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The Market for Subscription Television Service in the United States

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Abstract

This study develops a simultaneous equations model of the market for subscription television service consisting of analog and digital cable service. Beyond modeling the market for subscription television service and identifying the factors that impact the demand and supply of analog and digital cable service, an effort is made to determine the extent to which DBS service competes with cable television for subscribers in this market. The model consists of four equations - demand equations for analog cable service and digital cable service and supply equations for analog cable service and digital cable service. The model is estimated using the full information maximum likelihood technique. A number of factors clearly impact the demand and supply of analog and digital cable service and this impact is quantifiable. The size of the market measured as the number of households passed is, not surprisingly, a dominant factor in explaining analog and digital cable service demand and supply. Probably the most significant result is that the estimates indicate that while changes in the relative price of analog or digital cable service have no quantifiable impact on the demand for analog cable service, they do have a statistically significant effect on the demand for digital cable service. Finally, as the penetration of DBS service increases, the number of analog cable service subscribers is reduced.

Introduction

There are three primary technologies currently in the United States that deliver television service to individual households including over-the-air broadcasting, cable television, and DBS or Direct Broadcast Satellite. Each of these technologies is covered under a unique regulatory framework. Additionally, the channels that viewers watch on television fall into two primary categories: broadcast channels which include the broadcast networks and independent local channels and subscription channels. Over-the-air broadcasting is free to consumers with a television set and a suitable antenna. Cable television and DBS are subscription television services. A model of the market for subscription television service is presented which includes both the demand and supply of subscription television service. The model estimates empirically the extent to which cable television service and DBS service compete for subscribers. The model is based on data collected by the Federal Communications Commission on its 2004 FCC Annual Cable Price Survey. Before delving into the empirical issues, however, it is critical to understand the market for subscription television service.

Background

(a) Demand Considerations

The broadcast industry has two key components. The first is composed of local television stations. All television stations in the United States must be licensed by the Federal Communications Commission (FCC). The FCC license gives a station the right to use a specified portion of the radio spectrum to transmit video programming in a specific geographic region. A group of local television stations serving the same geographic region make up a television market. Because the video signal from a local television station is broadcast through radio waves or "over-the-airwaves," this method of providing television is called over-the-air broadcast television.

The broadcast television industry is funded primarily through national, regional, and local advertisements that are aired along with other programming on local television stations. Households that receive only broadcast television pay no subscription fee for access to the signals of the television stations in their geographic region. They only need to have a television set with an adequate antenna. The availability of broadcast stations has been shown to impact the market for television service. For example, a greater number of free broadcast stations will tend to reduce cable subscriptions and cable rates (Crandall and Furchtgott-Roth [1996]). According to the 2004 FCC Annual Cable Price Survey,[2] 36.4 percent of households in the United States did not subscribe to cable or any other subscription television service but relied on over-the-air broadcast technology for their television service.[3]

The second component of the broadcast industry is cable television. Cable television, originally called community antenna television service, developed as a way of providing the signals of local television stations to rural and mountainous areas that could not get adequate reception of those signals through conventional antennas. Cable systems obtain a franchise authorization under agreed upon terms and conditions from a local authority such as a city, county, or a township that grants them the right to operate in a specified area (known as the franchise area) and run cables along public rights-of-way.

During the 1970s developments in satellite technology enabled video signals to be transmitted economically via satellites permitting the development of new networks (e.g., CNN and HBO) designed primarily for the distribution of programming via satellite to cable systems throughout the United States. Unlike the broadcast networks which earn revenue mainly through advertising, these subscription networks are supported through advertising revenue and/or fees paid by cable systems.

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[2] This survey is discussed in greater detail below.

[3] Note that this and other summary statistics including means, standard deviations, and correlation coefficients from the 2004 FCC Annual Cable Price Survey are computed as weighted averages from the results of the survey. The weights are based on the total number of subscribers (i.e., analog plus digital subscribers) from the systems responding to the survey.

The most significant competitor to cable today is the direct-to-home satellite television industry. Satellite subscription television service emerged in the early 1980s as an alternative to cable service in rural areas not passed by cable systems. In 1994 Direct Broadcast Satellite (DBS) service was introduced. Subscribers could receive the video signals using small reception dishes that could be mounted on rooftops or window sills. Satellite subscription television service is available nationwide and each DBS company typically offers the same programming packages and prices throughout the United States. Monthly service charges are comparable to monthly cable rates for comparable packages of programming services.

Because DBS service was developed using digital technology, these systems have a greater channel capacity and transmit clearer video and audio signals with less degradation of the signals than analog cable systems. Additionally, digital technology uses radio spectrum more efficiently. Only recently have cable systems started to offer digitally transmitted service along with their analog service.

Based on the 2004 FCC Annual Cable Price Survey, 83.0 percent of households in the United States that subscribe to a subscription television service use cable television although DBS subscriptions are growing. Based on data collected on the 2004 FCC Annual Cable Price Survey, DBS accounted for 15.2 percent of the subscription television service in 2003.

There are a number of aspects of DBS service that make it attractive to some subscribers. First, through the use of digital technology, DBS's video and audio quality are state-of-the-art (General Accounting Office [1999] and CableFAX Daily (April 15, 2003)). Second, DBS providers typically offer a larger number of channels (wider programming selection) than most analog cable systems. Moreover, while most cable systems now offer a digital tier, their channel lineup is typically less complete than that offered by DBS. For subscribers who, for example, are interested in movies or sports, DBS may offer a better selection of channels than the competing cable system(s). Finally, DBS service has competitive pricing with cable service, a higher level of subscriber satisfaction,[4] expansion of local-into-local service, and the introduction of new products such as digital video recorders (Federal Communications Commission [2004a]).

(b) Supply Considerations

The ownership of cable operations is relatively concentrated. Additionally, there are ownership ties between cable systems and related firms. For example, there are vertical relationships between cable companies and program suppliers, horizontal concentration among cable companies, and clustered cable systems whereby cable companies consolidate ownership within a geographic area. Each of these relationships has implications for the cost of supplying cable service.

In recent years cable systems have engaged in a clustering strategy in order to consolidate their systems in and around specific cities or regions. Cable companies can obtain increased economies of scale from clustering as compared to having noncontiguous cable systems that are more geographically diffuse (Ford and Jackson [1997] and General Accounting Office [1999]). About 95.6 percent of the cable systems surveyed on the 2004 FCC Annual Cable Price Survey were part of a cluster.

The various ownership interrelationships that exist in the cable industry ostensibly provide efficiencies to cable companies that result in reduced costs of providing cable service. For example, relatively larger cable providers may realize reduced programming costs and also have cost savings in management and related overhead functions (Emmons and Prager [1997]).

This is the basic institutional structure of the market for subscription television service for cable service and DBS service in the United States. This structure will be used in developing an econometric model of the market. Given the nature of the data that are available and the inherent interest in measuring

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[4] See, e.g., Daily Yankee Viewpoint [2004].

the potential for competition between cable television service and DBS service, the focus is on only these two subscription television services.

2004 FCC Annual Cable Price Survey

Section 623(k) of the Communications Act, as amended by the Cable Television Consumer Protection and Competition Act of 1992, requires the FCC to publish annually a statistical report on cable prices, or more specifically, average rates for the delivery of basic cable service, cable programming service, and equipment.

The 2004 FCC Annual Cable Price Survey requested data from a sample of cable systems[5] as of January 1, 2004, January 1, 2003, and January 1, 2002. The 2004 FCC Annual Cable Price Survey was structured to allow the FCC to compare prices charged by two groups of cable systems: (1) systems that are deemed to face effective competition (nominally referred to as the competitive group); and (2) systems that do not face effective competition (the noncompetitive group).[6] Cable systems in the competitive group are limited to geographic areas where a cable operator has sought and obtained a FCC

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[5] A cable system is defined as the area served by a single headend. A headend is the control center of a cable television system, where incoming signals are amplified, converted, processed, and combined into a common cable along with any original cablecasting, for transmission to subscribers. A system operator is the individual, organization, company, or other entity that operates a cable television system.

[6] Cable systems cannot be subject to rate regulation in areas where the FCC has made a finding of "effective competition." A cable system is subject to effective competition when any one of the following conditions is met: (1) Fewer than 30 percent of the households in its franchise area subscribe to the cable service of a cable system (herein referred to as "the low penetration test"); (2) The franchise area is served by at least two unaffiliated subscription television service distributors each of which offers comparable programming to at least 50 percent of the households in the franchise area and the number of households purchasing subscription television service other than the largest subscription television service distributor exceeds 15 percent of the households in the franchise area (the "overbuild test"); (3) A subscription television service distributor, operated by the franchising authority for that franchise area, offers subscription television service to at least 50 percent of the households in the franchise area (the "municipal test"); (4) A local exchange carrier (LEC) or its affiliate (or any subscription television service distributor using the facilities of such carrier or its affiliate) offers subscription television service directly to subscribers by any means (other than direct-to-home satellite services) in the franchise area of an unaffiliated cable operator which is providing cable service in that franchise area, but only if the video programming services so offered in that area are comparable to the subscription television service provided by the unaffiliated cable operator in that area (the "LEC test"). In other franchise areas, local communities have the authority to regulate the rates of

finding of effective competition. For these purposes the FCC's formal legal decisions were used as a basis to determine whether effective competition exists based on the statutory definition of that term. The requirement to compare the price of cable service for systems where effective competitive has been found and the price of cable service where effective competition has not been found is important given the objectives of the 1992 Cable Act. The primary data used in this study rely on the results of the survey conducted as a result of this requirement.

The 2004 FCC Annual Cable Price Survey collected information about average monthly rates for the basic service tier (BST) and major cable programming service tier (CPST). The BST typically consists of local stations (e.g., broadcast channels) plus a few satellite channels and public, educational, and government access (PEG) channels if they are carried. The major CPST typically consists of satellite-delivered channels. About 88.4 percent of cable subscribers take both the BST and the major CPST while the remaining share of subscribers take BST only. In addition data were collected for the most highly subscribed digital tier of service. Information was also collected on the average monthly charge for equipment, consisting of an analog addressable converter and remote control and digital converter plus remote control. The 2004 FCC Annual Cable Price Survey further sought information needed to determine average rates per channel. Finally, information was gathered on other factors that affect cable prices and competition in the subscription television service market such as the cable system's best estimate of the number of subscribers to DBS service in the system area, as well as the availability of other services from the cable system such as Internet access and telephony.

Of the 665 Survey questionnaires mailed to cable systems from both groups, respondents completed 641 questionnaires.

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the basic service tier and equipment, but may or may not choose to exercise that authority.

Supplementary Data

The 2004 FCC Annual Cable Price Survey data are keyed to the five digit Zip code associated with the greatest number of subscribers in the franchise area. This allows for merging the data from the 2004 FCC Annual Cable Price Survey with social, economic, housing, and geographic information from auxiliary sources. These supplementary data can be used to quantify the influence of social, economic, and geographic factors on both the demand and supply of subscription television service.

While the 2004 FCC Annual Cable Price Survey data are keyed to the five digit Zip code, the decision was made to use three digit Zip code information for the social, economic, and housing data. The first digit of the Zip code represents the geographical area while the second two digits identify the central mail-distribution point known as a sectional center. The location of a sectional center is based on geography, transportation facilities, and population density. The last two digits identify the local delivery area. Cable system service areas are generally larger than a single Zip code area (i.e., a local post office delivery area). Moreover, given the data that are available, it is not possible to precisely assign all Zip codes to a cable service area. Hence, while use of either five digit or three digit Zip code data will not precisely reflect an average of the social, economic, and housing characteristics of cable subscribers for a specific cable system service area, three digit Zip code data were selected as being the better measure for capturing average subscriber and potential subscriber characteristics. This decision is based on an empirical examination and use of the data at these two levels of disaggregation in preliminary analyses.[7]

Data on the social, economic, and housing characteristics of subscribers by three digit Zip code were obtained from the 2000 Census of Population Summary Files provided by the U.S. Census Bureau.

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[7] In preliminary analyses for the demand side of the market, various measures of social, economic, and housing characteristics at the five digit Zip code level seldom appear significant while better (in a relative sense) results are obtained when three digit Zip code data are employed.

These data are quite comprehensive consisting of information on such things as school enrollment, educational attainment, marital status, disability, language spoken, country of birth, employment status, commuting patterns, occupation, income, type of housing unit, number of occupants, house heating fuel, rent versus own, mortgage status, and tenure of occupancy.

The final set of data merged with the data from the 2004 FCC Annual Cable Price Survey consisted of information on the size of the Zip code area, its latitude and longitude and the recommended azimuth, elevation, and skewness of the satellite dish.[8] The area, latitude, and longitude information was obtained from the U.S. Postal Service. The azimuth, elevation, and skewness data were obtained from the DirecTV web site. These data are important because physical features of the landscape can limit the demand if, e.g., the angle of elevation is too low, or impact costs if subscribers are relatively spatially diffuse.

Model Specification

The model specification is, of necessity, dependent on the data that are available. While there is a desire to have the specification as consistent with the previously discussed theoretical considerations as possible, empirical relationships frequently do not conform precisely to economic theory. Hence, the model specification is tempered by the data that are available. Additionally, the model specification is a straightforward extension of previous studies on the demand for cable service, drawing on their strengths and, to the extent possible, mitigating their weaknesses.

(a) Demand

For the demand side of the model presented here, Mayo and Otsuka [1991], Rubinovitz [1993],

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[8] The azimuth is the horizontal angular direction from a fixed reference point (i.e., the DBS subscriber) to a geosynchronous satellite. Elevation is the angle up needed to receive the satellite signal and skewness is required the dish rotation.

Beil et al. [1993], Ford and Jackson [1997], and Beard et al. [2001] serve as useful references.[9] These papers model the demand for cable service as a system of equations where the price and demand for subscription television service defined to include cable service and DBS service are jointly determined.

Rubinovitz [1993] uses the number of channels delivered over the cable system as a measure of service quality and estimates a system of equations using two-stage least squares including a demand function, a "quasi-supply" or price function, and a quality function where quality is measured by a proxy variable defined as the number of channels. Ford and Jackson [1997] closely follow Rubinovitz [1993] but add a programming cost function to the system in order to account for the cost of the quality level chosen by the cable operator. More recently, Beard et al. [2001] present a simultaneous equations model where the price of the basic service tier (BST), the price of the major cable programming service tier (CPST), the number of satellite channels (i.e., non-broadcast channels) offered, and the number of subscribers are endogenously determined. The number of satellite channels is used in this study as a proxy for service quality.

Recently, Otsuka and Braun [2003] provide a model of just the demand for cable service. They find that the demand for cable service is a statistically significant function of price and a log of the number of channels but little else including income and the number of homes passed. The fact that the number of homes passed is not statistically significantly different from zero at the five percent level is very surprising given the results of other studies of the cable service demand issue.

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9 There are also the General Accounting Office studies (i.e., General Accounting Office [1999, 2000, 2002, 2003a]). These rely essentially on the previous studies noted here. Note that Karikari et al. [2003] is essentially a reproduction of the 2000 General Accounting Office study and the 2003 General Accounting Office study is a elemental update of the 2002 study using mostly the same data. The 2002 and 2003 General Accounting Office studies explore the DBS issue but rely on proprietary data that are not readily available nor are the estimation results reproducible. There is also a series of Federal Communications Commission studies (e.g., Federal Communications Commission [2001, 2002]). These essentially reproduce the Ford and Jackson [1997] study using a different data set but using the same simultaneous system and functional specifications.

There are a number of interesting observations to be made about these previous studies. First, each, with the exception of Otsuka and Braun [2003], uses a log-linear specification asserting that it is the preferred specification. This is an empirical issue that should be tested but never is. Second, the number of channels offered by a cable operator is treated as being endogenous in the more recent studies. There are different sets of channel offerings provided by cable systems. There is the basic service tier and a major programming service tier. Within the basic service tier, there are over-the-air broadcast channels that subscribers could, in most instances, otherwise get free. There are also premium and pay-per-view channels although these are virtually never offered as part of the basic service tier or the major programming service tier. This mix of channel offerings in the model should be considered explicitly. It has the potential for providing some insight into subscriber behavior. Moreover, there is some disagreement as to whether the total number of channels or a subset of channels is important to subscribers and, in fact, truly endogenous. For example, Anstine [2001] finds that program guide channels have a negative marginal value. Jayarantne [1996] finds that the number of broadcast channels is unimportant to subscribers. Given these results, the endogeneity of the number of channels in a simultaneous equations model of the market for subscription television service is another issue that should be empirically investigated. Third, there is scant attention in previous studies to the possible presence of outliers in the data that serve to unduly influence the coefficient estimates.

Based on the preceding discussion, in order to portray accurately the demand for subscription television service, two separate demand equations are considered including the demand for analog cable service and the demand for digital cable service. The demand for cable service is disaggregated into its analog and digital components for a number of reasons. First, the primary data used in the estimation from the 2004 FCC Annual Cable Price Survey allow for this level of detail. Second, with digital cable, cable systems provide a higher quality signal and hence a better video image than is possible with analog cable service. Cable systems use digital technology to compress video signals, allowing more than one program service to be carried in the bandwidth space normally required for one analog program service. Typically, the signal is sent to the home and decompressed in the set-top box for display on the television (National Cable and Telecommunications Association [2003]). Finally, digital cable service offers channels not available via analog cable service. According to the results of the 2004 FCC Annual Cable Price Survey, digital cable channel offerings not available through analog cable service include, for example, America's Store, Arab Radio and Television, Chinese Central TV, EuroNews, Interfaith Channel, MBC Korean, and Saigon Broadcasting Network.

Disaggregating the demand for cable service into analog cable demand and digital cable demand will enable an assessment of whether analog cable subscribers respond differently than do digital cable subscribers to changes in various economic, demographic, and social factors. The demand for analog service is a function of the price of analog cable service (which includes the price of BST plus CPST service), the price of digital cable service, and the price of DBS service. With regard to the price of basic DBS service, it is uniform nationally with no inter-subscriber variability. Thus, its effects are captured in the constant terms of the demand relationships. DBS price is not explicitly included in the specification. The relevant prices are the monthly subscription prices for analog and digital cable service as well as the price of DBS service. These are the marginal prices upon which subscribers make their decisions. Also included in the demand equation specifications are variables reflecting the multiple system operator who owns the system designed to reflect the relative service quality and other difficult to quantify subjective cable service factors between cable operators,[10] the size of the market measured by the number of

[10] Umphrey [1989] finds that consumer satisfaction with a cable operator's service and offerings play a more significant role in the demand for cable service than does access to clear broadcast signals.

households passed by the cable operator in the franchise area for analog and digital cable demand and the total number of households in the franchise area in the case of DBS demand, the number of channels, and a set of economic, demographic, and social variables that impact potential subscriber's choice of whether to subscribe to a subscription television service and, if so, what type of service to subscribe to.

Several previous studies attempted to control for quality by introducing an aggregate measure of the total number of channels delivered over the cable system as a measure of quality of cable service. Such a measure, however, is overly broad since many channel offering do little to enhance perceived subscriber service quality (The Bridge [2003] and General Accounting Office [2003a]). Sports programming, measured as the number of analog (digital) sports channels available on national cable programming services, is a better measure of analog (digital) cable service quality (Nuthall [2003], Schultz and Sheffer [2004]).[11] Sports programming has been shown to be a significant factor in influencing the number of subscribers to cable service (Rizzuto and Wirth [2003]). Additionally, the number of analog (digital) news and public service channels serves as a good proxy for analog (digital) cable service quality (Smith et al. [1998]). With a larger the number of such channels comes a larger diversity of views and opinions, a feature valued by many subscribers.

The demand for both analog and digital cable service also has an added variable, the angle of elevation of the satellite dish. This is potentially important because if the angle of elevation is too low then satellite reception will be hampered by the presence of obstacles such as multi-story buildings, mountains, and ground clutter (e.g., trees) thereby reducing demand for DBS service and, all other things

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[11] The number of local and regional sports channels is not included in the cables service channel count since the sample constructed for the 2004 FCC Annual Cable Price Survey not take into account the distribution of these channels. To include them in the channel tally runs the risk of biasing the coefficient estimates on the econometric model.

given, increasing the demand for analog and digital cable service. The demand relationships are straightforward and closely follow conventional demand theory (Phlips [1974]).

The interesting additional variable included in this study in the analog and digital cable demand equations is the share of DBS service subscribers in the franchise area. This variable captures the market penetration of DBS service. It is used as the measure of the impact of the competitive fringe on the demand for the service supplied by the dominant firm. The extent to which DBS service impacts the demand for analog and/or digital cable service can be empirically determined by specifying in the demand equations for analog and digital cable service the number of DBS subscribers relative to the total number of subscribers in a franchise area. That is, *ceteris paribus*, the greater the relative number of DBS subscribers in an area (that is, the greater the DBS penetration in a franchise area), the fewer the relative number of potential analog and/or digital cable subscribers and hence the fewer the actual number of analog and/or digital cable subscribers (Wise and Duwadi [2004]).[12]

(b) Supply

The simultaneous equations model component of the supply of subscription television service focuses on the supply of analog and digital cable service. With regard to the supply of analog cable service, data unique to cable system operation on just programming expenses were collected on the 2004 FCC Annual Cable Price Survey. Hence, proxy variables are needed to adequately reflect all of the cost differences between cable systems. To this end, qualitative (dummy) variables are used to differentiate cable systems by type (e.g., municipal systems versus overbuilders) with the implication being that in the

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[12] Wise and Duwadi [2004] identify the factors that influence a subscriber's subscription television service choice as well as attempt to quantify the costs that affect a subscriber's desire to switch between cable service and DBS service.

presence of economies of scale or other cost efficiencies, costs will vary by operator characteristics. Also, qualitative variables are used to differentiate between whether a cable operator is a member of a cluster or not. As noted previously, in each instance cable systems who are members of a cluster ostensibly have lower production costs and a greater supply (Singer [2003]). Other factors that potentially serve to impact supply include the multiple system operator who owns the system, whether there exists effective competition in the franchise area and whether basic service is subject to local regulation. These factors are also considered. Variables reflecting the multiple system operator who owns the system are designed to reflect the relative supply efficiency and other difficult to quantify cable service supply factors between cable operators. Finally, the potential subscriber density of the franchise area supplied will directly impact costs (Law and Nolan [2002]). That is, if potential subscribers are relatively more spatially dispersed, costs of supplying these subscribers will be higher due to higher cabling costs, increased costs of getting the required construction permits and rights-of-way, and so on, all other things equal, than if subscribers are relatively concentrated.

Sports programming license fees are also a significant cost component for cable systems (The Bridge [2003] and Morgan Stanley [2002]). The number of analog (digital) sports channels is introduced to reflect this based on the presumption that the measure of programming expenses does not adequately capture variation in costs across cable systems attributable exclusively to sports programming.[13]

With regard to digital supply, there is one additional factor. To supply a digital signal to a subscriber, the cable subscriber needs to rent from the cable system or purchase a set-top digital converter. Larger cable systems can purchase these converters at a lower cost than can relatively smaller

[13] The correlation coefficient between the number of analog sports channels and the cable system's programming expenses is -0.19. For the number of digital sports channels and programming expenses, it is -0.25. Clearly, collinearity will not be a problem if both variables (the number of sports channels and programming expenses) are introduced into the functional specification.

cable systems due to substantial volume discounts. Hence, costs of supplying digital cable service would be relatively less for larger cable systems.

Some Preliminary Empirical Issues

Before turning to the actual estimates of the simultaneous equations econometric model of the demand and supply of subscription television service, some preliminary issues need to be dealt with. First, consider the issue of the appropriate functional specification. Previous studies have asserted that the appropriate functional form for each of the equations in a simultaneous equations model of the demand for cable television service is linear in logarithms. That is, both the dependent and explanatory variables are transformed by $\log_e$ (i.e., Napierian logarithms) before empirically estimating the relationships. To test the credibility of this assertion, a straightforward nonnested test is used. The test is applied to each of the demand and supply equations individually. (This is simply the nature of these tests.) The test chosen is the J-test developed by Davidson and MacKinnon [1981, 1993, 2004]. The basic idea of the test is to embed both of two competing regression functions in a more general one and then test one or both of the original models against it. Three functional specifications are considered - a linear specification, a log-linear specification where all of the explanatory variables are transformed by $\log_e$, and a semi-log-linear specification where just the dependent variables are transformed. Each of the specifications is considered in pairwise fashion with each of the functional specifications alternately serving as the correct specification (i.e., the null hypothesis). The results (available upon request) indicate that the log-linear specification is the clearly preferred functional specification for all of the equations except the digital cable supply equation. In this instance the log-linear specification is preferred over the linear specification but it is not preferred over the semi-log specification.

For the current model, a log-linear specification is used for each of the demand and supply equations. Measured changes are in percentage terms. That is, a coefficient estimate measures the percentage change in the dependent variable associated with a one percent change in that variable. This removes the units of measurement of the variables from consideration.

Because the survey collected information from cable systems of widely disparate sizes, the potential for heteroscedastic error terms exists (Davidson and MacKinnon [1993, 2004]). The demand and supply equations for analog cable service and digital cable service are considered separately. Again instrumental variables are used for the analog and digital cable service price. The Goldfeld-Quandt test is used to examine the issue of heteroscedasticity (Wooldridge [2002]). In each instance for the demand equations and the supply equations, the null hypothesis of homoscedasticity cannot be rejected at the five percent level. (Details are available from the author upon request.)

Next, we turn to the issue of the exogeneity of the number of channels provided by cable systems. Are the number of analog and digital channels provided in a cable system's franchise area simultaneously determined along with the price and the number of subscribers? To examine this issue, a Wu-Hausman test for exogeneity is used (Bowden and Turkington [1984], Hausman [1978], Wooldridge [2002], and Wu [1973]).

The Wu-Hausman test is conducted for each of the demand and supply equations.[14] For the number of analog cable channels using the analog demand equation as the reference and the number of channels measured as the number of BST plus CPST channels, the computed value of the test statistic is 0.94. This is less than the critical t-statistic value of 1.97. Hence, the null hypothesis is accepted implying that the number of analog cable channels is exogenous. This same result also holds for the digital cable demand equation (where the number of digital channels on the highest subscribed digital tier

[14] As before, to avoid the endogeneity problem, instrumental variables are used for the analog and digital cable price variables.

is used)[15] and the analog and digital cable supply equations. Computed values of the test statistic are 1.08, 1.38, and 0.67, respectively. In each instance the computed value is less than the critical t-statistic value of 1.97. The results are consistent with the null hypothesis that the number of analog/digital cable channels is exogenous.

Estimation Results for the Simultaneous Equations Model

A considerable amount of preliminary analysis went into determining the final specification of the simultaneous equations model for subscription television service. There is little to be gained from recounting all of the details this preliminary analysis.[16] Simply note that the objective has been to develop a model that is theoretically consistent and one that yields credible and robust coefficient estimates[17] but also one that can give some insight into the factors that influence the demand and supply of analog and digital cable service as well as the nature and extent of the substitutability and, consequently, the potential for competition, between cable television service and DBS service. The model is also data dependent. That is, it has been developed based on the data collected on the 2004 FCC Annual Cable Price Survey.

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[15] Most subscribers of digital cable service purchase just the major digital tier although there are frequently additional digital tiers offered.

[16] One of the details worthy of note is the impact that the presence of collinearity among the exogenous variables has on the parameter estimates. Considerable time was spent on mitigating the influence of collinearity. This was done by a judicious examination of the data for the presence of a high degree of correlation between the exogenous variables individually or in concert. When collinearity appeared to be an insurmountable problem, the variables were either combined or one or more deleted from the specification. One disappointing result was that there was not a greater finding of statistically significant relationships between the variables included in the large set of supplementary data compiled from the 2000 Census of Population Summary Files provided by the U.S. Census Bureau and the demand and supply of analog and digital cable service. These supplementary data were quite comprehensive consisting of information on such things as school enrollment, educational attainment, marital status, disability, language spoken, nativity, employment status, commuting patterns, occupation, income, type of housing unit, number of occupants, house heating fuel, mortgage status, rent, and tenure of occupants.

[17] In the sense being used here, robust estimates are estimates that are not extremely sensitive to the functional

For the final estimation, not all 641 observations could be used. There were 28 cable systems in the sample that did not provide digital cable service at the beginning of 2004.[18] It was necessary to drop these observations from the data set. All were either very small or small noncompetitive systems or LEC systems in the competitive group.[19] This gives a total of 613 observations used in the estimation. By dropping these observations, any inferences with regard to the behavior of subscribers and cable systems and the impact of the competitive fringe (DBS service) on the dominant firm (cable service) must be qualified accordingly. This understanding is implicit and the point is not pursued in the subsequent discussion. Descriptive statistics of the variables used in the estimation are presented in the Appendix.

The coefficient estimates of the simultaneous equations model of the demand and supply of subscription television service obtained using full information maximum likelihood technique are presented in Table 1a. The variables are defined and their sources are given in Table 1b.

The results are rather mixed from a statistical significance point of view. For the analog demand equation in the model, the coefficient estimates on neither the price of analog cable service nor the price of digital cable service are statistically significantly different from zero. This suggest that analog cable service subscribers are unresponsive to both the absolute change and the relative change (i.e., relative to the price of digital cable service) in the price of cable service at least within the range of prices currently in place for analog and digital cable service. For the digital demand equations, both price variables are statistically significantly different from zero at the five percent level and they have the *a priori* (i.e., consistent with conventional neoclassical microeconomic theory) expected signs. That is, as the price of

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specification or to which variables are included or excluded from the specification.

[18] The 2004 FCC Annual Cable Price Survey asked for subscriber and price information data as of January 1, 2004.

[19] The systems dropped from the sample constitute 4.37 percent of the sample but account for only 1.05 percent of subscribers. The smallest cable system dropped has 38 subscribers and the largest has 28,904 subscribers. For the entire sample, the average (mean) number of subscribers is 125,616 with a standard deviation of 152,361.

digital cable service rises by one percent, the number of digital cable service subscribers falls by 1.03 percent and as the price of analog cable service rises relative to the price of digital cable service by one percent, the number of digital cable service subscribers rises by 0.96 percent.[20]

These results are somewhat different from several previous studies. Ford and Jackson [1997], for example, find that for all subscribers (both analog and digital cable service), a one percent increase in the price of cable service results in a 2.4 percent reduction in the number of cable service subscribers, the General Accounting Office [2002] finds that a one percent increase in price results in a 2.1 percent reduction in the number of subscribers, and the General Accounting Office [2003a] finds that a one percent increase in price results in a 1.9 percent reduction in the number of subscribers. The Federal Communications Commission [2002] reports that a one percent increase in the price of cable service is associated with a 2.2 percent reduction in the number of subscribers. Not all studies, however, find a statistically significant impact of cable service price on the number of subscribers. Wise and Duwadi [2004], for example, detect no price effects on the number of subscribers for relatively small price changes and only a modest impact when the price change is relatively large. This result is attributed to the presence of switching costs.

The most significant factor explaining both analog and digital cable demand is, not surprisingly,[21] the number of households passed in the system area. This variable is introduced in the demand equations to provide for a control of the market size. Larger systems, for example, have a larger number of potential customers and, *mutatis mutandis*, have a larger number of subscribers. The simple correlation

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[20] As an additional consideration, the cross price elasticities on the demand equations were tested to determine whether they were equal. That is, the null hypothesis that the digital cable price coefficient on the analog cable demand equation is equal to the analog cable price coefficient on the digital cable demand equation was tested using a log likelihood ratio test. The value of the Chi-squared test statistic with one degree of freedom was equal to 15.34 exceeding the critical value of 3.84 at the five percent level. Hence, the null hypothesis is rejected.

between the number of analog cable subscribers and the number of households passed is 0.92. A similar result holds for digital cable subscribers where the simple correlation is 0.85. The estimated coefficients suggest that for each one percent increase in the number of households passed by a cable system, there will be a 0.98 percent increase in the number of analog cable service subscribers and a 1.07 percent increase in the number of digital cable service subscribers.

Since the simultaneous equations model assumes equilibrium, the supply of analog and digital cable service should increase by amounts comparable to the increase in the demand for analog and digital cable service, respectively, when the number of households passed increases.[22] This is precisely what the estimation results indicate.[23] As the cable system expands to provide service to areas previously unserved or as the number of households increase because of in-filling construction,[24] both the demand and supply of analog cable service increase by comparable (i.e., not statistically significantly different) amounts.

The penetration of DBS in a system area has a quite significant and negative effect on the number of analog cable subscribers and a negative but statistically insignificant at the five percent level effect on the number of digital cable subscribers.[25] A one percent increase in the proportion of DBS subscribers

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[21] What would be surprising is this not being empirically confirmed.

[22] This variable is introduced in the supply equations for exactly the same reason it was introduced in the demand equations - to provide for a control of the market size. Larger systems, for example, have a larger number of potential customers and, *mutatis mutandis*, have a larger number of subscribers and hence, higher average total costs (Owen and Wildman [1992]).

[23] For this comparison it is necessary to consider both the coefficient estimates and the standard errors of the estimates on the analog cable demand and digital cable demand and the analog cable supply and digital cable supply equations.

[24] That is, new housing units constructed in areas already served by a cable system.

[25] Recall that TWC did not provide estimates of DBS subscribers for the cable systems sampled. Consequently, it was necessary to estimate the number of DBS subscribers. A potential problem arises because these estimates might serve to bias the coefficient estimates on the demand equations. A number of different variable coefficient statistical

will result in a reduction of about 0.08 percent in analog cable subscribers in a system area. This result is statistically significantly different from zero at the five percent level. Thus, while the loss of analog subscribers by cable systems to an increase in DBS penetration is not relatively large, it is statistically significant. This value is consistent with the result of Goolsbee and Petrin [2001] who find a small, but statistically significant, impact of DBS service on the demand for cable service. Also, Wise and Duwadi find a modest impact of DBS service on cable service.[26] The presence of switching costs (e.g., the cost of switching between cable service and DBS service) limits this impact. This result is juxtaposed to the relatively large estimate of a 2.35 percent reduction in cable service subscribers for each one percent increase in the penetration of DBS subscribers obtained elsewhere (General Accounting Office [2003a]).

The estimated coefficient on the number of analog channels is statistically significantly different from zero at the ten percent level in the analog demand equation.[27] The inference is that a one percent increase in the number of channels results in a 0.25 percent increase in the number of subscribers. The implication of this is that subscribers do value in the aggregate the number of channels offered for BST plus CPST cable service. There are mixed results in other studies with regard to this variable and its impact on the number of subscribers. For example, Ford and Jackson [1997] do not find the number of channels offered by a cable operator to influence the number of subscribers. Mayo and Otsuka [1991] and Otsuka and Braun [2003] likewise do not find the number of channels to be a statistically significant factor in explaining the demand for analog cable service.

The coefficient estimates on the variables introduced to capture overall quality of analog cable

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tests were used to examine whether this in fact was the case. In each instance the null hypothesis of a statistically significant effect resulting from the use of estimated DBS data for TWC cable systems was rejected.

[26] The Wise and Duwadi estimate is not directly comparable to that reported here since their functional specification is much different.

[27] Surveys consistently stress the importance of programming variety and commercial-free entertainment as

service, the number of analog sports channels and the number of analog news channels, are both statistically significantly different from zero at the five percent level. The results suggest that a one percent increase in the number of sports channels is associated with a 0.11 percent increase in the number of analog cable service subscribers while a one percent increase in the number of news channels results in an increase in the number of subscribers of about one half that value. Thus, increasing sports channel offering is more important in attracting subscribers that is increasing news and public affairs channel offerings.

With regard to digital cable demand, there is a positive and a statistically significant at the five percent level relationship between the number of digital cable subscribers and the number of channels offered on the major digital tier. This effect is quantitatively not as large as it is for analog cable demand. For each one percent increase in the number of digital cable channels offered on the major digital tier, the cable system attracts about a 0.09 percent additional digital cable subscribes in a system area. The coefficient estimates on the variables introduced to capture overall quality of digital cable service, the number of digital sports channels and the number of digital news channels, are both statistically insignificant. That is, for digital cable service, these measures of service quality reveal nothing.

A major concern of potential DBS subscribers is the availability of local broadcast channels (nominally referred to as local-into-local service). Before changes to the Satellite Home Viewers Improvement Act (SHVIA) in 1999, the competitive disadvantage to DBS of its inability to offer local channels was well documented (see, e.g., General Accounting Office [2000] and Hawkins [1997] for a discussion of the issues). Even with the passage of the SHVIA, not all regions of the United States have local broadcast channels available ostensibly reducing the desirability of DBS service relative to cable service in those areas. A dummy variable is introduced into the demand equation specifications to

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important factors in attracting and retaining subscribers (Rothe et al. [1993]).

measure the quantitative extent to which the demand for analog cable service and the demand for digital cable service are affected by the availability of local-into-local service.[28] With regard to analog cable service demand, the availability of local-into-local service only impacts the number of subscribers marginally.[29] For digital cable service demand, the impact of local-into-local service is statistically significantly different from zero at the five percent level. Thus, in areas where local-into-local DBS service is available, the number of digital cable service subscribers declines by about 0.31 percent.

Another factor potentially affecting the competitiveness of DBS service and hence impacting the demand for analog cable service and the demand for digital cable service is the angle of elevation. This variable, however, does not prove to be a statistically significant factor influencing the demand for cable service. The factor is considered because if the angle of elevation is low enough, surrounding ground clutter, buildings, or other factors might serve as an impediment to satellite signal reception reducing the desirability of DBS service. The General Accounting Office [2002, 2003a] finds the angle of elevation to be a significant factor impacting the penetration of DBS. The results here do not lend support to that conclusion.

Nine separate dummy variables were used to account for individual multiple system operators (MSO) who own the cable systems responding to the 2004 FCC Annual Cable Price Survey. As noted previously, these variables are designed to capture relative service quality and other difficult to quantify subjective cable service factors such as effective marketing and subscriber retention campaigns between

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[28] A dummy variable takes on one of two possible values (e.g., 0 or 1), one value signifying one qualitative possibility and the other value signifying the other possibility.

[29] The coefficient estimate is not statistically significant.

cable operators.[30] A positive coefficient estimate suggest that the MSO is providing relatively better quality of service while a negative value suggest the opposite. For five of the MSOs (Adelphia, Cablevision, TWC, Cox, and Comcast), the coefficient estimate on the MSO variables in analog cable service demand equation is positive and statistically significantly different from zero at the five percent level. For none of the MSOs is the coefficient estimate on the MSO variable statistically significant and negative. The coefficient estimate on the MSO variables for digital cable service demand equation is positive and statistically significantly different from zero at the five percent level for four the MSOs (Adelphia, Charter, TWC, and Comcast). In no instance is the estimate on the MSO dummy variable statistically significant and negative.

Two separate measures of purchasing power were used in the analysis - median value of owner-occupied houses and the percent of the population that is classified as poor.[31] The more affluent an area or the relatively greater purchasing power it has, the larger ostensibly will be the number of analog and digital cable subscribers, all other things being equal. If this in fact is observed, cable service is a normal good (Ferguson [1972]). The poverty measure is the antithesis of the median house variable such that a greater portion of the population living below the poverty line in a area would be expected to be associated with a lower number of analog and digital cable subscribers since there is less discretionary

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[30] Actually, there are ten separate dummy variables with the tenth dummy variable defined as one for all cable systems in the sample not otherwise assigned to a multiple system operator and zero otherwise. In order to avoid the singularity problem upon estimation (Suits [1984]), the tenth dummy variable is omitted from the specification. Hence, the estimated coefficients on the remaining nine dummy variables indicate such things as service quality relative to the cable systems represented by the tenth dummy variable (i.e., those not explicitly included in the specification).

[31] Kieschnick and McCullough [1998] provide a survey of the literature on how purchasing power affects the demand for subscription television service. Little evidence is found that household income is an important determinant of whether a household subscribes to cable service. The empirical evidence suggests that households not subscribing to subscription television service choose to do so because they value other goods and services relatively more.

income available to be spent on such things as entertainment.[32] The coefficient estimates are interesting. The coefficient estimate on the median house value in the analog cable demand equation is positive as expected but statistically significantly different from zero only at the 10 percent level. The estimate suggests that a one percent increase in the median house value is associated with a 0.19 percent increase in the number of analog cable service subscribers. The coefficient estimate on the poverty variable is statistically significantly different from zero at the ten percent level but has a questionable sign. The estimates suggests that a one percent increase in the percent of the population below the poverty level is associated with a 0.19 percent increase in the number of analog cable service subscribers. This result seems anomalous.

Neither of the proxies for purchasing power or affluence is statistically significant for the demand for digital cable service suggesting that other factors besides relative purchasing power are more important in explaining the demand for digital cable service (Kieschnick and McCullough [1998]).

One final variable was included in the functional specifications for analog and digital cable service demand - availability of Internet service from the cable service provider. Including this variable is designed to look into whether bundling services (in this case, cable service with Internet service) impacts the demand for cable service.[33] In the case of analog cable service, clearly it does. Cable systems that offer access to the Internet realize a 0.29 percent increase in the number of analog cable service subscribers. This is statistically significantly different from zero at the five percent level. The cable systems that offer access to the Internet likewise realize a 0.23 percent increase in the number of digital cable subscribers although this result is statistically significantly different from zero only at the 10 percent

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[32] Note that the correlation coefficient between the median house value variable and the poverty variable is -0.47.

[33] Pricing issues are not discussed here. Such a discussion can be found elsewhere (e.g., Danaher [2002]).

level.

There are a few factors clearly having a statistically significant impact on the analog and digital supply of cable service. The most interesting variable is the total programming expenses for BST plus CPST per subscriber variable. This is the first time expense data have been collected on the FCC Annual Cable Price Survey.[34] Data on several different types of programming expenses were obtained on the 2004 FCC Annual Cable Price Survey including total programming expenses for all video programming services, total programming expenses for the BST plus the CPST, programming expenses for sports networks on the BST plus the CPST, and programming expenses for news networks for the BST plus the CPST.[35] The first expense measure is not really meaningful for the analysis here. The other measures, not surprisingly, are highly collinear.[36] Hence, just one of the variables is useable if meaningful coefficient estimates on programming expenses are expected for the two cable service supply equations. The coefficient estimate for the programming expense variable on the analog cable service supply equation has the correct sign and is statistically significantly different from zero at the five percent level. Thus, a one percent increase in per subscriber programming expenses for the BST plus the CPST leads to a 0.08 percent reduction in supply measured as the number of analog cable service subscribers. That is, as programming expenses increase, the average cost and the marginal cost of analog cable services rise

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[34] It has been argued that programming expenses make up the largest component of cable service prices (The Bridge [2003]).

[35] The most important factor leading to higher cable service rates is programming expense and is a critical factor influencing supply. Total programming expense has been estimated to equal about 33.6 percent of revenue giving cable systems about a 66 percent gross margin on total video programming in 2002 (Morgan Stanley [2002]). Direct and indirect sports surcharges accounted for about 20 percent of the increase in sports channel affiliate fees for this period.

[36] The correlation coefficient between total programming expenses for the BST plus the CPST and sports programming expenses is 0.80, between total programming expenses for the BST plus the CPST and news networks programming expenses is 0.84, and between sports programming expenses for the BST plus the CPST and news

(i.e., there is a greater cost for producing the same level of output) with an attendant reduction in supply. The only surprising fact here is that the change is relatively small. For digital cable supply, the estimated coefficient on the programming expense variable is statistically significantly different from zero at the five percent level but it has a theoretically incorrect sign. The estimate suggests that a one percent increase in the BST plus the CPST programming expenses is associated with a 0.84 percent increase in supply. This is not plausible and is another quirky result that remains to be explained in subsequent analysis.

The impact of cable service price on the supply of both analog and digital cable service is not statistically significant. The analog price of cable service is used in the analog cable service supply equation and the digital price of cable service is used in the digital cable service supply equation. The estimation results suggest that cable service supply is perfectly inelastic implying that cable systems are operating on a relatively flat portion of the marginal cost curve.

The coefficient estimate on the variable indicating whether the system is part of a cluster is not statistically significant for the analog cable service supply equation. Ninety one percent of the systems in the sample indicate they are part of a cluster. Hence, the lack of finding of any statistical significance for this variable might be an artifact of there being not enough variation across the entire sample. For digital cable service supply, however, the variable is statistically significantly different from zero at the five percent level and has the theoretically correct sign. That is, if the system is part of a cluster it will have lower average and marginal costs through sharing common personnel, management, marketing, and/or facilities and hence, a greater supply in the form of more digital cable service subscribers. Thus, being a member of a cluster is associated with a 0.19 greater digital cable service supply, which is statistically significant at the five percent level.

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networks programming expenses is 0.88.

For the nine MSO dummy variables introduced to reflect differences in relative supply efficiency and other difficult to quantify cable service supply factors between cable operators, the estimated coefficients are positive and statistically significantly different from zero at the five percent level for three of the MSOs (Cablevision, Cox and Comcast) for the analog cable service supply equation. Thus, these MSOs are relatively more efficient than other operators in supplying cable service with Cablevision being relatively the most efficient. With regard to digital cable service supply, the estimated coefficients are negative and statistically significantly different from zero at the five percent level for four of the MSOs (Mediacom, Charter, Comcast, and Wide-Open-West) for the analog cable service supply equation. Thus, these MSOs are relatively less efficient than other operators in supplying digital cable service with Wide-Open-West being relatively the least efficient. Also interestingly, Comcast is among the most efficient operators in supplying analog cable service but among the least efficient in supplying digital cable service.

The presence of effective competition has a statistically significant and negative impact on the analog supply of cable service, as would be expected. That is, cable systems that confront effective competition supply 0.21 percent fewer analog cable service subscribers than do cable systems not facing effective competition. This estimate is statistically significantly different from zero at the five percent level. For digital cable service supply, while the coefficient estimate is negative it is not statistically significant. Hence, it appears that the effective competition status does not affect digital cable service supply.

For the digital cable service supply equation, the coefficient estimate on the total number of subscribers of the parent operator variable, a proxy for the size of the cable system nationally, is statistically significantly different from zero at the five percent level. *Ex ante*, it was expected that parent companies with a substantial number of subscribers could demonstrate a relatively greater degree of market power in purchasing components to supply digital cable service so that their costs would be lower. With lower costs supply should be greater. The estimation results, as expected, do indicate that for each one percent increase in the number of subscribers nationally there is a 0.22 percent increase in digital cable service supply.

Finally, if there are economies of scope,[37] then providing joint products such as cable service, telephone service, and Internet access service that have production complementarities should result lower costs than if these services are provided independently. Four variables in the survey can be used in assessing the presence of economies of scope - whether the cable system provides Internet access service (answered yes or no), the number of Internet service subscribers (if the question is answered yes), whether the cable system provides telephone service (answered yes or no), and the number of telephone service subscribers (if the question is answered yes). To avoid the estimation problems associated with discrete choice modeling,[38] just the responses to the question of whether the cable system provides Internet access service and the question of whether it offers telephone service are used. For analog cable service supply, the coefficient estimates on both variables are statistically significantly different from zero at the five percent level but the coefficient estimate on the telephone service variable has a questionable sign. It is negative indicating the presence of diseconomies of scope.[39] There is little reason to expect this to be the case. This is another issue that needs further examination in subsequent analysis. Cable systems that offer Internet service experience a 0.45 percent increase in supply associated with cost savings from joint production with cable service relative to those that do not offer Internet access service. In the case of

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[37] Economies of scope arise from cost savings that result from producing joint products (Panzar 1989] and Waldman and Jensen [1997]).

[38] See, e.g., Wooldridge [2002] for a discussion.

digital cable service supply, there does not appear to be any economies of scope with Internet service of telephone service.

Conclusion

This study has rigorously developed a simultaneous equations model of the market for subscription television service consisting of analog and digital cable service with the objective of identifying the nature and extent to which market forces impact the demand and supply of subscription television service. Attention is focused on many of the important modeling issues frequently overlooked in studies of the market for subscription television service. These issues include the appropriate functional specification, the existence of heteroscedasticity, and endogeneity of the number of channels offered.

The model estimated consists of four equations - demand equations for analog cable service and digital cable service and supply equations for analog cable service and digital cable service. The model is estimated using the full information maximum likelihood technique. The estimation results are mixed. A number of factors clearly impact the demand and supply of analog and digital cable service and their effects are quantifiable. The size of the market measured as the number of households passed is, not surprisingly, a dominant factor in explaining analog and digital cable service demand and supply. Larger systems, for example, have a larger number of potential customers (households passed) which is associated with a larger number of subscribers. Additionally, the estimates indicate that while changes in the relative price of analog or digital cable service have no quantifiable impact on the demand for analog cable service, they do have a statistically significant effect on the demand for digital cable service. Moreover, the effect is consistent with economic theory. Educational attainment does affect demand.

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[39] This is not a consequence of collinearity between the Internet service variable and the telephone service variable.

There is an identifiable effect of the number of channels offered on both the analog and the digital demand for cable service and cable systems that also offer Internet service witness an increase in demand. There is some variation in analog and digital cable service demand and supply across multiple system operators. This variation is attributed to such factors as relative service quality and other difficult to quantify subjective cable service factors such as effective marketing and subscriber retention campaigns between cable operators in the case of demand and relative supply efficiency and other difficult to quantify cable service supply factors between cable operators in the case of supply. Finally, as the penetration of DBS service increases, the number of analog cable service subscribers is reduced.

The correlation coefficient between these two variables is just 0.05.

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Table 1a. Simultaneous Equations Model Coefficient Estimates

Variable	Coefficient Estimate	Standard Error of Estimate	t-statistic	P-value
1. Analog Cable Demand Equation				
Constant	-4.15912	3.49843	-1.18885	[.234]
Analog CablePrice	-0.33946	0.29977	-1.13240	[.257]
Digital Cable Price	0.41685	0.29970	1.39090	[.164]
Households Passed	0.97563	0.02114	46.1456	[.000]
% Rural	0.04807	0.01596	3.01065	[.003]
Proportion of DBS Subscribers	-0.08270	0.03083	-2.68221	[.007]
Number of Analog Channels	0.24796	0.12774	1.94114	[.052]
Number of Analog Sports Channels	0.10635	0.02722	3.90626	[.000]
Number of Analog News Channels	0.05930	0.02124	2.79117	[.005]
DBSLIL	-0.11642	0.07650	-1.52175	[.128]
Adelphia	0.16795	0.08977	1.87096	[.061]
Mediacom	0.06453	0.14686	0.43938	[.660]
Cablevision	0.79007	0.41381	1.90928	[.056]
Charter	0.06212	0.08678	0.71580	[.474]
Insight	0.33894	0.29773	1.13841	[.255]
TWC	0.30553	0.08250	3.70315	[.000]
Cox	0.31768	0.14840	2.14073	[.032]
Comcast	0.23568	0.08046	2.92891	[.003]
WOW	-0.36685	0.28278	-1.29727	[.195]
% RB	-0.02726	0.02174	-1.25400	[.210]
% RA	-0.00836	0.04563	-0.18333	[.855]
% Spanish	0.12596	0.04724	2.66617	[.008]
% Education-HS	0.48760	0.15796	3.08668	[.002]
% HU Occupied	-0.79741	0.58290	-1.36801	[.171]
% Poverty	0.18686	0.09651	1.93616	[.053]
% House>10	0.07258	0.06032	1.20320	[.229]
MedValue	0.18941	0.10581	1.79009	[.073]
% Ownr Occ	0.09611	0.27448	0.35017	[.726]
% LP Gas	-0.03169	0.03639	-0.87082	[.384]
Elevation	0.06641	0.16746	0.39658	[.692]
Internet	0.29140	0.07929	3.67513	[.000]
2. Digital Cable Demand Equation				
Constant	-2.89031	5.49278	-0.52620	[.599]
Analog Cable Price	0.96027	0.44135	2.17574	[.030]
Digital Cable Price	-1.02707	0.49040	-2.09431	[.036]
Households Passed	1.06945	0.03537	30.2354	[.000]
% Rural	0.02435	0.02838	0.85773	[.391]
Proportion of DBS Subscribers	-0.00727	0.04439	-0.16390	[.870]
Number of Digital Channels	0.09402	0.02422	3.88185	[.000]
Number of Digital Sports Channels	0.00473	0.01333	0.35534	[.722]
Number of Digital News Channels	-0.00581	0.01477	-0.39340	[.694]
DBSLIL	-0.30616	0.09357	-3.27198	[.001]
Adelphia	0.64018	0.16122	3.97078	[.000]
Mediacom	0.22291	0.25823	0.86323	[.388]
Cablevision	0.50194	0.32707	1.53464	[.125]
Charter	0.47517	0.14568	3.26170	[.001]
Insight	0.35970	0.62123	0.57901	[.563]
TWC	0.31407	0.14008	2.24199	[.025]
Cox	0.38864	0.24822	1.56572	[.117]
Comcast	0.42712	0.15745	2.71273	[.007]
WOW	-1.27021	0.69720	-1.82185	[.068]
% RB	0.00195	0.03483	0.05611	[.955]
% RA	0.09298	0.08263	1.12523	[.260]
% Spanish	0.00731	0.08298	0.08817	[.930]
% College	0.45357	0.18681	2.42797	[.015]
% HU Occupied	-0.11676	0.76647	-0.15234	[.879]
% Poverty	0.18707	0.20928	0.89387	[.371]
% House>10	-0.05605	0.10194	-0.54985	[.582]
MedValue	-0.02214	0.18363	-0.12059	[.904]
% OwnerOcc	0.24469	0.53138	0.46048	[.645]
% LP Gas	-0.03597	0.06104	-0.58925	[.556]
Elevation	-0.55206	0.30798	-1.79252	[.073]
Internet	0.22748	0.12079	1.88315	[.060]

Variable	Coefficient Estimate	Standard Error of Estimate	t-statistic	P-value
3. Analog Cable Supply Equation				
Constant	-0.92794	1.13725	-0.81595	[.415]
Analog Cable Price	-0.03839	0.17233	-0.22280	[.824]
Households Passed	1.00568	0.03003	33.4800	[.000]
Number of Analog Channels	0.26149	0.14207	1.84051	[.066]
Number of Analog Sports Channels	-0.02909	0.03126	-0.93047	[.352]
Adelphia	0.16384	0.10197	1.60668	[.108]
Mediacom	-0.72514	0.14014	-0.05175	[.959]
Cablevision	0.78960	0.31340	2.51944	[.012]
Charter	-0.01330	0.09891	-0.13453	[.893]
Insight	0.35880	0.24072	1.49053	[.136]
TWC	0.17540	0.10363	1.69259	[.091]
Cox	0.39591	0.14790	2.67688	[.007]
Comcast	0.24275	0.09281	2.61556	[.009]
WOW	-0.15924	0.27686	-0.57516	[.565]
Capacity	-0.15827	0.12749	-1.24143	[.214]
Cluster	-0.09814	0.08244	-1.19043	[.234]
Effective Competition	-0.20914	0.06360	-3.28811	[.001]
Regulation	-0.06031	0.06484	-0.93021	[.352]
Internet	0.44532	0.08289	5.37251	[.000]
Telephony	-0.16888	0.06910	-2.44392	[.015]
Programming Expenses	-0.08433	0.03543	-2.38006	[.017]
Size - NCL	0.09309	0.06604	1.40971	[.159]
Size - NCS	-0.03441	0.07670	-0.44865	[.654]
Type - DBS	0.00786	0.08590	0.09151	[.927]
Type - LP	-0.17886	0.10051	-1.77942	[.075]
Type - OB	0.03059	0.07123	0.42948	[.668]
Type - WL	0.05452	0.16187	0.33686	[.736]
Density	-0.06888	0.01581	-4.35646	[.000]
4. Digital Cable Supply Equation				
Constant	-10.0437	1.39641	-7.19254	[.000]
Digital Cable Price	-0.17113	0.20215	-0.84653	[.397]
Households Passed	1.01794	0.03641	27.9511	[.000]
Number of Digital Channels	-0.01216	0.02902	-0.41894	[.675]
Number of Digital Sports Channels	-0.00182	0.01064	-0.17168	[.864]
Parent Subscribers	0.22197	0.03360	6.60518	[.000]
Adelphia	-0.31122	0.18284	-1.70209	[.089]
Mediacom	-0.47253	0.20564	-2.29778	[.022]
Cablevision	-0.29397	0.20869	-1.40865	[.159]
Charter	-0.40556	0.19648	-2.06404	[.039]
Insight	0.07652	0.58919	0.12988	[.897]
TWC	-0.36772	0.20099	-1.82950	[.067]
Cox	-0.37235	0.23418	-1.58996	[.112]
Comcast	-0.47335	0.22152	-2.13682	[.033]
WOW	-1.52870	0.53409	-2.86222	[.004]
Capacity	0.22339	0.17345	1.28794	[.198]
Cluster	0.18847	0.08255	2.28292	[.022]
Effective Competition	-0.06006	0.07303	-0.82235	[.411]
Regulation	-0.00095	0.07337	-0.01295	[.990]
Internet	0.08210	0.10042	0.81815	[.413]
Telephony	0.05171	0.07939	0.65131	[.515]
Programming Expenses	0.84173	0.03415	24.6461	[.000]
Size - NCL	0.04427	0.07285	0.60772	[.543]
Size - NCS	-0.25442	0.08349	-3.04703	[.002]
Type - DBS	-0.15997	0.10312	-1.55138	[.121]
Type - LP	-0.31648	0.09520	-3.32427	[.001]
Type - OB	0.06546	0.08501	0.77001	[.441]
Type - WL	0.14755	0.15320	0.96308	[.336]
Density	0.00657	0.01921	0.34194	[.732]

Log of the likelihood function = − 1648.25

Table 1b. Variables and Their Sources

1. Analog Cable Demand is the total number of cable system subscribers to just analog cable service. The data come from the 2004 FCC Annual Cable Price Survey. It is computed as the total number of cable subscribers less the number of subscribers taking digital cable service.

2. Constant is just intercept term.

3. The Analog Cable Price is the sum of the BST and CPST1 cable service prices. The data come from the 2004 FCC Annual Cable Price Survey.

4. Digital Cable Price is the price of the most highly subscribed digital tier. The data come from the 2004 FCC Annual Cable Price Survey.

5. The Number of Households Passed is the number of households passed by a cable system in a franchise area. The data come from the 2004 FCC Annual Cable Price Survey.

6. % Rural is the percent of the population in a Zip code area classified as living in a non-urban environment. The data come from the 2000 Census of Population.

7. Proportion of DBS Subscribers is the ratio of the total number of subscription television service subscribers who subscribe to DBS to the number of subscribers to all subscription television service. The data come from the 2004 FCC Annual Cable Price Survey.

8. The Number of Analog Channels represents the number of BST plus CPST1 channels offered by the cable system and consists of all analog channels with the exception of national cable programming analog sports channels and analog news channels. The data come from the 2004 FCC Annual Cable Price Survey.

9. The Number of Analog Sports Channels represents the number of analog national cable programming services sports channels including Classic Sports Network, ESPN, Fox Sports, the Golf Channel, and the Speed Channel offered by the cable system. The data come from the 2004 FCC Annual Cable Price Survey.

10. The Number of Analog News Channels represents the number of analog national cable programming services news channels including CNBC, CNN, Fox News and MSNBC offered by the cable system. The data come from the 2004 FCC Annual Cable Price Survey.

11. DBSLIL is a dummy variable defined to equal one if DBS service available to cable subscribers in the system area carries local channels. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

12. Adelphia is a dummy variable defined to equal one if the cable system is owned by Adelphia Communications. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

13. Mediacom is a dummy variable defined to equal one if the cable system is owned by Mediacom Communications. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

14. Cablevision is a dummy variable defined to equal one if the cable system is owned by Cablevision Systems Corporation. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

15. Charter is a dummy variable defined to equal one if the cable system is owned by Charter Communications. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

16. Insight is a dummy variable defined to equal one if the cable system is owned by Insight Communications. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

17. TWC is a dummy variable defined to equal one if the cable system is owned by Time Warner Cable Communications. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

18. Cox is a dummy variable defined to equal one if the cable system is owned by Cox Enterprises. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

19. Comcast is a dummy variable defined to equal one if the cable system is owned by Comcast Corporation. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

20. WOW is a dummy variable defined to equal one if the cable system is owned by WideOpenWest Holdings. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

21. % RB is the percent of the population in a Zip code area classified as being Black. The data come from the 2000 Census of Population.

22. % RA is the percent of the population in a Zip code area classified as being Asian. The data come from the 2000 Census of Population.

23. % Spanish is the percent of the population in a Zip code area whose primary spoken language in the home is Spanish. The data come from the 2000 Census of Population.

24. % Education-HS is the percent of the population age 25 and older in a Zip code area who highest level of educational attainment is high school (completed). The data come from the 2000 Census of Population.

25. % HU Occupied is the percent of housing units in a Zip code area that are occupied. The data come from the 2000 Census of Population.

26. % Poverty is the percent of the population in a Zip code area that is classified as poor. The data come from the 2000 Census of Population.

27. % House > 10 is the percent of the housing units in a Zip code area in a structure with ten or more units. The data come from the 2000 Census of Population.

28. MedValue is the median value of a owner-occupied housing unit in a Zip code area. The data come from the 2000 Census of Population.

29. OwnerOcc is the percent of housing units in a Zip code area that are owner occupied. The data come from the 2000 Census of Population.

30 % LP Gas is the percent of housing units in a Zip code area that use liquefied petroleum gas as their primary heating fuel. The data come from the 2000 Census of Population.

31. Elevation is the angle of elevation of the satellite dish required for a DBS Subscriber to receive a satellite signal. The data are taken from the DirecTV web site.

32. Internet is a dummy variable defined to equal one if the cable system offers Internet service to its subscribers. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

33. Digital Cable Demand is the number of cable subscribers who also subscribe to the most highly subscribed digital tier for a franchise area. The data come from the 2004 FCC Annual Cable Price Survey. It is computed by multiplying the percent of subscribers taking digital cable service by the total number of subscribers.

34. The Number of Digital Cable Channels is the number of channels offered on the digital tier and consists of all digital channels with the exception of national cable programming digital sports channels and digital news channels. The data come from the 2004 FCC Annual Cable Price Survey.

35. The Number of Digital Sports Channels represents the number of digital national cable programming services sports channels including Classic Sports Network, ESPN, Fox Sports, the Golf Channel, and the Speed Channel offered by the cable system. The data come from the 2004 FCC Annual Cable Price Survey.

36. The Number of Analog News Channels represents the number of digital national cable programming services news channels including CNBC, CNN, Fox News and MSNBC offered by the cable system. The data come from the 2004 FCC Annual Cable Price Survey.

37. % Education-College is the percent of the population age 25 and older in a Zip code area who highest level of educational attainment is college (graduated). The data come from the 2000 Census of Population.

38. Analog Cable Supply is the total number of subscribers to which analog cable service is being supplied in a franchise area (i.e., subscribers to BST service). The data come from the 2004 FCC Annual Cable Price Survey. It is computed as the total number of cable subscribers less the number of subscribers taking digital cable service.

39. Capacity is the cable system capacity as of July 1, 2003 measured in terms of megahertz. The data come from the 2004 FCC Annual Cable Price Survey.

40. Cluster denotes whether the cable system is part of a MSO cluster of two or more systems. It is defined to equal one if the cable system is part of a cluster and zero otherwise. The data come from the 2004 FCC Annual Cable Price Survey.

41. Effective Competition denotes whether the FCC has made a finding of effective competition within the community. It is defined to equal one if there is effective competition and zero otherwise. The data come from the 2004 FCC Annual Cable Price Survey.

42. Regulation denotes whether the basic service tier price is subject to local regulation for the franchise area. It is defined to equal one if there is local regulation and zero otherwise. The data come from the 2004 FCC Annual Cable Price Survey.

43. Telephony is a dummy variable defined to equal one if the cable system offers telephony service to its subscribers. Otherwise, it is equal to zero. The data come from the 2004 FCC Annual Cable Price Survey.

44. Programming expenses are measured as the per subscriber total programming expenses for BST plus CPST1 tiers only. The data come from the 2004 FCC Annual Cable Price Survey.

45. Size - NCL and Size - NCS correspond to the definitions of large and small noncompetitive cable systems found in the text. The category Size - NCM (medium) is omitted to avoid the problem of singularity among the size/type dummy variables. The value of the variable is defined to equal one if the cable operator meets the definition criterion and zero otherwise.

46. Type - DBS, Type LP (low penetration), Type - OB (Overbuild wireline), and Type - WL (wireless) of DBS, low penetration, overbuild, and wireless competitive cable systems found in the text. The value of the variable is defined to equal one if the cable operator meets the definition criterion and zero otherwise.

47. Density is defined to equal the total population of the Zip code area divided by the geographic extent of the area (i.e., the number of square miles). The population data come from the 2002 Census of Population and the geographic extent data come from the U.S. Postal Service.

48. Digital Cable Supply is the total number of subscribers to which digital cable service is being supplied in a franchise area. The data come from the 2004 FCC Annual Cable Price Survey. It is computed by multiplying the percent of subscribers taking digital cable service by the total number of subscribers.

49. Parent Subscribers is the total number of subscribers that the parent company of the individual cable system has in the United States. The data come from the 2004 FCC Annual Cable Price Survey.

Appendix - Table A. Descriptive Statistics of the Variables

	Mean	Standard Deviation	Minimum	Maximum
Analog Cable Subscribers (000)	201.663	170.210	0.04700	619.280
Digital Cable Subscribers	107.085	65.6277	0.01100	227.600
DBS Subscribers (000)	47.7661	56.2596	0.01400	428.108
Proportion of DBS Subscribers	0.15395	0.11409	0.00036	0.83807
BST Price ($/mo)	12.9273	3.78946	4.75000	45.5000
CPST1 Price ($/mo)	27.5742	5.59138	0.00000	40.6800
BST + CPST1 Price ($/mo)	40.5015	4.37427	20.9500	53.9000
Digital Price ($/mo)	10.2535	4.75603	1.00000	45.3100
Households Passed (000)	531.856	362.446	0.42439	1368.05
% Rural	18.3117	21.3020	0.00100	91.1684
Analog Channels	68.6293	10.2473	8.00000	146.000
Analog Sports Channels	4.46824	1.26356	0.00000	11.0000
Analog News Channels	4.56610	1.06020	0.00000	6.00000
Digital Channels	34.9765	19.4129	8.00000	97.9980
Digital Sports Channels	2.30421	1.68257	0.00000	9.00000
Digital News Channels	0.46977	0.62907	0.00000	4.00000
DBSLIL	0.87873	0.32671	0.00000	1.00000
Adelphia	0.04556	0.20870	0.00000	1.00000
Mediacom	0.00086	0.02935	0.00000	1.00000
Cablevision	0.05250	0.22323	0.00000	1.00000
Charter	0.09954	0.29963	0.00000	1.00000
Insight	0.01459	0.12002	0.00000	1.00000
TWC	0.28970	0.45400	0.00000	1.00000
Cox	0.25268	0.43490	0.00000	1.00000
Comcast	0.21110	0.40842	0.00000	1.00000
WOW	0.01732	0.13059	0.00000	1.00000
% RB	14.1860	13.8621	0.14715	66.4645
% RA	3.17048	3.99803	0.16963	30.8906
% Spanish	10.0901	10.2778	0.96897	81.8210
% Education - HS	28.4878	6.26058	13.7254	48.5032
% Education - College	24.3847	8.50702	7.89902	61.6365
% HU Occupied	91.6420	4.67778	62.3029	98.1360
% Poverty	12.5599	5.73771	3.21495	35.6799
% House > 10	12.7870	11.1336	0.96831	89.7965
Median Value ($)	121570.	63944.9	44900.0	478300.
Owner Occupied (%)	66.5357	11.4006	19.4598	84.3062
% LP Gas	5.58892	5.99475	0.60339	37.0594
Elevation	38.3274	7.91341	23.0000	54.0000
Internet	0.99508	0.07002	0.00000	1.00000
Telephone	0.32701	0.46950	0.00000	1.00000
Capacity	751.249	95.2057	300.000	870.000
Cluster	0.95586	0.20557	0.00000	1.00000
Effective Competition	0.30663	0.46147	0.00000	1.00000
Regulation	0.44892	0.49779	0.00000	1.00000
Programming Expenses ($000)	135.422	45.2420	0.67123	2185.66
Size - NCL	0.55768	0.49707	0.00000	1.00000
Size - NCS	0.02465	0.15510	0.00000	1.00000
Type - DBS	0.07221	0.25905	0.00000	1.00000
Type - DLP	0.02659	0.16101	0.00000	1.00000
Type - OB	0.15007	0.35744	0.00000	1.00000
Type - WL	0.05758	0.23315	0.00000	1.00000
Density	72.3995	164.887	0.00384	1870.93
Parent Subscribers (000)	10122.1	6445.98	0.92900	21468.0