Statistical Evidence of Substitutability Among Video Delivery Systems

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CONTENTS

I. INTRODUCTION

The sharp increase in the number of television broadcast stations in the last two decades,[1] combined with the development of various new home video delivery systems, has brought the existing broadcast regulatory structure into question. If consumers can turn to close substitutes, the imposition of ownership and program content restrictions on full-power television stations may be superfluous or even counterproductive. For example, in 1982 an estimated 80 percent of television households were receiving five or more signals (Levy and Setzer 1982:81). While the rapid growth of traditional broadcasting services in their local markets in itself may justify elimination of ownership and content regulation, the arrival of new services can reinforce this conclusion. If the relevant product market for broadcast stations, according to standard antitrust analysis, includes all other means for distributing video programming—cable television, satellite master antenna television (SMATV), low-power television, direct broadcast satellites (DBS), multichannel MDS, and home videocassette recorders (VCRs), it is highly unlikely that broadcasters have significant market power in these local markets.

Market power refers to the ability of a firm or group of firms to profit by raising the price of a product or service above its cost. Two extensions of the concept are needed in order to apply it to video markets. First, quality must be considered. A reduction in the quality of a service (e.g., video programming) at constant price may be an exercise of market power. Second, advertising supports television broadcasting. There is no "price" paid by viewers for programming; advertisers pay broadcasters for exposures to viewers. Because VCRs and cable are currently both pay media, their impact on television advertising markets is slight. Radio and print provide the major substitutes for television advertising. This article will not address itself to that topic.[1]

The primary issue, then, is diversity and quality of programming. The presence of rival delivery systems is likely to improve the quality of broadcast programming. Movies, both theatrical and "made for TV," are staples of broadcast programming. The availability of inexpensive rental cassettes provides viewers with an alternative, one that broadcasters are likely to find increasingly important to consider as VCRs spread. The possibilities of substitution are present even for less similar programming. The advertiser-supported nature of television dictates that it appeal to the mass market. Pay media can appeal to more specialized interests. The possibility that viewers may shift from (mediocre) general-interest programming to specialized programming is likely to stimulate improvements in the quality of programs with mass appeal.

Substitution possibilities extend beyond entertainment programming. Information can also be presented via VCRs, and it is possible that video equivalents of magazines may develop. Even political messages may be distributed by VCR. (This method was used by Ayatollah Khomeini while in exile, for under the Shah, his access to the media was restricted. The fact that it is currently hard to imagine this technique being used in the United States is due perhaps to the wide diversity of readily available viewpoints here.)

If, then, the menu of alternatives available to viewers (and, indeed, speakers) is so wide, regulation of broadcast programming content or commercial messages will not improve consumers' lot. The same analysis supports the FCC policy of not regulating pay-television rates (and preempting state regulation). Indeed, it might support the case against regulation of basic cable rates.

One purpose of this study is to estimate the demand for VCRs and cable in order to obtain some statistical evidence on the substitution of these sources of programming for traditional broadcast service. Previous staff reports of the FCC's office of Plans and Policy have suggested that such substitutability may exist in the case of cable and VCRs (Levy and Setzer, 1982; Gordon, Levy, and Preece 1981; Setzer, Franca, and Cornell 1979). This paper will also attempt to obtain quantitative evidence on substitutability between cable and VCRs.

The next section develops a supply-and-demand model for VCRs and cable service, and describes the data set used to estimate it. The third section discusses the methodological problems arising out of using a state by state model as well as other features of the model. The fourth section describes the results of the data analysis. The final section summarizes our findings and presents suggestions for future research.

II. THE MODEL

A. Introduction

This section develops the empirical models for estimating VCR and cable demand. The basic exposition is presented in some detail for the VCR model, then more briefly for the cable model. Following the expositions is an examination of some methodological difficulties with the underlying model.

The models are simple partial equilibrium ones in which it is assumed that the quantity demanded (of VCR or cable services) is determined by income, population, tastes, own prices, and the prices of substitute and complement goods. The supply is assumed to be perfectly elastic in the relevant range. This assumption appears reasonable in light of the fact that the model is estimated on cross-sectional data.[2] The model can thus be written as:

(1) $Q_{VCR}{}^{d} = Q_{VCR}{}^{d}\,[P_{VCR}, P_{cable}, P_{TV}, P_{movies}, P_{cassettes}, Y, N, T]$
(2) $P_{VCR} = K$
(3) $Q_{VCR}{}^{s} = Q_{VCR}{}^{d}$

where the following definitions obtain:

$Q_{VCR}{}^{d}$ = quantity demanded of VCR services
P_{VCR} = price of VCRs
P_{cable} = price of cable service (see subsection B.3.b.)
P_{TV} = "price" of television services (see subsection B.3.c.)
P_{movies} = price of movies
$P_{cassettes}$ = price of cassettes (see below)
Y = income
N = population
T = tastes
$Q_{VCR}{}^{s}$ = quantity supplied of VCR services
K = the constant price of VCRs

Equation (2) reflects the perfect elasticity of supply assumption. Substituting (2) into (1) and (1) into the equilibrium condition (3) yields the following reduced-form equation (dropping superscripts):

(4) $Q_{VCR} = Q_{VCR}\,[K, P_{cable}, P_{TV}, P_{movies}, P_{cassettes}, Y, N, T]$.

As noted above, the model is estimated on cross-sectional data. Data availability and certain conceptual constraints dictate the modeling strategy. The consumer has several video distribution channels from which to choose, some of which are available on a local basis only (e.g., cable, broadcast television, and movies). For VCR services the market may be broader, since the availability of rental cassettes probably is similar across the country. While the local selection may be narrower outside the big population centers, differences are unlikely to be great. Furthermore, cassettes are available for rental on a mail-order basis as well. In any event, market-specific data are needed to examine interactions among the various products. Unfortunately, the least aggregated data available for VCRs are on a state-by-state basis. Data on movies are available for only a limited number of metropolitan areas, and therefore are not included. Although figures are compiled by state every five years, the most recent data are too old.[3]

Even though cable and broadcast markets are local in nature, the VCR data availability dictates using state figures for cable and broadcast television as well. The variables are constructed in such a way as to reflect actual market conditions as closely as possible.

The estimation of equation (4) using state data means that two independent variables drop out of the equation. It seems reasonable to assume $P_{\text{cassettes}}$ is constant across states.[4] It is also assumed that each state's population has the same distribution of tastes. This would clearly not be the case if people chose their state of residence on the basis of television availability. Nor would it be true if states varied by age of population or size of household. It is assumed that such variations are insignificant (but see note 9). Hence tastes also drop out of the equation. This leaves the following basic estimating equation:

$$(5)\quad Q_{\text{VCR}} = Q_{\text{VCR}}\,[P_{\text{cable}}, P_{\text{TV}}, Y, N]$$

B. The Dependent Variables in the VCR Equations

Data are available on VCR sales to dealers for 1979–1982, on a state-by-state basis. The latest data available on the other relevant variables are also for 1982. Thus, 1982 is the year for which the statistical analysis is made. The ideal VCR variable would consist of the flow of VCR services provided during 1982 by the VCRs in consumer hands then. Such a variable could be constructed by determining the stock of VCRs available and applying a pure rental rate to it. Although the home VCR was introduced to the public in 1975, sales records are only available beginning in 1978 (Electronic Industries Association 1983).[5] Table 2.1 shows the 1978–1982 sales to dealers. The sum of 1979–1982 sales to dealers is 4.7 million, while an estimated 4.5 million were in use at the beginning of 1983. (Electronic Industries Association 1983:16–18). Thus, sales to dealers and final sales are in rough correspondence, even taking into account the 400,000 VCRs sold in 1978. While the VCR is a durable product, some VCRs probably had been scrapped by 1982, and it is likely that most of those scrapped were older models. Thus it is reasonable to take 1979–1982 sales to dealers as an estimate of VCRs in consumers' hands.[6]

Table 2.1. VCR Sales to Dealers

Year	*Sales to Dealers*
1978	401,930
1979	475,396
1980	804,663
1981	1,360,988
1982	2,034,797

SOURCE: Electronic Industries Association (1983:18).

To convert this stock to a flow of services requires a pure rental rate. At least two issues arise in choosing such a rate. First, there have been significant improvements in the quality of VCRs over time. Thus the value of the services provided by a 1979 VCR is probably lower than that of a 1982 model. Second, the market rates for VCR rentals are probably overestimates. VCRs are usually rented for short periods of time—either periods of peak demand or perhaps for gathering information before a purchase. Also, the normal VCR rental includes some sort of maintenance provisions.

In the absence of a better way to deal with these problems, the initial form of the dependent variable will be simply the total number of VCRs in use. Had there been no problem with quality change, the transformation of the stock to a flow would have been accomplished by simply applying a fixed rental rate to the stock of VCRs. In that event, using the total stock as the dependent variable would not affect the statistical significance of the relevant coefficients, although their magnitude would be affected. Even with the quality differences, as long as there are no important differences in the quality mix across states, the significance of the results will be unaffected. Table 2.3 shows that the sales by state in each year are highly correlated with one another. Finally, table 2.1 indicates that 73 percent of the VCRs in use are 1981 or 1982 models, which suggests that the problem of quality change may not be that important.

An alternative form of the dependent variable is VCR penetration—the fraction of television households that own a VCR.[7] As the results reported below suggest, the total VCR variable seems to be more a reflection of the size of a state (in population and total income) than of anything else. The VCR penetration variable in effect holds state size constant and allows a more detailed analysis of other explanatory variables. The results in section IV and in the appendix include both of these dependent variables, along with a few transformations of them.

C. The Independent Variables in the VCR and Cable Equations

This subsection describes the independent variables used in the analysis and indicates the sources of the data. The independent variables include income, population, and broadcast and cable TV prices.

1. Income

The basic income data come from U.S. Department of Commerce (1983c). Total and per capita disposable personal income (i.e., after taxes) are available. Because choices such as VCR purchase and cable subscription are made on a household basis and because of the use of data on television households (see subsection 2 of this section), it is desirable to have a household income variable. Household income data are not available for 1982, and a series was therefore constructed on the assumption that the average household has three members. As long as there are no systematic differences in household size across states, the statistical significance of the results is unaffected (although the magnitude of the coefficient would be wrong if the average number of people per household were different).[8] However, there may be more retired-person households in Florida, there may be larger families in the South or West, and there may be variations in household size associated with income. It is assumed that these differences are not important.[9]

2. Population

Since a television receiver is required to make use of VCRs, cable television, and broadcast television, it is appropriate to limit attention to those who own receivers. The decision to make use of these video delivery systems is generally made on a household basis; so data on television households per state are employed. The data are collected by Arbitron and reported by Television Digest, Inc. (1983:20–36). Nationwide, 98 percent of households have television. The lowest penetration is 96 percent, achieved in one state. Most states have 98 or 99 percent penetration. It should be noted that the income data are for the entire population, not just for television households. If it is true that households without television receivers are of relatively low income, then the income data used slightly underestimate the income of television households.

3. Other Prices

a. General Considerations. The price of cable or broadcast television services has several components. The first is the out-of-pocket price. For basic cable or pay cable service, this is the monthly rate paid. For advertiser-supported broadcast television service, this price is zero, although the price of the television receiver is relevant. A second component of the "price" of service is availability. For example, the price of cable service to a home not passed by cable is infinite. The third component is the quality of the service. For example, the quality of broadcast television service is related to the number of channels available (the same is true for cable). Some of the prices mentioned have the character of "access charges." The price of basic cable service buys the subscriber not only basic service but access to pay service. The price of a television receiver buys "access" to broadcast television. These principles are applied in the discussions of the specific price variables.

b. Cable Prices. Paul Kagan Associates (1983b) provides state data on the number of homes passed by cable systems and on the average monthly basic and pay (per channel) rates in each state.[10] Two measures of the availability of cable service are used. The first is simply the number of homes passed by cable. The second is the fraction of television households in the state passed by cable. For homes not passed by cable, the price of cable service is, for all practical purposes, infinite. There are limited exceptions, which are ignored in this study. SMATV provides service akin to basic and pay cable, but its penetration was negligible, with an estimated 100,000 subscribers nationwide at the end of 1982 (Paul Kagan Associates 1983d:1). One-channel pay service is also available via multipoint distribution service (MDS) and subscription television (STV). However, by the end of 1982 these accounted for only 2.4 and 7.9 percent of pay subscriptions, respectively (Paul Kagan Associates 1983d).[11]

Homes passed by cable face out-of-pocket prices for basic and pay services.[12] As Dunmore and Bykowsky (1982:3–12) have shown, the prices relevant for basic cable demand are the basic rate and the composite (basic plus pay) rate. A viewer will subscribe to basic cable if he values it above the basic rate, *or* if he values it below the basic rate but his valuation of pay cable is sufficiently greater than the pay cable rate that the value of basic plus pay service is greater than the composite rate. In this event, he will find a basic subscription worthwhile just to gain access to pay cable.

Similar reasoning within the Dunmore-Bykowsky framework suggests that the relevant prices for pay service are the pay rate and composite rate. In order to choose pay service, it is necessary for the value placed on basic plus pay service to be greater than the composite rate. However, this is not sufficient. The value placed on pay service alone must also be above the pay rate. If the first condition were true because basic service was very highly valued but pay service was not, then only basic service would be purchased.

This reasoning has clear implications for the appropriate form of the cable demand equations. In each case the analysis takes into account the interplay of pay and basic services. However, for the VCR equation the implications are less clear. Both pay and basic cable may be substitutes or complements with respect to VCRs. Because the composite rate is the sum of the basic and pay rates, all three cannot appear in the same equation. Hence various combinations of cable price variables will be tried.

There are also quality differences across cable systems. The number and composition of channels in basic service differs from system to system, as does the availability of pay services. The movie channels may be of differing qualities, though there is no a priori way to assess the differences. This problem will be unimportant if the average quality does not differ across states. One possible proxy for different quality levels is the subscriber-weighted average number of channels available per state, but the data to calculate this measure were not available.

c. Television "Prices." As noted above, viewers pay no direct price for television programming. While it is necessary to pay an "access charge" by purchasing a television receiver, this study includes only television households. Also, receiver prices are unlikely to vary significantly across states. In order to derive a "price" proxy for broadcast television, quality considerations must be introduced.

When product prices are compared, it is necessary to specify the quality as well as the quantity of product available at a given price. For example, if two television receivers each cost $400, and were identical except for the fact that one of them had remote control and the other did not, it would not make economic sense to say that their prices were the same. By analogy, the quality-adjusted price of broadcast television service becomes lower as the number of stations available increases.

These considerations suggest using the average number of television broadcast stations available per household as a proxy for the "quality-adjusted price" of television service. As the number of stations available goes up, the "quality-adjusted price" goes down. The data collected come from Arbitron Television (1983). It is assumed that television households can receive every station in their ADI market. While this procedure is open to some criticism, particularly if conclusions about specific markets are attempted, it is likely to be fairly accurate for aggregate station availability estimates. For a brief discussion of the pros and cons of using ADI markets for station coverage, see Levy and Setzer (1982). For a pointed critique of the ADI procedure, see FCC, Network Inquiry Special Staff (1980:105–12). In addition to average total stations available per state the average numbers of VHF and UHF stations available are also compiled separately.

D. Dependent Variables in the Cable Equations

The Kagan Census provides data on basic cable subscribers and pay cable subscriptions by state. (Some homes subscribe to more than one pay cable service.) The cable equations were run after the VCR ones, and with the benefit of that experience it became clear that the dependent variables worked better on a "per television household" basis rather than on a "total" basis. Hence the dependent variables in the cable equations are "per television household" and transformations thereof. The basic estimating equation is:

(6) $Q_{\text{cable}} = Q_{\text{cable}}\ [P_{\text{cable}}, P_{\text{TV}}, Y/N]$

As in the VCR case, it is assumed that the supply of cable service is perfectly elastic to homes passed. Hence P_{cable} includes the share of homes passed by cable as well as the subscriber fees. As noted above, two subscriber fees are relevant for basic cable demand and two for pay cable demand. The equations are specified accordingly.

The cable quantities are basic subscribers and pay *subscriptions* from Paul Kagan Associates (1983b). In the pay case, households subscribing to more than one pay service are counted more than once. Hence in principle the pay household share could be above one. Data on unduplicated households are not available by state.

E. Hypothesized Signs

This subsection specifies the hypothesized signs of the independent variables. The income and population variables are hypothesized to have positive signs. The signs of the cable and television broadcast variables indicate whether these services are substitutes or complements with respect to the dependent variable.

A positive sign on the variable for the average number of television stations available indicates complementarity. That is, a larger number of stations available, which corresponds to a lower "price" of television service, is associated with higher consumption of the dependent variable. A negative sign would indicate substitution. Thus, if VCRs are used primarily for "time-shifting" or "librarying" of broadcast television programming (see section III.B. below), the sign would be positive in the VCR equation. If broadcast and cable television are substitutes, the sign would be negative in the cable equations.

The cable price variables represent prices of alternative products in the VCR equation and own prices in the cable equations. In the former case, a positive sign on the homes-passed variable indicates complementarity and a negative sign substitution. Thus, as the share of homes passed by cable rises, the "price" of cable falls; if this price decline is associated with a decrease in VCR use (i.e., a negative coefficient) then a substitution relationship is indicated.

The pay, basic, and composite cable subscription rates are standard prices. In the VCR equations, positive coefficients imply substitution and negative ones complementarity. In the cable equations, it is hypothesized that the cable price variables are negatively associated with cable quantities. Hence the hypothesized signs are negative for the subscription-rate variables and positive for the homes-passed variable.

F. Geographic Coverage

As noted above, the data are by state. Data availability limitations dictate that the sample consist of the 48 contiguous states.

III. PROBLEMS OF METHODOLOGY

This section considers four additional methodological problems with the model. First to be considered is the lack of equilibrium in the VCR market; second, the fact that a VCR can serve as both a substitute and a complement to broadcast and cable television. This is followed by brief discussions of the implications of not estimating VCR and cable equations jointly, and of differences among households in the opportunity cost of time.

A. The Partial Equilibrium Assumption

The VCR is a relatively new product. Nationwide penetration in 1982 was only 10 percent of households, but it is growing rapidly (*Videoweek,* January 2, 1984, p. 5). Clearly, the assumption made in the preceding section that the VCR market is in equilibrium, is not valid. Yet this problem cannot be alleviated in a purely cross-sectional analysis. In a time series study of the demand for computers, Chow (1967) grappled with the problem of estimating demand in a growing market. He combined a "natural growth" model based on the Gompertz curve (similar to the logistic) with a comparative statics model in which computer demand is a function of price and total output of those sectors using computers as an input. The result was an equation including the comparative statics parameters and the lagged stock of computers. The Batelle model of VCR demand, also a time series study, utilized another standard technique—a stock adjustment model. This model, which explicitly assumes that the market is not in equilibrium, also yields an equation which includes a lagged value of the dependent variable (Cronin et al. 1983:32–34). Both of these techniques require estimation on time series data, which data are not available here.

The effect of not accounting for the lack of equilibrium is unclear. If every state were at the same point on the growth curve (Gompertz or logistic), then the basic results would not be affected, although the magnitude of the coefficients would be. Moreover, the estimated coefficients are not presented as tools for predicting future VCR (or cable) penetration: so miscalculation of the *size* of the coefficients would not affect the conclusions of the analysis regarding relationships among the various video products. On the other hand, it is not obvious that every state is at the same point on the growth curve. VCRs were not introduced simultaneously in every state (major cities got them first). While it is unlikely that the lag in availability was significant and thus it is reasonable to assume that each state started at roughly the same point, it is possible that the parameters of the growth curve differ systematically across states. Furthermore, the differences in the diffusion rate may well be functions of some of the independent variables in the present model. Thus if, for example, VCRs and cable are substitutes, states with low cable penetration may have faster diffusion rates. The phenomenon would bias coefficients away from zero.

B. The VCR May Be Both Substitute and Complement

As the debate over the application of copyright laws to home taping reveals, there is more than one possible use for a VCR (*Sony v. Universal Studios,* 1984). In particular, VCRs may be used to record broadcast (or cable) programming for viewing at a different time. This activity encompasses "time-shifting" and "librarying." The former refers to recording a program that one is unable to view when it is broadcast and viewing it at a more convenient time. The latter entails recording a program for repeated later viewing, a program that one may actually watch while recording. In both cases, the VCR functions as a complement to television; that is, as use of the VCR increases, so does use of television.

To understand the phenomenon properly requires a careful definition of the term "use." Normally, there is a direct relationship between the quantity consumed of products that are complements. Here, however, it is possible that the VCR use is complementary to television use and yet television use in terms of hours viewed does not increase. For example, one may have watched ten hours per week of television before acquiring a VCR. Afterward, one may still watch ten hours per week but a totally different ten hours. It is possible that one's preferred programming is broadcast at times when one cannot watch it. Hence, VCR use may increase the *utility* of television even without increasing viewing time (unless one counts the time spent recording programs with no one watching). Indeed, it is possible that VCR use may increase the utility of television while reducing viewing time. At the other extreme, all viewing of VCR-recorded programming could represent a net increase in viewing. Of course, intermediate situations are possible too.

This complementary use of VCRs has implications for programming diversity. The VCR, while not increasing the diversity available in the marketplace, does allow the viewers to provide themselves with the maximum that is available.[13] This "diversity enhancement" makes the competition among outlets more intense and strengthens the presumption the regulation is not needed to guarantee diversity.

VCRs also can serve as substitutes for television. This happens when, for example, consumers rent or buy prerecorded tapes and view them instead of broadcast (or cable) programming.

It is likely that VCRs are used in both the substitute and the complement modes by the same household, at different times. The simple model of this paper is incapable of distinguishing the two effects. The practical consequence is that the price (and availability) coefficients are biased toward zero, since the signs for substitution and complementarity effects are opposite.

There is some a priori reason to think that, for pay television, the substitution effect is predominant. Most pay television consists of movie channels such as HBO, and each movie is shown several times per month anyway, which probably reduces the demand for time-shifting.

C. Joint Estimation

The VCR and cable equations are implicitly part of a system of demand equations. They may be interdependent in the sense that they are generated by a utility-maximization process in which first a share of income is allocated to "video services" and then that share is allocated among various particular services—VCRs and cable being two of them (movies, cassettes, and even DBS may be others). The various equations are subject to an "adding up" constraint. The econometric techniques designed to account for this constraint are not employed here.

D. The Opportunity Cost of Time

In addition to out-of-pocket expenses, the consumption of video services requires time. Time itself is a scarce resource (since it can always be used for something else), so it has an opportunity cost (price) that must be taken into account in estimating demand. The opportunity cost of time is difficult to measure. If it were assumed not to vary across states, it would drop out of the analysis entirely. However, the opportunity cost of time is often related to earnings. The intuitive idea is that a person's hourly earnings represent the amount forgone by choosing an hour of leisure. Although in the short run most people are not in a position to make such marginal choices about hours worked, this mechanism suggests a relationship between the cost of time and hourly earnings (or income). To the extent that the cost of time is correlated with household income, it is picked up by that variable in the equations estimated.

The effects of increases in income and the opportunity cost of time may, however, be offsetting. The standard income effect suggests that the demand for VCRs increases with income. On the other hand, consumers with high opportunity costs of time may devote less of it to leisure. This would reduce their demand for video services. Finally, the effect of the high opportunity cost of time may differ across media, with a smaller demand reduction for those systems that increase time flexibility (e.g., VCRs).

IV. RESULTS

This section discusses the regression results. Ordinary least squares regressions were estimated for VCR and cable dependent variables against various combinations of the independent variables suggested by the theoretical model constructed earlier. The first part presents a discussion of simple correlation coefficients for the various variables considered. The next part presents the regression equations which specify the determinants of VCR demand using the number of VCRs per household. The third part presents the regression equations specifying the determinants of cable demand. For reference, table 2.2 provides a list of variable names and definitions.

A. Simple Correlation Coefficients

Simple correlation coefficients were calculated for most pairs of variables.[14] Table 2.3 contains these results. This analysis was useful in selecting independent and dependent variables for regression analy-

Table 2.2. Variable Names

VCR79—VCR sales to dealers in 1979
VCR80—VCR sales to dealers in 1980
VCR81—VCR sales to dealers in 1981
VCR82—VCR sales to dealers in 1982
VCRTOT = VCR79 + VCR80 + VCR81 + VCR82

TVHHN—Number of television households

VCRPH = VCRTOT/TVHHN
VCRLN = *ln*(VCRPH/(1 − VCRPH))
PHLN = *ln*(VCRPH)
VTOTLN = *ln*(VCRTOT)

BASSUB—Number of homes subscribing to basic cable
PAYSUB — Number of subscriptions to pay cable
BASPH = BASSUB/TVHHN
PAYPH = PAYSUB/TVHHN
BASPHL = *ln*(BASPH/(1 − BASPH))
PAYPHL = *ln*(PAYPH/(1 − PAYPH))
PHPAY = *ln*(PAYPH)

HPASSE—Number of homes passed by cable
HPPH = HPASSE/TVHHN
HPPHLN = *ln*(HPPH)

DPI—Disposable personal income ($ millions)
DPIPC—Per capita disposable personal income
DPIHH = 3 · DPIPC
DPILN = *ln*(DPI)
DPIHLN = *ln*(DPIHH)

STATOT—Average total broadcast stations available per television household
STAVHF—Average VHF broadcast stations available per television household
STAUHF—Average UHF broadcast stations available per television household
STOTLN = *ln*(STATOT)
SVHFLN = *ln*(STAVHF)

BASRAT—Monthly basic cable rate ($)
PAYRAT—Monthly pay cable rate—one channel ($)
CRAT = BASRAT + PAYRAT
BASLN = *ln*(BASRAT)
PAYLN = *ln*(PAYRAT)
CRATLN = *ln*(CRAT)

TVHLN = *ln*(TVHHN)

C = the constant term

NOTE: "*ln*" means natural logarithm.

sis.[15] Three conclusions were reached on the basis of these correlation results and early regression equations.

First, the total sales of VCRs for 1979 through 1982, VCRTOT, was not as useful a dependent variable as the ratio of total VCR sales to the total number of television households (VCRPH). This is the case because the VCRTOT variable is so highly correlated with total disposable income (DPI) and the total number of television households (TVHHN). The correlation coefficient for VCRTOT–DPI is .954. The correlation coefficient for VCRTOT–TVHHN is .935. These high correlations might be expected to mask the effects of other independent variables on the demand for VCRs. In effect, regressions employing these variables merely reflect size differences across states. An ordinary least squares regression of VCRTOT against DPI alone gives an R^2 of .9087. (See table 2.9 in the appendix.) The VCR-per-household variable (VCRPH) is a more useful dependent variable because it is not as highly correlated with DPI (.559), TVHHN (.527), and disposable income per household, DPIHH (.508). Therefore, when analyzing the demand for VCRs, specifications using VCRPH and transformations thereof as the dependent variable were selected.

Second, table 2.3 reveals that there is a fairly high correlation between basic cable rates and pay cable rates (.483), and quite a high correlation between the pay and composite rates (.883) and between the basic and composite rates (.837). These high correlations help explain the fact that while theory might suggest otherwise, analysis of the various regression equations showed that these independent variables were rarely significant unless used alone. When two cable rates were used together, it was never the case that both were significant.

Third, the correlation coefficients suggest some other points about the appropriate independent variables to be used with the (admittedly less satisfactory) VCRTOT variable. Table 2.3 also shows that DPI is highly correlated with TVHHN (.994), while DPIHH is not as highly correlated with TVHHN (.356). A regression of VCRTOT against both DPI and TVHHN gives a high R^2, but the coefficient of the TVHHN variable is both *negative* and significant. (See table 2.9 in the appendix.)[16] That the demand for VCRs should be inversely related to the number of television households conflicts with any demand theory that is plausible. Apparently, multicollinearity is making it impossible to separate the effects of income and population. Regression of VCRTOT

Table 2.3. Selected Simple Correlation Coefficients

VCRTOT–DPI	.954
VCRTOT–DPIHH	.411
VCRTOT–TVHHN	.935
VCRTOT–HPASSE	.909
VCR82–VCR81	.991
VCR82–VCR80	.991
VCR82–VCR79	.982
VCR81–VCR80	.997
VCR81–VCR79	.993
VCR80–VCR79	.994
VCRPH–DPI	.559
VCRPH–DPIHH	.508
VCRPH–TVHHN	.527
HPASSE–DPI	.968
HPASSE–DPIHH	.353
HPASSE–TVHHN	.975
HPPH–DPI	.050
HPPH–DPIHH	.202
HPPH–TVHHN	.044
DPI–TVHHN	.994
DPI–STATOT	.499
DPI–STAVHF	.074
DPIHH–TVHHN	.356
DPIHH–STATOT	.498
DPIHH–STAVHF	.374
STATOT–TVHHN	.457
STATOT–STAVHF	.345
CRAT–PAYRAT	.883
CRAT–BASRAT	.837
PAYRAT–BASRAT	.483

against both DPIHH and TVHHN, however, produces intuitive results. Both DPIHH and TVHHN are positive and TVHHN is highly significant. (See table 2.9 in the appendix. Table 2.10 presents additional

VCRTOT results.) Table 2.3 also shows a very high correlation between TVHHN and HPASSE. This suggests that equations using DPIHH, TVHHN, and HPPH as independent variables are most appropriate.

B. The VCR Results

This subsection examines those regression equations which best explain the demand for VCRs. On the basis of the correlation coefficient analysis, it was determined that VCRPH, the VCRs-per-household variable, is preferable to VCRTOT, the total number of VCRs. Five specifications were employed: VCRPH with the independent variables in linear and log forms; VCRLN (i.e., *ln*[VCRPH/(1 − VCRPH)]) with the independent variables in linear and log forms; and PHLN (i.e., *ln*VCRPH) with the independent variables in log form. As suggested by the model, independent variables reflecting household disposable income, the share of television households passed by cable, total television station availability per household,[17] and cable subscription rates were included.

There is some ambiguity in the theory on the question of what cable rates should be included in the equation. As explained in section II.C.3., both the pay and composite rates are relevant for the choice of pay cable, and both the basic and combined rates are relevant to the basic cable choice. If basic and pay cable are distinct products, each of which could be a substitute or complement to VCRs, then all three rates should go into the VCR equation. Since the composite rate is a simple linear combination of the other two, this is clearly impossible. Furthermore, the pairwise simple correlation coefficients of the cable rates are relatively high, suggesting that it may be difficult to separate their effects in a single equation. Therefore various combinations were tried.

The results, reported in tables 2.4, 2.5, and 2.6 (and in table 2.11 in the appendix) are quite similar for all five specifications. The preferred equations appear in columns two and four of tables 2.4 and 2.5, and in column two of table 2.6. The homes-passed variable is significant at the 95 percent level and negative in all cases, the household income variable is significant and positive in all cases, while the variable of total station availability is always positive but not quite significant.[18] The cable price variables are never significant either alone or in pairs. The coefficients are sometimes positive and sometimes negative. The re-

Table 2.4. Selected VCR Regression Results with VCRPH as the Dependent Variable

Independent Variables	(1)	(2)	(3)	(4)	(5)
DPIHH	.340E05* (4.00)	.311E05* (3.25)	—	—	—
DPIHLN	—	—	—	.080* (3.14)	—
HPPH	—	−.051* (−2.44)	−.042 (−1.83)	—	—
HPPHLN	—	—	—	−.023* (−2.06)	−.020 (−1.60)
STATOT	—	.167E02 (1.54)	.334E02 (3.17)	—	—
STOTLN	—	—	—	.012 (1.42)	.023* (2.85)
PAYRAT	—	−.507E04 (−.01)	.220E02 (.51)	—	—
PAYLN	—	—	—	−.784E03 (−.02)	.024 (.62)
C	−.048* (−2.06)	−.022 (−.57)	.024 (.61)	−.801* (−3.23)	−.066 (−.75)
R^2	.2416	.3235	.1766	.2907	.1483

NOTES: See table 2.2 for variable definitions. "E" means exponent; E02 means "multiplied by .01," E04 means "multiplied by 10,000," etc.

The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.

*Significant at the 95 percent level.

sults reported in tables 2.4 through 2.6 include the pay rate alone; this choice was made because, with the preferred set of independent variables, the station availability variable came closest to significance there in four of the five specifications.

These also show results for two other specifications. The first equation in each table indicates that the disposable-income variables alone explain a substantial portion of the total variation in the dependent variables. Equations with the income variable removed are also presented. These equations were estimated because of the relatively high simple correlation coefficient (.498) between DPIHH and STATOT, which may make it impossible to identify clearly their separate effects. The results are consistent with this interpretation, since without the

Table 2.5. Selected VCR Regression Results with VCRLN as the Dependent Variable

Independent Variables	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
DPIHH	.841E04*	.820E04*	—	—	—
	(4.06)	(3.52)			
DPIHLN	—	—	—	2.113*	—
				(3.45)	
HPPH	—	−1.306*	−1.058	—	—
		(−2.56)	(−1.87)		
HPPHLN	—	—	—	−6.13*	−.519
				(−2.26)	(−1.72)
STATOT	—	.031	.075*	—	—
		(1.19)	(2.89)		
STOTLN	—	—	—	.226	.534*
				(1.12)	(2.63)
PAYRAT	—	−.013	.046	—	—
		(−.13)	(.43)		
PAYLN	—	—	—	−.126	.544
				(−.14)	(.56)
C	−5.469*	−4.761*	−3.568*	−25.247*	−5.734*
	(−9.75)	(−5.18)	(−3.72)	(−4.22)	(2.63)
R^2	.2482	.3261	.1517	.3061	.1340

NOTES: See table 2.2 for variable definitions. "E" means exponent; E02 means "multiplied by .01," E04 means "multiplied by 10,000," etc.

The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.

*Significant at the 95 percent level.

income variable in the equation the station-availability coefficient becomes significant and larger in magnitude (taking up some of the effect of the income variable). These specifications are, of course, less satisfactory over all, due to the omission of income, the reduced significance of the homes-passed variable, and the lower R^2, but they do strengthen the conclusion that the sign of the station-availability variable is positive.

The results therefore support the conclusion that VCRs and cable are substitutes, and less strongly that VCRs and broadcast television are complements. The negative sign on the homes-passed variable indicates that, as the share of homes passed rises (i.e., as the "price" of cable service *falls*) fewer homes acquire VCRs. The positive sign on the television station-availability variables indicates that as the average number of broadcast stations available rises (i.e., as the "price" of television service falls), more homes acquire VCRs. The positive signs of the income coefficients indicate that the VCR is a normal good; that is, the quantity of VCRs demanded increases when personal income increases.

C. The Cable Results

This subsection discusses the results of the estimation of basic and pay cable demand. While no interesting results were obtained for basic cable, good results were obtained for pay cable under a variety of specifications.

1. The Basic Cable Results

For basic cable, linear equations were estimated with BASPH and BASPHL as dependent variables. While the portion of variation explained is high, almost all of it is due to HPPH, which has the expected

Table 2.6. Selected VCR Regression Results with PHLN as the Dependent Variable

Independent Variables	*(1)*	*(2)*	*(3)*
DPIHLN	2.142*	2.030*	—
	(4.06)	(3.46)	
HPPHLN	—	−.589*	−.499
		(−2.26)	(−1.72)
STOTLN	—	.214	.509
		(1.10)	(2.62)
PAYLN	—	−.125	.519
		(−.15)	(.56)
C	−25.087*	−24.404*	−5.662*
	(−4.66)	(−4.26)	(−2.71)
R^2	.2478	.3058	.1328

NOTES: See table 2.2 for variable definitions.
The figures in parentheses are t statistics.
R^2 is adjusted for degrees of freedom.
*Significant at the 95 percent level.

positive sign and is always significant. This variable plus the constant term together explain 77 percent of the variation in the dependent variables. No equation explains more than 79 percent. Table 2.12 in the appendix exhibits some basic-cable demand regression results. None of the other variables is ever significant, with the exception of DPIHH, which is occasionally significant but has a negative sign, contrary to hypothesis. The station availability variables are of mixed sign, as is BASRAT. CRAT is always positive, contrary to hypothesis, but never significant.

2. *The Pay Cable Results*

Five specifications of the pay-cable demand equation were estimated, and the results obtained were robust with respect to all alternatives. While the homes-passed variable once again explained most of the variation in the dependent variable, the other independent variables also add substantially to the goodness of fit. (Compare columns 1, 2, and 3 of table 2.7 to columns 1, 4, and 5 of table 2.8.)

The following five specifications were estimated: PAYPH with the independent variables in linear and log forms; PAYPHL with the independent variables in linear and log form; and PHPAY with the independent variables in log form. Each equation included a household income variable, a homes-passed variable, a total broadcast station availability variable,[19] and a cable price variable or variables. The income variable is always significant and positive, as hypothesized. The homes-passed variable is also significant and positive, as hypothesized. As the share of homes passed by cable rises, the collective "price" of pay cable to the residents of a state falls, and more subscriptions are purchased. (Recall that the pay-cable dependent variables are based on subscriptions rather than on unduplicated homes subscribing). The total station-availability variable is always negative and frequently (60 percent of the time) significant. This suggests that broadcast television and pay cable are substitute services. The results indicate that as the number of television broadcast stations available increases (i.e., as the "price" of broadcast television service decreases) pay cable subscriptions decrease.

As explained in section II.C.3., theory suggests that pay cable rate *and* the composite (pay plus basic) rate belong in the equations. In every case, however, while the pay rate was significant, the combined

Table 2.7. Pay Cable Regression Results: Homes-Passed Only and Theoretically Preferred Specifications

	Dependent Variable				
	(1) *PAYPH*	*(2)* *PAYPHL*	*(3)* *PHPAY*	*(4)* *PAYPHL*	*(5)* *PHPAY*
Independent Variables					
DPIHLN	—	—	—	1.514*	1.108*
				(5.99)	(6.15)
HPPHLN	—	1.247*	.946*	1.277*	.966*
		(7.33)	(7.46)	(10.95)	(11.63)
HPPH	.420*	—	—	—	—
	(7.07)				
STOTLN	—	—	—	−.170*	−.125*
				(−1.98)	(−2.05)
PAYLN	—	—	—	−2.725*	−2.269*
	—	—	—	(−3.51)	(−4.10)
CRATLN	—	—	—	.316	.449
				(.33)	(.65)
C	.013	−.387*	−.862*	−10.339*	−8.157*
	(.38)	(−3.66)	(−10.97)	(−3.87)	(−4.29)
R^2	.5100	.5287	.5379	.8048	.8247

NOTES: See table 2.2 for variable definitions.
The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.
*Significant at the 95 percent level.

rate proved insignificant. Its sign varied. This lack of significance may be due to the relatively high simple correlation between the pay and combined rates (see table 2.3). Equations were therefore estimated using the pay rate alone and the combined rate alone. These coefficients were invariably significant and negative, as hypothesized.

Columns 4 and 5 of table 2.7 present examples of the theoretically preferred set of independent variables (i.e., including both the pay and combined cable rates). These are the only two cases in which the station availability variable is significant and the theoretically preferred set of independent variables is used. In the other three cases, the sign is negative but the coefficient is not quite significant. (See table 2.13 in the appendix.) When only the composite rate is used, the station availability variable becomes significant in all cases, and all other independent variables are significant. Table 2.8 presents these results. When

Table 2.8. Pay Cable Regression Results: Five Alternative Specifications with Composite Cable Rate Only

	Dependent Variable				
	(1) *PAYPH*	*(2)* *PAYPH*	*(3)* *PAYPHL*	*(4)* *PAYPHL*	*(5)* *PHPAY*
Independent Variables					
DPIHH	.100E-04*	—	.525E-04*	—	—
	(4.72)		(4.69)		
DPIHLN	—	.288*	—	1.508*	1.103*
		(5.13)		(5.31)	(5.23)
HPPH	.462*	—	2.579*	—	—
	(9.75)		(10.33)		
HPPHLN	—	.238*	—	1.353*	1.030*
		(9.37)		(10.51)	(10.79)
STATOT	−.523E-02*	—	−.030*	—	—
	(−2.19)		(−2.41)		
STOTLN	—	−.041*	—	−.234*	−.179*
		(−2.21)		(−2.49)	(−2.56)
CRAT	−.029*	—	−.161*	—	—
	(−5.12)		(−5.43)		
CRATLN	—	−.475*	—	−2.692*	−2.055*
		(−4.70)		(−5.26)	(−5.42)
C	.266*	−1.097	−.942	−7.520*	−5.810*
	(2.78)	(−1.94)	(−1.87)	(−2.63)	(−2.74)
R^2	.7282	.7143	.7454	.7533	.7602

NOTES: See table 2.2 for variable definitions. "E" means exponent; E-04 means "multiplied by .0001," etc.

The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.

*Significant at the 95 percent level.

only the pay rate is used, the station availability variable is significant in two of five specifications. In their basic-cable demand work, Dunmore and Bykowsky (1982) found the same pattern found here: the composite rate was significant and negative, while the basic rate was insignificant (and positive) in their equation.

V. CONCLUSIONS

This paper has presented estimates of VCR and cable demand, based on 1982 cross-section data for the 48 contiguous states. In spite of the fact that the state is not the best unit of analysis (market data would be preferable), several significant results were obtained.

VCR demand equations were estimated with the fraction of television households owning a VCR as the dependent variable. Several transformations of that variable were also used, and the independent variables were expressed in both linear and logarithmic forms. In every equation with a dependent variable based on the fraction of television households owning a VCR, the household-income coefficient had its expected positive sign and was significant. In equations with the preferred set of independent variables, the homes-passed coefficient was consistently negative and significant, lending strong support to the proposition that VCRs and cable are substitutes. The consistent positive sign on the television station-availability variable lends some support to the conclusion that VCRs and broadcast television are complements. These coefficients are not quite significant when estimated with the preferred set of independent variables, but this appears to be due to multicollinearity with the income variable. The complementary relationship is quite consistent with the survey data on use of VCRs for time-shifting. To the authors' knowledge, these results are the first to estimate statistically the VCR-cable and VCR-television relations. The R^2 values of the equations are reasonably good for cross-sectional data.

There are two fragments of evidence on VCR use that are worthy of mention. First, a survey conducted for the Motion Picture Association of America sheds some light on VCR-cable substitution (NPD Special Industry Services 1983b:78).[20] The survey indicates that .05176 (5.2 percent) of homes passed by cable owned a VCR, while .05405 (5.4 percent) of homes not passed by cable owned one. The figures, from April 1982, show that .05273 (5.3 percent) of all households owned VCRs.

Second, some international data collected by the Motion Picture Association of America, Inc. (1984c) illustrate the complexity of the relationship between VCRs and other video delivery systems. The figures are estimates of numbers of television receivers and VCRs by country for 1983. Although there is some doubt about the quality of the data, the variation in the ratio of VCRs to television receivers across countries is interesting. For the United States, the figure is 5.4 percent. The figures for France, West Germany, and Britain are 8 percent, 13.6 percent, and 30 percent, respectively. For Australia it is 18 percent. These countries have per capita incomes in the same range as the United States, but they have fewer television alternatives, and much broadcasting is on a noncommercial basis. It appears that VCRs are being used by viewers in those countries to substitute for over-the-air broadcasting. Italy, with an unusually free, heavily commercial broadcasting system, has only a 1.8 percent ratio (although this may be explained in part by relatively low income). At the other extreme, the ratios for Israel and the United Arab Emirates are 44 percent and 411 percent, respectively. The substitution effect is relevant in both cases, while high per capita income probably is important in the latter case. The case of Japan, with a 29.4 percent ratio, shows that the pattern is not uniform, since Japan has a relatively diverse menu of broadcast fare available (but Japan is the center of world VCR production and innovation). While those data are suggestive of substitution, they are by no means conclusive. In particular, there may be differences in fractions of multiple television receiver households across countries. Such differences would mean that the ratios reported here distort the picture of VCR penetration of households.

The results for pay cable demand were also good, in terms of goodness of fit and significance of coefficients. However, no meaningful results were obtained for basic cable demand. Pay-cable equations were estimated with pay-cable subscriptions divided by television households as the dependent variable, and for several transformations of that variable. Again the independent variables were included in linear and logarithmic forms. The income and homes-passed variables were positive and significant, as expected, while the cable-rate variable (when only one was included in an equation and multicollinearity problems avoided) was significant and negative, as an own price should be. The station-availability coefficient was consistently negative and frequently significant. This implies a substitution relationship between cable and broadcast television. While these results are not unfamiliar, they are useful because they provide additional empirical documentation on cable demand, and because replicating familiar results on this new data set gives some confidence that the distortions due to the less-than-optimal unit of observation are not great. Hence the cable results allow somewhat more credence to be placed in the VCR results.

While the empirical results are interesting and useful, their significance is tempered by the methodological difficulties encountered in the analysis. The primary one is the fact that the VCR can be both a substitute and a complement to other video delivery systems for the same household. In statistical terms, this biases the price and availability coefficients for other video delivery systems toward zero. This is a two-edged sword. The confidence one has in statistically significant coefficients is increased, but there may be differences in fractions of multiple television receiver households across countries. Such differences would mean that the ratios reported here distort the picture of VCR penetration of households.

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The VCR and cable results, when considered together, appear at first to exhibit a "transitivity paradox." The pay-cable results suggest that broadcast television and pay cable are substitutes. The VCR results suggest that pay cable and VCRs are substitutes. This seems to imply that broadcast television and VCRs are substitutes. Yet the empirical results suggest that they are complements. This may be explained by the fact that VCRs provide a bundle of services, e.g., they can be used for time-shifting and for playback of prerecorded materials. Thus, VCRs may serve as a complement to broadcast television when used to time-shift broadcast programming, and serve as a substitute for cable when used to play prerecorded cassettes in place of some pay-cable programming. The dual nature of the VCR thus resolves the apparent inconsistency.[21]

Just as the dual nature of the VCR may blur the underlying economic relationships, the use of state-level data may have done the same thing. This is because the state is not likely, in general, to be a meaningful economic market.

While it would have been nice to have been able to take explicit account of disequilibrium in the VCR market, it is unlikely that doing so would have altered the basic results. As explained in section III.A., new products frequently follow an S-shaped growth curve (of penetration plotted against time). The parameters of the growth curve may differ by state. States with "faster" diffusion curves will have higher VCR penetration, aside from the static effects of price and availability of other video systems. However, it is likely that the same factors that influence that static choice among video delivery systems also influence the dynamic phenomenon of diffusion, and in the same way. Thus, if VCRs and broadcast television are complements, states with high availability of television might have faster diffusion rates. While this would bias the station-availability coefficient away from zero (in the positive direction), it would do so only because of the complementary relationship. Thus, while the coefficient may reflect both the effect of television on the diffusion rate of VCRs and on the static (at one point in time) decision to acquire a VCR, both of them are reflections of the same underlying relationship.

Thus, the statistical evidence tends to support the proposition that the video product market should be broadly defined—to include, at least, broadcast television, cable, and VCRs. This proposition has important implications in terms of the reduced need for content regulation, structural (ownership) regulation, and rate regulation for cable and other pay services. The results could be strengthened by the following improvements, which await future work: (1) the collection of better data—on a market basis and including theater movies: (2) the construction of a richer model, one that can accommodate the use of VCRs as both substitute and complement to other delivery systems and can handle disequilibrium (for this, time series data would be needed); and (3) the application of more sophisticated econometric techniques.

Appendix

This appendix provides a brief description of the VCRTOT regressions and the basic cable regressions, and provides some additional statistical results.

Linear equations were estimated with VCRTOT as the dependent variables. Selected results are presented in tables 2.9 and 2.10. Table 2.9 shows that DPI alone or DPIHH plus TVHHN explains most of the variance in VCRTOT. As suggested in section IV.A., it appears that the VCRTOT regressions are primarily picking up differences in state size. The counterintuitive negative coefficient for TVHHN in column 2 of table 2.9 probably results from the high simple correlation between DPI and TVHHN.

Table 2.10 shows additional VCRTOT results. They reflect the fact that TVHHN is negative in equations with DPI and positive (and significant) in equations with DPIHH and other variables. The homes-passed variable is always negative and never significant. The total station-availability variable is of mixed sign and never significant. As column 3 of table 2.10 indicates, the VHF variable is occasionally positive and significant. The cable service-price variables had positive coefficients most of the time. The only time they were significant was when alone; and even then they were not always significant, as table 2.10 indicates.

There were also some regressions run using the natural logarithm of VCRTOT as the dependent variable. These, like the other VCRTOT regressions, were not very useful.

Table 2.11 provides some additional VCR results with VCRPH and VCRLN as the dependent variables. Columns 1 and 2 illustrate the point

Table 2.9. VCRTOT Regression Results with VCRTOT as the Dependent Variable and with Income and Population Variables

	(1)	*(2)*	*(3)*
Independent Variables			
DPI	3.015*	6.679*	—
	(21.65)	(5.66)	
DPIHH	—	—	4.292
			(1.64)
TVHHN	—	−.105*	.081*
		(−3.12)	(16.44)
C	−3.824E04*	−2.071E04*	−.159E06*
	(−4.10)	(−2.03)	(−2.33)
R^2	.9087	.9233	.8761

NOTES: See table 2.2 for variable definitions. "E" means exponent; E04 means "multiplied by 10,000," etc.
The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.
*Significant at the 95 percent level.

that the cable rate variables are not significant when more than one is included in an equation. They also allow comparison of results using the total station-availability variable and results with separate VHF and UHF variables. The latter are inferior. Columns 3 and 4 show the result of using the VHF variable instead of total stations available. (Compare with column 2 in tables 2.4 and 2.5.)

Table 2.12 displays selected basic-cable regression results. As columns 1 and 4 make clear, most of the variation in basic-cable penetration is explained by the homes-passed variable. When DPIHH is added, its sign is negative (contrary to hypothesis) and sometimes significant. The other variables are generally insignificant. The combined cable rate variable is positive (contrary to hypothesis) and sometimes significant. These results are not particularly useful.

In table 2.13 are some additional pay-cable results. Columns 1, 2, and 3 show the preferred set of independent variables in the three specifications out of five in which the total station-availability variable was *not* significant. The other two specifications are exhibited in table 2.7 (columns 4 and 5). Columns 4 and 5 of table 2.13 can be compared with columns 1 and 3 to see the effect of substituting separate VHF and UHF station-availability variables for the total station-availability variable. The total availability variable specification is better.

Table 2.10. Selected Regression Results with VCRTOT as the Dependent Variable and Alternative Homes-Passed Variables

Independent Variables	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
DPI	6.128*	—	—	6.033*	—	—
	(4.04)			(4.04)		
DPIHH	—	.613	.079	—	1.170	.570
		(.22)	(.03)		(.42)	(.21)
HPASSE	−.014	−.034	−.025	—	—	—
	(−.53)	(−1.08)	(−.83)			
HPPH	—	—	—	−5.578E03	−8.965E04	−5.225E04
				(−1.07)	(−1.48)	(−.84)
TVHHN	−.078	.104*	.101*	−.084*	.083*	.085*
	(−1.62)	(5.09)	(5.13)	−(2.02)	(16.54)	(18.51)
STATOT	−1.397E03	3.851E03	—	−1.174E03	3.821E03	—
	(−.48)	(1.17)		(−.41)	(1.18)	
STAVHF	—	—	1.382E04*	—	—	1.273E04
			(2.19)			(1.93)
CRAT	9.270E03	2.125E04*	1.708E04*	1.080E04	2.238E04*	1.768E04
	(1.37)	(2.86)	(2.31)	(1.58)	(3.02)	(2.32)
C	−.181E06	−.469E06*	−.411E06*	−.177E06	−.450E06*	−.399E06
	(−1.41)	(−3.65)	(−3.24)	(−1.46)	(−3.65)	(−3.22)
R^2	.9221	.8920	.8999	.9237	.8945	.8999

NOTES: See table 2.2 for variable definitions. "E" means exponent; E04 means "multiplied by 10,000," etc.
The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.
*Significant at the 95 percent level.

Table 2.11. Additional VCR Regression Results with VCRPH and VCRLN as Dependent Variables

	(1) *VCRPH*	*(2)* *VCRPH*	*(3)* *VCRPH*	*(4)* *VCRLN*
Independent Variables				
DPIHH	.316E05*	.310E05*	.363E05*	.927E04*
	(3.24)	(3.07)	(3.93)	(4.16)
HPPH	−.049*	−.047*	−.048*	−1.266*
	(−2.21)	(−1.99)	(−2.16)	(−2.35)
STATOT	.156E02	—	—	—
	(1.37)			
STAVHF	—	.221E02	.130E02	.018
		(.87)	(.53)	(.30)
STAUHF	—	.146E02	—	—
		(1.23)		
PAYRAT	.723E03	.374E03	−.560E03	−.019
	(.16)	(.08)	(−.13)	(−.18)
BASRAT	−.207E02	−.236E02	—	—
	(−.38)	(−.42)		
C	−.013	−.906E02	−.026	−4.863*
	(−.29)	(−.20)	(−.65)	(−5.13)
R^2	.3097	.2937	.2907	.3055

NOTES: See table 2.2 for variable definitions. "E" means exponent; E02 means "multiplied by .01," etc.

The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.

*Significant at the 95 percent level.

Table 2.12. Selected Basic Cable Regression Results

	Dependent Variable					
	(1) *BASPH*	*(2)* *BASPH*	*(3)* *BASPH*	*(4)* *BASPHL*	*(5)* *BASPHL*	*(6)* *BASPHL*
Independent Variables						
DPIHH	—	−.436E-05	.364E-05	—	−.252E-04*	−.223E-04
		(−1.78)	(−1.46)		(−2.12)	(−1.83)
HPPH	.670*	.678*	.656*	3.249*	3.301*	3.213*
	(12.62)	(12.22)	(11.27)	(12.75)	(12.28)	(11.32)
STATOT	—	−.145E-02	—	—	.469E-04	—
		(−.51)			(.003)	
STAVHF	—	—	−.830E-02	—	—	−.027
			(−1.33)			(−.90)
STAUHF	—	—	−.753E-03	—	—	.272E-02
			(−.26)			(.19)
BASRAT	—	−.024	−.025	—	−.061	−.065
		(−1.13)	(1.18)		(−.59)	(−.62)
CRAT	—	.020	.023*	—	.062	.075
		(1.77)	(2.02)		(1.12)	(1.33)
C	−.054	−.079	−.115	−2.609*	−2.536*	−2.675*
	(−1.70)	(−.71)	(−1.00)	(−17.17)	(−4.69)	(−4.79)
R^2	.7710	.7870	.7895	.7747	.7861	.7860

NOTES: See table 2.2 for variable definitions. "E" means exponent; E-02 means "multiplied by .01," etc.
The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.
*Significant at the 95 percent level.

Table 2.13. Selected Pay Cable Regression Results

Independent Variables	(1) PAYPH	(2) PAYPH	(3) PAYPHL	(4) PAYPH	(5) PAYPHL
DPIHH	.982E-05* (4.95)	—	.511E-04* (5.22)	.976E-05* (4.74)	.515E-04* (5.08)
DPIHLN	—	.289* (5.42)	—	—	—
HPPH	.442* (9.84)	—	2.442* (11.04)	.444* (9.26)	2.430* (10.29)
HPPHLN	—	.227* (9.25)	—	—	—
STATOT	.367E-02 (−1.59)	—	−.019 (−1.71)	—	—
STOTLN	—	−.032 (−1.76)	—	—	—
STAVHF	—	—	—	−.314E-02 (−.61)	−.024 (−.94)
STAUHF	—	—	—	−.371E-02 (−1.53)	−.019 (−1.59)
PAYRAT	−.046* (−2.67)	—	−.323* (−3.79)	−.046* (−2.64)	−.323* (−3.73)
PAYLN	—	−.391* (−2.39)	—	—	—
CRAT	−.247E-02 (−.22)	—	.022 (.41)	−.265E-02 (−.23)	.024 (.43)
CRATLN	—	−.043 (−.21)	—	—	—
C	.234* (2.59)	−1.502* (−2.67)	−1.167* (−2.62)	.236* (−2.49)	−1.195* (−2.57)
R^2	.7621	.7426	.8057	.7561	.8011

NOTES: See table 2.2 for variable definitions. "E" means exponent; E-02 means "multiplied by .01," etc.

The figures in parentheses are t statistics. R^2 is adjusted for degrees of freedom.

*Significant at the 95 percent level.

Notes

1. The views expressed herein are those of the authors. They do not necessarily reflect the views of the Federal Communications Commission or other members of its staff. The authors gratefully acknowledge the comments of Jerry

Brock, Ken Gordon, John Haring, Evan Kwerel, and Florence Setzer. The authors alone are responsible for any remaining errors.

2. The assumption of a perfectly elastic supply of VCRs was also used in the Batelle study, a time series model estimated on three years' worth of monthly data (Cronin et al. 1983:32–34). This study was provided to the authors by the Motion Picture Association of America, Inc. Its public release was pending. Here the supply elasticity assumption simply implies that VCR prices are constant across the continental United States and that more can be supplied at that constant price. The availability of VCRs by mail order makes the assumption reasonable. For cable the supply will be considered perfectly elastic among homes passed by cable.

3. These data come from the *Census of Service Industries*, conducted every five years. The 1977 data are too old and the 1982 data, while scheduled for release in the spring of 1984, were not available in time for this study. The lack of data dictates that P_{movies} be eliminated as well.

4. $P_{\text{cassettes}}$ should be thought of as a vector that includes the purchase prices of blank and prerecorded cassettes as well as the rental rate for the latter. There may in fact be some variation in these prices between population centers and rural areas.

5. State data were first collected in 1979. These data were unpublished, but the Electrical Industries Association was kind enough to supply them to the authors.

6. As long as there are no systematic differences across states in the relation between VCRs in use and sales to dealers, the conclusions on whether the VCR is a substitute or a complement will not be affected.

7. The data do not allow multi-VCR households to be distinguished. The assumption of one VCR per household introduces a (small) distortion in the variable.

8. In fact, the average household had 2.72 members in 1982 (U.S. Department of Commerce 1983a:1).

9. State-level figures on household size in 1982 are not available. However, U.S. Department of Commerce (1983b) provides 1980 figures. The national average was 2.75 persons; 37 of 48 state averages were between 2.65 and 2.85 (i.e., within 3.6 percent of the average). Utah had the largest average (3.20), and Florida had the smallest (2.55).

10. The cable systems covered in the Kagan Census are those that offer pay television. Kagan estimates that the Census excludes only some small cable systems, with a total of 300,000 basic subscribers (Paul Kagan Associates, 1983d:1). By Kagan's reckoning, this amounts to 1.1 percent of cable subscribers, a negligible omission.

11. The data are for subscriptions; cable homes subscribing to more than one tier are counted twice. Kagan estimates the number of unduplicated pay homes at 17.8 million. (Paul Kagan Associates 1983d:1). On the assumption that no MDS or STV homes get more than one tier (which is not quite accurate, since late night "adult" tiers are offered in many cases), this implies that 87 percent of pay subscribers are on cable.

12. There is also an installation fee for cable. However, this one-time fee is frequently waived or reduced in promotional campaigns to sign up new subscribers. (Dunmore and Bykowsky 1982:14). Furthermore, even when it is paid it is amortized over a matter of years. Hence the per-month equivalent is probably low and can be ignored safely.

13. In a sense, the VCR functions in the same way that resellers of voice- and data-communications services do. Resellers don't change the underlying competitive conditions, but they do help insure that the maximum benefits available from the existing market structure can be obtained by all consumers.

14. The simple correlation coefficient ranges from zero to one in absolute value. It measures the association between two variables without accounting for the effects of additional variables. See Johnston (1972:32–35). Multiple regression analysis is used to separate the effects of several independent variables on a dependent variable. See Kmenta (1971:347–408).

15. In fact a variety of specifications suggested by the model were estimated before examining the correlation coefficients, which were then used to rationalize poor results as well as choose additional specifications to estimate. The correlation coefficient discussion is placed first for expositional convenience.

16. R^2 is a measure of "goodness of fit," i.e., of how much of the variation in the dependent variable is explained by the independent variables. See Kmenta (1971:364–366).

17. A few regressions were estimated with separate VHF and UHF station-availability variables. These coefficients were positive but invariably far more significant. In some of the VCRTOT regressions a VHF station variable used alone was positive and significant. However, as noted, these regressions have other fatal deficiencies.

18. In this paper, whenever coefficients are described as significant, it should be understood as significant at the 95 percent level using a two-tailed test. See Kmenta (1971:136–44, 225–27).

19. As noted earlier, some preliminary regressions were estimated using separate VHF and UHF station availability variables. This specification was rejected because the VHF variable was never significant, the UHF variable was rarely significant, and the R^2 was lower than for corresponding equations with the total station-availability variable.

20. This study was provided to the authors by the Motion Picture Association of America, Inc. before publication.

21. Fischer (1971) uses the economic theory of consumer demand to analyze the substitute and complement properties of three- and four-good systems. Using the (relatively implausible) assumption of only three goods, it is possible to show the following. If VCRs and cable are substitutes, and cable and broadcast television are complements, then VCRs and broadcast television may be either substitutes or complements. This is reassuring but of limited relevance due to the restrictiveness of the three goods only assumption and to the fact that the multiple attributes of the VCR are ignored in the theory.