# ESTIMATING CATV DEMAND PATTERNS FOR SYSTEM DEVELOPMENT

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This paper describes a methodology for estimating CATV subscriber densities suitable for use in the financial planning and engineering design of a CATV system in a city with good over-the-air broadcast TV reception.

The method provides estimates of demand as a function of time, and confidence limits on these estimates, for sections of the city formed in consideration of various characteristics of the city. The method is based on an advanced econometric model of CATV penetration developed by R.E. Park of the Rand Corporation and takes into account characteristics of local over-the-air broadcast stations, features of the proposed CATV system, demography of the community served, and growth stimulating factors.

The paper includes a brief review of the basic econometric model, a discussion of an adaptation made to it and an illustrative case study.

## INTRODUCTION

Lenders to the CATV industry require cash flow projections for various stages of a system's development in order to determine the cash flow available for debt servicing, for structuring the amortization schedule of the loan and for evaluating the long term economic viability of the system. Since a CATV operator's prime source of revenue is monthly subscription fees, among the key factors in establishing positive cash flow are the system density and its penetration.[1]

It was with the investor's viewpoint in mind that this method of estimating CATV subscriber demand by sections of a proposed system as a function of time was developed. By being able to rank-order sections of the community on the basis of their estimated subscriber densities and associated construction costs it should be possible to develop an optimum engineering plan in terms of the expected number of subscribers, related costs, and revenues upon which to base a financial plan that demonstrates positive cash flows during the early years of operation and a long term economic viability.

## DESCRIPTION OF METHODOLOGY

### General Approach

Demand for CATV in a community depends on the existing TV environment, the characteristics of the proposed CATV system and the demography of the community served. For engineering and financial plans, highly disaggregate estimates of demand for CATV are desired. For example, if estimates by neighborhood or block were available, capital costs and revenues could be balanced by developing the most promising routes in the early years.

An econometric model expressing CATV penetration in terms of the TV environment, the proposed CATV system and the community served has been developed by R.E. Park of the Rand Corporation[2]. However, this model is based on CATV systems in their entirety. Furthermore, the data required by it is generally not available at the neighborhood or block level. Thus in developing an estimation method, we were faced with three major (and conflicting) considerations.

1) The engineering and financial plans should, ideally, be based on estimates of demand at a highly disaggregate level.

2) The most advanced econometric model of CATV penetration available in the literature was developed on the basis of entire CATV systems.

3) The level at which the data required by the model is readily available varies from city-wide to census tract.

In the suggested method we resolve these conflicting conditions by using Park's model (adapted to take into account special interest channels) to obtain

[1] David M. Carlisle, "Financing Community Antenna TV," Thesis, the Stonier Graduate School of Banking, Rutgers University (June 1973).

[2] R.E. Park, "Prospects for Cable in the 100 Largest Television Markets," The Bell Journal of Economics and Management Science 3, No. 1, 130-150 (Spring 1972).

an indication of penetration at the census tract level. Then, we combine contiguous tracts of similar subscriber densities into sections of the city which are large enough for valid application of Park's model while, at the same time, sufficiently disaggregated to be of value in developing engineering and financial plans. Estimates of the demand in each section are obtained at several stages of development by taking into account the dynamics of demand. By ranking the sections of the city according to their estimated subscriber densities, an ordering of areas for system development can be provided.

The Econometric Model

Park's model of CATV penetration is a cross-sectional model based on data from 63 cable systems located in communities whose television environment resembles that of the 100 top TV markets. That is, at least three television stations are received in the community and over-the-air reception is generally unimpaired (except possibly by distance from the transmitter). While a full description of the systems in the sample and their associated data are not available, it is reasonable to assume from the date of the study (1971) that the sample systems offered a minimum of local originated programming and no two-way services. Furthermore, the sample systems are of different ages; a maturity factor is included in the model to compensate for variations in penetrations due solely to age differences.

The estimating equation is linear in the logarithm of the exogenous variables which include income, price, color set ownership, and a set of variables which compare the service offered by the CATV system to that available over-the-air. A comparative service variable is defined for each type of channel (network, duplicate network, independent, educational, and foreign); it is expressed as the ratio of the number of CATV channels of a given type to the number of available TV stations of the same type, weighted according to the transmission mode (VHF, UHF) of the station, the percent of UHF receivers in the community and by a reception degradation factor defined in terms of the distance the community is from the station's transmitter.

In developing an econometric model*, a basic functional form is assumed along with a set of exogenous variables in an attempt to explain, in part, the observed behavior of an economic variable. Consistent observations on the dependent and independent variables are used to determine the values of the coefficients in the model which will account for a significant amount of the observed variation in the phenomenon. The model can then be used to investigate the logical consequences of the assumptions (and changes in them) or to estimate the value of the endogenous (dependent) variable in cases where it cannot be observed. The validity of the results obtained with the model is limited by the extent to which the assumptions on which it is based apply; the amount of variation unexplained by the model is reflected in the standard error associated with the estimate, or equivalently, in its confidence limits.

In using the suggested estimation method, care must be taken to stay within the domain of the basic model. It should not be applied to communities with significant TV reception problems, nor to systems whose appeal is based on innovative services (e.g., two-way services, premium TV) and no attempt should be made to obtain estimates for small homogeneous sections. In all applications the method should be validated by combining the estimates by section into an estimate for the system as a whole and comparing the result with the estimate obtained by applying the model to the entire system. If the two estimates differ by more than several percentage points the size and composition of the sections should be re-examined.

Treatment of Special Interest Channels

Certain channels offered on the proposed CATV system may be of primary interest to a special interest group within the community so that subscriber demand for the service may vary from section to section as the special interest population varies. Since we wish to rank the sections of the community according to their demand, this variation in demand due to a special interest channel was taken into account by a modification of the basic model which takes advantage of the continuity of the regression equation and is intuitively satisfactory. The modification consists of redefining the comparative service variables to include the value of a special interest channel in the functional form $p + k(1-p)$ where $p$ is the proportion of the special interest group in the population and $k$ is a factor representing the general interest of the remainder of the population. This allows the value of the channel to vary from 0 to 1 depending on the values of $p$ and $k$. Foreign language channels and channels having a major portion of their programming with an ethnic orientation are handled in this fashion.

Data Sources

Most of the data required by this method is readily available. Demographic data at the census tract level can be obtained from the U.S. Bureau of Census. Areas by census tract, maps showing census tracts and land use, and projections of population can usually be obtained from local planning councils. The current TV Factbook provides the necessary information on the over-the-air stations received in a community.

Some substitutions and a certain amount of adjustment of the raw data are required. For instance, median household income, an exogenous variable in the basic model, is not provided at the census tract level; median family income, available by census tract, must be used as a proxy. Data on color set and UHF receiver ownership is generally available only on a citywide basis and must be assumed to apply uniformly throughout the community. Data for a census tract not wholly contained within

*E. Malinvaud, Statistical Methods of Econometrics, Rand McNally and Company, Chicago (1966) Chapter 2.

city limits must be adjusted to reflect the fraction of the tract within the city. Estimates of non-residential land use in the tracts usually have to be made from maps.

Preliminary penetration estimates are obtained for each census tract from the model. These, along with the demographic data of the tracts constitute the information required for forming sections of the city.

Forming Sections of the City

The sections of the community can be formed in consideration of various characteristics of the city, e.g., areas of poor reception, land use patterns, cabling requirements, municipal districts and socio-political boundaries. The number and composition of the sections are determined by the population and from the range of subscriber densities in the community. Sections are formed of contiguous census tracts and should contain a minimum of 7500 - 10,000 households in order to stay within the domain of the model. The constituent tracts of each section should have similar subscriber densities and the resulting sections should have significantly different subscriber densities so that a definite ranking of the sections can be made. Demand estimates for each of the sections are obtained by applying the econometric model to each section using data constructed from the data of its constituent tracts. For all but one of the variables the data for the section can be formed either as the aggregate or as the weighted average of the tract data. However, the median income of the section is not the average of the median incomes in the tracts. In order to estimate the median income for the section, the income distribution for each tract is required. If these are not available demand estimates for the section could be obtained by using the weighted average of the penetrations of the tracts.

Demand Estimates

Our method provides estimates of penetration, subscribing households and subscriber densities.

Penetration is calculated by the model as the ratio of subscribing households to households passed by the cable. We are using this parameter as a probability of subscription and as such it is most meaningful for many miles of cable, i.e., for relatively large areas.

The estimate of subscribing households is obtained as the product of penetration and households passed by the cable. In the absence of a construction schedule, estimates are based on the total number of households in the section which assumes that all homes are passed by the cable. If, however, information is available on the projected number of miles of constructed cable and the number of homes per cable mile for each section, this data along with the penetration estimate should be used in computing the estimate of total subscribers.

Subscriber densities, by which the sections are ranked, can be expressed either in terms of subscribers per square mile or subscribers per cable mile, depending on the data available. Ranking the sections on the basis of subscribers per square mile is equivalent to ranking by subscribers per cable mile provided the ratio of cable mile to square mile and the construction costs per cable mile do not vary significantly from section to section. If there are significant variations in these factors, they should be included in the estimates when determining the construction schedule.

Confidence limits for each demand estimate are provided based upon the standard error associated with the econometric model. This error is applied to the penetration estimates calculated for each section to give upper and lower limits on the penetration. These limits are then used to obtain corresponding limits on total subscribers and subscriber density.

After a CATV system is operational, the number of subscribers can be expected to change due to changes in system penetration resulting from the maturing of the system, from changes in the exogenous variables (e.g., reception quality, income, price, etc.) and from population shifts. The effect of these dyanmic factors has been included in our methodology by the use of income and household projections which take into account shifting population and income patterns within the community, and by the maturity factor in the econometric model. Thus we are able to make estimates of demand at different stages of the proposed systems operation.

Use of Demand Estimates

The primary use of the results of this method is for comparative analysis. While the actual demand estimates for the sections contain a substantial amount of uncertainty, the relative rankings of the sections should be quite reliable provided their subscriber densities differ significantly. The method also lends itself to use in a sensitivity analysis in which relative changes in demand or shifts in the ranking of the sections due to changes in the independent variables are studied.

The confidence limits associated with the demand estimates reflect the uncertainty in the estimates and should, therefore, be taken into consideration in any additional analysis based upon the numerical values. They should be used to obtain confidence limits for any further estimate derived from either the penetration or demand estimates.

## A CASE STUDY

To illustrate this method consider the following situation: A CATV system is proposed for a city located in one of the 100 top TV markets with good-over-the-air reception. There is currently being received in the city a total of 6 over-the-air stations; 3 VHF network stations, 2 UHF independent stations and 1 VHF educational station. The subscription fee for the proposed cable system is $72 per year. The system will offer a total of 10 channels; 3 network channels, 5 independent channels and 2 educational channels. One of the independent channels is a Spanish language station and one of the educational channels has a major portion of its programming devoted to Black oriented programming.

Our objective is to divide the city into sections of uniform density which can be ranked for system development. For the sake of this example we will assume that construction costs per cable mile are approximately the same and that the ratio of cable mile to square mile does not vary significantly throughout the city. Therefore, estimates of subscriber density in subscribers per square mile are adequate for ranking purposes. No specific construction schedule will be included in this analysis; the estimate of subscribers and subscriber densities in each section is based on the assumption that all households are passed by the cable. Estimates of demand after two years of operation (1975) will be provided.

The 1970 Census is the most recent enumeration for the 61 census tracts in the city. At that time the total population of the city was 520,000 with a total of 180,500 households. Data for the key demographic variables in the census tracts exhibited the following ranges of values.

Population: 126-23,000

Households: 34-7118

Area (sq. mi.): 0.26-9.80

% Black Households: 0-100

% Spanish Surname Households: 0-75

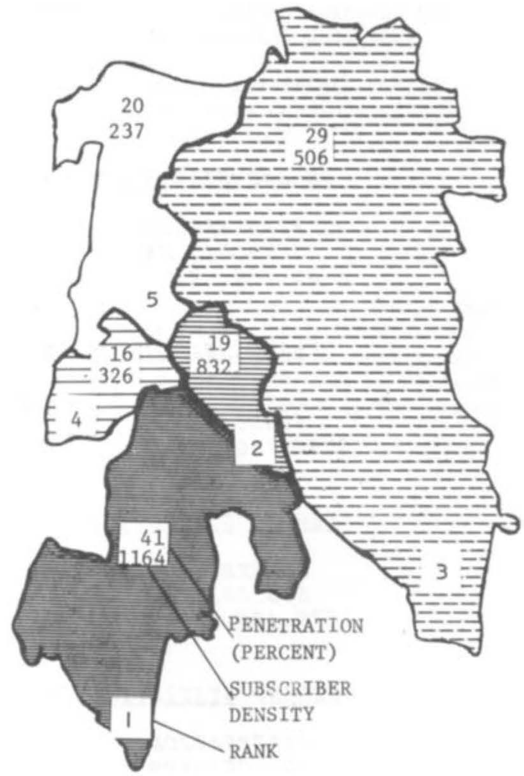
Median Income: $3,383-$29,663

Data pertaining to 1975 is developed in the following ways: Projections of households by census tract for 1975 are obtained from the local planning board. Because projections by ethnic group are not available for 1975, this data is constructed by applying the 1970 percentages to the 1975 household projections by census tract. Income projections by census tract for 1975 are developed by using a factor based on data for the city obtained from the Bureau of Labor Statistics. Recent citywide data on color set and UHF receiver ownership are assumed to apply uniformly throughout the city.

Topological data for the city indicates that reception quality of the over-the-air broadcast stations can be assumed to be uniformly good and so degradation factors of zero are used for all stations. On the basis of surveys, general interest in the two special interest channels is estimated to be 25% in the educational channel and 15% in the independent channel.

The estimated penetration obtained by applying Park's model to the city as a whole using 1975 data is 31.1% with a subscriber density of 626 subscribers per square mile. Preliminary estimates of penetration by census tracts range from a low of 9% to a high of 67% reflecting, for the most part, the income ranges and, to a lesser degree, the ethnic composition in the census tracts. Subscriber densities in the individual tracts range from 60 subscribers per square mile to 1440 per square mile. By grouping contiguous census tracts of similar subscriber densities, we can form five sections of the city with penetrations in the sections ranging from 16% to 41% and with subscriber densities of 237 to 1164 subscribers per square mile. The penetration and subscriber density of the city obtained by aggregating the section estimates are 30.9% and 621 subscribers per square mile which are in close agreement with the estimates obtained by applying the econometric model to the city as a whole. The recommended order for system development based on the ranking of the sections is shown in Figure 1. The demand estimates and their confidence limits for each section are given in Table 1.

FIGURE 1.




DEMAND ESTIMATES AND RANKS FOR

SECTIONS OF THE CITY WITH

GOOD RECEPTION

TABLE 1. *GTE LABORATORIES INC.,PROJECT 482*

*CATV PENETRATION PROFILE*
*(BASED ON MODEL BY R.E.PARK, RAND CORP. )*

*ASSUMPTIONS*

*PERCENT UHF SETS*: 95.0
*PERCENT COLOR SETS*: 66.0
*SPANISH STATION INTEREST*:0.15
*BLACK CHANNEL INTEREST*:0.25
*BROADCAST STATIONS*: 6
*CATV CHANNELS*:10
*RECEPTION QUALITY*: GOOD
*PRICE*:$72
*AREA BASE*: ADJUSTED

| *DEMAND STATISTICS*: 1 | *LOWER LIMIT* | *EXPECTED VALUE* | *UPPER LIMIT* |
|---|---|---|---|
| *PENETRATION* | 17.86 | 40.82 | 47.05 |
| *SUBSCRIBERS* | 11340 | 25918 | 29870 |
| *SUBS./SQ. MILE* | 509.43 | 1164.33 | 1341.86 |

| *DEMAND STATISTICS*: 2 | *LOWER LIMIT* | *EXPECTED VALUE* | *UPPER LIMIT* |
|---|---|---|---|
| *PENETRATION* | 9.68 | 18.65 | 25.51 |
| *SUBSCRIBERS* | 1654 | 3185 | 4356 |
| *SUBS./SQ. MILE* | 431.85 | 831.59 | 1137.33 |

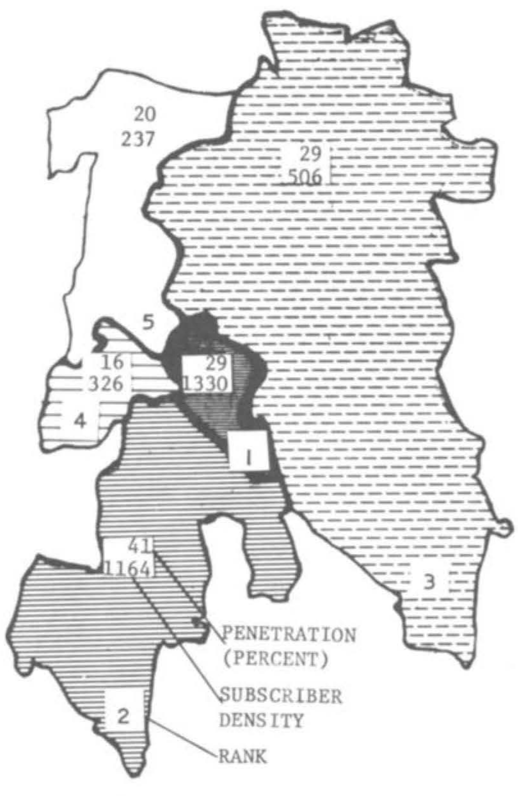
| *DEMAND STATISTICS*: 3 | *LOWER LIMIT* | *EXPECTED VALUE* | *UPPER LIMIT* |
|---|---|---|---|
| *PENETRATION* | 14.00 | 29.40 | 36.88 |
| *SUBSCRIBERS* | 12591 | 26444 | 33165 |
| *SUBS./SQ. MILE* | 240.92 | 506.00 | 634.61 |

| *DEMAND STATISTICS*: 4 | *LOWER LIMIT* | *EXPECTED VALUE* | *UPPER LIMIT* |
|---|---|---|---|
| *PENETRATION* | 8.58 | 16.18 | 22.60 |
| *SUBSCRIBERS* | 912 | 1719 | 2400 |
| *SUBS./SQ. MILE* | 173.05 | 326.18 | 455.40 |

| *DEMAND STATISTICS*: 5 | *LOWER LIMIT* | *EXPECTED VALUE* | *UPPER LIMIT* |
|---|---|---|---|
| *PENETRATION* | 11.01 | 21.76 | 29.00 |
| *SUBSCRIBERS* | 1679 | 3318 | 4423 |
| *SUBS./SQ. MILE* | 120.61 | 238.36 | 317.74 |

Variations can be introduced into the problem: Suppose, for instance, that over-the-air TV reception in the community is unimpaired except in one area of the city where, due to tall buildings, the reception quality is equivalent to that experienced midway in the B contour of the stations. Assume, also, that this is an area with a high population density and relatively low median income. Should system development start in this area rather than in a higher income, less dense area where reception quality is good? Using reception degradation factors of 0.5 we find an increase of penetration of 10 percentage points resulting in a subscriber density of 1330 subscribers per square mile and a change in the ranking of the sections as shown in Figure 2.

FIGURE 2.




DEMAND ESTIMATES AND RANKS FOR

SECTIONS OF THE CITY WITH

LOCALLY IMPAIRED RECEPTION.

It should be noted that, in practice, construction costs might also be significantly different in this area and should be taken into account in the ranking.

Conditions imposed by the franchise can also be included in the analysis of a community. If, for instance, portions of the city are in different political districts (e.g., counties) and the franchise stipulates that system development must progress simultaneously in each, sections can be formed and ranked within each political district and a development schedule provided for each.

## CONCLUSIONS

A flexible and systematic method for estimating CATV subscriber densities in a large city with good over-the-air TV reception has been developed. The method has the following features:

1) Provides demand estimates suitable for engineering and financial planning.

2) Incorporates local constraints and/or restrictions on system development and includes local demography.

3) Employs readily available data.

4) Is based on the most advanced model of CATV penetration currently available.

As more cable systems are implemented, and as innovative subscriber features are introduced, a new penetration model which takes into account these advancements could be devised and used in place of the econometric model presently used in the method.