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PRIVATE SECTOR MONOPOLIES: THE CASE OF CABLE TELEVISION FRANCHISES

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For many years, the economic discussion of the relation between market structure and productivity has been characterized by two points of view. On the one side are what may be termed the "competitive structuralists," that is, those who believe that noncompetitive market structure has a direct and negative impact on performance, be it through monopolistic and oligopolistic misallocations ("y inefficiencies") or through simple operational inefficiencies where competitive pressures are weak ("x inefficiencies"). A different view is taken by some institutionalist and political economists, in particular by followers of Joseph Schumpeter. They, too, argue that market structure makes a difference, but they see large or oligopolistic firms as a main agent for innovation.

> What we have got to accept is that [the large firm] has come to be the most powerful engine of [economic] progress. . . . In this respect,

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perfect competition is not only impossible but inferior, and has no title to being set upon a model of ideal efficiency [Schumpeter, 1950: 106].

In this view, productivity improvements usually require internal rearrangement of the production process, new management techniques, capital outlays, and labor reallocation and training. These tasks may well be most effectively undertaken by enterprises that benefit from economies of scale, have large resources at their disposal, and can hedge risks through diversification.

The empirical evidence for a relation between market structure and productivity is ambiguous. Early research was contradictory (for example, see Stigler, 1956; Phillips, 1956; Weiss, 1963; Allen, 1969). A good number of studies have pursued this question, primarily through investigations of patent grants and R&D expenditures of firms of different sizes, or of their adoption of new production techniques.[1]

Typically, such studies are highly aggregated on the industry level, and are estimated across different industries, comparing concentration indices with dependent variables such as productivity; such procedure is usually chosen because it is difficult to find different concentration ratios for the same industry. Yet industries vary widely, and their comparison is problematic. For example, an important role in productivity change is played by the presence of basic knowledge ready for application, referred to as "technological opportunity" (Phillips, 1971), which varies from industry to industry. One way to escape the problem of comparison is to use the same industry across different countries; but this only raises new problems.

This study, on the other hand, proposes to proceed by concentrating on one industry, and in one country only. It proceeds in a very different fashion from the research mentioned above, in that it looks at the rate of productivity increase within an industry that is, interestingly enough, characterized by thousands of local monopolies. Furthermore, a large number of new entries occur, making it possible to determine the trend of state-of-the-art technology.

The results of the investigation can yield potentially interesting conclusions; first, they shed light on the cable television industry itself — an industry of much public policy importance — and, second, they illuminate the relation of productivity and monopoly in general.

Methodologically, the objective of this chapter is to find and measure the rate of technical progress in the operations of already existing — and locally monopolistic — cable television companies, and to contrast this *internal* rate of innovation with the *external* rate of

change in the "state-of-the-art" or "best-practice" technology. Technical progress is described, in the way used by economists, as those shifts in the production function over time that are unexplained by changes in factor inputs (Solow, 1957). These shifts, reflecting the productivity increase of firms over time, are decomposed in this chapter into three components:

(a) the effects of the "vintage" of technology, that is, of the age of the technology;
(b) the effects of maturity in operation, that is, of "learning by doing";[2] and
(c) the effect of economies of scale.

In including these three factors the study goes beyond other writings that do not distinguish among them, specifically not between vintage and maturity. This is a methodological contribution of this chapter. Empirically, it adds to the analysis of an industry whose importance — and list of unsettled regulatory questions — is growing, yet whose production characteristics have received only scant statistical attention (Babe, 1975; Owen, 1982). In providing some empirical evidence, this study can rely on data for nearly 5000 U.S. cable television systems.

BACKGROUND TO THE PRODUCTIVITY ISSUE IN CABLE TELEVISION

While the substantial communications potential of cable television is well known, it is less recognized that the locally monopolistic industry structure of the medium may lead to its suboptimal development. This danger has been commented upon for the issue of product diversity, which may be lessened by the operator's gatekeeper control over programming (Sloan Commission, 1971; Cabinet Committee on Cable Communications, 1974). Far less attention has been given to the issues of productivity and innovation. The rapid development of cable television technology has been far from uniform in its diffusion.

> A pattern is emerging in cable television service across the United States. Large companies that own cable systems, eager to win franchises in unwired cities, are quite willing to spend hundreds of millions of dollars to build modern systems. At the same time, they give much lower priority to rebuilding their older systems in areas where there are no competitive reasons to offer the more lavish services. . . .

> In Queens, for example, Teleprompter . . . is proposing 107 channels. . . . In Manhattan, by contrast, Teleprompter offers . . . only 26 channels.
>
> The rates in the new systems, also born in a competitive atmosphere, are far lower than those in New York. The same ATC that charges $11.75 a month in Manhattan for 26 channels is proposing a rate of $3.75 a month for 50 channels in Denver [New York Times, November 8, 1982: B-1, 29].

The root causes for such discrepancy may be sought in the structure of the industry. The cable television industry consists of a series of parallel local monopolies, each de facto based on the award of a local operating franchise. In a monopolistic situation, profit maximization does not necessarily lead to adoption of a "best-practice" technology, even if such would be economically feasible under competitive conditions. For example, the upgrading of channel capacity by the use of more sophisticated converters and the like may not be undertaken, because it would primarily *divert* viewers from already-existing program channels rather than *generate* new viewers; therefore, a monopolist in the supply of cable program channels normally has incentives to supply less than the competitive capacity.[3] Within each franchise area, the licensed company is, for all practical purposes, in control over the technical innovation of the transmission system. While it is true that the cable operator is bound by the terms of a local franchise contract, and has an incentive not to lose the franchise for lack of innovation, such loss has not occurred outside a handful of tiny localities:

> Where cities have tried to spur competition during re-franchising by inviting competitive bidding, they have been unable to inspire even a nibble of interest from any companies other than the incumbent operator. City officials contend that operators are reluctant to enter an already franchised area for fear that the same will happen to them on what they consider their turf. Operators accuse cities of using competitive bidding only as a ploy to get better service from an incumbent [Stoller, 1982: 36].[4]

In many instances city officials are uninformed about the available technology set:

> If you start the refranchising process by asking officials what they want that they don't already have, you'll probably find that most of them don't have the slightest idea what is available. . . . So far, there has been a lot of talk about rebuilds, but not a lot done [Tony Hoffman, a security analyst at A. G. Becker, as quoted in Rothbard, 1982: 22].

The more general question that such observations raise is the extent to which available innovation is adopted in a locally monopolistic setting. Because of its present institutional peculiarities, cable television provides an unusual opportunity to observe and contrast both the competitive and the monopolistic adoption of innovation within the same industry. Cable system operators usually pass through an intensely competitive phase at the beginning of their operation, when they vie with other companies in attempting to gain the local franchise. The normal franchising procedures call for applicant firms to present the merits of their systems; by the nature of the intensive bidding process that ensues, companies compete in the technology that is offered as well as in its cost-effectiveness, since the proposed rates are part of the bid.[5] After a franchise has been awarded, however, there is little competitive pressure for the operating company to upgrade a system according to the subsequent technological development.[6] This is not to say that there are no improvements; but they will be motivated by considerations other than the presence of intraindustry competition. Therefore, there is no reason to assume that established cable systems will necessarily keep up their internal improvements with the external rate of change in the industry.

Empirically, there are special advantages of analyzing the cable television industry:

(a) It consists of several thousand firms, all essentially operating in a local one-plant production mode, and all reporting data according to a uniform system.
(b) Each year brings the entry of hundreds of new systems, an unusual opportunity to observe the trend of new vintages.
(c) The technology is nearly entirely nonproprietary to the operators, and is generally available to all operating companies. Virtually no vertical integration into the manufacture of capital equipment exists.

THE MODEL

Three different causes for shifts in productivity are normally left unseparated: first, the internal improvements in operations, which is

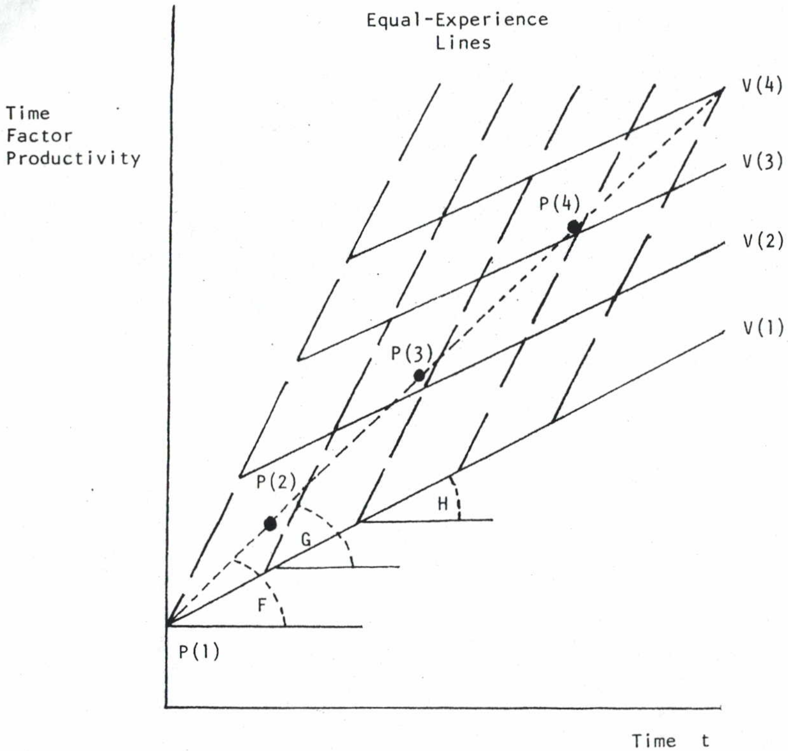

FIGURE 8.1

here termed the "maturity effect" of a system; second, the technical progress external to the system, termed the "vintage effect"; and third, the economies of scale that may result from expansion. To illlustrate the first two factors: In Figure 8.1, time is mapped on the abscissa, together with that period's output relative to inputs (total factor productivity). Observations made at time t(1), t(2), and so on then show points such as P(1), P(2) and so on, and an apparent productivity trend F. However, the underlying reality may in fact be more complex; internal productivity improvements of firms may increase at the rate of the slopes of the lines V(1), where each line corresponds to the maturity trend of a given vintage of technology. At the same time, technical progress raises each year's vintage productivity from V(i) to V(i+1). Hence the trend line F is in fact a

combination of the two rates of technical progress, that of movement along a function and that of a shift of the function itself. The slopes G of the lines connecting the "equal-maturity" points of different vintages reflect the rate of external technical progress, while the slopes H are the trend of the experience gains for a given vintage.

To this analysis one must add the factor of scale economy. To the extent that cable operations grow as time passes, they reap potentially existing economies of scale (Noam, 1983a, 1983b), apart from the effects of any technical progress.

Past research on the productivity of other industries has allowed for scale economies (Dhrymes and Kurz, 1964; Christensen and Green, 1976; Denny et al., 1982; Nadiri and Schankerman, 1981; Gollop and Roberts, 1981). But they do not distinguish between the vintage[7] and maturity[8] rats of productivity increase.

We now formalize the model, using a multiproduct setting. Consider the production of m outputs using n inputs. The cost function, uniquely corresponding to the production function under the assumption of duality theory, is at each time t

$$C(t) = f[P(1_t) \ldots P(n_t);\ Q(1_t) \ldots Q(m_t);\ V(s);\ M(t);\ K] \qquad [1]$$

where C(t) is total costs of production; $P(i_t)$ is the prices for the factors of production i, given exogenously; $Q(j_t)$ is the output quantities for the different products of a multiproduct firm; V(i) is the vintage of the plant; and M(t) is the plant's maturity at the time t; and K is other factors that may affect cost of production. The partial logarithmic derivatives of cost with respect to input prices, output quantities, vintage, and maturity are the partical elasticities E with respect to these variables. The total change in cost of equation 3 can then be expressd as composed of the contributions of price and quantity changes and of vintage and maturity effects.

Furthermore, a cost-minimizing behavior by the firm is assumed. Using Shepard's lemma, the cost-price elasticities are then equal to the share of each input factor in total cost, that is,

$$S_i \equiv \frac{P_i X_i}{C} = \frac{\partial \ell n C}{\partial \ell n P_i} = E_{CP_i} \qquad [2]$$

where X_i is the quantity of input i, P_i is the price, and C is total costs. The estimation of these cost-share equations jointly with the cost function increases the degrees of freedom and the statistical weight of an empirical estimation.

For the purposes of estimation, let the cost function f be given by the translog cost function, a second-order logarithmic approximation to an arbitrary twice-differentiable transformation surface (Griliches and Ringstad, 1971; Christensen et al., 1973). The general translog function imposes no restrictions on production such as homogeneity, homotheticity, or unitary elasticities of substitution, and is hence covenient for the testing for the existence of these properties.[9]

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 funcational form that is well behaved. As pointed out be Caves et al. (1980), the use of the log metric for outputs in the generalized translog function is unnecessary for a homogeneity of degree one in factor prices, a condition that is usually imposed. Instead, one can substitute the Box-Cox metric

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

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

$$\ell nC(P_i, Q_q, M, V, K_k) = a_0 + \sum_i a_i \ell nP_i + \sum_q a_q \frac{Q_q^w - 1}{w} + a_v \ell nV \qquad [4]$$

$$+ a_m \ell nM + \sum_k a_k \ell nK_k + \frac{1}{2} \sum_i \sum_j a_{ij} \ell nP_i \ell nP_j$$

$$+ \frac{1}{2} \sum_q \sum_p a_{qp} \frac{Q_q^w - 1}{w} \frac{Q_p^w - 1}{w} + \frac{1}{2} a_{vv} (\ell nV)^2 + \frac{1}{2} a_{mm} (\ell nM)^2$$

$$+ \frac{1}{2} \sum_k \sum_\ell a_{k\ell} \ell nK_k \ell nK_\ell + \sum_i \sum_q a_{qi} \ell nP_i \frac{Q_q^w - 1}{w} + \sum_i a_{iv} \ell nP_i \ell nV$$

$$+ \sum_i a_{im} \ell nP_i \ell nM + \sum_i \sum_k a_{ik} \ell nP_i \ell nK_k + \sum_q a_{qm} \frac{Q_q^w - 1}{w} \ell nM$$

$$+ \sum_q \sum_k a_{qk} \frac{Q_q^w - 1}{w} \ell nK_k + a_{vm} \ell nV \ell nM + \sum_k a_{vk} \ell nV \ell nK_k$$

$$+ \sum a_{mk} \ell nM \ell nK$$

The partial elasticities of total cost are then the logarithmic partial derivatives,

$$E_{CPi} = a_i + \sum_j a_{ij} \ell nP_j + \sum_q a_{iq} \frac{Q_q^w - 1}{w} + a_{im} \ell nM \qquad [5]$$

$$+ a_{iv} \ell nV + \sum_k a_{ik} \ell nK$$

$$E_{CQq} = Q_q^w \; a_q + \sum_p a_{qp} \frac{Q_p^w - 1}{w} + \sum_i a_{iq} \ell nP_i + a_{qm} \ell nM \qquad [6]$$

$$+ a_{qv} \ell nV + \sum_k a_{qk} \ell nK$$

$$E_{CM} = a_m + a_{mm} \ell nM + \sum_i a_{im} \ell nP_i + \sum_q a_{qm} \frac{Q_q^w - 1}{w} + a_{vm} \ell nV \qquad [7]$$

$$+ \sum_k a_{mk} \ell nK$$

$$E_{CV} = a_v + a_{vv} \ell nV + \sum_i a_{iv} \ell nP_i + \sum_q a_{qv} \frac{Q_q^w - 1}{w} + a_{mv} \ell nM \qquad [8]$$

$$+ \sum_k a_{vk} \ell nK$$

$$E_{CKk} = a_k + a_{kk}\ell nK + \sum_i a_{ik}\ell nP_i + \sum_q a_{qk}\frac{Q_q^w - 1}{w} + a_{mk}\ell nM + a_{vk}\ell nV \quad [9]$$

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

$$\sum_i a_i = 1;\ \sum_i a_{ij} = \sum_i a_{iq} = \sum_i a_{im} = \sum_i a_{iv} = \sum_i a_{ik} = 0 \quad [10]$$

Furthermore, the cross partial derivatives of the translog cost function must be equal, by its second order approximation property, that is, the symmetry condition exists

$$a_{ij} = a_{ji} \text{ and } a_{qp} = a_{pq}, \text{ where } i \neq j,\ p \neq q \quad [11]$$

The cost function is homothetic if and only if it can be written as a separable function of factor prices and outputs (Shephard, 1970). The optimal factor share combination is then independent of output, that is, the expasnsion path is linear. From equation 5, it then must be

$$a_{iq} = 0 \quad [12]$$

which imposes n – 1 independent restriction, where n is the number of inputs i. Furthermore, the function is homogeneous at the sample mean if overall cost elasticity with respect to output is constant, that is, if the conditions hold.[10]

$$a_{qp} = a_{iq} = a_{qm} = a_{qv} = a_{qk} = w = 0 \quad [13]$$

Economies of scale must be evaluated along output rather than along input-mix, since the relative composition of inputs may change over the range of output. Only when the cost function is homothetic will the two be identical (Hanoch, 1975). The implication is that scale

economies are better described by the relation of cost to changes in output rather than by that of outputs to changes in inputs, which makes a cost function an advantageous specification.

Following Frisch (1965), the cost elasticity with respect to output E is the reciprocal of scale elasticity E. For the multiproduct case, local overall scale economies, as shown by Fuss and Waverman (1982), are

$$E_s = \frac{1}{\sum_q E_{CQq}} \quad [14]$$

Product-specific economies of scale are, using the definition in Baumol et al. (1972),

$$E_{sq} = \frac{IC_q}{Q_q \frac{\partial C}{\partial Q_q}} \quad [15]$$

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

$$IC_q = C(Q_1, \ldots Q_N) - C(Q_1, \ldots Q_{q-1}, 0, Q_{q+1} \ldots Q_N) \quad [16]$$

This elasticity can be written as

$$E_{sq} = \frac{IC_q}{C} / E_{CQq} \quad [17]$$

For the hybrid translog function, sample mean values are P = Q = M = V = K = 1; thus the cost functions simplify to

$$C(Q \ldots Q_N) = \exp(a_0) \quad [18]$$

$$C(Q \ldots Q_{q-1}, 0, Q_{q+1} \ldots Q_N) = \exp\left(a_0 - \frac{a_q}{w} + \frac{a_{qq}}{2w^2}\right) \quad [19]$$

so that equation 19[11] for the product-specific economies of scale becomes

$$E_{sq} = \frac{\exp(a_0) - \exp\left(a_0 - \frac{a_q}{w} + \frac{a_{qq}}{2w^2}\right)}{\exp(a_0) \cdot a_q} \quad [20]$$

The form of estimation that is used to determine this multiequation system is Zellner's (1962) iterative method for seemingly unrelated regressions. This technique is a form of generalized least squares, shown to yield maximum likelihood estimates 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 equation and the cost equation are additive, and that they have a joint normal distribution. These assumptions are made here too.[12]

DATA

The empirical estimation of this study is based on an unusually good body of data for several thousand cable television systems, all producing essentially the same service,[13] 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.[14]

The data cover virtually all 5000 U.S. cable systems, and are composed of four disparate and extensive files for each of the years 1976-1981 for technical and programming, financial, local community, and employment information.[15] The financial data include both balance sheet and income information.[16]

All variables are standardized around the sample mean in order to overcome the problem of arbitrary scaling that can become an issue in translog function.[17] Furthermore, the nonnormalized variables and a nonnormalized alternative definition of labor (total hours) are used to test for the robustness of the results of scaling.

LABOR 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.

CAPITAL INPUTS

Accounting data for different classes of assets are 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. In that report, the required investment flow in a medium-sized cable system over a period of ten years was calculated. (Weinberg, 1972: 128). We assume that (a) this distribution of investment over the first ten years is proportionally the same for all systems; (b) investment in the eleventh and further years is identical to that of the tenth year; and (c) 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.[19] 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 deductibility of interest expenses (tax rate = w).

$$P_k = r_E \cdot \frac{E}{k} + r_D(1 - w)\frac{D}{k} \quad [21]$$

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 (Sharpe, 1964; Lintner, 1965), 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 is listed by Moody's (1981) and can be used to calculate the risk premium 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 (Moody's, 1981). This procedure is novel but is based on previous study in the finance literature of bond ratings and their relation to financial ratios.[20]

Tax-free 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,[21] programming is supplied by broadcasters and program networks.[22] 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 total programming; indirect costs that must also be considered are the forgone earning 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 that of forgone 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 forgone advertising revenue is defined as the potential minus the actual advertising revenue obtained by cable operators. Actual figures are reported to the FCC; potential revenues are estimated by reference to the average advertising revenue in television broadcasting per household and viewing time.[23] The unit price of programming

inputs is their total divided by the number of program hours and channels.

It is one of the convenient properties of cable television that is uses very little in inputs beyond those of capital, labor, and programming. It does not use raw materials or intermediate inputs to speak of, apart from programming. Even its energy requirements are quite small, in the order of .7 percent of total expenses, if capital expenses are included (Weinberg, 1972: Tables C-1, C-2). Office supplies, telephone, postage, insurance, and so on add another 1.8 percent of costs that include capital inputs. For consistent treatment of inputs and outputs, this small residual input is added to the inputs K, L, and P; since one cannot determine for what the residual input is a substitute, we prorate it to K, L, and P.

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. Hence the numbers of actual and potential subscribers — as opposed to their viewing — are 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 number of *potential* subscribers that are reached. The latter is reflected by the number of "homes passed." The larger this number, the more subscribers can potentially be enrolled.

VINTAGE

Vintage is defined according to the year in which the cable operator commenced transmission, expressed by that year divided by the sample mean. Most cable systems, particularly those of medium or large size, have started operation in the past 15 years.

MATURITY

To estimate the maturity effect, that is, the productivity gains due to operational experience — holding equal for vintage and scale economies — for each observation maturity is defined as the time lapsed since the commencement of operations. For each observation, there are therefore one vintage value and a series of maturity observations.

TECHNICAL VARIABLES

Two other variables are introduced in order to adjust for differences in the cable systems that may affect costs of production and ability to attract subscriptions. First, 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.[24] 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 second variable is the number of video channels offered by a cable operator. Clearly, the more channels offered, the more inputs 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

The three-stage estimation of the model yields statistically strong results; system R^2 is .9610. Most of the parameter estimates have very high t values and are significant at the .01 level, particularly the first-order terms and their squares.

We first look at the economies of scale in the system. Using equation 14, we find an overall elasticity of scale of E = 1.0728. This means that cost increase is proportionally less than that of output, and that the relative cost decrease is in the range of 7 percent for each doubling of output.

We next look at the effects of maturity in operation on cost. Here we find at the sample mean a coefficient of −.2827; that is, cost decreases fairly pronouncedly with experience in operation — holding everything else equal. Cable systems seem to reduce costs as they mature, gain experience, and absorb innovations.

However, these internal productivity increases are considerably smaller than those due to the *external* changes in technology. Isolating the vintage effect, we find a coefficient of −.9223, indicating a very substantial cost reduction that accompanies the introduction of new vintages of cable technology.

A look at the control variables is interesting, too. Here we can observe the coefficient for density to have a value of a(D) = .0897,

TABLE 8.1 Regression Coefficients of Cable Television Cost Function

Variable	*Parameter Estimate*	*t Ratio*
a(0)	−0.3531	(16.5549)
a(P1)	0.2944	(19.2708)
a(P2)	0.3937	(33.6621)
a(P3)	−0.3118	(5.8929)
a(Qa)	0.2587	(4.6172)
a(Qb)	0.0228	(4.3273)
a(Qc)	0.6506	(32.3799)
a(D)	0.0897	(2.0221)
a(E)	0.0978	(3.5970)
a(V)	−0.9223	(4.0401)
a(M)	−0.2827	(4.3183)
a(P1) (P1)	0.0305	(3.7581)
a(P1) (P2)	0.1916	(9.0650)
a(P1) (P3)	−0.2527	(12.3445)
a(P1) (Qa)	0.3394	(7.6900)
a(P1) (Qb)	−0.1049	(2.3791)
a(P1) (Qc)	0.0617	(4.4189)
a(P1) (D)	0.1841	(4.3476)
a(P1) (E)	−0.2295	(5.1174)
a(P1) (V)	1.9556	(4.0270)
a(P1) (M)	0.2229	(3.1701)
a(P2) (P2)	0.3241	(20.8342)
a(P2) (P3)	−0.8400	(26.2213)
a(P2) (Qa)	−0.0776	(1.5564)
a(P2) (Qb)	0.4071	(7.7252)
a(P2) (Qc)	0.5099	(22.7455)
a(P2) (D)	−0.1828	(3.1995)
a(P2) (E)	−0.9596	(13.9032)
a(P2) (V)	−5.2167	(8.3702)
a(P2) (M)	−0.6017	(6.5762)
a(P3) (P3)	0.5464	(25.8846)
a(P3) (Qa)	−0.2618	(4.8682)
a(P3) (Qb)	−0.3021	(5.5893)
a(P3) (Qc)	−0.5717	(21.1098)
a(P3) (D)	−0.0012	(0.0196)
a(P3) (E)	1.1891	(15.7176)
a(P3) (V)	3.2611	(5.1043)
a(P3) (M)	0.3787	(4.3185)
a(Qa) (Qa)	−0.0909	(2.1082)
a(Qa) (Qb)	0.3126	(3.8775)
a(Qa) (Qc)	0.0532	(1.4516)
a(Qa) (D)	−0.2617	(3.3656)
a(Qa) (E)	−0.9160	(6.3550)
a(Qa) (V)	−0.4586	(0.3587)

(continued)

TABLE 8.1 Continued

Variable	*Parameter Estimate*	*t Ratio*
a(Qa) (M)	−0.0822	(0.4751)
a(Qb) (Qb)	−0.0634	(1.3644)
a(Qb) (Qc)	0.1121	(3.1282)
a(Qb) (D)	0.1813	(2.0675)
a(Qb) (E)	0.2354	(1.6430)
a(Qb) (V)	0.6078	(0.4725)
a(Qb) (M)	0.0738	(0.4187)
a(Qc) (Qc)	0.2070	(21.9804)
a(Qc) (D)	0.0749	(1.8272)
a(Qc) (E)	−0.6012	(12.3100)
a(Qc) (V)	−2.0652	(4.7361)
a(Qc) (M)	−0.2051	(3.3710)
a(DD)	−0.0951	(1.8131)
a(DE)	0.0115	(0.0900)
a(DV)	−7.0066	(5.2132)
a(DM)	−1.0726	(4.7507)
a(EE)	0.8912	(9.1418)
a(EV)	−1.9036	(1.1501)
a(EM)	0.1087	(0.4030)
a(VV)	0.1658	(5.4133)
a(VM)	1.5182	(4.7460)
a(MM)	0.5853	(3.7343)
R^2	.9610	

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 conform to the observation that in highly dense inner-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.

What do these results suggest? They show productivity increases —defined as reductions in production cost that are not due to changes in input cost — resulting from economies of scale, vintage, and maturity. This, of course, is not surprising. However, the relative contribution of these factors to production cost reduction is very interesting. The effect of economies of scale is relatively small. Operating experience, that is, "internal" innovation, on the other hand,

has a much larger effect. And by far the largest contribution is made by the "external" development of the technology, as expressed by the contribution of new vintages to cost reduction.

Some differential between internal and external contributions to cost reduction, of course, could be expected. Adapting an existing technology is likely to be more costly and slower than starting with a brand new technology. But when the rates of cost decrease are as far apart as we find them to be, it is a strong indicator that more than these usual adjustment issues are at hand. Clearly, if cable systems were to compete head on, a cost differential as large as we observe would all but assure that the older systems would be driven off the market, unless they can *maintain* a vast difference in scale, and unless they have been operating for a very substantial time.

Other than in those unusual circumstances, then, a competitive situation would not permit a firm with the slower "internal" rate of cost reduction to survive entry in the face of the rapid change in technology. But, of course, they *do* survive in the real world. One reason is that no head-on competition exists, outside of a very few instances of "overbuilds," because existing operators are not contested by competitive entry and are instead protected by legal barriers such as de facto franchise monopolies.

The existence of such a productivity trend differential therefore raises a challenge to public policy. It suggests, first, the need for a reduction of legal entry barriers as a way of removing a protection to inefficiency. Sluggish operators should be subject to challenge by new entrants with more advanced technology, so that they would gain incentives to innovate.

When such a contesting of an existing market does not materialize as a reality or reasonable possibility, regulatory policies may be called for to reduce the differential in productivity trends. Instruments of such a policy could be regulatory oversight, franchise contracts that have built-in innovation requirements, and refranchising conditions requiring upgrading.

Clearly, these changes are likely to be painful to the cable television industry. It is likely to point to its record of internal innovation. It is also likely to demonstrate the major capital requirements that must be part of such an upgrading, and argue that cable firms would then have to be permitted to abandon the redistributory aspects of their operations, such as universal service, public and government access channels, and undifferentiated subscription rates. However, these arguments disregard the fact that substantial capital investments are made today in new systems, which tend to be under at least as many redistributive requirements as old systems, and that these new systems are still low-cost producers relative to older systems.

For some time now, concern has been growing whether the communication revolution, of which cable television is an important part, would lead to the emergence of a class of "information poor," who would not be able to afford the new offerings (and lose some of the previously "free" ones), either for reasons of low income or because they live in remote or low-density areas. We can now add the concern of service differentials between newer and older systems. The former may have a great diversity of program types and program sources, spread over many dozens of channels, as well as interactive services such as videotex, home banking, home shopping, and burglar alarms. The older systems, at the same time, may have not much more than a dozen of one-way channels. Perversely, those communities that welcomed cable television first are likely to find themselves neglected in terms of system innovation, while those that took a long time to permit cable can enjoy the benefits of advanced systems. Of course, this scenario is painted in somewhat stark colors; but it points to a real danger.

The present study, through its statistical estimation of cost-reducing productivity increases, thus points to the need to reduce the gap between internal and external innovation through policies that lower entry barriers and encourage competition or through some regulatory mechanism. The aim of this chapter was to demonstrate the problem. The analysis of optimal public policy responses ought to be a subject for further work.

NOTES

1. Excellent reviews of the literature may be found in Nelson (1981), Kamien and Schwartz (1975), Scherer (1980), Mansfield (1968), Norris and Vaizey (1973), Weiss (1971), Johnston (1966), and Vernon (1972). A recent survey of empirical evidence is presented by Scherer (1984).

2. Maturity may include the internal adoption of innovation, and is a more descriptive term than "experience," which may assume a static technology.

3. This would hold true even when access onto cable is leased to outside program syndicators under a system of common carriage, unless regulation forces requirements for an upgrading of capacity, or unless perfect price discrimination for access is possible.

4. Cable operators usually have been astute in the refranchising. The major trade publication of the industry quotes good advice to its members: "Do it while it is

quiet. . . . Start your negotiations while the public eye is focused on other issues" (Rothbard, 1982).

5. It is of course possible that bids are nonoptimal in response to excessive local requirements. In most new franchising, however, bids are above the minimum requirements.

6. This may change some years from now as direct satellite broadcasting (DBS), multipoint distribution systems (MDS), subscription television (STV), and satellite master antenna systems (SMATV) become established. Cable operators, however, do not appear to be affected at present by potential competition. In an industry survey, 78 percent of operators responded in the negative to a question asking whether they thought that DBS would have an inhibiting effect on their growth (Multichannel News, April 26, 1982: 46).

7. In another line of inquiry, that of "vintage" capital models, capital has been held to embody technical progress, and has been disaggregated according to its age. Those models, very different from the present analysis, go back to the "embodied capital" hypothesis (Abramovitz, 1952; Solow, 1960; Salter, 1966; Solow et al., 1966; Dhrymes and Kurz, 1964). Another approach has been to measure inputs in quality-adjusted units (Denison, 1978; Griliches and Jorgenson, 1967).

8. Starting with Arrow (1962), research considered experience processes or "learning by doing" (Kaldor, 1962; Alchian, 1963; Rapping, 1965; Flaherty, 1981; Duchatelet, 1977, Boston Consulting Group, 1968).

9. Furthermore, as Diewert (1974) has demonstrated, a Divisia index of total factor productivity that is based on a translog function is exact rather than approximate.

10. This imposition of $w = 0$ leads to a general multiproduct cost function, and this is reasonable. For the concept of homogeneity to be meaningful, all output quantities must be able to vary, and none can be restriced to zero, obviating the need for the transform (3).

11. Without the hybrid specification, an equation of the type of equation 19 could not be expressed numerically in translog form.

12. The parameter w is found by minimizing the residual sum of $\sigma^2(w)$ (Madalla, 1977: 315).

13. Reporting is done according to local operations; national cable companies (multiple systems operators, or MSOs) must therefore report their different operations separately.

14. 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 actively seeking new franchises.

15. FCC, Cable Bureau, Physical System File; Community File; and Equal Employment Opportunity File.

16. To assure confidentially, 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 such categories of financial information — had been made available to the author specially.

17. On the statistical aspects of this scaling, which is widespread in translog estimations, see Denny and Fuss (1977).

18. All input prices are assumed to be independent of production level. Futhermore, input prices are not controlled by cable operators. 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.

19. The formula employed is as follows: current value = book value × T, where T is the adjustment factor.

20. Such models have existed since 1966 (see Horrigan, 1966), and have been refined by Pogue and Saldofsky (1969), Pinchas 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 as follows: (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 Investor Services (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 percent above prime); for the next higher ratings, interest rates were reduced proportionally until the reported ratings were reached.

21. These are usually restricted to a studio for a low-budget public-access channel, or an automated news/weather display.

22. It would be faulty to view the quantity of programs themselves as the outputs of a cable operator rather than as inputs. Neither are they produced by operators, as mentioned, nor are they sold on a quantity basis. Under the currently existing subscription-based system of revenue generation (as opposed to the embryonic pay-per-view system), programs serve as an incentive to buy subscriptions, not as the product itself.

23. This calculated by dividing total TV advertising billing (McCann-Erickson, as reported in Television Factbook, Inc., 1980: 76a) by a number of TV households (Arbitron, as reported in Television Factbook, Inc., 1980: 104a) and by viewing time. Nielsen figures for average weekly viewing of TV households is 42.6 hours; of cable households, 51.7 hours (Nielsen Cable Status Report, May 1981). TV advertising revenues per houshold viewing hours is found at close to 5.5 cents.

24. On the other hand, in dense inner-city operations, costs may go up, too, because cable must be buried underground. For the year of observation, however, only few inner-city franchises existed.

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