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Is Cable Television a Natural Monopoly?

The Research Issue

This study is an investigation of the economies of scale in cable television operations, and of the variation in these economies over the range of output. The results are intended as an empirical clarification of the question of whether cable television is a "natural" monopoly, an issue with significant public policy interest; its implications will be discussed first.

The American television industry is presently undergoing rapid change. Where once there was a limit on viewing options imposed by the scarcity of electro-magnetic spectrum, confining most viewers to a handful of channels that were dominated by three competing distribution systems, cable television is emerging now as "the television of abundance," (*Sloan Commission*, 1971). Yet ironically, the market structure of "abundant" cable television is more restrictive than that of "scarce" conventional television, since the present franchising system has created a series of local cable distribution and programming monopolies. This raises concern about a cable operator's ability, if left unconstrained, to charge monopolistic prices to subscribers, and, more significantly, to control the content of dozens of program channels. A variety of reform proposals have therefore been made, seeking to impose some of either conduct regulation, public ownership, common carrier status, or competitive market structure. The latter approach, in particular, has been taken by the Federal Communications Commission. After eliminating most of its conduct regulations over the past two years, the FCC's current philosophy is to rely on and encourage *inter-media* competition between cable and other video technologies.¹

A second and distinct competitive approach is to rely on *intra* medium competition among cable companies. In New York State, for example, a recent Governor's Bill, based on recommendations by *Alfred Kahn and Irwin Stelzer* (1981), seeks to open each cable franchise area to additional cable companies, thereby reducing their local monopoly power. The possibility of such entry, however, is based on the assumption that more than one cable company could successfully operate in a territory. But such competition is not sustainable if

cable television distribution exhibits local monopoly characteristics. The question whether cable television is a natural monopoly is thus important for an evaluation of the potential for intramedium competition. If significant economies of scale exist, it is unlikely that other cable companies would enter. It is still possible, however, that other multi-product firms would be able to enter. This argument has been made theoretically by *Panzar and Willig* (1977), based on a concept of "economies of scope" of a multi-product firm, and, applied, to a potential entry of telephone companies into cable television "broadband" transmission, by the author (*Noam* 1981 a).

The question of cable television's natural monopoly characteristics has also implications on the scope of local regulation, and on the treatment of the medium as a "public utility". These issues have arisen in a number of court cases. Most recently, in the Boulder case² currently pending before the U.S. Supreme Court, the city's moratorium on expansion had been challenged by the local cable company. As the Appellate Court described it "The City concluded that cable systems are natural monopolies. Consequently, the City became concerned that CCC, because of its headstart, would always be the only cable operator in Boulder if allowed to expand, even though it might not be the best operator Boulder could otherwise obtain . . . The City concluded that direct competition in Boulder within the same geographic area will not be possible in the foreseeable future . . ." Yet the factual issue of natural monopoly is hotly disputed. As a dissenting judge notes in Boulder I, "On appeal, the city's sole defense is to pretend disingenuously and contrary to the extensive, uncontradicted testimony and the findings of the trial judge, . . . that cable is a natural monopoly". In another case, (*Greater Fremont, Inc. v. City of Fremont* 302 F. Supp. 652 (N. D. Ohio. 1968)), the Court flatly declared that "unlike water, gas and electric companies where there is great public inconvenience in having numerous concerns serving the same geographical market, CATV is not a natural monopoly. There is only the inconvenience of having another pair of wires, if that, involved in having an additional CATV company in a geographical market. Thus, the scope of regulation which is necessary in the natural monopolies is not here necessary . . . Even if in fact the CATV system is the only one in the market, it is not a monopoly in the economic sense . . . Thus CATV is not a public utility within the definition that has been accepted."³

Information about scale economies of cable television transmission is also important in assessing its future *national* market structure and in the setting of regulatory or antitrust policies, if any. The presence of strong economies of scale would indicate that local franchises are likely to become consolidated in regional or national cable systems. Furthermore, several large cities, partly in order to lessen any company's power, partly in order to reduce the likelihood of a disgruntled unsuccessful applicant appealing the city's decision in the courts, have decided to carve up their area into several franchise zones, each to be awarded to a different company. This may be, however, an economically

inefficient approach to a reduction of cable company power. At the least, the economically optimal size of such a partial franchise should be determined, in contrast to the present ad hoc approach.⁴ Similarly, a clearer notion about the cost of operations involved in cable television may help local governments in assessing the viability of competing bids for a cable franchise. The existence of a natural monopoly also has implications on the price structure of cable television. If average costs fall continuously – as the presence of natural monopoly conditions suggests – marginal costs are below average cost. At a market clearing, non-discriminatory price, $P=MC$, a cable company will therefore operate at a loss. (Scherer 1980.) If prices are regulated to be at a uniform level equal to average costs, $P=AC$, there are no losses, but allocative inefficiency exists, since there are consumers left without service who would have been willing to pay above marginal cost. A set of discriminatory prices is therefore most likely.

Despite the relevance of the question of cable television economies of scale described in detail above, it has not been investigated empirically in a serious fashion.⁵ This, then, is the task of the paper. In so doing, this study can rely on an unusually good body of data. Most cross section studies of other industries suffer from a variety of problems, including a small number of observations, non-homogeneous products, the difficulty of properly allocating costs in a multi-product, multi-plant firm, lack of information on the age of capital assets, different firm locations in a national market, and the frequent unavailability of financial data. Many of these problems are greatly reduced in the present study, which is based on several thousands of firms, all producing essentially the same service,⁶ operating and accounting in a single-plant mode, supplying their local market only, and reporting financial data according to the fairly detailed categories of a mandatory Federal form.⁷

Competition in Cable Television: Anecdotal Evidence

Before commencing the empirical work, we undertake a brief look at the actual occurrence of competition among cable companies. Competitive cable operations, usually caused by disputes about the scope of the initial award, exist today in less than ten franchises out of more than 4,000. Of these operations, only those in the cities of Allentown, Pennsylvania, and Phoenix, Arizona, are of appreciable size. Such competitive franchising is known in the industry as an "overbuild," as distinct from a "co-franchising" in which a city is subdivided into several portions, each to be awarded to an exclusive franchisee. In Allentown, the overbuild has generated some rivalry, if several lawsuits between the two operators are an indicator. On the other hand, subscriber rates are identical at \$ 7.65, above the national average of \$ 7.33 (Noam, 1981 b, p. 28), and duplication of facilities exists. As the executive of one of the companies

put it, "You could have another city wired with all the extra cable around here." According to the Vice President of the other company, "I don't know that the competition has been that good to the subscriber. If there was one system, there would probably be lower rates. As far as service, we may, however, be more conscious to subscriber needs because of the competition." In Phoenix, cable operations are fairly new. The city had awarded franchises to four companies in 1980, without guidelines as to which areas should be wired by which of the companies. But while the initial expectation had been one of a "range war" in which companies would race to wire the neighborhoods, the contrary has happened so far.

Cable operators clearly prefer the stability of market division to the uncertainties of multiple entries. As one company spokesman puts it longingly, "I wish the council would have split the city in designated areas. The city could either take the initiative to split up the city or sit around and watch . . ."

The Model

The concept of natural monopoly, introduced (with a different terminology) by *John Stuart Mill* (1848), and refined by *Richard T. Ely* (1937), has been used as a prime argument for regulation. "Natural monopoly is traditionally the classic case for extensive regulation . . ." (*Kaysen and Turner* 1959), though others disagree (*Posner* 1969; *Lowry* 1973). *Kahn*, in his treatise on regulation (1971), properly distinguishes the case of natural monopoly from one of mere duplication of facilities an insufficient condition. He describes the "critical and – if properly defined – all-embracing characteristic of natural monopoly (as) an inherent tendency to decreasing unit cases over the entire range of the market." *Kahn* lists factors that make a natural monopoly likely: large fixed investments; a fixed and essentially immovable connection between suppliers and customer; a non-storable type of service; obligation of instantaneous supply; wide fluctuations in demands for service. Of these, all but the last appear to apply to cable television.

Natural monopoly and economies of scale are closely related but not identical concepts. *Baumol* (1977a, b) formalized the analysis and extended it in a series of papers, together with *Bailey, Panzar, and Willig* (1977), defining natural monopoly as "An industry in which multifirm production is more costly than production by a monopoly (subadditivity of the cost function)," (p. 810), and establishing that for the single product firm "evidence of scale economies is always *sufficient* but not *necessary* to prove (such) subadditivity." (p. 809). Furthermore, these economies need be shown over a wide range of actual or potential outputs to reach valid conclusions. It is intuitively plausible that there are some economies of scale in some range; what is more important, however, is whether those efficiencies persist. The approach of this paper is therefore to

investigate empirically economies of scale – *Baumol's* sufficient condition – over the output range. This calls for a functional form that permits variations in economies of scale, i. e., a non-homogenous production function, ruling out the more conventional Cobb-Douglas, CES, and VES functions. The limitation of these functional forms has led to the development of more generalized production functions (*Berndt and Kaled* 1978), a primary example of which is the Transcendental Logarithmic Production Function. The “translog” function was proposed independently by *Griliches and Ringstadt* (1971), who generalized it and provided its theoretical underpinning (1973). It was applied to telecommunications specifically to the Bell System, by *Denny et al* (1979), *Nadiri and Shankerman* (1979), and *Eldor et al* (1979), though not for issues of economies of scale, and concentrating on time series estimation of the Bell System in the U.S. and in Canada.

Let the production relation

$$(1) \quad Y = f(X_1, X_2)$$

be given by the translog function

$$(2) \quad \ln Y = a_0 + a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_1 \ln X_2 + a_4 (\ln X_1)^2 + a_5 (\ln X_2)^2 + \sum a_{6i} \ln Q_i$$

Where Y is output, X_i are labor and capital inputs, and Q_i a vector of other variables that affect production, such as particular local conditions.

Marginal elasticities of production with respect to the inputs are (*Frisch* 1965)

$$(3) \quad E_1 = \frac{\ln Y}{\ln X_1} = a_1 + a_3 \ln X_2 + 2a_4 \ln X_1$$

$$(4) \quad E_2 = \frac{\partial \ln Y}{\partial \ln X_2} = a_2 + a_3 \ln X_1 + 2a_5 \ln X_2$$

The scale elasticity E is the sum $\sum E_i$ of the marginal elasticities with respect to each input. It shows the percentage change in output associated with a percentage change equal in all inputs. Hence,

$$(5) \quad E = \sum E_i = a_1 + a_2 + (a_3 + 2a_4) \ln X_1 + (a_3 + 2a_5) \ln X_2$$

This expression shows the scale elasticity to be nonconstant and a function of inputs $E = g(X_i)$.

Such a measure is sufficient to establish the extent of economies or diseconomies of scale, but it is inconvenient operationally. Since the inputs X_i depend, after all, on output Y (and on the relative output prices $P_1/P_2 = P$). The interesting question is what E is at a given *output*, assuming cost-minimizing

production rather than what it is for a given combination of *inputs*. The change in E with output is generally different from the for E with inputs, since expansion paths do not coincide with rays from the origin in input space, unless the production function is homothetic, i. e. a monotone transform of a positive homogeneous function. (*Hanoch 1975*) Since the translog function is non-homogeneous, this identity does not occur. To find $E(Y)$ is useful since it also describes the elasticities of the cost curves with respect to output.⁸ By *Shephard's Duality Theorem* (1953) the minimum cost function $C(Y, P_i)$ is derived from a regular production function $U(X_i)$. The Average Cost curve AC is U-shaped (i. e., has a unique minimum) with respect to Y if $\frac{d(AC)}{dY} = 0$ for a $Y > 0$; this implies that the cost elasticity w.r.t. output

$$(6) \quad E_{AC} = \frac{d(AC)}{dY} \cdot \frac{Y}{C} = 0$$

This elasticity, it will be shown, is

$$(7) \quad E_{AC} = \frac{1}{E} - 1,$$

the bottom of the U-shaped average cost curve is then where

$$(8) \quad E_{AC} = \frac{1}{E} - 1 = 0, \text{ i. e. when } E = 1$$

What we seek is the relation of elasticity and output

$$(9) \quad E = M(Y, P)$$

We now define the concept of an „elasticity of economies of scale“ with respect to *output* Y , given by

$$(10) \quad \eta = \frac{dE}{dY} \cdot \frac{Y}{E}$$

It can be shown that, holding prices constant, for n inputs the general solution is

$$(11) \quad \frac{dE}{dY} = \frac{1}{Y} (1-E) - E \frac{[h_n]}{[B_n]} - 1$$

where $[B_n]$ ist the Hessian matrix $[H_n]$ of order n bordered by the marginal products (*Hanoch 1975*). The elasticity of scale economy is therefore

$$(12) \quad \eta = \frac{dE}{dY} \cdot \frac{Y}{E} = \frac{1}{E} - Y \frac{[H_n]}{[B_n]} - 1$$

This still requires knowledge of the input combinations for a given Y , i. e., of the expansion path.

To find the latter, inputs X_i are determined for each output Y by minimizing cost subject to the production function constraint (2).

$$(13) \quad Z = X_1 P_1 + X_2 P_2 - (a_0 + a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_1 \ln X_2 + a_4 (\ln X_1)^2 + a_5 (\ln X_2)^2 + \sum a_{6i} Q_i) - \ln Y$$

Partial differentiation with respect to X_1 and X_2 then yields the isocost-isoquant tangencies

$$(14) \quad \frac{P_1}{P_2} = \frac{X_2 E_1}{X_1 E_2}$$

For any given input X_1 the other input can be found. The production relation (2) for each desired level of output Y and price combination P can therefore yield the required inputs X_1 , i. e., the expansion path

$$(15) \quad X_1 = g_i(Y, P).$$

Referring back to the expression for the elasticity E , (5), we have

$$(16) \quad \frac{dE}{dY} = (a_3 + 2a_4) \frac{d(\ln X_1)}{dY} + (a_3 + 2a_5) \frac{d \ln X_2}{dY}$$

$$(17) \quad = \frac{a_3 + 2a_4}{1} \frac{dX_1}{dY} + \frac{(a_3 + 2a_5)}{2} \frac{dX_2}{dY}$$

So that

$$(18) \quad \eta = \frac{dE}{dY} \frac{Y}{E} = \left(\frac{a_3 + 2a_4}{x_1} \frac{dX_1}{dY} + \frac{a_3 + 2a_5}{x_2} \frac{dX_2}{dY} \right) \times \frac{a_0 + a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_1 \ln X_2 + a_4 (\ln X_1)^2 + a_5 (\ln X_2)^2}{a_1 + a_2 + (a_3 + 2a_4) \ln X_1 + (a_3 + 2a_5) \ln X_2}$$

where the inputs X_i are defined by (15).

The analytical expression for the elasticity of scale efficiency in terms of Y and P is cumbersome. However, there is no computational problem in its calculation.

We can also express the elasticities of total and average costs with respect to output. The first order conditions for a minimum of total cost (*Frisch* 1965, *Vinod* 1972) are to equalize the marginal cost of production to the ratio of factor input price and its marginal productivity

$$(19) \quad \frac{dC}{dY} = \frac{P_i}{Y/X_i}$$

Furthermore, we have marginal productivity

$$(20) \quad \frac{Y}{X_i} = E_i \frac{Y}{X_i}$$

Substituting, it is

$$(21) \quad EC = \frac{dC}{dY} \cdot \frac{Y}{C} = \frac{dC}{dY} \cdot Y \cdot \frac{1}{\frac{dC}{dY} \cdot Y (E_1 + E_2)}$$

$$= \frac{1}{E_1 + E_2} = \frac{1}{E}$$

The cost elasticity with respect to output is then the inverse of the scale elasticity with respect to inputs. The elasticity of average cost is similarly

$$(22) \quad E_{AC} = \frac{d(AC)}{dY} \cdot \frac{Y}{AC} = \frac{d(AC)}{dY} \cdot \frac{Y^2}{C} = \frac{Y \frac{dC}{dY} - C}{Y^2} \cdot \frac{Y^2}{C}$$

$$= \frac{Y}{C} \cdot \frac{dC}{dY} - 1 = \frac{1}{E} - 1$$

This measure is easily obtained once E is known, and permits the locating of the bottom of the U-shaped average cost curve – if such exists. As has been shown, for such a point to exist at a positive output Y , E must be $E = 1$ at that output, assuming cost-minimization.

Empirical Estimation

Data

The data covers virtually all 4,200 U.S. cable systems, and is composed of four disparate and extensive files – which had to be matched to each other – for technical and programming,⁹ financial,¹⁰ local community,¹¹ and employment¹² information. The financial data includes both balance-sheet and profit-and-loss type information. To assure confidentiality, financial data has been aggregated. However, particularly detailed subaggregations – for each state according to seven size categories, and with many such categories of financial information – has been made available to the author by the *FCC*. The data refers to the year 1980.

Definition of the Variables

A. Labor

Two alternative measures for labor inputs are used. The first is the physical measure of labor, i. e., the numbers of manhours (2000 for full-time employees plus one half of that number for part-time employees). The second is a financial measure – total wages and salaries paid – adjusted for the variation in regional salary levels (*U.S. Department of Labor, 1971*).

B. Capital Inputs

Accounting data for net assets is reported to the FCC and available. However, this information represents historical book values rather than current values; although the great bulk of assets in the cable television industry have been acquired within the past decade, thus limiting the extent of inflationary distortion, it was, on balance, considered prudent to revalue assets. To do so, the study took advantage of a detailed engineering study, commissioned by the Federal Government, on the cost and pattern of investment that is required to build a cable system. In that report, the required investment flow in a medium sized cable system over a period of ten years was calculated in great detail.¹³ We make the following assumptions:

- (a) This distribution of investment over the first ten years is proportionally the same for all systems.
- (b) Investment in the 11 th year and further years are identical to that of the 10th year.
- (c) The cost of acquiring capital assets required in a cable television system increases at the rate of the Price Index of Capital Goods.

For each observation, we know the first year of operation and the aggregate historical value of capital assets. It is then possible to allocate investments to the different years, and to inflate their value to 1980 prices. The formula employed is

$$(23) \text{ Current Value} = \text{Cook Value} \times T_A$$

where T_A is the adjustment factors

$$(24) T_A = \frac{\sum_{i=0}^A E_i}{\sum_{i=0}^A \frac{E_i}{R_S + i}}$$

with A = age (in years) of system

E = annual capital investment for a cable operator in year i

R = inflation adjustment factor for years $S + i$ of cable operation

S = starting year

The inflation adjustment is defined such that $R_{1980} = 1.00$. R inflates the investment of earlier years, i. e. reflects on how much a one-dollar investment in year X would cost in today's prices.

Capital inputs are defined as a *flow* of capital services K due to current assets A , where the flow is determined by the alternative uses of the funds used for capital expenditure, such that

$$(25) \quad K = rE + i(1 - t)D$$

where r = required return to equity
 E = equity
 i = cost of debt
 D = long term debt
 t = tax rate¹⁴

Equity is defined as owner's net equity, i. e., net assets minus debt.

The required return r is determined according to the risk premium q required above risk-free investments R_F . $r = R_F + q$. *Ibbotson and Sinquefeld* (1979), in their study of these premiums, found q for the Standard and Poor 500 portfolio during 1926-1977 to be 8.8 %. Hence, according to the Capital Asset Pricing Model (*Sharpe* 1964; *Lintner* 1965) an estimate of q for a specific firm is 8.8 times β , where β is the measure of non-diversifiable (systematic) risk of the stock. The average β for cable companies listed by *Moody's* is, for 1980, $\beta = 1.42$, resulting in a risk premium of 12.49 over the treasury bill rate of 11.50 % (*Moody's* 1981). Hence the required rate of return on equity is $r = 23.99$ %.

For i , the return on long-term debt, the following method was employed: for each observation it was determined, using several financial measures, what its hypothetical bond rating would have been. These "shadow" bond ratings for each observation were then applied to the actual average interest rates existing in 1980 for bonds of various ratings. (*Moody's* 1981) This procedure is novel but is based on a series of previous studies on bond ratings and on their relation to financial ratios. Such models exist since 1966 (*Horrigan*), and were further refined by *Pogue and Saldofsky* (1969), *Pinches and Mingo* (1973, 75) and *Altman and Katz* (1974). The model used here is taken from *Kaplan and Urwitz* survey article (1977) (Table 6, Model 5) which determines bond rating with a fairly high explanatory power ($R^2 = .79$). The financial variables that are substituted into this model are: (a) "cashflow before tax/interest charges; (b) long term debt/net worth; (c) net income/total assets; (d) total assets; (e) subordination of debt. Bond ratings from AAA/(model values ≥ 9) to C (≤ 1) can then be obtained for each financial observation. Bond rates are those reported by *Moody's* (1981).¹⁵ Tax rate t is defined as the corporate income tax rate for 1980. Debt is defined as long term liabilities.

Output

Four alternative measures for output are employed. The first is a physical measure, the number of "Households Served."¹⁶ (Cable television is a stand-by service which sells a consumption *potential* to households. The marginal cost of operation to the operator for the *actual* use by a household is trivial.) A second

measure is total sales – “Subscriber Revenue” – of the cable system. A third, “Total Operating Revenue” includes also advertising revenues. A fourth output measure is defined as the number of “Programs Sold,” which is the product of subscribers times the number of program channels of the system.

Input Prices

Input prices P_i , as assumed earlier, are constant over the range of production; they are held to be the mean of the prices actually paid, where total expenditures on the factors are divided by their quantity. (These measures are not required in the estimation of the production function, but are used to calculate the elasticity of scale economies, η .)

Other Variables

The translation of inputs into outputs can also be affected by several other variables. First, there may be some effect of time. Learning-by-doing has been observed in many industries; on the other hand, cable systems of recent vintage may be more efficient to operate than older ones. Thus, there may be an effect of time on the production relation, although its direction is uncertain. We therefore introduce a time variable of “Years of Operation” of the system. Second, there may be effects to the program offering of a cable system. More attractive programs may result in more subscribers. Three variables are therefore used to describe the programming:

- (a) Number of “Imported Signals,” i. e., program channels that are not available over the air.
- (b) Costs of local “Program Origination.” This is a measure for the cable operators’ own involvement in local program origination, including, e. g., automated news and weather, cost of maintaining public access facilities, etc.
- (c) Costs of “Pay-Television Programs” to cable operator. This is a measure for the expenditure incurred to supply “premium” services.

A final variable controls for the effects of density of population. One would expect that it is more costly to supply cable services in rural areas. Hence, a variable for “Urbanization” is introduced, defined as the share of a state’s population that lives in a Standard Metropolitan Statistical Area.

Methodology of Estimation

The translog production function (2), including the variables Q_i , described in the last section, was estimated by the OLS and the Ridge Regression Technique. The latter has been used in a number of production function studies

of telecommunications, since it may reduce the degree of multicollinearity in the data (Vinod 1972; Eldor and Sudit 1981; Sudit 1973). On the other hand, ridge regression introduces a bias in the estimates. A comparison of the results will follow. Also tested, for purposes of comparison, is a general Cobb-Douglas type exponential function, by setting $a_3 = a_4 = a_5 = 0$.

Results

The results of equation (2), for the translog and Cobb-Douglas functions, are given in *Table 1*. The results were very similar for the alternative definition of labor inputs as salaries, and for the use of the ridge regression estimation technique. Hence, only OLS results for the number of man-hours as the labor variable are reported.¹⁷

As can be seen from *Table 1*, both the Cobb-Douglas and the translog production functions have a high explanatory power, as evidenced by the R^2 terms that are generally above .9. Furthermore, the statistical significance of almost all input variables is high. Turning to the Cobb-Douglas estimations, we find strong sized coefficients for labor inputs, and smaller sized ones for capital inputs. Their sum is in the range of 1.183–1.038, which is evidence for the existence of economies of scale. Since the homogeneous functional form does not permit variable scale elasticities, we proceed to find those through the translog-specification and report them in *Table 2*. In that table, the range of production is listed in the left hand column (with output defined as subscribers served); the corresponding labor and capital inputs are calculated from equations (2), (13), and (14); they, in turn, permit a calculation of the scale elasticity E at the different output levels. As can be seen, this elasticity is consistently larger than unity, $E > 1$, implying economies of scale in the range of 5000–200,000 subscribers. (There are currently only five cable operations in the United States with more than 100,000 subscribers.) Furthermore, this elasticity increases with output. A measure of this increase is given by η , the elasticity of scale economies. As can be seen, η is positive – implying an increase in scale economies – and of relatively steady though small size. In the middle range of production, η becomes somewhat smaller, but it increases steadily thereafter. Overall, η is of a size of approximately $\eta = .06$. This means that for each one percent of increase of output, scale economies increase by about .06%. A doubling of output is hence associated with an increase of about 6% in scale economies.

These results also show that the average cost curve is not u-shaped, but continuously decreasing with output. The bottom of a U-shaped average cost curve is reached when $E_{AC} = 0$ as $Y > 1$. As has been discussed, this corresponds to the point where $E = 1$. This point is not reached over the investigated range of production. Hence, average costs are continuously falling,

Table 1: Production Function Coefficients

Variable	Total Operating Revenue	Subscriber Revenue	Subscribers	Channels x Subscribers	Total Operating Revenue	Subscriber Revenue	Subscriber	Channels x Subscribers
ln L	.7060 (8.3480)	.6847 (7.6225)	.9083 (13.3372)	1.0415 (12.7202)	7.3123 (3.9999)	6.8726 (3.5043)	2.8148 (1.9811)	4.0925 (2.3485)
ln K	.3900 (5.3433)	.3533 (4.5576)	.1720 (2.9261)	.1415 (2.0757)	-6.2956 (3.6934)	-6.0591 (3.3135)	-2.6039 (1.9959)	-3.8890 (2.3935)
ln L ln K					-.5963 (3.2787)	-.5500 (2.8187)	-.1149 (-.7925)	-.2128 (1.2274)
(ln L) ²					.1995 (1.6873)	.1616 (1.2742)	-.1092 (-1.1597)	-.0906 (.8041)
(ln K) ²					.3205 (3.8931)	.3057 (3.4619)	.1230 (1.9741)	.1823 (2.3231)
R ²	.8842	.8582	.9165	.9013	.8768	.9303	.9015	.9186

Table 2: Scale Economies and Elasticities of Scale Economies with Output

Output (Subscribers)	Scale Economies E	Elasticity of Scale Economies η
5,000	1.109	.0668
10,000	1.2035	.0575
20,000	1.2224	.0068
50,000	1.2463	.0534
100,000	1.2887	.0639
200,000	1.3535	.0749

and marginal costs are consistently below average costs in the observed range. These are the economic symptoms of a natural monopoly situation.

Summary

A study of the entire U.S. cable industry, using 1980 data for more than 4000 cable companies, shows that economies of scale exist in the current range of production. The model introduced the concept of an elasticity of scale economies with respect to output. This elasticity was found to be positive and of a size of approximately .06, suggesting that for each doubling of production economies of scale increase by 6%. The implications of these results are that large cable operations have cost advantages over smaller ones, and that these advantages increase with the disparity in size. Hence it should be difficult for a smaller cable operator to be competitive with a larger one, setting aside cream-skimming instances. Put differently, multifirm production is costlier than single firm production.

The existence of economies of scale throughout the relevant range of output meets *Baumol's* sufficiency criterion for a natural monopoly for the single product firm. Cable television operations are thus found to have natural monopoly characteristics (when they operate as cable companies only), and their position appears sustainable in the single product market of cable

transmission. However, as *Willig and Panzar* (1977), and *Baumol* (1977) point out, theoretically it is still possible that a multi-product firm (in this case, e. g., telephone companies) could enter successfully. But as against other "pure" cable companies the economies of scale characteristics are operative and suggest that competitive entry is under normal conditions unlikely.

Applied to some of the issues raised at the beginning of the paper, these results suggest that intra-medium competition will be difficult to maintain; they justify the concern of the Boulder City Council that rival companies are unlikely to enter, unless the existing franchisee is constrained; they furthermore lead to the prediction that over the long run, a truly competitive cable system will not survive in Allentown or Phoenix, and that a future consolidation of local cable operators into regionally or nationally interconnected systems is likely. Furthermore, the results suggest that the break-up of franchise territory into smaller units is not efficient, if only economics are taken into account. Finally, the results would lead to expect discriminating pricing by a cable operator, since at a market-clearing uniform price he would incur losses, while a break-even uniform price would be economically inefficient. To the extent that an intra-medium competition is not likely to be sustainable under normal circumstances, alternative public policies need be given closer attention.

Notes

1 e. g. conventional commercial television, subscription television (STV), direct broadcast satellites (DBS), or multipoint distribution (MDS) (FCC 1080). Other observers believe, on the other hand, that the unique two-way capability of cable television which permits a host of economic services as well as a per-program charging, and the freedom of cable technology from the scarcity of spectrum, cannot be matched by other forms of broadcasting, and will permit cable TV to become predominant mass medium outside of low-density areas. (*Noam* 1981 a)

2 *Community Communications Co. v. City of Boulder*, (1981-2 Trade Cas., P 64,300, Sept. 22, 1981. Previously also 630 F2d 704 (10th Cir. 1980) (Boulder I), 48 S F. Supp. 1035 (D. Colo. 1980).

3 The judge in Fremont was not without sophistication in his economic analysis. Note e. g. a sentence from his opinion, "Since U (Utility) will vary from individual to individual, the price will tend to stabilize at that point where the system can maximize its profits, which will be near but above the point where the rate of the CATV service equals A (amortized cost). id, p. 668. For a discussion of cable as a public utility, see *Webbink* (1972).

4 An excellent example is the cable consulting plan for New York City, written by the prestigious Washington law firm *Arnold & Porter* for a fee of more than one million dollars. In that two-volume report, which recommends a subdivision of the city's boroughs into several franchise areas, the entire analysis of economies of scale consists of the following sentences: "... there were only twelve - of more than 4,000 operating cable systems in the United States - which served more than 50,000 subscribers. Unquestionably, this is an acceptable minimum for the size of a franchise area. Moreover, economies of scale would also exist for smaller franchise areas." *Arnold & Porter*, New York City Cable Action Plan, Vol. I, p. 135.

5 The only attempts have been chapters in two doctoral dissertations on the economics of Canadian cable television (*Good* 1974, *Babe* 1975), which include simple regressions of cost per size for several Canadian systems, and which come to conclusions that are contradictory to each other.

6 Reporting is according to local operations; national cable companies (Multiple Systems Operators, or MSO's) must therefore keep their different operations separate in their reporting. Furthermore, national program services of some of the large cable companies are operations of separate entities, and do not disturb the data.

7 These reports are likely to be fairly accurate due to cable companies' vulnerability to FCC charges of misreporting in a period in which they are aggressively seeking new franchises. - It is interesting to note that two of the most accomplished industry studies of the economies of scale, *Nerlove's* classic analysis of electricity generation (1968, 63) and *Christensen and Green* (1976), a more recent approach, are also based on transmission systems with reporting requirements. See also *Belifante* (1978), and *Dhrymes and Kurz* (1964).

8 *Basset and Borcharding* (1970).

9 FCC, Cable Bureau, Physical System File.

10 FCC, Cable Bureau, By communication and by annual newsrelease.

11 FCC, Cable Bureau, Community File.

12 FCC, Cable Bureau, Equal Employment Opportunity File.

13 That study looks into hundreds of items of equipment, different techniques for laying cable, etc. Its use here is only for the relative distribution of investment over time. *Weinberg* (1972), p. 128.

14 Cable companies are not subject to rate-of-return regulation which permits the flow-through of taxes to customers.

15 For low ratings, no measures are reported by the rating services. For the lowest rating (C), the values estimated by an investment banker specializing in cable television, (4 % above prime) were used; for the next higher ratings, interest rates were reduced proportionally until the reported ratings were reached.

16 This is likely to change under a billing system where changes are imposed for actual viewing, and the revenue for each viewing is shared with program suppliers; but in 1980 less than five systems out of more than 4,200 had such billing capability.

17 The variables Q_1 are not included yet in the Tables 1 and 2.

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Zusammenfassung – Summary – Résumé

Das amerikanische Kabelfernsehen ist vom Stadium, in dem es ursprünglich ein Gemeinschaftsantennensystem war, zu einem „Transmissionssystem“ geworden, dessen Hauptfunktion ist, Signale, die über Antennen nicht erhältlich sind, zu liefern. Durch das aktuelle System von lokalen monopolistischen Konzessionen entstehen jedoch für Kabeloperatoren Anreize für eine vertikale Integration in die Produktion von Programmen und Dienstleistungen sowie Antriebe, Konkurrenten vom Zugang zu den Zuschauern im Bereich von Konzessionen auszuschließen. Das führt zu einer Transformation der Kabelindustrie von der des Transmitters von Dienstleistungen zu der eines Produzenten, dessen Kabelnetz zu einem Marketingkanal für den Besitzer der Konzession wird. In der Marketing-Phase des Kabelfernsehens geht die ursprüngliche Quelle von Gewinnen einer Kabelgesellschaft von der Transmission zur Dienstleistung und zur Programmlieferung über: übernimmt die Funktion eines exklusiven und ausschließenden Marketingmittel. Dieses Problem wird besonders gravierend, wenn Kabel zum dominierenden Massenkommunikationsmittel wird und das Prinzip der Pressefreiheit sich an ihren Operationen etabliert.

American cable television has progressed from the stage where it was primarily a community antenna system into a “transmission” phase, where its main function is the delivery and importation of signals that are unavailable over the air. However, the present system of locally monopolistic franchises creates incentives for vertical integration by cable operators into the production of programs and services, and to a foreclosure of competitors from access to the viewers in a company’s franchise area. This leads to a transformation of the cable industry from that of transmitter of services to that of a producer, with the cable link constituting a marketing channel for the franchise holder. In the “marketing” phase of cable television, the primary source of profits for a cable company shifts from transmission to service and program supply, with the function of the physical cable being that of an exclusive and excluding marketing device. This problem will tend to become more serious as cable becomes the dominant mass communications medium, and establishes freedom-of-the-press over its operations.

La télévision par câble américaine est passée d’un stade où elle était principalement un système d’antenne communautaire à une phase de «transmission» où sa fonction principale est de délivrer et d’importer des signaux qui ne sont pas disponibles par les ondes. Cependant, le système actuel de franchises monopolistiques crée pour les opérateurs de systèmes de transmission par câble une prime à l’intégration verticale dans la production de programmes et services et pousse à interdire aux concurrents l’accès aux spectateurs dans la zone de franchise de la compagnie. Ceci amène à une transformation de l’industrie de la transmission par câble d’une industrie de transmetteurs de services en celle de producteurs dont le réseau câble est un canal de marketing pour le détenteur de la franchise. Dans la phase «marketing» de télévision par câble, la source principale de revenu pour une compagnie qui possède un réseau de câbles passe de la transmission au service et à la délivrance de programmes, avec la fonction du câble lui-même devenant celle d’un moyen de marketing exclusif et excluant. Ce problème tendra à devenir plus sérieux avec la transmission par câble devenant le moyen de grande communication prépondérant et affirmant le principe de liberté de l’information pour ses opérations.