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Abstract

This work examines the relationship between multimarket contact (MMC) and entry in the US broadband service industry. I examine unique data on entry into ADSL broadband over the years 2005-2008 in the US. Results indicate that MMC increases the probability of entry into local broadband markets by incumbent local telephone companies, which is consistent with the firms' expectations that competition will be softer in such markets. Thus, the evidence is consistent with the notion that MMC facilitates mutual forbearance. A deeper investigation uncovers evidence consistent with firms using MMC to help build "spheres of influence" to limit competition. Evidence for using MMC to "transfer power" (shifting slackness in the incentive constraint to other markets) is weaker and contradictory. This result indicates that heterogeneity among firms within markets may be a more important driver of competition (or its lack) than heterogeneity among markets.

Keywords

Multimarket contact, mutual forbearance, strategic entry, spheres of influence, transfer of power, broadband Internet access.

I. Introduction*

It has long been understood by both researchers and market participants that multimarket contact (hereafter, "MMC") between competitors may facilitate mutual forbearance (tacit collusion) and soften price competition.[1] MMC occurs when two or more firms meet in many geographic or product markets. Bernheim and Whinston (1990) show that the simplest story for why MMC facilitates collusion, that MMC gives rivals more chances to retaliate against a firm deviating from collusion, is incorrect.[2] Instead, multimarket contact makes it easier to satisfy the incentive constraints for mutual forbearance among firms, since the constraint for a firm need hold only in the aggregate, not in the individual markets. A sizeable empirical literature has grown over the years testing various hypotheses connected to MMC and market outcomes. Most studies conclude that MMC indeed leads to less aggressive competition among firms.[3] However, the empirical literature on MMC has not explored fully *why* MMC causes enterprises to compete less aggressively. Sorenson (2007) takes the empirical literature to task for not clearly linking the evidence to why MMC might matter. In particular, Bernheim and Whinston (1990) suggest two settings (int. al.) in which MMC facilitates collusion. The first occurs when firms are heterogeneous in cost within markets. If so, then MMC helps sustain a firm's strategy of dominating in its low-cost markets—developing a "sphere of influence" (SOI)—with the tacit acquiescence of its rivals, which do the same elsewhere. The second occurs when markets are heterogeneous in the degree of rivalry. In this case, MMC facilitates collusion by allowing the firms to transfer slack in the incentive compatibility condition for collusion from markets that are nonrivalrous to markets where collusion would otherwise break down. The latter case is termed "transfer of power" (TOP).

This paper explores data from the US broadband service market to explore the relationship between MMC and entry. The work contributes to the literature in two ways. While there are many studies looking at the impact of MMC on prices or profits, there are fewer studies on the impact of MMC on

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[1] See Bernheim and Whinston (1990) and their review of the literature.

[2] If firms and markets are identical, then meeting in multiple markets merely scales up the competitive considerations involved in a single market without altering the incentive constraint for mutual forbearance.

[3] See the summary of the literature in Waldfogel and Wulf (2006), for example.

entry into markets. I explore how MMC relates to the strategic decisions of incumbent telephone companies to offer ADSL broadband. Furthermore, there are unexplored hypotheses to test. The investigation here includes tests of whether SOI or TOP is responsible for the observed strategies of the firms regarding entry.

The plan of the paper is as follows. A review of the literature and discussion of the issues involved is in the next section. In Section III, I describe the data. I develop my empirical model in Section IV and present results in section V. The final section contains concluding discussion.

II. Literature Review and Hypotheses

Bernheim and Whinston (1990) perform a seminal exploration of MMC and collusion that is grounded rigorously in game theory to model strategic interactions among noncooperating firms. They show that MMC makes mutual forbearance easier to sustain among firms. Tacit collusion can be sustained only if the incentive-compatibility constraint is satisfied in a market: the gains from collusion must outweigh the immediate profit from defecting from forbearance. Under MMC, the incentive constraint for a firm need hold only in the aggregate, not in each individual market. Thus, MMC can encourage mutual forbearance among the market players. With forbearance comes the expectation of higher profit. While profitability may be unobserved to the researcher, a key insight from the work of Bresnahan and Reiss (1987) is that the strategic decisions of firms both to enter and to remain in a market reveal information about profitability. The more profitable a market is expected to be, the more likely it is that a firm will decide to enter the market and the less likely the firm will be to exit. Thus, MMC should lead (by way of expected profitability) to an increased probability of entry by a potential market entrant, other things equal, and a reduced probability of exit. For shorthand, these outcomes will be referred to as "more entry" below.

> Hypothesis 1: Higher levels of multimarket contact among strategic firms will lead to more entry.

The next hypothesis to explore concerns SOI created by heterogeneity among firms within a market. Bernheim and Whinston (1990) show that differences in cost among firms can give MMC a role in sustaining tacit collusion. In particular, in a single market setting the cost-disadvantaged firm typically must receive some market share to incentivize forbearance. With multiple markets, however, the high-cost firm in one market can be rewarded for tacitly colluding by receiving market share in another market in which it is the low-cost firm. Thus, spheres of (monopolistic) influence can form. Again, the reason MMC helps sustain mutual forbearance is the pooling of the incentive-compatibility constraints across markets. This suggests looking for evidence that cost factors specific to the focal firm and the market affects the degree of influence that MMC has on entry. Under Hypothesis 1, MMC leads to more entry. Under the SOI hypothesis, a variable that pertains to a firm having lower relative cost in a market will *increase* the impact of MMC on entry (where, as before, "entry" is short for both entry and lack of exit).

> Hypothesis 2 (SOI): A firm's cost advantages in a market will increase the positive impact of multimarket contact on its entry decisions.

Furthermore, since a SOI concerns keeping rivals out of "home" markets (i.e., where the focal firm has low relative cost), the impact of MMC on entry should be less where competitors have already entered the market (Baum and Korn, 1996).

> Hypothesis 3 (SOI): The presence of more rivals in a market will decrease the positive impact of multimarket contact on a firm's entry decisions.

Turn now to the TOP hypothesis. Under the TOP hypothesis, MMC causes price-cost margins to fall in markets where the collusion condition is met with slack, as the slack is transferred to other markets where the condition does not bind. In latter markets, margins and hence profitability rise. Therefore, the impact of MMC on entry should be lowest in markets where the slackness of the collusion constraint is greatest. Whereas differences among firms' costs underlie the SOI hypotheses, differences among *markets* create the possibilities for conglomeration and the transfer of market power in the TOP hypothesis.

> Hypothesis 4 (TOP): Factors that are positively associated with slackness in the collusion constraint will decrease the positive impact of multimarket contact on a firm's entry decisions.

The early empirical literature on MMC examined data across manufacturing industries (Scott, 1982, 1991; Hughes and Oughton, 1993) and showed that MMC increased the profitability of firms. Later studies honed the precision of the analysis by looking at specific industries: Heggestad and Rhoads (1978) and later authors for banking; Evans and Kessides (1994), Ciliberto and Williams (2012), and others for airlines; Fernandez and Marin (1998) for hotels; Fu (2003) for newspapers; Chiao (2014) for shipping; and Jans and Rosenbaum (1997) for cement. Reviews of the MMC literature such as Jayachandran, Gimeno and Varadarajan (1999) and Korn and Baum (1999) note that such studies typically find that MMC is positively associated with price-cost margins or other quantities related to higher profits or less-competitive outcomes among firms. The role of MMC in broadband service markets has not yet been examined. Perhaps the closest related industry is telecommunications more broadly defined. Parker and Roller (1997) and Busse (2000) both examine MMC in the wireless telecommunications industry, and find association between MMC and higher prices. This naturally leads one to look for a role for MMC in other markets in which these (and other) firms meet and compete.

A smaller body of research considers how MMC affects entry. Baum and Korn (1996) found that MMC lowered entry rates in California airlines markets. Haveman and Nonnemaker (2000) find an inverted U shape to the relationship between MMC and entry in banking, which Stephan et al (2003) also find for hospitals. Other studies in this vein include Fuentelsaz and Gómez (2006) for banking, and Kang, Bayus, & Balasubramanian (2010) for new product entry in the personal computer industry, Alcantara and Mitsuhashi (2015) for auto parts, and Skilton and Bernardes (2014) for product entry in the aircraft modification market. Some of the papers cited above look for and find an inverted U: when MMC is low, increases in MMC increase entry, but after a threshold level of MMC further increases in MMC deter entry. These papers justify the nonmonotonic relationship as follows. To create the conditions for MMC to facilitate collusion, firms must enter each other's markets. However, once MMC and the attendant collusion are well established it deters aggressive actions by rivals, and entry is one of the deterred actions (Stephan et al., 2003).

Regarding empirical methodology, the entry literature uses a variety of estimation methods. Some of these papers, such as Haveman and Nonnemaker (2000), use hazard rate models for entry, treating the time until a firm enters a market as a duration. Others use a logit model (e.g., Stephan et al., 2003) or count data models (e.g., Skilton and Bernardes, 2014) for entry. In these articles, the dependent variable for entry is defined as *new* entry into a market. Thus, after entry occurs nothing else is modelled.[4] This is in contrast to the empirical industrial organization literature on entry, where the dependent variable is the firm's presence in a market (or the count of firms present).[5] As discussed above, Bresnahan and Reiss (1987) and others show that since both choosing to enter a market and deciding to remain in a market are strategic choices, both can be used to infer the profitability of the market. My approach here

[4] But see Baum and Korn (1996), who after entry also model the probability of failure and exit.
[5] Alcantara and Mitsuhashi (2015) also take this approach in their study of MMC and entry in the management literature.

relies heavily on this fact, for while I do not observe margins (or even prices) in the local markets, I assume that entry is driven by the expectation of what those margins will be.

III. Description of the Data

The data on broadband entry for the empirical investigation come from the US Federal Communications Commission (FCC) Form 477. The FCC has collected data from providers of end-user broadband service since 1999. All facilities based broadband providers in the US are required to complete the semi-annual Form 477, which until 2009 required them to list each five-digit ZIP code in which they provide service. The firms provide separate ZIP code lists for each type of wireless, wired, fixed, or mobile broadband service offered. Thus the number and identity of firms offering service of each type of broadband is known at the ZIP code level, although subscribership data are available only at the state level.[6] The period examined in the study is midyear 2005 to midyear 2008.[7] Previous investigation of these data revealed that there is a surprising amount of apparent entry and exit for a single period only, some of which may be due to filing errors (Prieger and Connolly, 2013). For this reason, I group the semi-annual filings into four periods, an initial baseline taken from the June 30, 2005 filing (Period 0), and subsequent periods grouping data from the December 31 and June 30 filings (see Table 1). If a firm was present in either the December or June filing for periods 1-3, it is treated as having entered (or remained in the market) that period.

Any study on entry must define the geographical markets to be studied. The delineation of markets is difficult in the broadband industry, since different companies have different, overlapping service footprints. Any geographic delineation of broadband markets for purposes of academic inquiry must be artificial and only an approximation of how the firms involved view their markets and competitors. The market definition I choose is the *ZCTA group*. The building block for a ZCTA group is the Zip Code Tabulation Area (ZCTA), an area defined by the US Census Bureau (in my case, for the 2000 Decennial Census) that generally is meant to coincide with a US postal (ZIP) code.[8] Using ZCTAs allows linking the ZIP code data from the FCC to ZIP code and ZCTA data from other sources. However, in urban areas the

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[6] The FCC does not publically release the data except in heavily censored form. This study makes use of the raw source data, which were provided under a confidentiality agreement. I therefore do not identify any of the providers by name in this study.
[7] The data before 2005 are not comparable, because the smallest providers were not required to file Form 477; the data after our period are not available to us under our agreement with the FCC.
[8] ZIP codes do not define areas, but instead consist of collections of addresses. ZIP codes, which are defined by the USPS, are constantly changing, whereas ZCTAs are stable (at least between decennial censuses).

ZCTAs tend to be quite small compared to (for example) central office serving areas. Therefore I aggregate some ZCTAs with other contiguous ZCTAs to form a group. I refer to both single ZCTA and multi-ZCTA markets as ZCTA groups, for simplicity.[9]

While it is straightforward to determine where any given broadband provider offers service using the FCC data, it is much more difficult to ascertain where the provider is a potential entrant. I focus on a subset of potential broadband providers whose likely areas of entry are readily determined: incumbent local exchange carriers (ILECs). The advantage of focusing on ILECs and their entry into the ADSL broadband market is that due to the legacy of telecommunications regulation, we know where these firms offer telecommunications service.[10] In addition, ILEC broadband is reported separately in Form 477, so their entry is readily observable. In this paper, I examine entry by ILECs into ADSL broadband in mainland US markets. Coverage is not quite complete, for I dropped markets exhibiting discrepancies in the data.[11] The final data set comprises 475 ILECs potentially offering ADSL broadband in 42,962 market-periods (over 14,000 ZCTA groups in each of the three periods).

Other data from various sources are matched to each market for use as regressors. Demographic data for the ZCTAs come from GeoLytics. Counts of business establishments in the markets are taken from the US Census Bureau's *ZIP Business Patterns*. Geophysical land cover characteristics were calculated for the markets from NLCD data,[12] and elevation data were calculated from SRTM data,[13] to control for network deployment costs.

[9] The aggregation procedure, briefly: I defined any ZCTA with area less than π square miles (corresponding to a radius of one mile if the area were circular) as "small" and in need of aggregation. When the wire center area (WCA) is less than 5 square miles, I group all ZCTAs in it (if it contains any small ones). For remaining small ZCTAs, I aggregated them to the WCA if the WCA is not too large (< 20 sq. miles) and at least 2/3 of ZCTAs in the WCA are small. For remaining small ZCTAs, I joined them to the nearest larger ZCTA unless the distance was suspiciously large. About 25 small ZCTAs remained, and I examined each visually to determine appropriate aggregation. All GIS work was performed in ArcMap 10.

[10] I took the location of all the wire centers in the US and the identities of the firms operating them from various filings of NECA Tariff No.4 for the period studied. The tariff lists V&H coordinates of the wire centers, which I converted to latitude and longitude for analysis in ArcMap.

[11] I dropped markets in which an ILEC associated with the market based on the data from the NECA tariff did not offer broadband, but the data from Form 477 indicate that some ILEC did offer ADSL in the market. In such markets, it may well be the case that there are multiple ILECs serving parts of the area, some offering broadband and others not. However, the phenomenon may also be caused by mismatching company names between data sources, and to be safe I excluded such markets, which were about 10% of the total.

[12] National Land Cover Database 2006; see http://www.mrlc.gov/nlcd2006.php (Fry *et al.,* 2011).

[13] Shuttle Radar Topography Mission V4 (30m data). See http://srtm.csi.cgiar.org (Jarvis et al., 2008)

IV. Empirical Model

In this section, I describe how multimarket contact is measured and introduce the empirical model.

A. Measuring multimarket contact

There are a multiplicity of measures of MMC found in the literature, including market, firm, and firm-market specific measures. The measures range from a simple count of markets where two firms meet to more nuanced measures involving weighting or averaging. I adapt the firm-market specific formulation of Baum and Korn (1996) for my primary measure of MMC. The measure, denoted MMC_{imts} in the equation to follow but just $MMC_{t,s}$ in the text for simplicity, relies on several fundamental notions. Let D_{imt} be a binary indicator variable for firm *i*'s presence in market *m* at period *t*. If *m* is not the focal market (i.e., the particular market firm *i* is considering entering), then D_{imt} measures actual entry. If *m* is the focal market, then for purposes of the calculations below $D_{imt} = 1$. Thus, the potential entrant into focal market *m* thinks about what MMC would be there *if* it entered, taking as given the actual entry decisions *i* has already made in all the nonfocal markets. This approach mimics the aspect of a firm's optimal entry strategy that no single-market deviation from the strategy is profitable, given the entry decisions in the strategy for other markets.

Let d_{js}^{it} be the number of markets in which firms *i* and *j* "meet," where firm *i*'s presence is at period *t* and *j*'s presence is at period *s*. Thus d_{jt}^{it} counts actual coincidence in markets, while d_{jt-1}^{it} counts the number of *expected* meetings between the two firms when *i* forms expectations about *j*'s entry decisions based on where *j* was last period. Formally, we have $d_{js}^{it} \equiv \sum_m (D_{ims} D_{jmt})$. Within a particular focal market *m*, let N_{ms}^{it} be the number of multimarket rivals that focal firm *i* would expect to meet there if *i* entered, where expectations about *j*'s market presence are formed from *j*'s market presence in period *s* (i.e., using D_{jms}). For inclusion in N_{ms}^{it}, a multimarket rival is defined as a firm that firm *i* expects to meet in at least one other market besides *m* (i.e., a firm *j* for which $d_{jt}^{is} > 1$, where meeting in market *m* is treated as the first contact). With these quantities in hand, the expression for $MMC_{t,s}$ is:

$$MMC_{imts} = \begin{cases} \dfrac{\sum_{j \neq i} 1(d_{js}^{it} > 1) D_{jms} d_{js}^{it}}{N_{ms}^{it} \sum_m D_{imt}} & \text{if } N_{ms}^{it} > 0 \\ 0 & \text{if } N_{ms}^{it} = 0 \end{cases} \tag{1}$$

where 1(a) is the indicator function, taking value 1 if expression a is true and 0 otherwise. To see what $MMC_{t,s}$ is measuring, consider the case for $s = t$. Then the summand in the numerator is the number of markets in which i and a multimarket rival j meet. If j does not meet i anywhere outside of market m or is not present in m, the summand is zero. The numerator is the sum of such multimarket contacts over all other firms. The scale of the numerator is on the order of (# rivals) ×(# of markets). Since it is important to isolate the impact of MMC on a firm's behaviour separately from impact of the scale of the firm, the terms in the denominator normalize $MMC_{t,t}$. The first term in the denominator by itself converts the measure to a count of multimarket contacts per multimarket rival met in m. The second term in the denominator, the number of markets in which firm i is present, completes the mapping of the measure to the [0,1] interval. Thus, $MMC_{t,t}$ is the fraction of the markets firm i is in where it meets its multimarket rivals from m, averaged over multimarket rivals in m.

When $s \neq t$, the interpretation of $MMC_{t,s}$ is the same as above, except that expected instead of actual contacts are used in the computation. For robustness checks, I also calculate a weighted version of $MMC_{t,s}$ where in the computation of d_{js}^{it} and $\sum_m D_{imt}$ in (1) each of the markets is weighted according to how many people and business establishments are in the market.[14]

B. The empirical model

The estimations consist of OLS and fixed effects panel data specifications. Using OLS means adopting a linear probability model for the binary entry decision in each observation.[15] The reduced-form empirical model used here is:

$$Y_{imt} = f(\text{market, firm and market-firm characteristics}) + \beta_1 E(MMC_{t,t}) + \beta_2 E(NR_{imt}) + \varepsilon_{imt} \qquad (2)$$

The dependent variable is binary and equals 1 if firm i is present in market m in period t, zero otherwise. $E(MMC_{t,t})$ is the multimarket contact that the firm expects if would face if it enters market m. $E(NR_{imt})$ is the expected number of rivals (not necessarily multimarket rivals; multimarket considerations are accounted for in the previous term) the firm would face in market m. The error term may contain a

[14] The weights for a market are composed from a weighted count of households and business establishments in the ZCTA group, where the latter are multiplied by 2.6. The multiple was determined by comparing the actual number of business and residential lines for ADSL and cable modem service with the number of households and establishments in the US, June 2007, which showed that each business is 2.6 times more likely than a household to demand service.

[15] Use of the linear probability model ensures that there is no incidental parameter problem when including fixed effects, as there would be in the panel probit model (for example).

market-, firm-, or firm-period-specific fixed or random effect as well as idiosyncratic error, depending on the specification used below.

The expectations in (2) are modelled as follows. Consider the case where the firm bases its expectations on where the rivals were last period and an updating term *v*:

$$E(MMC_{t,t}) = MMC_{t,t\text{-}1} + v_{imt} \tag{3}$$

A firm which simply assumes that the present will be like the past has *v* in (3) = 0. However, even if *v* is nonzero, $MMC_{t,t\text{-}1}$ can be a valid regressor in place of $E(MMC_{t,t})$. Putting equation (3) into equation (2), we have:

$$Y_{imt} = \ldots + \beta_1 MMC_{t,t\text{-}1} + (\beta_1 v_{imt} + \varepsilon_{imt}) \tag{4}$$

As long as *v* is uncorrelated with $MMC_{t,t\text{-}1}$ and the other regressors, and $MMC_{t,t\text{-}1}$ is a predetermined regressor,[16] then the new composite error term in the parentheses in (4) satisfies the usual requirements for OLS estimates to be unbiased and consistent. For *v* to be uncorrelated with $MMC_{t,t\text{-}1}$, however, requires that the firm believe that the change in MMC is a "memoryless" process, in that it is uncorrelated with the level of MMC last period. While this assumption may be restrictive, it is not as restrictive as the assumptions required to treat $MMC_{t,t}$ as a valid regressor, which most of the literature does.[17]

V. Results

We begin the empirical examination with a few summary statistics to learn about these markets (some of which are from Table 2). Of the 42,962 opportunities for entry in the dataset, the firm entered (or stayed in the market) 88% of the time. The number of rivals to the focal firm in the market averages 6.6. On average the focal firm meets one other firm offering ADSL in each market, a firm offering cable

[16] A *predetermined* regressor is one uncorrelated with current and future error terms.
[17] It is not hard to see why current period MMC is likely to be endogenous. For example, if a positive demand shock attracts large firms to a market, MMC will naturally rise. Thus entry and MMC will exhibit spurious positive correlation driven by unobserved heterogeneity across markets instead of by causal factors. Waldfogel and Wulf (2006) make this point in the context of price-cost margins instead of entry. Evans and Kessides (1994) appear to be the first to acknowledge the endogeneity problem.

modem service in three out of four markets, 1.75 satellite broadband firms per market, one firm offering fixed wireless broadband out of every three markets, and two mobile wireless firms in every three markets.[18] There is significant MMC present. $MMC_{t,t}$ averages 0.166 across as markets, periods, and potential entrants. This figure means that when the focal firm considers entering a market, on average it will meet its rivals there in 16.6% of its markets nationwide. The distribution of $MMC_{t,t}$ is in Figure 1. In about 23% of markets, $MMC_{t,t}$ is zero. In such markets, the focal firm either faces no rivals at all, or the rivals it does (or would) face it meets nowhere elsewhere. This is about five times more likely to happen in rural areas than urban areas, where there are fewer CLECs and cable modem firms, and any competitors are more likely to be satellite firms, which do not count toward MMC. Summary statistics for the rest of the data are in Table 2, and correlations among the strategic and other non-demographic variables are in Table 3.

1. The impact of MMC on entry

I begin with estimations based on equation (3) for the expectations for MMC and the presence of rivals in the market. Under the assumptions that v in equation (3) is uncorrelated with the other regressors, and that MMC and NR are predetermined regressors, the coefficients from OLS regression are consistent and the coefficient on $MMC_{t,t\text{-}1}$ is the impact of expected $MMC_{t,t}$. Table 4 contains the results of two OLS regressions. Regression 1 in Table 4 illustrates the potential pitfall of omitted variable bias that can plague empirical investigations of MMC. When $MMC_{t,t\text{-}1}$ is the only regressor included, its coefficient is large and highly significant. If the estimated coefficient, 0.475, were a causal impact it would imply that the focal firm is 47.5 percentage points more likely to enter a market in which it meets all its multimarket rivals in all the other markets it is entering the same period, compared to a market in which it meets no multimarket rivals. However, this estimate suffers from severe omitted variable bias. Attractive markets will naturally contain many multimarket rivals even in the absence of strategic considerations. Once market and focal firm related control variables are included as regressors, in Regression 2, the coefficient falls to 0.187. While still highly significant and relatively large, comparing the two estimates shows that more than half of the apparent impact of MMC from Regression 1 was due to the correlation of $MMC_{t,t\text{-}1}$ with other factors that drive the entry decision.

[18] The latter figure includes some double counting, because I haven't yet removed the focal firm from this count and some ILECs also offer mobile broadband.

The firm related variables included in Regression 2 are an indicator for the presence of the firm in the focal market last period (*firm presence*$_{t-1}$),[19] the number of broadband rivals in the market (NR_{imt-1}, listed as *# rivals*$_{t-1}$ in the table), and the log distance to the nearest other market in which the firm enters at t (*nearest*$_t$). The variable *firm presence*$_{t-1}$ is not always equal to y_{t-1}, because the former is adjusted to account for mergers and other forms of corporate reorganization.[20] *Firm presence*$_{t-1}$ controls for the presence of sunk costs involved with de novo entry in a market. When there are sunk costs of entry, once a firm has entered it is less costly to continue to offer service in subsequent periods. Thus, one would expect the coefficient on *firm presence*$_{t-1}$ to be positive, which it is (0.606). The high degree of economic and statistical significance of this estimate suggests that sunk costs play an important role in entry decision into broadband, a result in accord with Xiao and Orazem (2011). Without market fixed effects in the specification, however, *firm presence*$_{t-1}$ may also be picking up the impact of unobserved market specific factors relevant for entry.

The sign of the coefficient on *# rivals*$_{t-1}$ is equivocal a priori. Under full information among firms, reasonable assumptions about the nature of post-entry competition, and a complete set of all confounding factors for the entry decision, a larger number of firms in a market should lead to a negative coefficient, for entry would be less profitable. However, when information is incomplete or when the number of rivals proxies in part for market-specific factors inadequately controlled for in the regression, the sign of the coefficient for *# rivals*$_{t-1}$ may be positive. For example, when firms receive independent private signals about the profitability of a market, a larger number of competitors may signal to the focal firm that entry is more desirable than otherwise would be expected. Since the present purpose of including this variable in the regression is to control for omitted variable bias that may affect the apparent impact of MMC, I do not pursue which story is correct here (and indeed, the sign of this coefficient switches around between specifications).

The purpose of including *nearest*$_t$ is twofold. First, given the nature of broadband network infrastructure, is it typically less costly to deploy broadband service in an area close to where broadband is deployed elsewhere. This is for two reasons. It may be that a neighbouring market is in the same wire

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[19] To be precise, the indicator variable takes value 1 only if the firm offered ADSL in the focal market at t-1. Even if the firm offered broadband of some other type, the regressor is 0. If one splits the indicator variable into two (one for offering broadband of the focal type at t-1, another for offering broadband of another type at t-1), the coefficient on MMC changes little.

[20] Consider, as one of the many examples I adjusted for, the case of a merger between focal firm A and another firm B in period t. When A was not present last period but B was, *firm presence*$_{t-1}$ = 1 because no sunk costs needed to be paid for A to enter the market.

centre serving area, and broadband equipment deployed in the central office can be used to serve customers in both markets. Even when that is not the case (and given that I tried not to make markets too small, if may often not be the case), there may be other economies of agglomeration of network traffic in the network at levels beyond the central office. The second purpose that $nearest_t$ serves is to proxy for unobserved spatial correlation in cost or demand. A local cost or demand shock may affect several neighbouring markets, and thus controlling for entry in nearby areas through $nearest_t$ helps to control for such shocks.

The market specific variables included in Regression 2 include several measures of the market size: the log number of households and establishments, as well as the population growth rate. Demographic characteristics of the area include the median age in quadratic form and educational attainment. Socioeconomic factors include log median household income and the unemployment rate specific to the market. Four cost-related factors are included: population density, the fractions of the land area covered by snow or ice and wetlands, and the standard deviation of the elevation of the land area.[21] Most of the estimated coefficients for these control variables have the expected signs—for example, the firm is more likely to enter larger markets—but since these variables are not of primary interest for present purposes, I do not discuss them further.[22] Although all the control variables in Regression 2 are included in all subsequent regressions, they are not shown in subsequent tables.

In Regression 3, also reported in Table 4, the specification of Regression 2 is repeated with the addition of market-specific fixed effects.[23] The fixed effects capture the impact of all time-constant factors in the market—i.e., market-specific entry shocks—observed and unobserved. Including the fixed effects halves the apparent impact of MMC from Regression 2. The new coefficient on $MMC_{t,t\text{-}1}$ is 0.093 and is still highly statistically significant. The significance level on the other control variables generally falls, as is typical in such panel data estimations, since there is not as much variation over time in these variables within a market as there is between markets. Observed regressors that do not vary over time (land

[21] The elevation variable is meant to capture the presumed increased cost of deploying telecommunications infrastructure in mountainous areas.

[22] The most puzzling finding is that wealthier areas are associated with a *lower* probability of entry. However, the marginal effect is small: a 1% increase in median income is associated with only a 0.03 percentage point decrease in the likelihood of entry.

[23] If a random effects specification is chosen instead (results not shown), the coefficient and significance of the coefficient for MMC is nearly identical to that from Regression 2. Given how different the fixed effects estimates are, it is likely that a Hausman test would reject the RE model (to be done…).

cover and elevation variables) are absorbed into the fixed effects. If a squared term in $MMC_{t,t\text{-}1}$ is added to the regression (to test for nonmonotonicity as discussed in Section II), it is not significant.

Summarizing the results of this section, we have found that MMC apparently matters a lot for the entry decision of ILECs into the ADSL broadband market. Regressions 2 and 3 suggest that the impact of a one unit increase in $MMC_{t,t}$–a change from no multimarket contact to complete multimarket contact—on entry is in the range of nine to 19 percentage points.

2. A deeper inquiry into MMC: SOI and TOP

In this section, I take a closer look at why MMC affects the entry decision of broadband firms and test Hypotheses 2-4. Hypothesis 2 asserts that a variable that pertains to a firm having lower relative cost in a market will increase the magnitude of the impact of $MMC_{t,t\text{-}1}$ on entry. As noted above, the regressor $nearest_t$ should be negatively correlated with cost. To convert it to a relative measure ($relative\ distance_{t,t\text{-}1}$), I divide $nearest_t$ by the average value of the same measure last period for potential entrants the market.[24] Hypothesis 3, on the other hand, predicts that the impact of MMC on entry is smaller where competitors have already entered the market. Thus in Regression 4, reported in Table 5, $relative\ distance_{t,t\text{-}1}$ and $\#\ rivals_{t\text{-}1}$ are interacted with $MMC_{t,t\text{-}1}$. The coefficients on the interaction terms are the estimates of interest to test Hypotheses 2 and 3. The estimated coefficient on the interaction of $MMC_{t,t\text{-}1}$ and $relative\ distance_{t,t\text{-}1}$ is negative and highly significant, in accord with Hypothesis 2. The same is true for the interaction of $MMC_{t,t\text{-}1}$ and $\#\ rivals_{t\text{-}1}$, in accord with Hypothesis 3. Thus, how the impact of MMC varies across markets is in the manner exactly predicted by the SOI hypotheses.

In Regression 5, I turn to the TOP hypothesis. Under Hypothesis 4, variables that are proxies for slackness in the collusion constraint will attenuate the impact of MMC on entry. Such variables include the following: 1) the number of other markets in which the focal firm expects to meet its multimarket rivals from the focal market (averaged over multimarket rivals in *m*; denoted $\#\ MMC\ contacts_{t,t\text{-}1}$); 2) the fraction of rivals' total lines in the state that are business lines; 3) the fraction of rivals' total lines in the state that are relatively fast residential lines;[25] and 4) an index of the speed of rivals' total lines in the state. The first variable relates to the aggregate slackness in the incentive constraint. As Sorenson (2007)

[24] I only have location data for CLECs and a subset of cable modem firms. Any potential entrant among these is included in the denominator of $Relative\ distance_{t,t\text{-}1}$.

[25] For this variable, "relatively fast" means speed in excess of 200 kbps in *both* directions, instead of merely in the fastest direction. This is still slow by current standards, but there are no other measures of speed specifically for residential lines in Form 477 during these years. About 68% of focal and 74% of rival firms' residential lines are "fast" by this definition.

suggests, “the more contacts firms have, the greater are their chances of finding slack in their incentive constraints that can be used to shore up collusion where it is not otherwise sustainable” (124-5) . The other variables are directly associated with the expected level of competition in the market. The business niche of the telecommunications market is generally more competitive than the residential side (variable 2). When competitors offer higher speeds to their customers, they may be expected to be fiercer rivals as well (variables 3 and 4).[26] According to Hypothesis 4, the sign of the interaction of each of these variables with $MMC_{t,t\text{-}1}$ should be positive.

In order to isolate the impact of *# MMC contacts* on entry, it is important to control for the overall scale of the firm. A larger firm operating in more areas will naturally have higher values of *# MMC contacts*. To control for the scale of the firm each period, and indeed to control for all firm-period specific unobserved factors, I switch from OLS to panel data fixed effects regression, where the fixed effect is specific to the firm and period. The fixed effects also control for other firm-period factors included by other authors in the literature on MMC (e.g., the geographic dispersion of the firm, as in Haveman and Nonnemaker (2000)).

The results for Regression 5, in the middle column of Table 5, provide only scant evidence for TOP. The coefficient on *# MMC* $contacts_{t,t\text{-}1} \times MMC_{t,t\text{-}1}$ is positive and significant.[27] However, the coefficients on the other three interaction terms are either of the wrong sign (variables 2 and 3) or insignificant (variable 4). The unexpected negative coefficients on two of the competition variables may actually provide evidence for SOI. Just as the impact of MMC on facilitating SOI should be negatively related to the number of rivals, it may also be negatively related to the expected threat posed by those rivals.

Regression 6 combines the TOP and SOI variables in the same estimation. The same fixed effects specification is used as in Regression 5. One small change was made to the specification of the SOI variables: the square of *relative distance* was included, since significant nonlinearity was found here. The same general conclusions from the separate estimations still hold: the SOI-specific interactions are significant and consistent with Hypotheses 2 and 3,[28] while the TOP-specific interactions are not consistent with Hypothesis 4, excepting the interaction of *# MMC* $contacts_{t,t\text{-}1}$ with $MMC_{t,t\text{-}1}$ as before.

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[26] Due to the nature of the data available, the line counts are at the state level and do not pertain to the market. They thus proxy the overall threat posed by the rival, not a market specific threat to the focal firm. Nevertheless, variables 2-4 vary across markets in a period because the identities and number of rivals varies.

[27] While this result is consistent with TOP, it is not necessarily inconsistent with SOI—it is just less clear “why the frequency of contact would be essential to an SOI arrangement” (Sorenson, 2007, p.124).

[28] This is despite the fact that Regression 6 includes firm-period fixed effects, which Regression 4 did not.

On balance, it appears that MMC matters in these markets less through the shifting around of slackness in the collusion constraint than through the sustenance of SOI.

VI. Conclusion

The work here uncovers evidence that consideration of MMC is part of the firms' strategic decisions to entry and to not exit local broadband markets. Furthermore, exploration of theories about why MMC matters points toward the Spheres of Influence phenomenon; evidence for the Transfer of Power phenomenon is either contradictory or weak. The results have some practical implications. For example, by uncovering evidence that MMC plays a role in entry decisions, the results argue against traditional merger review in which the competitiveness of local markets are examined in isolation, ignoring competition networks created by MMC (Skilton and Bernardes, 2014). Even in the absence of cooperative agreements not to compete, MMC can facilitate the creation and maintenance of spheres of influence allowing locally dominant firms to increase their profitability.

There are many aspects in which the current work can be improved. Instead of only including ILECs in the estimation, future work will also include other broadband providers (cable modem providers and CLECs). Adding these other types of firms will allow exploration of additional hypotheses that involve heterogeneity among firms.

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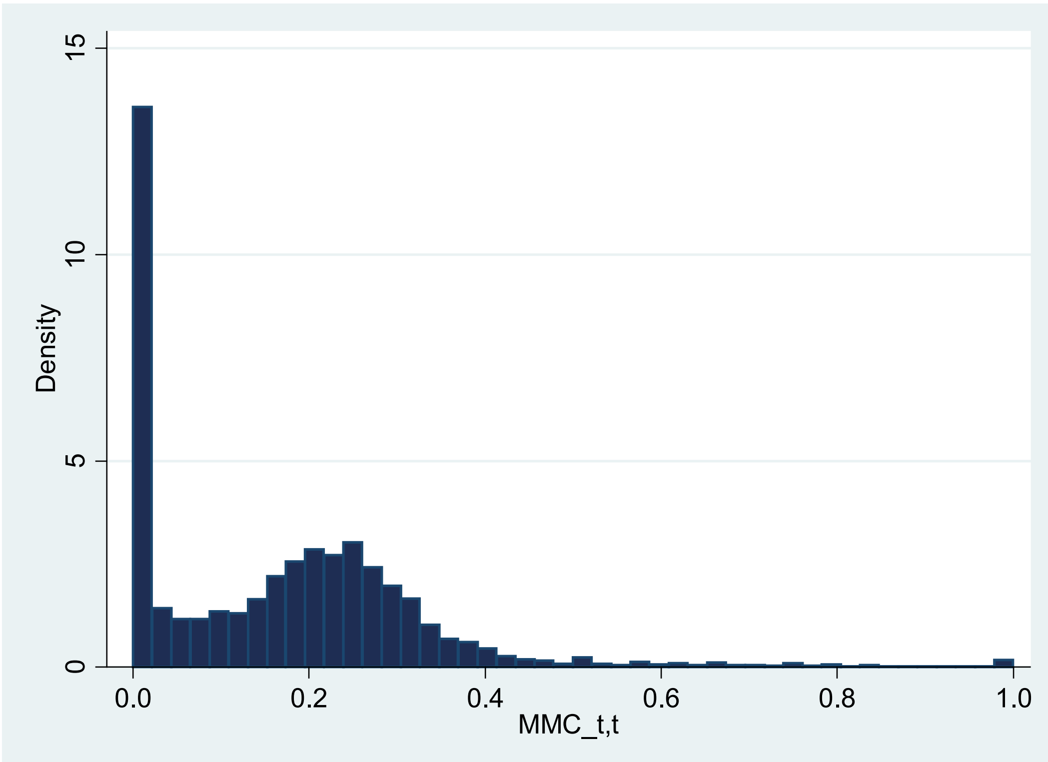
Figures

Figure 1: The Distribution of MMC$_{t,t}$



Tables

Table 1: Vintage of the Data and Grouping into Periods

Period	Forms 477 Included	Year of matched external economic and demographic data
0	June 30, 2005	2005
1	December 31, 2005 June 30, 2006	2006
2	December 31, 2006 June 30, 2007	2007
3	December 31, 2007 June 30, 2008	2008

Table 2: Summary Statistics for the Data

Variable	Obs	Mean	Std. Dev.	Min	Max
Y_{imt} (Firm presence in market)	42,962	0.878	0.327	0.000	1.000
Multimarket contact: $MMC_{t,t}$	42,962	0.166	0.159	0.000	1.000
firm $presence_{t-1}$	42,962	0.832	0.374	0.000	1.000
# $rivals_t$	42,962	6.589	3.644	0.000	27.00
dist. to nearest other presence, log	42,947	1.963	0.963	-0.676	8.424
relative $distance_{t,t}$, log	42,947	-4.002	1.640	-7.669	5.274
# multimarket contacts per $rival_{t,t}$, log	42,962	6.047	3.621	0.000	9.030
competitor business lines	42,962	0.436	0.302	0.000	1.000
competitor fast residential lines	42,962	0.740	0.349	0.000	1.000
competitor speed index	42,962	0.173	0.128	0.000	0.608
# households, log	42,962	7.501	1.549	0.000	12.01
# establishments, log	42,962	4.549	1.773	-0.693	9.623
median HH income, log	42,962	10.55	0.320	8.889	12.14
pop growth rate, annualized	42,962	0.008	0.028	-0.266	0.187
median age	42,962	43.75	4.589	21.60	79.50
education: high school diploma	42,962	0.343	0.092	0.043	0.636
education: some college, no 4 year degree	42,962	0.269	0.065	0.000	0.646
education: 4 year degree or more	42,962	0.183	0.121	0.000	0.801
unemployment rate, %	42,962	4.375	2.595	0.000	50.00
population density (pop/SqMi), log	42,962	4.425	2.241	-2.303	11.58
snow, ice landcover, %	42,962	0.000	0.002	0.000	0.148
wetlands landcover, %	42,962	0.058	0.100	0.000	0.909
elevation (s.d.)	42,962	45.75	74.91	0.040	858.7

Table 3: Pairwise Correlations Among Strategic Variables

	Variable	1	2	3	4	5	6	7	8	9
1.	Y_{imt} (Firm presence in market)									
2.	multimarket contact: $MMC_{t,t}$	0.23**								
3.	firm presence$_{t-1}$	0.78**	0.22**							
4.	# rivals$_t$	0.23**	0.30**	0.24**						
5.	dist. to nearest other presence, log	-0.41**	-0.29**	-0.34**	-0.38**					
6.	relative distance$_{t,t}$, log	-0.22**	-0.21**	-0.17**	-0.34**	0.59**				
7.	# multimarket contacts per rival$_{t,t}$, log	0.22**	0.38**	0.22**	0.57**	-0.42**	-0.31**			
8.	competitor business lines	0.00	-0.18**	-0.03**	-0.01*	0.18**	-0.02**	-0.28**		
9.	competitor fast residential lines	0.22**	0.38**	0.21**	0.55**	-0.30**	-0.24**	0.58**	-0.14**	
10.	competitor speed index	0.15**	0.38**	0.17**	0.36**	-0.34**	-0.13**	0.55**	-0.66**	0.63**

Notes: see previous table for number of observations.

*p<0.05; **p<0.001

Table 4: Estimations Exploring the Impact of MMC on Entry

Y_{imt} = 1 if firm is present in market	Regression 1 (OLS)	Regression 2 (OLS)	Regression 3 (Market FE)
$MMC_{t,t\text{-}1}$	0.4753	0.1871	0.0925
	(0.0138)**	(0.0089)**	(0.0107)**
firm $presence_{t\text{-}1}$		0.6059	0.1511
		(0.0063)**	(0.0064)**
# $rivals_{t\text{-}1}$		-0.0008	0.0072
		(0.0003)*	(0.0005)**
dist. to nearest other presence, log		-0.0784	-0.1282
		(0.0023)**	(0.0055)**
# households, log		0.0327	0.7704
		(0.0029)**	(0.2503)**
# establishments, log		0.0088	-0.0336
		(0.0023)**	(0.0144)*
median HH income, log		-0.0303	-0.0679
		(0.0053)**	(0.0972)
pop growth rate, annualized		0.0969	-2.4751
		(0.0431)*	(1.3290)
median age		-0.0107	-0.0276
		(0.0024)**	(0.0141)
median age squared		0.0001	0.0003
		(0.0000)**	(0.0002)*
education: high school diploma		0.1136	-0.7410
		(0.0223)**	(0.7830)
education: some college, no 4 year degree		-0.0367	-2.5538
		(0.0193)	(0.7421)**
education: 4 year degree or more		0.0484	-1.5859
		(0.0173)**	(0.8510)
unemployment rate, %		-0.0048	-0.0452
		(0.0006)**	(0.0036)**
pop/SqMi, log		-0.0391	-0.3085
		(0.0014)**	(0.1840)
snow, ice landcover, %		1.3348	
		(0.4269)**	
wetlands landcover, %		0.0167	
		(0.0104)	
elevation (s.d.)		-0.0002	
		(0.0000)**	
constant	0.8036	0.9483	-0.5742
	(0.0040)**	(0.0687)**	(2.1850)
F statistic	1,185.73	1,289.23	110.94
R^2	0.054	0.649	0.145
Adjusted R^2 (OLS) or Within R^2 (FE)	0.054	0.648	0.200

* p<0.05; ** p<0.01

Notes: N = 42,962. S.e.'s are robust to heteroskedasticity and account for clustering within markets.

Table 5: Estimations Exploring SOI vs. TOP

Y_{imt} = 1 if firm is present in market	**Regression 4 (OLS)**	**Regression 5 (Firm-Period FE)**	**Regression 6 (Firm-Period FE)**
$MMC_{t,t-1}$	0.1254	0.0620	0.0425
	(0.0183)**	(0.0361)	(0.0396)
$MMC_{t,t-1}$×(relative $distance_{t,t-1}$, log)	-0.0284		-0.0384
	(0.0029)**		(0.0121)**
$MMC_{t,t-1}$×(relative $distance_{t,t-1}$, log)^2			-0.0081
			(0.0017)**
$MMC_{t,t-1}$×(# $rivals_{t-1}$)	-0.0130		-0.0091
	(0.0028)**		(0.0032)**
firm $presence_{t-1}$	0.6071	0.6827	0.6817
	(0.0063)**	(0.0064)**	(0.0064)**
# $rivals_{t-1}$	0.0014	-0.0026	-0.0006
	(0.0006)*	(0.0004)**	(0.0008)
dist. to nearest other presence, log	-0.0770	-0.0706	-0.0739
	(0.0023)**	(0.0034)**	(0.0035)**
$MMC_{t,t-1}$×(# MM contacts per $rival_{t,t-1}$)		0.0116	0.0149
		(0.0034)**	(0.0037)**
$MMC_{t,t-1}$×(competitor business lines)		-0.0727	-0.0495
		(0.0403)	(0.0409)
$MMC_{t,t-1}$×(competitor fast residential lines)		-0.1639	-0.1416
		(0.0331)**	(0.0340)**
$MMC_{t,t-1}$×(competitor speed index)		0.1201	0.1458
		(0.1153)	(0.1166)
# MM contact $markets_{t,t-1}$		0.0025	0.0019
		(0.0006)**	(0.0007)**
competitor business lines, proportion		-0.0000	-0.0025
		(0.0083)	(0.0083)
competitor fast residential lines, proportion		0.0176	0.0140
		(0.0068)**	(0.0069)*
competitor speed index		0.0103	0.0044
		(0.0239)	(0.0240)
constant	0.9349	0.5382	0.5599
	(0.0686)**	(0.0554)**	(0.0555)**
Controls as in Estimation 2	included	included	included
F statistic	1,173.63	3,553.87	3,192.03
R^2	0.649	0.634	0.633
Adjusted R^2 (OLS) or Within R^2 (FE)	0.649	0.679	0.680

* p<0.05; ** p<0.01

Notes: N = 42,947. S.e.'s are robust to heteroskedasticity and account for clustering within markets.