Residential Broadband Competition in the United States

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Abstract

This paper uses a new FCC dataset on residential broadband subscribership and speeds at the census tract level combined with data from a number of additional sources to explore the state of broadband competition in the U.S. and test the effects of competition on speeds, penetration, and prices.

We find that the number of wireline providers in a census tract is positively correlated with the highest available broadband speeds, even when controlling for housing density, household income, state fixed effects, and endogenizing the number of providers. That is, we find that DSL, cable, and fiber speeds are each significantly higher where there is more than one provider than when there is only a single provider.

We also find evidence that prices for broadband subscriptions, especially for slower speeds, are lower where there are more wireline providers. Prices for slower DSL (768 kbps and lower) are the most strongly negatively correlated in terms of magnitude to the number of other providers. Unfortunately, the low quality of our price data makes it difficult to draw firm conclusions. Indeed, the overall analysis points to the need for better data to conduct more rigorous competition analyses.

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1. **Introduction**

Competition in broadband, as in other industries, is crucial to spurring investment and innovation and increasing consumer well-being. The structure of the broadband industry in the U.S. is somewhat unique in that unlike many countries, the majority of broadband subscribers in the U.S. do not connect to the internet over lines owned by an incumbent telephone company. U.S. cable television infrastructure was advanced and ubiquitous enough to allow cable companies to offer broadband service to large portions of the country in many cases before the telephone companies. As a result, in the U.S. two wireline broadband platforms have been competing directly in most of the country since broadband was first widely available to consumers. And similar to other countries, fixed and mobile wireless broadband providers now also offer broadband services.

This paper uses a new FCC dataset on residential broadband subscribership and speeds at the census tract level combined with data from a number of additional sources to explore the state of broadband competition in the U.S. and test the effects of competition on speeds, penetration, and prices.

We find that the number of wireline providers in a census tract is positively correlated with the highest available broadband speeds, even when controlling for housing density, household income, state fixed effects, and endogenizing the number of providers. That is, we find that DSL, cable, and fiber speeds are each significantly higher where there is more than one provider than when there is only a single provider. The result is highly robust to the empirical specification. We first use an ordered logit since that approach fits the way the FCC aggregates speeds into groups, then ordinary least squares, and finally two-stage least squares to endogenize the competition variable.

While the data make it difficult to draw firm conclusions, we also find evidence that monthly prices for broadband subscriptions, especially for slower speeds, are lower where there are more wireline providers. Prices for slower DSL (768 kbps and lower) are the most strongly negatively correlated in terms of magnitude to the number of other providers. Unfortunately, we cannot endogenize competition in the price model and the low quality of our price data makes it difficult to draw firm conclusions. Indeed, the overall analysis points to the need for better data to conduct more rigorous competition analyses.

A large number of papers study broadband competition, but nearly all of them try to determine whether intra-platform (i.e., competitors have regulated access to incumbents’ networks) or inter-platform (i.e., competitors build their own facilities) competition is more effective at increasing broadband adoption. These papers are usually cross-country analyses, and reach no consensus conclusion.¹ Other research has examined factors related to broadband adoption, but these tend not to focus on competition.² Our paper differs substantially from the existing

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¹ See, for example, Wallsten and Hausladen (2009), Benkler (2009), Hazlett (2005), Frieden (2005), Aron and Burnstein (2003), Distaso, Lupi, and Manenti (2004).
² See, for example, Flamm and Chaudhuri (2007), Flamm (2005).
literature. We are not attempting to compare regulatory models. Instead, we use two highly
detailed datasets that have not been used previously to examine the state of competition
among network providers and to test the effects of competition on speeds and prices.
Additionally, our data allow us to endogenize competition, helping to separate the effects of
competition from factors that affect the degree of competition.

The remainder of this paper is structured as followed. Section 2 provides a framework for
thinking about the economics of broadband competition. Section 3 describes the state of
competition in the U.S. Section 4 tests the effects of competition on speeds, penetration, and
prices. Section 5 concludes.

2. The Economics of Broadband and Competition

Understanding competition in broadband networks requires considering features that affect
supply and demand.

2a. Supply

Building broadband networks requires large fixed and sunk investments, which has two
implications.

First, because carriers must recover the high fixed costs of investment, average prices must
exceed marginal costs if providers are to continue investing in their networks. The most
efficient way to recover those fixed costs is to charge different types of consumers different
prices. In principle, that means charging high prices to consumers willing to pay a lot for
broadband and low prices to consumers who are not willing to pay much for it.³ In reality, it is
generally not possible to identify a particular consumer’s preferences, so instead providers
create different products that appeal to different groups, even though the marginal cost of
serving each group may be similar.⁴

This type of pricing can benefit or harm consumers. Shifting more of the costs of the
infrastructure onto high-end users can bring lower prices for low-end users (see, for example,
Baker 2003; Brennan 2005). That kind of price discrimination typically increases consumer
welfare by bringing people into the market who otherwise would be excluded. Firms with
market power, however, can use price discrimination in ways that harm consumers (e.g., Varian
1985).

Bundling products is also common in broadband. Bundles can increase efficiency and benefit
consumers by, for example, reducing costs and making it easier for consumers to purchase

³ Prices commonly differ from marginal costs, even in highly competitive markets. See, for example, Baumol (1970;
2006).
⁴ In practice it is not always true that serving different types of consumers has the same costs. To the extent that
networks are built to handle demands of high-end users, those users affect costs, though once that cost is sunk the
marginal costs on the network from even those high-end users is minimal as long as they do not create congestion.
In addition, different types of consumers may generate different costs in terms of customer service, though that
does not affect the network except to the extent it diverts funds from investment to customer service.
particular baskets of products they value (e.g., Evans and Salinger 2005). But they can also harm consumers by, for example, making it possible for a provider to extend its market power or making entry more difficult for firms that cannot offer bundles (e.g., Carlton and M. Waldman 2002; Nalebuff 2003).

Evaluating the broadband industry is difficult because it simultaneously exhibits characteristics consistent with “good” and “bad” price discrimination and bundling. The implication is that it is difficult to know in general if the prices and bundles we observe are welfare-enhancing and “competitive,” or not. Such an evaluation will require case- and fact-specific analysis.

Second, for any foreseeable demand and supply conditions the industry will most likely continue to have only a relatively small number of wireline facilities-based competitors. Bringing down the cost of entry is crucial and may encourage new entry in some places, but we are unlikely to see new wireline entry on a large scale.\(^5\)

The lack of a large number of providers is not, by itself, necessarily cause for concern. While older economic models of competition assumed that competition always improved with additional firms, Bresnahan and Reiss (1991) found that in markets too small to support many firms the biggest competitive effects come from the second or third entrants, with little additional effective competition beyond the fifth entrant.\(^6\) That analysis tells us that a small number of firms can yield a competitive market but does not tell us how aggressively two, three, or even four or five wireline providers combined with imperfect competition from fixed and mobile wireless will compete.

To understand how even imperfect competition can affect broadband markets, it is important to consider the nature of demand in more detail, which we turn to next.

2b. Demand

Consumers’ preferences differ, and their willingness to pay for broadband features like speed depends on what they do with their broadband connections. Some value speed more than any other attribute, some value reliability, some value mobility, and new converts from dialup may

\(^5\) See, for example, Shelanski (2007) for a discussion. Even in the early days of high-speed access some recognized that the market structure of high-speed retail ISPs would differ from that of dialup ISPs. Faulhaber and Hogendorn (2000), for example, estimated that the market for wired broadband would support two or three providers. Atkinson (2009) argues that the economics of “ultrabroadband” access will result in an even more concentrated industry.

\(^6\) Similarly, Sutton (1991) introduced the concept of “endogenous sunk costs” (ESC), in which firms can choose how much to invest in sunk costs. The key insight is that in such industries the total number of firms is likely to be limited and may even shrink as the market grows. As Bresnahan and Greenstein (1999, 7) state, “when ESC are important, demand growth does not lead to fragmentation; a larger market will have higher ESC, not more firms, in equilibrium.” Xiao and Orazem (2006) apply the Bresnahan-Reiss framework to the broadband access market and find no additional competitive effects beyond a third competitor. While suggestive, the research relies on the FCC’s zip code counts from the old Form 477 data. Those data, discussed elsewhere, show that most zip codes have multiple high-speed providers, but those providers do not always offer service to the same areas within the zip code.
even value the simple “always on” connection. A consumer who does not mind a slow connection and uses the Internet only for, say, email and basic news browsing has, in principle, several choices—nearly any broadband access technology will do. But a power user who streams HD video to several televisions and enjoys gaming probably wants high bandwidth and low latency. That user will have few choices.

In reality, most consumers do not have such extreme preferences, but value some attributes more or less than others. This variation among consumers can have profound effects on competition. Consider, for example, a person who lives alone and can obtain the speed she desires from either a fixed or a mobile connection. Her choice will depend on the relative price of each connection type and how much she values mobility.

Suppose that a relatively slow wireline broadband connection in her area costs $25 per month and a wireless connection costs $55 per month. If she thinks mobility is worth at least an extra $30, she will choose the wireless connection. For her, the quality-adjusted price of wireless service is lower than the price of wireline service. Some consumers will prefer mobile service at these relative prices, and more will choose a wireless connection as the price gap shrinks.

If a sufficiently large fraction of customers view the choice as close, the fixed and the mobile providers will both pay attention to the price gap and each technology will exert competitive pressure on the pricing of the other. The smaller that fraction, the more likely the wireless and wireline providers are to each set its price without regard to the price of the other. The critical fraction will depend, among other things, on the price-cost margins each firm can earn from switchers, relative to the margin it would earn from ceding likely switchers to the other technology and pricing only with regard to customers who do not see the other technology as a close substitute.

Another factor affecting the degree to which the services will exert competitive pressure on each other is how well the providers can identify how much a given consumer or group of consumers values different attributes. Suppose that the person in the example above lives with a large family. If a broadband provider knows that several people will share the connection then the provider knows that this consumer probably will not value mobility especially highly for her household. In that case, the provider could set a price for the wireline connection with much less regard for the price of the wireless connection even if other attributes (e.g., speed) are identical.

7 Rosston, Savage, and Waldman (2010) estimate willingness to pay for a variety of broadband attributes, such as speed and reliability, and online activities, such as watching videos and interacting with health care providers.

8 Another factor that may affect this type of decision is the amount of data that can be downloaded each month. While most wireline plans today offer unlimited data or very high data caps, many mobile plans have lower data limits.

9 Determining the point at which it would become profitable to lower prices is in many ways analogous to determining the “critical loss” of customers at which a price increase would no longer be profitable (Katz and Shapiro 2003; Farrell and Shapiro 2007).
Consider also the interaction between consumer preferences and the prices of different speed tiers. If most consumers do not use applications that require very high speeds and are therefore not willing to pay much for higher speeds, then a provider’s decision to offer 50 mbps or higher may have little effect on competition in general even if only a single provider offers those higher speeds. Additionally, some consumers will have strong demand (high willingness to pay) for those faster speeds, meaning that if only a single provider offers that speed it will be able to charge relatively high prices regardless of the cost of providing the service.

Just as wireless broadband can impose competitive pressure on the price of lower-speed wireline broadband, so, too can the prices of one speed affect the prices of another speed. Similar to the wireless example above, consumers will choose a price-speed combination that best matches their preferences. If a sufficiently large group of consumers are relatively indifferent between two speeds, then providers will pay attention to the price gap so that the price of a lower speed can help bring down the price of a higher speed.\(^\text{10}\)

2c. Summing up

The economics of the industry imply that the market is likely to consist of a relatively small number of firms, whose average prices will be above marginal cost. While a small number of firms can yield a competitive outcome, the economics do not tell us what the critical number of competitors is. In addition, evaluating competition is complex because of imperfect competition between wireless and wireline platforms. The extent to which wireless and wireline will impose competitive discipline on each other depends on how technology, costs, and consumer preferences evolve.

We turn next from theoretical considerations to empirical analysis of broadband network competition in the United States.

3. The State of Residential Broadband Competition in the United States

Approximately 78% of the U.S. population lives in areas where both the local cable and telephone companies offer residential broadband service. An additional 4% of the population has a third wireline option from a cable overbuilder. 13% of the population faces a single wireline provider, and 5% has no wireline provider (Figure 1).

\(^{10}\) Even outside choices for broadband access could, in principle, affect prices. According to the FCC’s consumer adoption survey, 3 percent of adults without broadband connections say that they have sufficient access at work and do not want to pay for a home connection. If that group were sufficiently large then providers would adjust prices or design specific plans to induce more people from that group to subscribe.
Figure 1: Share of housing units in census tracts with 0, 1, 2, and 3 wireline providers

Note: The lack of useful data on availability makes it difficult to estimate these figures with precision. The numbers in the figure come from estimates based on the FCC’s Form 477 data (Dec 2008) and the FCC cost model described in the National Broadband Plan. See section 3a for details on how we derive estimates from Form 477.

Other types of fixed broadband providers compete for customers as well, although these services tend to be more expensive and offer lower speeds than today’s wireline offerings. For instance, satellite-based broadband service is available in most areas of the country from two providers, hundreds of fixed wireless internet service providers offer service to more than two million subscribers, and Clearwire offers WiMax service in a number of cities.

A number of mobile wireless providers also offer broadband service. About 98% of the population lives in census tracts with 3G coverage, including about 77% of the population that can choose from three or more mobile 3G providers (Figure 2).

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11 The estimates for zero and one provider are from the FCC cost model and are based on where there is either no wireline provider or only a single wireline provider that offers a service with at least 768 kbps download speeds.

Figure 2: Share of population living in census tracts with 0, 1, 2, 3 or more 3G mobile providers

Source: Derived from American Roamer Advanced Services data (EV-DO, HSPA, and WiMAX). Nov 2009.

Mobile data users typically receive download speeds ranging from hundreds of kilobits per second to about one megabit per second. Several competing firms serve consumers who are willing to pay a premium for mobile broadband. In addition to the nationwide carriers AT&T, Verizon, Sprint, and T-Mobile, new competitors such as Leap Wireless and Metro PCS have emerged in metropolitan markets in recent years offering differentiated and inexpensive services.

Wireless and wireline platforms, however, are not perfect substitutes. In principle, consumers interested only in applications requiring slower speeds may be equally well-served by any of these technologies. In practice, for now wireless broadband is generally more expensive than wireline plans offering similar speeds, cannot match the high-end speeds available via wired connections, and has lower data caps than wireline plans.

Looking forward, wireless broadband may become an increasingly effective competitor. Theoretical maximum speeds of wireless technologies have increased dramatically in recent years, including for LTE, which is in the very early stages of deployment (Figure 3). Wireless is

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13 According to ComScore data, the median measured mobile broadband download speed in the first half of 2009 was 682 Kpbs. The first and 99th percentiles were 241 Kbps and 1.7 Mbps, while the 90th percentile was 1.1 Mbps.
14 In practice, achievable data throughput depends on a number of factors, including spectrum, demand, and characteristics of topography and buildings that may affect signal strength.
probably not likely to provide direct competition to very high speed wireline broadband, but the degree to which wireless and wireline providers exert competitive pressure on each other will depend on changes in the nature of demand, improvements in wireless technologies, and costs. So even if wireless and wireline never become close substitutes, as some analysts suspect, the competitive effect of wireless may be larger than its technical degree of substitutability might otherwise imply.

Figure 3: Evolution of spectral efficiency of wireless technologies

![Graph showing spectral efficiency evolution of wireless technologies]

Source: Letter from Dean R. Brenner, Vice President Government Affairs, Qualcomm Incorporated, to Marlene H. Dortch, Secretary, FCC (Dec. 9, 2009) at 1.
Note: Figure shows downlink capacities calculated for 2x10MHz spectrum availability. Estimates of spectral efficiency calculated for each technology with the following antenna configuration: WCDMA, 1x1 and 1x2; HSPDA, Rel.5, 1x1; HSPA Rel. 6, 1x2; HSPA, Rel. 7, 1x1 and 1x2; LTE, 1x1 and 1x2.

The remainder of the section discusses these issues and trends in more detail and concludes with recommendations for ensuring future competition and the ability to evaluate competition in the face of changing demand and supply conditions.

3a. Availability and Speeds

The lack of good data makes evaluating broadband competition difficult. While the FCC's new Form 477 dataset is an important improvement over previous data, it does not provide sufficient information to evaluate the industry fully. An improvement is that it collects data at the census tract level rather than the zip code level, which is potentially better for analysis because census tracts tend to be smaller than zip codes and their definitions are more stable.
over time. While the data are more disaggregated than they were previously, the FCC still collects no data on important factors like prices, product bundles, or consumer switching costs.

The raw 477 data, while much improved from previous years, provide little information about competition. For instance, those data show an average of 2.8 residential wireline providers per census tract. Even the most casual observer of the industry knows that most people can choose from two wireline providers and a few from three. The 477 average is high because the data identify providers that operate anywhere in a census tract and not whether their service areas overlap geographically.

Fortunately, from the raw data we can adjust the provider counts to make them more useful for analyzing competition in several ways. First, we eliminate providers with less than one percent of broadband subscriptions in a given census tract under the assumption that a provider with such a small number of subscribers is probably not available to a large part of the tract. Second, we identify cable overbuilders (such as RCN) in the data, which allows us to make reasonable assumptions about where cable companies actually provide service to the same geographic areas. Specifically, we assume that any given area is served by a maximum of one facilities-based DSL provider and one cable provider unless a cable overbuilder is present, in which case we count both cable providers. We also count fiber-specific competitors, but do not double-count telco providers that offer both DSL and fiber in the same tract (e.g., Verizon DSL and FiOS). Finally, we do not count CLECs providing service over another company’s lines because we focus on facilities-based providers and the relationship between deployment decisions and other variables and their inclusion would overstate the extent of facilities-based competition. With these adjustments to Form 477 data, the average number of residential, facilities-based wireline providers per census tract is approximately 1.9.

According to the U.S. Census, census tracts “are small, relatively permanent statistical subdivisions of a county. Census tracts are delineated for most metropolitan areas (MA’s) and other densely populated counties by local census statistical areas committees following Census Bureau guidelines (more than 3,000 census tracts have been established in 221 counties outside MA’s). Six States (California, Connecticut, Delaware, Hawaii, New Jersey, and Rhode Island) and the District of Columbia are covered entirely by census tracts. Census tracts usually have between 2,500 and 8,000 persons and, when first delineated, are designed to be homogeneous with respect to population characteristics, economic status, and living conditions. Census tracts do not cross county boundaries. The spatial size of census tracts varies widely depending on the density of settlement. Census tract boundaries are delineated with the intention of being maintained over a long time so that statistical comparisons can be made from census to census.” [http://www.census.gov/geo/www/cen_tract.html](http://www.census.gov/geo/www/cen_tract.html)

In addition, we are not conducting an antitrust-style analysis of market power, so we do not define relevant geographic or product markets, nor do we believe that census tracts would necessarily constitute relevant geographic markets.

The data show an average of 3.8 providers per census tract when also including fixed (but not mobile) wireless.

For the purposes of this analysis we use the phrase “facilities-based wireline provider” to indicate “own local loop facilities wireline provider.” Note that the 1.9 average is slightly higher than the average implied by Figure 1 (1*0.13 + 2*0.78 + 3*0.04 = 1.81). The reason for this discrepancy is that the 477 data understates the share of the population with no wireline access because most people without access live in census tracts that have access elsewhere. Our more accurate, we believe, estimate of the share of people with no wireline access is based on the FCC’s deployment model, which combines input from several sources.
The number of providers in any given area is determined in part by cost and expected demand characteristics. That is, one would expect more providers where it is less costly to build and where demand will be higher. Figure 4 below shows the average number of wireline providers by housing density and income. The vertical axis in the figure shows the average number of wireline providers in the census tract identified by the income and housing density axes. Thus, the near corner shows the poorest, most rural census tracts, while the far corner shows the densest, wealthiest tracts.

**Figure 4: Average number of residential wireline providers by density and income**

The figure yields two important observations. First, housing density has a strong effect on the number of wireline providers across income levels, while income appears to have a smaller effect, except at the extremes. In other words, housing density appears to be a more important determinant of the number of wireline firms in an area than is income. Second, places that are both extremely rural and poor and places that are extremely dense and wealthy are quite different from the rest of the country. The areas that are both very rural and very poor have significantly fewer providers than the rest of country. Indeed, in those areas the data

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18 Analysis of FCC Form 477 data (Dec 2008)
probably to overstate availability due to the way the FCC’s Form 477 counts availability.\textsuperscript{19} Contrarily, areas that are both very dense and very wealthy have significantly more providers than the rest of the country.

While housing density appears to have the strongest effect on the number of wireline providers, a different view of the data shows the strong effect income has on adoption, as opposed to availability. Figure 5 below shows household broadband penetration from census tracts with the lowest housing density to census tracts with the highest density, as well as the share of census tracts by density that have zero, one, two, or three competing wireline providers (left axis). The figure also shows median household income for census tracts in that percentile (right axis).

\textbf{Figure 5: Number of wireline providers by tract density}\textsuperscript{20}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure5}
\caption{Number of wireline providers by tract density}
\label{fig:fig5}
\end{figure}

\textsuperscript{19} Recall that in the raw 477 data a provider is considered to serve a census tract if it has any subscribers at all in that tract. We do not count any provider that has one percent of subscribers or less, but in rural areas the smaller number of subscribers and larger geographic areas and providers in general makes this filter less effective.

\textsuperscript{20} Analysis of FCC Form 477 data (Dec 2008). Bar height represents average household penetration (left axis) in census tracts in that density centile. Each bar represents about 650 tracts. The dot above the bar represents median household income (right axis) in census tracts in that centile (median household income is from Census 2000 data). This figure will tend to understate penetration levels, as we limit the maximum penetration level in any tract to 1.1 fixed broadband lines per household. In the raw data approximately 10% of tracts have more residential connections than households. As most of these tracts are in rural or semi-rural areas, these penetration levels are likely due to provider reporting errors.
The figure reveals information that does not, at first blush, comport with conventional wisdom. It is generally assumed that because housing density affects the costs of installing infrastructure, broadband penetration will also be associated with density. The figure shows that broadband penetration increases quickly with housing density, but penetration begins to decrease beyond the 37th percentile of housing density. The figure shows that penetration is more strongly correlated with income—wealthier areas have higher broadband penetration, which is consistent with survey data.21

Figure 6 below shows the relationship between broadband penetration, housing density, and income in three dimensions, demonstrating graphically the important role income plays in broadband adoption. While Figure 4 showed that the number of providers was relatively constant across income levels, except the very extremes, for any given housing density, Figure 6 shows that penetration is fairly constant across housing densities for any given income level. In other words, income appears to be a far more important determinant of broadband penetration than housing density.

Figure 6: Average broadband penetration by income and density (excludes mobile)22

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21 Surveys consistently reveal income to be a strong determinant of adoption. See, for example, Horrigan (2009, 2010) and NTIA (2010).
22 Analysis of FCC Form 477 data (Dec 2008). This figure will tend to understate household broadband penetration (as explained in footnote 20).
Figure 7 below shows household penetration by technology rather than by the number of competing firms. The figure shows how income and housing density are both correlated not just with the number of wireline firms that provide service, but also with the types of technologies that provide service in different areas. In particular, the figure shows a relatively uniform distribution of DSL adoption except in the densest areas, which are dominated by cable. Conversely, we see very little cable broadband in the most rural areas. Rural areas also show, not surprisingly, the highest use of fixed wireless and satellite broadband. Fiber, meanwhile, appears primarily in suburban areas, which are also among the wealthiest census tracts.

![Figure 7: Shares of different broadband technologies by tract density](image)

In particular, the figure shows a relatively uniform distribution of DSL adoption except in the densest areas, which are dominated by cable. Conversely, we see very little cable broadband in the most rural areas. Rural areas also show, not surprisingly, the highest use of fixed wireless and satellite broadband. Fiber, meanwhile, appears primarily in suburban areas, which are also among the wealthiest census tracts.

Figure 8 below shows the number of 3G mobile wireless providers by income and housing density. Unlike wireline providers, where housing density seemed to matter more for the number of providers than did income except at the extremes, the number of 3G providers appears to be related to both housing density and income.

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23 Analysis of FCC Form 477 data (Dec 2008). This figure will tend to understate household broadband penetration (as explained in footnote 20).
Figure 8: Average number of 3G wireless providers in a Census tract by density and income

Source: Analysis of FCC Form 477 data (Dec. 2008).
Note: “3G” is defined here as mobile broadband service with advertised download speeds higher than 768 Kpbs. We recognize that this is an imperfect measure, but we believe it is the best definition available given the constraints of the Form 477 data. These data may overstate the number of providers in rural census tracts as providers report serving a tract if they have coverage anywhere in it, not whether they cover the entire tract. In addition, the quality of the wireless signal at any given location will vary depending on a number of factors, including demand, topography, and the characteristics of nearby buildings.

3b. Prices

Data on broadband prices are far scarcer than data on subscribership and are more difficult to interpret when they are available. The nearly complete lack of consistent and comprehensive price data at a disaggregated level makes it difficult to evaluate price competition. The data that do exist suffer from one or more of several flaws from an analytical perspective.

First, some focus on the price of broadband service when not bundled with any other services even though the vast majority of consumers purchase broadband along with voice, video, or both.\(^ {24} \) Estimates of the share of subscribers with some type of bundle range from 65 percent (Yankee Group) to 90 percent (TNS). According to the Yankee Group (2009) and UBS Securities

\(^ {24} \) See Rosston, Savage, and Waldman (2010) for estimates of how much consumers are willing to pay for certain features to be bundled into their broadband services.
(2009), about 21 percent of subscribers have a triple-play bundle. Rosston, Savage, and Waldman (2010) found that 41 percent of households had double-play and 33 percent had triple play subscriptions. Data from UBS demonstrate that the share of consumers subscribing to bundles has increased significantly in the past few years (Figure 9).

**Figure 9: Share of broadband subscribers purchasing a triple-play bundle**

![Chart showing the share of broadband subscribers purchasing a triple-play bundle from 2005 to 2009, with a steady increase.]

Second, sources that have data on bundles do not provide sufficient information to determine the incremental price of the broadband component. That is, it would be possible to derive the price of the broadband component of a triple-play bundle if we knew the price of a voice-video package and the price of the voice-video-broadband package, but no data source appears to provide such information in a comprehensive, consistent, and comparable way.

Third, broadband providers frequently offer promotions to attract new customers. No data source consistently captures the relevant details of those promotions, including details such as how long the promotional price lasts, the length of the contract the consumer signs to get the promotional price, the price once the promotion expires, and any early termination fee.

While the data do not allow us to examine competition in detail, it is possible to examine certain aspects of prices over time. In particular, Greenstein and McDevitt (2010) analyze about 1,500 broadband contracts tracked by the consultancy Point Topic to construct price indices (Figure 10). The figure shows that the price index for standalone prices, adjusted for upload and download speeds, changed only modestly between 2006 and 2009 while the index for bundled prices remained relatively constant. The authors bound their estimates,

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26 Point Topic collects information about advertised broadband services from providers around the world. The relevant information they collect for this purpose includes data on price, speed, and bundles. They do not have market shares of the providers, which means the analysis cannot weight the offers.
27 The bundled price index cannot be calculated prior to 2006 due to the lack of available data on bundled plans.
concluding that broadband service declined modestly—between 3% and 10%—from 2006-2009.

Figure 10: Broadband price indices

![Graph showing broadband price indices from 2004 to 2009]

We combine cross-sectional data from the consultancy Telogical on non-promotional standalone prices in specified geographic areas, technologies, and speed tiers with the FCC’s Form 477 data. The biggest analytical problem is that wireline broadband service is often purchased as part of a bundle, making it difficult to isolate the price of broadband. Figure 11 below shows median monthly prices by speed tier for DSL, cable, and fiber. Not surprisingly, faster speed tiers are generally more expensive than slower speeds.

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28 Fisher price indices as calculated by Greenstein and McDevitt (2010). The indices are based on all advertised plans recorded by Point Topic from 2004 through 2009 and calculated by regressing the advertised price on upload speed, download speed, and year dummy variables separately for DSL and cable plans and then using the number of subscriptions to each type of service as the weight for creating a single broadband index. We set the indices to 1 in 2006 in order to facilitate comparison.

29 Telogical collects data on advertised prices and plans. We are able to match data to Form 477 based on the technology and speed Telogical reports.

30 Rosston, Savage, and Waldman (2010) found that subscribers buying telephone and Internet together paid $38.59 per month for their Internet connection and $82.73 for the total bundle, subscribers buying TV and Internet paid $43.87 for their Internet and $105.55 for their total bundle, and triple-play subscribers paid $49 for their Internet and $141.76 for their bundle.
Figure 11: Median monthly broadband prices by speed tier and technology\textsuperscript{31}

Figure 12 shows the same information in a different format to make it easier to compare prices across technologies. The figure shows that prices for any given speed tier are similar across technologies, but that cable prices tend to be somewhat higher than DSL for the more common speed tiers and that fiber prices are generally higher than cable or DSL.

\textsuperscript{31} Analysis of Nov. 2009 price data from Telogical Systems combined with Dec. 2008 subscribership data from the FCC’s Form 477. We combine these data to create a census-tract-level dataset containing both the number of providers present in a given tract and the prices of various broadband plans offered in that tract. Specifically, the 477 data allow us to identify census tracts with zero, one, two, and three wireline providers (through the methodology described earlier) while the Telogical data allow us to identify available broadband prices by technology & speed tier in many census tracts. We include all monthly non-promotional broadband plans offered by the top 40 providers (identified by each provider’s total number of subscribers in the 477 data). While most plans appear to be "stand-alone" plans, some plans may require a cable or voice subscription.
4. The Effects of Competition

The previous section described many of the characteristics of broadband. This section evaluates the effects of competition. We begin by presenting some simple figures showing how speeds, penetration, and prices differ by the number of wireline providers in a census tract. Because simple cross-tabulations may be misleading, we then turn to a more rigorous econometric analysis. Importantly, the econometric analysis explicitly accounts for factors that might simultaneously affect the number of firms in a market and the outcomes we wish to measure. An analysis that does not properly account for this effect may inappropriately draw conclusions about competition that are incorrect or attributable to some other underlying characteristic.

Firms may compete for customers in a variety of ways. They can offer similar services and compete on price, tailor different products and services to different types of consumers. This section evaluates both price and non-price competition.

4a. Non-Price Competition

Broadband providers can compete by catering to different consumer types by offering different speeds, bundles, or contract terms. Chen and Savage (2009) find that consumer preferences

---

32 Research on CLECs has found that they tend to target different types of consumers rather than lower prices See
matter significantly in how cable and DSL compete with each other. They find that in areas in which people are similar in terms of educational achievement cable and DSL appear to compete on price. In areas in which people exhibit substantial variation in educational attainment, firms seem to compete in dimensions other than price.

One way providers may compete is by focusing on different types of consumers. Cable and DSL providers appear to focus on different types of consumers in much—though by no means all—of the country as Figure 13 and Figure 12 make clear. Though some of the speeds cable advertises overlap with speeds DSL advertises, the figure shows that cable tends to serve consumers who want higher speeds and are willing to pay higher prices while DSL serves consumers who are not willing or able to pay as much or otherwise care less about faster speeds.

![Figure 13: Distribution DSL and cable internet subscribers by speed tier](image)

Source: FCC Form 477 data (December 2008)

At least two factors explain this outcome. First, the order of entry matters. Cable tended to provide broadband first and therefore capture the population with the highest willingness to pay for broadband. DSL came later and was able to capture the population that was more price sensitive provided switching costs are sufficiently high. Second, technology matters. DSL speeds are generally limited by the length of the copper loop, while the constraint on cable—

the number of homes served by a node—is easier to change. Depending on switching costs and service prices, this particular market segmentation may fade as the FiOS and U-verse rollouts continue and as VDSL upgrades become more effective and less costly.

Nevertheless, broadband providers also compete on speed. Form 477, and thus the modified dataset we use, reports only subscribership, not availability, which means that we cannot observe the actual highest speeds advertised in a census tract. We can, however, make some assumptions based on the subscribership information about available speeds. In particular, we assume that a particular download speed is widely available if at least 10% of subscribers in a tract subscribe to that speed. We impose this filter because the highest speed observed anywhere in the tract may not be widely available or may even be an error in the data. The average fastest download speeds to which even a single user in a tract subscribes is approximately twice as high as when we impose the 10% filter, but we have no way to verify whether the highest speed observed anywhere in a tract is actually widely available, available only to a small share of people in the tract, or even a coding error by the responding firm.

Figure 14 below, derived from Form 477 data, shows the distribution of highest average available speed tiers (to which at least 10% of subscribers in a tract subscribe) with one, two, and three providers. Available speeds are the top speeds widely available in a tract. Specifically, for census tracts with one, two, and three wireline providers the figure shows the share of tracts whose highest available speed falls within each speed tier. To ease interpretation we also show the average top available speed in tracts with one, two, and three wireline providers in the figure insert. The figure shows that available speeds are higher where there are more wireline competitors.

---

33 We also do our analyses with a 5% threshold to check for robustness, and the results are similar.
34 We take the midpoint of each tier to calculate an average speed from the tiers.
The figure is consistent with the hypothesis that competition affects speed, but several possibilities other than competition could explain it. It is possible, for example, that demand conditions affect both competition and speed. That is, average speeds in areas with one provider could be lower than areas with two and three wireline providers because areas with only one provider tend to be poorer. If poorer areas attract less entry and if poorer people are less willing to pay for faster speeds, then lower available speeds in areas with one provider could be more attributable to lower incomes than to the lack of competition, per se.

We can deal with that issue by examining each technology separately by number of providers. Figure 15 shows the average top advertised speed by technology and number of wireline providers. The figure is similar—with one exception, providers of each technology type (DSL,
cable, and fiber) each offer faster speeds when more wireline providers are present. The exception is that the average available cable speed is higher when cable is by itself than when one other provider is available. This seemingly peculiar result for cable shows why it is important to control for additional factors such as deployment costs.

Figure 15: Average top advertised speed by technology and number of wireline technologies

In particular, we saw in section 2 that cable is more likely to be available in urban areas than in rural areas and may offer faster speeds in those areas for a variety of reasons unrelated to competition, per se. Thus, an analysis must control for factors like income and density, since more providers may be in wealthier areas, as shown in section 2, and may also offer higher speeds in those areas not because they are competing with each other but because residents there are willing to pay for faster speeds. Analysis must also account for underlying factors that influence the number of wireline providers in an area.

To estimate the effects of competition more rigorously, we estimate two sets of regressions. Form 477 data do not show exact advertised connection speeds. Instead, they group connections into speed tiers and report the number of connections in a census tract in each tier. That is, we observe the speed tier of the connection, but not the speed itself. This grouping implies that the best approach from an empirical point of view is to treat these as categorical outcomes.

The tiers are ordered from the slowest speeds to the fastest speeds, suggesting that an ordered logit model is the right approach for this analysis. In particular, in the ordered logit model we assume (in this case) that speeds are a function of several variables, as in equation (1) below.
(1) \[ \text{speed}_i = \beta_1 (\text{housing density}_i) + \beta_2 (\text{median income}_i) + \beta_3 (\text{one provider}_i) + \beta_4 (\text{two providers}_i) + \beta_5 (\text{three providers}_i) + \gamma_j + \epsilon_i \]

An observation in the data is a census tract, indexed by \( i \) in the equation.\(^{36} \) The variables \textit{housing density} and \textit{median income} in the tract control for underlying supply and demand characteristics. \( \gamma_j \) represents state fixed effects, to capture the effects of state laws and regulations that may affect investment. The variables \textit{two providers} and \textit{three providers} are dummies indicating whether the census tract has two or three competing wireline providers. The variable indicating the presence of only one provider is excluded, meaning that the coefficients on the other variables indicate differences from having a single provider. The error term, \( \epsilon_i \), is assumed to have a logistic distribution.

As discussed above, we do not observe speed and instead observe only the speed tiers shown in Table 1.

\[ \text{Table 1: Download Speed Tiers from FCC Form 477} \]

<table>
<thead>
<tr>
<th>Speed Tier</th>
<th>Advertised Download Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 200 kbps</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>768 kbps</td>
</tr>
<tr>
<td>3</td>
<td>1.5 mbps</td>
</tr>
<tr>
<td>4</td>
<td>3 mbps</td>
</tr>
<tr>
<td>5</td>
<td>6 mbps</td>
</tr>
<tr>
<td>6</td>
<td>10 mbps</td>
</tr>
<tr>
<td>7</td>
<td>25 mbps</td>
</tr>
<tr>
<td>8</td>
<td>100 mbps</td>
</tr>
</tbody>
</table>

Note: The Form 477 data indexes speed tiers beginning with tier 2, meaning that in the original 477 data our tier 1 is called tier 2, our tier 2 is called tier 3, and so on. We changed the labels to make them more intuitive.

The probability that an observed maximum available speed tier in census tract \( i \) equals \( j \) can therefore be represented by equation (2).

\[ \text{Pr[speed tier } = j \text{]} = \frac{1}{1 + e^{x_{i} \beta - \alpha_j}} - \frac{1}{1 + e^{x_{i} \beta - \alpha_{j-1}}} \]

Table 2 shows the results of estimating the ordered logit where the dependent variable is the top speed tier available in a census tract. That is, the dependent variable takes the values (tier) 1 through (tier) 7. The dummy for one wireline provider is excluded, so the coefficients on two and three wireline providers can be interpreted as affecting the probability of being in a higher

\(^{36} \)As a robustness check we run the same regressions with a county-level dataset (i.e., a dataset in which an observation in the data is a county rather than a census tract). The results are qualitatively unchanged.
tier than a tract with only one wireline provider. Nevertheless, it is difficult to interpret the odds ratios presented in Table 2 in a meaningful way, so we convert these estimates into probabilities and then construct a figure from the results.

Table 2: Ordered logit results: Speed Tiers

<table>
<thead>
<tr>
<th></th>
<th>ADSL</th>
<th>Cable</th>
<th>Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two wireline providers</td>
<td>2.40</td>
<td>1.49</td>
<td>2.99</td>
</tr>
<tr>
<td></td>
<td>(29.13)**</td>
<td>(8.78)**</td>
<td>(9.66)**</td>
</tr>
<tr>
<td>Three wireline providers</td>
<td>2.18</td>
<td>3.38</td>
<td>2.79</td>
</tr>
<tr>
<td>Median HH income</td>
<td>1.06</td>
<td>1.09</td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>(11.01)**</td>
<td>(17.15)**</td>
<td>(6.96)**</td>
</tr>
<tr>
<td>Housing density</td>
<td>1.74</td>
<td>1.00</td>
<td>8.36</td>
</tr>
<tr>
<td></td>
<td>(15.82)**</td>
<td>(5.20)**</td>
<td>(11.20)**</td>
</tr>
<tr>
<td>Observations</td>
<td>57853</td>
<td>55344</td>
<td>7191</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-52534</td>
<td>-45711</td>
<td>-4297</td>
</tr>
<tr>
<td>Likelihood ratio chi-squared</td>
<td>6587.75</td>
<td>17133.73</td>
<td>3990.4</td>
</tr>
<tr>
<td>Pr &gt; chi-squared</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Absolute value of z-statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
State fixed effects included but not shown. The variable indicating one wireline provider is excluded. Odds ratios reported.

Table 3 translates the coefficient estimates into probabilities. In particular, Table 3 shows the probability that a given speed tier will be the maximum available for each technology given a number of wireline providers. So, for example, without implying causality the estimates show a 34% chance that tier 4 will be the maximum available and a 55% chance that tier 5 will be the maximum available for ADSL in tracts with only a single wireline competitor. Similarly, the analysis estimates a 20% chance that tier 4 will be the maximum available and a 71% chance that tier 5 will be the maximum available when two wireline providers are available.

Table 3: Probability of speed tiers being the maximum available by number of providers and technology

<table>
<thead>
<tr>
<th>Speed tier</th>
<th>1 provider</th>
<th>ADSL 2 providers</th>
<th>3 providers</th>
<th>1 provider</th>
<th>Cable 2 providers</th>
<th>3 providers</th>
<th>1 provider</th>
<th>Fiber 2 providers</th>
<th>3 providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>7%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>3</td>
<td>34%</td>
<td>20%</td>
<td>21%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>4</td>
<td>55%</td>
<td>71%</td>
<td>70%</td>
<td>6%</td>
<td>4%</td>
<td>2%</td>
<td>15%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>5</td>
<td>2%</td>
<td>5%</td>
<td>5%</td>
<td>56%</td>
<td>49%</td>
<td>32%</td>
<td>9%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>6</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>37%</td>
<td>46%</td>
<td>66%</td>
<td>74%</td>
<td>89%</td>
<td>89%</td>
</tr>
</tbody>
</table>
Another way to view the results is to use the estimates to construct expected speeds for each technology given the number of wireline competitors. We do this by assigning the midpoint of each tier as the speed representing that tier, and then calculating an “expected speed” from the probabilities. Figure 16 shows these expected speeds along with 95% confidence intervals. The analysis shows that each technology offers faster speeds when there are two providers than when it is the only provider. Available cable speeds are higher with three wireline providers than with two wireline providers, though DSL and fiber speeds are not statistically different with three wireline providers from their speeds with two wireline providers.

![Figure 16: “Expected” maximum available speed by number of providers and technology](image)

(bars show expected maximum speed, lines show 95% confidence intervals)

While we were surprised to see a marginal positive effect of a third wireline provider only for cable, the result has several plausible explanations. First, the result is consistent with the general theme of the Bresnahan and Reiss (1991) line of research that competitive effects diminish quickly with only a small number of competitors. Second, the confidence interval for fiber with three providers includes speeds higher than fiber with only two providers (though by

37 So, for example, using the tier midpoints that can be derived from Table 1 and probabilities from Table 3, the “expected” maximum ADSL speed in tracts with only one provider is 0.01*.484 + 0.07*1.134 + 0.34*2.25 + 0.55*4.5 + 0.02*8 + 0*17.5 = 3.48.
the same token, it also includes speeds lower than fiber with only two providers). We believe the most likely explanation, however, has to do with the type of facilities-based competition we see in the United States that leads to tracts with one, two, or three providers. In particular, tracts with one provider have either cable or DSL. Tracts with two providers typically have cable and DSL, but sometimes cable and fiber. Tracts with three providers in our dataset always have two cable companies (the incumbent plus and overbuilder) plus either a DSL or a fiber provider. Thus, the apparent stronger effect of moving from two to three competitors for cable may indicate areas where cable competes against another cable company, potentially inducing more intense competition. DSL and fiber show no measurable speed benefits when moving from two to three wireline providers.

This analysis, however, is still not sufficient as the number of providers in a tract is likely to be endogenous. The problem with equation (1) is that many of the same factors that affect competition also affect the outcomes we wish to measure. For example, the costs of buildout may affect both the number of competitors in the market as well as the broadband speeds those firms can offer. As a result, a correlation between available speeds in an area and the number of competitors may reflect underlying costs rather than the effects of competition, per se.

Dealing with endogeneity requires modeling separately a firm’s decision to enter a market and then, conditional on the firm’s presence in the market, the effects of competition on price. Endogenizing the number of firms requires an instrumental variable that helps explain the number of wireline providers in a tract but is not correlated with speeds except through the number of providers. Instrumenting separately for areas with one, two, and three wireline providers is not possible given our data. Instead, we simply count the number of wireline providers and instrument for that count variable.38

Figure 4 above showed that housing density was a good predictor of the number of wireline providers. At the same time, density itself should not affect speeds except for DSL, where longer copper loop lengths can reduce available speeds. Thus, housing density is the best available instrument for number of firms in the analysis of the effects of competition on available speeds from cable and fiber providers. Unfortunately, we do not have an adequate instrument for DSL, so do not use the 2SLS approach for DSL speeds.

For tractability we use the midpoints of the speed tiers to estimate a highest available speed, which we treat as a continuous variable. We then estimate two equations using two-stage least squares. Equation (2) estimates the number of wireline firms in a market and Equation (3) estimates the effects of that competition measure on outcomes. Equation (3) excludes housing density under the assumption that density drives costs but not speeds except through the number of firms once the investments are sunk.

\[
\begin{align*}
(2) \quad \text{number of wireline firms}_i &= \beta_0 + \beta_1 \text{(housing density}_i\text{)} + \beta_2 \text{(median income}_i\text{)} + \gamma_f + \epsilon_i \\
(3) \quad y_i &= \delta_0 + \delta_1 \text{(number wireline firms}_i\text{)} + \delta_2 \text{(median income}_i\text{)} + \chi_f + \epsilon_i
\end{align*}
\]

38 As a robustness check we run the same regressions using a dummy variable indicating when the number of
Before estimating the two-stage model, however, we estimate equation (1) using OLS and the midpoint of the highest available tier as the dependent variable to make sure that least squares yields results similar to the ordered logit approach. Table 4 shows that they are similar. Each of the three wireline technologies is faster where two providers offer service than when it is the only option. And, as above, only cable also shows a significant increase when going from two to three providers. Though the coefficient estimates show DSL and fiber speeds slightly slower with three providers than with two, the speed of each technology with two wireline providers is not statistically different from the speed with three.

Table 4: OLS regression of available DSL, cable, and fiber-to-the-home speeds on competition

<table>
<thead>
<tr>
<th></th>
<th>Top available DSL speed</th>
<th>Top available cable speed</th>
<th>Top available fiber speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of dependent variable (mbps)</td>
<td>4.02</td>
<td>10.94</td>
<td>14.85</td>
</tr>
<tr>
<td>Two wireline providers</td>
<td>1.32 (56.25)**</td>
<td>6.38 (101.59)**</td>
<td>3.01 (8.70)**</td>
</tr>
<tr>
<td>Three wireline providers</td>
<td>1.21 (26.31)**</td>
<td>8.14 (66.22)**</td>
<td>2.30 (4.34)**</td>
</tr>
<tr>
<td>Housing density</td>
<td>0.62 (22.15)**</td>
<td>0.83 (11.17)**</td>
<td>2.07 (5.72)**</td>
</tr>
<tr>
<td>Median HH income ($10000)</td>
<td>0.03 (6.60)**</td>
<td>0.16 (13.86)**</td>
<td>0.14 (3.44)**</td>
</tr>
<tr>
<td>Constant</td>
<td>2.43 (39.55)**</td>
<td>4.42 (26.82)**</td>
<td>1.95 (1.32)+</td>
</tr>
<tr>
<td>Observations</td>
<td>57,853</td>
<td>55,344</td>
<td>7,191</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.11</td>
<td>0.32</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Absolute value of t statistics in parentheses
State fixed effects included, not shown
+ significant at 10%; * significant at 5%; ** significant at 1%

Because we cannot instrument separately for tracts with two and three providers, in our two-stage model we use a single variable indicating the number of wireline providers in the tract. We treat it as continuous, though it equals only one, two, or three. Table 5 shows the results of this specification estimated using OLS, which yields similar results, including finding a larger (in

wireline firms is two or more. The results are qualitatively unchanged.
magnitude) correlation between cable and competition than the other technologies, probably for the reasons discussed above.

Table 5: OLS regression of available DSL, cable, and fiber-to-the-home speeds on competition

<table>
<thead>
<tr>
<th></th>
<th>Top available DSL speed</th>
<th>Top available cable speed</th>
<th>Top available fiber speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of dependent variable (mbps)</td>
<td>4.02</td>
<td>10.94</td>
<td>14.85</td>
</tr>
<tr>
<td>Number of wireline providers</td>
<td>0.95</td>
<td>5.18</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>(47.36)**</td>
<td>(96.39)**</td>
<td>(5.50)**</td>
</tr>
<tr>
<td>Housing density</td>
<td>0.54</td>
<td>0.58</td>
<td>1.94</td>
</tr>
<tr>
<td></td>
<td>(19.26)**</td>
<td>(7.71)**</td>
<td>(5.35)**</td>
</tr>
<tr>
<td>Median HH income ($10,000)</td>
<td>0.03</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>(6.40)**</td>
<td>(13.54)**</td>
<td>(3.34)**</td>
</tr>
<tr>
<td>Constant</td>
<td>1.72</td>
<td>-0.01</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td>(24.70)**</td>
<td>(0.07)</td>
<td>(0.93)</td>
</tr>
<tr>
<td>Observations</td>
<td>57,853</td>
<td>55,344</td>
<td>7191</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.10</td>
<td>0.31</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Absolute value of t-statistics in parentheses
State fixed effects included, not shown
+ significant at 10%; * significant at 5%; ** significant at 1%

We next estimate equations (2) and (3) using 2SLS and instrumenting for the number of providers in a census tract. Recall that we do not estimate the 2SLS model for DSL because housing density directly affects DSL speeds meaning that it is not an appropriate instrument for the number of firms. Table 6 shows the results of this estimation. Column (1) of Table 6 shows the first stage estimates for cable speeds and column (2) shows the second stage—the effects of the number of providers on cable speeds, assuming the instrument properly predicts the number of providers. Similarly, column (3) shows the first stage of the fiber equation and column (4) the results of the second stage.

Table 6: 2SLS regression, effects of competition on available cable and fiber speeds

<table>
<thead>
<tr>
<th></th>
<th>Cable</th>
<th>Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>1st stage</td>
<td>2nd stage</td>
</tr>
<tr>
<td>Number of providers</td>
<td>10.50</td>
<td>(14.13)**</td>
</tr>
<tr>
<td>Median HH income ($10,000)</td>
<td>0.032</td>
<td>-0.013</td>
</tr>
<tr>
<td></td>
<td>(36.58)**</td>
<td>(0.55)</td>
</tr>
<tr>
<td>Housing density</td>
<td>0.11</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>(19.03)**</td>
<td>(9.10)**</td>
</tr>
<tr>
<td>Constant</td>
<td>1.82</td>
<td>-9.70</td>
</tr>
<tr>
<td></td>
<td>(149.96)**</td>
<td>(7.05)**</td>
</tr>
<tr>
<td>Observations</td>
<td>55344</td>
<td>55344</td>
</tr>
<tr>
<td>R-squared</td>
<td>.11</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>7191</td>
<td>7191</td>
</tr>
<tr>
<td>Absolute value of t statistics in parentheses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ significant at 10%; * significant at 5%; ** significant at 1%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Housing density used as IV for the number of providers in first stage. State fixed effects included, not shown.

The 2SLS estimates yield results similar to those in the analyses above, though much larger in magnitude. Even controlling for factors that affect the number of providers in a tract, the number of providers is positively associated with higher available speeds. While the magnitude seems somewhat implausibly large given the ordered logit and least squares results, it suggests that the competitive effects are real and are likely larger than the more simple correlations imply.

4b. Price Competition

We are also interested in the effects of competition on prices. Prices are more complicated to examine for reasons discussed above and because broadband is available at many speeds, all of which means that it is difficult to define the precise product when comparing prices. Nevertheless, we are able to combine data on prices from Telogical with Form 477 data in a way that allows us to identify at the census tract level the prices of the different speed tiers by technology (Figure 11 above showed national median prices by technology and speed tier).39

As with speeds above, we begin by looking at a simple average of price by the number of available wireline providers. Rather than aggregating all plans together to get some weighted mean price, Figure 17 shows prices for each speed tier. The figure is consistent with some price competition at the very slowest tier (768 kbps and less), but no particular pattern for higher speeds.

39 We combine Nov. 2009 price data from Telogical Systems with Dec. 2008 subscribership data from the FCC’s Form 477 to create a census-tract-level dataset containing both the number of residential providers present in a given tract and the prices of various residential broadband plans offered in that tract. We discussed the 477 data earlier. The Telogical data allow us to identify available broadband prices by technology and speed tier in many census tracts. We include all monthly non-promotional broadband plans offered by the top 40 providers (identified by each provider’s total number of subscribers in the 477 data). While most plans appear to be "stand-alone," some may require a cable or voice subscription.
Just as above, the figure does not sufficiently control for other factors that may affect prices. In addition, the analysis is complicated by the incomplete nature of the data, which means that we do not have sufficient information to evaluate prices for every technology and speed tier. We therefore focus only on the most relevant speed tiers. For DSL, we focus on speed tiers 1 – 4, as that includes about 98 percent of all DSL subscriptions. For cable, we focus on tiers 4 – 6, as that includes about 90 percent of all cable subscriptions. The data do not allow us to analyze fiber in a meaningful way.\footnote{We had hoped to evaluate fiber tiers 4 – 7, since those include 95% of fiber subscriptions. Unfortunately, we have extremely limited data for tiers 4 and 5. Tiers 6 and 7 include about 70 percent of all fiber subscriptions, but these data also are problematic. For tier 6, the dependent variable (price) takes only two values in 94% of tracts. Tier 7 has almost the opposite problem - the range of the dependent variable is unrealistically large, likely because any plan between 25 Mbps and 100 Mpbs falls into tier 7.}

We thus estimate equation (1) using OLS and where the dependent variable is the lowest price observed in a census tract. We estimate the equation separately for each speed tier and technology so that the dependent variable is actually the lowest price observed in a tract for that speed tier and technology. Unfortunately, we cannot estimate the two-stage model in this case because we lack an appropriate instrument. Above we used housing density to instrument for the number of providers under the assumption that density affects costs but does not directly affect speeds, except for DSL. Density is not an appropriate instrument in this case.

\footnote{Analysis of FCC Form 477 subscriber data (Dec 2008) and Telogical price data (Nov 2009)}
because if density affects costs, then it would also affect prices directly rather than just indirectly through its effects through competition.

Table 7 shows the results of the price regression. The variable indicating tracts with only a single wireline provider is omitted, so the coefficients on the variables two providers and three providers indicate the change in price compared to tracts with one provider. The strongest correlation in terms of magnitude, is on prices for the slowest DSL speeds (768 kbps and lower). In DSL tier 1 we see monthly prices about $3.93 lower with two providers than with one, and about $5.72 less with three than with one.\textsuperscript{42} Coefficients on the provider variables for the other DSL tiers are all negative, suggesting competition is correlated with lower monthly prices, but the magnitudes are in general smaller and in the case of tier 3 not statistically significant. The results on cable are similar, although here we tend to see a much stronger correlation in terms of magnitude with three providers than with two. As discussed above with speeds, this result may be because tracts with three providers almost always have an overbuilder meaning that two cable firms are competing.\textsuperscript{43}

Table 7: OLS regression results of prices and competition

<table>
<thead>
<tr>
<th></th>
<th>DSL tier 1</th>
<th>DSL tier 2</th>
<th>DSL tier 3</th>
<th>DSL tier 4</th>
<th>Cable tier 4</th>
<th>Cable tier 5</th>
<th>Cable tier 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two providers</td>
<td>-3.93</td>
<td>-0.49</td>
<td>-0.03</td>
<td>-1.18</td>
<td>-0.13</td>
<td>-1.62</td>
<td>1.22</td>
</tr>
<tr>
<td>(23.41)**</td>
<td>(4.74)**</td>
<td>(8.56)**</td>
<td>(12.28)**</td>
<td>(0.62)</td>
<td>(8.07)**</td>
<td>(4.55)**</td>
<td></td>
</tr>
<tr>
<td>Three providers</td>
<td>-5.72</td>
<td>-1.28</td>
<td>-0.70</td>
<td>-1.91</td>
<td>-2.35</td>
<td>-4.84</td>
<td>-1.25</td>
</tr>
<tr>
<td>(21.81)**</td>
<td>(7.35)**</td>
<td>(8.84)**</td>
<td>(13.83)**</td>
<td>(8.76)**</td>
<td>(17.43)**</td>
<td>(3.38)**</td>
<td></td>
</tr>
<tr>
<td>Housing density</td>
<td>-0.70</td>
<td>-0.17</td>
<td>-0.11</td>
<td>-0.21</td>
<td>-0.11</td>
<td>-0.47</td>
<td>-0.28</td>
</tr>
<tr>
<td>(34.24)**</td>
<td>(15.91)**</td>
<td>(23.64)**</td>
<td>(18.96)**</td>
<td>(4.59)**</td>
<td>(26.91)**</td>
<td>(13.26)**</td>
<td></td>
</tr>
<tr>
<td>Median household income</td>
<td>-0.37</td>
<td>-0.16</td>
<td>-0.06</td>
<td>-0.05</td>
<td>0.04</td>
<td>-0.08</td>
<td>-0.54</td>
</tr>
<tr>
<td>(16.19)**</td>
<td>(9.53)**</td>
<td>(8.59)**</td>
<td>(4.22)**</td>
<td>(1.48)</td>
<td>(2.87)**</td>
<td>(15.24)**</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>26.42</td>
<td>35.31</td>
<td>39.02</td>
<td>44.37</td>
<td>54.74</td>
<td>63.60</td>
<td>78.56</td>
</tr>
<tr>
<td>(69.97)**</td>
<td>(111.99)**</td>
<td>(227.77)**</td>
<td>(168.93)**</td>
<td>(134.84)**</td>
<td>(140.27)**</td>
<td>(110.74)**</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{42} The mean price of DSL tier 1 ($15.36) is lower than might be expected due to the presence of a $10 plan offered by AT&T under an agreement with the FCC. To test whether this plan was driving the results in this tier, we reran the DSL tier 1 regression excluding this $10 plan. We found that the results were generally unchanged, although the mean price of DSL tier 1 increased to $21.56.

\textsuperscript{43} We also run the regression for fiber tiers 6 and 7 despite fiber data problems discussed in footnote 41. Not surprisingly, that analysis yields largely statistically insignificant results on the competition variables. The one exception is a statistically significant positive, though very small in magnitude, coefficient on two providers for fiber tier 6. On its face it implies that tier 6 fiber is $0.36 more per month in areas with two providers than in areas with one. The statistically insignificant results combined with the one tiny (in magnitude) result with the “wrong” sign confirm our suspicions that the fiber price data are not good enough to allow for meaningful analysis.

5. Conclusions

This paper uses two detailed datasets to examine the extent and effects of broadband competition, focusing especially on residential wireline broadband. Analysis of the FCC’s Form 477 data on subscribership reveals how the number of providers depends on housing density,
how penetration depends largely on income, and how different wireline technologies are more or less prevalent in areas of differing housing density.

The econometric analysis shows that the number of wireline providers is positively correlated with the top available download speed in a census tract, even controlling for housing density, household income, and state fixed effects, including after our attempt to endogenize the number of providers in a tract. Interpreted causally, this suggests that competition is important in spurring investment, which is consistent with the round of wireline upgrades currently underway. Our analysis of prices is less conclusive. Evidence from other sources suggests that quality-adjusted broadband prices have not changed much over the past few years. Our econometric evidence, based on incomplete data on prices combined with subscribership data shows, in general, a negative correlation between the number of providers and monthly prices even controlling for density, income, fixed effects. However, the quality of the data and our inability to explore product bundles and promotions makes us less confident in those results.

Overall, the analysis points to the need for better data to conduct more rigorous competition analyses. Better data on availability would be useful, but most important would be good data on prices. Obtaining such data is not simple given the number of different types of broadband plans, bundles, and promotions. Nevertheless, it is not possible to conduct competition analyses with data on quantities alone. Going forward, recommendations contained in the National Broadband Plan will help remedy these data deficiencies, making more thorough analyses possible.
References


