THE EFFECTS OF COMPETITION ON THE PRICE FOR CABLE MODEM INTERNET ACCESS

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Abstract—Theory suggests that a firm facing competition will raise prices as consumer preferences become more diverse, and with high enough diversity, a duopolist under product differentiation may price higher than a monopolist. Focusing on the price for cable modem Internet access, with or without DSL competition, and using the standard deviation of education attainment as a proxy for preference diversity, we find empirical support for these results. In markets where cable competes with DSL, the cable Internet price increases with preference diversity. Moreover, the cable Internet price under DSL competition can exceed that without competition when preferences are sufficiently diverse.

I. Introduction

HOW does competition affect prices? The economics literature has traditionally considered this question from the perspective of the prevailing market structure, focusing on the role of the number of firms. The standard insight of economics, most apparent in a model of homogeneous products, is that competition lowers prices. While it has been well known since the seminal work of Hotelling (1929) that the competitive effects are weakened when consumers have diverse preferences toward different firms' products,[1] there has been surprisingly little empirical study of how the price effects of competition depend on the diversity of consumer preferences. Recently Chen and Riordan (2008; hereafter, C-R) showed that increases in consumer preference diversity can systematically raise market prices in a discrete choice model of product differentiation; more strikingly, this phenomenon can be profound enough to cause the price in a symmetric duopoly to exceed the price of a single-product monopoly. This new theoretical development makes it all the more important that we investigate empirically the relationship between preference diversity and the price effects of competition.[2]

This paper conducts an empirical analysis of the effects of competition on the price for cable modem Internet access. We consider a data set in which there are two market structures for high-speed Internet access: the monopoly market in which there is a single provider of Internet access through cable modem and the differentiated duopoly market in which there is a cable modem and a digital subscriber line (DSL) provider. We study this data set primarily to address two empirical questions. First, how do prices in the duopoly market relate to consumer preference diversity? And second, (when) can the price be higher under duopoly competition than under monopoly?

We estimate reduced-form pricing equations for cable modem Internet access for monopoly and duopoly markets, respectively. Prices are a function of consumer preference diversity, demand and costs factors, and the determinants of DSL deployment. Using the standard deviation of the population's number of years of schooling as a proxy for consumer preference diversity, we find that preference diversity has a positive and statistically significant impact on the price in the duopoly market. This finding is robust to an econometric specification that considers potential omitted variable bias by controlling for cable modem Internet quality. In contrast, we find no significant positive relationship between preference diversity and price in the monopoly market. We further find that the comparison of duopoly price and monopoly price depends crucially on preference diversity. In markets where the standard deviation of education attainment is relatively low (at the 50th percentile), competition reduces monthly subscription prices by about $5.33 per month. As the standard deviation of education attainment increases the negative effect of competition on prices diminishes and when the standard deviation is high enough, competition can increase prices. These findings remain qualitatively valid when we use an alternative proxy for preference diversity that measures the distribution of ethnicities among individuals within a given market population.

Other empirical studies have also found that competition sometimes increases prices. For example, Bresnahan and Reiss (1991) provide survey evidence that automobile tire prices are somewhat higher in local markets with two dealers rather than one; Perloff, Suslow, and Seguin (2006) find that new entry raises prices in the antiulcer drug market; Ward et al. (2002) present evidence that the entry of private labels raises prices of name-brand goods in the food industry, and Goolsbee and Syverson (2008) find that airlines raise route prices when Southwest Airlines opens new routes to the same destination from a nearby airport. Our paper contributes to this literature by offering new evidence from the high-speed Internet access market; more important, we show how price differences between monopoly and

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[1] See also Salop (1979), Shaked and Sutton (1982), and Perloff and Salop (1985).

[2] Other theoretical studies have also found that prices can be higher with more firms, but they tend to assume asymmetric information (Stiglitz, 1987; Schulz & Stahl, 1996), rely on mixed strategies (Rosenthal, 1980), or contain a spatial structure with perfect negative preference correlation (Perloff et al., 2006; Chen & Riordan, 2007). In C-R, there is complete information, firms use pure strategies, and general preference relations are considered.

duopoly vary systematically with certain measures of consumer preference diversity.[3]

The paper is organized as follows. Section II discusses the theoretical background underlying our empirical analysis. Some comparisons of cable modem Internet prices in duopoly versus monopoly markets and in low- versus high-preference diversity markets are also presented. Section III presents the empirical model, and section IV describes the data. Section V presents estimation results and section VI concludes.

II. Background

A. Theory

We are interested in the market for residential high-speed Internet access. This is a market with two potential differentiated products—cable modem and DSL. A consumer would purchase only one of the products, so a discrete choice model is appropriate.

As in C-R, we assume that the preferences of a consumer are described by reservation values for the two goods, (v_1, v_2), where $v_i \in [\underline{v}, \bar{v}]$ and $0 \leq \underline{v} < \bar{v} \leq \infty$. To connect with our empirical work closely, we focus on one class of consumer valuation distributions studied in C-R: the joint uniform distribution. Specifically, we assume that (v_1, v_2) are uniformly distributed on a rectangular area on the $v_1 - v_2$ space that is formed by segments of four lines with the following inequalities:

$$\begin{aligned} 2(1+a) \geq v_1 + v_2 \geq 2; \\ b \geq v_1 - v_2 \geq -b, \end{aligned} \tag{1}$$

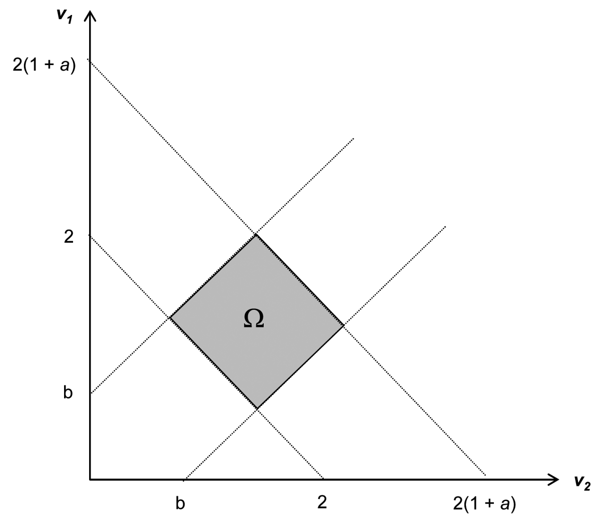
where $a \in [0, \infty]$ reflects the range, or dispersion, in consumer valuations for Internet access and $b \in [0, 1]$ reflects the diversity in consumer preferences for cable modem versus DSL products. This area defines the support for (v_1, v_2), Ω, and the joint probability density function is

$$\phi(v_1, v_2) = \frac{1}{2ab}, (v_1, v_2) \in \Omega. \tag{2}$$

Figure 1, reproduced from C-R, illustrates Ω for representative values of a and $b = 1$. As explained in C-R, this particular model has the interesting property that it contains both the Bertrand and Hotelling duopoly model as limiting cases. When $b \to 0$, Ω converges to an upward sloping line, and in the limit, the model becomes the standard model of Bertrand competition with a downward-sloping demand curve. On the other hand, when $a \to 0$, Ω converges to a downward-sloping line, and in the limit, the model becomes one of Hotelling competition.

[3] In an interesting paper from an unrelated literature, Alesina et al. (2004) investigate whether political jurisdictions form in response to the trade-off between economies of scale and the costs of a heterogeneous population. Using several different measures of income and racial inequality, they find that the more heterogeneous the tastes of a given population are, the larger the number of districts.

FIGURE 1.—Ω IS AN ORIENTED RECTANGLE



For this model, C-R shows that the equilibrium duopoly price is $p^d = b$, and the optimal price for the (single-product) monopoly is

$$p^m = \begin{cases} \frac{a+b+2}{4} \text{ if } 0 < a < b - \frac{2}{3} \\ \frac{2-b}{3} + \frac{1}{6}\sqrt{24ab - 4b + b^2 + 4} \\ \qquad \text{if } \max\{b - \frac{2}{3}, 0\} \leq a < 1 + b \\ \frac{1+a}{2} \text{ if } 1 + b \leq a \end{cases}. \tag{3}$$

The variance and the correlation coefficient are, respectively:

$$\mathrm{Var}(v_1) = \frac{1}{12}(a^2 + b^2) = \mathrm{Var}(v_2),$$
$$\rho = \frac{(a-b)(a+b)}{a^2 + b^2}.$$

Therefore, as the measure of preference diversity, b, increases, equilibrium duopoly price increases monotonically. On the other hand, the relationship between b and p^m is generally not monotonic; for instance, p^m increases in b when a is sufficiently small and b is large, whereas p^m decreases in b when $1/3 < a < ½$.

Furthermore, the difference between the monopoly price p^m and the symmetric duopoly price p^d is

$$p^d - p^m = \begin{cases} \frac{3b-a-2}{4} \text{ if } 0 < a < b - \frac{2}{3} \\ \frac{4b-2}{3} + \frac{1}{6}\sqrt{24ab - 4b + b^2 + 4} \\ \qquad \text{if } \max\{b - \frac{2}{3}, 0\} \leq a < 1 + b \\ b - \frac{1+a}{2} \text{ if } 1 + b \leq a \end{cases}. \tag{4}$$

It follows that $p^d > p^m$ if

$$0 < a < \frac{(3b-2)(7b-2)}{8b} \text{ and } b > \frac{2}{3},$$

TABLE 1.—GROUP MEAN COMPARISON TESTS OF PRICES

A: Prices								
Duopoly and monopoly (1)			Duopoly (2)			Monopoly (3)		
Group	Number of Observations	Mean	Group	Number of Observations	Mean	Group	Number of Observations	Mean
Monopoly	128	44.67 (1.18)	Low diversity	101	44.14 (1.18)	Low diversity	44	41.95 (1.77)
Duopoly	408	46.65 (0.61)	High diversity	102	47.43 (1.29)	High diversity	32	47.61 (2.71)
Difference		1.98 (1.33)	Difference		3.29* (1.75)	Difference		5.65* (3.24)
B: Quality-Adjusted Prices								
Monopoly	128	−0.23 (0.85)	Low diversity	101	−1.18 (0.81)	Low diversity	44	−1.21 (1.20)
Duopoly	408	0.07 (0.44)	High diversity	102	1.11 (0.94)	High diversity	32	1.98 (2.20)
Difference		0.31 (0.95)	Difference		2.29* (1.24)	Difference		3.19 (2.51)

The dependent variable in panel A is the monthly subscription price for cable modem Internet access with self-installation and own modem (*PRICE*). The dependent variable in panel B is the residual from a regression of *PRICE* on a constant and download speed. Monopoly is a cable system served by cable modem Internet only. Duopoly is a cable system served by cable modem and DSL. High diversity equals 1 when the standard deviation of education attainment is greater than or equal to the 75th percentile and 0 otherwise. Low diversity equals 1 when the standard deviation of education attainment is less than or equal to the 25th percentile and 0 otherwise. Standard errors in parentheses. *Significant at the 0.1 level.

which holds if a is small enough relative to b and b is above a certain critical value, or if ρ is small and $\text{Var}(v_i)$ is high enough; otherwise, $p^d \leq p^m$. In other words, competition increases price if consumer preferences are sufficiently negatively correlated and diverse.[4] In these situations, the residual demand for each firm under duopoly is steeper than the demand curve under monopoly, and this price sensitivity effect dominates the market share effect under competition, resulting in an equilibrium duopoly price that is higher than the monopoly price.[5]

B. *Preliminary Empirical Evidence*

The theory suggests two predictions for our empirical analysis. First, under duopoly competition, higher diversity in consumer preferences for cable modem versus DSL products will lead to higher cable modem Internet prices. Second, competition in differentiated-product markets does not necessarily lower prices. The direction of the effect of competition on prices can depend crucially on the diversity of consumer preferences. Specifically, it is possible that competition increases price when preference diversity is sufficiently high.[6]

To examine these predictions, we first present some simple comparisons of cable modem Internet prices in duopoly versus monopoly markets and in low- versus high-preference diversity markets. The sample comprises monthly subscription prices, as of July 2008, for 536 cable Internet plans supplied by 56 cable operators from 238 markets and 14 states. Duopoly markets are served by a cable modem Internet and a DSL provider. High-preference diversity markets are those where the standard deviation of the education attainment of the given population is greater than the sample's 75th percentile. Low-preference diversity markets are those where the standard deviation of education attainment is less than the 25th percentile.[7] A detailed description of the sample data is provided in section IV.

Table 1 presents group mean comparison tests of cable modem Internet prices. Column 1 of panel A shows that cable prices are not lower in duopoly markets. Columns 2 and 3 of panel A separate duopoly prices into low- and high-preference diversity markets and show that duopoly prices are about $3.29 higher in educationally diverse markets. Monopoly prices, however, are also about $5.65 higher in more educationally diverse markets.

A possible explanation for this result is that differences in preference diversity are positively correlated with differences in the quality of cable modem Internet plans. One way to control for quality is to adjust prices for download speed. Panel B compares quality-adjusted prices, where

[4] In their more general model, C-R show that consumer preferences need not be negatively correlated in order for price to be higher under duopoly than under monopoly, but preference diversity is always necessary for competition to increase price.

[5] As C-R explains, the market share effect is that a reduced quantity per firm under competition motivates the firms to cut price below the monopoly level. The price sensitivity effect is that a steeper demand curve resulting from greater consumer choice under competition encourages the firms to raise price. Whether competition raises or lowers price depends on the balance of these two effects.

[6] Even when preference dispersion is high, price-increasing competition is a possibility, not a necessity, since the result also depends on whether b is high enough relative to a.

[7] We expect that a higher standard deviation of education attainment will increase b, a measure of preference diversity toward cable Internet versus DSL, and will therefore increase p^d according to the first theoretical prediction. We also expect that a higher standard deviation will increase the overall range of consumer valuations for Internet access. Hence, a finding that $p^d - p^m$ becomes higher, or positive, with a higher standard deviation of education attainment would support the second theoretical prediction.

adjusted prices are the residuals from a regression of prices on a constant and each plan's download speed. Column 1 of panel B continues to show that quality-adjusted prices are not lower in duopoly markets. Columns 2 and 3 of panel B show that duopoly prices are about $2.29 higher in more diverse markets, while the price difference in monopoly markets is not statistically different from 0. These preliminary results suggest that duopoly prices for cable modem Internet access may be positively related to diversity in consumer preferences. The results also suggest that the empirical analysis of prices should be conducted with a regression approach that controls for quality, cost, and demand factors.

III. Empirical Model

We are interested in the relationship between the diversity in consumer preferences and the price of cable modem Internet access, and whether this relationship varies between monopoly and duopoly markets.[8] A direct test of these effects would be to estimate demand in both the monopoly and duopoly settings and see how the demand curves shift with changes in preference diversity. However, because Internet subscription data are not readily available, it is not possible to estimate the residual demand for cable Internet. An alternative approach, similar to Goolsbee and Petrin (2004), is to estimate the "true" reduced-form pricing functions for each market structure directly and use them as complementary regressions.[9] That is, estimate reduced-form pricing equations for cable modem Internet access for monopoly and duopoly markets, respectively, with all demand and cost factors, and the determinants of DSL deployment. We can then see whether, conditional on these factors, there is a systematic relationship between the duopoly price and preference diversity and whether, when preference diversity is high enough, prices become higher in duopoly markets than they are in the "equivalent" monopoly markets.

The reduced-form pricing function for cable modem plan $i = 1, 2, \ldots, n$ in market $j = 1, 2, \ldots, J$ is:

$$PRICE_{ij}^{k} = \alpha^{k} + \beta^{k} SPEED_{ij}^{k} + \delta^{k} DIV_{j}^{k} + X_{j}^{k}\gamma^{k} + \varepsilon_{ij}^{k}, \quad (5)$$

where k = monopoly (M) or duopoly (D), *PRICE* is the monthly subscription price for cable modem Internet access with self-installation and own modem, *SPEED* is downstream cable modem Internet speed in mbps, *DIV* is diversity in consumer preferences toward cable modem Internet versus DSL, X is a vector of market-specific demand and cost factors and determinants of DSL deployment, and ε is an error.

The parameters of interest are

$$\partial PRICE^{k}/\partial DIV^{k} = \delta^{k}.$$

Rejection of the null hypothesis that δ^k equals 0 provides evidence that prices are related to diversity in consumer preferences. When $\delta^D > 0$ and $\delta^D > \delta^M$, an increase in preference diversity has a more positive impact on the duopoly price than the monopoly price. However, ordinary least squares (OLS) estimates of equation (5) may be biased when unobserved quality is correlated with both preference diversity and prices. For example, when bigger differences in unobserved quality occur in more diverse markets and more unobserved quality leads to higher prices because it shifts demand or increases costs, the estimate of δ^k will have positive bias. One way to minimize the effects of unobserved quality is to decompose the error term into

$$\varepsilon_{ij}^{k} = Q_{j}^{k}\theta^{k} + e_{ij}^{k},$$

where Q is a vector of quality controls and e is an error. The assumption is that within-market cable modem Internet quality, other than *SPEED*, is plan invariant and can be controlled for with various observable market-level proxies for quality in Q.

IV. Data

A. Product Market

The product market under investigation is residential high-speed Internet access. The product permits household consumers to use a high-speed connection to the Internet to obtain, for example, high-bandwidth information, music and video libraries, interactive gaming services, and video-on-demand. High speed differs from dial-up Internet access with respect to always-on functionality and speed. Always-on is a constant connection to the Internet whenever the computer is on; a telephone call is not required to establish connection. Speed, measured in megabytes per second (mbps), is the time it takes to send and receive information to and from the home computer. The Federal Communications Commission (FCC) (2001) defines high-speed access as supporting, in both the Internet-to-household (downstream) and the household-to-Internet (upstream) directions, speeds that are at least four times faster than dial-up access through a telephone line.

The differentiated products of interest are cable modem and DSL.[10] Cable modem access is provided by the local

[8] Because there are fewer markets where DSL is the monopoly product, we do not estimate the effects of competition on DSL prices. To the extent that Internet accesses through cable modem and DSL are horizontally differentiated products, we expect that DSL price would also increase with preference diversity in the duopoly market and could be higher with competition when preference diversity is sufficiently high.

[9] Goolsbee and Petrin (2004) estimate the true reduced-form pricing function for cable television (TV) service to examine competition between cable and satellite TV providers. In their specification, they exclude the measure of market structure, that is, satellite market share, from the right-hand side of the price equation and include a range of demand and cost factors. These include estimates of unobserved quality obtained from BLP estimation of the cable and satellite TV demand system.

[10] High-speed access is also available through fiber-to-the-home, satellite, fixed and mobile wireless, and power line products.

cable TV operator using hybrid coaxial-fiber architecture. Cable operators provide downstream Internet access over their own network and upstream access by a telephone line (one-way capability) or both upstream and downstream over the entire cable network (two-way capability). One-way access, however, is not really high speed; the service is not always on, so subscribers must place a dial-up telephone call to upload data to the network, and the upstream speed is the same as dial-up Internet. While cable modem subscribers share the network with other active users in their local area network, they have a much higher bandwidth threshold relative to DSL because the cable system typically contains more fiber. Interestingly, many cable operators upgraded their systems with fiber and two-way capability in the mid- to late 1990s for the provision of digital, pay-per-view, and video-on-demand TV services.

DSL is provided by the local telephone company using copper telephone wires and a DSL access multiplexer. DSL subscribers have a dedicated connection with the telephone company's central office, but the maximum bandwidth threshold is lower than cable modem and the quality of the connection degrades with distance from the central office.[11] The provision of DSL can also involve up to three separate entities: the telephone company, the DSL provider, and the Internet service provider. By contrast, the cable modem product is typically a "one-stop-shop" service.

Until recently, cable and incumbent DSL providers also differed in the way they were regulated. Cable operators began providing high-speed Internet in 1995 without any regulatory obligation to share their network infrastructure to rival service providers (Rosston, 2009). In contrast, incumbent local-exchange telephone carriers (ILECs) faced regulations intended to encourage entry by DSL service providers and increase subscribership.[12] They were required to separate out and offer the high-frequency component of their local loops (the connection between the household and the central office) to service providers on a common carrier basis. Common carriage meant that the ILEC could not price-discriminate for the same transmission service. Because they were forced to share their networks with rivals and could not set prices freely, ILEC investment in high-speed infrastructure was relatively lower than cable operators between 1999 and 2004.[13] Asymmetric regulation of ILECs ended in August 2005.

[11] A freeway provides a useful analogy for comparing consumer preferences for DSL versus cable modem Internet access. In terms of service reliability, DSL provides a dedicated lane with a low speed limit, while cable modem users share the freeway with other users but have a much higher speed limit. Because DSL is a dedicated lane, some consumers may also believe that it is more secure than cable.

[12] An exchange, or wire center, is the geographical area served by a telephone company's switch. The central office houses the switch, DSL, and other equipment used to relay voice and data between customers both within and between wire centers.

[13] Using quarterly data from 1999 to 2004, Hazlett and Caliskan (2008) infer that asymmetric regulation deterred DSL investment and household penetration.

B. Sample

We follow the industry standard and define a cable system as a community or group of communities that receive the same services at the same prices from the same cable operator. Each system is designated as an integrated cable area (ICA) and assigned a unique ICA identifier that can be matched to census block groups that generally contain between 600 and 3,000 people.

Data on each cable operator's ICA service area, ownership structure, and provision of high-speed Internet access are sourced from Warren Publishing (2004, 2008). Census block groups are then assigned to each system using Direct Group's (2008) MEDIAPRINTS Block Group Translation Table. This gross sample initially encompassed 1,700 systems from Arizona, Colorado, Idaho, Iowa, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. The decision to study these fourteen states is deliberate. The ILEC in these states— and, hence, the most likely facilities-based provider of DSL—provided confidential information on the timing of their DSL deployments by wire center, as well as their costs of provisioning and maintaining the underlying telephone network within each wire center. Table 2 presents cable system characteristics for our 14 states with the 56 states, districts, and territories of the United States in October 2006.

Given that the reporting dates for high-speed Internet access obtained from Warren Publishing (2004) are from mid- to year-end 2003, we define a smaller sample of cable systems that definitely had Internet access on December 31, 2003, and were also in the ILEC's service area. A system is deemed to provide cable modem Internet access when it reports an operational Internet service and the corresponding monthly price.[14] These 260 systems are merged with our confidential ILEC data on DSL deployment and costs by wire center, and with telephone network data from Claritas (2003). The Claritas database lists all census block groups by wire center, including full and partial geographical coverage, the number of households, and the number of households with a fixed telephone line. We use the twelve-digit census block group identifiers to match each cable system's service area with the corresponding ILEC's service area. This information is used to determine whether the cable system is a monopoly in July 2008 (cable households are served by cable modem Internet only) or a duopoly (cable households are served by cable Internet and DSL accesses).[15]

[14] We initially considered using price data in 2003 and 2008 for difference-in-differences analysis. However, Warren (2003) price data turned out to be somewhat unreliable with no information provided on speed and whether the service is bundled with a modem or cable TV.

[15] Some of our duopoly markets may be served by more than two companies. However, FCC (2008) data on June 30, 2007, show that cable modem with 51% national share and DSL with 38% national share are the important strategic players in high-speed Internet markets.

TABLE 2.—CABLE OPERATOR CHARACTERISTICS 2006

State	Systems	Basic TV Subscribers	Expanded Basic TV Subscribers	Coaxial Miles of Plant	Homes Passed by Network
Arizona	76	1,089,655	186,455	22,122	2,452,083
Colorado	129	852,304	234,576	25,605	641,031
Idaho	54	193,774	63,722	5,500	345,364
Iowa	286	601,291	371,615	15,660	876,911
Minnesota	255	955,590	649,748	25,289	1,668,087
Montana	105	163,018	113,823	4,123	267,768
Nebraska	193	453,030	294,017	7,517	639,972
New Mexico	65	322,179	229,783	8,596	522,072
North Dakota	86	161,770	38,937	3,621	279,211
Oregon	101	749,464	449,726	19,816	1,019,991
South Dakota	100	158,046	35,858	5,489	274,964
Utah	64	285,632	174,728	8,919	357,823
Washington	132	1,297,968	729,874	28,969	2,020,330
Wyoming	52	115,123	77,802	3,532	137,990
Sample total	1,698	7,398,844	3,650,664	184,758	11,503,597
U.S. total	7,090	65,912,593	27,757,537	1,503,275	95,111,668

U.S. total is the sum of cable systems for the 56 states, districts and territories. Data as of October 2006.
Source: Warren Publishing (2006).

Cable operators often provide several Internet access plans with different characteristics within each market. These plans vary, for example, by downstream speed, modem rental versus ownership, whether Internet access is bundled with cable TV service, and self-installation versus company installation. Information on Internet access plans and prices for 238 of the 260 cable systems at July 2008 are obtained directly by telephone calls to cable operator officers or indirectly from cable operator Web sites and online broadband service locaters. When using cable operator Web sites and online broadband service locators, we first obtained a sample of addresses within the cable system from city hall, fire department, the library, schools, and so forth. These addresses were then entered into the search engines to obtain information on the prices and characteristics of cable modem Internet plans provided in these markets.

C. *Variables and Summary Statistics*

The unit of observation is cable modem Internet plan $i = 1, 2, \ldots, n$ provided by the incumbent cable operator in market $j = 1, 2, \ldots, J$. The outcome variable of interest is the monthly subscription price for cable modem access for plan i with existing cable TV service, self-installation, and own modem (*PRICE*). Each plan i varies by download speed in mbps (*SPEED*). The net sample comprises 536 cable Internet plans in 238 markets and 14 states. These plans are provided by 56 different cable operators, of which 48 are companies and the remainder are cooperatives or municipality owned.

The key explanatory variables of interest are market structure and diversity in consumer preferences. We define the cable system as a *DUOPOLY* when the ILEC has deployed DSL to any wire centers that have a geographical boundary that overlaps the cable operator's service area. One hundred twenty-eight plans are provided in 57 monopoly markets, and 408 plans are provided in 171 duopoly markets.

Measuring preference diversity or how preferences for different products are correlated is difficult. To construct these measures, we require an appropriately sized sample of consumers' valuations for cable Internet and DSL for each market or structural estimates from a differentiated-products model that permits unobserved preference heterogeneity to vary by product. Unfortunately, cable operators do not readily share consumer choice data. As in Alesina, Baqir, and Hoxby (2004), we use a proxy for preference diversity that is more easily observed and intuitively appealing. One indicator is education attainment, or years of schooling, obtained from the distribution of the population over 25 years of age with less than 9th grade, 9th to 12th grade (no diploma), high school graduate, some college, associate degree, bachelor's degree, and graduate or professional degree. Because consumers with different education backgrounds are likely to evaluate the relative merits of competing products differently, they should have different preferences for cable modem versus DSL accesses to the Internet.[16]

We use the within-market standard deviation of the population's number of years of schooling (*DIV_EDUC*) as an indicator of consumer preference diversity.[17] The higher *DIV_EDUC* is in the market, the more likely it is that consumers have diverse preferences for cable Internet versus

[16] In this horizontal setting, consumers have preference differences for cable modem versus DSL products, and we assume that the intensity of this preference diversity varies with the standard deviation of education attainment. For example, one could speculate that highly educated consumers have a strong preference for the service reliability or security of one product over another. Less educated consumers may simply have a strong historical preference for their cable TV operator over their telephone company, or vice versa.

[17] For robustness, we also estimate the price equation with an alternative proxy for consumer preference diversity that measures the distribution of ethnicities among individuals within a given market population.

DSL products. *DIV_EDUC* is constructed for each cable system with census block group data on educational attainment from the 2000 Census obtained from Caliper Corporation's (2007) "U.S. Census Block Groups Data CD."

The Caliper Corporation (2007) database also includes demographic, social, economic, and housing profile data that can be used to construct a range of cable system or, market-level, demand and cost controls. The vector X includes houses per square mile (*DENSITY*); mean household income for the cable system in $1,000 (*INCOME*); average number of years of schooling for the population over 25 years of age (*EDUC*); a qualitative variable that equals 1 when the cable operator is a multiple-system operator and 0 otherwise (*MSO*);[18] and a qualitative variable that equals 1 when the cable system is owned by a cooperative or municipality (*CO-OP*). We also include thirteen state indicator variables that equal 1 when the cable system is state $s = 1, 2, \ldots, 13$ and 0 otherwise ($STATE_s$) in X to proxy for different state laws and regulations that may also affect demand and costs.[19]

We use Claritas (2003) data and the confidential telephone network data obtained from the ILEC to measure three determinants of DSL deployment for inclusion in X: the number of telephone lines in the wire centers of the ILEC with a geographical boundary that overlaps the cable system (*TEL*); the number of telephone lines per square mile in wire centers of the ILEC that overlap the cable system (*TELEDENSITY*); and the expense-related costs per telephone line in the wire centers of the ILEC that overlap the cable operator's market (*TEL_COSTS*). Larger markets have higher demand for Internet, so *TEL* is expected to be positively related to the ILEC's decision to deploy DSL. Marginal operating costs are lower in markets with higher telephone density so *TELEDENSITY* should be positively related to DSL deployment. Expense-related costs are the costs of provisioning and maintaining the underlying telecommunications network.[20] Wire centers with higher expense-related costs per telephone line should have a higher-quality network that is more easily compatible with the new DSL equipment being deployed. As such, *TEL_COST* is also expected to be positively related to the ILEC's decision to deploy DSL. Table 3 presents estimates of a probit regression of *DUOPOLY* (equals 1 if the cable system is served by both cable Internet and DSL and 0 otherwise) on *TEL*, *TELEDENSITY*, and *TEL_COST* for our sample of 238 cable systems. The results show that the ILEC is more likely to deploy DSL in large markets and in markets with higher telephone density and expense-related costs.

Table 3.—Probit Estimates of DSL Deployment

Independent Variables	Coefficient	Robust s.e.
TEL	0.0001*	0.0006
TELEDENSITY	0.0050*	0.0027
TEL_COST	0.3108***	0.0642
CONSTANT	−2.6207***	0.4987
Log likelihood	−15.747	
Wald $\chi^2(3)$	27.110***	
Pseudo-R^2	0.8902	
Observations	238	

Dependent variable is *DUOPOLY* (equals 1 when the cable system is served by cable Internet and DSL). ***Significant at the 0.01 level. *Significant at the 0.1 level.

The vector Q contains two controls for market-level differences in cable quality obtained from Warren Publishing (2000, 2007, 2008): the number of fiber-optic miles of plant in the system (*FIBER*) and a qualitative variable that equals 1 when the cable system is two-way capable at mid-year 1998 and 0 otherwise (*TWO-WAY*). An additional control for quality differences, the number of houses in the cable system (*SIZE*), is obtained from Caliper Corporation (2007).

Theory and previous studies guide a priori expectations for some of the independent variables in the price equation. Cable modem Internet prices are expected to increase with *SPEED*. Because much of a cable operator's outside plant is shared among houses in a given geographic location, an inverse relationship exists between marginal costs and housing density. As such, a negative sign is expected for *DENSITY*. Chipty (1995) argued that MSOs with a higher concentration of national cable TV systems and subscribers obtain lower-cost deals from program suppliers. Relatively large MSOs, considering the provision of cable Internet access, may obtain similar deals from equipment suppliers, service contractors, and advertising agencies, for example. The finding of a negative relationship between *MSO* and *PRICE* and between *CO-OP* and *PRICE* would support Chipty's argument. However, it also possible that *MSO* measures reputation advantages, which would imply higher prices.

Cable systems with more fiber, relative to coaxial cable, in the network have a higher-bandwidth threshold and a potentially higher-quality Internet service. A positive relationship is expected between *FIBER* and *PRICE*. All other things being equal, cable operators would be expected to begin deployments of two-way capability in high-valuation, high-quality markets. Therefore, an indicator of the early deployment of two-way capability can also control for cable modem Internet quality. Since demand should be higher in these markets, a positive relationship is expected between *TWO-WAY* and *PRICE*.[21] Because it measures the number

[18] An MSO is a company that has acquired more than one cable system and brought them under the umbrella of a single corporate entity.

[19] For example, some states have passed or are considering statewide franchise laws where cable operators no longer negotiate franchise agreements with local municipalities, but apply with the state public utilities commission for statewide authority.

[20] Expense-related costs are for the year ended June 2008 and exclude the costs related to DSL deployment.

[21] Digital video compression, which permits the transfer of more channels, is a precursor to two-way capability. More channels mean more capacity and a higher bandwidth threshold for the cable system.

TABLE 4.—PRICE EQUATION VARIABLES

Variable	Description and data source
PRICE	Monthly subscription price for cable modem access at July 2008 with self-installation and own modem. Source: Cable system Web sites, various online broadband service locators, personal phone calls to cable system operators.
DIV_EDUC	Within-market standard deviation of the number of years of schooling for the population over 25 years of age (2000 Census). Source: Caliper Corporation (2007).
SPEED	Downstream cable modem speed in mbps. Cable system Web sites, various online broadband service locators, personal phone calls to cable system operators.
DENSITY	1,000 houses per square mile (2000 Census). Source: Caliper Corporation (2007).
INCOME	Mean household income in $1,000 (2000 Census). Source: Caliper Corporation (2007).
EDUC	Mean number of years of schooling for the population over 25 years of age (2000 Census). Source: Caliper Corporation (2007).
MSO	1 when the cable operator is a multiple-system operator, 0 otherwise. Source: Warren Publishing (2008).
CO-OP	1 when the cable network is owned by a cooperative or municipality. Source: Warren Publishing (2008).
TEL	Number of telephone lines in the wire centers of the ILEC with a geographical boundary that overlaps the cable system. Sources: Caliper Corporation (2007), Claritas (2003), MediaPrints (2008), personal correspondence with ILEC (2008).
TELEDENSITY	Number of telephone lines per square mile in wire center(s) of the ILEC that overlap the cable system. Sources: Caliper Corporation (2007), Claritas (2003), MediaPrints (2008), personal correspondence with ILEC (2008).
TEL_COST	Provisioning and maintenance costs per telephone line in wire center(s) of the ILEC that overlap the cable operator's market. Sources: Caliper Corporation (2007), Claritas (2003), MediaPrints (2008), personal correspondence with ILEC (2008).
SIZE	1,000 houses (2000 Census). Source: Caliper Corporation (2007).
FIBER	Number of fiber miles of plant in the system. Source: Warren Publishing, (2007, 2008).
TWO-WAY	1 when the cable system is two-way capable at mid-year 1998, 0 otherwise. Source: Warren Publishing (2000).
$STATE_s$	1 when cable system is in state *s*, 0 otherwise.
DIV_ETHNIC	Within-market entropy measure calculated for seven ethnic groups: white; black or African American; American Indian and Alaska Native; Asian; Native Hawaiian and other Pacific Islander; some other race; and two or more races (2000 Census). Source: Caliper Corporation (2007).
DSL_2005	1 when DSL deployment occurred in 2005 or after and 0 otherwise. Sources: Caliper Corporation (2007), Claritas (2003), MediaPrints (2008), personal correspondence with ILEC (2008).
DIV_INCOME	Within-market standard deviation of household income (2000 Census). Source: Caliper Corporation (2007).
DIV_AGE	Within-market standard deviation of the age for the population (2000 Census). Source: Caliper Corporation (2007).
AGE	Mean age for the population (2000 Census). Source: Caliper Corporation (2007).
DIV_OCC	Within-market entropy measure calculated for six occupations: management, professional, and related; service; sales and office; farming, fishing, and forestry maintenance; construction, extraction and maintenance; and production, transportation, and material moving (2000 Census). Source: Caliper Corporation (2007).
LOAD-COIL	Percentage of deloaded telephone lines in the wire centers of the ILEC with a geographical boundary that overlaps the cable system. Sources: Caliper Corporation (2007), Claritas (2003), MediaPrints (2008), personal correspondence with ILEC (2008), http://www.qwest.com/disclosures/netdisclosure459/deload_archive.html#help.

of houses in the market, *SIZE* controls for urban versus rural differences in unobserved quality. When demand is higher in markets of greater size, a positive relationship between *SIZE* and *PRICE* is expected. However, this effect could be dampened, or even reversed, when size conveys cost advantages. The signs for the other independent variables remain an empirical question.

Table 4 describes the variables used in the empirical analysis, and table 5 presents summary statistics. The average cable modem Internet plan in the duopoly markets has 7.33 mbps of downstream speed and a monthly subscription price of $46.65. The average cable Internet plan in the monopoly markets has 6.25 mbps of downstream speed and a monthly subscription price of $44.67. Duopoly and monopoly markets have reasonably similar education attainment. However, the duopoly and monopoly markets differ considerably in terms of several cable system characteristics. The duopoly markets have more households (*SIZE*) and houses per square mile (*DENSITY*) but less municipal ownership (*CO-OP*). The duopoly and monopoly markets also differ with respect to the underlying characteristics of the telephone networks that serve these markets. The local telephone networks in duopoly markets are larger in the number of households served with a fixed telephone line (*TEL*) and the number of telephones per square mile (*TELEDENSITY*). They also have higher network costs per telephone line (*TEL_COST*).

V. Estimation Results

The empirical model and data described in sections III and IV are used to investigate the relationship between diversity in consumer preferences and cable modem Internet subscription prices. We estimate several model specifications of the price equation (5), with and without controls for cable modem Internet quality, an additional control for DSL quality and with an alternative measure of preference diversity. We assume that the pricing decisions of cable operators are made at the market level and that the prices of plans within the same market are correlated. As such, the estimate of the variance-covariance matrix, used to calculate the standard errors for the estimated coefficients of the price equation, is robust to heteroskedasticity and within-market correlation between errors.

A. Baseline Price Estimates

Estimates of the double-log price equation are presented in table 6. The first and second columns show the baseline model specification (1) for duopoly and monopoly markets.

TABLE 5.—PRICE EQUATION SUMMARY STATISTICS

	Duopoly			Monopoly		
Variable	Number of Observations	Mean	s.d.	Number of Observations	Mean	s.d.
PRICE	408	46.65	12.25	128	44.67	13.38
SPEED	408	7.33	5.47	128	6.25	6.07
EDUC	181	12.88	0.67	57	12.42	0.51
DIV_EDUC	181	2.92	0.34	57	2.85	0.38
DIV_ETHNIC	181	0.18	0.11	57	0.10	0.07
DENSITY	181	130.78	259.58	57	38.30	50.79
INCOME	181	47.73	8.57	57	44.24	8.38
MSO	181	0.90	0.31	57	0.75	0.43
CO-OP	181	0.02	0.13	57	0.09	0.29
TEL	181	12,418.55	12,252.54	57	2,160.68	2,982.94
TELEDENSITY	181	206.90	423.84	57	31.30	50.07
TEL_COST	181	50.07	27.48	57	1.44	2.20
SIZE	181	55,384.70	140,052.20	57	4,234.88	6,243.27
FIBER	177	58.12	261.65	56	25.11	136.17
TWO-WAY	181	0.43	0.50	57	0.26	0.44
DSL_2005	181	0.14	0.35	n.a.	n.a.	n.a.
DIV_INCOME	181	3.59	0.13	57	3.49	0.12
DIV_AGE	181	22.6	1.51	57	23.7	1.35
AGE	181	36.7	3.23	57	39.1	3.24
DIV_OCC	181	0.68	0.03	57	0.70	0.02
LOAD_COIL	181	0.40	0.26	57	0.29	0.15

Plan observations for *PRICE* and *SPEED*. Market observations for all other variables.

We regress cable modem Internet prices on downstream speed (*SPEED*), diversity in consumer preferences (*DIV_EDUC*), and the vector of market-specific demand and cost factors and determinants of DSL deployment (X). A Chow test ($F(24, 237) = 8.17$; Prob $> F = 0.00$) rejected the equality of coefficients between monopoly and duopoly markets and supported the specification of separate price equations for each market. The estimated coefficients on *SPEED* are significant at the 1% level and similar in magnitude across duopoly and monopoly markets. They show that a 10% increase in downstream speed is associated with about a 2% increase in cable Internet prices. The estimated coefficient on *DIV_EDUC* for duopoly markets is positive (0.308), significant at the 5% level, and indicates that a 10% increase in the within-market standard deviation of education attainment increases duopoly prices by about 3%. In contrast, the estimated coefficient on *DIV_EDUC* for monopoly markets is negative (−0.036) and is not significantly different from 0.

To address concerns with omitted variable bias, we include the vector Q in model specification 2 to control for market-level differences in cable quality. The third and fourth columns of table 6 show model 2 for duopoly and monopoly markets. Here, we regress prices on *SPEED*, *DIV_EDUC*, X, and Q = [*SIZE*, *FIBER*, *TWO_WAY*].[22] F-tests indicate that the specification of quality controls is appropriate for the duopoly price equation ($F(3, 176) = 4.10$; Prob $> F = 0.00$) and the monopoly price equation ($F(3, 55) = 2.67$; Prob $> F = 0.06$). The results are qualitatively similar to those reported for model 1. The estimated coefficient on *DIV_EDUC* for duopoly markets is 0.406 and significant at the 1% level. The estimated coefficient on *DIV_EDUC* for monopoly markets is −0.032 and not statistically different from 0.

The next specification considers the ILEC's timing of DSL deployment. Because the ILEC was regulated prior to August 2005, there may be unobserved differences in the quality of DSL investments, made before and after 2005, that are related to our measure of preference diversity and to cable modem prices. We control for these potential differences with model specification 3, which regresses prices on *SPEED*, *DIV_EDUC*, X, Q, and *DSL_2005* (equals 1 when DSL deployment occurred in 2005 or after). Column five of table 6 reports the estimates of model 3. The additional control for DSL quality is not statistically significant, and the overall results are similar to those reported for model 2. Cable modem Internet prices in duopoly markets continue to increase with diversity in consumer preferences. The estimated coefficient on *DIV_EDUC* is 0.415 and is significant at the 1% level.

Figure 2 uses estimates from model specification 2 in table 6 and sample means of the independent variables to plot predicted prices against the sample range of the standard deviation of education attainment from 2.02 to 4.22. We observe that the price in the duopoly market increases systematically with consumer preference diversity and that it is possible for the price to be higher under duopoly than under monopoly. In markets where the standard deviation

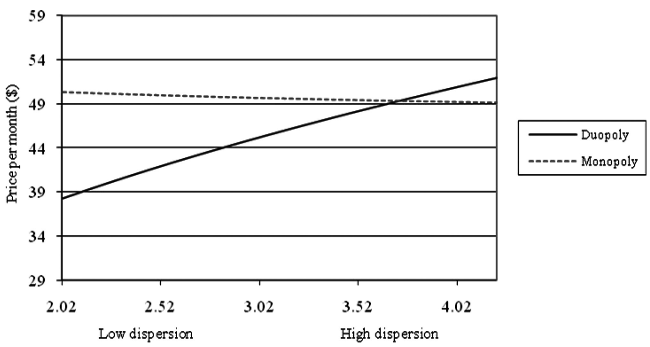
[22] Because of missing data for *FIBER*, the duopoly sample is reduced from 408 to 401 observations, and the monopoly sample is reduced from 128 to 127 observations. Several cable systems also have no fiber in the system so *FIBER* equals 0. Because we use log *FIBER* in our price specification, we replace these 0 values with the second lowest value of *FIBER* in the sample divided by 2.

TABLE 6.—OLS ESTIMATES OF PRICES AND PREFERENCE DIVERSITY: STANDARD DEVIATION OF EDUCATION ATTAINMENT

	Model 1		Model 2		Model 3
Independent Variable	Duopoly	Monopoly	Duopoly	Monopoly	Duopoly
SPEED	0.211***	0.204***	0.211***	0.208***	0.211***
	(0.009)	(0.014)	(0.008)	(0.016)	(0.008)
DIV_EDUC	0.308**	−0.036	0.406***	−0.032	0.415***
	(0.120)	(0.243)	(0.127)	(0.259)	(0.125)
DENSITY	−0.020*	−0.013	−0.020**	−0.005	−0.021**
	(0.011)	(0.021)	(0.010)	(0.028)	(0.010)
INCOME	−0.070	−0.033	−0.019	−0.146	−0.009
	(0.084)	(0.211)	(0.083)	(0.208)	(0.084)
EDUC	0.217	−0.377	0.261	−0.255	0.248
	(0.319)	(1.010)	(0.316)	(1.025)	(0.316)
MSO	−0.052	0.214	−0.027	0.167	−0.028
	(0.054)	(0.099)	(0.051)	(0.101)	(0.051)
CO-OP	0.120	0.420**	0.091	0.421***	0.096
	(0.081)	(0.103)	(0.080)	(0.093)	(0.083)
TEL	0.011	−0.083**	0.036**	−0.093**	0.044**
	(0.015)	(0.038)	(0.017)	(0.045)	(0.018)
TELEDENSITY	−0.007	0.043	0.013	0.036	0.012
	(0.011)	(0.027)	(0.014)	(0.027)	(0.014)
TEL_COST	0.008	0.046**	0.006	0.053**	0.006
	(0.013)	(0.023)	(0.013)	(0.023)	(0.013)
SIZE			−0.048***	0.028	−0.048***
			(0.017)	(0.053)	(0.017)
FIBER			0.002	0.030*	0.002
			(0.005)	(0.015)	(0.005)
TWO_WAY			0.039**	−0.038	0.041**
			(0.019)	(0.049)	(0.020)
DSL_2005					0.035
					(0.029)
CONSTANT	2.864***	5.006**	2.598***	4.894**	2.514***
	(0.676)	(2.161)	(0.656)	(2.262)	(0.653)
F-test			4.10***	2.67*	1.42
Adjusted R^2	0.756	0.725	0.771	0.736	0.772
Number of markets	181	57	177	56	177
Total observations	408	128	401	127	401

The dependent variable is cable modem Internet subscription price (*PRICE*). Standard errors, robust to heteroskedasticity and within-market correlation between errors, in parentheses. ***Significant at the 0.01 level. **Significant at the 0.05 level; *Significant at the 0.1 level. Coefficient estimates of state dummy variables not reported. *F*-test tests the restriction that *SIZE*, *FIBER* and *TWO_WAY* jointly equal 0 in model 2 and *DSL_2005* equals 0 in model 3.

FIGURE 2.—PREDICTED PRICES AND PREFERENCE DIVERSITY: STANDARD DEVIATION OF EDUCATION ATTAINMENT



Predicted prices are calculated using coefficient estimates from model 2 in table 6, the sample means of all the independent variables except the standard deviation of education attainment and the sample range for the standard deviation of education attainment from 2.02 to 4.22.

of education attainment is relatively low, competition reduces monthly cable Internet subscription prices. For example, when the standard deviation equals 2.92 (at the 50th percentile), duopoly prices are about $5.33 lower than monopoly prices. However, as standard deviation of education attainment increases the negative effect of competition on prices diminishes and when it equals 3.82, competition can increase prices.

For robustness, we estimated the price equation (5) with an alternative (horizontal) proxy for consumer preference diversity that measures the distribution of ethnicities among individuals within a given market population. For market *i*, Theil's entropy measure is

$$-\sum_{l=1}^{L} s_l \log s_l,$$

where s_l is the ratio of ethnic group l's population to the market's total population and l = white; black or African American; American Indian and Alaska Native; Asian; Native Hawaiian and other Pacific Islander; some other race; and two or more races. When one ethnic group comprises the entire population, entropy (*DIV_ETHNIC*) equals 0. In this market, it is more likely that consumer preferences

TABLE 7.—OLS ESTIMATES OF PRICES AND PREFERENCE DIVERSITY: ENTROPY MEASURE OF ETHNIC DIVERSITY

	Model 1		Model 2		Model 3
Independent variable	Duopoly	Monopoly	Duopoly	Monopoly	Duopoly
SPEED	0.212***	0.206***	0.212***	0.209***	0.212***
	(0.009)	(0.015)	(0.008)	(0.016)	(0.008)
DIV_ETHNIC	0.041*	−0.051	0.057**	−0.058	0.062**
	(0.022)	(0.040)	(0.026)	(0.042)	(0.027)
DENSITY	−0.020*	−0.013	−0.020**	−0.004	−0.022**
	(0.011)	(0.021)	(0.010)	(0.027)	(0.010)
INCOME	−0.063	−0.072	−0.016	−0.199	−0.005
	(0.081)	(0.204)	(0.078)	(0.198)	(0.078)
EDUC	−0.086	−0.298	−0.122	−0.220	−0.138
	(0.293)	(0.663)	(0.295)	(0.666)	(0.291)
MSO	−0.048	0.210**	−0.025	0.160	−0.025
	(0.053)	(0.104)	(0.052)	(0.108)	(0.052)
CO-OP	0.158**	0.420***	0.149**	0.422***	0.158**
	(0.076)	(0.109)	(0.075)	(0.098)	(0.078)
TEL	0.007	−0.084**	0.027	−0.100**	0.036**
	(0.017)	(0.033)	(0.017)	(0.039)	(0.018)
TELEDENSITY	−0.008	0.050*	0.010	0.040	0.009
	(0.011)	(0.026)	(0.014)	(0.027)	(0.014)
TEL_COST	0.007	0.043**	0.005	0.049**	0.005
	(0.013)	(0.021)	(0.013)	(0.022)	(0.014)
SIZE			−0.043**	0.039	−0.044**
			(0.019)	(0.052)	(0.019)
FIBER			0.002	0.028*	0.001
			(0.005)	(0.015)	(0.005)
TWO_WAY			0.038*	−0.026	0.040*
			(0.021)	(0.050)	(0.022)
DSL_2005					0.042
					(0.030)
CONSTANT	4.038***	4.818***	4.125***	4.831***	4.058***
	(0.569)	(1.212)	(0.574)	(1.344)	(0.574)
F-test			2.78**	2.55*	1.96
Adjusted R^2	0.752	0.729	0.766	0.740	0.766
Number of markets	181	57	177	56	177
Total observations	408	128	401	127	401

Dependent variable is cable modem Internet subscription price (*PRICE*). Standard errors, robust to heteroskedasticity and within-market correlation between errors, in parentheses. ***Significant at the 0.01 level. **Significant at the 0.05 level. *Significant at the 0.1 level. Coefficient estimates of state dummy variables not reported. *F*-test tests the restriction that *SIZE*, *FIBER*, and *TWO_WAY* jointly equal 0 in model 2 and *DSL_2005* equals 0 in model 3.

for cable Internet versus DSL are not that diverse. When all ethnic groups have an equal share of the population, *DIV_ETHNIC* equals its maximum positive value. Here, consumer preferences for cable Internet versus DSL are more likely to be more diverse.

Estimates of models 1 through 3 using *DIV_ETHNIC* as the measure of diversity in consumer preferences are presented in table 7. When the focus is on model specifications 2 and 3, the estimated coefficients on *DIV_ETHNIC* for duopoly markets are 0.057 and 0.062, respectively, and significant at the 5% level. These estimates indicate that a 10% increase in the within-market entropy measure of ethnic diversity is associated with about a 0.6 % increase in duopoly prices. In contrast, the estimated coefficients on *DIV_ETHNIC* for monopoly markets are about -0.058 and not significantly different from 0.

Because the sample of duopoly and monopoly markets is not large and is drawn from a population of fourteen states, it is informative to examine the robustness of model estimates to outliers. We use bounded influence estimation to account for influential observations. First, the $DFITS_{ij}$ statistic of Welsch (1980) is calculated:

$$r_{ij}\sqrt{\frac{h_{ij}}{1-h_{ij}}},$$

where r_{ij} is the studentized residual, $h_{ij} = z_{ij}(Z'Z)^{-1}z_{ij}'$ is the leverage value,[23] and z_{ij} is the *ij*th row of the matrix $Z = [SPEED, DIV, X, Q, DSL\_2005]$. Highly influential observations are then identified by comparing $|DFITS_{ij}|$ to the cutoff values suggest by Besley, Kuh, and Welsch (1980), $2\sqrt{\kappa/Obs.}$, where κ is the number of independent variables and *Obs.* is total observations. Next, the effect of influential observations on the magnitude of OLS estimates is minimized by estimating the price equation by weighted least squares (WLS). The weights w_{ij} are:

$$w_{ij} = \begin{cases} 1 & if\ |DFITS_{ij}| \leq 2\sqrt{\kappa/Obs.} \\ \frac{2\sqrt{\kappa/Obs.}}{|DFITS_{ij}|} & if\ |DFITS_{ij}| > 2\sqrt{\kappa/Obs.} \end{cases}.$$

[23] A data point has high leverage when its inclusion in the sample has a large effect on the coefficient estimates.

TABLE 8.—WLS ESTIMATES OF PRICES AND PREFERENCE DIVERSITY

Independent Variable	Model 2 Duopoly	Model 3 Duopoly	Model 2 Monopoly	Model 2 Duopoly	Model 3 Duopoly	Model 2 Monopoly
SPEED	0.210***	0.210***	0.205***	0.212***	0.212***	0.208***
	(0.006)	(0.006)	(0.015)	(0.006)	(0.006)	(0.015)
DIV_EDUC	0.404***	0.409***	0.063			
	(0.110)	(0.110)	(0.226)			
DIV_ETHNIC				0.045**	0.049**	−0.070*
				(0.022)	(0.022)	(0.040)
DENSITY	−0.023***	−0.024***	−0.013	−0.022***	−0.024***	−0.009
	(0.008)	(0.008)	(0.026)	(0.008)	(0.008)	(0.025)
INCOME	−0.002	−0.009	−0.183	−0.000	0.011	−0.238
	(0.074)	(0.076)	(0.183)	(0.070)	(0.071)	(0.178)
EDUC	0.206	0.189	0.146	−0.185	−0.200	−0.076
	(0.259)	(0.260)	(0.940)	(0.238)	(0.237)	(0.632)
MSO	−0.020	−0.019	0.219**	−0.013	−0.012	0.212**
	(0.039)	(0.039)	(0.085)	(0.040)	(0.040)	(0.092)
CO-OP	0.107**	0.116**	0.405***	0.166***	0.178***	0.406***
	(0.052)	(0.054)	(0.082)	(0.050)	(0.053)	(0.080)
TEL	0.035**	0.044***	−0.090**	0.029*	0.038**	−0.096***
	(0.015)	(0.015)	(0.043)	(0.015)	(0.016)	(0.035)
TELEDENSITY	0.011	0.010	0.049*	0.006	0.006	0.054**
	(0.011)	(0.012)	(0.026)	(0.012)	(0.012)	(0.023)
TEL_COST	0.008	0.009	0.037*	0.006	0.007	0.033*
	(0.012)	(0.012)	(0.020)	(0.019)	(0.013)	(0.019)
SIZE	−0.041***	−0.042***	0.007	−0.035**	−0.036**	0.017
	(0.014)	(0.014)	(0.051)	(0.015)	(0.015)	(0.049)
FIBER	0.002	0.002	0.024*	0.003	0.002	0.022
	(0.005)	(0.005)	(0.014)	(0.005)	(0.005)	(0.014)
TWO_WAY	0.033*	0.036**	−0.035	0.032*	0.036*	−0.018
	(0.018)	(0.018)	(0.046)	(0.020)	(0.020)	(0.046)
DSL_2005		0.035			0.042	
		(0.026)			(0.027)	
CONSTANT	2.641***	2.558***	4.035***	4.132***	4.052***	4.668***
	(0.547)	(0.547)	(2.089)	(0.464)	(0.462)	(1.300)
Number of markets	177	177	56	177	177	56
Observations	401	401	127	401	401	127
Observations with $w_{ij} < 1$	29	28	9	25	25	7

Dependent variable is cable modem Internet subscription price (*PRICE*). Standard errors, robust to heteroskedasticity and within-market correlation between errors, in parentheses. ***Significant at the 0.01 level. **Significant at the 0.05 level. *Significant at the 0.1 level. Coefficient estimates of state dummy variables not reported. w_{ij} are the weights for WLS estimation.

WLS estimates of model specifications 2 and 3 are reported in table 8. Columns 1 through 3 of table 8 report estimates for duopoly and monopoly prices using the standard deviation of education attainment as the proxy for preference diversity. For model 2, there are 29 observations in the duopoly price equation and 9 in the monopoly equation that receive a weight that is less than unity. For model 3, there are 28 observations in the duopoly price equation that receive a weight that is less than unity. Columns 4 through 6 report estimates for duopoly and monopoly prices using the entropy measure of ethnic diversity as the proxy for preference diversity. Here, there are 25 observations in the duopoly price equation and 7 observations in the monopoly equation that receive a weight that is less than unity. Qualitatively, there is not much difference between the WLS estimates of the coefficients on preference diversity and the OLS estimates reported in tables 6 and 7. When the standard deviation of education attainment is the proxy for preference diversity, cable prices in duopoly markets are positively related to preference diversity, while monopoly prices have no statistically significant relationship. When the entropy measure of ethnic diversity is the proxy, duopoly prices are positively related to preference diversity, while monopoly prices and preference diversity are inversely related.

Finally, all previous model specifications of the price equation assumed that the pricing decisions of cable operators are made at the market level. However, because many cable operators are multiple-system operators, it is possible that pricing decisions are made at the firm (or MSO) level and that the prices of all plans within the same firm are correlated. To account for this type of interdependence between observations, we reestimated all price equations with a robust estimate of the variance-covariance matrix that accounted for within-firm correlation between errors. Model results, not presented here, are qualitatively similar to those reported in tables 6 through 8.

B. *Sensitivity Analysis*

We conclude the results section with some additional sensitivity analysis that considers several other measures of preference diversity, the interaction of preference diversity

TABLE 9.—OLS ESTIMATES OF PRICES AND PREFERENCE DIVERSITY: ALTERNATIVE MEASURES OF DIVERSITY

	Model 3	Model 2	Model 3	Model 2	Model 3	Model 2
Independent Variable	Duopoly	Monopoly	Duopoly	Monopoly	Duopoly	Monopoly
SPEED	0.210***	0.208***	0.211***	0.208***	0.211***	0.205***
	(0.008)	(0.015)	(0.008)	(0.016)	(0.008)	(0.017)
DIV_INCOME	0.389*	0.246				
	(0.228)	(0.477)				
DIV_AGE			0.677*	0.180		
			(0.351)	(0.988)		
DIV_OCC					−0.124	0.694
					(0.462)	(0.912)
DENSITY	−0.019*	−0.006	−0.020*	−0.006	−0.020*	−0.002
	(0.011)	(0.029)	(0.010)	(0.028)	(0.011)	(0.029)
INCOME	−0.204	−0.303	0.001	−0.079	−0.002	−0.150
	(0.140)	(0.355)	(0.101)	(0.230)	(0.087)	(0.197)
EDUC	−0.475	−0.120	0.156	−0.214	−0.374	0.038
	(0.323)	(0.700)	(0.321)	(0.869)	(0.353)	(0.755)
AGE			−0.652***	0.090		
			(0.237)	(0.577)		
MSO	−0.031	0.176*	−0.030	0.191*	−0.033	0.162
	(0.055)	(0.100)	(0.056)	(0.114)	(0.055)	(0.106)
CO-OP	0.122	0.421***	0.143*	0.431***	0.131	0.397***
	(0.087)	(0.097)	(0.082)	(0.104)	(0.083)	(0.100)
TEL	0.041**	−0.098**	0.029	−0.096**	0.040**	−0.094**
	(0.018)	(0.043)	(0.019)	(0.042)	(0.019)	(0.044)
TELEDENSITY	0.009	0.036	0.006	0.037	0.006	0.036
	(0.014)	(0.029)	(0.014)	(0.028)	(0.014)	(0.027)
TEL_COST	−0.001	0.052**	0.007	0.053**	0.004	0.056***
	(0.014)	(0.021)	(0.012)	(0.021)	(0.014)	(0.021)
SIZE	−0.041**	0.023	−0.033*	0.026	−0.030*	0.029
	(0.018)	(0.054)	(0.017)	(0.053)	(0.017)	(0.053)
FIBER	0.002	0.031*	0.001	0.030*	0.002	0.030*
	(0.005)	(0.016)	(0.005)	(0.015)	(0.005)	(0.015)
TWO_WAY	0.036*	−0.036	0.037*	−0.039	0.036*	−0.032
	(0.021)	(0.047)	(0.020)	(0.050)	(0.021)	(0.049)
DSL_2005	0.033		0.031		0.025	
	(0.031)		(0.030)		(0.031)	
CONSTANT	4.148***	4.325***	3.415***	3.625***	4.373***	4.402***
	(0.590)	(1.617)	(1.114)	(2.785)	(0.771)	(1.466)
Adjusted R^2	0.763	0.737	0.763	0.735	0.760	0.738
Number of markets	177	56	177	56	177	56
Observations	401	127	401	127	401	127

Dependent variable is cable modem Internet subscription price (*PRICE*). Standard errors, robust to heteroskedasticity and within-market correlation between errors, in parentheses. ***Significant at the 0.01 level. **Significant at the 0.05 level. *Significant at the 0.1 level. Coefficient estimates of state dummy variables not reported.

with cable modem quality, and potential sample selection bias.

Other measures of preference diversity. Intuitively, one may expect the demographics used to measure variation in preferences, that is, education and ethnicity, to be less tightly linked to demand than, say, other demographic variables. Table 9 presents estimates of models 2 and 3 using several alternative measures of preference diversity based on household income, age, and occupation. Columns 1 and 2 report OLS estimates of prices for duopoly and monopoly markets, respectively, using the standard deviation of household income (*DIV_INCOME*) as the proxy for preference diversity. The results are qualitatively similar to those reported in tables 6 through 8. The estimated coefficient on *DIV_INCOME* for duopoly markets is 0.389 and significant at the 10% level, while the coefficient on *DIV_INCOME* for monopoly markets is relatively smaller and not significantly different from 0. Columns 3 and 4 report OLS estimates of prices using the standard deviation of age (*DIV_AGE*) as the proxy for preference diversity.[24] These results are qualitatively similar to those when using education, ethnicity, or income as measures of preference diversity.

We also considered another horizontal proxy for consumer preference diversity calculated from Theil's entropy measure of the distribution of occupations among individuals within a given market population (*DIV_OCC*). The $l = 6$ occupations are management, professional, and related; service; sales and office; farming, fishing, and forestry maintenance; construction, extraction, and maintenance; and production, transportation, and material moving. The results, presented in columns 5 and 6 of table 9, show that *DIV_OCC* does not correlate very well with cable prices.

[24] The price equation with *DIV_AGE* also includes a control for the mean age of the population (*AGE*).

TABLE 10.—OLS ESTIMATES OF PRICES AND PREFERENCE DIVERSITY, QUALITY INTERACTIONS

Independent Variable	Model 3 Duopoly	Model 2 Monopoly	Model 3 Duopoly	Model 2 Monopoly
SPEED	0.211***	0.211***	0.212***	0.211***
	(0.008)	(0.016)	(0.008)	(0.016)
DIV_EDUC	0.261	0.025		
	(0.163)	(0.255)		
DIV_EDUC×FIBER	−0.067	−0.248*		
	(0.048)	(0.127)		
DIV_EDUC×TWO_WAY	0.403**	0.912**		
	(0.189)	(0.348)		
DIV_ETHNIC			0.047	−0.066
			(0.029)	(0.044)
DIV_ETHNIC×FIBER			0.005	0.001
			(0.008)	(0.021)
DIV_ETHNIC×TWO_WAY			0.042	0.035
			(0.032)	(0.070)
DENSITY	−0.018*	−0.019	−0.021**	−0.002
	(0.011)	(0.026)	(0.010)	(0.029)
INCOME	−0.036	−0.198	−0.025	−0.217
	(0.084)	(0.199)	(0.079)	(0.202)
EDUC	0.347	0.243	−0.083	−0.199
	(0.307)	(1.019)	(0.283)	(0.713)
MSO	−0.028	0.212**	−0.033	0.155
	(0.052)	(0.092)	(0.054)	(0.107)
CO-OP	0.099	0.416***	0.146*	0.438***
	(0.085)	(0.084)	(0.078)	(0.099)
TEL	0.045**	−0.101**	0.037**	−0.100**
	(0.018)	(0.039)	(0.018)	(0.040)
TELEDENSITY	0.012	0.051*	0.006	0.036
	(0.014)	(0.027)	(0.014)	(0.029)
TEL_COST	0.008	0.039*	0.004	0.051**
	(0.013)	(0.021)	(0.014)	(0.022)
SIZE	−0.047***	0.024	−0.041**	0.039
	(0.017)	(0.052)	(0.019)	(0.053)
FIBER	0.073	0.280**	0.008	0.029**
	(0.052)	(0.129)	(0.015)	(0.059)
TWO_WAY	−0.395*	−0.996***	0.118*	−0.058
	(0.202)	(0.358)	(0.069)	(0.167)
DSL_2005	0.035		0.043	
	(0.030)		(0.030)	
CONSTANT	2.501***	3.823*	3.958***	4.824***
	(0.648)	(2.152)	(0.563)	(1.453)
F-test	3.29**	4.39**	1.44	0.13
Adjusted R^2	0.776	0.748	0.767	0.736
Number of markets	177	56	177	56
Observations	401	127	401	127

Dependent variable is cable modem Internet subscription price (*PRICE*). Standard errors, robust to heteroskedasticity and within-market correlation between errors, in parentheses. ***Significant at the 0.01 level. **Significant at the 0.05 level. *Significant at the 0.1 level. Coefficient estimates of state dummy variables not reported. *F*-test tests the restriction that *DIV_EDUC × FIBER* and *DIV_EDUC × TWO-WAY* jointly equal 0 in columns 1 and 2, and the restriction that *DIV_ETHNIC × FIBER* and *DIV_ETHNIC × TWO-WAY* jointly equal 0 in columns 3 and 4.

Preference diversity and quality. Our baseline results in tables 6 through 8 control for differences in quality between markets, and potential changes in quality over time, with the vector of market-level quality controls $Q = [SIZE, FIBER, TWO\_WAY]$. Overall we found no significant positive relationship between *SIZE* and *PRICE*, which suggests that market size is largely measuring cost advantages. In contrast, we did find some positive and significant relationships between *FIBER* and *PRICE* and *TWO-WAY* and *PRICE*, respectively, which are more indicative of quality effects. We also find that the inclusion of quality controls in models 2 and 3 provides qualitatively similar results with respect to prices and preference diversity to those reported for model 1, where the quality controls are omitted.

It is possible, however, that the relationship between prices and preference diversity varies with quality, as measured by *FIBER* and *TWO_WAY*. The first and second columns of table 10 report OLS estimates of prices with the additional interaction variables *DIV_EDUC×FIBER* and *DIV_EDUC×TWO_WAY*. *F*-tests show that the specification with interactions is appropriate for the duopoly ($F(2, 176) = 3.29$; Prob $> F = 0.04$) and monopoly price equations ($F(2, 55) = 4.39$; Prob $> F = 0.02$). Moreover, the individual coefficients on the interactions,

$$\partial logP^D/\partial logDIV\_EDUC = 0.261 - 0.067 logFIBER + 0.403 TWO\_WAY \text{ and}$$

$$\partial logP^M/\partial logDIV\_EDUC = 0.025 - 0.248 logFIBER + 0.912 TWO\_WAY,$$

also indicate differences in the measured impacts of preference diversity on prices for markets with different qualities. For example, let high-quality markets be those where *FIBER* (the number of fiber miles of plant in the cable system) is greater than the sample's 75th percentile (14 miles) and *TWO_WAY* (1 when the cable system is two-way capable at midyear 1998 and 0 otherwise) is greater than the sample's 75th percentile (one). Low-quality markets are those where *FIBER* is less than the sample's 25th percentile (one mile) and *TWO_WAY* is less than the sample's 25th percentile (0). Using the estimated coefficients for *DIV_EDUC*, *DIV_EDUC* × *FIBER* and *DIV_EDUC* × *TWO_WAY*, we observe that, qualitatively, our baseline results continue to hold when we evaluate the effects of preference diversity on prices for high- and low-quality markets, respectively. In low-quality markets, the effect of preference diversity on duopoly prices is 0.261 and just marginally insignificant at the 10% level ($t(371) = 1.60$; Prob $> t = 0.11$), while the effect on monopoly prices is not significantly different from 0 ($t(103) = 0.10$; Prob $> t = 0.92$). In high-quality markets, the effect of preference diversity on duopoly prices is 0.487 and significant at the 1% level ($t(371) = 3.09$; Prob $> t = 0.00$), while the effect on monopoly prices is not significantly different from 0 ($t(103) = 0.69$; Prob $> t = 0.49$).

The third and fourth columns of table 10 report OLS estimates of prices and *DIV_ETHNIC* with the additional interaction variables *DIV_ETHNIC* × *FIBER* and *DIV_ETHNIC* × *TWO_WAY*. *F*-tests show that the specification with interactions is not appropriate for the duopoly ($F(2, 176) = 1.44$; Prob $> F = 0.24$) and monopoly price equations ($F(2, 55) = 0.13$; Prob $> F = 0.88$). Nevertheless, a similar exercise of calculating the effects of preference diversity on duopoly and monopoly prices for high- and low-quality markets produces qualitatively similar results to those presented above.

Sample selection. A final question is whether sample selection in determining the type of market structure (duopoly versus monopoly), or the type of consumers who choose to live in large cities with predominantly duopoly markets plays a role in determining prices. For example, the telephone company may choose to systematically deploy DSL in markets with specific consumer preferences or cable characteristics that are not observed by the researcher. When these unobserved determinants of market structure also affect cable modem prices, the error terms in the market structure (or selection) equation and the price equations are correlated. To obtain consistent estimates of prices, we use Heckman and Lee's two-step estimation procedure.

In the first step, we let the telephone company's decision to deploy DSL be based on their expected profits:

$$\pi_{ij}^{*} = W_{ij}\phi + \varphi FC_j + u_{ij}, \tag{6}$$

where $W = [SPEED, DIV, X, Q]$ is a vector of cost and demand variables that affect variable profits, FC is a proxy for the fixed costs of DSL entry, ϕ and φ are parameters, and u is an error. Although expected profits are not observable to the researcher, it is possible to observe when the telephone company provides DSL access, with $DUOPOLY_{ij} = 1$ if $\pi_{ij}^{*} > 0$ and $DUOPOLY_{ij} = 0$ if $\pi_{ij}^{*} \leq 0$. The probability of a duopoly market structure for high-speed Internet access is

$$\begin{aligned} Prob(\pi_{ij}^{*} > 0) &= Prob(u_{ij} < W_{ij}\phi + \varphi FC_j) \\ &= F(W_{ij}\phi + \varphi FC_j), \end{aligned} \tag{7}$$

where $F(\cdot)$ is the standard normal distribution function. In the second step, the price for cable modem service is

$$\begin{aligned} PRICE_{ij}^{k} = \alpha^k + \beta^k SPEED_{ij}^{k} + \delta^k DIV_j^k + X_j^k\gamma^k \\ + Q_j^k\theta^k + \sigma_{\varepsilon}^{k}\lambda(.)_{ij}^{k} + \varepsilon_{ij}^{k}, \end{aligned} \tag{8}$$

where

$$\lambda(.)_{ij}^{D} = -f(W_{ij}\hat{\phi} + \hat{\varphi}FC_j)/F(W_{ij}\hat{\phi} + \hat{\varphi}FC_j)$$

for duopoly markets,

$$\lambda(.)_{ij}^{M} = f(W_{ij}\hat{\phi} + \hat{\varphi}FC_j)/\{1 - F(W_{ij}\hat{\phi} + \hat{\varphi}FC_j)\}$$

for monopoly markets, $f(\cdot)$ is the standard normal density function, and σ_{ε}^{k} is the covariance between u and ε^k.

The specification of the selection equation (7) suggests that the excluded instrumental variables required for identification should proxy the telephone company's fixed costs of entering high-speed Internet markets and providing a DSL product. A potential candidate is the share of telephone lines with load coils in the wire center of the ILEC with a geographical boundary that overlaps the cable system (*LOAD_COIL*). In a traditional voice telephone network, load coils were often placed intermittently along the local loop to prevent degradation of the quality of voice calls. While load coils boosted the strength of voice calls, they do not permit DSL signals to pass through them easily, if at all. The telephone company incurs additional costs of entry when removing load coils from their network in order to provide DSL. All other things being equal, DSL deployment and the corresponding duopoly market structure should be more likely in markets with a relatively low value for *LOAD_COIL*. Moreover, because it is a fixed entry cost decision for the telephone company, *LOAD_COIL* should not have a direct impact on cable Internet prices.

We initially estimated the two-step model for specifications 1 through 3. Because they contained prefect indicators, several of the first-step probits failed to converge. However, we were able to estimate a variant of model 2, without the control for the timing of DSL deployments, by removing *SIZE*, *TW0_WAY* and the state indicator variables for Colorado, Idaho, North Dakota, New Mexico, and South

TABLE 11.—TWO-STEP ESTIMATES OF PRICES AND PREFERENCE DIVERSITY

	Step 1: Selection	Step 2: Model 2′		Step 1: Selection	Step 2: Model 2′	
Independent Variable	All Markets	Duopoly	Monopoly	All Markets	Duopoly	Monopoly
SPEED	0.433***	0.208***	0.212***	0.320***	0.208***	0.213***
	(0.069)	(0.012)	(0.017)	(0.107)	(0.012)	(0.017)
DIV_EDUC	−7.022**	0.377**	−0.077			
	(3.050)	(0.175)	(0.361)			
DIV_ETHNIC				1.470***	0.047*	−0.051
				(0.501)	(0.028)	(0.072)
DENSITY	−0.749***	−0.023	−0.017	−0.645***	−0.026	−0.018
	(0.227)	(0.019)	(0.034)	(0.209)	(0.018)	(0.033)
INCOME	0.550	−0.066	−0.137	0.968	−0.115	−0.087
	(1.850)	(0.130)	(0.343)	(1.673)	(0.127)	(0.308)
EDUC	−4.412	0.315	−0.284	8.793	−0.070	−0.102
	(4.842)	(0.429)	(1.502)	(4.717)	(0.364)	(1.113)
MSO	0.742	−0.027	0.194	0.550	−0.021	0.188
	(0.459)	(0.075)	(0.174)	(0.570)	(0.075)	(0.176)
CO-OP	3.427***	0.117	0.426**	2.764***	0.172	0.422**
	(0.837)	(0.112)	(0.187)	(0.755)	(0.117)	(0.189)
TEL	1.513***	0.019	−0.084	0.635*	0.018	−0.087*
	(0.423)	(0.021)	(0.058)	(0.381)	(0.024)	(0.052)
TELEDENSITY	0.148	−0.023	0.048	0.249	−0.019	0.056
	(0.310)	(0.018)	(0.050)	(0.355)	(0.018)	(0.045)
TEL_COST	2.380***	0.007	0.057	2.405***	0.006	0.055
	(0.325)	(0.019)	(0.040)	(0.273)	(0.019)	(0.038)
FIBER	−0.388***	0.003	0.031	−0.240	0.004	0.032
	(0.111)	(0.007)	(0.043)	(0.195)	(0.007)	(0.044)
LOAD_COIL	−0.731***			−0.817***		
	(0.183)			(0.227)		
$\hat{\lambda}$		0.053	−0.079		0.057	−0.109
		(0.569)	(0.369)		(0.616)	(0.374)
CONSTANT	1.025	2.517**	5.106	−31.93***	4.144***	4.703**
	(14.17)	(1.095)	(3.253)	(11.57)	(0.805)	(2.220)
Log likelihood	−10.66			−9.879		
Pseudo R^2	0.959			0.962		
Adjusted R^2		0.749	0.736		0.744	0.740
Number of markets	189	133	56	189	133	56
Observations	423	296	127	423	296	127

Dependent variable in selection equation is (*DUOPOLY*). Dependent variable in price equation is cable modem Internet subscription price (*PRICE*). Standard errors, robust to heteroskedasticity and within-market correlation between errors, in parentheses. Bootstrapped standard errors for price equations. ***Significant at the 0.01 level. **Significant at the 0.05 level. *Significant at the 0.1 level. Coefficient estimates of state dummy variables for selection and price equations are not reported. Observations for Colorado, Idaho, North Dakota, New Mexico, and South Dakota are excluded from the sample.

Dakota from the right-hand side. We report this specification, model 2′, as a test for potential selection bias.[25]

Table 11 presents two-step estimates of prices and preference diversity for model 1. Columns 1 through 3 report estimates of the selection equation, duopoly prices, and monopoly prices, respectively, using the standard deviation of education attainment as the measure of preference diversity. We first note in column 1 that the coefficient on the excluded instrument in the selection equation, *LOAD_COIL*, has the expected negative sign and is precisely estimated.[26] All other things being equal, duopoly is more probable in markets with fewer load coils in the telephone network. Columns 2 and 3 report the two-step estimates of cable modem prices. The estimated coefficients on the selection term, $\hat{\lambda}$, in both the duopoly and monopoly markets are not statistically significant different from 0 and suggest there is not a sample selection problem.[27] Moreover, as expected, the estimated coefficients on *DIV_EDUC* in the duopoly and monopoly price equations are very similar to the single-equation OLS estimates reported in table 6. Qualitatively similar results are also obtained in columns 4 through 6, when we use the entropy measure of ethnic diversity as our measure of preference diversity.

VI. Conclusion

This paper has empirically examined the price effects of competition in the high-speed Internet access market. Our key findings are that the effects of competition depend in a systematic way on consumer preference diversity. In particular, the price for cable modem Internet access increases in preference diversity under competition but not necessa-

[25] In the first step, the state indicator variables for Colorado, Idaho, North Dakota, New Mexico, and South Dakota predict success perfectly and are dropped from the probit model, along with their corresponding 105 observations. We estimate the second-step price equations on the reduced sample of 423 observations.

[26] Some sample observations have 0 values for *LOAD_COIL*. Because we estimate a double log model, we replace these 0 values with the second lowest value of *LOAD_COIL* in the sample divided by 2.

[27] Because λ is estimated in the first step, the asymptotic variance of the second-step estimator may not be valid, so we report bootstrapped standard errors for prices with 1,000 replications.

rily under monopoly. Moreover, the presence of a DSL provider in competition with a cable modem provider may or may not lower the cable provider's price, depending crucially on consumer preference diversity. Specifically, DSL competition lowers the cable modem Internet access price if consumer preference diversity is relatively small, but raises the price if consumer preference diversity is large enough. These results are robust whether we use the standard deviation of education attainment or the entropy measure of ethnic diversity as the measure of preference diversity. Our findings, consistent with the theoretical work from C-R, shed new light on the long-standing question in economics concerning how competition affects prices.

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