Economies of Scale and Scope In Cable Television

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I. The Research Issue

The study is an investigation of the economies of scale and scope in cable television operations. The results are intended as an empirical contribution to the question of whether competition among rival cable television operators is likely, an issue of significant interest for regulatory policy towards the new medium.

Methodologically, the study proceeds by specifying a multi-product function, and by incorporating the effects of regulation in the multi-equation model. The statistical estimation is based on data for all 4,800 U.S. cable systems.

The U.S. 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, 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 has raised 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, 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..."**) Information on scale elasticities is also important in assessing the likelihood of future consolidations into regional or national cable systems, 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 cable television economies of scale and scope, it has received scant research attention.#

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* In Community Communications Co. v. City of Boulder, ___ U.S. ___ (1981); (1981-2) Trade Cas., P 64,300, Sept. 22, 1981, (previously also 630 F2d 704 (10th Cir. 1980) (Boulder I), 485 F. Supp. 1035 (D. Colo. 1980)), recently decided by the U.S. Supreme Court, the city's moratorium on expansion had been challenged by the local cable company. "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..." Yet the factual issue is hotly disputed, as a dissenting judge notes: "the city's sole defense is to pretend disingeniously and contrary to the extensive, uncontradicted testimony and the findings of the trial judge, ...that cable television is a natural monopoly."

** (Greater Fremont, Inc. v. City of Fremont, 302 F.Supp. 652 (N.D. Ohio 1968).

*** An example for the present ad hoc approach to this question is the cable plan for New York City. In that two-volume report, which recommends several franchise areas, the entire analysis of economies of scale consists of the following non-sequitur: "...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.

****If average costs fall continuously, marginal costs are below average cost, and at a non-discriminatory price P = MC, a cable company will operate at a loss. (Scherer 1980). If prices are regulated at a uniform level P = AC, there are no losses, but allocative inefficiency exists, since some consumers are left without service who would have been willing to pay above marginal cost. A set of discriminatory prices is therefore most likely.

Examples for research on scale exist for other industries; in particular, for electric generation, Christensen and Greene (1976), Gollop and Roberts (1981), Nerlove (1968), Belinfante (1978), Dhrymes and Kurz (1964). For telephone service, the controversy over the nature of telecommunications has sparked studies in the U.S. and Canada, indluding Vinod (1972); Sudit (1973); Dobell et. al.

(footnote continued)

II. The Model.

Consider the multi-product cost function of firm i

(1) $$C_i = f_i \, (P_1 \ldots P_n ; \, Q_1 \ldots Q_q ; \, M_m)$$

where C_i are total costs of production, Q_q is the output vector, P_i are the prices for input factors i, assumed to be independent of output of the system, and M_m are a set of other variables that may affect cost. Under the assumption of cost-minimization, we have from Shepherd's lemma an identity of the cost-price elasticities E_{CP_i} 1 with the share of each input factor in total cost, i.e.,

(2) $$S_i \equiv \frac{P_i X_i}{C} = \frac{\partial \ln C}{\partial \ln P_i} = E_{CPi}$$

where X_i is the quantity of input i.

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. Thus, one can substitute the Box-Cox metric

(3) $$g_i(Q_q) = \frac{Q_q^w - 1}{w}$$

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

(4) $$\ln C \, (P_i, Q_q, M_m) = a_0 + \sum_i a_i \ln P_i + \sum_q a_q \left(\frac{Q_q^w - 1}{w}\right) + \sum_m a_m \ln M_k + \frac{1}{2}\sum_i\sum_j a_{ij} \ln P_i \ln P_j$$
$$+ \frac{1}{2}\sum_q\sum_p a_{qp} \left(\frac{Q_q^w - 1}{w}\right) \left(\frac{Q_p^w - 1}{w}\right) + \frac{1}{2}\sum_m\sum_n (\ln M)^2 + \sum_i\sum_q a_{iq} \ln P_i \left(\frac{Q_q^w - 1}{w}\right) + \sum_i\sum_m a_{im} \ln P_i \ln M$$
$$+ \sum_m\sum_q a_{qm} \left(\frac{Q_q^w - 1}{w}\right) \ln M$$

and Willig (1982)

(11) $$E_{Sq} = \frac{IC_q}{Q_q \frac{\partial C}{\partial Qq}}$$

where IC_q are the incremental costs of producing product q. This incremental cost is described by

(12) $$ICq = C(Q_1, \ldots Q_N) - C(Q_1 \ldots Q_{q-1}, 0, Q_{q+1} \ldots Q_N)$$

This elasticity can be rewritten as

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

For the hybrid translog function, sample mean values are $P_i = Q_q = M = 1$; thus the cost functions simplify to

(14) $$C(Q_1 \ldots Q_N) = \exp(a_o)$$

(15) $$C(Q_1 \ldots Q_{q-1}, 0, Q_{q+1} \ldots Q_N)^* = \exp\left(a_o - \frac{a_q}{w} + \frac{a_{qq}}{2w^2}\right)$$

so that equation (13) for the product-specific economies of scale becomes

(16) $$E_{Sq} = \frac{\exp(a_o) - \exp\left(a_o - \frac{a_q}{w} + \frac{a_{qq}}{2w^2}\right)}{\exp(a_o) \cdot a_q}$$

The degree of overall economies of scope is the proportion of the total cost of joint production that is saved by joint production (Bailey 1982)

(17) $$S_C = \frac{\left(\sum_q^N C_q(Q_q)\right) - C(Q_1 \ldots Q_N)}{C(Q_1 \ldots Q_N)}$$

* Without the hybrid specification, an equation of type (15) could not be numerically expressed in translog form.

The model for estimation is the multivariate regression system comprising the cost function (4), the behavioral equations (2) and (5) - (7), and the restrictions (8) and (9). The form of estimation that is used to determine this system follows Zellner's (1962) iterative method.*

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* In estimating such a system, it is generally assumed that disturbances in each of the share equations are additive, and that they have a joint normal distribution. These assumptions are made here too. The parameter w is found by minimizing the residual sum of squares $\sigma^2(w)$. Madalla, 1977, p. 315.

Inputs*

The factor quantity is the number of full time employees (with part-timers added at half value); its cost is the average salary of employees.

Accounting data for different classes of capital 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.**

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* 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.

** In that report, the required investment flow in a medium-sized cable system over a period of ten years was calculated. The study looks into hundreds of items of equipment, different techniques for laying cable, etc. Its use here is for the relative distribution of capital investments over time. Weinberg (1972), p. 128. We assume that this time distribution of investment over the first ten years holds proportionally for all systems, with investment in the 11th year and further years identical to that of the 10th year in real terms, and that the cost of acquiring capital assets required in a cable system increases at the rate of a weighted index of communications and utilities equipment. The formula employed is: Current Value = Book Value x T_M; where T_M is the adjustment factor

$$T_M = \frac{\sum_{i=0}^{M} T_i}{\sum_{i=0}^{M} E_i \quad / \; R_S + i}$$

with M = age (in years) of system; I = annual capital investment for a cable operator in year i; R = inflation adjustment factor for years S+i of cable

(footnote continued)

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 (Moody's 1981). 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.*

Tax rate t is defined as the corporate income tax rate (federal and state). Debt is defined as long term liabilities.

The third production factor of the model is the input of programming. A cable system that carries no communciations 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, i.e. outlays for program services, and indirect costs, i.e., foregone net earnings from advertising.#

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* Such models exist since 1966 (Horrigan), and have been refined by Pogue and Saldofsky (1969), Pinches and Mingo (1973, 1975) and Altman and Katz (1976). 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 ≥ 9) to C (≤ 1) can then be obtained for each observation point by substitution of the appropriate financial values. Bond rates are those reported by Moody's (1981). 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% above prime); for the next higher ratings, interest rates were reduced proportionally until the reported ratings were reached.

** Usually restricted to a studio for a low budget public-access channel, and of an automated news/weather display.

\# 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 for the supply of the program. Direct costs are reported to the FCC and are available. Included are also ment and cost to carriers. The indirect cost of forgone advertising revenue is defined as the potential minus the actual advertising revenue obtained by cable

(footnote continued)

Outputs

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 also very rare at present. Advertisements, simularly, are largely supplied by program providers as part of an exchange arrangement. Subscriptions are cable operators' predominant revenue-producing source. Hence, the number of actual and potential subscribers is the measure of the operator's outputs.

Cable television operators' major outputs are then defined along the following dimensions: (a) basic service subscriptions; (b) pay-TV service subscriptions; and (c) the number of potential subscribers that are reached, measured by the number of "homes passed." The larger this number, the more subscribers can be potentially enrolled.*

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.

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* Owen and Greenhalgh (1982) simularly use "homes passed" as an output measure.

IV. Results

Table 1 represents the parameter estimates for the multiproduct specification. for the multiproduct specification, for the year 1981.

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 seperately.

Overall elasticity of scale is calculated, using equ. (10), as E_S = 1.096. That is, a 10% increase in size is associated with a unit cost decrease of about 1%. Thus we find economies of scale, but they are moderate in size, and correspondant in that magnitude to those observed in telephone distribution.

E_S (Homes Passed) = 1.020

E_S (Basic Subscriptions) = 1.054

E_S (Pay Subscriptions) = 1.072

Economies of scale are thus observed for three outputs: basic and pay subscriptions and channel capacity. For "Homes Passed," these are relatively small; it may be recalled that this output description refers to a physical measure, namely the extent of the cable network in accessing a market.*

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* The definition of output-specific economies of scale is particularly important in the analysis of an industry with the technological characteristics of cable television, where outputs are not necessarily changed along a ray, i.e., by equal proportions. For example, if two cable companies serve an area that has previously been served by only one firm, their technical outputs "homes passed" and "channels provided" are, let us assume, as large for each separate firm as they had been for the monopolist. However, their outputs "basic subscribers" and "pay subscribers" are smaller than before, since they now share the market. Multi-firm rivalry would normally not be sustainable if product-specific economies of scale for these products existed over the range of production of the other outputs.

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

A look at the other control variables is interesting, too. Here, we can observe the elasticity for density (trunk length/homes passed) to have a value of a (D) = .19, with a good statistical significance. 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 highly dense city franchise areas costs increase again.

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.

V. Conclusion

This study of the U.S. cable industry, using 1981 data for the more than 4,800 American cable companies, shows that economies of scale exist in the current range of production, though they are of moderate size. Fairly small returns to scale are observed for the technical output measure "Homes Passed." This suggests that the cost advantages of size are not derived primarily by the technology-based transmission characteristics. Furthermore, the results show economies of scope to exist, pointing to the integration of transmission and subscription-generation function as a major source of economies.

assures a head start and thus the advantages 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 the 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 non-transmission 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

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* For example, a study commissioned by the National Cable Television Association found that an above average proportion of customers of both subscription (i.e., pay) television (STV) and of cable television remain with the previous system after the introduction of a new one. (Browne, Bortz, and Coddington 1982).

Table 1

Cost Function Parameters

Output Definition: Multiproduct

Parameter	Coefficient
a(P1)(Qa)	0.0814 (0.9600)
a(P1)(Qb)	0.2438 (2.8283)
a(p1)(Qc)	0.0094 (0.2667)
a(P1)(D)	0.1481 (1.7573)
a(P1)(E)	-0.4059 (3.8088)
a(P1)(M)	-0.0478 (0.9377)
a(P2)(SQ)	0.4082 (12.4739)
a(P2)(P3)	-0.9922 (13.4510)
a(P2)(Qa)	-0.2334 (2.1867)
a(P2)(Qb)	0.4235 (3.7497)
a(P2)(Qc)	0.7728 (12.0940)
a(P2)(D)	-0.2435 (2.2640)
a(P2)(E)	-0.5717 (3.8874)

Parameter	Coefficient
a(0)	-0.4295 (21.0098)
a(P1)	0.3349 (12.4595)
a(P2)	0.3417 (10.2453)
a(P3)	0.3233 (7.6582)
a(Qa)	0.2920 (4.1001)
a(Qb)	0.1211 (1.5862)
a(Qc)	0.4987 (13.5994)
a(D)	0.1927 (2.4782)
a(E)	0.4407 (6.1587)
a(M)	-0.0092 (2.0556)
a(P1)(SQ)	0.0192 (1.2457)
a(P1)(P2)	0.1757 (4.5319)
a(P1)(P3)	-0.2142 (5.1888)

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