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The Consumer Gains from Direct Broadcast Satellites and the Competition with Cable TV*

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February 26, 2002

Abstract

This paper examines the introduction of Direct Broadcast Satellites as an alternative to cable television and the welfare gains such satellites generated for consumers. The extent to which the entry of satellites has provided competition to local cable monopolists has become an important issue in the debate over re-regulation of cable prices. We estimate a consumer level demand system for satellite, basic cable, premium cable and local antenna using micro data on the television choices of more than 45,000 people as well as price and characteristics data on cable companies throughout the nation. Our framework uses extensive controls for unobserved product quality and permits the distribution of unobserved tastes to follow a fully flexible multivariate normal distribution. We find the own-price elasticity of both expanded basic and premium are close to -1. The satellite demand is much more elastic, with an own-price elasticity between -4 and -5 and a cross-price with respect to expanded basic of around 2. The welfare gain to satellite buyers averages approximately $100 per year, or about $1 billion annually in the aggregate. Estimates that do not control for unobserved attributes and endogenous prices yield very inelastic demand curves and welfare estimates that are several magnitudes larger than methods which correct for these problems.

*We would like to thank Lanier Benkard, Steve Berry, Severin Borenstein, Judy Chevalier, Greg Crawford, Kevin Murphy, Ariel Pakes, Greg Werden, and numerous seminar participants. We would also like to thank Andrew Lee for superb research assistance and David Rowley, of the Geophysical Sciences department at the University of Chicago, for computations using the data from the U.S. Geologic Survey. Goolsbee and Petrin would like to acknowledge the Centel Foundation/Robert P. Reuss Faculty Research Fund at the University of Chicago, GSB. Goolsbee also acknowledges the National Science Foundation and the Alfred P. Sloan Foundation for financial support.

1 Introduction

In the last two decades economists have devoted increasing attention to the importance of new goods and to their role in enhancing competition. Although debate remains over the magnitude of the welfare gains arising from these new products, considerable strides have been made in developing methods to quantify such gains. These developments address the traditional difficulties such as unobservable product quality, the endogeneity of prices, and the importance of functional form assumptions that existed in welfare gains calculated using hedonic regressions or other methods.[1] We add to this literature by developing a framework to estimate the consumer demand for television which combines consumer-level choice data with information on product characteristics and prices, while also controlling for unobserved product quality and allowing the distribution of unobserved tastes to follow a fully flexible multivariate normal distribution.

The role of new goods is potentially quite important in industries like consumer electronics and telecommunications, where the pace of innovation is rapid. In this paper we use our framework and over 45,000 observations on consumer behavior to analyze the introduction of a major consumer electronics good, direct broadcast satellite (DBS), which provides the *only* multichannel video alternative to local cable monopolists for almost all Americans. Starting in the mid-1990s, consumers could purchase a small satellite dish for their home, pay a monthly subscription fee, and then receive multichannel video programming without having to subscribe to cable. This product has been quite successful from its onset in 1994. Indeed, by 1998, 10 million households had a dish, making it one of the fastest adopted consumer products in U.S. history.

Americans seeming love affair with television makes the entry of DBS particularly interesting. In 1999, some 97% of households had a television and almost 75% had cable or a satellite (the so called multichannel video distribution systems). The

[1]See Trajtenberg (1989), Hausman (1997b), Crawford (1997), Hausman (1998), Berry and Pakes (1999),Berry, Levinsohn, and Pakes (1995),Berry, Levinsohn, and Pakes (1998), Nevo (2000), Petrin (2001), and the papers in Bresnahan and Gordon (1997), as well as the discussion over the Consumer Price Index such as Boskin Commission (1996) and Shapiro and Wilcox (1996).

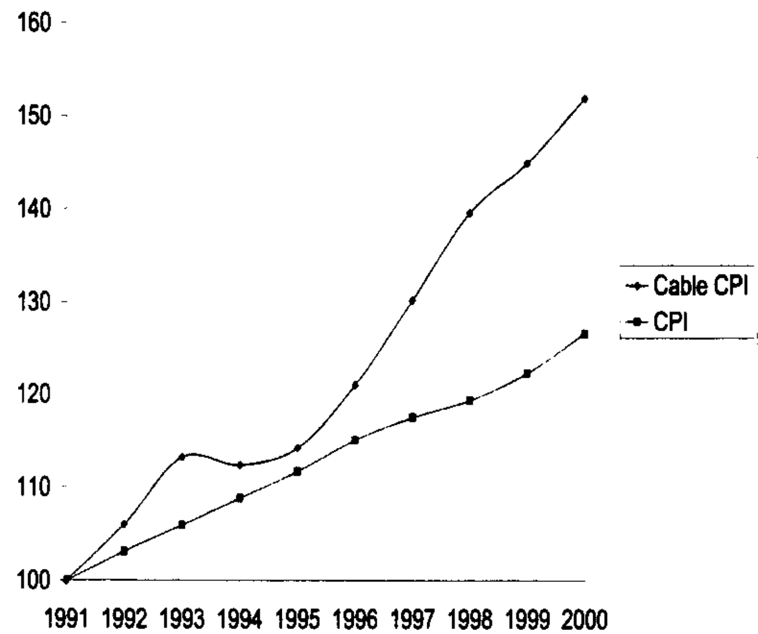
average household watched more than seven hours of television per day(!), making it the number one leisure activity in the nation (Nielsen Media Research (1999)). Total television advertising in 1999 exceeded $45 billion and consumers spent an additional $37 billion on cable subscriptions (National Cable Television Association (2001)). In an industry this big, even minor product improvements can generate large welfare gains.

In addition, because of its role as cable's only competitor, the demand substitutability with DBS is one of the central issues in the debate over the regulation of cable as well as merger policy in the video market. For the most part, cable television is dominated by local monopolies whose prices were once rather heavily regulated. The Telecommunications Act of 1996, however, phased out most price regulation and instead tried to promote competition as a check on prices. The explicit goal of the act was to stimulate local phone companies or new cable start-ups to enter the market, but the effort failed. Phone company and new cable entrants have been rare and the cable consumer price index (CPI) has risen about 2.5 times faster than the overall CPI since price regulations began phasing out in 1996 (see figure 1).[2] Consumer advocates say that unfettered monopolies can now raise prices with impunity and they have called for Congress and the FCC to re-regulate cable, at least until there is viable competition (Consumers Federation of America (2001), Kimmelman (1998)). For most markets in the U.S., the only serious alternative to getting multichannel video from the cable monopoly is to buy a satellite dish. Indeed the National Cable Television Association, in their rebuttal to the consumer advocates' calls for regulation, has cited the fact that DBS is available in every market and growing rapidly as direct evidence that there *is* effective competition (Gregory, Brenner, Schooler, and Nicoll (2000)).

In this paper we will analyze these issues by estimating the demand system for cable and satellite using discrete choice methods developed in recent years and applying them to new micro data on the television choices of more than 45,000 households.

[2]There is debate over the importance of unmeasured quality change in the cable price index, especially in periods following major regulatory shifts such as this one. See the work of Crawford (1997) and Hazlett and Spitzer (1997).

Figure 1: Cable Prices and the CPI, 1991-2000



The estimated demand system will allow us to infer both the welfare gains from the existence of DBS for the new adopters as well as the own and cross-price elasticities of basic cable, premium cable, and DBS.[3] Because of the wide variation in market shares (induced by wide variation in the relative prices between cable and satellite), we can show that our estimates of the welfare gain are not sensitive to functional form assumptions used to extrapolate demand out to the choke price (where demand is zero).

After accounting for unobservable product attributes and the endogeneity of price, we find a low own-price elasticity (in absolute value) of both expanded basic and premium around -1. The satellite own-price elasticity is much higher, between -4 and -5, and the cross-price with respect to expanded basic is around 2. The direct welfare gain to satellite buyers averages approximately $100 per year or approximately $1 billion annually in the aggregate. We show that failing to control for unobserved attributes and endogenous prices yields highly inelastic demand curves and thus welfare estimates that are biased upward by several orders of magnitude.

The paper proceeds in seven sections. In section 2, we give background on the cable and satellite industries. In section 3 we describe our data. In section 4 we lay out our demand model and estimation method. In section 5 we discuss the basic results and price elasticities. In section 6 we estimate the welfare gains in our model and using other methods. In section 7 we conclude.

[3] Within the literature on cable, Crawford (1997), Crawford (2000) and Chipty (2001) are the first papers to apply the new industrial organization methods for analyzing the cable industry. Our work is in the spirit of an older literature that sought to examine the demand for (the then newly available) cable television and the impact it was expected to have on the existing demand for network television (see Ellickson (1979) and Park (1971)). It is also in the spirit of the large literature that seeks to test for market power among cable companies such as Wildman and Dertouzos (1990), Rubinovitz (1993), Jaffe and Kanter (1990), Prager (1990), Zupan (1989), Mayo and Otsuka (1991), or Hazlett and Spitzer (1997).

2 Cable Television, Satellite, and the Market for Video Services

In this section we discuss the two primary alternatives for multi-channel video distribution that exist for most U.S. customers.

2.1 Cable Television

Over the past three decades, cable television has had an extraordinary rise to prominence. Cable began as a way for rural customers to improve their network television signal but by the 1980s had become a major alternative source of programming. By 1999, almost 70 percent of households in the United States had cable and the average customer received 57 channels from their cable provider (Nielsen Media Research (1999).)

Cable television has faced a winding road of regulatory treatment over this time period. For most of its lifetime, the cable industry's high fixed cost nature lead regulators to treat it as a natural monopoly in each local market. As a result, cable firms bid to become the monopoly provider in an area and paid a franchise fee generally amounting to a few percent of gross revenue. Prices were then regulated. In 1984, the government began deregulating cable prices. Over the next seven years, average prices rose two to three times faster than the overall rate of inflation, although considerable controversy remains over whether this was due to quality improvements or to increased markups.[4] Regardless of the true answer, it is clear that the public outcry over rising prices lead the government to re-regulate cable in 1992. The impact and evolution of cable after this period is analyzed in Crawford (2000).

Only a few years later, general dissatisfaction with regulatory solutions caused the government to again deregulate cable prices as part of the Telecommunications Act of 1996. Previous to this bill, people noted that in the markets where there had been entry of a second cable company (known as overbuild markets) prices were lower and services better than in traditional monopoly markets. The effort of the 1996 act was to encourage direct competition as an alternative to regulation. The act

[4]See Rubinovitz (1993), Jaffe and Kanter (1990), and Crandall and Furchtgott-Roth (1996).

tried to encourage local phone companies to enter local cable markets (FCC 97-423). Somewhat on the presumption of this future competition, the act also began phasing out price regulation of cable during the 1996-1999 period. By mid-1999, everything but the minimum basic channel package was deregulated.[5]

Since 1996, however, few phone companies have entered the cable business and the number of overbuild markets has remained small. As indicated at the outset, prices of cable have risen almost three times faster than inflation and, as a result, there are increasing calls to re-regulate cable prices. In most locations, the only competitor to the local cable monopoly is DBS.

2.2 Home Satellite Systems

Television satellites broadcast from a geosynchronous orbit (i.e., they remain fixed in the same point in the sky as the earth turns) and to do so must be in a specific orbit above the equator. As the number of television satellites increased in the 1970s and 1980s and the cost of a satellite receiver fell to a few thousand dollars some rural viewers bought 9 foot C-band satellite receiver dishes for personal use. By the mid-1980s, however, most broadcasts were encrypted so they could not get free programming. Currently the C-band dishes tend to have a weak signal, are difficult to use and seem to be almost exclusively located among rural customers. They are not a serious competitor to cable and subscribership has been in decline so we will restrict our sample to major metropolitan areas in order to avoid including C-band customers in our sample.

Although the 9-foot dishes did not catch on in most areas, by the mid-1990s, an explosion in the amount of programming and distinct improvements in satellite receiver and digital compression technology set the stage for the next generation of home satellite systems.[6] These new DBS systems broadcast on the Ku-band at frequencies of up to 17.8 gigahertz to satellite dishes as small as a 18 inches in diameter. The most popular of the systems at the time of our sample were DirecTV, the DISH Network,

[5]For details on how the regulations were phased out in the period from 1996 to 1999 see Bracco (1996). For more information on the act itself see Aufderhide (1999) or (FCC 97-423).

[6]See Owen (1999) for a history of DBS systems.

and Primestar (since then, Primestar was bought by DirecTV). These satellites offer subscribers hundreds of channels, including more extensive sports, movies, and pay-per-view options than are available on most cable systems. In addition, their digital video and sound is superior to traditional cable television or local-antenna reception.

These advantages can be expensive, however. In addition to the monthly programming fees, consumers subscribing to these services usually pay for the equipment themselves, averaging around $232 including installation. The comparable programming packages are slightly more expensive on DBS than on most cable systems, as well. In 1998, the average cost for the standard cable channels on DirecTV was $32, and this did not include the major networks (i.e., ABC, NBC, and the like).[7]

Table 1

Cable and DBS Subscribers (millions of households)

Year	Cable	DBS
1994	59.4	0.4
1995	62.1	2.2
1996	63.5	4.3
1997	64.9	5.0
1998	66.1	7.2
1999	66.7	10.1

Source: (FCC 99-418).

Despite the large installation costs, consumers have embraced the product. As table 1 shows, from a base of about 400,000 in 1994, the number of households that subscribe to satellite exceeded 7 million by 1998 and 10 million in 1999 (FCC 99-418). DBS now accounts for about two-thirds of all new subscriptions to multichannel video systems.

There have been some physical and regulatory disadvantages of DBS systems, however, that have limited their spread and we will control for these factors in our

[7]For more information see (FCC 97-423), (FCC 98-335), and (FCC 99-418).

estimation. At the time of our sample (end-of-year 1998), the most well known problem with satellites was the regulatory restriction preventing the DBS systems from broadcasting local network content to anyone that can get such channels with a regular television antenna.[8] This meant that people living in television markets where antenna reception is spottier (such as mountainous places or places with bad weather) might find the satellites to be a worse substitute for cable.

A second regulatory hurdle at the time of our sample was the unclear interpretation of the 1996 Satellite Home Viewer Act. That act forbid most regulations against home owners putting up satellite dishes. However, the act did not give a clear right for renters to do the same.[9] Thus, at the time of our sample, we would expect that, holding other individual characteristics equal, renters will be less likely to prefer satellites to cable.

The most important physical problem with DBS systems is that to get a good signal, the user must have a clear line-of-sight to the broadcast satellite's spot in the sky. Buildings, geography, and even trees can degrade the signal. This means that people living in single family homes or trailers have a much better chance of being able to get the signal than people living in multi-unit dwellings. It also means that people living in higher latitudes should have a greater chance of ground based interference because their dishes will be pointed closer to the horizon. A person in Seattle, for example, needs a clear line of site at 31.5 degrees above the horizon. In Houston, they need a clear line at only 55 degrees (straight up is 90 degrees).[10] In other words, the quality of the satellite product (in the utility sense) will vary depending on the location of the subscriber.

[8]Technically, anyone that could receive a grade B signal was ineligible. This rule was changed in the Satellite Home Viewer Improvement Act of 1999 so that consumers in most major television markets can now receive their local channels for an additional fee.

[9]In January of 1999, an added clarification established the right of a renter to install a dish on any well-defined space that they "controlled", such as a patio. They are still not allowed to put a satellite dish on the roof of a building without the landlord's permission even if they have free access to it.

[10]This problem of greater interference at higher latitudes is well known in the industry and, incidentally, explains the efforts of the Soviet Union (almost all of which is at a high latitude) to develop satellite systems in non-geosynchronous orbits (see Owen (1999)).

3 Data and Identification

In this section we describe our data sources and provide an overview of how our data and modeling approach are related.

3.1 Micro Data on Television Choices and Characteristics

Our goal is to estimate the demand system for cable and satellite. The basis of our estimation will be data on household television choices. This information comes from surveys done by Forrester as part of their Technographics 1999 program (conducted from December 1998-February 1999). Forrester is a leading market research company focusing on the information economy. In this survey they ask people about their ownership and use patterns of various electronic and computer related goods. The survey is meant to be nationally representative and more details about it can be found in McQuivey, et. al. (1998) or Goolsbee (2000).

The survey provides various demographic information about households, including gender, family income, marital status, household size, education, and type of living accommodations. It also includes their state and their television market, known as the DMA, an MSA-like designation that typically includes several cable franchises. Finally, households report the cable company that serves them. The choices include the seven largest multiple system operators (MSOs)- AT+T/TCI, Adelphia, Americast, Cablevision, Cox Communications, Media One, and Time Warner, and an "other" category.

We model a household's television choice between expanded basic cable, premium cable (which can only be purchased bundled with expanded basic), Direct Broadcast Satellite, and no multi-channel video (i.e., local antenna reception only). In the survey, consumers report whether they have cable or satellite, and the amount they spend on premium television. We classify respondents as having premium if they report that they have cable and spend more than $10 per month on premium viewing, the average price of the most popular premium channel HBO. We classify respondents as choosing expanded basic if they report that they have cable and they spend less than $10 per month on premium viewing. We look at the top 132 cable franchises in the largest 69 DMAs. These markets represent approximately 75% of the U.S. population (Nielsen Media Research (2000)). We choose them because they each have at least 100 survey respondents and because cable availability is pervasive and C-band dishes uncommon.[11]

Table 2 provides summary statistics for some of the variables used in the study for this sample of more than 45,000 households. Approximately 20% of households choose not to have multi-channel video (i.e., no cable and no DBS, only their local antenna). Almost 70% of households have either expanded basic or premium cable and about 10% of the sample has DBS.[12] Our sample, which is restricted to the larger metropolitan areas, has approximately the same relative market shares between satellite and cable as the numbers reported in table 1 from the FCC.[13]

To these household data on consumer choices, we match information on the cable system prices and characteristics that each household faces. These cable system data come from Warren Publishing's 1999 Television and Cable Factbook (Warren Publishing (1999)), the most comprehensive reference for cable system characteristics in the industry.

We match consumers to their cable company using three observed characteristics: DMA, state, and MSO. To get the characteristics of the cable system the consumer faces, we match each respondent to the largest cable franchise owned by the stated MSO (say Time-Warner) in the respondent's DMA-State of residence.[14] For people reporting an "other" MSO, we find the largest franchise in the DMA-State that is not

[11]The Forrester survey is not detailed enough to allow us to estimate the value of DBS to the 5% of consumers that the FCC reports do not have access to cable. While they are perhaps the biggest winners in a per capita sense from the DBS introduction, they are a small fraction of the total viewing market.

[12]Satellite users can, of course, simultaneously subscribe to cable, and about 3% of our sample does so. Since the higher channel offerings on satellite fully dominate the cable offerings in almost all the markets during our sample, we assume that anyone reporting that they subscribe to both satellite and cable are subscribing to the minimum cable package that gives access to get the local networks.

[13]Our survey takes place at the beginning of 1999 and has about 7 times more cable subscribers than satellite subscribers. This is close to the ratio of 6.6 found in the FCC report for the year 1999.

[14]Several television markets cross state lines. The New York City DMA, for example, includes individuals in New York, New Jersey, and Connecticut.

Table 2

Summary Statistics: Consumer Data

Variable	Mean	Std. Dev.
Indicators		
Local Antenna Only	0.213	0.409
Expanded Basic Cable	0.372	0.483
Premium Cable	0.316	0.465
Satellite	0.097	0.297
Rent	0.222	0.415
Single	0.179	0.384
Single Unit Dwelling	0.783	0.412
Household Size	2.698	1.264
Household Income	$57,365	$28,641
Observations	46,861	

Source: Forrester Technographics, 1999.

affiliated with the top seven MSOs. The characteristics we include are the channel capacity of a cable system, the number of pay channels available, whether pay per view is available from that cable franchise, and the price of basic plus expanded basic and the price of premium for the system. We also get from the Factbook the number of over the air channels available on the system, the year the company began, and the city franchise fee (a tax on cable company revenue). Table 3 reports some summary statistics of these numbers.

Some other important features of the market for which we have controls include the angle at which the dish is set, the weather, and the variance in local terrain. These can affect the quality of local antenna and satellite reception as well as the amount of time spent watching television. For each of the television markets, we control for the angle of elevation (up/down) at which a potential user of DBS would have to position their dish.[15] To measure potential geographic interference, we calculate the

[15]We obtain this number by taking the primary zip code for the major city from the World Almanac (1999) and plugging it into the DirecTV dish pointer (DirecTV (2000)). We use a neighboring

Table 3

Summary Statistics: Television Markets

Variable	Mean	Std. Dev.
Annual Expanded Cable Price	$302.76	$94.20
Annual HBO Cable Price	$133.92	$18.72
Over-Air Channels	10.18	3.20
Channel Capacity	63.75	18.86
Premium Channels	5.69	1.42
Pay-Per-View Available	.878	.327
City Fixed Fee	4.1%	1.4%
Angle	41.88°	6.45°
Observations	132	

Source: Warren Publishing 1999 Television and Cable Factbook. Angle from DirecTV dish pointer.

variance of the local terrain and average elevation using data from the One Degree U.S. Geologic Survey Digital Elevation Model data.[16] We take a measure of the local weather the Climate Stability Index from the *Places Rated Almanac* (Savageau and Lotus (1997)).

3.2 Identification

The goal of our empirical work is to estimate the price sensitivity of demand for cable and satellite television and the welfare gains to consumers from having access to DBS. To make these calculations, we employ a discrete choice model of demand, using the variability of price, product characteristics, and household demographics across the United States to estimate demand elasticities. In essence, the demand estimates are identified by comparing how the likelihood of purchase for people with the same observable characteristics changes as prices and characteristics of products

zipcode if the dish pointer information is missing for the primary zipcode.

[16]We choose a point at the center of the DMA and calculate a variance of the elevation in a 30 pixel by 30 pixel area centered at that point.

change.

Demographics

As described earlier, we observe a detailed set of demographics at the individual level and some market-level demand shifters. Table 4 indicates that some of these observables are highly correlated with demand in a manner consistent with the technological and regulatory factors described in section 2.2. In particular, both quality of signal and ease of installation appear to be important factors for DBS adoption, as satellite ownership is much higher for people with higher dish angles, for people who do not rent, and for people living in single-unit dwellings. These demographic differences can be large. For example, the probability of DBS adoption more than doubles, from 6.8% to 15.3%, if one lives in a single unit dwelling versus a multiple unit dwelling.

Table 4

Characteristics of Multi-Channel Video Consumers

	High Angle	Low Angle	Own	Rent	Single Residence	Multiple Residence
Satellite	16.6%	10.0%	14.9%	9.0%	15.3%	6.8%
Cable	83.4%	90.0%	85.1%	91.0%	84.7%	93.2%

Price Differences

Monthly satellite prices are fixed across the U.S. at $32, giving no identifying variation. The relative prices of cable and satellite, however, vary a great deal across markets because of variations in the price of basic and premium cable. The average monthly price difference between satellite and expanded basic in the U.S. is $6.75, and two standard deviations in either direction ranges approximately from $22.45 to -$8.95. There is similar variation in the price of premium relative to DBS.

We can identify the demand elasticities and the welfare gains using just the relative price differences because demand is symmetric and the choice set is complete (i.e., everyone in the sample chooses to have at least local reception). Since the sum of the market shares across goods must be 1, the derivative of the shares with respect to the price of satellite must sum to zero, or

$$\frac{\partial s_{Sat}}{\partial p_{Sat}} = -\frac{\partial s_{Base}}{\partial p_{Sat}} - \frac{\partial s_{Prem}}{\partial p_{Sat}} - \frac{\partial s_{Ant}}{\partial p_{Sat}}, \tag{1}$$

where s_{Sat}, s_{Base}, s_{Prem}, and s_{Ant} index the market share for satellite, expanded basic, premium, and antenna-only (and similarly for the price terms). If the income effects from a price change are negligible (and the results below will indicate that they are), the symmetry of demands implies that a small change in the price of satellite affects the share of expanded basic in an amount equal to the effect on satellite share of a small change in the price of expanded basic, or

$$\frac{\partial s_{Base}}{\partial p_{Sat}} = \frac{\partial s_{Sat}}{\partial p_{Base}}. \tag{2}$$

In our data we observe satellite share variation as the expanded basic price varies (that is, as the price difference between satellite and basic varies across markets). Our estimator uses this variation to estimate the first term on the right hand side of the equality in (1) (via (2)). Similarly, we estimate the second term in (1) using

$$\frac{\partial s_{Prem}}{\partial p_{Sat}} = \frac{\partial s_{Sat}}{\partial p_{Prem}}, \tag{3}$$

and the observed changes in satellite share when the premium price of cable varies.

The third term is the only problem, since there is no variation across markets in the relative price difference between local reception and DBS (antenna is free in every market and DBS is always $32 per month). If local reception and subscribing to DBS are poor substitutes, the problem will be minimal because $\frac{\partial s_{Ant}}{\partial p_{Sat}}$ will be close to zero. Certainly the characteristics of the two products suggests they are not close substitutes. In our model, we will parameterize demands as a function of product characteristics and demographics and estimate this substitutability. Our results confirm this intuition; when people shift away from DBS, fewer than 5 percent switch to local reception (i.e. 95 percent switch to basic or premium cable).

Price Endogeneity

Our final concern with estimating such a demand curve is the potential for price endogeneity. If we cannot observe some of characteristics of the local cable franchise that are known by both the consumers and the suppliers, and if cable prices respond to these factors, the price elasticity will typically be biased towards zero. For example, a cable system with the same observables but with relatively good service will tend to be more desirable and have higher prices, making it seem as though consumer demand does not fall in response to high prices.[17] For this reason we will include a full set of product fixed effects that will account for the unobservable product quality of basic cable, premium cable, and satellite in each market (in addition to our individual-level demographics).

Because we include these market-level fixed effects, we will need market-level cost shifters to recover the effect of price changes on demand (since the price of each product is captured in the fixed effect). We will employ three different instruments for price that vary at the market-level. The first is the tax levied by the city on the gross revenue of the cable company, called the city franchise fee. This fee is typically negotiated and then fixed for long periods of time, and is reported in Warren Publishing (1999). The second is the density of population in the area (computed using the data in Census (2002)) since more densely populated areas are thought to have lower costs for operating a cable franchise (see Owen (1999)). Finally, we extend the approach of Hausman (1997b) as done in Crawford (2001), averaging over the prices of the cable companies with the same multiple system operators but operating in different markets. These average prices reflect common cost side factors, in particular the costs of programming purchased at the MSO level, and should exclude the idiosyncratic market specific demand features of any one market that might be correlated with price in that market.

4 Utility Theory and Estimation

4.1 Utility Theory and Discrete Choice

We follow the standard characteristics approach of Gorman-McFadden-Lancaster-BLP. We assume that consumers choose the type of television that gives them the highest utility and that their utility can be written as a function of tastes for the

[17] See, for example, Trajtenberg (1989).

characteristics of those goods.[18] Here the four goods are local antenna reception (Ant), expanded basic cable (Base), premium cable (Prem), and Direct Broadcast Satellite (Sat). Thus, a given household i will choose the type of television that solves

$$V_i = \max_{j \in \{Ant, Base, Prem, Sat\}} V(p_j, y_i, i, j), \tag{4}$$

where V_i and $V(\cdot)$ are the indirect and direct utility functions, j indexes the four different television viewing mediums available, y_i is income, and p_j is price of medium j.

We choose a linear random utility model

$$V_{ij(m)} = \alpha_i(y_i - p_{j(m)}) + \delta_{j(m)} + \beta_j' Z_i + \epsilon_{ij}, \tag{5}$$

which automatically satisfies $\frac{\partial s_k}{\partial p_j} = \frac{\partial s_j}{\partial p_k}$.[19] The market index $m = m(i)$ is determined by household i's residential location. $p_{j(m)}$ is the annual cost of the medium in market m, leaving $(y_i - p_{j(m)})$ for consumption of other goods if j is purchased. α_i is a marginal utility of wealth term (a parameter) that allows price sensitivity to vary by income quintile. $\delta_{j(m)}$ represents the common quality/utility for the product (a product-market fixed effect). Z_i is a vector of household-specific characteristics that affect people's preferences for television medium j (according to the taste vector β_j). For example, we allow demographics like education, marital status, single male, and household size to affect tastes for each television medium j separately. ϵ_{ij} is a household-specific idiosyncratic unobserved taste for product j.[20]

We follow the literature, assuming the product-market fixed effect $\delta_{j(m)}$ is linear in characteristics and given by

$$\delta_{j(m)} = -\alpha_0 p_{j(m)} + \overline{\beta}' X_{j(m)} + \xi_{j(m)}. \tag{6}$$

Here α_0 is the price-sensitivity term for the base income group, so the price-sensitivity for any given consumer is given by $-\alpha_0 + \alpha_i(y_i)$.[21] $\overline{\beta}$ are the taste terms common

[18] Gorman-Lancaster introduced the characteristics approach to modeling demands. McFadden (1981) developed much of the econometrics.

[19] See Anderson, de Palma, and Thisse (1992), pp. 91-92, for a proof.

[20] This specification makes the usual assumptions, restricting product-demographic taste coefficients β_j and the distribution of unobservables ϵ_{ij} to be common across markets.

[21] If $\alpha_i > 0$ households become less price sensitive as their wealth increases.

across consumers for product j's characteristics $X_{j(m)}$, and $\xi_{j(m)}$ is the unobserved (to the researcher) quality of the product.[22]

We begin with the index for expanded basic, the most popular of the four choices. It is given by

$$V_{iBase} = \alpha_i(y_i - p_{Base(m)}) + \delta_{Base(m)} + \beta'_{Base} Z_i + \epsilon_{iBase}. \tag{7}$$

$\alpha_i(y_i - p_{Base(m)})$ is the utility derived from the consumption of other goods conditional on the purchase of j. $\delta_{Base(m)}$ is the utility term common to market m consumers of expanded basic. It contains characteristics of the local cable market that include price, channel capacity of the system, whether pay-per-view is available, and other features specific to market m. $\beta'_{Base} Z_i$ is the household-specific utility associated with product j. Finally, ϵ_{iBase} represents household specific tastes for expanded basic not captured by other observables. For the researcher, this term is the unobserved idiosyncratic taste term. If a household, for example, finds having more than channels 2-13 unsatisfactory (or more unsatisfactory than other people with the same observables find it), this will show up as a low ϵ_{iBase}.

The premium and satellite indices are similar to the expanded basic index. They each contain a market-specific fixed effect $\delta_{Prem(m)}$ and $\delta_{Sat(m)}$. Demographics are allowed to affect taste for premium and for satellite via the parameters β_{Prem} and β_{Sat}. Since premium must be purchased along with basic, we treat premium as "expanded basic plus premium." $p_{Prem(m)}$ is then the sum of the expanded basic plus the premium price in market m (see table 2). For satellite the annualized "expanded basic" price is fixed across the U.S. at $p_{Sat(m)} = p_{Sat} = \$384$, plus the annualized equipment and installation cost, less the resale value of the dish. The FCC reports an equipment and installation fee of \$232 in 1999. Our results are robust to assumptions about how this cost is annualized into the price of DBS.

The fourth good, which completes the choice set, is antenna reception. The quality of television viewing when a consumer is constrained to having only local antenna reception and no multi-channel video is given by

$$V_{iAnt} = \alpha_i y_i + \delta_{Ant(m)} + \beta'_{Ant} Z_i + \epsilon_{iAnt}. \tag{8}$$

[22]The price endogeneity problem arises because consumers and producers do know the value of this quality term, so it is taken into account when pricing decisions are made.

The cost of antenna reception is zero, so all income is left for consuming other goods. $\delta_{Ant(m)}$ embodies things like the number of over-the-air channels available in the market and the quality of local reception. Choice data identifies only the relative rankings so we normalize $\beta_{Ant} = 0$ and $\xi_{Ant(m)} = 0 \ \forall m$, where $\xi_{Ant(m)}$ denotes "base" unobserved utility for antenna only.

Unobserved Tastes

Most empirical work in the discrete choice literature uses some kind of logit form for the idiosyncratic error. It is a natural candidate, as it leads to a simple computational solutions for some difficult problems. In particular, there are two principle advantages. First, a closed-form solution for the integral over the unobserved term exists, allowing one to avoid the costs of undertaking simulation to integrate. Second, an algorithm provided by Berry, Levinsohn, and Pakes (1995) "automatically" locates product-specific fixed effects. While fixed effect terms are easily concentrated out of linear frameworks, in non-linear frameworks simple solutions to this problem exist only in very special cases. Their algorithm - provided by a contraction mapping - and the proof that it will always locate the fixed effects, depends critically on a *logit* error being appended to the utility function.[23]

Logit models (and the Generalized Extreme Value distribution from which they come) have been criticized, however, for imposing unrealistic restrictions on demand systems (see, for example, Hausman and Wise (1978), Berry, Levinsohn, and Pakes (1995), Berry and Pakes (1999), Petrin (2001), and Bajari and Benkard (2001)). Hausman and Wise (1978) argue that more reasonable approximations to human behavior obtain when these random taste coefficients are permitted to follow a fully general multivariate normal distribution. Equivalently, they suggest putting random coefficients on indicator variables for *each* available choice, allowing these random coefficients to freely vary and covary across choices. We follow this suggestion, allowing unobserved tastes

$$\epsilon_i = (\epsilon_{Ant}, \epsilon_{Base}, \epsilon_{Prem}, \epsilon_{Sat}) \tag{9}$$

to be normally distributed and to freely vary and covary.

[23]See Berry and Pakes (1999) for attempts to extend this algorithm to other utility frameworks.

Since choice data only identifies relative rankings, we must normalize to one good. Normalizing to the antenna only choice yields

$$\epsilon_i^* = (\epsilon_{Base} - \epsilon_{Ant}, \epsilon_{Prem} - \epsilon_{Ant}, \epsilon_{Sat} - \epsilon_{Ant}) \sim \text{MVN}(0, \Omega^*) \tag{10}$$

which also is distributed multivariate normal with a variance covariance matrix given by

$$\Omega^* = \begin{bmatrix} 1 & \sigma_{B,P} & \sigma_{B,S} \\ \ldots & \sigma_P^2 & \sigma_{P,S} \\ \ldots & \ldots & \sigma_S^2 \end{bmatrix}. \tag{11}$$

This symmetric matrix has five unique parameters that describe the distribution of unobserved tastes, which we call σ. $\sigma_{B,P}$ is (for example) the covariance between the Base minus Antenna only term and the Premium minus Antenna only term.[24]

4.2 Estimation

We use maximum likelihood to obtain parameter estimates for the discrete choice model with four choices: antenna-only, expanded basic cable, premium cable, and satellite. There are four distinct vectors of parameters that enter our likelihood function: α, the marginal utility of income parameters, β, the parameters associated with taste for television viewing related to observables in our data, δ, the product-market specific fixed effects for expanded basic cable, premium, and satellite, and σ, the diagonal and off-diagonal terms of the covariance matrix of errors.

The likelihood function with the consumer level data takes the form

$$L = \Pi_{i=1}^{N} \Pi_{j=1}^{J} s_j(\alpha, \beta, \sigma, \delta; Z_i)^{j(i)} \tag{12}$$

where $j(i)$ is the indicator function

$$j(i) = \begin{cases} 1 & \text{if household } i \text{ chose } j \\ 0 & \text{otherwise} \end{cases}$$

and $s_j(\cdot; Z_i)$ is the probability with which household i is predicted to purchase good j. This share is given by

$$s_j(\cdot; Z_i) = \int_\epsilon \{V_{ij} = max_{k\in(A,B,P,S)} V_{ik}(\epsilon; Z_i, \alpha, \beta, \sigma, \delta)\} dP(\epsilon),$$

[24] σ_B^2 is normalized to one.

where (A, B, P, S) index the four choices. It obtains by conditioning on Z_i and the parameter values and integrating out the multivariate normal errors.[25]

Our estimation algorithm proceeds by fixing the 23 parameters for (α, β, σ) in the base specification at a candidate value for the maximum. We then use the observed product-market shares combined with the first order conditions for maximum likelihood to concentrate out the 396 fixed effects (in a manner we describe next). The search is then conducted over the smaller parameter space (α, β, σ), where at each considered value we must solve for the implied fixed effect terms.

Concentrating out the fixed effects

We face a significant computational challenge when product/market fixed effects are included for all product-market pairs. Unlike the case when these fixed effects enter linearly, it is not clear how we can concentrate them out if we do not assume the error follows a logit distribution. Estimating these parameters directly is computationally prohibitive; with 132 markets, 396 fixed effect parameters must be estimated in addition to the rest of the parameters in the model. We combine a result from Berry (1994) with the first order conditions for maximum likelihood to loosen this computational constraint.

Berry (1994) shows that, for discrete choice models satisfying standard regularity conditions, there exists a vector for each market $\delta^*_m = (\delta^*_{B(m)}, \delta^*_{P(m)}, \delta^*_{S(m)})$ – fixed effects – that equate the model predictions for market shares to those observed in the data.[26] Thus, we proceed by first fixing (α, β, σ) at a potential solution. Then, market by market, we solve for the vector $(\delta^*_{B(m)}, \delta^*_{P(m)}, \delta^*_{S(m)})$ that solves the three equations exactly:

$$\begin{aligned} s^*_B &= s_B(\alpha, \beta, \sigma, \delta^*_B, \delta^*_P, \delta^*_S) \\ s^*_P &= s_P(\alpha, \beta, \sigma, \delta^*_B, \delta^*_P, \delta^*_S) \\ s^*_S &= s_S(\alpha, \beta, \sigma, \delta^*_B, \delta^*_P, \delta^*_S), \end{aligned} \tag{13}$$

where (s^*_B, s^*_P, s^*_S) are the observed market shares for each of the three products, the m index is suppressed, and we get model predictions for the product-market shares from averaging over the Z_i's (i.e. the households) in a market.[27]

[25] We use simulation with 4000 draws per household (the error is negligible).

[26] B, P, and S, are short for expanded basic, premium, and satellite.

[27] To locate the fixed effects, we use the Nelder-Mead non-derivative search, which required more

5 Demand Results

We use the parameter estimates from our estimation routine to evaluate the own- and cross-price elasticities of demand for the various goods and to infer the welfare from the existence of DBS as a choice. The welfare calculations and the elasticity computations are really just two versions of the same question. The elasticities indicate what would happen to demand for a very small increase in the price of satellite. The welfare gain reflects what would happen to utility from a rise in the DBS price large enough to eliminate all DBS demand.

We include variables that the cable literature indicates are important (see Hazlett and Spitzer (1997), Crandall and Furchtgott-Roth (1996)). Gender, household size, marital status, and education enter all of the equations (except, of course, the baseline of antenna-only) allowing them to influence the taste for each good differently. We have controls in the satellite dish equation for the angle of the dish, renter status, and single-unit dwelling status. We also have controls for differences across markets in the weather, variance in elevation, and the number of over-the-air channels, which may affect the quality of and demand for the different types of television. We report the results of our estimation routine in table 5.

Before turning to these results, we test to see if our specification is flexible enough to capture household-specific variation in price sensitivity. We estimate a more general specification that interacts the demographic coefficients with prices for the expanded basic and premium choices, allowing price sensitivity to vary across different groups. With four demographics in expanded basic and premium each, there are eight additional parameters. The estimates on the price interaction terms are small in magnitude and the likelihood function value changes by only a small amount. We could not reject the null that all of the parameters (considered en bloc) are equal to zero at the 10% level of significance. We proceed with the simpler specification reported in table 5.

As with any non-linear framework, the coefficients do not have the direct interpretation as marginal effects on purchase probabilities. Instead, they indicate the

function evaluations than a Gauss-Newton approach, but did not require the computation of the Jacobian or Hessian matrix (see Nelder and Mead (1965).)

change in the utility relative to the antenna only option. Most of the variables have the expected signs. The results indicate that increases in household size increase the purchase probability of multichannel video relative to antenna only. Both living in a single unit dwelling and not renting increase the likelihood of having satellite. Single females are much less likely to adopt satellite dish relative to single males and to other households generally. Price sensitivity decreases monotonically as income increases (reported in table A1 in the Appendix).

We translate these parameters into marginal effects in table 6. We compute marginal effects by first choosing a group for consideration, say renters, and then asking how the average purchase probability of DBS for that group changes if they change their group status (i.e., become non-renters). In Column 1, for example, we report the average change in purchase probability as a multi-unit dweller moves to a single-unit dwelling. This is calculated by averaging over all of the purchase probability changes for multi-unit dwellers (holding other characteristics at their observed levels).[28] Thus, the first column shows the average percentage change in market shares (for multi-unit dwellers) that results from everyone in the sample that resides in a multi-unit dwelling moving to a single-family home, holding all other characteristics constant. The results suggest that living in a single-family home makes it 55% more likely that one will adopt satellite relative to living in a multi-unit dwelling, holding other observables constant. This comes largely at the expense of expanded basic and premium cable (which have smaller percentage changes because their base probability is much larger). Similarly, holding other characteristics equal, switching from renter to non-renter substantially increases satellite adoption probability at the expense of the three other alternatives. Increasing household size reduces the likelihood of antenna-only and expanded basic cable in favor of premium and (especially) satellite.

Note that the income elasticity that comes out of these estimates is quite modest. Doubling income from thirty to sixty thousand leads only to an 8.8% increase in satellite adoption, an income elasticity of less than 0.1. This estimate is robust across

[28] Instead of evaluating the marginal effect at (for example) the average of the household demographics, this approach evaluates the effect for every household, and then averages across households.

Table 5

Parameter Estimates: Consumer-level Demographics

Four Choices: Antenna Only, Expanded Basic, Premium, and Satellite

Variable	Coefficient	Asymp. Std. Error
Expanded Basic:		
Single	-0.057	0.027
Male*Single	-0.004	0.040
HHSize	0.017	0.006
Education	-0.026	0.005
Premium:		
Single	-0.020	0.042
Male*Single	-0.047	0.058
HHSize	0.070	0.010
Education	0.003	0.008
Satellite:		
Rent	-0.285	0.028
HHsize	0.124	0.013
Single	-0.179	0.055
Male*Single	0.172	0.068
Education	-0.003	0.010
Single Unit Dwelling	0.443	0.010
Log Likelihood	-52758	
Observations	46861	

Note: Specification is estimated using the largest 132 cable franchises in the top 69 television markets (DMAs). Annualized fixed cost for satellite is set at $100. The specification also includes 396 product-market fixed effects, 4 terms allowing price sensitivity to vary across income groups, and 5 parameters characterizing the distribution of the unobserved terms. See the Appendix for these parameters (all of which are precisely estimated).

Table 6

Marginal Effects on Group Purchase Probabilities

Changing from	MU Dwelling	HH Inc. = $30K	High Sch Educ. (HoH)
To	SU Dwelling	HH Inc. = $60K	Post College Educ. (HoH)
Changes avg prob (%):			
Antenna Only	-0.60	-23.23	6.11
Expanded Basic (EB)	-3.16	6.64	-8.27
EB and Some Premium	-3.82	10.27	5.01
Satellite	55.86	8.80	1.75

Changing from	Renting	HH Size=2	Single
To	Not Renting	HH Size=4	Not Single
Changes avg prob (%):			
Antenna Only	-0.45	-6.04	-4.54
Expanded Basic (EB)	-2.38	-5.14	3.53
EB and Some Premium	-2.97	5.52	-0.03
Satellite	30.72	14.35	3.37

Notes: Specification is estimated using the largest 132 cable franchises in the top 69 television markets (DMAs). Probabilities obtained by evaluating each household's change in probability (holding all other characteristics constant), and then averaging these changes across households for the demographic group under consideration. MU/SU Dwelling is Multi-Unit/Single Unit Dwelling, HH Inc is household income, and HH Size is household size.

different values of the income change. Given that average spending on television is about $300 per year, well less than 1 percent of household income, increasing prices by 10 percent would reduce demand by less than 0.1 percent through the income effect. The price results later suggest that the same price change would reduce demand by almost 50 percent through the substitution effect. Thus, we feel that assuming zero income effects when calculating the demand elasticities leads to negligible bias.

Deriving Price Elasticities

We face one remaining identification issue before we can compute price elasticities. The effect of price on average quality, $\frac{\partial \delta}{\partial p}$, remains unidentified.[29] To estimate price elasticities we need an estimate of

$$\frac{\partial V_{ij}}{\partial p_j} = \frac{\partial \delta_j}{\partial p_j} + \alpha_i(y_i) = -\alpha_0 + \alpha_i(y_i).$$

Although estimates of the α_i's obtain from the maximizing the likelihood function, α_0 is nested inside the estimated fixed effects.

We estimate α_0 (and the $\overline{\beta}$'s) using a regression of the estimated fixed effects on cable company characteristics, including price, channel capacity, pay-per-view availability, number of premium channels available, franchise age, and dummy variables for the MSOs. In essence, we directly estimate equation (6) using the cross-market variation in $\hat{\delta}_{Base}$ and $\hat{\delta}_{Prem}$ and the observed cable characteristics. Note that the fixed effects – the dependent variables in this regression – are themselves estimates, so the results of this regression can informally be used to check the plausibility of our model, since we expect, for example, that (conditional on price) better characteristics should improve utility.

We present the results in table 7. In column 1 we estimate these parameters using OLS and the expanded basic fixed effects as dependent variables. This is equivalent to assuming that there is no correlation between price and the unobservable component of quality. An endogeneity problem will arise whenever the unobserved quality component, which is known by consumers and the cable company but not by us, is also correlated with price. Usually, this biases the price elasticity towards zero, since the unobserved characteristics tend to be positively correlated with price.

[29]See Berry, Levinsohn, and Pakes (1998) for a discussion of this issue.

Table 7

Parameter Estimates from Market Fixed Effects
Dependent Variable: $\hat{\delta}_{Base}$ or $\hat{\delta}_{Prem}$

	OLS Coefficient (Std. Error)	2SLS Coefficient (Std. Error)	2SLS Coefficient (Std. Error)	G2SLS Coefficient (Std. Error)
Dependent Variable	$\hat{\delta}_{Base}$	$\hat{\delta}_{Base}$	$\hat{\delta}_{Prem}$	$\hat{\delta}_{Base}$
price	-0.175	-0.445	-0.430	-0.496
	(0.072)	(0.160)	(0.151)	(0.177)
intercept	-35.3	-36.7	-41.8	-37.8
	(28.8)	(30.5)	(30.8)	(28.0)
channel capacity	0.002	0.011	0.013	0.013
	(0.007)	(0.009)	(0.009)	(0.010)
pay-per-view avail.	-0.085	0.165	0.161	0.202
	(0.390)	(0.433)	(0.435)	(0.465)
number pay channels avail.	0.121	0.048	0.082	0.026
	(0.106)	(0.118)	(0.115)	(0.097)
AT+T/TCI	2.37	2.20	2.71	2.29
	(0.402)	(0.434)	(0.435)	(0.403)
Cablevision	1.50	1.27	1.89	1.30
	(0.723)	(0.775)	(0.792)	(0.607)
Comcast	1.89	1.63	1.93	1.69
	(0.508)	(0.555)	(0.563)	(0.475)
Cox Communications	3.25	2.79	3.09	2.79
	(0.688)	(0.766)	(0.774)	(1.020)
Jones Intercable	1.66	1.36	1.60	1.28
	(0.706)	(0.764)	(0.786)	(0.492)
Media One	2.47	2.20	2.43	2.16
	(0.515)	(0.563)	(0.575)	(0.459)
Time-Warner	3.49	3.62	4.06	3.82
	(0.414)	(0.443)	(0.446)	(0.748)
R-squared	0.543	n.a.	n.a.	n.a.
Reject Using Overidentification Test?	n.a.	NO	NO	NO
Observations	132	132	132	132

Note: Specification is estimated using the largest 132 cable franchises in the top 69 television markets (DMAs). All regressions also include controls for the top 7 MSOs, weather, and variance in elevation, number of over-the-air channels available, and year established. Generalized two-stage-least-squares accounts for sampling variation in market shares.

Columns 2, 3, and 4 report results from three different instrumental variable approaches designed to address the potential price endogeneity. Column 2 includes estimates from a standard two stage least squares (2SLS) estimator for the expanded basic fixed effects on characteristics of the cable company, MSO dummies, and controls for weather and the variance in elevation (which may influence how much people watch television or whether people choose local antenna reception). Column 3 reports the same regression but uses the fixed effects obtained for premium as dependent variables. Column 4 uses the expanded basic fixed effects and a generalized 2SLS estimator that accounts for the sampling variability in the market shares (and the variance they introduce into the estimated fixed effects).[30] Our cost shifters that instrument for price include the average price for the MSO to which the cable company belongs (excluding its own price), log(density) of the population, and the city franchise fee (a tax on revenue). The increase in r-squared that obtains when the instruments are added to the regression of price on characteristics is close to 0.2 for both the expanded basic and premium price regressions.

The OLS coefficient on price is only one-third the magnitude of that obtained from the IV regressions. Thus, the OLS results suggest that unobserved qualities (or omitted variables) of the cable services in an area are positively correlated with the price of cable. This bias will be apparent when we report the elasticities and welfare numbers.

The results from all three IV estimators are quite similar, and the price sensitivity is significantly higher. As predicted by the model, the price coefficient obtained from the expanded basic fixed effects regression of -0.44 is almost identical to the -0.43 obtained from the regression of premium fixed effects on price and characteristics. All of the coefficients we obtain on the other variables are consistent with our priors, as characteristics we would associate with higher quality increase δ (and thus the pur-

[30] The weighting scheme for generalized 2SLS accounts for the variance in δ from the sampling error in the market shares s. This variance is given by

$$V(\delta) = \frac{\partial \delta}{\partial s} V(s) \frac{\partial \delta}{\partial s}' \qquad (14)$$

and we use estimates of $V(s)$ and $\frac{\partial \delta}{\partial s} = \frac{\partial s}{\partial \delta}^{-1}$ to approximate it.

chase probability), though the coefficients are not significant. Higher quality systems are those systems that have more channel capacity, availability of pay-per-view, and more pay channels. The seven MSO dummies are significant and are associated with higher quality. In none of the three cases do we reject the test of over-identifying restrictions (a Hausman test) at the 10 percent level. Having recovered an estimate of α_0, we now proceed with estimating demand and welfare.

Table 8

Elasticity of Demand with Respect to Price

Method:	OLS	2SLS	2SLS
Elasticity of			
Expanded Basic w.r.t.			
Expanded Basic	-0.37	-1.27	-1.35
Premium	0.11	0.42	0.39
Satellite	0.23	0.82	0.74
Premium w.r.t.			
Premium	-0.21	-0.74	-0.68
Expanded Basic	-0.16	-0.58	-0.52
Satellite	0.13	0.47	0.35
Satellite w.r.t.			
Satellite	-1.39	-4.92	-4.10
Expanded	0.59	2.08	2.10
Premium	0.12	0.44	0.37
Annualized Fixed Cost	$100	$100	$50

Notes: 2SLS is two stage least squares. Specification is estimated using the largest 132 cable franchises in the top 69 television markets (DMAs). Annualized fixed cost is the amount consumers perceive they pay each year towards the cost of dish and installation.

Table 8 presents the relevant own and cross-price elasticities of market share for each television choice. All results use the largest 132 cable franchises located in the top 69 DMAs. In the estimation we treat the premium choice as expanded basic plus premium. When we compute the elasticities, the price of expanded basic is also included in the price of premium (but not vice versa, of course).[31]

In column 1 we present results using OLS estimates from fixed effects regression and an annualized fixed cost of $100. Assuming there is no endogeneity problem leads to estimates of the own price elasticities of expanded basic, premium, and satellite that are very low. Without instruments, one would conclude from the magnitudes that none of the component markets of television are very price sensitive. This is the root of the problem with using conventional hedonic methods in a situation where there are unobservable attributes.[32]

Columns 2 and 3 use the estimates of α_0 obtained from the two stage least squares (2SLS) fixed effects regressions. Column two is the IV equivalent of column 1. Column three uses an annual fixed cost of $50. For the most part, results are not sensitive to this choice. The own price of expanded basic ranges between -1.27 and -1.35 and satellite ranges between -4.10 and -4.92. These cable price elasticities are similar in magnitude to the results found in the literature such as Crawford (1997), Hazlett and Spitzer (1997), U.S. General Accounting Office (2000), or Crawford (2000).

As we expect, the cross-price elasticity of premium with respect to the price of basic, is negative. Expanded basic is a component of premium cable (to get HBO, the customer must already be a basic cable subscriber). Thus, raising the price of basic eliminates premium consumption for some consumers.

Overall, the elasticities suggest that demand for satellite is quite price sensitive to its own price and to the price of cable. In the elasticity sense, cable prices are not too influenced by the price of satellite. This is primarily a result of the market shares; if a price change leads a consumer to switch, this individual has a larger percentage effect on the demand for satellite than it does for cable.

[31] Thus, symmetry still holds in the demand model despite the apparently anomalous cross-price terms in the table.

[32] For a discussion of the importance of instruments in the context of estimating welfare gains, see the debate in Hausman (1997a) and Bresnahan (1997), and Petrin (2001).

6 Welfare

Our measure of the welfare gains accruing to DBS consumers is a standard surplus estimate of the compensating variation. In other words, we ask how much money a consumer would need to be given to make them indifferent to losing their satellite.[33]

Before presenting the results, we describe the algorithm that the estimator uses to translate observed price differences across markets into aggregate welfare numbers. To illustrate the idea, think of a world where the only multichannel video alternative to satellite is expanded basic, that expanded basic is of equal quality across all markets, that consumer preferences across markets are identical, that income effects are negligible, and that variation in price differences between satellite and cable are large enough to induce, in at least one market, no consumption of satellite.

The algorithm starts in the market with the smallest price difference between satellite and cable. It compares the satellite share in this market to the satellite share in the market that has a slightly higher price difference (between satellite and cable). For small changes in the price difference, the change in the market share of satellite is approximately equal to the share of consumers with surplus equal to the change in the price difference. Similarly, as price differences increase (as more markets are considered), the changes in share associated with incremental changes in the price difference give the fraction of consumers with this higher amount of surplus. Once demand reaches zero, the share-weighted sum of surpluses gives the average aggregate welfare gain from the existence of DBS.

In practice, we follow this approach but control for differences in demand (and valuation) that arise from variation in demographics and the quality of the available choices across markets. Thus, for the baseline we use the level of utility when satellite is available and then ask how much money it would take to achieve this utility level

[33]Unlike a Paasche or Laspeyres index, this measure can accommodate the substitution effects brought about by changes in relative prices, making it well-suited to compute welfare gains due to new product introductions, since they can be viewed as a major reduction in the relative price of the new good from infinity (or at least from some very large number where demand is zero) to the actual price that exists in the market. Hicks (1946) introduces a number of different cost-of-living indexes. Hause (1975) and Mishan (1977) provide helpful discussions.

without the satellite option. We can write this compensating variation (CV) as the change in income that equates $V(\cdot)$ across the two environments considered, or

$$V_i(p, y_i; Sat) = V_i(p, y_i + CV_i; NoSat). \tag{15}$$

Table 9 reports the welfare gains to satellite consumers from entry of DBS. We begin by stressing the importance of using methods to control for endogeneity. We obtain estimates of welfare gains approximate three and a half times larger than corrected estimates when we assume there are no unobserved quality differences across markets (i.e., using OLS).

We estimate welfare using the IV estimates from table 7 with annualized equipment cost numbers for consumers of \$100 and \$50. The welfare results are robust to these choices, and are approximately equal to \$100 dollars per year (in excess of the price they pay for satellite). This is about \$1 billion in the aggregate. In terms of substitution, almost 95% of satellite consumers turn to some form of multichannel video (either expanded basic or premium) when they lose the satellite option. Antenna-only appears to be a poor substitute for satellite. Of those that turn to multichannel video, between 50% and 60% are estimated to turn to premium cable, with the rest going to expanded basic.

A standard criticism of the literature on calculating the welfare gains from new goods is that much of the welfare gain comes from extrapolating a functional form estimated using market prices and quantities out to regions where no data are observed (i.e., that the true choke prices are not observed).[34]. In our final specification, we illustrate that in our setting this is not true. We have sufficient price variation and variation in market shares (after controlling for observable attributes) to yield actual market data on choke prices. We observe markets where, after controlling for attributes like the angle of dish reception and so on, the market share of DBS is very close to zero. To illustrate this, we bound the welfare calculation to be only from raising the price of satellite to the largest observed difference in price in our sample. The result for this exercise is in the final column, and we see that more than 96 percent of the total welfare gain computed in column two can be accounted for without extrapolation outside the sample.

[34] See the discussion in Goolsbee (2002)

Table 9

The Welfare Change

Annual Compensating Variation for Satellite Purchasers

	OLS	IV	IV	IV
Mean	$363.48	$98.80	$102.44	$95.16
Std. Dev	$129.48	$26.52	$28.08	—
% substituting to exp basic	38.0	38.0	45.7	—
% substituting to premium	57.1	57.3	49.7	—
Annualized Fixed Cost	$100	$100	$50	$100
Uses only observed price variation	NO	NO	NO	YES

Notes: Annualized fixed cost is the amount consumers perceive they pay each year towards the cost of dish and installation. Column 4 uses only price differences between satellite and cable up to the maximum observed in the data (i.e. does not increase it to infinity).

We close by considering other sources of welfare gains from new products. In the results above, we have shown that the estimated direct gains to satellite buyers from DBS are certainly positive but not enormous, once we properly estimate the demand system. We have assumed, though, that eliminating satellite would not change the incumbent price of expanded basic or of premium cable, in keeping with the findings of the U.S. General Accounting Office (2000). The standard practice in the demand literature is to take supply characteristics as given when estimating the demand system. It is perfectly plausible, however, that the introduction of home satellites could reduce (or perhaps increase) the prices of cable television for the people who do not switch to the new technology. These welfare gains or losses are part of the proper social welfare gain from new products and Petrin (2001) and Hausman and Leonard (1998) show that (at least in the cases of minivans and toilet paper) these indirect welfare gains can be quite large.

We take up the supply response of cable companies to the threat of satellite in Goolsbee and Petrin (2002). This subject is complicated by the fact that there are many potential margins of response in addition to price.

7 Conclusions

In this paper we use an extensive micro data set to examine the welfare gains from the introduction of a new form of television, the Direct Broadcast Satellite, and to estimate the demand system for cable. We add to the discrete choice literature on demand estimation, developing a framework that exploits consumer-level data and data on product characteristics and prices, uses extensive controls for unobserved product quality, and permits the distribution of unobserved tastes to follow a fully flexible multivariate normal distribution. We find a low own-price elasticity of both expanded basic and premium around -1. The satellite own-price elasticity is much higher (in absolute value), between -4 and -5, and the cross-price with respect to expanded basic is around 2 and much smaller for cable. The direct welfare gain to satellite buyers averages $100 per year or approximately $1 billion annually in the aggregate. While we find that without satellite most consumers would substitute to the premium cable option, many would also turn to just expanded basic. Estimates that do not control for unobserved attributes and endogenous prices yield very inelastic demand curves and welfare estimates that are several magnitudes larger than methods which correct for these problems.

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Table A1

Income Effect Parameters

Four Choices: Antenna Only, Expanded Basic, Premium, and Satellite

Variable	Coefficient	Asymp. Std. Error
Income terms:		
α_1 (\$27.5K - \$47.5K)	0.038	0.004
α_2 (\$47.5K - \$65K)	0.060	0.005
α_3 (\$65K-\$87.5K)	0.072	0.005
α_4 (\$87.5K+)	0.088	0.004
Log Likelihood	-52758	
Observations	46861	

Note: Specification is estimated using the largest 132 cable franchises in the top 69 television markets (DMAs).

Table A2

Unobserved (MVN) Taste Distribution Parameters

Four Choices: Antenna Only, Expanded Basic, Premium, and Satellite

Variable	Coefficient	Asymp. Std. Error
Multivariate Normal terms:		
$\sigma_{BA,PA}$	1.275	0.010
$\sigma_{BA,SA}$	2.233	0.014
$\sigma_{PA,SA}$	0.938	0.015
σ^2_{PA}	1.432	0.014
σ^2_{SA}	1.108	0.010
Log Likelihood	-52758	
Observations	46861	

Note: Specification is estimated using the largest 132 cable franchises in the top 69 television markets (DMAs).