A Basic Analysis of Entry and Exit in the US Broadband Market, 2005-2008

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Abstract: We conduct a basic analysis of entry and exit in the US broadband market, using a complete FCC census from 2005 to 2008. There is a tremendous amount of (simultaneous) entry and exit in the US broadband market. Our other findings include the following. Entry and exit varies widely across the various modes of provision, and the highest entry rates also generally have the highest entrant shares. Entry rates display positive autocorrelation, and the same is true for exit. Without controlling for market-specific factors, there is positive correlation between the entry and exit rates at various leads and lags. Controlling for market-specific factors, there is negative correlation between the entry and exit rates. We discuss some implications these results may have for both policy purposes and future work in the broadband market.

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I. Introduction

The importance of broadband to modern life as consumers, citizens, students, producers of goods and services, and providers of public safety is well established. The entire edifice of the market for broadband rests on the foundation of its infrastructure. Since demand for broadband service cannot be satisfied and the enjoyment of the benefits of broadband usage cannot begin until supply is available, it is critical to monitor and explore the evolution of the market on the supply side. The broadband market is also of particular interest given the importance of broadband for local economic development, labor productivity, and GDP growth (Gillett *et al*., 2006; Kolko, 2010; Greenstein and McDevitt, 2009). For the IO economist, broadband markets are a potentially fertile laboratory to develop and test theories about market dynamics.

Despite the importance of the broadband market, however, little work has been done on the dynamics of the market. Most studies of entry in the market for broadband service provision are static in nature. In a typical such study, either the number of broadband firms or an indicator for the presence of at least one firm in the local area is regressed on various market and demographic characteristics (Prieger, 2003; Grubesic and Murray, 2004; Flamm, 2005, Prieger and Church, forthcoming). From such studies of broadband availability in the US, we have learned that the willingness of a firm to

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deploy network resources in a local area is driven by economic and regulatory considerations.[1] Demand factors such as the size of the local market, average income in the area, and other demographic characteristics such as the education and age profile of the area have all been shown to affect broadband penetration (Prieger, 2003; Grubesic and Murray, 2004; Flamm, 2005; Flamm and Chaudhuri, 2007; Prieger and Hu, 2008b).[2] The same studies show that cost factors such as population density and the fixed costs of deployment, which are affected by the terrain, etc., also influence broadband penetration. Due to low population density and generally rougher topography than urban areas, rural areas are less likely to have broadband available at all, or more likely to be served only with lower-speed broadband or by few providers (Stenberg *et al.*, 2009; Li *et al*., 2011). Prospective and actual competition among providers, both intra- and intermodal also affects the incentives to enter the local broadband markets (Denni and Gruber, 2006; Prieger and Hu, 2008a; Wallsten and Mallahan, 2010). Regulatory policy toward broadband, such as mandated unbundling of network elements for use by competitors, can also impact the deployment decision by altering the expected return on network investment (Prieger and Lee, 2008). Almost all these results have all been gleaned from cross-sectional, static studies of current market participants.

This paper examines the FCC's data on where broadband service was offered from June 2005 to June 2008. By linking broadband service providers' data submissions over time, we are able to measure and investigate the sources and determinants of entry and exit in the US broadband market. We define markets two ways for purposes of study. The smallest market we examine has the geographic extent of a ZIP code area and is

[1] This paragraph closely follows Prieger and Church (forthcoming).
[2] See also the review of broadband demand studies in Hauge and Prieger (2010).

restricted to a single type of broadband in product space. We call this market *ZIP-BB*, since markets are distinguished by ZIP code and type of broadband. Widening the geographic extent of the market to the entire US and including all broadband types gives us the *US* market.

Instead of jumping directly to regressions or structural modeling of the industry, we instead conduct a basic investigation of entry and exit in this paper. In taking this approach, we apply the lessons from recent decades in the IO literature that establishing basic descriptive facts about industry entry and exit can motivate better theoretical and empirical modeling. As an example, Einav and Levin (2010) cite the findings of Dunne, Roberts, and Samuelson (1988) and others that there is a great deal of heterogeneity between firms' entry and exit patterns, which motivated a wave of new theoretical and empirical models of industry dynamics including firm heterogeneity, simultaneous entry and exit, and other "real world" features (e.g., Jovanovic, 1982; Hopenhayn, 1992; Ericson and Pakes 1995). These models were better able to account for the stylized facts the literature had accumulated, including that a great deal of exit can coexist with entry, and that entry and exit rates are highly correlated across industries, so that industry-specific factors appear to be important in explaining market dynamics.

Toward the goal of building a set of basic facts about market dynamics in broadband markets, we address several questions in this paper. How do the market dynamics compare with what is known about other markets? Where is entry in the local markets coming from, truly new entrants or expansion of existing firms? Are there substantial differences in entry and exit across geographic and product-type markets? And finally, how much turnover of firms is there?

First, how do entry and exit in the broadband market compare with that in other markets? The striking conclusion is that there is a tremendous amount of dynamic activity in the US broadband market. In the national market, the entry rate is about 20% annually, which is far greater than the entry rates the economic literature has found for manufacturing industries. The exit rate for broadband is also higher than for manufacturing, but not as high as the entry rate, so that net entry averages 2.6% annually. With a narrower market definition (at the ZIP code and broadband type level), the entry rates average twice as high as in the national market. Thus, the dynamic element in the market is huge.

The second question, whence comes entry, has policy relevance to questions regarding competition and mergers in the telecommunications and broadband industry. While the FCC pays great attention to potential dominance by large providers at the national level (e.g., their denial of the AT&T/T-Mobile merger), what matters for consumers is the number of options available where they live.[3] We demonstrate that more than two-thirds of entry at the ZIP code level occurs from existing firms expanding geographically into the area and that more than one-fifth of entry comes from firms already operating in the area diversifying their product mix (i.e. offering another type of broadband access). These entrants are also larger than *de novo* entrants. Thus, most entry and much of the dynamism in the market, along with the new options entry provides for consumers, comes from large, existing firms.

The third question of heterogeneity in dynamics among areas and broadband service types also has policy relevance. Since the main form of competition in broadband markets at the time was between the incumbent DSL provider and the local franchise

[3] And, in the case of mobile broadband, where they travel.

cable company offering cable modem service, it is important to understand how the dynamics among those types of firms may differ. We show that average entry and exit rates mask much variation among different types of broadband service; entry is much more prominent in some broadband types than others. The entry rate is highest for mobile wireless, fiber, and DSL, and lowest for satellite, fixed wireless, cable modem, and BPL. There is also great variation in exit rates. Thus, analyses lumping all broadband types together in a market, as most of the previous work cited above had to do, may miss much interesting variation and strategic interaction via intermodal competition.

The final question of turnover of firms in the marketplace impinges directly on previous work done in this area. Only one paper of which we are aware has attempted to directly address dynamics in the broadband marketplace. Xiao and Orazem (2005) extend Bresnahan and Reiss's (1991) model of local oligopoly to allow firms to enter and exit the ZIP code-level markets. Their work makes clever use of the publicly available data from the FCC, which (at the time) consists only of counts of firms (undifferentiated by type) offering service in the ZIP code. The data do not reveal the identities of market participants, and so true longitudinal data on the firms in the local markets is unavailable. They find that once the market has one to three firms, the fourth and succeeding entrants have little effect on competitive conduct, which they infer from their findings regarding the role of sunk costs in determining entry conditions. A key assumption, which the authors are forced to hold out of necessity given the available data, is that there is no simultaneous entry and exit. In other words, when net entry is zero in a market/period, it is assumed that there is no churn. Our investigation here shows this assumption is untenable. In fact, using the same FCC data (but for our later time period, 2005-2008),

we find that in ZIP codes with no net entry in a period, a full 44.6% of the time there was simultaneous entry and exit (i.e. within the prior six months).

II. Measuring the Entry and Exit Broadband Providers

A. Data Construction

1. Broadband provider data

The FCC has collected data from providers of end-user broadband service since 1999. Broadband providers complete the semi-annual Form 477, which requires them to list each five-digit ZIP code in which they provide service. The firms provide separate ZIP code lists for each type of broadband service offered. During the period June 2005 to June 2008, the years we study here, the broadband types were categorized as asymmetric DSL (ADSL), broadband over power line (BPL), cable modem, fiber, satellite, fixed terrestrial wireless (also known as wireless Internet service providers, WISPs), mobile terrestrial wireless, symmetric DSL (SDSL), and a residual "other" category.[4] The lists do not include information on the number of subscribers served within the ZIP code area.

Given our interest in marketplace dynamics—the entry and exit of broadband providers—we linked firms' Form 477 filings over time.[5] Thus, a major task in the project was to link firms' filings over time, accounting for variation in company names, mergers, acquisitions, spin-offs, cable system area swaps and other asset sales and transfers, and other phenomena affecting matching.[6]

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[4] The "other" category in the FCC ZIP code lists includes traditional wireless services such as T1 (1.544 Mbit/s) and T3 (44.736 Mbit/s) dedicated lines (non-fiber high-capacity digital lines, also known as DS-1 and DS-3). For reasons of consistent data quality that we describe below, we drop the "other" category from our empirical investigation.

[5] Due to some violations we found of the FCC's rule that providers should file one form combining the information for all service companies in a state under the same holding company, our final count of providers differs a bit from the official FCC reports.

[6] Details on the matching process will eventually be put into a data appendix.

After creating a common set of identification codes for the broadband providers, we set out to account for as many mergers and other forms of corporate reorganization as feasible. Within each round, we examined the lists of firms that disappeared from many (or all) ZIP codes to determine if a merger, name change, or major sales of assets explained the apparent exit. Similarly, we examined the lists of firms that newly showed up in many ZIP codes to determine if a name change or major purchase of assets explained the apparent entry. We collected information on as many mergers, etc., as we could find. Nevertheless, it is important to note that we undoubtedly missed some corporate reorganizations and (particularly) asset sales. To the extent that we missed some forms of corporate reorganization, our measures of entry and exit may be overstated.

We now explain how we treat entry and exit due to mergers and other reorganizations. Our aim was to adhere to existing practice in the academic literature on empirical studies of firm dynamics, most particularly Dunne, Roberts, and Samuelson (1988) (hereafter denoted *DRS*).[7] First, straightforward asset sales and swaps are not treated as exit of the old owner followed by entry of the new owner, whenever we had information on the transactions. For example, as part of the Adelphia acquisition that was effective in August 2006, Comcast and Time Warner swapped system ownership in various areas. Any apparent exit of Comcast in a market followed by subsequent apparent entry of Time Warner (or vice versa) was thus not treated as actual exit or entry. We note (again) that we undoubtedly missed some asset transfers among firms, leading to overstated measures of turnover within some markets.

[7] *DRS*, the seminal empirical study of firm entry and exit in the modern industrial organization literature, study entry and exit in the manufacturing sector of the US economy during the years 1963-1982.

For mergers and acquisitions, when the two merging firms already compete in the same market, we treat the combination of the firms in the market as resulting in one continuing firm and one exit.[8] (As we explain below, we consider various definitions of market in the study.) When the acquired firm offered service in a market in one period and the new entity appears in the market in the next period after the merger, we treat it as a continuing firm.

For reverse mergers and corporate spin-offs, when the involved parties go from one firm to two firms within a market, we treat only one of the firms as entering the market. For example, consider the case when ALLTEL spun off its wired broadband service business as Windstream in 2006. If ALLTEL was in a market before the spinoff, and both ALLTEL and Windstream are in the same market after, then Windstream alone is counted as an entrant. On the other hand, if ALLTEL is in a market before the spinoff but only Windstream is in the same market afterward, then Windstream is treated as a continuing firm.[9]

2. ZIP code data

The second issue involved with creating a dynamic picture of the market is that the universe of ZIP codes changes over time. The US Post Office constantly creates new

[8] The decision of which firm we treat as the exiting company matters in some of the measures of exit we consider below (namely, the measures of exiters' market share and relative size). In the case of acquisitions, we treat the acquired firm as the exiter. For mergers, we judged which firm appeared to be the dominant partner in the merger (e.g., we treated SBC as the continuing firm and AT&T as the exiting firm in the SBC-AT&T merger, despite the fact that the new firm kept the AT&T moniker). In one case, three firms merged (Choice One Communications, CTC Communications, and Conversent Communications merged to form One Communications Corp. in July 2006), and so in markets where all three competed, two were marked as exiting.

[9] For the few unwindings of 50-50 partnerships we found (e.g., the Comcast-Insight Communications Company partnership unwinding in 2007), we treat any name change in a market (e.g., an Insight system in Illinois changing to a Comcast system after the unwinding) as exit followed by entry, under the assumption that the holding company that filed the area in its Form 477 probably had the upper hand in its management under the partnership.

codes and removes obsolete codes from use. We deal with this issue by restricting our analysis to the same set of ZIP codes that the FCC's Industry Analysis and Technology (IATD) Division used to analyze the Form 477 data for the semi-annual *High-Speed Services for Internet Access* reports. The IATD procured annual data on ZIP code area boundaries from the Tele Atlas Dynamap GIS product.

B. Entry and Exit Measures

We analyze several measures of entry and exit in the market for broadband provision. To allow comparison and to follow best practice in the academic literature on market dynamics, we define our measures as in *DRS*, as we describe in this section. We analyze gross entry and exit (i.e., counts of entering and exiting firms separately) rather than net entry (i.e., the net change in the number of firms in a market, where net exit is counted as negative net entry). Recent work in the economic literature on market dynamics (such as *DRS*) points out that gross measures are appropriate to examine industry dynamics, since gross entry and exit may be high even when net entry is low.[10] It is worth noting that with the publicly available Form 477 data, in which company identities are not revealed, only the number of existing firms or net entry can be studied. Even then, the FCC censors the publicly available data when one to three providers are in the ZIP code. Our data do not have these limitations.

1. Market definition

To begin with, the market must be defined, since quantifiable entry and exit must be with reference to a precisely defined market. From the household's perspective, the

[10] It is worth noting that with the publicly available Form 477 data, in which company identities are not revealed, only net entry can be studied (as in Xiao and Orazem (2005). Even then, not all net entry is observable, given that the FCC censors the publicly available data when one to three providers are in the ZIP code.

market consists of all broadband providers able to serve the household's location. Thus, the geographic extent of the market in this perspective is no larger than the walls of the house. Using the logic of the familiar SSNIP test from antitrust law and economics,[11] for example, one can see that the prices offered to households adjacent to our original "market of one" household are irrelevant in the original household's demand decision. Thus, starting with a market of one household, the SSNIP test never increases the size of the market. That is, the household can never "go next door" to buy broadband service at a better price.[12] In the product space, however, different modes of broadband provision are substitutable to some degree. Thus, it may make sense to put cable modem service in same market as DSL, even though they are not perfectly substitutable. It may make less sense to put mobile wireless broadband in the same market as DSL, given that DSL service does not "travel" with the user.[13]

Some economists argue that the mechanical application of traditional antitrust definitions such as SSNIP to technologically dynamic settings results in markets that are inappropriately small (Pleatsikas and Teece, 2001).[14] In the geographical dimension of the market, we do not have household-level data to work with anyway. It also may be inappropriate to think of market definition in purely antitrust terms. On the supply side, a

[11] "A Small but Significant and Non-transitory Increase in Price (SSNIP) test asks whether a hypothetical monopolist could profitably impose a small increase in price. If sufficient numbers of buyers would switch to alternative products or to suppliers at other locations such that the price increase is unprofitable, then the market definition must be expanded to include at least some of those substitute products or locations" (Connolly and Prieger, 2009).

[12] We recognize this statement is subject to falsification by *reductio ad absurdum*. Clearly if the price of broadband service were $1000 in Household A and $10 in neighboring Household B, there would be ways for the households to mutually benefit from "trade," (for example, through Household A piggybacking off the wireless home network of Household B).

[13] For a discussion of how *traditional* market definition may proceed for the broadband industry, see U.S. Department of Justice, *Ex Parte Comments in the Matter of Economic Issues in Broadband Competition: A National Broadband Plan for Our Future* (GN Docket No. 09-51), section III.A, available at http://www.justice.gov/atr/public/comments/253393.htm (accessed November 19, 2010).

[14] See also the discussion of the issue of market definition in Connolly and Prieger (2009), section 2.4.1.

broadband provider clearly does not enter a market household by household, due to the economies of scale that make it economic to begin offering service with a footprint covering many households or businesses. At the small end of the geographical entry decision may be fiber, where entry into the broadband market may mean deploying the optical carrier infrastructure to serve a small group of office buildings in a dense urban center. At the other end of the geographic spectrum are the satellite firms, who upon enter can serve any location in the US with a clear view of the southern sky. The relevant geographic markets on the supply side for DSL, cable modem service, and wireless services fall between these extremes.

In the end, our choice of market definition is driven by what is available in the Form 477 data. In this initial work, we present results for two markets that are feasible to define with the data at hand. The smaller market we examine has the geographic extent of a ZIP code area and is restricted to a single type of broadband in product space. We call this market *ZIP-BB*, since markets are distinguished by ZIP code and type of broadband. Widening the geographic extent of the market to the entire US (including Puerto Rico) and broadening the extent in product space to include all forms of broadband gives us the *US* market, which groups all types.[15] While there is only one market per round with the *US* definition, there are an average of 241,011 markets per round with the *ZIP-BB* definition.

[15] We also define and examine two intermediate sized markets in other work not presented here: the *US-BB* market, with national geography and separate broadband types, and the *ZIP* market, with grouped broadband types and ZIP code area geography. We do not discuss those results here for the sake of brevity for the conference paper.

2. Measures of entry

We use the following notation to measure the amount and scale of entry:[16]

$NT_i(t)$ = total number of firms; the count of broadband providers present in market i (however defined) in period t. All firms under the same holding company count as a single firm.

$NE_i(t)$ = number of entrants; the count of broadband providers that enter market i in period t. In particular, the count of providers present in the Form 477 data in period t that were not present in the Form 477 data from period t-1.

$QT_i^k(t)$ = proxy for the quantity produced by a firm; the number of ZIP codes in which broadband provider k (one of those present in market i) offers service in period t. For market *ZIP-BB*, only ZIP codes where the same type of broadband service is offered are counted.

$QT_i(t)$ = proxy for the total quantity produced; the sum of the number of ZIP codes served in period t by each of the broadband providers present in market i in period t: $QT_i(t) = \Sigma_k QT_i^k(t)$.

$QE_i^k(t)$ = proxy for the quantity produced of an entrant; the number of ZIP codes in which broadband provider k (one of the entrants in market i) offers service in period t. For market *ZIP-BB*, only ZIP codes where the same type of broadband service is offered are counted.

$QE_i(t)$ = proxy for the total quantity produced by entrants; the sum of the number of ZIP codes served in period t by each of the broadband entrants present in market i in period t: $QE_i(t) = \Sigma_k QE_i^k(t)$.

Using these definitions, the entry rate *ER* in market i in period t is:

$$ER_i(t) = NE_i(t)/NT_i(t\text{-}1)$$

Following the convention of *DRS* and other authors, the denominator is the number of firms present in the previous period. In the absence of exit, $ER_i(t)$ is thus the percentage increase in the number of firms between periods t and t-1. Note that the entry

[16] This section and the next follow *DRS* closely.

rate is undefined for previously "empty" markets, for which $NT_i(t\text{-}1) = 0$. This is problematic for new markets, where $NE_i(t) > 0$ and $NT_i(t\text{-}1) = 0$. For the *ZIP-BB* market definition, which (we will see) includes many instances of new markets, we may instead be interested in the alternative entry rate ER^{alt}, defined as

$$ER_i^{alt}(t) = NE_i(t) / NT_i(t)$$

which is the fraction of firms present in period *t* that are entrants. Unlike $ER_i(t)$, $ER_i^{alt}(t)$ is defined for new markets.[17]

To examine how the size of entrants compares with that of existing providers in the market, we define *ESH*, the entrants' share of the ZIP codes served by all the firms active in market *i* as

$$ESH_i(t) = QE_i(t)/QT_i(t)$$

Care must be taken in interpreting $ESH_i(t)$, for it is not the market share of output in market *i* that is produced by entrants.[18] Market share cannot be known, since providers were not required to report lines by ZIP code (i.e., we have no measure of broadband subscribership at the ZIP code level). Instead, $ESH_i(t)$ is the number of ZIP codes across the nation in which the entrants in market *i* are present, expressed as the ratio to the number of ZIP codes nationally in which all firms in market *i* are present.[19] Thus *ESH* measures the proportion of the *national* scale of firms in market *i* (which may be sub-national) due to entrants.

We define the average size of entering firms (measured as the national scale of their operations) relative to that of incumbents, *ERS*, as

[17] Furthermore, ER^{alt} is bounded between 0 and 1, inclusive. In markets that are growing, $ER > ER^{alt}$.
[18] Here we are departing from *DRS*; since they have market-specific output quantities, they can measure the market share *in market i* of entrants.
[19] Since the latter includes the former, *ESH* is bounded between 0 and 1, inclusive.

$$ERS_i(t) = \frac{QE_i(t)/NE_i(t)}{[QT_i(t) - QE_i(t)]/[NT_i(t) - NE_i(t)]}$$

ERS allows us to compare the relative national scale of entrants to incumbents at a point in time. In the denominator, the measures appropriate to the incumbents are calculated by removing the entrants' measures from the totals. *ERS* is undefined when there is no entry.

3. Measures of exit

Similarly, we measure exit using the following:

$NX_i(t)$ = number of exiting firms ("exiters"); count of the broadband providers that exit market *i* between periods *t*-1 and *t*. In particular, $NX_i(t)$ is the count of providers present in the Form 477 data in period *t*-1 that were no longer present in the Form 477 data from period *t*.

$QX_i^k(t)$ = proxy for the quantity produced by an exiter; the number of ZIP codes in which broadband provider *k* (one of the providers exiting market *i* between periods *t*-1 and *t*) offered service in period *t-1*. For market *ZIP-BB*, only ZIP codes where the same type of broadband service was offered are counted.

$QX_i(t)$ = proxy for the total quantity produced by exiters; the sum of the number of ZIP codes served in period *t*-1 by each of the broadband firms exiting market *i* between periods *t*-1 and *t*: $QX_i(t) = \Sigma_k QX_i^k(t)$.

Note the convention for the timing: an "exiter" in period *t* exited the market between periods *t*-1 and *t*, and the quantities associated with the exiters pertain to the last period in which they provided service. Using these definitions, the exit rate *XR* in market *i* in period *t* is:

$$XR_i(t) = NX_i(t)/NT_i(t\text{-}1)$$

In the absence of entry, $XR_i(t)$ is thus the percentage decrease in the number of firms between periods t and t-1. Note that the exit rate is undefined for empty markets (those for which $NT_i(t\text{-}1) = 0$).

To examine how the size of exiting firms compares with that of existing providers in the market, we define the exiters' share (*XSH*) of the ZIP codes served by all the firms active in market i as

$$XSH_i(t) = QX_i(t)/QT_i(t\text{-}1)$$

$XSH_i(t)$ is the number of ZIP codes nationally in which the firms that exited market i just prior to period t are present, expressed as the ratio to the number of ZIP codes nationally in which all firms in market i are present (also in period t-1).[20] Thus, *XSH* measures the proportion of the national scale of firms in market i due to exiters.

Finally, the average size of exiting firms (measured as the national scale of their operations) relative to that of incumbents, *XRS*, is:

$$XRS_i(t) = \frac{QX_i(t)/NX_i(t)}{[QT_i(t-1) - QX_i(t)]/[NT_i(t-1) - NX_i(t)]}$$

XRS allows us to compare the national scale of exiting firms relative to incumbents at a point in time. In the denominator, the measures appropriate to the incumbents are calculated by removing the exiters' measures from the totals. *XRS* is undefined when there is no exit.

4. Sources of entry and exit

We also investigate from where entry arises. In the *US* market, an entrant in period t is a firm appearing somewhere in the Form 477 data in period t but nowhere in the data

[20] Since the latter includes the former, *ESH* is bounded between 0 and 1, inclusive.

in period *t*-1. We refer to such entry as *de novo* (also called "greenfield" entry in the literature). *De novo* entrants are new firms (labeled *NF* in the following) that did not previously offer any type of broadband in the US.[21] We assume that the new firm uses new infrastructure to provide service (labeled NP, for "new plant"), which will be the case to the extent that we have properly accounted for asset sales. Thus *de novo* entry will be marked as *NF/NP* in the tables to follow.

In the *ZIP-BB* market, it is possible to break entry down by whether it is *de novo*, through diversification of existing firms, or through diversifying its product mix. Entry can be by new firms (*NF/NP*), as above. Entry can also occur through geographic diversification: the first appearance of the firm in the ZIP code with *any* broadband type. In this case, the diversifying firm (*DF*) previously offered service in other ZIP codes. To maintain correspondence with *DRS*, we denote geographic diversification as *DF/NP*, even though we recognize that a new ZIP code may be served by existing telecommunications infrastructure in some cases. Finally, a firm can enter through diversifying its product mix (labeled *PM*). For example, a firm offering ADSL in period 15 in the ZIP area who expands its service offerings to include SDSL in period 16 is counted as an entrant of type *CF/PM* in the period 16 SDSL market in the same ZIP area.

We will also use similar nomenclature for exit. Exit of type *EF/EP* (for "exiting firm" and "exiting plant") means the disappearance of the firm from all markets. Exit of type *CF/EP* is the disappearance of the firm from the ZIP code, while continuing to serve customers elsewhere. Here, *CF* stands for "consolidating firm". *CF/PM* exit means the firm stops offering one type of broadband while continuing to offer other modes in the

[21] At least, they weren't in the market in the previous period. They may have served the market in period *t*-2 or earlier, however, as we discuss below.

geographic market. In other words, exit of type *CF/PM* means the consolidating firm is reducing its product mix.[22]

III. Basic Analysis of Entry and Exit

We now turn to the analysis of entry and exit in the market for broadband service provision. We look at the basic statistics on entry and exit, reserving regression analysis for future work. Throughout this section we will compare our results with those of *DRS*. One thing to keep in mind is that since the periods we analyze are six months long, the entry and exit rates we compute for the broadband market would need to be multiplied by 10 to be comparable to the five-year intervals considered by *DRS*. In any event, we focus mostly on qualitative comparisons with *DRS*, since our industry studied and market definitions are different.

We begin by examining the average levels of entry and exit in the broadband market, breaking each down into specific modes of entry and exit. In subsection B, we consider how entry and exit rates are distributed within markets, to give a sense of how the industry dynamics vary both within and across markets. In subsection C, we look at how the entry and exit rates are correlated with themselves and with each other, which sheds additional light on the dynamics of the broadband market.

A. Average Entry and Exit Statistics

We begin our description of entry and exit in the broadband market by measuring the average levels. Unlike *DRS*, who drop the smallest firms from their analysis, we include all firms in our calculations.[23]

[22] Note that our exit statistics are calculated differently than that of *DRS*, who break down exit by the category of the firm's *entry*, rather than its type of exit.

1. National level market, grouping all broadband types

For the national broadband market including all types of broadband (the *US* market), the entry and exit rates measure the turnover in firms that show up at least once in the Form 477 data. The figures are given in Table 1. The first fact that is apparent is the great amount of entry and exit that occurs. The semi-annual entry rate varies from 5.5% (June 2008) to 15.4% (December 2005), and has an average of 9.7% per (six-month) period. The low-end figure from June 2008 implies a *yearly* entry rate of about 11.0% in the national market. Even this low-end figure the national broadband market is higher than the entry rates of about 9.8% for manufacturing firms from *DRS*.[24] The high-end broadband entry rate (from December 2005, annualized to 30.8%) is more than three times the rate from *DRS*. Thus, as is to be expected in a rapidly growing industry,[25] entry is relatively high. There is an overall slowing in the entry rate over the years, but the period-to-period variation is high and the reduction in the entry rate is not smoothly decreasing. While the variation in the entry rate may point to some underlying incompleteness in the data,[26] it may also merely reflect the volatile nature of the market.

Entrants are small in the national market, compared both to the entire market and to incumbents. The entrants' share of the market (*ESH*, also shown in Table 1; refer to section II.B.2 for its definition) is 5% or less in all periods. This is much smaller than

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[23] It makes sense for *DRS* to drop small manufacturing firms, since the geographic extent of their market definition is the entire US, and small firms are not very important in that context. The nature of broadband service provision, however, means that even small firms may be very important to subscribers within the area they serve. Subscribers cannot go to larger firms offering service in other areas, and the relevant options for the household or business include all market participants, no matter how small. Furthermore, excluding smaller firms would exclude virtually all rural telecommunication carriers, which are important providers of broadband in many rural areas.

[24] The simple average of the manufacturing entry rates reported over 1963-1982 in *DRS* (for firms of all sizes) is 9.8%.

[25] See Siegfried and Evans (1994), p. 127.

[26] One unanswered question is why is the entry rate is always higher in the December filings. One possibility is that some firms did not actually update there mid-year data as they were supposed to, but instead submitted the same ZIP code list as for the previous December filing.

DRS' figures for manufacturing, but at least some of the difference is accounted for by their five-year periods, which gives entrants more time a grow their market share. Entrants are also seen to be small by considering their relative size (*ERS*), which is always well below one (*ERS* equal to one would imply that the entrants are just as large as incumbents). In fact, *ERS* is always below 35%, with an average rate of about 24%, which implies that incumbents as a group are 4.2 times larger than entrants are. *DRS* also find that entrants are smaller in terms of market share and relative size to incumbents.[27]

The exit rate (*XR*) also generally trends downward, from the highest rate of 11.3% (December 2005) to the lowest rate of 5.4% at the end of the sample. The average exit rate is 8.3%, for a yearly average exit rate of 16.6%. This is about twice as high as the yearly exit rate for manufacturing firms from *DRS*. Comparison with the entry rate reveals two interesting facts. First, the exit rate is slightly lower on average than the entry rate, which reflects that the number of firms in the market is growing slowly during 2005 to 2008. More interesting, however, is how much of the dynamism of the market one would miss if only net entry were examined. Net entry in the *US* market is about 2.6% per year during this period.[28] The gross entry and exit rates, which are in the range 11-31% per year, contrast markedly with the relatively slow net growth rate. Any entry analysis conducted on the publicly available FCC data, which provides only the count of firms operating each period, would miss much of the action.

As with the entrants, exiting broadband providers are also smaller than other firms in general. However, they are larger than entrants (which is in accord with the findings

[27] Due to the differences in how we calculated *ERS* and *ESH*, by counting ZIP codes instead of lines served, we cannot compare the magnitude of our figures directly to those in *DRS*.
[28] By our count, there were 1,230 distinct holding companies offering some sort of broadband service in June 2005, and 1,330 in June 2008 (for a continuous growth rate of 2.6% per year).

of *DRS*). The share of the exiting firms (*XSH*) is less than 9% in all periods, and averages 4%. Exiting providers are also small relative to surviving firms (*XRS*), which is always less than one except for December 2006, which has an outlier of 108%. The December 2006 figure is high because of the Verizon acquisition of MCI;[29] the latter was much larger than the typical exiting firm. Except for December 2006, *XRS* is always at or below about 50%, which implies that surviving firms are (in typical periods) at least twice as large as exiting firms.

2. ZIP-code level market for a single broadband type

We now turn to our other market definition, the *ZIP-BB* market, which draws narrower boundaries around the market in both geographic and product space. Each broadband type within a ZIP code area is treated as a distinct market. With such a narrow definition of the market, we must confront a difficulty in our data. In many ZIP codes, there are some broadband types that are not offered. Since the count of service providers in the market appears in the denominator of the entry rate (see section II.B.2 for the definition of *ER*), the entry rate for the first entrant is infinite. Following *DRS*, any of our statistics that are undefined are not included in the averages appearing in the tables. However, in the *ZIP-BB* market, *ER* is undefined for 48% of markets. Naturally enough, *ER* is undefined most often for the least-common broadband types: BPL and fixed wireless.[30] Accordingly, we include a second measure of entry in Table 2, ER^{alt}, which gives the fraction of firms in the market in the present round that are new entrants. This

[29] Although the official closing date of the merger was January 6, 2007, the data for Verizon for December 2006 already incorporate the assets acquired from MCI.

[30] *ER* is undefined for BPL in 99.9% of ZIP code-rounds, and is undefined for TFW in 78% of ZIP code-rounds. Other modes of service with a large number of ZIP codes-rounds with undefined *ER* are fiber (61%) and SDSL (59%). At the other end of the spectrum, *ER* is undefined for satellite service in only 10% of markets, since it is available (and has customers) in most ZIP code areas.

measure has the advantage of being defined in the case of the first entrant (but see section II.B.2 for its different interpretation).[31]

a) Average entry and exit statistics

For the *ZIP-BB* market, we see from Table 2 that the entry and exit rates are quite a bit higher than in the *US* market. The narrower market definition leads to a more dynamic picture of entry and exit. The semi-annual entry rate (whether measured by *ER* or ER^{alt}) generally declines over time, similar to our findings with the other market definitions. The entry rate *ER* is highest in June 2006 (21.6%) and lowest in December 2007 (13.4%), and averages 17.3% per period. The yearly average entry rate is 34.6%. ER^{alt} averages 18.5% per round, meaning that a little less than one out of every five firms in a typical market is an entrant.

The market share of entrants in the *ZIP-BB* market is about the same as the fraction of firms that are entrants (compare *ESH* to ER^{alt}), implying that the importance of entrants in the market is the same whether measured by counting firms or their market share. *ESH* ranges from 12.9% to 23.3%, and averages 18%. However, the relative size of entrants is much larger than that of incumbents: *ERS* averages 9.2, which is much higher than *DRS* found for manufacturing firms. *ERS* varies widely over time, but the overall trend appears to be downward.[32]

[31] Of course, ER^{alt} is still undefined when there are no firms in the market (for then its formula calls for dividing zero by zero). ER^{alt} is undefined 46% of the time.

[32] It may seem contradictory that the market share of entrants is about the same as the fraction of firms that are entrants, but that entrants are so much larger than incumbents. The apparent discrepancy is a composition effect. *ESH* is defined for all markets, and so has many zeroes averaged in. *ERS* is calculated only when entry actually occurs, and thus cannot have any zeroes at all.

The exit rate (*XR*) is generally downward with some deviations. The highest exit rate of 16.7% is at the beginning and the lowest rate of 6.0% is at the end of the sample. The average exit rate is 11.7%, for a yearly average exit rate of 23.4%.

Exiting firms leave with smaller market share than that with which entrants arrive (see figures for *XSH* in Table 2). The average *XSH* is 11.6%, compared to the average entrant share of 18%, and the exiter share is less than the entrant share each round except December 2007. In that round, a large provider exited (or at least lost its customers in) many local fiber (OC) markets, which contributed greatly to the relatively large exit rate. Exiting broadband providers are larger than non-exiting firms in general, as shown by the figures for *XRS* in Table 2. Exiting firms are anywhere from six to 15 times larger than surviving firms.

b) Disaggregating the sources of entry

With the narrower market definition come new categories of entry. In addition to *de novo* (*NF/NP*) entry, firms can enter through geographic expansion (*DF/NP*) or through product market expansion (*CF/PM*); see section II.B.4. The figures are in Table 3. Most entry in the *ZIP-BB* market is from geographic expansion. On average, 71% of entry is of type *DF/NP*, 22% is of type *CF/PM*, and the remaining 7% is from *de novo* entrants. So, from the consumer's point of view most entry takes the form of an existing provider beginning to offer service in the area. The same is true when measuring entrants by their market share. Nearly three-quarters of entry is from geographic expansion on average (from the figures for *ESH* in Table 3), which is in line with the portion of the entry rate due to *DF/NP* entry.

The relative size of entrant to incumbent (*ERS*) in the ZIP code is much larger for diversifying firms, whether they enter a new area or add to their product mix, than for completely new firms. In decreasing order of relative size, geographic diversifiers are 9.6 times as large as incumbents, product diversifiers are 9.3 times as large, and completely new entrants are 3.7 times as large. Diversifying firms tend to be firms with large service footprints expanding into a new area. The *ERS* of type *NF/NP* entrants, setting aside a large outlier for June 2006 (which is unusually large due to the appearance of some large cable modem providers), is generally below one. The median *ERS* of type *NF/NP* over the remaining periods is about one-half, indicating that a typical *de novo* entrant in the *ZIP-BB* market is about half the same size as the incumbents.

c) Disaggregating the sources of exit

The disaggregation of the exit rates is in Table 4. In addition to the complete disappearance of a firm from all ZIP codes (exit type *EF/EP*), in the *ZIP-BB* market a firm can also exit by consolidation in the geographic dimension (exit type *CF/EP*) or by reducing its product mix in the area (exit type *CF/PM*). The figures for the exit rates in Table 4 show that just as most entry stems from geographic diversification, most exit reflects geographic contraction. The same was true in the *ZIP* market examined above. On average, 56% of exiting firms are of type *CF/EP*, 25% are of type *CF/PM*, and the remaining 19% completely exit all markets. Measuring exit by market shares instead does not change the relative importance of the three modes of exit (from the breakdown of *XSH* in Table 4).

The relative size of consolidating firms, whether by geography or product mix, is generally greater than the relative size of completely disappearing firms. From the

statistics for *XRS* in Table 4, the disappearing firms are on average 6.7 times larger than remaining firms. *XRS* of type *EF/EP* is largest in June 2006, due to the a merger between two large providers.[33] Geographic consolidators are 9.4 times larger than firms remaining in the market, and product mix reducers are 12.7 times larger than remaining firms. This finding may reflect that larger firms are engaged in more dynamic behavior overall than are smaller firms.

B. Variation in Entry and Exit across Broadband Types

The average statistics in the previous section mask much variation in the entry and exit rates among different types of broadband service. In this section, we look within each modes of provision to examine how the measures of entry and exit vary across time and (for some market definitions) geography. By doing so, we can thus compare both the mean and variance of entry and exit across types of broadband.

In the *ZIP-BB* market, variation occurs not only across the six rounds of data but also across the approximately 30,000 ZIP codes in the US. Table 5 presents the average and first-to-ninth decile spread in the entry rates and shares and entrant relative sizes. It is apparent that the local markets are highly dynamic, and also that there is a great variety of outcomes within each broadband type. The result follows in part from the small geographic scale of the *ZIP-BB* market and the small number of providers in a ZIP code.[34]

[33] There are many ZIP codes in which one of the merging firms offered fiber service in round 13 but the combined firm did not offer fiber in round 14 after the merger. Since the former firm offered service in so many ZIP codes, their relative size as an exiter looks huge compared to non-exiting incumbents.

[34] A firm beginning to offer ADSL may be the first, second, or third entrant in a given ZIP code in which it offers service, which explains both the higher entry rates in the *ZIP-BB* market as well as the great variance in the entry rate.

Table 5 also shows that entry is much more prominent in some broadband types than others. The entry rate is highest for mobile wireless (as in the national market), at 38.5%, and lowest for BPL. Overall, the ranking of the entry rates is roughly similar to that in the national market (the Spearman correlation between the rankings is positive), although there are three notable exceptions to the pattern. From the greatest to the least average entry rate, the order is: mobile wireless, fiber, ADSL, SDSL, satellite, fixed wireless, cable modem, and BPL. BPL, having a zero or undefined (infinite) entry rate everywhere at the ZIP code level, is ranked last in terms of *ER*. Entry in the satellite market looks quite different in the *ZIP-BB* market, compared to the national level. While there are no new satellite broadband providers at the national level during this period, there are many local markets where the satellite firms enter by picking up customers where they formerly had none.[35] So, while the entry rate for satellite is zero in the national market, it is ranked fifth in the *ZIP-BB* market.

The distribution of the exit statistics in the *ZIP-BB* market is in Table 6. In order from the greatest to the least average exit rate, the order is fiber (with a 26.6% exit rate), SDSL, fixed wireless, mobile wireless, BPL, ADSL, cable modem, and satellite (with a 3.3%). The small exit rate for satellite service comes from fact that only two firms exited the national market during the period, and that the service footprints of the other providers did not change. Exit in the satellite *ZIP-BB* market nearly always comes from losing all customers in a ZIP code, not from making the service physically unavailable.

The correlation between the mean entry rates and shares in Table 5 and those for exit in Table 6 is high (0.98). Thus, similar patterns emerge for entry and exit across

[35] It is important to note that "entry" for the satellite firms mainly reflects changes in demand, not supply, since the firms do not deploy new infrastructure to "enter" a new ZIP code. That is not to say that the firms did not perhaps engage in targeted marketing efforts in certain areas.

markets: when entry is high or has a large share for a broadband type, exit does too. *DRS* also found large positive correlation between entry and exit in manufacturing as well. One implication of positive correlation between entry and exit is that there is therefore less variation in the *net* entry rate across markets than there is in the gross entry and exit rates, yet another indication that examining net entry alone leaves would fail to uncover much of the market dynamics.

Comparing the average entry and exit rates in the *ZIP-BB* market, we see that types with high entry rates also tend to have high exit rates. The correlation between the entry rates in Table 5 and the exit rates in Table 6 is 0.37. Thus, similar patterns emerge for entry and exit across markets: when entry is high or has a large share for a broadband type, exit does too. *DRS* also found large positive correlation between entry and exit in manufacturing as well. One implication of positive correlation between entry and exit is that there is therefore less variation in the *net* entry rate across markets than there is in the gross entry and exit rates, yet another indication that examining net entry alone leaves would fail to uncover much of the market dynamics.

The correlation between the entry and exit shares is 0.73, and the correlation between entrant and exiter relative sizes is nearly perfect at 0.96. *DRS* found a similar pattern for manufacturing. Thus, as *DRS* concludes, "while there is substantial variation in entry and exit patterns across [markets] within a sector [which is the broadband type, in our application], there are also some systematic relationships between entry and exit…."[36] We examine these relationships in more detail in the following section. Finally, note that the exit shares produce the same ranking of broadband types as the exit rates.

[36] See *DRS*, page 507.

C. Correlation in Entry and Exit

To look at market-specific differences in entry and exit, we follow *DRS* and ask two questions. First, are the measures of entry and exit positively correlated with themselves over time? If so, then the implication is that high entry (for example) in one period is likely to be followed by high entry in succeeding periods. Second, do high entry rates correspond with high exit rates? If so, then there would appear to be underlying factors causing the "churn rate" of firms in a market to be more stable within markets than across markets. We deal with these two questions in turn in this section.

1. Autocorrelation of entry and of exit

In Table 7, we present the autocorrelations for the *ZIP-BB* market. Both the entry and exit rates show positive autocorrelation for all measures and at all lags, excepting only the fifth autocorrelation for the entry rate. *DRS* interpreted their similar finding for the manufacturing industry as suggesting that there are persistent market-specific factors that affect both entry and exit. In other words, when entry is higher in, say, the mobile wireless market in an area in a period than the average entry rate for all markets, then it is likely that the entry rate will continue to be higher in that mobile wireless market. Thus, there is evidence for factors unique to each mode of broadband provision or each location that determine the dynamics of the market. In results not reported here, we created a table similar to Table 7 but for the market definition at the ZIP code level but grouping all types of broadband. The autocorrelations for the various measures of exit were generally smaller, indicating that broadband type-specific determinants of exit are more persistent and important than are location-specific determinants.

2. Correlation between entry and exit

The second question regarding market-specific differences in entry and exit is whether high entry and exit tend to occur together in a market. To address this, we calculate the correlation between each entry measure and its counterpart on the exit side, at various leads and lags. We already noted in section B above that the mean entry and exit measures for the broadband types were positive correlated, which suggests that entry and exit are systematically and positive related within markets. *DRS* and several other empirical studies of market dynamics find that entry and exit rates are positively correlated across industries.[37]

In this section, we refine that conclusion in three ways. First, we now are calculating the correlation between entry and exit in a single market, not just how entry relates to exit when both are averaged across all ZIP codes. Second, we look at how entry is correlated with exit at other periods, as well as contemporaneously, to be able to answer (for example) how entry today correlates with exit six months or a year from now. Third, we also see whether the apparent positive correlation we find between entry and exit is due solely to unobserved, fixed market-specific factors. Removing such factors allows us to examine whether periods with entry that is high *relative to that market* correspond to high (or low) exit in the same market.

The results are in Table 8. The correlation between the contemporaneous entry and exit rates is positive, at 0.058 (see the entry for the XR_t row in the first column of Table 8), which means that broadband markets with higher than average entry rates also tend to have higher than average exit rates. The correlation of the entry rate with previous and

[37] The theoretical model of Asplund and Nocke (2006) shows that entry and exit rates may rise together in response to an increase in fixed costs.

future exit rates is also positive (see the top half of the first column of Table 8), demonstrating that there is persistence in the association between entry and exit. Thus, broadband markets with high entry rates in general over time also have high exit rates, and broadband types with low entry rates also have low exit rates. The correlations are higher for the market shares than for the rates, and generally diminish as the distance in time widens, both of which *DRS* also found.

One possible cause for the positive correlation between entry and exit may be that there are systematic differences in the height of entry and exit barriers among the broadband markets. Economic theory suggests many reasons why entry and exit barriers may be positively related within a market, and two may apply to the broadband service market in particular.[38] First, exit barriers are themselves entry barriers to forward looking firms. An exit barrier such as regulatory pressure to continue operating in a market even with losses makes it less likely that firms would want to enter.[39] Second, when incumbents have cost advantages over potential entrants, creating an entry barrier, the advantages often come from specific assets with little scrap value. When a large portion of capital costs are sunk (i.e., non-recoverable), as may be the case particularly with

[38] See Siegfried and Evans (1994), p.147, and references cited therein.

[39] The pressure to remain in an unprofitable market need not take the form of formal designation as a broadband carrier of last resort. Regulators in some states, and the FCC itself, have pushed telecommunications firms for many years to expand their broadband offerings, especially in areas labeled "disadvantaged." For example, the FCC approved the SBC acquisition of Ameritech in 1999 only subject to an agreement by the company to promote broadband Internet access (among other conditions). In particular, SBC was required to locate at least 10% of their advanced service facilities in low-income areas in the Ameritech region. State regulators in Ameritech's operating region (Illinois, Indiana, Michigan, Ohio, and Wisconsin) also pushed for the merged firm to accelerate broadband deployment. Presumably neither the federal nor the state regulators would have been satisfied to see the firm begin to offer broadband in low-income areas only to have the service offerings cease after a short period. See Prieger and Hu (2008).

wired broadband,[40] then (conditional on entry having occurred) exit is discouraged because the opportunity cost of remaining in the market is lower.[41]

In the second column of Table 8, the time-averages within each market (the market fixed effects) have been removed before computing the correlations between the measures of entry and exit. Correcting for the market fixed effects allows us to address the question of whether periods of relatively high entry (where "high" means relative only to other periods within the same market) in a market are also periods of relatively high exit.[42] We find the opposite: periods with higher entry than average within a market are also periods of relatively *low* exit, although the level of the association is small (-0.038). Since firms present in these local markets are likely to be in head-to-head competition with each other, this finding has an intuitive appeal. When expected profitability is high, perhaps due to increased demand in the market, firms are both more likely to enter and are less likely to leave (Siegfried and Evans, 1994). The negative correlation between contemporaneous entry and exit also implies the converse: in periods with more unprofitable conditions, firms are more likely to exit and less likely to enter.

It is also interesting to examine how entry in one period relates to exit in another, and vice versa. The correlation between the entry rate in period t and the exit rate in period t+1 is positive for both definitions of the market. This means that periods of high entry tend to be followed immediately by relatively high exit. This pattern could arise

[40] See U.S. Department of Justice, *Ex Parte Comments*, *op. cit*., section II.E.

[41] See Siegfried and Evans (1994), p.145: "Tangible barriers to exit may include sunk costs in durable, industry-specific assets, which discourage exit because such assets do not have valuable alternative uses…." These authors conclude the balance of the empirical evidence supports this assertion.

[42] The correlation between entry and exit in Table 8, by not removing the market-specific time averages, mostly picks up differences in entry and exit among markets. Once the time averages are removed from each market, then all (average) differences among markets are removed, and the remaining correlation isolates how entry and exit *within each market* are related.

either because firms were overoptimistic in entering the market and are shortly forced to exit, or because the arrival of entrants forces incumbents who cannot compete to exit. Similarly, the correlation between the entry rate in period *t* and the exit rate the previous period is also positive for all definitions of the market. Thus, periods of high exit tend to be followed by a period of relatively high entry. This could happen because of the "vacuum effect," where exiting firms create opportunities for more efficient entrants to enter and pick up the stranded subscribers.[43]

The negative correlation between the contemporaneous entry and exit rates in the *ZIP-BB* markets does not occur with the market shares. Since *DRS* uncovered the same phenomenon in their study of the manufacturing sector, we will quote their discussion:

> In this case the entrants' market share is positively correlated with the exiters' share after [market fixed] effects have been removed. Periods of higher than average entrant shares are thus periods of higher than average exiter shares. Since these are periods with relatively low exit rates, the exiting firms in these periods must tend to be unusually large (*DRS*, p.508).

The positive correlation between entrant shares in period *t* and exiter shares in periods *t*-1 and *t*+1 remains, with the exception that correlation between entrant shares in one period and exiter shares the next period is small but negative.

IV. Conclusions

We collect the findings of our work here, and conclude by discussing some avenues for future work.

> **Finding 1**: There is a tremendous amount of (simultaneous) entry and exit in the US broadband market.

[43] Siegfried and Evans (1994), *op. cit.*, discuss the vacuum effect and related literature on p.147.

The large amount of entry is particularly striking considering that the provision of broadband has several economic characteristics that are typically associated with barriers to entry: large fixed or sunk costs that create absolute cost disadvantages for entrants, and economies of scale, network economies, and economies of scope in the provision of multiple modes of broadband (e.g. ADSL and SDSL) that create relative cost disadvantages for entrants.[44] Apparently the dominant factor in the market, the growing demand for broadband service, trumped all other considerations during the period of study.

Furthermore, the fact that there is a high "churn rate" of firms in broadband markets has interesting implications for work analyzing entry decisions. Existing structural modeling of entry decisions in the closely related and partially overlapped industry of competitive local telephone services, as in Greenstein and Mazzeo (2006) and Golfarb and Xiao (2011) relies mostly on cross sectional data to identify the parameters of the firms' profit functions and to test interesting hypotheses about the role of product differentiation or the sophistication of the mangers in the entry decision. With such a high turnover rate of firms, one suspects that the firms' expected profits often did not appear, and understanding why new firms are willing to enter even as others are exiting is important to our understanding of firms' strategies.

> **Finding 2**: Entry and exit varies widely across the various modes of provision, and the highest entry rates also generally have the highest entrant shares.

[44] Siegfried and Evans (1994), *op. cit.*, section II.B.

The markets for some modes of provision are more stable than others, and this suggests future work explicitly modeling asymmetric competition among intermodal competitors, as in the work by Loomis and Swann (2005).

> **Finding 3**: Entry rates, shares, relative sizes display positive autocorrelation. The same is true for exit.

The implication is that there are persistent factors specific to both the broadband mode and the ZIP code area that cause high entry (or exit) in one period to be followed by high entry (exit) in succeeding periods. The type-specific factors appear to be more important than the location-specific factors, but both appear to be present.

> **Finding 4**: Without controlling for market-specific factors, there is positive correlation between the entry and exit rates at various leads and lags.

Broadband markets with higher than average entry rates also tend to have higher than average exit rates, whether contemporaneously or at other leads and lags, demonstrating that there is persistence in the association between entry and exit. This persistence suggests that there are systematic differences in the height of entry and exit barriers among the broadband types. There appear to be underlying factors causing the "churn rate" of firms in a market to be more stable within than across markets.

> **Finding 5**: Controlling for market-specific factors, there is negative correlation between the entry and exit rates.

After removing the time averages within each market from the entry and exit rates, we show that periods of high entry (now relative to that local market only) are associated

with periods of *low* exit. This result is expected if, for example, periods of relatively high profitability forecasts in the market both encourage entry and deter exit.

We intend that these findings can both stimulate and guide future empirical and theoretical work, by us and others, in this market.

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Tables

Table 1: Entry and Exit Statistics for the *US* Broadband Market

	Dec. 2005	June 2006	Dec. 2006	June 2007	Dec. 2007	June 2008
Entry Rate (*ER*)	0.154	0.083	0.142	0.063	0.084	0.055
Entrant Share (*ESH*)	0.051	0.032	0.013	0.020	0.014	0.013
Entrant Relative Size (*ERS*)	0.317	0.351	0.083	0.293	0.159	0.228
Exit Rate (*XR*)	0.100	0.113	0.080	0.086	0.065	0.054
Exiter Share (*XSH*)	0.027	0.065	0.086	0.010	0.011	0.018
Exiter Relative Size (*XRS*)	0.252	0.545	1.071	0.103	0.162	0.323

Table notes: The *US* market has the geographic extent of the entire US and Puerto Rico and groups all broadband types together. See section II.B.2 and II.B.3 for definitions of statistics.

Table 2: Entry and Exit Statistics for the *ZIP-BB* Broadband Market (Averages Over All ZIP Codes and Broadband Types)

	Dec. 2005	June 2006	Dec. 2006	June 2007	Dec. 2007	June 2008
Entry Rate (*ER*)	0.191	0.216	0.148	0.189	0.134	0.161
Alternate Entry Rate (ER^{alt})	0.249	0.229	0.179	0.187	0.136	0.132
Entrant Share (*ESH*)	0.233	0.232	0.166	0.190	0.132	0.129
Entrant Relative Size (*ERS*)	15.817	5.317	11.169	6.015	12.170	4.665
Exit Rate (*XR*)	0.167	0.115	0.091	0.128	0.142	0.060
Exiter Share (*XSH*)	0.173	0.112	0.084	0.128	0.147	0.053
Exiter Relative Size (*XRS*)	10.610	14.998	7.809	14.328	8.598	5.629

Table notes: The *ZIP-BB* market has the geographic extent of a single ZIP code area and differentiates among broadband types. See section II.B.2 and II.B.3 for definitions of statistics.

Table 3: Entry Statistics for the *ZIP-BB* Broadband Market by Method of Entry (Averages Over All ZIP Codes and Broadband Types)

	Dec. 2005	June 2006	Dec. 2006	June 2007	Dec. 2007	June 2008
Entry Rate						
Total (*ER*)	0.191	0.216	0.148	0.189	0.134	0.161
NF/NP	0.016	0.013	0.010	0.014	0.009	0.011
DF/NP	0.133	0.155	0.096	0.137	0.103	0.116
CF/PM	0.042	0.048	0.042	0.038	0.022	0.034
Entrant Share						
Total (*ESH*)	0.233	0.232	0.166	0.190	0.132	0.129
NF/NP	0.012	0.028	0.012	0.009	0.006	0.009
DF/NP	0.179	0.167	0.108	0.141	0.101	0.094
CF/PM	0.042	0.037	0.046	0.040	0.025	0.026
Entrant Relative Size						
Total (*ERS*)	15.817	5.317	11.169	6.015	12.170	4.665
NF/NP	0.466	17.459	0.553	0.742	0.276	2.495
DF/NP	17.684	5.196	12.349	5.825	11.567	5.158
CF/PM	11.239	2.618	9.909	8.511	19.779	3.794

Table notes: The *ZIP-BB* market has the geographic extent of a single ZIP code area and differentiates among broadband types. See section II.B.2 and II.B.4 for definitions of statistics.

Table 4: Exit Statistics for the *ZIP-BB* Broadband Market by Method of Exit (Averages Over All ZIP Codes and Broadband Types)

	Dec. 2005	June 2006	Dec. 2006	June 2007	Dec. 2007	June 2008
Exit Rate						
Total (*XR*)	0.167	0.115	0.091	0.128	0.142	0.060
EF/EP	0.028	0.039	0.032	0.009	0.011	0.015
CF/EP	0.090	0.060	0.036	0.085	0.094	0.027
CF/PM	0.049	0.016	0.023	0.034	0.038	0.018
Exiter Share						
Total (*XSH*)	0.173	0.112	0.084	0.128	0.147	0.053
EF/EP	0.025	0.042	0.029	0.007	0.008	0.011
CF/EP	0.092	0.054	0.033	0.087	0.098	0.023
CF/PM	0.056	0.016	0.022	0.034	0.041	0.019
Exiter Relative Size						
Total (*XRS*)	10.610	14.998	7.809	14.328	8.598	5.629
EF/EP	12.955	17.310	6.227	0.489	0.515	2.955
CF/EP	11.214	12.001	7.648	15.184	7.572	3.053
CF/PM	8.969	12.707	7.386	20.506	13.667	12.731

Table notes: The *ZIP-BB* market has the geographic extent of a single ZIP code area and differentiates among broadband types. See section II.B.3 and II.B.4 for definitions of statistics.

Table 5: The Distribution of Entry Statistics across Broadband Types and ZIP Code Areas (Means and 10% and 90% Deciles across Time and Geography)

	Entry Rate (*ER*) Mean (1st decile, 9th decile)	**Entrant Share (*ESH*)** Mean (1st decile, 9th decile)	**Entrant Relative Size (*ERS*)** Mean (1st decile, 9th decile)
ADSL	0.144 (0.00,0.50)	0.095 (0.00,0.34)	14.216 (0.03,2.28)
BPL	0.000 (0.00,0.00)	0.199 (0.00,1.00)	NA NA
Cable Modem	0.035 (0.00,0.00)	0.068 (0.00,0.00)	23.375 (0.01,11.08)
Fiber	0.214 (0.00,1.00)	0.310 (0.00,1.00)	29.073 (0.17,5.23)
Satellite	0.125 (0.00,0.50)	0.076 (0.00,0.33)	0.738 (0.29,0.92)
SDSL	0.136 (0.00,0.50)	0.194 (0.00,1.00)	7.365 (0.10,2.51)
Fixed wireless	0.109 (0.00,0.50)	0.234 (0.00,1.00)	5.346 (0.03,13.17)
Mobile wireless	0.385 (0.00,1.00)	0.367 (0.00,1.00)	2.984 (0.39,2.44)

Table notes: means and deciles are calculated for each broadband type, across the six rounds and all the ZIP codes in the data. The 1st decile means the value with 10% of the data below it, and the 9th decile means the value with 90% of the data below it. The first-to-ninth decile range is given in parentheses. *ERS* is undefined for BPL firms because there is only ever a single firm providing BPL service at a time, and so there are never any incumbents upon entry.

Table 6: The Distribution of Exit Statistics across Broadband Types and ZIP Code Areas (Means and 10% and 90% Deciles across Time and Geography)

	Exit Rate (*XR*) Mean (1st decile, 9th decile)	**Exiter Share (*XSH*)** Mean (1st decile, 9th decile)	**Exiter Relative Size (*XRS*)** Mean (1st decile, 9th decile)
ADSL	0.070 (0.00,0.33)	0.057 (0.00,0.17)	9.243 (0.03,2.45)
BPL	0.096 (0.00,0.00)	0.096 (0.00,0.00)	NA NA
Cable Modem	0.061 (0.00,0.00)	0.057 (0.00,0.00)	17.010 (0.01,8.24)
Fiber	0.266 (0.00,1.00)	0.275 (0.00,1.00)	29.558 (0.23,5.69)
Satellite	0.033 (0.00,0.00)	0.026 (0.00,0.00)	0.862 (0.28,1.19)
SDSL	0.243 (0.00,1.00)	0.251 (0.00,1.00)	8.218 (0.28,3.28)
Fixed wireless	0.170 (0.00,1.00)	0.163 (0.00,1.00)	4.535 (0.03,8.10)
Mobile wireless	0.149 (0.00,0.50)	0.162 (0.00,0.70)	3.887 (0.90,2.38)

Table notes: see notes to previous table. *XRS* is undefined for BPL firms because there is only ever a single firm providing BPL service at a time, and so there are never any remaining incumbents upon exit.

Table 7: Correlations between Market Entry and Exit Measures across Time (ZIP-BB Market)

Measure x_t	Cor(x_t,x_{t-1})	Cor(x_t,x_{t-2})	Cor(x_t,x_{t-3})	Cor(x_t,x_{t-4})	Cor(x_t,x_{t-5})
Entry Rate (*ER*)	0.002	0.087	0.036	0.042	-0.019
Entrant Share (*ESH*)	0.132	0.230	0.161	0.204	0.204
Entrant Relative Size (*ERS*)	0.147	0.315	0.175	0.335	0.543
Exit Rate (*XR*)	0.133	0.087	0.122	0.192	0.023
Exiter Share (*XSH*)	0.133	0.084	0.139	0.213	0.035
Exiter Relative Size (*XRS*)	0.444	0.606	0.572	0.288	0.007[†]

[†]Not significant at the 10% level.

Table notes: a cell entry is the autocorrelation between the measure *x* given in the row heading and the same variable at various lags. Unless otherwise noted, all autocorrelations are statistically significant at the 0.01% level (i.e., *p*-value less than 0.0001). The first column of figures is the first autocorrelation, the second column in the second autocorrelation, and so on up to the fifth autocorrelation.

Table 8: Correlations between Market Entry and Exit Measures in the ZIP-BB Market

	No Correction for Market Fixed Effects	Correction for Market Fixed Effects
	Entry Rate (ER_t)	Entry Rate (ER_t)
Exit Rate		
XR_{t-4}	0.071	-0.078
XR_{t-3}	0.083	-0.046
XR_{t-2}	0.119	-0.020
XR_{t-1}	0.319	0.156
XR_t	0.058	-0.038
XR_{t+1}	0.135	0.032
XR_{t+2}	0.060	-0.026
XR_{t+3}	0.033	-0.005
XR_{t+4}	0.014	-0.048
	Entrant Share (ESH_t)	Entrant Share (ESH_t)
Exiter Share		
XSH_{t-4}	0.120	-0.276
XSH_{t-3}	0.187	-0.129
XSH_{t-2}	0.169	-0.168
XSH_{t-1}	0.573	0.370
XSH_t	0.404	0.296
XSH_{t+1}	0.253	-0.086
XSH_{t+2}	0.145	-0.142
XSH_{t+3}	0.162	-0.047
XSH_{t+4}	0.157	-0.030

Table notes: each entry is the correlation between the exit variable in the row heading with the entry variable in the column subheading. The market is defined in the column heading.