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Economies of Scale and Regulation in CATV

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The Research Issue

The U.S. television industry is presently undergoing rapid change. Where once there was a limit on viewing options imposed by the scarcity of electromagnetic spectrum, confining most viewers to a handful of channels, cable television is emerging as "the television of abundance" (Sloan Commission 1971). Yet, ironically, the market structure of "abundant" cable television is more restrictive than that of "scarce" broadcast television, since the present franchising system has arranged the medium into parallel local distribution monopolies, one for each franchising area. 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 form 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, whose philosophy it has become to permit entry and encourage intermedia competition between cable and other video technologies.

A second, and distinct, competitive approach is to rely on *intramedium* competition among cable companies. In New York State, for example, a Governor's Bill, based on recommendations by Alfred Kahn and Irwin Stelzer, had sought to open each cable franchise area to additional cable companies, thereby reducing their local economic power. The likelihood 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 exhibits strong scale and scope economies, that is, cost advantages of diversified production.

This research is supported by the National Science Foundation under Grant #IST-82-09485. Support by the Columbia Business School is also acknowledged. The author is grateful to Zvi Griliches, Betsy Jaeger, Claire Kessinger, Florence Ling, Mark Nadel, and Menachem Petrushka. Special thanks go to Nadine Strossen.

The question of cable television's scale economies also has implications on the scope of local regulation and on the treatment of the medium as a "public utility," issues that have arisen in a number of court cases. In one decision, for example, the court declared that "CATV is not a natural monopoly. Thus, the scope of regulation which is necessary in the natural monopolies is not here necessary . . . (and) CATV is not a public utility . . ." (*Greater Fremont, Inc.* v. *City of Fremont,* 302 F. Supp. 652 [N.D. Ohio 1968]). Information on scale elasticities is also important in assessing the likelihood of future consolidations into regional or national cable systems, in finding the economically most efficient subdivision of large cities into franchise zones, and in analyzing the price structure of cable television.

Despite the relevance of the question of scale and scope economies of cable television, it has not received much empirical investigation. Previous studies of cable television have typically centered on questions of demand analysis and of audience diversion. They are also mostly dated, since their impetus was the 1966 FCC rules restricting CATV.

As pointed out in an article jointly authored by a comfortable majority of the economists engaged in cable television research [Besen, Mitchell, Noll, Owen, Park, and Rosse (1977)]: "All of these models are synthetic and eclectic, drawing their cost data for the specific components of a system from engineering specification and field experience; no satisfactory data set exists from which to estimate econometric cost or production functions" (p. 66).[1]

Since that observation, several empirical studies on the demand for pay-cable services was undertaken (Block and Wirth 1982; Dunmore and Bykowsky 1982; Smith and Gallagher 1980). However, no comparable research on the production side was undertaken, with the exception of Owen and Greenhalgh (1982), which relies on projected, rather than actual, data.

The Model

For purposes of analysis and estimation of economies of scale, consider the multiproduct cost functions of firm i, uniquely corresponding to the production function under duality assumptions

$$C_i = f_i(P_1 \ldots P_n; Q_1 \ldots Q_q; M), \tag{7.1}$$

where the C_i are total costs of production, Q_q is the output vector, the P_i are the prices for input factors i, assumed to be independent of output, and M is the maturity of the system in terms of operating experience. Under the assumption of cost minimization, we have, from Shephard's lemma, an identity of the cost-price elasticities E_{CP_i} with the share of each input factor in total cost, that is,

$$S_i = \frac{P_i X_i}{C} = \frac{\partial \ln C}{\partial \ln P_i} = E_{CPi}, \tag{7.2}$$

where X_i is the quantity of input i.

Furthermore, let the cost function f be given by the translog function, a second-order logarithmic approximation to an arbitrary twice-differentiable transformation surface. A major problem with the application of a multiproduct specification of a cost function is that if even one of the products has the value zero, the observation's value becomes meaningless. For that reason it is necessary to specify an alternative functional form that is well behaved, and we can substitute the Box–Cox metric

$$g_i(Q_q) = (Q_q^w - 1)/w, \tag{7.3}$$

which is defined for zero values, and which approaches the standard natural logarithm $\ln Q_q$ as $w \rightarrow 0$. Using this expression, we can define the "hybrid" multiproduct translog cost function.

$$\begin{aligned} \ln C(P_i, Q_q, M_m) = a_0 &+ \sum_i a_i \ln P_i + \sum_q a_q \left(\frac{Q_q^w - 1}{w}\right) \\ &+ \sum_m a_m \ln M + \frac{1}{2}\sum_i \sum_j a_{ij} \ln P_i \ln P_j \\ &+ \frac{1}{2}\sum_q \sum_p a_{qp} \left(\frac{Q_q^w - 1}{w}\right)\left(\frac{Q_p^w - 1}{w}\right) \\ &+ \frac{1}{2}\sum_m \sum_n a_{mn} (\ln M)^2 + \sum_i \sum_q a_q \ln P_i \left(\frac{Q_q^w - 1}{w}\right) \\ &+ \sum_m \sum_i a_{im} \ln P_i \ln M + \sum_m \sum_q a_{qm} \left(\frac{Q_q^w - 1}{w}\right) \ln M. \end{aligned} \tag{7.4}$$

Several parametric restrictions must be put on the cost function. The cost shares must add to unity, which implies that $\sum E_{CPi} = 1$; hence, the cost function must be linearly homogenous in factor prices at all values of factor prices, output, and maturity.

Furthermore, the function is homogenous at the sample mean if overall cost

$$a_{qp} = a_{iq} = a_{qm} = w = 0. \tag{7.5}$$

For a test of constant returns to scale to exist, we add the independent restriction

$$a_q = 1. \tag{7.6}$$

Finally, for a neutrality of technical change, we impose the $n - 1$ independent restrictions, for an M that measures time,

$$a_{im} = 0. \tag{7.7}$$

For the multiproduct case local overall scale economies, as shown by Fuss and Waverman (1982), are

$$E_S = 1 \Big/ \sum_q E_{CQq}, \tag{7.8}$$

so that

$$E_S = 1 \Big/ \sum_q \left(Q_q^w \left(aq + \sum_p a_{qp} \left(\frac{Q_p^w - 1}{w} \right) + \sum_i a_{iq} \ln P_i + \sum_m a_{qm} \ln M \right) \right).$$

Product-specific scale economies are, using the definition in Baumol, Panzar, and Willig (1982),

$$E_{Sq} = \frac{IC_q}{Q_q(\partial C/\partial Q_q)} \tag{7.10}$$

(where IC_q are the incremental costs of producing product q), which is

$$E_{Sq} = \frac{IC_q}{C} \Big/ Q_q^w \left(a_q + \sum_p a_q \left(\frac{Q_q^w - 1}{w} \right) + \sum_i a_{iq} \ln P_i + \sum_m a_{qm} \ln M \right). \tag{7.11}$$

For the hybrid translog function, sample mean values are $P_i = Q_q = M = 1$, so that equation (7.11) for the product-specific economies of scale becomes

$$E_{Sq} = \frac{\exp(a_o) - \exp(a_o - a_q/w + a_{qq}/2w^2)}{\exp(a_o) \cdot a_q}. \tag{7.12}$$

The form of estimation that is used to determine this system follows Zellner's (1962) iterative method. That technique is a form of generalized least squares, shown to yield maximum likelihood estimates (Dhrymes 1964) that are invariant to which of the cost-share equations is omitted (Barten 1969). In estimating such a system it is generally assumed that disturbances in each of the share equations are additive and have a joint normal distribution. These assumptions are also made here.

Effects of Regulation

The model has so far assumed the absence of regulation by treating each cable operator as an unconstrained profit maximizer. However, cable firms may operate under a set of constraints. Of these the most frequent are restrictions on profitability, the usual corollary to the franchise-awarded monopoly status. These constraints will now be incorporated into the model.[2]

We first assume the existence of a rate of return regulation in the prices of cable television services. Such regulation exists explicitly in a number of jurisdictions and implicitly in many others by the regulating authority's restriction of basic rates to result in a "reasonable" overall return, including pay-channel revenues, that does not discourage further investments in the cable system.

Let total cost be given by

$$C = \sum_i X_i P_i, \tag{7.13}$$

where, as before, X_i and P_i are the quantities and prices of input factors. Total differentiation with respect to time in operating experience yields

$$\frac{dC}{dm} = \sum_i X_i \frac{dP_i}{dm} + \sum_i P_i \frac{dX_i}{dm}. \tag{7.14}$$

We define, for any variable A, the term $\dot{A}$ as the change dA/dm proportional to its size. We also recall that the cost shares S_i were defined as $S_i = X_i P_i / C$. Therefore, the previous expression becomes, after some manipulation,

$$\dot{C} = \sum_i S_i \dot{P}_i + \sum_i S_i \dot{X}_i. \tag{7.15}$$

Suppose now that cable operators minimize cost subject to a constraint z of return on capital. Under the constraint z Shephard's lemma leads to modified optimization conditions (Fuss and Waverman 1981). With unconstrained inputs i, constrained capital input K, and Lagrangian multiplier λ, these conditions are

$$\partial C/\partial P_i = (1 - \lambda) X_i, \tag{7.16}$$

$$\partial C/\partial P_K = X_K, \tag{7.17}$$

$$\partial C/\partial z = -\lambda K. \tag{7.18}$$

A total differentiation of the cost function yields

$$\frac{dC}{dm} = \sum_i \frac{\partial C}{\partial P_i}\frac{dP_i}{dm} + \sum_q \frac{\partial C}{\partial Q_q}\frac{dQ_j}{dm} + \frac{\partial C}{\partial m} + \frac{\partial C}{\partial z}\frac{dz}{dm}, \tag{7.19}$$

and, after substitutions,

$$\dot{C} = \sum_i (1 - \lambda) S_i \dot{P}_i + S_K \dot{P}_K + \sum_q E_{Qq} \dot{Q}_q + \dot{C}_m - \frac{\lambda z X_K}{C} \dot{z}. \quad (7.20)$$

After setting (7.20) equal to (7.15), the shift in the cost function is, therefore,

$$\dot{C}_m = \sum_i S_i \dot{X}_i + S_K \dot{X}_K - \sum_q E_{Qq} \dot{Q}_q + \sum_i \lambda S_i \dot{P}_i + \frac{\lambda z X_K}{C} \dot{z}. \quad (7.21)$$

We now define total quantity changes as the sum of the component changes, weighted by their share in total cost C. That is, let

$$\dot{Q} = \sum \dot{Q}_q \frac{IC_q}{C}, \quad (7.22)$$

and after substituting for the elasticities E_{Qq} and rearranging, let equation (7.21) then be rewritten

$$T\dot{F}P = \dot{Q} - \dot{I} = -\sum_q \frac{\dot{Q}_q \cdot Q_q}{C} \left(\frac{\partial C}{\partial Q_q} - \frac{IC_q}{Q_q} \right)$$

$$+ \lambda \left(\sum_i S_i \dot{P}_i + \frac{z X_K}{C} \dot{z} \right) - \dot{C}_m. \quad (7.23)$$

This expression now shows changes in total factor productivity as composed of the effects of falling average costs and of rate-of-return regulation, as well as of the more conventional effect of technical progress in operations.

What is the interpretation of the first term of the right-hand side equation? The terms inside the parentheses are, respectively, the marginal cost and the average cost of product q. We will later observe that marginal costs tend to be below average costs. Hence, the entire term is likely to be positive, and the observed growth in total factor productivity, if this effect is not considered, is likely to overstate the contributions of maturity in operations $\dot{C}_m$.

The second expression (preceded by the λ term) shows the effect of rate-of-return regulation. If no negative rate of regulation exists ($\lambda = 0$), *TFP* growth is measured by maturity progress $\dot{C}_m$. However, if rate-of-return regulation is effective, and if—as is reasonable to assume under inflation—for each factor i, $\dot{x}_i \geq 0$ and $\dot{z} \geq 0$, then the measured total factor productivity growth also overestimates the contribution of operating experience.

The following section is an empirical estimation of the model (7.1)–(7.10). For the regulated model sufficient data is not available at this point; their generation and use is the subject of further research.

Data

The empirical estimation of this study is based on an unusually good body of data for cable television systems, all producing essentially the same service, operating and accounting in a single-plant mode, supplying their local market only, and reporting data according to the fairly detailed categories of a mandatory Federal form.

The data covers virtually all 4,200 U.S. cable systems and is composed of four disparate and extensive files for the year 1981 for technical and programming, financial, local community, employment information.[3] The financial data includes both balance sheet and income information.[4]

All variables are standardized around the sample mean in order to overcome the problem of arbitrary scaling that can become an issue in translog functions.

Labor Inputs[5]

The factor quantity is the number of full-time employees (with part-time employees added at half value).

Capital Inputs

Accounting for the different classes of assets is reported to the FCC in book value form. 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 considered prudent to revalue these assets. To do so the study took advantage of a highly detailed engineering study, commissioned by the Federal Government, on the cost and pattern of investment in the construction of cable systems (Weinberg 1972). In that report the required investment flow in a medium-sized cable system over a period of ten years was calculated. We assume that this time distribution of investment over the first ten years holds proportionally for all systems, with investment in the eleventh year and further years identical to that of the tenth year in real terms, and that the cost of acquiring capital assets required in a cable television system increases at the rate of a weighted index of communications and utilities equipment.

For each observation we know the first year of operation and the aggregate historical value of capital assets. It is then possible to allocate capital investments to the different years and different types of investment and to inflate their value to the prices of the observation year. The input price P_K of this capital stock K is determined by its opportunity cost in a competitive environment, consisting of potential returns r on equity E and payments for debt D, with an allowance for the deductability of interest expense (tax rate $= t$).

$$P_K = r_E \cdot \frac{E}{K} + r_D(1 - t)\frac{D}{K}. \tag{7.24}$$

The required return on equity is determined according to the risk premium ρ required above the return on risk-free investments R_F; that is, $r_E = R_F + \rho$. Ibbotson and Sinquefield (1979) found ρ for the Standard & Poor 5000 to be 8.8 for the period 1926–1977. Hence, using the capital asset pricing model, an estimate of ρ for a specific firm is 8.8 times β, where β is the measure of nondiversifiable (systematic) risk. The average β for cable companies listed by Moody's is, for 1980, $\beta = 1.42$, resulting in a risk premium of 12.49 percent over the treasury bill rate.

For r_D, 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, based on a company's financial characteristics. These "shadow" bond ratings for each observation were then applied to the actual average interest rates existing in the observation years for different bond ratings. This procedure is novel, but is based on a series of previous studies in the finance literature of bond ratings and their relation to financial ratios.[6]

Tax rate w is defined as the corporate income tax rate (federal and average net state). Debt is defined as long-term liabilities.

Programming Inputs

The third production factor of the model is the input of programming. A cable system that carries no communications messages would be of no interest to subscribers. Therefore, cable operators supply programs in addition to providing the communication wire. These programs are not produced or generated by the operators; with trivial exceptions, programming is supplied by broadcasters and program networks. Program costs are both direct and indirect. Direct costs are the outlays for program services, for example, to pay-TV networks and to suppliers such as Cable News Network (CNN), which charge operators according to the number of their subscribers, plus the cost of program importation and its equipment. Direct costs, however, are only part of the programming cost; indirect costs that must also be considered are the foregone net earnings from advertising. For example, CNN is able to sell some of its "air" time to advertisers. This time is, in effect, a compensation in kind by the cable operator to CNN for the supply of the program. Similarly, local broadcasters are carried by cable for free, and the programming cost of these "must carry" channels to cable operators, too, is the foregone earnings, largely in advertising revenues.

Direct costs are reported to the FCC and are available. Included are also such capital costs as those of origination studios and signal importation equipment and cost to carriers. The indirect cost of foregone advertising revenue is defined as the potential minus the actual advertising revenues obtained by cable operators' net cost. Actual figures are reported to the FCC; potential revenues are estimated by reference to the average net advertising revenue in television broadcasting per household/and viewing time. The unit price of programming inputs is their total divided by the number of program hours and channels.

Output

Costs and revenues in cable television are nearly entirely for subscription, rather than actual, use. Pay-per-view billing systems are exceedingly rare, and in their absence there are only negligible marginal costs to the operator for a subscriber's actual viewing of the channels. Active communications services, though maybe of future importance, are very rare at present. Advertisements, similarly, are largely supplied by program providers as part of an exchange arrangement; as discussed above, they are an input. Hence, the number of actual and potential subscribers—as opposed to their viewing—are the measures of the operator's outputs.

Cable television operators' major outputs are then of the following dimensions: (a) basic service subscriptions; (b) pay-TV service subscriptions; and (c) the size of the market developed, measured by the number of *potential* subscribers that are reached. The latter is reflected by the number of "homes passed" by cable. The larger this number, the more subscribers can be potentially enrolled. Cable trunk lines or feeder lines pass their houses; only drops need to be added for their inclusion as paying customers. Subscriptions as share of homes passed vary widely.

Other Variables

M, maturity in operation, is one variable that is introduced to allow for the period that a cable operator had to improve operations and to establish himself in the local market. It is defined by the number of years of actual operation.

This variable may be thought of as if it were an input factor. Quite possibly, it is substitutable for the more conventional input factors of capital and labor, reflecting improvements in productivity of a firm whose experience shifts the cost function downwards.

Two additional variables, which may affect costs of production and ability to attract subscribers, are introduced in order to adjust for differences in the cable systems. The density of population has a role in determining cost. The further houses are from each other physically, the more capital and labor inputs must go into reaching each. To allow for density variations, we define *D* as the length of cable trunk lines per household passed. The resultant ratio is used as a proxy for density.

A third variable is the number of video channels offered by a cable operator. Clearly, the more channels offered, the more inputs are required. At the same time one would expect subscription outputs to be affected positively, ceteris paribus, since the cable service is more varied and, hence, probably more attractive to potential subscribers.

Results

Table 7.1 represents the parameter estimates for the five models (A–E), for the multipoint specification, for the year 1981. Results for the unrestricted model are discussed.

Table 7–1
Cost Function Parameters
(Output Definition: Multiproduct)

Parameter	*Model A Unrestricted*	*Model B Homotheticity*	*Model C Homogeneity*	*Model D Constant Returns to Scale*	*Model E Neutrality*
a(0) Constant	−0.4295 (21.0098)	−0.3551 (16.3044)	−0.2669 (14.1049)	−0.4353 (9.2915)	−0.3780 (18.4553)
a(*P*1) Labor Cost	0.3349 (12.4595)	0.2824 (9.4205)	0.2150 (8.2853)	0.4507 (13.3905)	0.2889 (11.2621)
a(*P*2) Capital Cost	0.3417 (10.2453)	0.2490 (7.2420)	0.1584 (6.3529)	0.3947 (11.5193)	0.2831 (8.6899)
a(*P*3) Programming Cost	0.3233 (7.6582)	0.4685 (10.1526)	0.6265 (27.2923)	0.1545 (4.9320)	0.4278 (10.3827)
a(*Qa*) Basic Subscriptions	0.2920 (4.1001)	0.3219 (5.4185)	0.5476 (12.7492)	0.5399 (12.6206)	0.2858 (4.0156)
a(*Qb*) Pay Subscriptions	0.1211 (1.5862)	0.1629 (2.0956)	0.1972 (3.7183)	0.2977 (2.0495)	0.2762 (3.5872)
a(*Qc*) Homes Passed	0.4987 (13.5994)	0.3622 (9.2298)	0.1970 (11.5557)	0.5585 (22.4069)	0.4314 (11.8519)
a(*D*) Trunk/Households	0.1927 (2.4782)	0.0844 (1.0149)	−0.2019 (2.8993)	−0.1778 (0.9504)	0.0029 (0.0407)
a(*E*) Channel Capacity	0.4407 (6.1587)	0.4219 (5.4698)	0.5284 (7.2090)	0.0204 (0.1173)	0.4089 (6.0793)
a(*M*) Maturity of System	−0.0092 (2.0556)	−0.0587 (1.6472)	−0.0296 0.6157)	0.0209 (0.1649)	0.0552 (1.1232)
a(*P*1)(*SQ*)	0.0192 (1.2457)	0.0169 (1.2603)	0.0653 (5.0556)	0.1096 (5.4497)	0.0318 (2.1764)
a(*P*1)(*P*2)	0.1757 (4.5319)	0.0126 (0.5000)	−0.0996 (4.4764)	−0.1322 (3.6293)	0.0297 (0.8589)

Table 7–1 (Continued)

Parameter	Model A Unrestricted	Model B Homotheticity	Model C Homogeneity	Model D Constant Returns to Scale	Model E Neutrality
a(P1)(P3)	−0.2142 (5.1888)	−0.0464 (4.3946)	−0.0309 (3.4134)	−0.0870 (6.1643)	−0.0935 (2.5117)
a(P1)(Qa)	0.0814 (0.9600)	— —	— —	— —	0.2007 (2.7285)
a(P1)(Qb)	0.2438 (2.8283)	— —	— —	— —	0.0231 (0.3134)
a(P1)(Qc)	0.0094 (0.2667)	— —	— —	— —	−0.0807 (2.4471)
a(P1)(D)	−0.1481 (1.7573)	−0.0095 (0.1166)	0.1114 (1.7598)	0.1900 (2.2280)	— —
a(P1)(E)	−0.4059 (3.8088)	0.2317 (2.3676)	−0.0369 (0.4621)	0.0406 (0.3447)	— —
a(P1)(M)	−0.0478 (0.9377)	0.1963 (4.6775)	0.0493 (1.3034)	0.0750 (1.2297)	— —
a(P2)(SQ)	0.4082 (12.4739)	0.0332 (2.4624)	0.0750 (6.6422)	0.1204 (6.4273)	0.2905 (9.3819)
a(P2)(P3)	−0.9922 (13.4510)	−0.0792 (5.9905)	−0.0504 (5.4034)	−0.1086 (7.4886)	−0.6109 (10.0694)
a(P2)(Qa)	−0.2334 (2.1867)	— —	— —	— —	0.1112 (1.1449)
a(P2)(Qb)	0.4235 (3.7497)	— —	— —	— —	−0.0737 (0.7668)
a(P2)(Qc)	0.7728 (12.0940)	— —	— —	— —	0.4742 (8.7495)
a(P2)(D)	−0.2435 (2.2640)	−0.2612 (2.7856)	−0.0077 (0.1290)	0.0252 (0.2989)	— —
a(P2)(E)	−0.5717 (3.8874)	0.3377 (3.0053)	0.0485 (0.6524)	0.0625 (0.5585)	— —
a(P2)(M)	0.3278 (4.7756)	0.2077 (3.3537)	−0.0280 (0.8139)	0.0314 (0.5559)	— —
a(P3)(SQ)	0.6032 (12.5321)	0.0628 (7.8259)	0.0406 (14.8110)	0.0314 (0.5559)	0.3522 (9.1544)
a(P3)(Qa)	0.1520 (1.1172)	— —	— —	— —	−0.3120 (2.5455)
a(P3)(Qb)	−0.6674 (4.7819)	— —	— —	— —	0.0505 (0.4287)
a(P3)(Qc)	−0.7823 (9.8163)	— —	— —	— —	−0.3935 (6.0579)
a(P3)(D)	0.3916 (2.9928)	0.2708 (2.2879)	−0.1037 (3.5403)	−0.2152 (2.8686)	— —
a(P3)(E)	0.9776 (5.4791)	−0.5694 (3.8618)	−0.0115 (0.3923)	−0.1031 (1.3260)	— —
a(P3)(M)	−0.2800 (3.7788)	−0.4041 (5.8027)	−0.0213 (1.1789)	−0.1065 (2.3104)	— —

Table 7–1 (continued)

Parameter	Model A Unrestricted	Model B Homotheticity	Model C Homogeneity	Model D Constant Returns to Scale	Model E Neutrality
a(Qa)(SQ)	0.1509 (0.9408)	0.2967 (1.7608)	— —	— —	0.1634 (1.0060)
a(Qa)(Qb)	−0.5721 (1.6672)	−0.7997 (2.2508)	— —	— —	−0.4138 (1.2027)
a(Qa)(Qc)	−0.1156 (0.9659)	0.0691 (1.6512)	— —	— —	0.2345 (2.0869)
a(Qa)(D)	0.2968 (1.2781)	0.4290 (1.7567)	— —	— —	0.2673 (1.1416)
a(Qa)(E)	0.0502 (0.1517)	−0.0498 (0.1501)	— —	— —	−0.4212 (1.2502)
a(Qa)(M)	0.0305 (0.1895)	0.0410 (0.2419)	— —	— —	−0.2483 (1.5042)
a(Qb)(SQ)	−0.0337 (3.3132)	0.0334 (0.4302)	— —	— —	−0.3023 (3.3153)
a(Qb)(Qc)	0.2981 (2.4572)	−0.2418 (5.5954)	— —	— —	−0.2545 (2.3535)
a(Qb)(D)	−0.5525 (2.2777)	−0.5936 (2.3360)	— —	— —	−0.4203 (1.7505)
a(Qb)(E)	−0.5389 (1.6146)	0.2512 (0.7674)	— —	— —	0.3580 (1.0777)
a(Qb)(M)	−0.0251 (0.1617)	0.0802 (0.4982)	— —	— —	0.2326 (1.4746)
a(Qc)(SQ)	0.0319 (9.4927)	0.0292 (4.1997)	— —	— —	0.1710 (6.0260)
a(Qc)(D)	−0.2008 (1.9116)	−0.1169 (1.2390)	— —	— —	0.0794 (2.1344)
a(Qc)(E)	−0.5338 (3.7968)	0.5509 (4.4980)	— —	— —	0.1880 (5.1626)
a(Qc)(M)	0.2751 (4.2650)	0.3351 (5.3635)	— —	— —	0.0190 (0.9946)
a(D)(SQ)	−0.0316 (0.3699)	0.0862 (0.9853)	0.0972 (2.0793)	0.1290 (1.0478)	0.0117 (0.1594)
a(D)(E)	0.5141 (2.0282)	0.4598 (1.7958)	0.4015 (2.7186)	0.9788 (2.4377)	0.3799 (1.6409)
a(D)(M)	0.1819 (1.5034)	0.2374 (1.8710)	0.1653 (1.5121)	0.2217 (0.7486)	0.1005 (0.8209)
a(E)(SQ)	1.0449 (4.8100)	−0.1151 (0.5416)	0.1148 (0.6843)	0.5262 (0.1270)	0.2549 (1.4826)
a(L)(M)	0.5639) (3.0229)	−0.0926 (0.4949)	0.4372 (2.8572)	1.1679 (2.8955)	0.6205 (3.3830)
(M)(SQ)	0.1849 (3.7133)	0.0779 (1.4725)	0.1309 (2.9945)	0.3789 (3.4417)	0.2041 (44.0412)
R^2	0.9971	0.9816	0.9707	0.8714	0.9772

The system has a good fit, with system R^2 values above .97 for the models. Similarly, the coefficients are generally significant at the .05 level, and common parameters are of similar size. High R^2 values are found for the cost share equations when these are estimated separately.

Overall elasticity of scale is calculated, using equation (7.14), as E_S = 1.096. That is, a 10 percent increase in size is associated with a unit cost decrease of about 1 percent.

We are also able to calculate, using equation (7.19), measures for the product-specific economies of scale for the four outputs. They are:

E_S (Homes Passed) = 1.020,

E_S (Basic Subscriptions) = 1.054,

E_S (Pay Subscriptions) = 1.072.

Scale economies are thus observed for three outputs: basic and pay subscriptions, and channel capacity. However, for "Homes Passed," these are relatively smaller and significant; it may be recalled that this output description refers to a physical measure, namely the extent of the cable network in accessing a market. These results do not change markedly when the small, old, and low-capacity systems are omitted from the observations.

The implication from this result is that scale economies do not appear to reside primarily in the technical distribution aspects of cable television, as reflected by "Homes Passed." Instead, they are observed for the output definitions that include a strong element of marketing success.

It is particularly interesting to observe that the overall economies of scale are larger than the product-specific economies of scale. There are then economies to joint production, or of "scope."

The product-specific scale elasticity measures listed above also provide another insight. Since they are the ratio of average to marginal cost, their being generally above unity reflects marginal costs that are below average costs. This suggests that in a hypothetical competitive environment, where subscriber prices are driven to marginal cost, total costs will not be recovered.

It is also interesting to look at the estimates for the effects of operational maturity M. This factor, it may be recalled, measures the effects of experience in operation. We find the elasticity of costs with respect to such maturity to be $E_{CM} = -.01$, suggesting a small downward shift of the cost function with experience, with inputs and outputs held even.

It should be noted that M actually embodies two separate effects, that of experience, given a technology, and that of change in the technology itself. Conceptually, it is the difference between a movement along a curve and the shift of the curve. Separating these effects is a question for further research.

A look at the other control variables is interesting, too. Here, we can observe the coefficient for density (trunk length/homes passed) to have a value of $a(D) = .19$ with a good statistical signficance. That is, costs are declining with density, which is an expected result, though its magnitude is not particularly great. Furthermore, cost savings decline with density and there are diminishing economies to density. This would confirm the observation that in dense city franchise areas, costs increase again since underground ducts are necessary.

The number of channels, on the other hand, is associated with increasing cost; this, too, is as intuitively expected. Here, cost increases rise with channels, implying increasing marginal cost of channel capacity beyond the mean.

While this chapter deals with scale economies of cable, such conditions are not the only factor pertinent to entry. Theoretically, it is, for example, possible that several rivals coexist in a market, even in the presence of subadditivity, if they enter into some form of oligopolistic agreement to assure their mutual survival. However, such interaction is less likely with a single incumbent, as is the case in cable television. A hostile entry, on the other hand, is costly: since many of the cable companies operate multiple systems across the country, a hostile entry would, under normal circumstances, invite retaliation or a protective price cut (Milgrom and Roberts 1982).

The likelihood of competitive entry could also be affected by sunk cost of the incumbent cable operator. Sunk cost—the difference between the ex ante cost of investment and its ex post sale value—may permit strategic investment behavior in order to create entry barriers (Dixit 1979).

It differentiates the cost of incumbents from those of contestants and imposes an exit cost on a contestant. Knieps and Vogelsang (1982) have shown that entry and a multifirm equilibrium may still be possible in a sunk cost situation under Cournot assumptions provided that demand is high relative to cost, but, under a Bertrand behavioral assumption, entry can be deterred if a sufficiently high share of cost is sunk. It is not clear which of the assumptions better reflects a hypothetical oligopolistic interaction in cable television, or even if one can accept the simplistic assumption of invariable post-entry behavior. As an empirical matter it is very hard to assess the existence of sunk cost and to separate it from good will in cable television, although there are indications for its existence. In a sale of cable assets the physical cable network may be acquired by other communications carriers as a broadband transmission facility, possibly as a "by-pass" to telephone companies, but such use is only in its beginning and probably not profit-generating for some time.

Beyond the theoretical arguments there is also the reality of competitive entry, or rather the lack thereof. In practice there are no second entrants, apart from minor cream-skimming instances. Competitive cable television services (known in the industry as "overbuild") exist in less than 10 franchises out of 4,200 and are usually caused by disputes about the scope of the initial franchise award. Of these operations only those in Allentown, Pennsylvania and Phoenix, Arizona are of appreciable size. Despite rivalry, subscriber rates in Allentown are above the national average.

The rivalry among cable operators is thus primarily for the right of first entry. Being first assures a head start and thus the advantage of economies of larger size; this, together with the likely existence of sunk costs, the ability of the incumbent to cut prices fairly rapidly, and consumers' conservative adjustment to new offerings, violates the criteria for actual or potential contestability.

If the estimation results are accepted, their implications are that large cable corporations have cost advantages over smaller ones when they function as more than a mere distributor. Under these results a pure distribution network with no programming or marketing role, such as a passive common carrier, is not likely to have a *major* cost advantage over potential rivals. The imposition of such a common carrier status would therefore be doubly injurious to the cable television industry (which strenuously opposes it): it would not only eliminate operators' control over and profit from nontransmission activities such as program selection, but it would also reduce the cost-advantage protection of incumbents against entry.

On the other hand, the conclusions require a subtle change in the pro-separations argument. That position—held by institutions as disparate as the Nixon White House and the American Civil Liberties Union—is normally presented as one of protection against a vertical extension of the natural monopoly in one stage of production (transmission) upstream into other stages such as program selection. The implications of our estimation, however, do not support the view that such advantages are primarily derived from a naturally monopolistic distribution stage. Instead, the cost advantages appear to lie in the *integration* of transmission and marketing activities. It is this integration which appears to provide cable television firms with protection against rivalry in the distribution phase of their operations.

Notes

1. Two earlier attempts at cost studies of cable television have been chapters in two doctoral dissertations on the economics of Canadian 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.

2. While the effect of regulation was investigated for other industries, no such investigation exists for cable television. Industry studies are for trucking (Friedlaender 1978); air transport (Gollop and Jorgenson 1980); railways (Caves et al. 1980); environmental regulation (Denison 1978); electric power (Christensen and Greene 1976); and gas pipelines (Callen 1978). Closest to the present study is an investigation of Canadian telephone service (Fuss and Waverman 1981), to which credit is due.

3. FCC, Cable Bureau, Physical System File; Special financial data printout; Community File; Equal Employment Opportunity File.

4. To assure confidentiality, financial data had been aggregated in the publicly available FCC documents; particularly detailed subaggregations—for each state according to seven size categories, and with many categories of financial information—had been made specifically available to the author.

5. All input prices are assumed to be independent of production level. Furthermore, input prices are not controlled by cable operators. This seems unexceptional in light of the mobility of capital and labor. For programming, some market power will exist in the future if cable should become a dominant medium. As an advertising outlet, cable television has no particular market power.

6. The model used here is taken from the Kaplan and Urwitz survey (1979, table 6, model 5) which determines bond rating with a fairly high explanatory power (R^2 = .79). The financial variables used in that model are: (a) cash flow before tax/interest charges; (b) long-term debt/net worth; (c) net income/total assets; (d) total assets; (e) subordination of debt. Bond ratings ranging from AAA (model values $\geq$ 9) to C ($\leq$ 1) can then be obtained for each observation point by substitution of the appropriate financial values. Bond rates are those reported by Moody's. For low ratings no interest rates are reported by the services. For the lowest rating (C) the values estimated by an investment banker specializing in cable television were used (4 percent above prime); for the next higher ratings interest rates were reduced proportionally until the reported ratings were reached.