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

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December 3, 2000

Preliminary: Please do not cite without permission

*We would like to thank Steve Berry, Judy Chevalier, Greg Crawford, Steve Levitt, Kevin Murphy, and Greg Werden for helpful discussions. We would also like to thank Andrew Lee for superb research assistance and David Rowley, Chairman of the University of Chicago Geophysical Sciences department, 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.
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Abstract

This paper examines the welfare gains due to the introduction of Direct Broadcast Satellite, the alternative to cable television. Our measure uses extensive micro data on the television consumption of 100,000 people, including the prices and characteristics of cable companies throughout the nation. Our results suggest that the introduction of home satellites created about $185 per year on average of surplus for adopters, putting the total annual gain (for adopters) at approximately $1.33 billion. The estimated own price elasticity for cable is slightly above one at (-)1.21.

1 Introduction

In the last two decades economists have devoted increasing attention to the importance of new goods (see Bresnahan and Gordon (1997)). Considerable strides have been made in developing ways to estimate the demand for new goods and the welfare gains they bring to consumers (Feenstra (1988),Trajtenberg (1989),Crawford (1997),Hausman (1997a), Berry, Levinsohn, and Pakes (1993),Petrin (1999),Nevo (2000)).[1] The role of new goods is especially important in fast-growing industries like telecommunications and consumer electronics. In this paper we consider the introduction of a major consumer electronics good, the direct broadcast satellite (DBS).

Starting in the mid-1990s, consumers could purchase a small satellite dish and pay a monthly fee to receive satellite programming as an alternative to cable television. We examine consumer demand for this new product for three reasons. Our primary reason for focussing on this market is that Americans, it is often said, have a love affair with their television. Some stylized facts include: the average household has the television on more than seven hours of television per day (NielsenMediaResearch (1999)), total television advertising in 1999 exceeded $45 billion, 97% of U.S. households have at least one television, and almost 75% have cable or a satellite (the so called multichannel video systems), and millions of these households had by 1998 paid the fixed cost of $400 to obtain satellite television. Thus, minor product improvements in this industry may generate large welfare gains to consumers.

Second, the demand for DBS versus cable is central to the debate over deregulation. For the most part, cable television is dominated by local monopolies. In an attempt at encouraging start-up cable companies and/or local phone companies to compete with the existing cable franchises, the FCC has gradually deregulated prices over the past several years. In general, this encouragement has not succeeded, and for most U.S. consumers DBS is the *only*

[1] The failure to account for the welfare gains from new products has also been at the root of government policy debates such as computing the Consumer Price Index or the deadweight costs of regulatory and tax policies that affect product quality or new product introductions (see (Boskin Commission,**),Shapiro and Wilcox (1996), Hausman (1997b),Hausman (1998), Goolsbee, (1999),Crawford (2000)).

multi-channel video alternative to the local cable monopoly. An estimate of the substitutability of cable and satellite at current market prices is fundamental to evaluating the market power of cable and the first step in understanding the ramifications of deregulation.

We provide estimates on the own and cross price elasticities for cable and satellite. The own price elasticity of satellite (in absolute value) is almost 3. The own price elasticity of cable is actually less than one, suggesting possibly the continued role of the threat of regulation and/or some form of predatory pricing on the part of cable companies.

2 Cable, Satellite, and the Market for Video Services

In this section we discuss the history and context of the two primary alternatives to regular network television that exist for most U.S. consumers–cable and DBS.

2.1 Cable Television

The context for the introduction of home satellites is the overwhelming success of cable television in the last two decades. Cable began many years ago as a way for rural customers to improve their signal for network television. By the 1980s, however, it had become a major source of programming in its own right and since 1980, has spread enormously and expanded its offerings. By 1999, almost 75 percent of households in the United States had cable and the average customer received 57 channels from their cable provider NielsenMediaResearch (1999).

For most of its history, regulators treated cable as a natural monopoly. This entailed franchise bidding in each market coupled with price regulations. The government began a process of rate deregulation in 1984. Over the next seven years, average prices rose significantly faster than the rate of inflation, and controversy remains over whether this was due to increased markups or to quality improvements (see Rubinovitz, 1993; Jaffe and Kanter, 1990; Crandall and Furchtgott-Roth, 1996). In response to this period of rising cable prices, the federal government decided to reregulate cable prices in 1991. The impact and evolution of cable after this period is analyzed in Crawford (2000).

General unease with regulatory solutions lead the government to take a different approach to cable in the Telecommunications act of 1996. The act phased out most price regulation under the view that the best way to help consumers was not to regulate but to encourage entry and competition. One of the justifications for this view was the evidence on cable prices in places where a second cable company had entered to compete with the incumbent firm (known as overbuild markets). The evidence indicated that in these markets, existing cable companies charged much lower prices and offered more channels and services (see the discussion of the evidence in Hazlett and Spitzer, 1997). The FCC tried to get out of the business of regulating cable prices and instead encouraged Local Exchange Carriers (i.e., local phone companies) to enter the cable market and create direct competition (see FCC, ***). Since that time, however, few phone companies have entered the cable business and overbuild markets are relatively rare. In most cases, the only direct competitor to the incumbent cable monopoly are DBS systems.

2.2 Home Satellite Systems

Television satellites broadcast from a geosynchronous orbit–22,300 miles above the earth exactly at the equator thus always remaining in the same spot in the sky. During the 1970s and 1980s, the cost of a satellite receiver fell to a few thousand dollars and numerous rural consumers bought the large 9 foot C-band dishes from which they could view programming. The C-band signal is weak, however, and the dish and programming relative expensive (and impractical in most urban areas). Although the precursor to todays DBS systems, the older dishes are not viewed as a serious competitor to cable and we exclude rural areas from our analysis to avoid them.

By the mid-1990s, however, an explosion in the amount of programming broadcast via satellite as well as some key improvements in satellite receiver and digital compression technology enabled the creation of the DBS services as they currently exist (see Owen (1999) for a more detailed history). These satellites broadcast on the Ku-band at frequencies of up to 17.8 gigahertz to receivers as small as 18 inches in diameter. The most popular of the systems is DSS, a joint venture of DirecTV and USSB. This system began in 1994. Other systems include (at the time of our sample) Primestar and the DISH network (since then, Primestar was taken over by DirecTV). These satellites offer subscribers hundreds of channels of programming with digital video and sound whose quality is superior to that of video broadcast over-the-air or on conventional cable. The DBS systems also offer much more extensive sports and movie programming than most cable systems as well as more extensive pay per view options.

These advantages do not come cheaply, however. In addition to the monthly programming fees, consumers subscribing to these services usually pay for the equipment themselves, averaging around $400 including installation at the time of our sample. The comparable programming packages are slightly more expensive on DBS than on most cable systems, as well. In 1998, the average cost of expanded basic was $31 for the average cable system (DirecTV (2000), FCC, **) while the average cost for the standard cable channels on DirecTV was $32 and this did not include the major networks (e.g., ABC, NBC, CBS, Fox). Clearly with its pricing and programming options, DBS was intended for the higher end of the market.

Despite the large installation costs and higher programming fees, consumers have embraced the product. From a base of about 600,000 at the end of 1994, the number of households that subscribe to satellite exceeded 7 million by 1998 and ** by 2000 (FCC, **). DBS systems now account for about two-thirds of all new subscriptions to multichannel video systems (FCC, **).

There have been some obstacles, part regulatory and part physical, to consumer adoption of the DBS systems. At the time of our sample (the start of 1998), the most well known drawback from buying a DBS system vis-a-vis cable was the regulatory restriction preventing DBS customers from receiving local network content if they lived in an area where such channels were available using an over-the-air television antenna (FCC, **).[2] This meant that in television markets where there are fewer over-air channels available or where mountainous terrain makes over-air reception difficult, consumers might find the satellites to be a worse substitute for cable. It might be best to think of this as, in some sense, a price increase for satellite in these areas since individuals are allowed to subscribe just to the local broadcast stations from their cable company for a fee (and, indeed, many satellite customers do subscribe to cable to get network channels).

A second regulatory hurdle at the time of our sample was the unclear interpretation of the 1996 Satellite Home Viewer Act. While this act forbid most regulations against home owners putting up satellite dishes, it did not establish a clear right for renters to do the same.[3] Thus, we would expect that, holding everything else constant, renters will be less likely to prefer satellites to cable.

The most important physical drawback to DBS versus cable is that the user must have a clear line-of-sight to the broadcast satellite in the sky in order to receive programming. Buildings, terrain, even foliage can block or degrade the signal. This means that people living in single family dwellings can position the dish in many directions, and thus have a better chance of getting an unobstructed line-of-sight than people living in multi-unit buildings. It also means that people may have widely differing probabilities of ground based interference depending on their elevation, latitude, and longitude. For example, a person in Seattle needs a clear line of site at 31.5 degrees above the horizon. In Houston, they need a clear line at only 55 degrees.[4] We now turn to our data.

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[2] Technically, anyone receiving a grade B signal was eligible to get network via the satellite dish. This rule was changed in the *** act of 2000 so that consumers in most major television markets can now receive their local channels for an additional fee.

[3] 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.

[4] This problem of greater interference at higher latitudes is well known in the industry and explains why the Soviet Union (almost all of which is at a high latitude) has spent considerable effort to develop non-geosynchronous satellite systems(see Owen (1999).

3 Data on Television Choices

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

3.1 Sources

Our primary data on individual consumers' television choices comes from surveys done by Forrester as part of their Technographics 1998 and Technographics 1999 programs. Forrester is a leading market research company focusing on the information economy and each year they survey close to one hundred thousand 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. (1999) or Goolsbee (2000).

Table 1
Summary Statistics

Variable	Mean	Std. Dev.
Just Network	0.26	0.43
Cable	0.66	0.46
Satellite	0.04	0.19
Cable and Satellite	0.04	0.19
Angle	41.82	5.87
Rent	0.31	0.46
Income	$46,250	$28,461
Household Size	2.57	1.31

The survey provides various demographic information about the individuals in the sample including race, gender, age, family income, marital status, presence of children, education, as well as their state and their television market (known as the DMA). Table 1 gives summary statistics for some of the variables used in the study for our sample by medium choice. We exclude people living in metropolitan areas smaller than 250,000 people or in rural areas to avoid the rural C-band satellite customers, as mentioned before, as well as to avoid locations where cable itself might not be available. The centerpiece of our estimation uses the 1998 survey (conducted in December of 1997). This survey asked individuals whether they had a television connected to cable, a television connected to a satellite dish, and how many hours they watch per week of network television and of cable or satellite television. In the sample, 8% of households have a satellite dish and 26% has neither cable nor satellite.[5]

Our measures of cable system prices and characteristics come from Warren Publishing's 1999 Television and Cable Factbook (WPI, 1999). This is the most comprehensive reference for cable system characteristics in the industry. Since there are many different cable franchises within a given market, we take the largest cable franchise in the television market-state combination for the information.[6] We include the number of channels, the number of pay channels available, whether pay per view is available from that cable franchise, the price of basic plus expanded basic for the system, and the city franchise fee as a percent of revenue. We also get from the Factbook the number of over the air channels available in the market area. As an alternative measure of price, we also use data from the Technographics 1999 survey (conducted in December of 1998) on the average price paid by people in the area for cable television. Finally, for some of the larger cable companies (like AT+T, Time Warner and Media One), we observe the fraction of households signed up in the DMA-State regions with these companies.

For each of the television markets, we also calculate the angle of elevation (up/down) and azimuth (right/left) at which a potential user of DBS would have to position their dish by taking the primary zip code for the major city from the World Factbook, 1998 and plugging it into the DirecTV dish pointer

[5] As described above, satellite users have the option of also signing up for cable. Since the higher channel offerings on satellite fully dominate the cable offerings in almost all markets during our sample, we assume that anyone reporting that they subscribe to both satellite and cable are only subscribing to basic cable in order to get the local networks and that they have chosen satellite for their multi-channel video.

[6] Many of the television markets cross state lines. The New York City DMA, for example, covers individuals in New York, New Jersey, and Connecticut so we would include the largest company in each of the three areas.

DirecTV (2000). We calculate the average elevation and variance of the local terrain using data from the One Degree U.S. Geologic Survey Digital Elevation Model data.[7] Various other data we use include the total population of the DMA given by NielsenMediaResearch (2000), and the quality of the weather in the area as measured by the climate stability index of the Place Rated Almanac (**) which may be correlated with peoples' incentives to spend hours watching television.

3.2 Overview and Identification

The goal of our empirical work is to estimate the price sensitivity of demand for both cable and satellite television and to use the consumer demand model to compute the welfare gains from the existence of DBS. To make this calculation, we will need structural models, which we describe shortly. Here we motivate our approach, providing some intuition for why the model works the way it does.

We start by noting that although the price and characteristics of DBS are constant across all the markets, the price and characteristics of cable vary considerably. In essence our demand estimates are identified by comparing people with the same observables to see if they are more likely to buy a satellite when the price of cable is higher.

One problem with estimating such a demand curve, of course, is the possible endogeneity of prices. If there exist unobservable (to us) characteristics of the local cable franchise that are known by both the consumers and the suppliers, and price responds to these unobservables, the price elasticity (typically) is biased towards zero. A cable system with the same observables but with notoriously bad service, for example, will tend to be less desirable and have lower prices, making it seem as though consumer demand doesn't respond to low prices. For this reason we try to 1) include as many important features of the market as possible, and 2) find plausibly exogenous variables that influence

[7] 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. The average elevation is just an average over-the-same area.

the price of cable but are uncorrelated with the unobserved (by us) characteristics of cable companies. Fortunately, as described above, there are several factors that might satisfy the exogeneity restriction and affect cable demand, including satellite angle, renter status or single-unit dwelling status. As table 2 indicates, these factors are indeed correlated with the share of people in the market who choose DBS over cable. In particular, satellite ownership is much higher for people with higher dish angles, people who rent, or people living in a single-unit dwelling. As long as these observables are uncorrelated with the unobserved characteristics of the cable markets, they are valid instruments for the price of cable.

To estimate our choice model, we make the standard assumption that prices and supply characteristics are given at the time of the sample. In future work we hope to examine the supply responses of cable companies to the introduction of satellite technology in the mid-1990s to see if cable companies endogenously altered their programming packages or their prices in response to the threat of satellite.[8] We also abstract from programming choices and differences between cable companies except on the observable dimensions described above.

Table 2

Characteristics of Multi-Channel Video Consumers

	High Angle	Low Angle	Own	Rent	Single Res.	Multiple Res.
Cable	86.85%	91.90%	87.82%	93.20%	87.71%	94.48%
Satellite	6.99%	3.54%	6.30%	2.72%	6.44%	1.67%
Cable and Satellite	6.15%	4.56%	5.88%	4.08%	5.85%	3.85%

[8]See Crawford (1997) for an analysis of changes in the programming, bundling, and quality choices in response to various types of price deregulation.

4 Demand and Welfare Estimation

This section describes the different approaches we use to estimate demand and the change in welfare. Our discussion includes a brief review of both the consumer's problem and some frequently used measures of welfare. We then describe the discrete choice approach that we use.

4.1 The Consumer's Problem

A consumer derives utility from many activities. Some of these activities require the consumer to make a fixed outlay in order to have the option of undertaking the activity. In our case, the consumer derives utility from television consumption, and three kinds of television are available: network, cable, and satellite. The consumer must pay a fixed cost to view cable or satellite television. The consumer can make one (or both) outlays, and these outlays determine the number of different types of television from which the consumer can choose. We index this choice set J by j, and note that

$$J = \{network, (network, cable), (network, satellite), (network, cable, satellite)\}.$$

The consumer solves

$$V(p, W) = \max_{j \in J} V(p, W; j), \tag{1}$$

where $V(\cdot)$ and $V(\cdot; j)$ are the unconditional and conditional indirect utility functions, j indexes the different combinations of television viewing mediums available, W is the dollar value of the consumer endowment, and p is the vector of prices.

4.2 Some Welfare Measures

Here we review a few commonly used measures of welfare and motivate the two that we choose. We start with a willingness-to-pay measure. We then turn to cost-of-living indexes, including the Laspeyres price index, which the U.S. government uses to construct the Consumer Price Index (CPI), and a compensating variation (i.e. utility-equivalent) index, which is probably what the U.S. government would ideally like the CPI to measure.

Willingness-to-pay measures are useful for determining the lower bound of consumer valuation. When the alternative (second) choice is known, the price difference between the first and second choice (e.g. satellite and cable) bounds from below the value of the first choice relative to the second. These price differences are often observed in data, and in fact are the price differences that will ultimately identify welfare gains in the discrete and discrete/continuous models that we employ. Thus, they provide a natural starting point when considering the change in welfare due to the introduction of the satellite dish.

Table 3

Willingness-to-pay for Satellite Dish

	Households	Lower Bound Value	Aggregate WTP
Just Satellite	3,639,000	$350	$1.556 Billion
Satellite and Cable	3,553,000	$400	$1.162 Billion

Table 3 reports a lower bound on willingness-to-pay (WTP) for satellite dish. It is based on the observation that anyone purchasing satellite could have consumed cable; thus, by revealed preference, they must value satellite more than cable by at least the amount of the difference in cost. For those folks that purchase both satellite and cable, WTP is the fixed cost of obtaining satellite. Roughly, for the U.S. as a whole, the aggregate WTP lower bound (which sums WTP across people) is $2.71 billion.

While easy to compute, WTP cannot tell us directly how much better or worse off consumers are, as WTP is not a cost of living index. One cost of living index that is often employed is the well-known Laspeyres price index. This index defines a bundle of goods (a standard of living) and asks how the cost of purchasing this bundle changes across environments or over time.

Unfortunately, this kind of index is not particularly well-suited to evaluating changes in the standard of living that come about as new goods enter the choice set. The reason is straightforward; new goods are not priced in both periods (or priced at infinity in the initial period, if you like), and by definition cannot be in the bundle of goods. Much of the focus on (mis)measurement in the CPI has been targetted at how the Laspeyres price index should me modified to account for new goods or quality changes in existing goods, in part because of findings like Armknecht (1984) that changes in the index are mostly due to the price inflation for new goods or from goods undergoing quality changes.

An alternative to the Laspeyres price index are utility-equivalent indexes.[9] Similar to the Laspeyres price index, which asks how income must change in order to be able to purchase the same basket of goods, one kind of utility-equivalent measures asks how income must change in order to achieve the same *level of utility* provided by a reference basket of goods.[10] Thus,this index can accommodate the substitution effects brought about by changes in relative prices when computing the change in the cost of living. This feature makes these indexes particularly well-suited to computing welfare changes due to new product introductions, which might be viewed as lowering the relative price of the new good from infinity (or some very large number where demand is zero) to the price difference that obtains in the market.

For our utility-equivalent cost of living index, we ask how much money a consumer would need to voluntarily give up their satellite dish. Thus, we use the utility level achieved with the satellite dish in the basket as the benchmark utility (our data is post-introduction), asking how much money one needs without the satellite dish to achieve the utility level with the satellite dish available. Using (1), we can write this compensating variation (CV) as the change in income that equates $V(\cdot)$ across the two environments considered, or

$$V(p^S, y) = V(p^{NS}, y + CV), \tag{2}$$

where p^S is the price vector with satellite in the market and p^{NS} is the price vector when it is not in the market. In order to compute this cost-of-living

[9] Hicks (1946) introduces these measures. Hause (1975) and Mishan (1977) provide helpful discussions.

[10] The Laspeyres index offers a first-order approximation to this kind of index.

index, we need to place more structure on the problem. We turn to the discrete and discrete/continuous approaches for this additional structure.

4.3 The Discrete Choice Approach

Discrete choice frameworks provide enough functional form to estimate changes in welfare.[11] A number of important results have recently been developed when using these characteristics approaches in demand estimation. Trajtenberg (1990) and Berry (1994) show that, without product-specific fixed effects, left out product characteristics (which are typically many) tend to be positively correlated with price, resulting in price-elasticities that are biased towards zero. Berry, Levinsohn, and Pakes (1998) show that even with detailed micro-level data, where one can let tastes for observed characteristics depend on many observed demographics, one does not fully capture taste heterogeneity; conditional on all of these observables, unobserved consumer-specific tastes for observed characteristics play an important role in explaining consumer demand for automobiles. We incorporate all of these aspects into our model of demand for television, as we suspect tastes for television viewing relate to both observed and unobserved product and consumer characteristics.

The conditional indirect utility function that consumer i (who is in market m) has for good j is given by

$$V_{ij} = \alpha_i(y_i - p_j) + \delta_j + \sum_r z_{ir}\beta_{jr} + \epsilon_{ij} \tag{3}$$

where α_i is the marginal utility of income, y_i is income, p_j is the price of good j, δ_j is the utility component common to all consumers for good j, z_{ir} is the rth demographic characteristic of consumer i that (potentially) affects demand for good j in an amount determined by the taste parameter β_{jr}. ϵ_{ij} is an idiosyncratic consumer-specific term that affects demand for good j. We discuss each of these components in turn.

We see income effects in our conditional means, and thus allow for income effects in a manner similar to Petrin (1999). The approximation takes a simple

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

form, where the parameter α_i is given by

$$\alpha(y_i) = \begin{cases} 0 & \text{if } (y_i \leq \overline{y}_1) \\ \alpha_1 & \text{if } (\overline{y}_1 \leq y_i < \overline{y}_2) \\ \alpha_2 & \text{if } (y_i \geq \overline{y}_2), \end{cases}$$

where $\overline{y}_1$ and $\overline{y}_2$ divide annual income into three different groups, less than \$30,000, between \$30,000 and \$60,000, and greater than \$60,000. There is a common price component for all consumers (part of the common utility term δ_j). The α's allow this price sensitivity to vary as income varies.

The common utility component is given by

$$\delta_j = \sum_k x_{jk}\overline{\beta}_k + \xi_j \tag{4}$$

where β_k are the common tastes across consumers for observed characteristics and ξ_j is an unobserved taste term associated with product j. The endogeneity of price concern arises because the ξ_j is likely to be correlated with price, as products with better unobserved characteristics are likely to cost more. In the television market, price is common across all markets for network (\$0) and satellite, so only cable presents a potential price endogeneity problem. Thus, including the dummy variable δ_j for each cable market yields an estimator consistent for all parameters that do not enter δ_j; those parameters contained within δ_j need additional restrictions to achieve identification.

Estimtates of price elasticities require an estimate of the price effect that is contained in the common utility component δ_j (the $\overline{\beta}_k$ associated with p_j) as $\frac{\partial \delta_j}{\partial p_j}$ is one component of this elasticity. Even the detailed consumer level data used in Berry, Levinsohn, and Pakes (1998) is not sufficient to solve this problem because there is only one observed market outcome, and thus only one observation for each product on δ_j. We are fortunate in the respect that we see many markets, and we have some plausibly exogenous demand shifters for cable; thus, we can estimate the coefficient $\frac{\partial \delta_j}{\partial p_j}$. We explore how our results change when we do not account for the endogeneity of price.

Since estimates of demand and welfare rely on consistent estimates of the substitution patterns between satellite and cable or network television, we allow tastes for television medium (i.e cable, satellite, or just network) to depend both on observed consumer demographics and on unobserved, idiosyncratic tastes for the product (that may, for example, derive from taste for movies or sports.) Tastes associated with observed demographic characteristics enter through $\sum_r z_{ir}\beta_{jr}$, which interacts demographics z_{ir} with product-specific tastes β_{jr}. Unobserved idiosyncratic tastes are given by the vector

$$\epsilon_i = (\epsilon_{i1}, \epsilon_{i2}, \epsilon_{i3}),$$

where every consumer has their own taste for network, cable, and satellite television.

The nested logit is perhaps the most popular choice for allowing unobserved covariances in taste across products, primarily because one can capture some forms of covariance between $(\epsilon_{i1}, \epsilon_{i2}, \epsilon_{i3})$ and still obtain a closed-form solution for market shares. We use a multinomial probit (MNL) because we want to allow for *differing* variance in tastes for network, cable, and satellite each, and for arbitrary covariance in tastes between network, cable, and satellite.[12] Since the nested logit cannot accommodate these richer patterns of potential substitution, we use the MNL (with simulation to integrate.) The cross-market variation in market shares is important for identifying the variances and covarianes of these unobserved tastes.

5 Estimation

We use a maximum likelihood estimator for our discrete choice model. 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 common utility component, and σ, the diagonal and off-diagonal terms for the variance covariance matrix of the unobserved taste heterogeneity. We model the purchase probability of four choices: just network, cable, satellite, and both cable and satellite, where we assume only basic cable is purchased (for access

[12]We want to allow, for example, the possibility that strong taste for satellite television might be correlated with strong taste for cable or network, and these tastes may be independent of observables.

to local channels.) In the end, we will use the model estimates to obtain estimates of demand elasiticities (changes in demand for small changes in price) and welfare numbers (changes in demand for large changes in price.)

The likelihood function with the consumer level data takes the form

$$L = \Pi_{i=1}^{N} \Pi_{j=1}^{J} s_j(\alpha, \beta, \sigma, \delta; z_i, X_j)^{j(i)} \tag{5}$$

where $j(i)$ is the indicator function

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

and N indexes individuals. We employ an insight by Berry (1994), noting that the market share function for cable, $s_j(\alpha, \beta, \sigma, \delta_j)$ is monotonic in δ_j for any fixed values of (α, β, σ). This observation permits us to concentrate out these 90 fixed effect parameters. Our estimation routine proceeds by first fixing (α, β, σ) at a potential solution to the maximization problem. Then, market by market, we solve for the δ_j^* that exactly matches observed cable market shares s_j^* to those predicted by the model, or

$$s_j^* = s_j(\alpha, \beta, \sigma, \delta_j^*).$$

(We do so because the maximum likelihood estimator would do exactly the same.) We then compute the value of the likelihood function at $(\alpha, \beta, \sigma, \delta^*(\alpha, \beta, \sigma))$, and continue by constraining our search for the maximum over the smaller parameter space (α, β, σ). We now turn to the results.

6 Results

We begin by discussing the parameter estimates. We then turn to implications of these estimates for the elasticities of demand and for consumer welfare.

Table 4 presents the parameter estimates. The first part of this table includes the estimates for the coefficients on the terms that interact the medium with demographics. The negative coefficient for renters on satellite is consistent with the conditional means presented earlier and the fact that, by law, it is more difficult for renters to locate a satellite dish on their premises (relative to a homeowner.) The negative coefficient on angle, while small, is inconsistent with the story that consumers in geographic regions which require the satellite dish to be set at a higher angle are more likely to get a satellite dish because reception is, on average, better. Single people appear to have a much lower propensity to consume either cable or satellite, perhaps a consequence of this status being correlated with lower income (and the need for more than three income effect terms.) Generally, these parameters are precisely estimated.

As described in the previous section, we include two terms to allow for income effects (the α's): α_1 is the income parameter for the median income group, and α_2 is parameter associated with the high income households. These parameters are precisely estimated and consistent with higher income consumers being less sensitive to price increases.

Correlation in cable and satellite taste is positive, estimated to be approximately 0.5. This outcome is consistent with one of our other important reduced form results. Most DMAs average approximately 75-80% viewership subscribing to cable or satellite. Within DMAs, the fraction of households that subscribe to cable and the fraction that subscribe to satellite is negatively correlated, suggesting that, within markets, people are substituting between cable and satellite. In the discrete choice results, it is this "across market" variation that provides some information on the correlation in taste between cable and satellite. This variation plays an important role in the welfare estimates because it identifies the fraction of satellite consumers that switch to cable under the counterfactual of no available satellite dish.

Table 5 presents the results from the regression of the estimated δ's (the market fixed effects) on characteristics common to individuals in a market. These characteristics include channel capacity of the cable system, number of channels provided on the system, pay-per-view available over the system, and market shares of some of the nationally dominant cable companies. We estimate the OLS model, which is akin to assuming the market unobserveds are uncorrelated with price. We also use instrumental variables to control for potential price endogeneity. The instruments are rental status (% in market that rent), angle, and type of residence (single or multi-unit dwelling). There

Table 4

Discrete Choice Parameter Estimates

Four Choices: Network, Cable, Satellite, Both

Variable	Coefficient	Asymp. Std. Error
Network:		
Over-the-Air Channels	-0.0375	0.0010
Cable:		
HHSize	-0.0028	0.0022
Single	-0.1881	0.0026
Education	0.0437	0.0021
Male	0.1182	0.0043
Satellite:		
Angle	-0.0010	0.0004
Rent	-0.1844	0.0024
HHsize	-0.0014	0.0023
Single	-0.2213	0.0037
Education	-0.0475	0.0023
Male	0.1346	0.0033
Both Cable and Sat (Satellite above plus)		
Over-the-Air Channels	0.0186	0.0041
Log Likelihood	-24786	
Observations	27302	

Table 4 (continued)

Discrete Choice Parameter Estimates

Four Choices: Network, Cable, Satellite, Both

Variable	Coefficient	Asymp. Std. Error
Income terms:		
α_1 (\$30K-\$60K)	0.1600	0.0017
α_2 (\$60K+)	0.1137	0.0020
Unobserved Taste Distribution:		
β_{Sat}	0.0951	0.0032
β_{Both}	0.1502	0.0043
$\sigma_{Network,Cable}$	0.4134	0.0028
$\sigma_{Network,Sat}$	0.4985	0.0031
$\sigma_{Cable,Sat}$	0.7311	0.0031
σ^2_{Cable}	1.7533	0.0039
σ^2_{Sat}	1.6809	0.0039
Log Likelihood	-24786	
Observations	27302	

are 90 market observations.

Table 5

Parameter Estimates from Market Fixed Effects

Four Choices: Network, Cable, Satellite, Both

	OLS		IV	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
intercept	1.760	0.660	3.100	1.800
price	-0.233	0.127	-0.505	0.363
channel capacity	0.001	0.001	0.002	0.002
number pay channels avail.	0.062	0.030	0.068	0.032
pay-per-view avail.	0.104	0.136	0.131	0.144
Observations	90		90	

Note: share of national cable companies in each market included. Instruments include angle, rental status, and type of residence (single or multi-unit dwelling.)

Table 6 presents the elasticities of market share for each medium with respect to the price of the medium. The high covariance in tastes between cable and satellite is reflected in the high estimated cross-price elasticity of 3.08 between satellite market share and the price of cable. The cable own-price elasticity doubles to -1.21 when we instrument (relative to OLS), suggesting unobserved characteristics play an important role here. If we ignore the price effect term altogether in the fixed effect, the elasticity falls to one-sixth of what obtains with instruments.

Table 7 presents the welfare numbers accruing to satellite purchasers. The counterfactual is evaluated at the prices that existed with both products in the market, and thus understates the true welfare gains to consumers. Thus, all gains to cable consumers from lower prices are ignored under this counterfactual.[13] (these numbers are a lower bound to the annual gains accruing to the

[13]We investigate the benefits accruing to non-satellite purchasers in separate work.

Table 6

Elasticity of Demand with Respect to Price

Elasticity of	IV	OLS	$\overline{\beta}_p$=0
Network w.r.t.			
Cable	2.15	1.19	0.37
Satellite	—-	—-	—-
Cable w.r.t.			
Cable	-1.21	-0.67	-0.20
Satellite	0.15	—-	—-
Satellite w.r.t.			
Satellite	4.34+	—-	—-
Cable	3.08	1.66	0.48

overall U.S. market.) Over 75% of previous satellite purchasers are estimated to substitute to cable. For the full specification with instruments, the average consumer requires $185 annually to compensate for the loss of satellite dish. Overall, with 7.2 million households purchasing a satellite dish, the annual gain works out to approximately $1.33 billion.

Table 7

The Welfare Change

Annual Compensating Variation for Satellite Purchasers

Mean	$185.64
Std. Dev.	$113.88
% substituting to cable	75

7 Conclusions

Americans, it is often said, have a love affair with their televisions. 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. Using a structural model of consumer demand, our results suggest that the average consumer buying satellite had an annual welfare gain of $185, with the total annual welfare gain at the time of the sample exceeding $1.33 billion. Finally, we find the own price elasticity of cable just barely above one, at -1.21.

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