market has grown rapidly since the 1996 Telecommunication Act facilitated entry of more telecommunication service providers. The number of high-speed lines increased more than 10 fold from 2.8 millions in December 1999 to 37.9 millions in December 2004.[14] Over the same period, the total number of broadband providers increased from 105 to 552 and the fraction of zip codes with at least one provider rose from 60% to 95%. The number of zip codes with more than one provider rose from 34% to 83%.[15] By the end of 2004, only 1% of the U.S. population did not have broadband service in their home zip code.

There are three major types of players in the broadband market: cable television companies, incumbent local exchange carriers (ILECs), and competitive local exchange carriers (CLECs). Cable companies provide broadband services by cable modems using hybrid fiber-coaxial cable networks, and telephone companies by asymmetric digital subscriber lines (DSL) with speeds in one direction greater

[14] The vast majority of these lines, for example, 35.3 out of 37.9 million lines in December 2004, served residential and small business subscribers.
[15] FCC (2005) reports most of the statistics we refer to in this section.

than speeds in the other direction.[16] As of December 2004, coaxial cable has accounted for 56.4% of all high-speed lines, while DSL has accounted for 36.5%. Recent rapid technological changes and increased competition have led to a sharp decline in the cost of cable and DSL service. Monthly prices were $27 in many areas in 2004, down from $40 in 2003.

The 1996 Telecommunication Act intended to encourage competition in the local telecommunication markets, and has been at least partially successful in achieving its goal. A few recent papers have investigated the nature of strategic interaction among competitors and the welfare effects of new entry into local telephone markets. Greenstein and Mazzeo (2006) found that CLECs differentiate themselves strategically when entering local markets. Economides, Seim, and Viard (2006) show that households in New York state benefit significantly from the product differentiation that results from new entry. However, we are not aware of any research on the strategic entry decisions of firms into the broadband market and the implications of the Act for competition in this industry.

3.2 The Data

Our analysis is based on information from the Survey of High Speed Internet Providers, collected twice a year by the Federal Communications Commission (FCC) beginning in 1999. The FCC requires every facilities-based provider with at least 250 high-speed lines to report its presence in a given zip code as long as it serves at least one customer in that zip code.[17] The FCC releases summary statistics to the public aggregated to the zip code level, which provides us semi-annual snapshots of the number of providers in each zip code. From these snapshots of market structure, we can observe the timing of net entry and exit of broadband providers over six month intervals. In our study, we only use the December data to allow sufficient time for changes in market structure to occur, and so our net entry and exit is measured over one year intervals.

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[16] Other technologies include: wireline technologies "other" than ADSL, including traditional telephone company high-speed services and symmetric DSL services; optical fiber to the subscriber's premises; and satellite and terrestrial wireless systems, which use radio spectrum to communicate with a radio transmitter.
[17] High-speed lines are defined as those that provide speeds exceeding 200 kilobits per second (kbps) in at least one direction.

This FCC dataset, covering the entire United States and spanning over multiple time periods, is a rare opportunity for researchers to study market evolution in the early stages of a rapidly-growing service industry. However, we have to acknowledge that the data set has some disadvantages, due mainly to the lack of firm identities in the data. As a result, we can only observe net entry rather than actual entry and exit of firms. That also means that our inference of entry threat is derived from observations of the number but not the identity of incumbent providers across markets. We also cannot distinguish between different types of broadband services such as cable and DSL, and so we cannot measure the different impacts that entry threat may generate by type of broadband provider. Furthermore, very small providers (with less than 250 high-speed lines), many of which serve sparsely populated areas, are not required to report to FCC, generating measurement errors in our econometric analysis.[18] Lastly, the FCC summary data by zip code lumps 1, 2 or 3 providers into a single category for concerns over confidentiality, which prevents us from studying the first three providers' entry decision respectively. With all these limits in mind, we still argue that the breadth and depth of the data set generate interesting inferences about local firm entry decisions that are not possible from other data sets.

We use two supplementary data sets along with the FCC data. We first merge in selected variables from the 2000 Population Census based on zip code tabulation areas (ZCTAs).[19] The variables selected include population, average income, education, age, ethnicity, commuting distance, population density and so on, which affect local demand for and/or the cost of providing high-speed Internet services. We then merge in the number of business establishments for each zip code from the Zip Code Business Pattern (2000), which acts as a proxy for local business activities. We include these variables, whose description and summary statistics can be found in table 1, as X_m in our latent profit function (1) as controls for local markets' profitability.[20]

[18] Fortunately, few providers fall into this category. Research shows that entry will not pay off unless there are at least 200 lines in a DSL service area (Paradyne, 2000).

[19] ZCTAs, defined by the Census Bureau, are not identical to zip codes, defined by the U.S. postal service. However, all the zip codes from the FCC data do have a match in the 2000 Census data.

[20] To conserve on paper length, we do not report results on these controlled variables. The signs and magnitudes of estimated coefficients of these variables are as what common sense would suggest in most cases.

3.3 Definition for Local Markets: Zip Codes as Markets

Consumer mobility determines the boundary of a local market in any service industry. For example, before automobiles were invented, a local grocery store may only need to compete with rivals in walking distance. Therefore, defining a local market for a service industry can be challenging, especially when researchers have no good data on consumers' willingness to travel for desirable services. In the local broadband market, however, consumers have no mobility at all ---- they can only use providers offering service at their residences. Thus we are able to circumvent the problem of blurring geographic boundaries of local markets resulted from consumer mobility, which has plagued many market structure studies.[21]

The FCC deployment data offer a natural definition for markets ---- zip codes ---- by telling us exactly how many firms offer services within a zip code. As consumers cannot order broadband services from providers not serving their home market, the zip code market boundary is cleaner than most of the previous studies on entry into local markets. However, one may wonder whether broadband providers make their entry decisions at such a fine geographical level. A provider may decide to enter a much broader geographical area, such as a city, a county, or even a large region, although it may spend a few years to build up infrastructure for the full coverage of this area. This long-run entry decision not only compromises our market definition, but also makes it difficult for us to define appropriate instruments, as discussed in section 2.4. Furthermore, broadband providers are a very heterogeneous group. A few have national or near-national footprints,[22] others offer services beyond one city, and hundreds of small providers only cover a small geographic area. Different sized providers differ in their business strategies regarding the scale of geographic markets to cover. Without firm identities and firm-specific coverage area in our data, the problem of a universal market definition for all providers would be insurmountable if we chose to investigate providers' entry decisions in the long run.

[21] We may suffer from the problem of consumer immobility, however. If a local market is define to be too large, a service provider may not be able to offer services to every household of the market.

[22] For example, Time-Warner America Online and Comcast.

Instead, we focus on the short-run entry decisions ---- the gradual "rolling out" process of broadband providers ---- rather than the long run entry decision. The roll out of the broadband is a provider's marginal decision to expand its service to one more local market. If rolling out to a local area involves sunk costs, we can define a local market depending at what geographical level sunk costs are committed. For example, if the sunk costs of serving a new area were mainly local TV and newspaper advertising, we could define the local markets by county or city boundaries, which usually reflect the boundaries of the local mass media markets. [23]

We think the marginal decision of serving one more area involves sunk costs that are mostly committed at the zip code level, and therefore for this study zip codes are an ideal definition for local markets. The sunk costs of entry mainly involve the so-called "last mile" technology that connects the switching and distribution centers of local telecommunications and cable television companies to the home users of broadband services.[24] Broadband providers, mostly cable and telephone companies, must make sunk investments in renovating their existing cables or telephone wires and in building switching and distribution towers in order to provider high speed Internet service to a new area (Jackson, 2002).[25] The distance between the user's premises and a phone or cable company's central office is a primary factor in determining which neighborhoods can be served and the speed of these services. This physical constraint puts a limit on the radius of a local market. DSL is typically available within a radius of 3.5 miles from the central office.[26] Based on the 2000 population Census, a typical zip code covers a radius of 3 to 4 miles, roughly consistent with the area that could be covered by a DSL system. This makes zip code areas an appropriate geographic approximation to a local broadband market. Other geographic

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[23] For example, Augereau, Greenstein, and Rysman (2004) take local calling areas as distinct markets to study Internet service providers' adoption of different technology standards for 56K modems. In their study, a provider's technology adoption decisions do not vary with small areas such as zip codes, and the sunk costs in technology development and adaptation are incurred in a higher geographical level.

[24] The FCC only requires facilities-based broadband providers to report their presence, which means all the providers in the data sets have to at least incur costs for laying out network facilities.

[25] Jackson (2002) compares the costs of cable versus DSL from many aspects: 1) the cost of modems; 2) the cost of connecting to the aggregated traffic; 3) the cost of the transmission plants; 4) the cost of the DSL's central office and the cable system's head end; 5) the cost of marketing, installation, and customer support. He concludes that the costs only differ slightly across the two platforms.

[26] For example, San Francisco has 24 zip code areas and 12 central offices, none of which are more than four miles from each other (Prieger, 2003).

boundaries such as cities, counties, or MSAs are too large, housing including providers that do not actually compete with each other. In fact, if a customer goes to a cable company's website to search for services, she would be most likely to be requested to input her zip code to find out the availability of services, which suggests that these cable companies treat a zip code as a local service area.

3.4 Definition for Neighboring Markets

We define zip codes whose population centers are within 5 miles of each other as neighboring markets.[27] The reason is technological. Entry threat is more likely to originate from a DSL provider whose distribution tower can cover only about 3.5 miles. Imagine zip code markets are areas in circles and the population centers are also geographic centers. Suppose a DSL provider builds a distribution tower in the population center of a zip code for coverage of the entire zip code. The tower can potentially reach the population center of another zip code which is about 3.5 miles away. That means that the provider can serve two zip codes as long as the centers of the two zip codes are no more than 7 miles away. The reasonable radius to select in assessing plausible entry threats from other firms in the area would be between 3 to 7 miles. Our selection of five miles is the middle value of this range. To test the robustness of results, we have tried with different cutoffs (R =3, 4, 6, 7 miles) and the results are quite similar.[28]

3.5 Sample Selection and Summary Statistics

The U.S. zip codes, from which the FCC collected the deployment data, constitute the universe of markets in this study. Out of 31,843 zip codes with valid demographic data, we drop 12,689 because they have no neighbors within 5 miles of their population centers. This typically happens when a rural zip code covers more than 5 miles in radius. We have to drop these zip codes because on these zip codes we lose our

[27] We use geographic software to determine the distance between the population centers of any two zip codes.
[28] We have also tried R = (3+ the approximate radius of market m) to deal with the concern that larger zip codes have fewer neighbors within a fixed radius but small areas away from the center in these large zip codes might be equally likely to have neighbors as smaller zip codes . The results do not display qualitative changes.

identification strategy, which uses the average attributes of the neighboring markets as instruments.[29] We also drop 1,661 zip codes because the neighbors of these zip codes have no valid demographic data, which again prevent us from using our identification strategy. Lastly, we drop 1,250 zip codes because they have more than 30 neighbors. These zip codes cover extremely small geographic areas and therefore are not suitable for our market definition.[30] We are left with a sample of 16,243 zip code markets that fit our empirical needs.

Tables 1 to 3 report summary statistics on market structure, market characteristics, and entry and exit patterns for zip codes markets with at least one neighbor. As table 1 shows, the number of broadband providers has grown rapidly from 1999 to 2004. In the beginning of the sample period an average zip code houses only 1 to 2 providers. The average rises rapidly to 4 to 5 providers per zip code. An average zip code has 5 to 6 neighbors, and over 22 non-overlapping neighbors' markets. The bottom half of table 1 summarizes market demographics. Compared to the universe of zip code markets in the U.S., whose summary statistics we do not report here, a typical zip code market we have selected for this study has a larger population, fewer native Americans, fewer home-based workers, and a smaller rural population. It is also richer, more densely populated, and has more business activity as reflected by the number of business establishments per thousand people.

Table 2 reports the evolution of the market structures over time. The percentage of markets with 4 or more providers is monotonically increasing, while the percentage of markets with less than 4 providers displays the opposite pattern. In December 1999, about a half of the zip code markets had 1 to 3 providers, and more than one third had no providers at all. Rapid entry changes this pattern in just a few years. By December 2004, more than half of the zip codes in the working sample had 4 or more providers, and only 12% had none. Looking into the entry pattern in more detail, however, we can see that market structures do not tend to change dramatically from one year to the next. Table 3 shows the transition of

[29] For robustness check, we code entry threat for theses zip code as 0 and include these observations in our OLS and Probit regressions, which do not use instruments. The results are in line with the regressions without these observations.

[30] We tried different cutoffs for the number of neighbors, such as 20, 40, and 50, and have received similar results.

market structures from period $t-1$ to t. The majority of markets house the same number of providers in successive years, and the most common change is up one incumbent size category (for example, 0 to 1-3; 1-3 to 4). Only a few jump more than one or two categories (for example, 0 to 4, 0 to 5, 1-3 to 5). Net exits are rare outside the 2001 recession year.

4 RESULTS

4.1 Define Entry Threat

In order to identify entry threat, we need to determine the existence of an additional provider in the neighboring markets. For example, a prospective 1st entrant will be threatened if a neighboring market houses either: 1) a single firm other than the prospective entrant; or 2) more than one firm so that there must exist at least one provider other than the prospective entrant. Because we do not observe firm identities, we cannot identify the entry threat posed by a single firm as in the first scenario, but we can identify the entry threat posed by multiple neighboring firms as in the second scenario. A further complication is that the FCC lumps 1 to 3 firms into one category out of concerns over confidentiality. Therefore, we can only insure that the first 1 to 3 entrants are threatened if a neighboring market houses at least 4 providers; that a 4th entrant is threatened if a neighboring market houses at least 5 providers; and so on.

We treat every one year time period independently. We focus on markets with either 0 or 1 to 3 providers. For markets with 0 providers, the 1st set of entrants is considering entry; for markets with 1 to 3 providers, the 4th entrant is considering entry. To generalize, we select markets where the n^{th} provider is considering entry at period t. These are markets with less than n providers in period $t-1$ and with n or more providers in period t.[31] For example, if a market has 4 providers at period $t-1$ but 6 providers at period t, the 5th entrant must have expected a positive profit from entering this market. Entry threat for this prospective n^{th} entrant into market *m* means that at least one of *m*'s neighboring markets had at least

[31] We do not consider markets experiencing exit in this study.

$n+1$ providers in period $t-1$. For example, the 1st set of entrants is threatened when at least one neighboring market had at least 4 providers in the previous period.

Table 4 reports summary statistics on entry and entry threat over time. Taking a snapshot in December 2000: of the 5,911 open markets as of December 1999, 33.6% experienced entry of 1-3 providers within one year and 17.9% experienced entry of a 4th provider within 5 years. A typical market had 2 to 3 neighbors and 8 to 9 non-overlapping neighbors' neighbors.[32] Around 3% of these markets were threatened by a 4th provider in a neighboring market in 2000. These threat statistics change gradually over time as the open markets in one period become 1-3 provider markets and 1-3 provider markets become 4 provider markets. The general trend is that markets are increasingly threatened but less likely to experience the next set of entrants in the near or more distant future. However, this trend only suggests that firms select more profitable markets to enter first, and not necessarily that entry threat is causing entry delay.

To show the relationship between entry threat and entry delay, we need to compare threatened and unthreatened markets within each single period. For example, we can look at zip codes 77384 and 77417, which are listed right next to each other in the 5911 open zip codes in December 1999. Both zip codes were waiting for the 1st set of entrants, but zip code 77384 was threatened by a neighboring incumbent while zip code 77417 was not. Zip code 77417 experienced its 1st entrant by December 2000 but did not have its 4th entrant until December 2002. Zip code 77384 experienced both its 1st and its 4th entrant in the year ending December 2001. The threatened market 77384 attracted its first entrant later but its fourth entrant earlier than did the unthreatened market 77417. This specific example seems to generalize as illustrated in Figure 1. Taking entry after December 1999 as an example, the 1st set of entrants and the 4th entrant react differently when facing entry threat. For open markets waiting for a 1st entrant, we observe from the top graph that threatened markets experienced less entry of the 1st set of

[32] Across all time periods, around one third, but far from all, of these neighboring markets have experienced entry in the same period, which supports our argument that zip codes are good measures for market boundaries. In the extreme case, if none of the neighboring market has experienced simultaneous entry, then we can argue that zip codes markets are perfect definition for markets.

providers but more entry of the 4th providers, both in the near term (1 year) and in the long term (5 years). For markets with 1 to 3 incumbents as of December 1999, the bottom graph shows that threatened markets were more likely to experience a 4th entrant in both the near and longer terms. This comparison is crude because we do not control for differences in attributes across markets or for the endogeneity of the entry threat. We present more systematic evidence of the impact of entry threats in the next section.

4.2 Entry Threat's Realization

We have argued that entry threat arises when the number of incumbent providers in neighboring markets implies an additional provider to the market an entrant is considering entering. To support this claim, we present regression results on whether there is an increased probability of market *m* with less than *n* providers accommodating *n+1* providers in the future when there are at least *n+1* incumbents in the neighboring markets. Tables 5 and 6 report these results. The structures of these two tables are the same: panels A and B report OLS results with and without market characteristics controlled and treating entry threat as an exogenous event; panels C and D report results from linear probability models controlling for market characteristics, instrumenting measures of entry threat and assuming zero spatial correlation; finally, panels E and F repeat the analysis in C and D except allowing spatial correlation in the errors using our GMM model.[33]

Tables 5 and 6 show that, once we take into account the endogeneity of the entry threat, the threat from neighboring markets is consistently "real", no matter which set of instruments we use. A market with 0 incumbents in the previous period has a higher likelihood of having at least 4 firms by December 2004 if threatened. Similarly, a market with 1 to 3 incumbents has a higher likelihood of having at least 5 firms by December 2004 if threatened.[34] Note in both tables we use December 2004 to define the future, the last period for which we had available data. We obtain similar results if we consistently use period *t*,

[33] Note in both tables (and in tables 7 and 8) we report estimated coefficients instead of marginal effects in order to be consistent in treating γ (the coefficient for the entry threat variable) and ψ (the coefficient for spatial correlation).
[34] We also have results showing that a market with 4 incumbents has a higher likelihood of having at least 6 firms by December 2004 if threatened, but to conserve on the length of paper, we choose not to report the results.

$t+1$, $t+2$ etc. to define the future. We choose to report this version of results to best use all periods of data and to show that entry threat exists for both the near term (December 2003 looking forward to December 2004) and the longer term (December 2000 looking forward to December 2004).

4.3 The 1st Set of Entrants Delays Entry When Threatened by Future Entrants

Facing entry threat, does the n^{th} prospective entrant adjust its entry strategy? The answer hinges on whether the n^{th} entrant expects a change of competitive conduct with the arrival of additional firms. If the potential entrant expects that market power will decrease with the presence of additional competitors, then entry threat will decrease the appeal of a market. An already competitive firm, however, should not be concerned about future market structure. Xiao and Orazem (2006) find that the population increase required to induce additional entry into a local broadband market stabilized at as few as four incumbents. This implies that the decisions regarding entry into a local broadband market have largely reverted to highly competitive conditions after four incumbents or more. We therefore hypothesize that from the 4th entrant on, the remaining decisions for entry are largely driven by demand or technological factors instead of the concerns about future market structure.[35]

Tables 7 and 8 report results from OLS, IV and GMM estimation for the entry decisions of the 1st three providers and of the 4th provider, respectively. The structures of these two tables are the same as in tables 5 and 6. Results are qualitatively similar across the different specifications and they strongly support the conclusions from the cruder analyses above. An open market is less likely to experience the entry of the 1st set of providers if threatened, as shown in table 7. However, a 1-3 provider market is more likely to experience the entry of the 4th provider if threatened, as shown in table 8.[36] We think results in table 8 mainly reflect the positive "spillover" effects due to economies of scale in building broadband

[35] Goolsbee and Syverson (2006) find that incumbent airlines cut fare to respond to entry threat by Southwest airline only on routes that were concentrated before, which can serve as another motivation for our hypothesis.

[36] We also have results showing that a market with 4 incumbents has a higher likelihood of having at least 5 firms in the next period if threatened, but to conserve on the length of paper, we choose not to report the results.

networks across adjacent markets. The same "spillover" effects may apply for the 1st set of entrants, but the negative effects of rival entry on expected profits dominate any expected positive spillover effects.

In table 7, for all time periods there are strong spatial correlations as captured by significantly positive estimates of ψ, which measures the correlation of unobserved profit potential across adjacent markets. We think this is a natural result given that the 1st set of entrants into a broadband market are usually cable companies and incumbent local exchange carriers, who already offer coverage to broad areas in their existent lines of service. It is natural to expect that they would plan on geographic expansion in the broadband market as well.[37]

So far we have refrained from discussing the quantitative aspects of our results. Our intention is not to mislead the readers into thinking that this paper gauges the magnitude of the strategic entry effects. As we stated earlier in section 2, we are not able to distinguish between the strategic entry effect and the "spillover" effect from the estimates, although we can be confident in claiming that the 1st set of entrants do delay their entry out of concerns over a more competitive market structure in the future. We can evaluate the combined strategic entry and technology spillover effects. In table 9, we report the marginal effects of entry threat on the 1st set of entrants using our GMM model. Note that entry threat is a binary variable, so we evaluate the marginal effects by comparing the probabilities that the 1st set of firms enter a market as the entry threat changes from 0 to 1. Comparing panels A and B, we find results robust across the two different sets of instruments. In December 2000, a threatened 1st entrant is 27% to 30% less likely to enter an open market than an unthreatened entrant. For other periods, the likelihood of entry is 10-20% lower for threatened entrants. Perhaps these numbers are due to an underlying positive correlation between the size of the anticipated spillover benefits and the existence of entry threat, but it seems

[37] It is worth noting that in table 5 spatial correlation matters for the 4th entrant in December 2000 and 2001, but is non-existent for later 4th entrants. Our explanation is that after a few rounds of selection, the open markets in later periods are relatively farther apart from each other so that smaller, more competitive entrants ---- the 4th entrant in the broadband market is typical a competitive local exchange carrier ---- do not tend to consider geographical expansion into markets in the sample.

plausible that the delayed entry reflects at least in part an anticipated lower profit stream following the expected additional entry.

5 CONCLUSION

In this paper we explore a uniquely detailed time series of local broadband markets to examine the strategic interaction between earlier and later market entrants. We find evidence of reversed "entry deterrence" effects: the 1st set of providers into a local broadband market significantly delay their entry when an additional provider from a neighboring market "threatens" to enter the target market. This result suggests that the 1st set of broadband providers with no threat of entry do enjoy a certain degree of market power. If firms had been competitive they would not have reacted to entry threat strategically. More importantly, this result supports the view that the mere threat of entry may alleviate market power associated with oligopolistic market structure. In industries such as telecommunications services, our results imply that policies encouraging entry will play an important role in determining the timing of the provision of new services to local markets.

The welfare implication of this reversed "entry deterrence" is ambiguous. On the one hand, a monopolist or oligopolist may behave more competitively by lowing prices and offering better services in order to fight off future competitors, thus benefiting all consumers. On the other hand, consumers with high willingness-to-pay may not be able to receive services as early as they want due to entry delay of the 1st set of providers. To answer the welfare questions associated with entry threat, one would require more detailed data on prices, services provided, and firm identities and a more structured model of how firms compete with each other once they enter.

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Table 1 Summary Statistics on Zip Code Market Attributes

Variable	Definition	Mean	Standard Error	Min	Max
$M = 16243$: the number of zip code markets with at least one neighboring market					
# Dec 1999	# of providers in Dec 1999	1.498	1.626	0	10
# Dec 2000	# of providers in Dec 2000	2.623	2.660	0	16
# Dec 2001	# of providers in Dec 2001	3.304	3.159	0	18
# Dec 2002	# of providers in Dec 2002	4.148	3.756	0	19
# Dec 2003	# of providers in Dec 2003	4.805	4.093	0	20
# Dec 2004	# of providers in Dec 2004	5.194	4.153	0	21
# neighbors	# of zip codes whose center lie within 5 miles	5.844	6.371	1	30
# non-overlapping neighbors' neighbors	# of non-overlapping neighboring zip codes of all neighbors	22.130	40.515	1	467
pop/1000	# people living in a zip code, in thousands	11.322	14.374	0.001	113.984
% black	% population: African Americans	0.075	0.156	0	1
% hispanic	% population: Hispanics	0.062	0.130	0	0.989
% native	% population: native American	0.007	0.031	0	1
% asian	% population: Asians	0.018	0.043	0	0.8
log m_income	log of household median income	10.606	0.404	7.824	12.206
% college	% population over 25 with some college education	0.467	0.189	0	1
hh_size	average household size	2.591	0.355	0	10.250
% female	% population: females	0.505	0.036	0	1
% senior	% population over 60	0.299	0.089	0	1
% w_home	% working population over 16 working at home	0.038	0.039	0	1
% long_cmu	% working population over 16 spending more than 40 minutes on commuting	0.192	0.123	0	1
% rent	% households renting	0.252	0.156	0	1
% phone	% households with a telephone at home	0.973	0.042	0	1
% rural	% population living in rural areas	0.492	0.447	0	1
log (pop density)	log of # people per square mile	5.667	1.887	-1.962	11.649
Log (firm density)	log of # firms per thousand of population	2.847	6.372	-9.210	11.142

Note: FCC lumps 1 to 3 providers into one category but provides percentage of zip codes with 1, 2, and 3 providers in their semiannual report. We use this information to calculate the adjusted mean of number of providers in a zip code market in each time period.

Table 2 Number and Percentage of Zip Codes with n Firms

	Dec 1999	Dec 2000	Dec 2001	Dec 2002	Dec 2003	Dec 2004
$n=0$	5,911 (36.39)	4,112 (25.32)	3,839 (23.63)	2,933 (18.06)	2,459 (15.14)	1,953 (12.02)
$n=1-3$	8,177 (49.97)	7,303 (44.96)	5,876 (36.18)	5,546 (34.14)	5,074 (31.24)	4,894 (30.13)
$n=4$	989 (6.09)	1,380 (8.50)	1,623 (9.99)	1,555 (9.57)	1,581 (9.73)	1,675 (10.31)
$n=5$	640 (3.94)	980 (6.03)	1,276 (7.86)	1,337 (8.23)	1,294 (7.97)	1,354 (8.34)
$n=6$	356 (2.19)	721 (4.44)	926 (5.70)	1,043 (6.42)	1,052 (6.48)	1,119 (6.89)
$n\geq 7$	230 (1.42)	1,747 (10.76)	2,703 (16.64)	3,829 (23.57)	4,783 (29.45)	5,248 (32.31)
M=16243	100%	100%	100%	100%	100%	100%

Note: For each cell, the first row is the number of zip codes with n firms and at least one neighbor in a given year; the second row is the percentage of such zip codes among all zip codes with at least one neighbor.

Table 3 Entry and Exit Patterns from Period $t-1$ to t

		Dec 2000				Total
		0	1-3	4	≥5	
Dec 1999	0	3,925 (66.40)	1,937 (32.77)	40 (0.68)	9 (0.15)	5,911 (100)
	1-3	187 (2.30)	5,294 (65.22)	1,161 (14.30)	1,475 (18.17)	8,117 (100)

		Dec 2001				Total
		0	1-3	4	≥5	
Dec 2000	0	3,136 (76.26)	968 (23.54)	7 (0.17)	1 (0.02)	4,112 (100)
	1-3	703 (9.63)	4,612 (63.15)	1,092 (14.95)	896 (12.27)	7,303 (100)

		Dec 2002				Total
		0	1-3	4	≥5	
Dec 2001	0	2,782 (72.47)	1,047 (27.27)	5 (0.13)	5 (0.13)	3,839 (100)
	1-3	151 (2.57)	4,260 (72.50)	905 (15.40)	560 (9.53)	5,876 (100)

		Dec 2003				Total
		0	1-3	4	≥5	
Dec 2002	0	2,362 (80.53)	568 (19.37)	3 (0.10)	0 (0.00)	2,933 (100)
	1-3	97 (1.75)	4,279 (77.15)	806 (14.53)	364 (6.56)	5,546 (100)

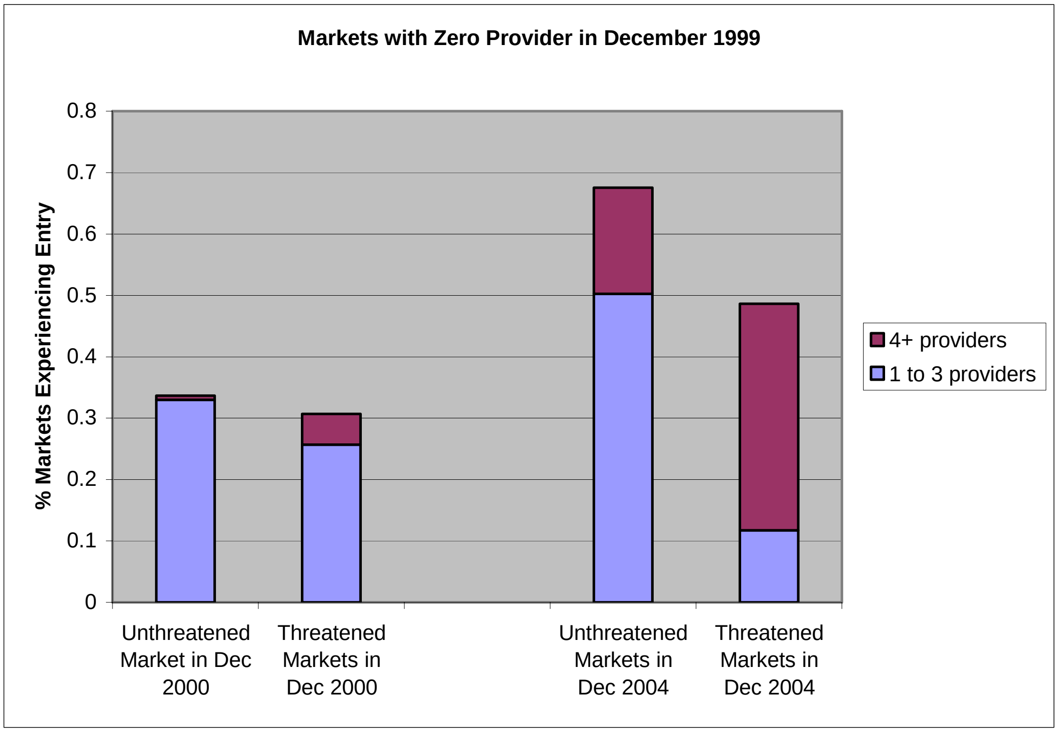
		Dec 2004				Total
		0	1-3	4	≥5	
Dec 2003	0	1,953 (79.42)	464 (18.87)	10 (0.41)	32 (1.30)	2,459 (100)
	1-3	0 (0.00)	4,110 (81.00)	711 (14.01)	253 (4.99)	5,074 (100)

Note: in parentheses are row frequencies.

Table 4 Entry and Entry Threat over Time

	Dec 2000	Dec 2001	Dec 2002	Dec 2003	Dec 2004
For markets with 0 provider at period *t-1*					
Entry of 1st set of providers (= 1 if yes; = 0 otherwise)	0.336 (0.472)	0.237 (0.425)	0.275 (0.447)	0.194 (0.396)	0.205 (0.404)
Have 4+ providers by Dec 2004 (= 1 if yes; = 0 otherwise)	0.179 (0.384)	0.073 (0.261)	0.040 (0.197)	0.020 (0.142)	0.017 (0.129)
# of neighbors	2.765 (2.899)	2.666 (2.704)	2.901 (2.893)	3.049 (3.011)	3.233 (3.189)
Entry threat by the 4th provider (= 1 if threatened; = 0 otherwise)	0.030 (0.171)	0.082 (0.275)	0.168 (0.375)	0.288 (0.453)	0.405 (0.491)
% of neighbors with simultaneous entry	0.372 (0.622)	0.340 (0.621)	0.395 (0.635)	0.348 (0.595)	0.307 (0.537)
# non-overlapping neighbors' neighbors	8.299 (17.014)	8.256 (16.540)	9.585 (18.525)	10.194 (19.101)	11.078 (20.329)
Sample Size	5911	4112	3839	2933	2459
For markets with less than 4 providers at period *t-1* and no net exit from *t-1* to *t*					
Entry of the 4th provider (= 1 if yes; = 0 otherwise)	0.193 (0.395)	0.186 (0.389)	0.154 (0.361)	0.139 (0.347)	0.133 (0.3340)
Have 5+ providers by Dec 2004 (= 1 if yes; = 0 otherwise)	0.396 (0.489)	0.289 (0.453)	0.175 (0.380)	0.089 (0.285)	0.037 (0.190)
# of neighbors	4.760 (5.452)	3.704 (4.346)	3.367 (3.906)	3.028 (3.256)	2.935 (3.075)
Entry threat by the 5th provider (= 1 if threatened; = 0 otherwise)	0.073 (0.261)	0.106 (0.308)	0.161 (0.368)	0.191 (0.394)	0.235 (0.424)
% of neighbors with simultaneous entry	0.386 (0.558)	0.347 (0.569)	0.376 (0.599)	0.331 (0.575)	0.306 (0.557)
# non-overlapping neighbors' neighbors	16.687 (33.318)	11.204 (21.672)	10.856 (22.683)	9.934 (20.528)	9.547 (19.724)
Sample Size	13841	10712	9564	8382	7533

Figure 1 **Comparison between Unthreatened and Threatened Markets**



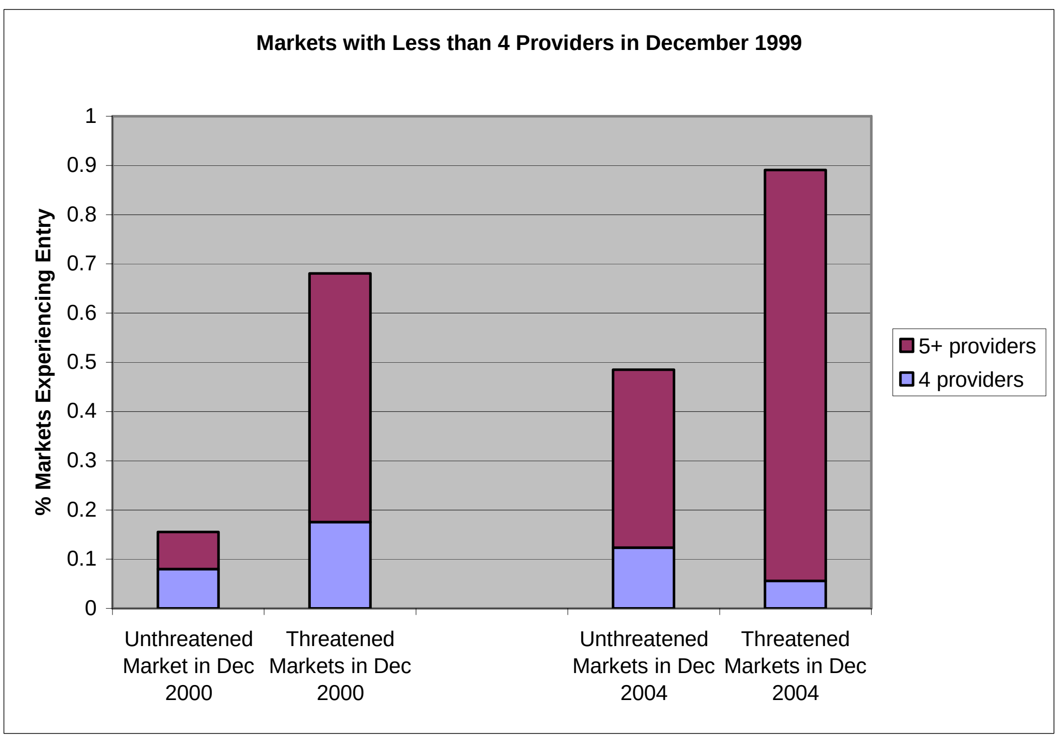


Table 5 Entry Threat's Realization for the 1st Set of Entrants

Sample: markets with 0 provider at period *t-1* Dependent Variable: = 1 if the market has at least 4 providers in December 2004; = 0 otherwise Entry Threat: a neighboring market has at least 4 providers at period *t-1*					
Panel A: OLS results, control X = No					
	Dec 2000	Dec 2001	Dec 2002	Dec 2003	Dec 2004
Entry Threat	0.195	0.039	0.035	0.038	0.034
	(0.029)***	(0.015)***	(0.008)***	(0.006)***	(0.005)***
R-Squared	0.008	0.002	0.004	0.015	0.016
Panel B: OLS results, control X = Yes					
Entry Threat	-0.056	-0.031	0.017	0.015	0.017
	(0.027)**	(0.015)**	(0.009)*	(0.006)***	(0.004)***
R-Squared	0.264	0.226	0.167	0.377	0.523
Panel C: IV results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	0.143	0.067	0.086	0.080	0.071
	(0.075)*	(0.033)**	(0.021)***	(0.013)***	(0.011)***
R-Squared	0.257	0.218	0.155	0.349	0.495
Panel D: IV results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	0.242	0.114	0.162	0.123	0.099
	(0.062)***	(0.033)***	(0.026)***	(0.018)***	(0.016)***
R-Squared	0.249	0.226	0.116	0.300	0.457
Panel E: GMM results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	**1.633**	**0.828**	**1.114**	**1.108**	**2.464**
	(0.517)***	**(0.380)****	**(0.431)*****	**(0.486)****	**(1.356)***
ψ	**1.058**	**1.091**	**0**	**0**	**0**
	(0.245)***	**(0.236)*****	**(n.a.)**	**(n.a.)**	**(n.a.)**
Panel F: GMM results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	0.891	0.935	0.879	1.085	2.056
	(0.431)**	(0.377)**	(0.479)*	(0.633)*	(1.166)*
ψ	1.256	1.078	0	0	0
	(0.136)***	(0.234)***	(n.a.)	(n.a.)	(n.a.)
# of markets	5911	4112	3839	2933	2459

Note:1) Numbers in parenthesis are standard errors for all tables reporting estimation results. * significant at 10% level, ** significant at 5%, and *** significant at 1%. 2) For 2002, 2003, and 2004, we can not reject the null hypothesis $\psi = 0$ so the covariance matrix estimation on ψ is not applicable. 3) For GMM results, we report coefficients instead of marginal effects.

Table 6 Entry Threat's Realization for the 4th Entrant

Sample: markets with less than 4 providers at period *t-1* and no net exit from *t-1* to *t* Dependent Variable: =1 if the market has at least 5 providers in December 2004; =0 otherwise Entry Threat: a neighboring market has at least 5 providers at period *t-1*					
Panel A: OLS results, control X = No					
	Dec 2000	Dec 2001	Dec 2002	Dec 2003	Dec 2004
Entry Threat	0.474	0.307	0.294	0.136	0.068
	(0.015)***	(0.014)***	(0.010)***	(0.008)***	(0.005)***
R-Squared	0.064	0.044	0.081	0.035	0.023
Panel B: OLS results, control X = Yes					
Entry Threat	0.105	0.077	0.124	0.066	0.039
	(0.013)***	(0.012)***	(0.011)***	(0.009)***	(0.006)***
R-Squared	0.501	0.409	0.323	0.155	0.123
Panel C: IV results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	0.599	0.432	0.269	0.127	0.124
	(0.038)***	(0.034)***	(0.022)***	(0.018)***	(0.014)***
R-Squared	0.444	0.364	0.310	0.151	0.100
Panel D: IV results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	0.453	0.395	0.384	0.247	0.159
	(0.029)***	(0.031)***	(0.027)***	(0.025)***	(0.020)***
R-Squared	0.472	0.373	0.282	0.115	0.076
Panel E: GMM results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	**4.539**	**1.777**	**1.058**	**0.527**	**1.022**
	(0.850)* **	**(0.323)*** **	**(0.184)*** **	**(0.203)*** **	**(0.311)*** **
ψ	**1.262**	**1.303**	**1.196**	**1.181**	**1.205**
	(0.081)* **	**(0.083)*** **	**(0.012)*** **	**(0.013)*** **	**(0.139)*** **
Panel F: GMM results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	2.169	0.904	1.540	1.136	0.938
	(0.301)***	(0.283)***	(0.273)***	(0.284)***	(0.451)***
ψ	1.114	1.179	1.207	1.206	1.216
	(0.085)***	(0.055)***	(0.039)***	(0.056)***	(0.057)***
# of markets	13841	10712	9564	8382	7533

Table 7 Entry Delay by the 1st Set of Entrants Facing Entry Threat

Sample: markets with 0 provider at period *t-1* Dependent Variable: =1 if the market has at least 1 provider at period *t*; =0 otherwise Entry Threat: a neighboring market has at least 4 providers at period *t-1*					
Panel A: OLS results, control X = No					
	Dec 2000	Dec 2001	Dec 2002	Dec 2003	Dec 2004
Entry Threat	-0.030	-0.172	-0.196	-0.177	-0.170
	-(0.036)	(0.024)***	(0.019)***	(0.016)***	(0.016)***
R-Squared	0.0001	0.012	0.027	0.041	0.043
Panel B: OLS results, control X = Yes					
Entry Threat	-0.227	-0.138	-0.096	-0.071	-0.078
	(0.035)***	(0.026)***	(0.022)***	(0.019)***	(0.018)***
R-Squared	0.165	0.108	0.116	0.133	0.208
Panel C: IV results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	-0.234	-0.217	-0.125	-0.131	-0.074
	(0.098)**	(0.057)***	(0.048)**	(0.041)***	(0.041)*
R-Squared	0.165	0.106	0.112	0.130	0.208
Panel D: IV results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	-0.079	-0.166	-0.159	-0.205	-0.067
	-(0.081)	(0.058)***	(0.060)***	(0.057)***	-(0.060)
R-Squared	0.163	0.108	0.111	0.117	0.208
Panel E: GMM results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	**-1.592**	**-1.958**	**-0.782**	**-0.969**	**-0.519**
	(0.707)**	**(0.707)*****	**(0.242)*****	**(0.248)*****	**(0.252)****
ψ	**1.361**	**1.060**	**1.304**	**1.202**	**0.978**
	(0.109)***	**(0.504)****	**(0.167)*****	**(0.205)*****	**(0.102)*****
Panel F: GMM results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	-1.251	-1.454	-1.101	-1.524	-0.849
	(0.467)***	(0.613)**	(0.344)***	(0.453)***	(0.364)**
ψ	1.291	1.039	1.416	1.596	1.509
	(0.056)***	(0.362)***	(0.039)***	(0.937)*	(0.779)*
# of markets	5911	4112	3839	2933	2459

Table 8 Entry Decision of the 4th Entrant Facing Entry Threat

Sample: markets with less than 4 providers at period *t-1* and no net exit from *t-1* to *t* Dependent Variable: =1 if the market has at least 4 providers at period *t*; =0 otherwise Entry Threat: a neighboring market has at least 5 providers at period *t-1*					
Panel A: OLS results, control X = No					
	Dec 2000	Dec 2001	Dec 2002	Dec 2003	Dec 2004
Entry Threat	0.525	0.249	0.238	0.129	0.120
	(0.012)***	(0.012)***	(0.010)***	(0.010)***	(0.009)***
R-Squared	0.121	0.039	0.059	0.022	0.023
Panel B: OLS results, control X = Yes					
Entry Threat	0.263	0.090	0.079	0.042	0.051
	(0.011)***	(0.011)***	(0.010)***	(0.011)***	(0.010)***
R-Squared	0.386	0.355	0.293	0.160	0.167
Panel C: IV results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	0.788	0.242	0.196	0.038	0.110
	(0.035)***	(0.029)***	(0.022)***	(0.022)*	(0.024)***
R-Squared	0.288	0.244	0.283	0.160	0.163
Panel D: IV results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	0.585	0.269	0.270	0.178	0.190
	(0.026)***	(0.028)***	(0.026)***	(0.030)***	(0.034)***
R-Squared	0.349	0.340	0.267	0.144	0.147
Panel E: GMM results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	**2.486**	**0.882**	**0.767**	**0.049**	**0.586**
	(0.316)***	**(0.207)*****	**(0.169)*****	**(0.190)**	**(0.261)****
ψ	**1.262**	**1.165**	**1.195**	**1.255**	**1.250**
	(0.043)***	**(0.156)*****	**(0.013)*****	**(0.445)*****	**(0.156)*****
Panel F: GMM results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	1.647	0.908	1.032	0.645	0.889
	(0.191)***	(0.343)***	(0.232)***	(0.288)**	(0.279)***
ψ	1.260	1.181	1.213	1.208	1.219
	(0.005)***	(0.078)***	(0.056)***	(0.109)***	(0.176)***
# of markets	13841	10712	9564	8382	7533

Table 9 Marginal Effects of Entry Threat on the 1st Set of Entrants

Sample: markets with 0 provider at period *t-1* Dependent Variable: =1 if the market has at least 1 provider at period *t*; =0 otherwise Entry Threat: a neighboring market has at least 4 providers at period *t-1*					
Panel A: GMM results, control X = Yes, Instruments = the average characteristics and number of neighbors					
Entry Threat	-0.303	-0.215	-0.190	-0.148	-0.097
	(0.041)***	(0.008)***	(0.037)***	(0.017)***	(0.034)***
Panel B: GMM results, control X = Yes, Instruments = the average characteristics and number of non-overlapping neighbors' neighbors					
Entry Threat	-0.272	-0.208	-0.230	-0.201	-0.158
	(0.046)***	(0.023)***	(0.036)***	(0.015)***	(0.039)***
# of markets	5911	4112	3839	2933	2459

Note: This table reports the decrease in the probability of entry by the 1st set of entrants when entry threat changes from 0 to 1. We obtain the standard errors using the delta method.