THE ECONOMIC VALUE OF THE SPECTRUM RESOURCE IN BROADCASTING AND LAND MOBILES

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Requisition No. 36100-7-0721
Contract No. OSU77-00338

The authors are with the Faculty of Administration and the Department of Economics, University of Ottawa

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FOREWORD

This report is a preliminary study of the economic value of the spectrum resource in broadcasting and land-mobiles. It is being submitted to the Department of Communications (DOC) in satisfaction of the terms of contract No. OSU 77-00338, as outlintd in DOC letter of January 24, 1978. As explained in the Introduction, we have concentrated our efforts on the two spectrum-using sectors of broadcasting and land-mobiles, since these two sectors account for most of the current "crowding" of the spectrum. We believe that for this pilot project these are the sectors that should absorb the bulk of the project's resources.

This report is organized in two parts. The first part is the main body of the report, containing an Introduction and a section each on Broadcasting and Land-mobiles. A list of references used in the report is also attached. The second part is a detailed literature review, covering most important works that have appeared on the subject in the recent past.

I Introduction

In this study we shall attempt to develop an economic theory of radio spectrum valuation and allocation, for use and eventual application by the Canadian Department of Communications (DOC). The radio spectrum is defined as a three-dimensional capability for transmitting information with electromagnetic energy. Hereafter spectrum is a range of radio waves utilized in communications, and its dimensions include frequency bandwidth, physical space and time.

Numerous studies in the U.S. and Canada (e.g. (3), (16), (24), etc.) have pointed out the growing use of spectrum by public and private entities, and have indicated the need for the adoption of appropriate regulatory policies in order to prevent spectrum crowding and eventual shortages. The currently followed DOC policies consist of a licensing system, in which only nominal user fees are charged. The central question to be examined by this study is the following: if a pricing system for spectrum usage is adopted, what would the consequences be upon the resulting spectrum demand viewed as a function of the pricing system? In a slightly different format, this question may be rephrased as follows: if the current system of purely administrative allocation of spectrum is replaced by a purely economic allocation system, or by a mixed administrative-economic allocation system, what would the spectrum demand be as a function of the parameters of the new system, and what would be the resulting consequences (if any) upon the user industries? In our context a purely economic allocation system is a system of exclusive licenses for time-limited spectrum usage, that are sold by DOC with a given (possibly discriminatory) price system, and are freely transferable by the licensee for the entire duration of his license, reverting to DOC upon the expiration of the license.

In a purely economic allocation system the crucial parameters are, of course, the prices charged for spectrum usage. A set of "small" prices will not play any role in the allocation mechanism, namely in slowing down the growth in spectrum demand, while too "large" prices may inhibit the growth of the user industries. Some recent estimates by DOC point out that the annual contribution to GNP of the various spectrum-using industries are in excess of $7 billion. It is clear that <u>any</u> positive price for spectrum-usage will create <u>ceteris paribus</u> an increase in the product costs of the user industries. On the other hand, the current system of (virtually) zero prices may eventually create a spectrum shortage in certain frequencies and places; to the extent that a user who could (and would be willing to) pay for the acquisition of a license may be prevented by the shortage from doing so, there would be a corresponding reduction in general welfare, since that particular user would be forced to adopt a more costly alternative, if any.

The idea of user prices assigned to spectrum is, of course, not new to this study. As the comments in (16), p. 85 show, virtually every economist who has studied spectrum allocation in the U.S. since the early sixties has advocated some sort of a pricing scheme. Needless to say, none of these schemes has had, until now, any chance of being adopted by the U.S. Federal Communications Commission (FCC). The reasons for this failure are complex, and Levin ((16), pp. 89-115) has given an excellent summary of the various types of objections that appear from time to time against proposed pricing schemes. The principal conclusion that he seems to derive is that the existing pattern of allocation and regulation has created many powerful vested interests on both sides (regulators and spectrum users), that militate against any proposed changes. Surprisingly, there does not seem to be much support for a change on the part of potential entrants to the ranks of spectrum users, even though the existing allocation pattern is heavily weighed in favor of the early users. For this reason Levin seems inclined more towards the support of a system that lies between the purely administrative and the purely economic allocation systems.

In Canada the question of spectrum allocation occupies, in addition to DOC, the activities of the Canadian Radio-television Commission (C.R.T.C.), which is exclusively concerned with the problems of radio and television broadcasting. While the technical problems of spectrum usage fall clearly within the provision of DOC, and the licensing and regulation of broadcasting forms part of the mandate of C.R.T.C., there can be no question that the economic issues raised by the pattern of spectrum allocation cut across both jurisdictions. Indeed, broadcasting is done in the range of spectrum frequencies where numerous competing industrial uses of spectrum exist, chiefly under the form of land-mobiles. This part of the spectrum, where either one or both of the activities of broadcasting and land-mobiles take place, is also the part where most "crowding" of the spectrum takes place. Hence, any proposed pattern of spectrum allocation has to confront the embarrassing choice of how much to increase or reduce the share of "crowded" spectrum devoted to broadcasting, as distinct from the other uses.

The question of land-mobile versus broadcasting has already confronted previous researches and, perhaps not surprisingly, they have come up with diametrically opposed recommendations. Thus, Levin cites data from a 1967 study by Casselberry and Gifford showing that a reallocation of spectrum from T.V. broadcasting to land-mobile would save land-mobile users "from $8 to $13 billion" (U.S.), while the broadcasting industry forced upon the next least costly alternative (cable T.V.), would incur costs at the level of the subscribers on the order of $3.6 billion U.S. (p.p. 133-135). On the other hand, a recent study by Crandall and Taggart (C-T), after a lengthy criticism of the earlier estimation attempts reaches the conclusion that "The cruel economics of the situation argue for a shift of spectrum from land-mobile to television" ((8) p. 40). Although the authors subsequently qualify this conclusion strongly, the fact remains that allocation decisions are really a question of valuation of the spectrum resource, and different methods of valuation would result in diametrically opposite conclusions.

The C-T study is valuable as a starting point, not only because it is the most recent study that attempts an economic valuation, but also because the authors are both economists and adopt a conceptual methodology that is solidly grounded on economic theory. As they point out (pp. 1-2), the origin of most attempts at spectrum valuation have been engineering studies, and such studies have produced "a variety of simple, misleading measures of spectrum value, which result in gross overestimates of the appropriate shadow price of individual frequencies". ((8), p. 1). The methodology proposed in this study shares a commom conceptual origin with C-T, but it differs radically in the measurement component, since this study is intended as a framework for econometric work, while theirs worked only with published data. Also, the economic valuation of spectrum assigned to land-mobiles (as in C-T) cannot be separated from the economic valuation of the spectrum devoted to broadcasting, since the two users are alternative consumers of the same resource. While C-T have recognized this interdependence ((8), pp. 39-40), and while we broadly agree with their statements on pp. 40-41, urging the shift of all T.V. to UHF and the freeing of VHF for land-mobile (at least insofar as their data is concerned), there is no question that the computation of the economic value of the spectrum devoted to broadcasting could benefit from a more sophisticated measurement methodology. To this date the emphasis in the economics of broadcasting ((2), (5) (6), (10), (17), (18)) has been towards the measurement of programming costs (correctly, since these are by far the largest costs in broadcasting). Yet the spectrum has a direct effect upon operating costs, since, for instance, the substitution of UHF for VHF results in a higher operating costs for both broadcaster and viewer.

In this study we shall concentrate almost exclusively to the question of spectrum allocation to broadcasting and land-mobiles, since these two competing sectors account for the bulk of the congestion problems in the VHF and UHF zones. The fundamental methodology will be the micro-economic theory of the firm, specifically the modelling of the production function or the cost function. The various dimensions of allocation (spectrum and power) are clearly parameters that may be treated as separate production inputs. These parameters are currently allocated administratively by DOC, either on its own (for land-mobiles) or in cooperation with C.R.T.C. (for broadcasting). The question that we shall take as a starting point is that of the valuation of these inputs by the firm, that is, given a price parameter attached to spectrum and/or power, how would the firm's decisions be affected? It turns out that the production function approach may yield useful models for actual empirical work.

Of particular interest to us is the set of values of the price parameters that are equal to the largest possible prices such that the spectrum users' current production decisions would remain unchanged. In other words, if spectrum is viewed as a renewable natural resource, what would be the largest royalties such that the current pattern of usage would remain unchanged?

Since the user price of the resource at present is equal to zero, the simplistic answer based on economic theory would be that any positive price would entail some reduction in usage by the marginal user. However, many users (e.g. broadcasters) operate in sectors characterized by indivisibilities and discontinuities in the production process, while the prevailing economic environment in those sectors is certainly very far from perfect competition. At any rate, the solution of these problems cannot be taken for granted and the empirical work following this pilot study should yield at least some partial answers.

II Broadcasting

In the area of broadcasting spectrum is an essential production input in the definition used in (21), in the sense that no production of output (in the sense of over-the-air broadcasting), is feasible without a positive spectrum allocation. On the other hand, given the wide availability of cable systems in most communities, there is no question that close substitutes exist for any type of broadcasting output, although the additional costs associate with over-cable broadcasting are certainly limiting this type of competition. The Canadian broadcasting industry is very closely regulated in both the over-the-air and the over-cable components, and this fact will have to be taken into account in any modelling for empirical purposes.

The fundamental hypothesis that needs to be tested before any spectrum pricing and allocation is decided upon the existence of economic rents to the spectrum input. To the extent that the spectrum resource is a public resource these rents may be taxed away by the imposition of a spectrum (or license) price, without any reduction of the broadcasting output, which is presumed fixed by the regulators. On the other hand, license prices are viewed as deterrents to spectrum usage in the "crowded" VHF region; broadcasters may be encouraged to migrate to the less crowded UHF zone if the spectrum price is at least as high as the excess economic rents earned by the VHF spectrum resource over and above the UHF rents, if any. In other words, the spectrum rents if they exist are a significant benchmark that needs to be evaluated.

The modelling that will take place (keeping in mind the fact that empirical research, i.e. a framework for data analysis, is the ultimate goal), will comprise a number of distinct stages. The first stage will examine the theoretical behavior of a firm or group of firms in the broadcasting industry given a stable institutional and economic environment. Unfortunately, the actual environment, in which Canadian broadcasters operated during recent years, was very far from being stable. For this reason, since the data covers various periods of differing characteristics, we shall examine in more detail the nature of the modifications that must be brought to the basic model in order to make it applicable. Finally the types of data, as well as their availability will also be briefly surveyed.

In what follows we shall index by $j = 1,\ldots J$ the firms broadcasting in a given region, and let Q_v and $Q_u < Q_v$ denote the maximum potential audience in that region, depending on whether the broadcasting takes place in VHF or UHF respectively. Since, with the current C.R.T.C. and DOC policies the broadcasters have very little choice in determining Q_v or Q_u, these variables will be considered as exogenous. Their value is a function of the spectrum and power allocation, and, henceforth, we shall drop the subscripts u and v from Q, since the analysis is equally applicable to both cases.

Let Π_j denote the profit of the j^{th} firm p_j its programming costs and $F_j(Q)$ the "other costs" (equipment, labor, and materials). The firm derives its revenues from advertising, and we denote by $r(A_j)$ the rate charged by the firm per unit of actual audience A_j, the exact function depending on the method of measurement of the latter. The total revenue, therefore, is $A_j r(A_j)$. We note that, while the analysis is identical for all modes of broadcasting, the function r may be different for differing broadcasting modes (e.g. AM radio, FM radio, T.V., etc.)

A broadcaster's actual audience A_j, is clearly dependent upon the total potential audience Q , as well as the programming expenses p_j. The programming expenses, on the other hand, are decision variables for the firm and their choice is determined by profit maximization considerations. While part of the C.R.T.C. mandate is the monitoring of broadcasting programming in accordance with cultural policies, there is reason to believe that the various regulatory rules (e.g. Canadian content) are uniform over most stations or areas. Alternative assumptions may be easily incorporated in the model.

The form of the dependence of the actual audience A_j upon p_j and Q is something that has to be established by reference to actual data. Obviously A_j is a non-decreasing function of p_j and Q. The total actual audience, $\sum_{j=1}^{J} A_j$ is dependent upon various other factors such as the availability of alternative programs such ascable T.V. and over-the-air broadcasting from United States stations. An appropriate starting set of assumptions might be the following: (a) The total actual audience of over-the-air broadcasting is dependent on Q and on the total programming expenses $\sum_{j=1}^{J} p_j = S$ b)Subject to this constraint, each broadcaster behaves as if the level of his competitors' programming expenses were independent of his own (the standard Cournot oligopoly assumptions). Alternatively, instead of (b) we may wish to adopt (c) Subject to the total audience constraint, all broadcasters maximize their joint profits by jointly choosing their programming expenses (a perfect collusion model). These two extreme cases form two convenient limits, between which the actual situation probably lies.

Assumption (a) is easy to justify. In a given community the level of total actual audience for over-the-air stations depends on the available alternatives (chiefly U.S. programs), whose level can be assumed with a reasonable degree of confidence to be independent of P_j. An increase in P_j <u>ceteris paribus</u> will have the dual effect of diverting audience from other over-the-air stations to station j, <u>and</u> of increasing the total over-the-air audience.

Analytically, we can summarize the structure of the model as follows:

(1) $\Pi_j = A_j r(A_j) - p_j - F_j\ (Q)$

(2) $A_j = A_j\ (p_j, Q)$

(3) $\sum_{j=1}^{J} A_j(p_j, Q) =$

for j = 1,...J, where A denotes the total over-the-air audience. Letting now λ denote a Langrange multiplier attached to (3), we have under assumptions (a) and (b) the following problem:

(4) $\underset{p_j}{\text{Max}} \left\{ A_j r(A_j) - p_j - F_j(Q) \right\} \qquad j = 1, \ldots J$

subject to (2)-(3), while under (a) and (c) we have

$$(5) \quad \underset{p_j}{\text{Max}} \left\{ \sum_{j=1}^{J} \left[A_j r(A_j) - p_j - F_j\ (Q) \right] \right\}$$

subject to (2) and (3). The first-order conditions corresponding to (4) are:

$$(6) \quad r \frac{dA_j}{dp_j} + A_j \frac{dr}{dA_j} \frac{dA_j}{dp_j} + \lambda j \left[\frac{dA_j}{dp_j} - \frac{dA}{ds} \right] = 1$$

$$\sum_{j=1}^{J} A_j(p_j, Q) = A\left[\sum_{j=1}^{J} p_j,\ Q \right]$$

The solution of the system (6) with respect to $(\lambda_j,\ P_j)$

given P_i, $i \neq j$ for all $j = 1,..J$ yields a system of programming expenditures that must satisfy (3). On the other hand, if the collusion model (5) is adopted the first-order conditions become.

$$(8) \quad r \frac{dA_j}{dp_j} + A_j \frac{dr}{dA_j} \frac{dA_j}{dp_j} + \lambda \left[\frac{dA_j}{dp_j} - \frac{dA}{ds} \right] = 1,\ j:1,\ldots,J$$

$$\sum_{j=1}^{J} A_j(p_j, Q) = A\left[\sum_{j=}^{J} p_j,\ Q \right]$$

and the solution of (7) yields the collusively optimal set of programming expenditures.

The first order conditions (6) or (7) may be converted directly into estimating equations, given an assumed form of the functions A_j. In the above for mulation, i.e. (2) and (3), it was assumed that P_j does not affect A_i for $i \neq j$, except insofar as total audience is affected, through (3). Perhaps a more realistic alternative would be to assume that $A_j = A_j(p_1, .., p_j, Q)$, with $\frac{dA_j}{dp_i} < 0$ for $i \neq j$. This still does not solve the problem of fitting a functional form to A_j. The solutions adopted by previous studies vary quite a bit on this subject. Thus Crandall assumes that in our notation $A_j(P_j) = \alpha p_j$, the dependence on Q being irrelevant in his case, since he discusses T.V. network programming, where the exposure is national ((6), p. 505). In the same vein, Park in his study of T.V. networks ((13), pp. 608-610) uses a rather complicated expression depending on an attractiveness index for each network, which is an increasing function of programming expenditures, the total share of the audience for each network being equal to a weighted attractiveness index of a particular network divided by the sum of the weighted attractiveness indices of all networks. The point to be made is that there is little justification for choosing one formulation over another, and the resolution of this issue will depend on the available data as well as analytical considerations. For whatever they may be worth, Crandall's results for audience response to a particular program as a function of programming costs, which were estimated as αp_j^{β} , as discussed earlier (j indicating a program), were that the estimates of λ varied between 4.2 and 2.5, while β was estimated within the range 0.58 - 0.73. The large variability of the estimates, as well as the poor fit of the regression ((6), p. 506) necessitate considerably more empirical work on this topic.

The fact that needs to be established at this point is that the C.R.T.C. license allocation defines exogenously a broadcaster's potential audience Q. Given Q, the broadcasters choose the programming expenditures optimally, either in oligopolistic competition (Cournot) according to (6) or collusively, according to (7). With these optimal choices the level of total broadcasting profits $\sum_{j=1}^{J} \Pi j$ becomes a function of the parameters of the systems (for instance r if r is independent of A_j, other exogenous variables like household income that may enter the function A_j, etc.) as well as total potential audience Q. It remains now to establish the link between profit and spectrum and power allocation, and clearly this link is dependent upon licensing policies.

With present policies broadcasters have very little choice in determining the area and method of broadcasting. We have established above that the only licensing variable that broadcasters are interested in is Q, the number of potential audience in a given area. Given the area, we have to establish a link between Q and spectrum and power allocation, for a fixed signal quality. Denote by

(8) $$\sum_{j=1}^{J} \Pi_j \equiv \Pi^J(Q)$$

the aggregate broadcasting profits of all J firms in a given area, given the optimal choice of programming expenditure. Let also P and s denote power and spectrum respectively. We postulate a function

(9) $Q = G(P, s)$

for a given geographical area, where P takes its values in a subset of the positive real line, and s is an integer variable that denotes the technological spectrum usage alternatives available to the broadcasting firms. Assume, for illustration purposes, that s can take only two values, s_u and s_v, the UHF and VHF allocations, that $G(P, s_u) < G(P, s_v)$ for all P, and that P is not a choice variable. Then Q can take only two values, Q_u and Q_v, respectively equal to $G(P, s_u)$ and $G(P, s_v)$. If, now, license prices are instituted, say W_u and W_v for UHF and VHF respectively, the effect of the relative size of W_u and W_v upon the structure of the broadcasting industry in that particular region can be computed as follows. Let J_u and J_v represent the number of firms in the UHF and VHF spectrum in that region. Assume that Q_u and Q_v are given by (9) and are insensitive to the number of stations in the UHF and VHF spectrum. This is, of course, a rather dubious assumption, since there are, undoubtedly, other variables (such as household income in the area) that affect Q, and a migration of a station from the VHF to the UHF spectrum might induce some listeners to convert their sets to UHF reception. With such an assumption, $\Pi^J(Q)$ is a decreasing (or, at least non-increasing) function of J, and the migration of one station from VHF to UHF increases the profits of the VHF group by the amount

(10) $$\Pi^{J_v-1}(Q_v) - \Pi^{J_v}(Q_v) + W_v \equiv \Delta\Pi^{J_v}(Q_v) + W_v$$

and reduces the profits of the UHF group by

(11) $$-\Pi^{J_u}(Q_u) + \Pi^{J_u-1}(Q_u) + W_u \equiv \Delta\Pi^{J_u}(Q_u) - W_u$$

For a migration to take place (10) must be larger than (11), implying that the licence price differential must be such that

(12) $$\Delta\Pi^{J_u}(Q_u) - \Delta\Pi^{J_v}(Q_v) \leq W_v - W_u$$

An alternative exercise that can be carried out with the help of the $\Pi^J(Q)$ functions is the following. Assume that no migration from VHF to UFH is intended, but that the licensing structure must be such that it would encourage broadcasters to conserve spectrum within (say) the VHF region. With T.V. broadcasting in mind, we assume that two alternative broadcasting technologies are available, with spectrum usage s and $s_1 < s$, and corresponding license prices w and $w_1 < w$. In this case, however, the technology s_1 requires a conversion of the receiver and let c_1 be the conversion cost per receiver. We also assume, as before, that power is not a choice variable, and we want to see the effect of the imposition of license prices w and w_1. Suppose that the broadcasters are willing to absorb the cost of the conversion of a number $Q_1 \leq Q$ of sets to the new technology (perhaps by subsidizing equipment manufacturers or otherwise). The effect of the license prices will induce a number $I \leq J$ of broadcasters to adopt the new technology. The broadcasting industry will select Q_1 and I by solving the problem.

$$\text{(13)} \quad \max_{I,\, Q_1} \left\{ \Pi^{(J-1)}(Q) + \Pi^{I}(Q_1) - Jw + I\,(w - w_1) - c_1 Q_1 \right\}$$

subject to

$$\text{(14)} \quad Q_1 \leq Q \;, \quad 0 \leq I \leq J$$

In this problem w and w_1 (as well as c_1) are parameters and the regulators can achieve any desired pattern of adoption of the new technology by selecting appropriate values of w and w_1.

This theoretical model is conceptually simple in structure and rigorous in economic thinking. In attempting to apply it, however, there are a number of important complications, that might necessitate substantial atlering of the theoretical structure. The institutional and organizational realities of the broadcasting industry are such that a variety of modes of ownership and operations exist within a group of firms operating in a given area. In what follows we shall attempt to make the operational, first by taking care of the complications that arise from this diversity, and second by discussing the data needed, as well as potential sources.

A broadcaster may be either independent, or affiliated with one of the Canadian networks (CBC, CTV, Global, TVA). If he is independent then he does his own programming, and incurs the programming expenses of P_j. An affiliate of a network, on the other hand, does very little programming of its own, but it does carry the network's program, together with part of the network's national advertising, while its own revenue is derived from the sale of additional local advertising (plus, possibly, some payments from the network). To the extent that an affiliate does no local programming of its own (and, therefore, does not incur any programming expenses), it forms part of the broadcasting firm represented by the network, to which it is affiliated. We may, therefore, decompose the problem of definition of markets, in which broadcasting firms compete, by considering separately the networks (with their affiliates) from the independent firms.

Of the networks CBC is a public enterprise, the other being privately owned. Clearly, the profit-maximization model cannot be applied to CBC, given the particular restrictions, under which the latter must operate. For the remaining networks, two alternative methods of approach may be tried, both representing approximations to the "true" situation. Each affiliated local station may be treated as an independent, with programming expenses equal to whatever it spends on local programming plus a portion of the network's expenses, allocated (say) nationally, in proportion to the total potential audience that the network reaches. Alternatively, the model can be applied to the nation as a whole, in which case the networks can be conceived of as optimizing their profits over the entire range of their operations, subject to local competition. There are no major analytical difficulties in such a formulation, but empirical considerations, such as the availability of data or the varying time periods, for which data is available in each market, would probably preclude such an approach. The issue will be left for resolution at a later date.

An additional issue for the period, from which most of the data will be drawn (the last decade) is the spectacular growth in cable TV (CATV) in the various urban areas. This has increased the availability of programming available in most local markets by bringing in distant signals, especially U.S. signals, <u>but</u> also by improving the reception quality of local over-the-air stations for the CATV subscribers. The current CRTC regulations oblige each CATV company to carry all local signals, as well as provide some local programming of its own. As most students of CATV have pointed out (e.g. (15), p. 69) the effect of the introduction of CATV in a given market means a decrease in the audience of local over-the-air stations. To the extent, however, that a CATV system carries the signals of a UHF station, it does enlarge its potential audience Q, since subscribers that could not receive "good" UHF signals over-the-air are now able to do so over cable.

There is no totally satisfactory way of accounting for this dynamic change in the economic environment of the broadcasting firm. The simplest way is to introduce a dummy variable in the estimating equations to account for the introduction (or expansion) of CATV in a given area. This is likely to have a rather large margin of error, since every CATV system takes some time to reach maturity (see, for instance, (4), (7), (15), and (17)). An alternative method is to introduce a separate modelling for the audience of CATV, and incorporate its results in the estimating equations derived from (6) or (7); the effect of such a modelling would be to change the functionnal form of the A_j's. The undesirable consequence would be the increased complexity of the estimating model, with the corresponding decrease in the accuracy of the estimation.

The large elements of uncertainty present in the estimations suggest an alternative approach to the problem of spectrum valuation. Since the direct estimation can (at best) provide estimates of the dependence of current profits upon various exogenous variables (such as Q, r, other variables entering the A_j functions, etc.) it might be plausibly argued that current profits are a poor indicator of the value to the firm of the license to broadcast to a given audience Q. This value should allow for the uncertainty of the profits, due to the various elements explained above, such as the introduction of CATV, future governmental regulatory policies, the number of competing stations in the given area, etc. Fortunately, during recent years an alternative source of data has appeared, which does allow for risk-adjusted value estimates. Such data comes from the frequent transfers of ownership of existing licensed broadcasting stations.

In (1), pp. 569-575 the issue of license tranfers is discussed within the general context of CRTC policies. Such transfers have occured very frequently in recent years. For instance, data presented in (1), p. 570 shows that in the period 1968-1975 there were a total of 62 applications for transfers of shares or assets of TV stations presented to CRTC, of which 45 were approved, 5 were conditionally approved, and 12 were denied. The corresponding figures for AM radio stations were 158, 1 and 18, and for FM stations 38, 0 and 10. While these figures betray the existence of wide-spread "trafficking" in licenses, they do provide for our purposes an important data base, which allows us to compute the value of a station <u>after</u> allowance for risk, as estimated by the financial markets.

From (6) or (7) it was established that the current profits Π_j of firm j are functions of the advertising rates r per unit of actual audience (assumed, for simplicity, independent of A_j), the number of competing firms J, the potential audience Q, and the "other" variables entering the functions A_j (P_j, Q), such as consumer income Y, the existence of CATV (represented by the dummy variable C which takes value 0 or 1) and the "maturity" of the CATV system (represented, say, by the years t since its introduction). Assume, for simplicity, that the <u>expected</u> profit accruing to the stockholders $E(\Pi_j)$ is a function of these aforementioned variables, i.e.

(15) $E(\Pi_j) = \Phi(r, Q, J, Y, C, t)$.

The value of the firm's financial assets V_j is equal to $E(\Pi_j)$ minus the "risk" of Π_j, discounted to the present by the riskless rate of interest. The exact form of the relationship is well-known in financial theory and follows the familiar Capital Asset Pricing Model (CAPM) of Sharpe, Lintner and Mossin (see, for instance, (13) and (14). According to this theory the value V_j is given by

(16) $$V_j = \frac{1}{R_F}\left[E(\Pi_j) - V_j b_j \left[E(R_M) - R_F\right]\right]$$

where

$R_F = 1 + r_F$, and r_F is the riskless rate of interest (as measured, say, by the yield on government bonds). $E(R_M)$ = the expected holding period return on the "market" portfolio; in practice such a return is computed from an aggregate stockmarket index, such as the TSEI.

b_j = the beta of the company, a parameter that will be estimated; in the case of a publicly traded company b_j is estimated as

$\frac{Cov\ (R_j, R_M)}{\sigma_M^2}$, where σ^2_M is the slope of the regression line of the company returns versus the market returns. In our case the broadcasting companies that change hands may not exist for a long time, or may not be publicly traded, so that this line of estimation may not be, in general, available.

From (15) - (16) we get directly

(17) $$V_j \left[R_F + b_j \quad E(R_M) - R_F)\right] = E(\Pi_j) = \Phi(r, Q, J, Y, C, t)$$

and taking logarithms:

(18) $\log V_j = \Phi(r, Q, J, Y, C, t) - \log \left[R_F + b_j\, E(R_M) - R_F\right]$

Equation (18) may be applied to the sample formed by broadcasting stations that were tranfered. The observable transfer value V_j is a function of the economic variables that serve as arguments of Φ as well as the financial variables that determine the market's valuation of the "risk" of the uncertain returns Π_j that accrue to the firm's owners. As it can be seen from (18), the estimation involves a highly non-linear equation, since the unknown parameter b_j enters the right-hand-side of the equation in the indicated manner. The functional form of Q is also unknown and, as discussed above, it will require an ad hoc fitting, given the complexity of the modelling. As a first approximation a linear or log-linear form of the relationship may be fitted to the data, but the exact specification should await empirical work.

Equation (18) is a much more satisfactory way of linking specturm usage to economic performance, since it is no more arbitrary than the direct approach through (6) or (7), and considerably broader in its coverage, since it does include data not needed for (6) or (7). The major advantage is, of course, the inclusion of the financial market's evaluation of the risk in the company's earnings stream which, as pointed out earlier, depends on subjective evaluations of future advertising market structure and CATV penetration.

From the point of view of empirical application, the data necessary for (18) is the same as the one needed for (6) or (7) minus data on the actual audience A_j (and its determinants) plus the sale price V_j, as well as the financial data on the return of the market portfolio R_M. As is well known from (1), data on V_j, Q, J, C, t, and elements permitting the estimation of r are available in the CRTC. Estimates of Y do not present any problem, while R_M (and, hence, $E(R_M)$) and R_F are publicly available in financial publications. In the case of radio stations the application of (18) is straightforward, while for TV the sample needs to be split into VHF and UHF components. In the absence of more detailed information about the composition of the sample, it is not know *a priori* if enough observations are available for the estimation of a separate equation for each sample. If not enough UHF (say) stations changed hands to justify a separate estimation, then we need to adjust Q in order to apply the derived equation to UHF. The issue needs to be faced at a later date.

A satisfactory estimation of a valuation equation such as (18) would allow us to predict the value of a license as a function of the spectrum allocation characteristics (i.e. Q), the nature of the competition and the state of the financial markets. This value would presumably represent the expected amount that a sealed tender auction for a new license would bring, in the event that the CRTC decides to hold such auctions in the future. It is also the amount that an original licensee can be induced to pay without being driven out of business.

In concluding this section we note that the empirical task of determining the industry profits as a function of the observed maximum potential audience Q (which is exogenously determined with the current allocation policies) is a starting point for any number of interesting policy questions. Such questions may be asked either in a piecemeal fashion, as in the illustrations presented above, or globally, starting from a nation-wide pattern of spectrum and power allocation that allows considerably more flexibility to economic forces. The advantage of a piecemeal approach is that it facilitates the transition from the current system of purely administrative allocation to (eventually) a purely economic system, if such a transition is considered desirable. As Levin pointed out ((16), p. 85), the economists' strong bias towards purely economic allocation systems represents a rather unrealistic ignorance of the resistance to change of long-established administrative mechanisms.

III Land-mobiles

A land-mobile system is a system composed of a base station and one or more mobiles, together with a transmission frequency used by the base station. As with broadcasting, the current DOC allocation policies have allocated frequencies for land-mobiles in the VHF and UHF zones.

The demand for land-mobiles has grown very fast in recent years. In most of Canada's metropolitan areas (where the spectrum congestion problems are presumably acute) the annual average growth rate of the total number of land-mobile systems for the period 1973-1977 has ranged from a high of 22.42%, for Saskatoon, to a low of 4.82% for Sudbury, the overall growth rate for 19 metropolitan areas being 14.13% ((20), p.15). Such rates are extremely large, and, if they are real, they point to serious shortage problems in the very near future. The possibility of shortages has also been encountered in the U.S., with the F.C.C. responding to the shortages by opening up new bands for land-mobiles in the UHF portion of the spectrum ((8), pp. 1-2). The aforementioned C-T study indicates quite clearly that the operation of land-mobiles in the UHF region is associated with significantly higher equipment costs ((8), p.18).

In terms of industrial sectors, for the country as a whole, in 1976 (as shown in (20)), the percentage wise most important users of land-mobile systems were Public Administration (20.06%) followed very closely by Transportation (19.37%). The sectors of Construction with 13.15% and Services (11.97%) came next, while Trade, Communications, Manufacturing, Utilities, Forestry and Mines and Oils followed in that order, with 7.84, 7.44, 6.14, 5.55, 4.74 and 1.81% respectively. For the purposes of this study this classification is adequate for some sectors (e.g. Construction), but too aggregated for others, like the Services. Further disaggregation is necessary whenever we wish to arrive at a definition of a land-mobile using sector with a relatively homogeneous product and production technology.

The current allocation policies of DOC leave very little discretion to the users. Each user is allocated channels on a non-exclusive basis, depending on the perception of his "needs" by the appropriate DOC authority. Obviously, there is a discrimination in favor of older users (at least in the case of private users), since these users broadcast in the "congested" VHF zone, where the equipment costs are lower. Similarly, since DOC monitors the actual utilization of each channel, as well as the technical parameters of broadcasting, the congestion is not allowed to exceed certain limits. The result is that the older VHF users enjoy some advantageous position with respect to equipment costs vis-à-vis the more recent UHF users.

From the rates of growth presented in (20) and (23) for the various metropolitan areas it would appear that the land-mobile spectrum congestion must have reached critical proportions in at least some of the important population centers of the country. Surprisingly, this does not turn out to be the case. In a recent DOC report ((3), section 3.3) data is presented for the city of Toronto, that shows that, of the 1,000 "assignable" frequencies in Toronto, nearly two-thirds are occupied less than 20% of the time. The comparable data for Ottawa is, needless to say, much lower. The first matter that needs to be examined, therefore, is whether it is possible to improve the frequency assignment procedure in order to equalize the load of the various channels.

It looks as if DOC is, at present, aware of this variability, and is taking initial steps to correct it by monitoring selected channels in various cities ((3)). In our opinion though, the variable of highest economic interest is not the channel occupancy, but the <u>average waiting time</u> for messages' transmissions since this variable is directly related to the loss of operating efficiency due to congestion. Queuing theory establishes the fact that average channel occupancy is derived from the characteristics of the distribution of message interarrival times, as well as the distribution of message lengths. If we wish to adopt the simplifying Poisson-exponential assumptions (for the number of arrivals and the message lengths) the <u>average</u> message arrivals and message lengths are sufficient to establish the average channel occupancy. Conversely, with the same simplifying assumptions, given the average channel occupancy and the average number of messages arriving per unit time, it is possible to generate most parameters of interest, such as for instance, average waiting time. The monitoring process currently in operation records data on the distribution of the number of messages per unit time, as well as channel occupancy. Such data may, therefore, be used in order to extract estimates of the distribution of the waiting time by means of a suitable queuing model. The main research, therefore, should, in our opinion. study as a priority item the variability of waiting times across channels in several locations and, if possible, check the correlation of waiting times and channel occupancy, since the latter seems to be the universally most popular measure of channel congestion.

A second consideration refers to the components of the observed extraordinary growth in land-mobiles, which does not seem to have caused, to this date, any appreciable congestion. This growth appears in both the number of land-mobile systems (as in the Quasar study, (20)), as well as in the total number of land-mobiles, as in (23) and (24). Unfortunately, the periods covered by the two studies are not comparable, so that no inferences may be made as to the components of this growth, i.e. whether the number of mobiles per base station has grown or not. This is another element that needs to be determined.

In comparing (20) and (23) certain similarities begin to emerge. In both cases, for instance, the Transportation sector seems to have declined in relative importance, while the Construction, Services and Trade sectors have certainly increased (as percentages of the total). The figures for the other sectors are in conflict with each other. The question that arises is what form this growth is taking. Does it consist of adoption by more firms of the technique of using land-mobiles, or does it consist of the addition of new frequencies and/or more radio mobiles by firms already equipped with a land-mobile system? This type of question is very important in projecting future growth, since in the former case we can forecast with an appreciable degree of confidence that, for instance, the growth in land-mobile systems used by the Construction sector is going to moderate considerably in the near future. There is a given number of construction firms in Canada at this moment, their number does not grow at a rate approaching even remotely 22.6% per year, so that once the sector is saturated the growth will be very much reduced. If, however, existing firms accumulate more than one frequency then there is no reason for the high growth to stop. This question can be answered very simply, by studying the data in the Integrated Radio Licensing System (IRLS), or the Domestic Frequency List (DFL), and should be also examined as a priority item in the main study.

Finally, and most important, the extraordinary growth in land-mobiles (whether total licenses or systems) may not have caused any appreciable degree of congestion because a large part of it may be due to non-congesting uses of spectrum. For instance, many firms use land-mobiles for intra-plant security and maintenance operations; the power allocated for such intra-plant uses is sufficient, in typical cases, in order to cover a half-mile radius around the base station, and does not affect other spectrum users beyond this area. The interesting thing about these users is that they are all on the same group of frequencies in every district office and, sometimes, across the entire country. In other words, if a large part of the growth in spectrum usage is of the non-congesting, intra-plant type, all dire predictions about impending spectrum shortage may be rather premature. The same thing may be true to a lesser extent with the growth in the usage of paging devices, which are also segregated in separate frequencies.

The point to be established at the beginning of the main study is that the starting hypothesis of spectrum scarcity (actual or potential) is a sine qua non for the economic analysis that will follow. If the spectrum is in plentiful supply then economic theory postulates that its rent is zero, that no price mechanism is necessary to "ration" its usage, but only in order to recover the costs of managing the allocation (the situation is different in the case of broadcasting, because there the license is also a barrier to entry by potential competitors). Even if the projected spectrum shortage will come much later than initially thought, this fact is by itself of tremendous interest and should not be neglected. We propose, therefore, to examine as a priority item the growth in land-mobile systems net of non-congesting uses such as intra-plant and paging devices, as explained above, by subtracting the growth within the frequency bands set aside for this purpose.

The foregoing should establish the fact that we believe that the case for imminent spectrum scarcity in some areas (as expressed in (20) and (23)) is not sufficiently strong at this moment and warrants further study. In what follows we shall assume that the additional evidence does indeed confirm the fact there is still appreciable congestion and delay in communications even after the adjustments and reassignments expalined above. We shall, therefore, proceed with the economic analysis, even though it might turn out to be unnecessary.

Our problem here is to forecast the sectoral spectrum usage growth pattern due to land-mobiles under current allocation policies, as well as the resulting modifications of this growth pattern if some sort of pricing system is adopted. We shall adopt the production function approach, which is conceptually simpler here than in broadcasting, but, on the other hand, more complex empirically, since there are more sectors to examine and these sectors are more heterogeneous.

Every land-mobile using firm contains a base station as well as a number of mobiles. We shall conceive of the mobiles as <u>production inputs</u> which, in cooperation with other inputs produce the firm's output. An indispensable production input is a <u>communication and coordination</u> (cc) spectrum input, whose size for any given number of mobiles may be measured by, for instance, the number of channels per mobile in the frequency used by the firm; other possible measures will be discussed below. To the extent that the same channel may be used by more than one firm, the operations of the sector are characterized by external diseconomies, since an expansion of some firms without a compensating increase in the spectrum allocation would cause a reduction in the cc input of any individual firm. It is also easy to see that all mobiles may not represent an equal loading for a given channel, since their average contributions to channel loading are rather unequal. For instance, data presented in the C-T study shows that the average channel occupancy for land-mobiles in Chicago in 1974 in the VHF zone varied from a high of 0.692 for the Motion Picture service category to a low of 0.059 for Press. Even within a relatively homogeneous service category, such as Taxicabs, there corresponded to an average channel occupancy of 0.489 a standard deviation of 0.366 for a sample size of 26. There is no data, on the number of mobiles that had been assigned to each channel, but the C-T study implies that an effort was supposed to have been made in the assignments in order to equalize channel loading.

These results suggest that measures such as channel occupancy or average waiting time might be better indicators of the cc input than the channels per mobile, but in such a case there is a need to link such indicators to the factors that determine their size. One such factor is the aforementioned number of mobiles per channel, but clearly the cc input is also influenced by output, in the sense that a higher level of activity of the sector would also cause a reduction of the cc input. To simplify the analysis we shall assume at this stage that the sector under consideration has exclusive use of the channels allocated to it.

Let $i = 1,\ldots,I$ denote the mobile using firm, q_i its output, n the number of mobiles, K_i the capital (other than mobile units) used in transmission, X_i the vector of "other" inputs (labor, and materials), h the cc input, however that may be measured. We then have

$$(19) \quad q_i \leq F(X_i, K_i, n_i, h) \qquad i = 1,\ldots, I$$

$$(20) \quad h = G\left(\frac{\Sigma_i n_i}{m}, \Sigma_i q_i\right)$$

where m is the number of channels allocated to the sector. The function G is non-increasing in both arguments. As for the production function, it follows the usual neoclassical properties. In addition, the technological realities of the use of land-mobiles show the following ((8), pp. 12-25).

a) There is some substitutability between h and K_i in the form of better equipment, for instance by a narrower splitting of the bands. The current allocation policies, however, remove all incentives for such a substitution. Another possibility is the use of repeater stations, or migration to the less congested UHF bands, with a concommittant increase in capital outlays.

b) In most cases, there is some substitutability between the number of mobiles n_i, and h and K_i. For instance Plotkin ((19), p. 31) quotes an FCC report to the effect that "three radio-equipped vehicles can do the work of four vehicles not so equipped in most situations" In other words, in our notation, $F(X_i, 0, \frac{4}{3}n_i, 0) = F(X_i, K_i, n_i, h)$, for some range of values of h. Conversely, if h is lowered because of congestion it is possible to achieve the same output by increasing n_i.

c) It is not unreasonable to assume a separability of the production function (19) under the form

(21) $F(X_i,K_i, n_i, h) = F(X_i, n_i, D(K_i, h)$

where the function D represents the contribution to production of the entire mobile communications system within the firm. While h is an index of the quality of the spectrum input, and K_i represents the capital used in transmission, D is the "output" of the information transmission mechanism.

With assumption (c) expressed by (21), assumption (b) implies a substitutability between n_i and D. Our purpose is to extract estimating equations out of (19) - (21). Suppose that p represents the output price, W the vector of "other" input prices, r the price of n_i, and that our data consist of I firms in the same geographical region (facing, therefore, the same prices), for t = 1,.., T periods of time; the subscript t characterizes all observations in the t^{th} period. Assume also that the industry is characterized by perfect competition, and that DOC "manages" the spectrum allocation in such a way, that the information transmission function D is the same for all firms in the industry during the same time period, independently from their transmission equipment. Then the production function becomes independent of K_i. Corresponding to the production function (19) we have a profit function gross of the transmission equipment expenses, which takes the following form:

$$(22) \quad \pi_i = \pi_i\,(p,\ W,\ r,\ h)$$

and the aggregate industry profits during period t become

$$(23) \quad \pi_t = \sum_{i=1}^{I} \Pi_{it} = \sum_{i=1}^{I} \Pi_i(p_t, W_t, r_t, h_t) = \pi\,(p_t, W_t, r_t, h_t)$$

where

$$(24) \qquad h_t = G\left(\frac{\sum_{i=1}^{I} n_{it}}{m_t},\ \sum_{i=1}^{I} q_{it} \right)$$

The system (23) - (24) is still not estimable in this form. To convert it into a system of estimating equations we use the convenient property of profit functions known as the Hotelling-Shephard Lemma ((9), (10)): The derivative of the profit function with respect to an input or output price is equal, correspondingly, to the derived demand for the corresponding input, and the supply function for the firm's output. Then instead of (24) we have

$$(25) \qquad h_t = G\left(\frac{\partial\pi/\partial r_t}{m_t},\ \partial\pi/\partial p_t \right)$$

(23) and (25) form now a system of two estimating equations, with prices and the channel allocation m_t as the exogenous variables, which completely specifies our industry.

For estimating purposes a variety of alternative functional forms (e.g. Cobb-Douglas, translog, Leontieff, etc.) are available for (23) but (24) or (25) require a micro-study of the particular queuing process. C-T and especially, Plotkin ((9), (19), Chapter V) have given examples of the usage of the queuing system's parameters in computing cost savings. In our case we need a linkage of the firm's output and number of mobiles with the frequency at which messages arrive in the system (the inter-arrival time of the queuing system), as well as with the average length of a message. (the service time), if such a linkage exists. While the formulation of specific equations should not present any problems in particular cases, a general form applicable to all types of industries would, in our opinion, introduce unnecessary assumptions and require some testing before being adopted.

Suppose now that (23) - (25) have been estimated in the indicated manner, and their functional form is, thus, specified. The system (23) - (24) may now provide an estimate of the derived demand for the spectrum input, i.e. the number of channels m, assuming that price s (in $ per channel per period) is charged for the use of the channel by DOC. In such a case the use of the channels allocated to them becomes proprietary to the firms in the sector, and the number of channels that they wish to purchase is now an endogenous variable. The total profit of the sector becomes now Π - sm, and the firms purchase the number of channels that maximizes their profits. The first-order conditions are now (ignoring the fact that m is discrete)

$$(26) \qquad s = \frac{\partial \Pi(p,W,r,h)}{\partial h} \; \frac{\partial G}{\partial \left(\frac{\Sigma n_i}{m} \right)} \; \frac{\Sigma n_i}{m^2}$$

where the subscript t has been omitted for convenience. If desired the number of mobiles, as well as the arguments of G, can be expresed in terms of the prices, if we use the Hotelling-Shephard Lemma.

We can now discuss briefly the relaxation of some of the assumptions used in constructing the estimating system (23) - (25), although a more complete specification would depend heavily on the particular sector under consideration. Suppose, for instance, that channels are not assigned exclusively to a single sector, but that the channels are shared between J sectors, without any consistent allocation pattern (other than having the same h). Then all J sectors have to be estimated simultaneously, with an equation such as (23) being applicable to each one of them, while (24) or (25) would still be valid, but it would now have J arguments (aggregate outputs) replacing the second argument in (24). The difficulties are technical rather than conceptual.

The second assumption to be relaxed does not affect the empirical work but has important conceptual implications concerning the pricing equation (26). Suppose, for instance that DOC introduces some flexibility in its spectrum allocation policies, allowing firms to "purchase" for channels on an exclusive usage basis either in the VHF or the UFH portion of the spectrum, with the freedom to use their own technology. For simplicity, assume also that the function $D(K_i, h)$ of (21) has exactly two values, $D(K_{iv}, h) = h_v$, or $D(K_{iu}, h) = h_u$, for $K_{iu} \geq K_{iv}$, the subscripts u and v referring to the UHF and VHF spectrums respectively. Let also k denote the price of the transmission capital. Given an existing channel occupancy pattern, a new firm would choose the UHF spectrum if

$$(27) \quad \Pi(p,W,r,h_u) - kK_u > \Pi(p,W,r,h_v) - kK_v \ ,$$

if the charge for spectrum usage is the same for both parts of the spectrum. The modification of (27) to account for differential pricing of the spectrum is obvious. We note that we need here two equations like (24), one each for UHF and VHF.

As a final point we discuss the assumptions of perfect competition, implicit in (22), and of the additivity or existence of an aggregate profit function for the sector, as in (23). None of these assumptions is, strictly speaking, necessary on a conceptual level, since the same oligopoly model as in the case of broadcasting may be adapted to our purposes. Since perfect competition is analytically more convenient, however, and since most sectors heavily represented in land-mobile usage (taxicabs, trucking, construction, etc.) are thought to be closely approximating the competitive model, we believe that it forms a convenient starting point.

IV Sectoral Studies for Land-Mobile Usage

In applying the model described in the previous section three sectors present themselves as obvious candidates: Transportation (including Public Utilities and Communications), Construction and Public Administration. These three sectors account for close to 65% of total land-mobile usage in Canada, however that may be measured. ((20), pp. 12 and 14). In addition, they present the advantage of being fairly well-defined and (comparatively speaking) homogeneous with respect to product. We proposed, therefore, that, should the hypothesis of spectrum scarcity be validated, these sectors be studied as far as their future land-mobile usage is concerned. The model developed in the previous section may serve as a starting point for econometric investigation in most of them.

For the Public Administration sector (i.e. police, firemen, other municipal services, etc.), while the profit function approach is, of course, no longer applicable, the modelling of the production process, under appropriate assumptions, may still yield estimating equations, for spectrum usage. We shall examine the case of police in some detail, the other cases being similar.

Equations (15) and (16) are still applicable in the police case, except that a conceptual problem exists with the definition of "output" which is multidimensional. In general, we shall assume that the police output is a function of a number of socioeconomic variables, that define, so to speak, the "demand" for police services. Such variables may be, as in (12) and (22) population, area covered by the police activities, economic activity in the retail, wholesale and service establishments, percentage of "young" people (say under 25 years of age), etc. Instead of the profit function (18) a cost function may be defined corresponding to (15) (since the output is now exogenous) and used in the empirical work. Given that specified demand function from police services, the estimating equations become now

(28) $C = C(q, W, r, h)$

(29) $q = D(E)$

where E represents the vector of socioeconomic variables referred to earlier, and W, r and h have the same meaning as in the general case. If necessary as it will be explained further on in this section), the spectrum input quality variable h can be replaced by a function such as (20), with arguments the number of vehicles per channel and the output q. Needless to say, the Hotelling-Shephard lemma is no longer valid, and (21) has to be modified by introducing D(E) as the second argument of G.

A number of issues ancillary to this research have a direct effect upon the assumed shape of the function C or D. For instance, the question of economies of scale in police services is reflected directly into the cost function: if there are no economies of scale (constant returns to scale or linear homogeneous production) then C(q, W, r, h) is linear in q (average cost constant with respect to q). This issue was examined in depth in (12) and (22), but the results of these two studies tended to contradict each other. Further, the exact definition of the variables that compose the vector E will be left to be determined empirically. We have used as a starting point the ones used in (12), but this initial list will undoubtedly be subsequently modified. Finally and from the empirical point of view, all variables are easily available either from municipal expenditure data or from other publicly available statistical sources.

The Construction sector is typically composed of small or medium-sized firms, and it has experienced a large growth in its use of land-mobiles, as documented in (20) and (23). As noted in (23), a number of technological developments in the industry, such as the increased use of prefabricated materials, the increased proportion of high-rise in relation to total residential construction, and the increased use of cranes and other heavy machinery, are responsible for this growth. By 1976 the total number of land-mobile systems used in Construction in the 19 main metropolitan areas of the country amounted to 2,204. As mentioned earlier, the high growth in the adoption of these systems by the Construction sector in recent years (22.64% per year over all 19 metropolitan areas according to (20), p. 20) is most probably not sustainable in the long run, since there is a limited number of construction firms, and once all of them are equipped with a land-mobile system the only possible growth would be through a growth in the number of firms. This conclusion is valid under the assumption that most past growth was due to existing firms adopting a land-mobile system for the first time and not to land-mobile using firms acquiring additional frequencies; this assumption should be investigated empirically for all sectors.

There are no particular problems about the application of the general model of the previous section to the Construction sector. The sector is well-defined and homogeneous and the assumption of perfect competition is most probably justified. Inputs, outputs and prices are all well defined and data for these variables is publicly available. Subject, therefore, to the caveat on the non-existence of congestion (see below) the estimating equations developed earlier are applicable here without further modifications.

Similar considerations apply to the Transportation sector, together with the related sectors of Communications and Public utilities, with the difference that the sector is no longer homogeneous. Hence, the empirical estimation should be carried out in relatively homogeneous subsectors such as Trucking. There is no reasons to repeat the earlier analysis, since very little conceptual novelty is involved here.

We conclude this section by pointing out the consequences of proceeding to empirical estimation without examining the existence of congestion in a given spectrum-using sector. Suppose that no congestion is present during the entire period from which the data is drawn. Then the observed spectrum quality input h_t in (20) and (21) becomes approximately constant and subject only to random variations for all observed levels of

Similarly, the profit function (19), given that all firms in the group use spectrum, becomes independent of h_t for estimation purposes, since h_t is approximately constant for all observations t. An interesting empirical work in such a case would be the estimation of profit functions for two different samples of firms, in the industry one using and the other not using land-mobiles in their operations. The data collection problems in such cases, however, are likely to be severe.

V. Summary of Proposed Research and Discussion on the Valuation of the Spectrum

We conclude this report by summarizing the steps outlined in the previous sections which are, in our opinion, necessary for the development of the main research. In so doing we shall also reiterate the basic premises that led us to undertake the examination of the items treated in this report.

The fundamental concept is that of of a scarce resource (the spectrum), allocated administratively among competing uses of varying economic and technological characteristics. In examining the value of this scarce resource we have to examine each using sector, since all such sectors are contributing to the scarcity. We identified as a target area of actual or potential scarcity the VHF portions and UHF of the spectrum, and as major types of users the broadcasting industry and the various land-mobile using sectors.

In the main body of the report we examined in detail the microeconomic structure of these types of spectrum users and we outlined some proposed methods of estimation, that will be also summarized below. In this final section we shall also establish the links between the proposed estimations and the question of spectrum valuation, that forms a major target of this report. These links have already appeared in various parts of the report and our purpose here is to discuss and summarize them.

Economic theory postulates that the value of a resource is equal to the contribution to total product of an additional unit of the resource (or vice-versa, the reduction of total product resulting from a reduction of the resource by one unit). This marginal value of the resource can be derived from the empirical work suggested in the body of the report, as we shall now establish. Before proceeding to this, however, we note that the marginal value of the spectrum with the current policies and practices, would probably be higher for broadcasting than for land-mobiles, and, within each category of service, will be higher for VHF than for UHF. The latter is, of course, obvious, but the validity of the former statement can be easily established by the following reasoning. As things currently stand, the acquisition of additional spectrum for land-mobiles will reduce the congestion (if any) of the channels already in use thus benefiting all existing users. Since no restriction in the number of users is currently enforced (nobody is presented from acquiring a land-mobile license if he so desires), and since it has already been argued that congestion is currently rather "small", the value of additional spectrum denoted to land-mobiles is likely to be close to zero. In broadcasting, by contrast, an increase in the VHF spectrum will create additional users in a given area, so that the marginal value of the spectrum in broadcasting is the adjusted value of an additional license in a given area (to be defined more precisely below) *minus* the reduction in value of existing licences. From the data in [1] this figure appears to be positive, at least for the VHF zone.

The proposed empirical work for broadcasting may be summarized by the following steps:

(i) Estimating equation

(18) $\log V_j = \log \phi(r,Q,J,Y,C,t) - \log [R_F + b_j(E(R_M)-R_F)]$

(ii) Collect data on sales prices for TV, AM and FM radio stations. Classify this data by type (e.g. UHF and VHF TV, AM and FM radio, etc.). (18) will be applied to each group thus defined. Let V_j be measured by the sales price of the station.

(iii) For each station let the potential audience Q be measured by (say) the A- or B-contours. Let Y be measured by the *per capita* income of the region in question during the year of the sale. For TV stations let t be measured by the number of years from the date CATV was introduced till the date of the sale. Let J denote the number of competing stations of the same type within the contour. Finally, let r be measured by total advertising revenue of the type of station under consideration divided by a measure of viewing frequency (such as Nielsen rating) during the year of the sale.

iv) For each station let R_F be measured by the observed yield on government securities at the date of the sale of the station. Let $E(R_M)$, the average yield on the market portfolio, be measured by the average return of the TSEI during the months before the date of the sale.

v) Estimate (18) with the data collected in steps (ii) to (iv) by finding an appropriate functional form for ϕ, as well as the value of b_j.

vi) Given the functional form of (18), find for each type of station the <u>average</u> value F(Q) of the physical capital necessary for broadcasting. (This information is collected annually for each license holder by Statistics Canada). The value of a license net of the physical investment is V_j minus the physical capital invested.

vii) Given the functions ϕ and b_j the value of an <u>additional</u> license in a given region that has already J stations of the type under consideration can be computed as follows: the new license will have a risk adjusted value equal to

$$[R_F + b_j(E(R_M)-R_F)]^{-1}\ \phi(r,Q,J + 1,Y,C,t)$$

Let also $\Delta\phi \equiv \phi(r,Q,J,Q,Y,C,t) - \phi(r,Q,J+1,Y,C,t)$, the decrease in value of each existing license (unajusted for risk). Hence, the total additional value (including the physical investment) is equal to

$$V = \frac{1}{R_F + b_j(E(R_M)-R_F} \{\phi(r,Q,J+1,Y,C,t) - J\Delta\phi\}$$

The value of the spectrum now (in \$ per unit, where each unit is equal to the number of channels necessary for the station in question) is equal to V - F(Q), where F(Q) is the value of the physical investment necessary in order to reach the potential audience Q.

viii) We note that the value of the spectrum in broadcasting cannot be separated from the political decision to allocated power to the station sufficient to reach its potential audience. Similarly, although we subtracted the value of the physical investment and computed the value of the spectrum (or, rather, of the license to use the spectrum in broadcasting) as a residual, the spectrum is really complementary to the physical investment and should be treated as such.

For land-mobiles the situation is considerably more complex. In contrast to broadcasting, demand for spectrum usage (at, virtually, zero price) has been left to proceed unchecked, and DOC has responded to the growth in demand by simply opening up more frequencies for land-mobile usage. The empirical problem problems to be examined in the main body of the follow-up research can be divided in the following parts: a) Estimate the growth in demand with current policies, as well as the contribution of the spectrum usage to total economic welfare. b) Estimate the value of the spectrum as a function of exogenous variables, again under current policies. c) Find a way to project the spectrum usage pattern under hypothesized spectrum pricing policies. The previous sections of this report dealt with (a) and (c), hence we shall have to discuss (b) at some length. The proposed research will follow different stages, each one of them depending on the results of the preceeding one.

Suppose that we have a land-mobile using sector in a given area, where all firms operating in that sector have already adopted land-mobiles for a number of years in the past. As we have established, the sector's total profits will be a function of the spectrum quality input h, given that this input has been both observable for some time in the past and has varied "appreciably" during the period. We have already identified as a satisfactory proxy for h (an index of "poor" quality, perfectly negatively correlated with h) the waiting time (either average or peak). On the other hand, we have also established that h depends on the number of mobiles per channel, as well as total output of the sector. Suppose also that the estimating system

(23)-(25) has already been estimated. Then the value of the spectrum (in $ per channel) is given by (26), i.e. it is equal to: (increase in sector profits per unit decrease in waiting time) times (drecrease in waiting time corresponding to an additional channel made available to the sector). In what follows we shall explain why this elegant and rigorous method is not likely to be of much help in our case, and we shall offer some imperfect but practical alternatives.

Analytically, the proposed empirical work for land-mobiles may be summarized as follows:

i) Examine raw data on channel occupancy and number of arrivals from the channel monitoring process in selected district offices. Such data exists, at least in the Ottawa and Toronto district offices, as evidenced by [3]. Convert the data into waiting time distributions (this is done through the SRI program) for each channel. Examine the consistency of these distributions across channels in a given area. Compute the following statistics for each channel: average waiting time, peak waiting time and again examine the distribution of these statistics across channels.

ii) Consider the following questions:

(a) Does congestion (as measured by waiting time) currently exist in any channel in the areas under study? If the answer to this question is no then the current value of the spectrum (and, by extension, the value in previous periods) in land-mobiles is equal to zero, since increasing the number of channels devoted to land-mobiles will not increase economic welfare. If the answer is <u>yes in some channels</u> (we already know that congestion does not exist in all channels, or even in most channels) then consider question (b).

(b) Can congestion be eliminated entirely by reassignment? If the answer here is <u>yes</u> then again the current (and past) value of the spectrum devoted to land-mobiles is zero, and our only concern is with predicting future congestion and with anticipating the time, when the value of the spectrum will become positive. See steps (vi)-(xi) below. If the answer is <u>no</u> then proceed to the estimation of the current value of the spectrum by the following steps (iii)-(v) below.

iii) Given that a "significant" waiting time (both average and peak) exists in a number of channels, run the following regression across these channels.

$$[\text{Waiting time in channel}] = a_o + a_1 \, [\text{Number of mobiles in channel}].$$

The estimation of a_o and a_1 will make it possible to find the reduction of writing time due to an increase in the number of channels. The regression should be applied with both average and peak waiting times in each channel as dependent variables.

iv) From the above regression we know that Δ[Average waiting time in all channels] = $a_1 \Delta$ [Average number of mobiles per channel across all channels], where the LHS denotes the difference (reduction) in the average waiting time created by the reduction in the average number of mobiles per channel, which is, in turn, created by an increase in the channels allocated to land-mobiles. Since a_1 was estimated in the previous step and the number of land-mobiles on all channels is known the LHS can be found straight-fowardly.

v) The value of the spectrum with current congestion levels is an imputed value to the reduction of the waiting time computed in step (iv) above. This imputation is subject to the well-known limitations and inaccuracies attached to similar exercises, but a starting point already exists in the literature due to the work of Plotkin([19]; see also the summary in [8], p.34). For a trucking firm Plotkin has estimated the costs of delayed transportation due to congested radio frequencies, as a function of the labor costs, equipment costs and vehicle speed. The estimation is based on a queuing model that assumes that messages arrise according to a Poisson process at a rate of λ, and mean message length of $1/\mu$. Thus, with Plotkin's data an average message length of 10 seconds and a message arrival rate of 1.2 per minute (corresponding to an occupancy of 0.20 and an average waiting time of approximately 0.20 minutes) yields annual congestion costs per channel of the order of $1,381 U.S. The relationship fitted by Plotkin between average waiting time and congestion costs is highly non-linear but conceptually fairly simple. Given the reduction in the waiting time per channel computed in step (iv) the Plotkin estimates yield a corresponding reduction in cost of congestion per channel, which, multiplied by the number of channels, yield the value of an additional channel allocated to land-mobiles. A few additional remarks on spectrum valuation are in order at this point. First of all the results of the Plotkin estimation show that occupancy and waiting time must rise "substantially" before the costs of congestion would become "appreciable". As discussed earlier, at least two thirds of the Toronto channels were below the level of occupancy of 0.20 used in the numberical illustration above. More important, C-T present some evidence ([8], pp. 33-36) that show a strong upwards bias in the Plotkin estimates, which, in their opinion, should be considered as an upper bound.

vi) Under all circumstances the future demand for spectrum for land-mobiles as a function of economic variables needs to be estimated. We established earlier the fact that three major users of land-mobiles are the sectors of Transportation, Construction and Public Administration. We shall establish the projections at the level of those three sectors, keeping always in mind that we are interested in spectrum wage insofar as it contributes to spectrum congestion. Hence, from past IRLS data we must find past growth net of non-congesting uses of spectrum such as intra-plant use and paging (by ignoring the frequencies where these uses are concentrated). From this resulting net past growth examine whether there has been an increase in mobiles per system (base station) and whether there has been any tendency of firms to acquire more than one frequencies in a given region.

vii) If (as is most likely) firms do not acquire more than one frequency then the upper limit in the total number of land-mobile systems used by a particular sector in a given region at a given time is equal to the total number of firms in the sector in the region in question. If, in addition, there has been no growth in the number of land-mobiles per system then the total number of firms in the sector and region times the average number of mobiles per base station yields the upper limit on the total number of mobiles in the region and sector. If the number of mobiles per system has grown, then follow step (viii) below.

viii) The increase in the number of mobiles per system *ceteris paribus* would increase waiting times and reduce sector profits as per system (23)-(25). However, it has already been established that the current waiting times and, *a fortiori*, the past waiting times, are rather low and the losses due to congestion too small to be detectable by econometric work. Hence, the production function approach can be used in empirical work only in order to project future growth in land-mobile usage as a function of the growth of the sector if the acquisition of additional mobiles does not increase the waiting times then the demand for additional licenses per frequency is equal to the demand for additional equipment that uses mobiles. The outline of the estimation will take place in (ix)-(xi) for the Trucking, Police and Construction sectors respectively.

ix) Trucking demand for Land-Mobiles: Consider a sample of firms, each with one single base station frequency, not necessarily in the same region, observed over a number of time periods. From IRLS we have data on the number of mobiles that these firms used each time period. Assume that each truck was equiped with a radio. From the Hotelling-Shepard (H-S) lemma we know that the number of trucks used by the ith firm is equal to $\frac{\partial M_{it}}{\partial r}$, where r_t is the annualized cost of the truck and M_{it} is given by (22). Assume, for illustration purposes, a log linear form of the profit function and fit the following time-series regression to the sample (omitting the error term).

$$\log_{nt} = a_o + a_1 \log P_t + a_2 \log W_t + a_3 \log f_t + a_4 \log Z_t$$

where $n_t = \sum_i n_{it}$, the total number of mobiles at time t (from IRLS).

P_t = the freight rate of the trucking industry (in \$/mile ton) at time t.

W_t = a wage index of the trucking industry at time t.

f_t = the price of fuel at time t.

r_t = the annualized cost of a truck at time t.

The above equation (which may be fitted on the percentage growth of all variables instead of the aboslute levels to avoid autocorrelation) yields the demand for land-mobiles originating from those firms already using land-mobiles. The total maximum demand by the trucking sector if all firms in a given region were equiped with land-mobiles can be found if the total number of land-mobiles in the region is divided by the proportion of firms in the region possessing a base frequency.

Given now the number of mobiles for the sector (current or maximum) the value of the spectrum in the trucking sector is a function of the number of channels allocated to the sector (on an exclusive basis). Steps (iii)-(v) are applicable here without change.

x) Police Demand for Land-Mobiles: The same considerations apply here, except that the H-S lemma is applied now to the cost function (28), i.e. $n_t = \frac{\partial C}{\partial r_t}$, and the output has been replaced in (28) by the function D(E). The following regression is applied to our sample which may be pooled cross-section and time-series here omitting again the error term.

$$\log n_{tt} = C_o + C_1 E_{1i} + C_2 E_{2i} + C_3 E_{3i} + C_4 E_{4i} + C_5 \log W_t + C_6 \log r_t$$

where n_t = the number of mobiles used by police in region i at time t (from IRLS).

E_{1i} = population in the ith region

E_{2i} = area covered by police activities in ith region

E_{3i} = economic activity in the retail, wholesale and service establishments in the ith region.

E_{4i} = percentage of "young" people (under 25) in the ith region.

W_t = average compensation paid to police at time t.

r_t = the annualized cost of a police vehicle at time t.

The above equation, (which again may be fitted on the percentage growth of the t-subscripted variables) yield the total demand for land-mobiles, under the assumption that all police vehicles are so equipped. Given the demand for land-mobiles and the number of channels allocated to police, the value of the spectrum in the police frequencies is derived by finding the average waiting time from the regression in step (iii), computing the reduction in waiting time corresponding to an increase in the channel allocation, and imputing a value to this reduction as in step (v).

xi) Demand for Land-Mobiles by the Construction Sector

This is for all practical purposes identical to the Trucking sector. For a number of firms possessing a frquency over a number of year let the estimating equation be:

$$\log n_t = C_o + C_1 \log P_t + C_2 \log W_t + C_3 \log m_t + C_4 l_4 + C_5 r_t$$

where $n_t = \sum_i n_{it}$, the total number of mobiles used by the firms in the sample at time t (from IRLS).

P_t price index for new housing at time t.

W_t wage index of the construction industry at time t

m_t price index for construction materials at time t.

l_t price index for serived land in the region at time t.

r_t price index for construction equipment at time t.

The remards about spectrum valuation made in (ix)-(x) are also applicable here.

(xii) As a final remark we note that the question of spectrum valuation <u>with current policies</u> is really a question of deciding about the relative level of waiting times across the various land-mobile using sectors. A reduction in the congestion of a given sector through an allocation of additional channels must come through one of three possible ways: a) from another sector within the land-mobile allocation. b) From broadcasting. c) By opening up new bands for land-mobiles. In case (c) as long as new bands exist the value of the spectrum is zero. In case (b) the value of the spectrum has been determined in the case of broadcasting. If, however, we have to remain in case (a) then an economically "optimal" allocation is to attempt to equalize value (as determined in (iii)-(v)) across all sectors.

VI. CONCLUSIONS

As we established in the previous section, the valuation of the spectrum in its various uses is a function of the (essentially arbitrary) administrative division of the spectrum into non-overlapping bands, with each type of use confined to its own band. The proposed research outlined in the previous section aimed at evaluating the spectrum in the two principal uses (broadcasting and land-mobiles) examined in this report. Presumably, the output of such a research can be used in finding the economic consequences of allocating more spectrum to each one or both of these types of uses, or shifting spectrum from one to the other. In the latter case the shift is economically justified if the value of the spectrum in the sector that loses is lower than the value of the spectrum in the sector that gains. We have already speculated that the empirical work is likely to show that a shift of VHF spectrum from land-mobiles to broadcasting is probably going to increase total value. The situation for the UHF spectrum is <u>a priori</u> unclear.

This kind of reasoning is valid for small, gradual and marginal changes in the relative allocation. Our valuation methodology is not valid for drastic changes, since such changes will alter the estimated coefficients of the regressions. In addition, drastic changes may trigger other developments with unclear results.

For instance, in the case of broadcsting Crandall and Taggart conclude in [8] that maybe an optimal allocation would consist in shifting the entire TV broadcasting industry to the UHF spectrum and allocate all VHF to land-mobiles. There is no data to support such an assertion, but it is safe to state that the consequences of such a drastic shift cannot be evaluated on the basis of past results. As an example of a consequence, of all (or,even, most) TV is shifted to UHF the handicap of UHF stations vis-à-vis VHF in terms of the potential audience Q would alsmost certainly disappear.

Two additional points of theoretical interest need to be made. The first refers to broadcasting and the identification of the value of the spectrum with the value of the license to the broadcaster. Such an identification has the advantage of yielding measurable results, but it is an underestimate of the total value to society, since it ignores the consumer surplus. The measurement of the latter is feasible, but the method is lengthy, full of questionable assumptions, and not directly comparable to the method proposed for land-mobiles. Nevertheless, for an essentially monopolistic sector the difference between total and producer surplus is likely to be substantial.

The second point has been raised before and deals with distributional questions. The spectrum is a public resource, and benefits accruing from <u>exclusive</u> use of a portion of it by a private individual should be treated no differently from the benefits derived from the exploitation of any other publicly owned renewable resource. In the case of land-mobiles the question does not arise, since the license to use the spectrum is not granted to somebody to the exclusion of other users (except for the relatively minor effect of cheaper equipment for the VHF zone). In the case of broadcasting, however, the granting of exlusive licenses at virtually zero price creates producer benefits from the use of the spectrum that accrue solely to the licensee. We saw that evidence exists that many licensees have subsequently realized these benefits by selling the license and pocketing the proceeds. As already mentioned, the empirical work proposed in this paper would allow us to estimate the expected price to be paid for a given license as a result of a sealed tender auction.

For land-mobiles we have focused our attention to the study of spectrum congestion, since we argued that this is what determine the value of the spectrum in land-mobiles. If congestion does not currently exist to any "appreciable" degree, we have indicated that a projection of the trend of past congestion into the future is desirable. Without exception, past studies have concentrated on projection of the trend of past land-mobile usage. We have argued that this is likely to be very different from the trend of congestion, because of the many non-congesting uses of spectrum. Hence, even simple extrapolation techniques could yield valuable results, if the data is adjusted as indicated. Next we examined projections of spectrum usage in land-mobiles on a sectoral basis. If it turns out that most past growth was due to new firms in a sector adopting land-mobiles, then this source of growth is going to disappear once all firms in a given sector and regiona have acquired a land-mobiles frequency. The forecasted congestion under such a hypothesis is easy to ascertain. If, on the other hand, part of the growth is due to more mobiles being added to an existing base frequency, then econometric models were developed in order to estimate such a growth on a sectoral basis for three important sectors. As indicated in the previous section, the whole research is organized into stages, with each stage being crucially dependent upon the results of the previous one.

ERRATA

Foreword, line 5, outlined

p. 11, expression (3): $= A[\sum_{j=1}^{j} P_j, Q]$

p. 13, line 4,: ap_j^b

p. 21, line 12: delete $= 1 + r_F$, and r_F

p. 21, expression (17): $b_j(E(R_M)-R_F)$

p. 22, expression (18): $= \log\phi(r,Q,J,Y,C,t)$

p. 22, line 12: ϕ is also

p. 22, line 10 from below: spectrum

p. 32, line 19: n_i the number ...

p. 38, line 6 from below: Equations (19) and (20)

p. 39, line 4: (22) a cost ...

p. 39, line 5: to (19)

p. 39, line 17: and (25)

p. 40, line 9 from below: (20, p. 20)

p. 41, line 5 from below: in (24) and (25)

p. 41, line 3 (missing) from below: $\frac{\sum_{i=1}^{I} n_{it}}{m_t}$ and $\sum_{i=1}^{I} q_{it}$

p. 41, line 2 from below: function (23)

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A P P E N D I X

Detailed Revue of Relevant Literature

Review of the Literature

Introduction

The difficulties found in the spectrum allocation seem due as much to the built-in deficiencies in the allocation practices as to the inherent characteristics of the radio spectrum resource.

Most of the allocation practices have been justified as a means to control interferences [2]. Some of those practices are:

1) Use rights are given by the government;

2) Recipients are not permitted to sell or buy any portion of their rights;

3) The available spectrum is subdivided and alloted to specific services. Some portions of the spectrum are alloted to specific services without a limit to the number of individuals who can use them; and

4) Government users receive first consideration in the distribution of the spectrum [14].

One of the striking features of the history of frequency spectrum management has been the failure to recognize the economic nature of the interference problem. Interference is not a technical problem peculiar to the use of the spectrum. It is a manifestation of scarcity, and its analogy to other resources, land, labor, and capital is obvious [2, 12, 13, 14].

Nevertheless the problem is not as simple as it could appear from the above remark. Consider a specific use of the spectrum, i.e. broadcasting. A broadcasting program is an economic object and its consumers and producers are economic subjects of a very peculiar kind [30]. Some of the peculiarities are:

1) To avoid interferences (externalities) there can only be a limited number of frequencies in certain areas, so that monopoly or oligopoly are inevitable except in cases of U.H.F. - sound or U.H.F.-T.V.;

2) The marginal cost to a producer of a new listener-viewer is zero;

3) The economies of scale are very large;

4) A broadcasted program is a public good with free disposal;

5) Payment is expensive to collect, i.e. the "cost of pricing" is far stronger than say the toll bridges or municipal transport;

6) The unit product in T.V. is very expensive. Programs are supplied in half an hour multiples, i.e. there are indivisibilities;

7) Since the article exchanged is either culture, entertainement, information or education it falls under the category of merit goods, i.e. some individuals are concerned with other individuals consumption.

It is well known that an economic environment with the above characteristics does not allow the existence of an efficient price system, i.e. a price that leads to a Pareto Optimal allocation. The problem of scarcity requires a system for allocating resources, in the first instance to broadcasting and, secondly, within broadcasting, among types of programs [16]. Consider "Subscription" and "Free" T.V. as two polar examples of price failure. In the case of "Subscription" T.V. why to prevent any family which would receive positive pleasure from turning in on a program it ifs marginal cost to the producer is zero? On the other hand if a zero price is charged to the viewers it is absurd to think that "there is no need for long-run considerations concerning the amount of indivisible resources to be allocated to an activity to take into account the opportunity cost of those resources in alternative uses" [25]. Furthermore the problems related to the individual revelation of preferences will make it impossible to achieve the optimal lump sum tax - T.V. program combination. Nevertheless, according to Samuelson, we do not need to be too pessimistic "To say that market mechanisms are non-optimal, and that there are difficulties with most political decision processes, does not imply that we can never find new mechanisms of a better sort" [24].

Since Cable-T.V. express their desire by forgoing some income for the privilege of viewing it has been widely used as source of information to evaluate the "Free" T.V.-Radio systems, [3], [6], [7], [13], [17], [19], [20] and [21].

Cable Television (CATV) has been seen as a "more rational" means to increase social welfare by increasing consumer choices. Nevertheless the implantation of CATV arises two problems: first can CATV pay its way? And second Is the CATV impact on "Free" T.V. being compensated by the increase in the viewing choice? These problems have being analyzed by Comanor and Mitchell [3], Park [19], [21] and

Nool, Peck and McGowan (NPG) [17]. In their pioneering article [3] Comanor and Mitchell estimated demand functions and prospective profitability for CATV systems. Their model consists of capital and operating cost items specified as functions of the number of subscribers, number and type of programs, housing density and penetration (demandas percentage of potential home subscribers). The penetration is a function of the price for cable services, family income and number of programs supplied by the CATV relative to the "Free" television. Revenue is derived from the penetration, system size and advertising. Cost are determined by audited accounting statements and penetration by least squares from a random sample of existing systems. C-M concluded that CATV systems will be able to enroll enough subscribers only in areas served by less than three commercial stations.

C-M and Park [21] assume that price is a predetermined variable and not a function of the expected subscriber penetration of the system contradicting the fact that higher penetration for given cable plant investment will lower the average cost of performing the cable services, and, therefore, the price which cable owners must charge in order to cover their total costs. Furthermore estimating demand functions by assuming that the price is predetermined leads to biased estimates of the price coefficients.

The demand equation for Noll, Peck and McGowan (NPM) is the only one that is built from a "basic utility - maximizing model of decision making by the individual potential subscriber" [17*]. NPM's estimating equation is based upon a Cobb-Douglas utility function in "quality of television service" and expenditure on other goods. Their estimates of ultimate penetration in the 100 largest markets are only slightly above the predictions derived from the C-M's model. On the other hand, the estimates of ultimate penetration based upon Park's model are on the order of two-third [19] to one-half [21] of those presented by NPM...

C-M [3] and Park [21] are pessimistic about the prospects for CATV in the U.S. major urban markets. C-M predicted that few cable systems would earn as much as 12 percent on capital before taxes. Park's conclusion was gloomier since he forecasted subscriber penetration levels still below those determined by C-M. On the other hand, according to NPM CATV will be highly profitable, generating an above normal profit of $500 M. and a consumer surplus of $1.7B. annually. Nevertheless they cautioned: "These profit estimates should not be regarded as definitive for both the costs and the revenues assumed in Table 6-2 can, for any particular system, be grossly in error, ..." [17*, p. 157].

T. V.-Radio networks operate as intermediaries between their affiliated stations and the suppliers of programs. Networks buy the programs and pay for the system interconnection. Networks and affiliates share the advertising revenues generated by the programs. Network behavior has been studied in [1*], [4], [8], [13*], [17*], [20*], [22], [27*], and [30*].

Is this network organization compatible with the welfare criterion <u>the more program diversity the better</u>? Steiner [27*] proved that competition among networks may lead to <u>duplication</u> in programming if it is assumed: (i) that individuals would listen only to their preferred program type, (ii) that stations will seek to maximize audience and (iii) that as many persons as possible should receive the programs they are willing to listen. Wiles [30*] "proved" out of <u>imaginary figures</u> that neither maximum nor minimum program diversity is a tendency under <u>laissez-faire</u>, but only the most profitable <u>degree of differentiation</u>. "Under the relationships between cost and revenue obtaining for T V, minimum differentiation is most profitable to an oligopoly or monopoly, maximum differentiation to a polypoly". Furthermore if community satisfaction is measured by consumer's willingness to pay money, an oligopoly produces less "satisfaction" than either a profit-maximising polypoly or "satisfaction" - maximising monopoly.

Crandall [4], Park [20*] and NPM [17*] studied the economic feasibility of new commercial networks in the U.S. Crandall suggested that the net benefit to viewers of a fully competitive fourth network could approach $1 B. per year but that it would add only marginally to total audience and so that the total network advertising revenues would be nearly the same as for the three-network market. Park's model predicted that the income for the fourth network would fall short of that necessary for viability. On the other hand NPM from extrapolation of costs and revenues for the three existing networks concluded that U.S. could support six over-the-air television networks and that the additional consumer surplus would amount to about $10 B... [17*, p. 118].

A formal model of relationships between networks, affiliate stations and program suppliers can be found in [17*, appendix B].

The concentration of ownership and the related problems of collusion and price fixing have been studied by Peterman [22]. He found no evidence of collusion in order to restrict the size of the audiences or to facilitate price discrimination. From the consumer sovereignty view-point Wiles [30*] also minimized the dangers of the network oligopolistic structure: "The motor-car manufacturers are <u>also</u> an oligopoly, yet why do they satisfy all tastes?" ... (script mine).

Another item widely discussed in the spectrum literature is the substitutability of the spectrum Levin [11]. Substitutability is important from an economic view point because it permits the determination of shadow prices, namely the maximum sums users of the spectrum would be willing to pay rather than do without some marginal amount of band with.

The main problem in finding substitutes for radio is less technical than economic. If one is willing to pay the price there are always substitutes for the spectrum [11]. Open wire, sunken coaxial cable, subsmarine cable are some substitutes for radio. A less obvious substitute is transportation. If mobile radio systems may reduce the need for vehicles, drivers and fuel in a fleet of taxis, trucks or police cars, it must also be true that these displaced factor inputs may in turn replace radio [13*]. Based upon that kind of substitutability Crandall and Taggart [5] developed a production function approach to measuring spectrum's value in land mobile. They assumed that the land mobile communication output was a function of spectrum, dollars of annual equipment costs, and the number of mobile units. Then for fixed output and number of mobile units the trade-off between spectrum and equipment cost could be found, i.e. spectrum marginal cost. Similarly it could also be found the trade-off between spectrum and communication for different congestion levels. The cost of congestion was estimated by Plotkin [23]. It was assumed that the cost of delayed transportation due to radio congestion "was a function of the labor costs, equipment costs, vehicle speed and necessity for timely messages". Given the parameters for each of the relevant variables, the calculation of the congestion costs followed immediately [5, p. 33].

In the previous models of land mobile spectrum use the value of the spectrum was a function of the number of vehicles. The problems related to the demand for taxicabs and police cars in a deterministic environment has been studied by [10], [23] and [29], and in a stochastic environment by [9].

Given the actual regulatory polices, shadow prices will evidently not give the true value of the spectrum, what is needed for efficiency purposes. On the other hand unsolved theoretical problems will not allow at the "present" time to develop a relevant general theory of the spectrum value. The dilemna is well described by Paul Valèry

"Tout ce qui est simple est faux
"Tout ce qui ne l'est pas est inutilisable".

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MARKET SIZE, VHF ALLOCATIONS, AND THE VIABILITY OF TELEVISION STATIONS*

BY

STANLEY M. BESEN AND PAUL J. HANLEY

The Intermixture of VHF and UHF in the same market and the policy of having a large number of local stations have simultaneously reduced the competition among stations and the number of ciewing alternatives. Park[1] has argued that one of the effect of unequal competition is that is has precluded the possibility of the formation of a fourth U.S. television network. This paper attempts to measure the effects of a frequency allocation plan on the number of viewing alternatives in each market.

THE MODEL. Bensen and Hanley assume the functional relation $N = f(TVH)$ where N is the number of stations in a market and TVH the number of households with T.V. sets in that market. Since the number of VHF allocations is limited at each market, the function f(TVH) will be valid only to the point at which TVH exhaust the VHF allocations. This number of households is given by

$$TVH^{*} = f^{-1}(VHF)$$

Beyond TVH^{*} the market follows a "lower path" g since additional stations must be UHF, which have less audience and inferior tranmission characteristics:

$$N = f(f^{-1}(VHF)) + g\ (TVH - f^{-1}(VHF)$$

The additivity assumption is somewhat more troublesome, since it implies essentially that all I firms are of identical size and operations. If such an implication seems to be empirically unwarranted, then short-run fixed factors such as the size of each firm's fixed assets, or the number of mobiles, have to enter the firm's profit function π_i in (18), replacing the corresponding prices as arguments. To proceed to aggregation then we have to adopt the assumption of linear homogeneity of the production function. See (5) and (7) for an extended discussion of the appropriate theory. Again considerations of this type have to be postponed till the actual empirical work.

For an allocation of spectrum now between broadcasting and land-mobiles the conventional approach, relying on general equilibrium theory, is to equalize the value of the spectrum, at the margin, between alternative uses. (See (4) for an extended discussion) In our notation this implies that the spectrum prices s used in (22) should equal the value used in (10), i.e. W_v divided by the number of channels corresponding to a given license. In our opinion, such economic arguments should not be extended too far, since the assumptions of equilibrium theory, that justifies the equality of marginal values, are sufficiently violated in order to render the conclusions rather dubious. Besides, under any pricing scheme the public authority would want to retain degree of control and impose many subsidiary goals, so that the spectrum prices would play the role of planning instruments, with values adjustable to the desired goals and the existing situation.

Bensen and Hanley first assumed that f and g are linear:

$$N = a_o - a_1 \text{ (TVH) and}$$

$$TVH^* = (VHF - a_o)/a,$$

1) $N = a_o(1 + (a_2/a,) + (a_1 + a_2)\ TVH - (a_2/a,)\ VHF + a_3D$

where D is a dummy variable that takes the value 1 if a market has no VHF allocation and zero otherwise. For the sake of genrality, Bensen and Hanley also derive a logarithmic version of the alsove equation

2) $\ell n\ N = \ell n\ b_o(1 + (b_2/b_1)) + (b_2 + b_1)\ \ell n\ TVH - (b_2/b_1)\ell n(VHF + D) + b_3D$

Equations (1) and (2) are estimated using ordinary least squares (OLS) and Tobin's limited dependent variable (LDV)[2] techniques. A comparison between the four set of estimates indicates that the (LDV) logarithmic equation is the "best" so it is employed through the analysis.

USES.

a) <u>"Breakeven" Market Size</u>

The estimated equation is used to compute, for any number of VHF allocations, the number of household required before a market can support a given number of stations.

b) <u>The Drop-in Proposal</u>

The U.S. Office of Telecommunication Policy proposed a "short-spacing" plan that would allow that 53 additonal VHF television broadcasting be inserted into the major 100 markets. Bensen and Hanley calculated using the estimated equation that only 3 more stations would go on the air and that 25 VHF stations would be replaced by VHF ones. Sixty VHF channels will remain idle...

The paper's final conclusion is that to increase viewing alternatives, a policy favoring relatively few powerful regional stations is better than one favoring a larger number of local stations. Under this last policy if as many VHF allocations as could be used are made available almost 20M households would still be living in markets too small to support four stations.

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The Federal Communication Commission*

R.H. Coase

This article can be divided in two parts. The first is an account of the development of ratio-TV regulations in the U.S.. It shows the interactions between spectrum users and policy makers. The second part is a plea for the private property and the price allocation of frequencies.

In the beginning the use of the spectrum was not regulated. A letter dated March 30, 1910 from the U.S. Department of the Navy to the Senate Committee on Commerce bought the enactement of legislation to bring some order in the use of the electric waves through the ether:

> "Calls of distress from vessels in peril on the sea go unheeded or are drowned out in the etheric bedlam produced by numerous stations all trying to communicate at once".

Two years after, August 13, 1912, an Act was approved providing that anyone operating a radio station must have a license issued by the Department of Commerce.

> "The license would include details of the ownership, wave lengths authorized for use, the hours for which the station was licensed for work, etc". (p. 2)

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* The Journal of Law and Economics, October, 1959.

In 1918 the Secretary of the Navy J. Daniels tried to obtain the exclusive ownership of all wireless communication for commercial purposes. He told to the members of a House Committee:

> "My judgement is that in this particular method of communication the government, ought to have a monopoly, just like it has with the mails - and even more so because other people could carry the mails on trains without interference, but they cannot use the air without interference... There is a certain amount of ether and you cannot divide it among the people as they choose to use it". (p. 3)

The broadcasting industry came into beeing in the early 1920's. On March 1, 1922 there were 60 stations, by November 1, the number was 564... (p. 4), so the problem of interference was growing up fast. In 1921 H. Hoover then Secretary of Commerce had no discretion to refuse a license but it seemed that according to the 1912 Act had the power to grant specific wave lengths:

> "In 1925 the Zenith Radio Corporation was assigned the wages length of 332.4 meters, with hour of operations limited from 10:00 to 12:00 p.m. on Thursday and then only when this period was not wanted by the General Electric Company's Denver Station". (p. 5)

The Zenith Radio Corporation appealed. In a court decision rendered in April, 1926, it was held that the Secretary of Commerce did not have the power to wage such stringent regulations. The Secretary of Commerce was then compelled to issue licenses to anyone who applied. And that was the chaos.

In July, 1926, as a first measure to stop the chaos the Congress pass a resolution preventing the licenses establishing property rights in frequencies.

> "The ehter and the use thereof was declared to be the inalienable possession of the people of the United States". (p. 6)

In February 1927, an Act brought into existence the Federal Radio Commission. This act would give the government not only ownership of the spectrum but also the power to control programming. The Commission got massive powers to regulate the radio industry. It was pointed out that

> "Nothing in this Act shall be understood or construed to give the licensing authority the power of censorship". (p. 6)

Nevertheless the Commission maintained and got approval from the courts "that to decide whether the public interest would be served by granting or renewing a license, it had to take into account proposed or past programs".

The Commission's attempt to influence programming was clearly shown in a 1940 decision called the Mayflower case. The Commission criticized a Boston station for urging the election of certain candidates for public office and renewed its license under the assurance that the station would no longer broadcast editorials".

In 1943, in the NBC v. United States case the justice Frankfurter in delivering the opinion of the Supreme Court said

> "The facilities of radio are no large enough to accomodate all who wishes to use them. Methods must be devised for choosing from among the many people who apply... The facilities of radio are limited and therefore precious, they cannot be left to wasteful use without detriment to the public interest". (p. 13, italics ours)

Coase believes that public ownership is wasteful and program regulation unfair if compared with the freedom of the press. For Coase neither the spectrum scarcity nor the interferences are good arguments for private ownership.

The scarcity argument is difficult to defend if we observe that all the resources are scarce and that most of them are not owned by the government. To preserve ownership the government is unwilling to require "any payment for the use of frequencies". However, Coase points out, when transfers of ownership of radio and television station takes place with the government approval there is little doubt that the price of those stations includes a substantial payment for the use of obtaining the frequency, what makes the whole argument of government ownership somehow irrelevant.

Coase does not accept the interference argument either. He believes that in a market system some broadcasters, following the profit objective, will buy out of the market some of the interferences leaving at the end an optimal level of "spectrum pollution". Clearly Coase stands for a regulated market where the rights to use the spectrum are clearly established.

The problems are What regulations? What rights? and Whose rights?

COMMUNITY ANTENNA TELEVISION SYSTEMS AND LOCAL TELEVISION STATION AUDIENCE*

FRANKLIN M. FISHER

VICTOR E. FERRAL, JR.

This paper estimates the effects of CATV competition on local stations. Fisher and Ferrall (F-F) are specially concerned with measuring the extent of the economic impact on local stations of not being carried or of being duplicated by CATV.

CATV's, which do no programming, affect local television stations by:

1) Excluding their subscribers from the potential audience of local stations whose signals are not carried by CATV,

2) Carrying a local station but also carrying the same program by one or more additional channels, and

3) Bringing programs which would otherwise be unavailable in the market.

The Audience-Revenue relation

F-F's study is based upon a cross-section analysis at 127 stations. Audience is denoted A and is measured as the average number of households viewing each station during prime time. A regression of M (Revenue) on A with 1963 data yielded

$$M = 103,300 \div 26.63 A$$

i.e. a household viewing $3\frac{1}{2}$ prime time hours is worth \$26.63 in yearly revenue.

The Model

F-F assumes that A is related both to market size and factors affecting viewing habits.

$$A = N_1F_1 - N_2F_2 - u$$

where F_1 and F_2 are functions specifying the viewing of the "average" members of the off-the-air station and of the CATV carrying the study station's signal. N_1 and N_2 define potential audiences and u a random disturbance.

The independent variables of F_1 and F_2 respectively describe the competition given to a study station by the stations carried on the CATV.

$$F_1 = F_1\ (Q,C,I,D) \text{ and}$$

$$F_2 = F_2\ (D,G)$$

where Q represents the number of program alternatives to the study station programming. As Q represents both independent and network alternatives a variable I is introduced to indicate the relatively slight competition of independent stations. D is the "duplication variable" and it measures the fraction of prime time network programming carried on a study station.

$$G = \begin{cases} 0 & \text{if the study station is not affiliated to more than one network} \\ \Sigma_i X_i^s - D & \text{if } \Sigma_i X_i^s X_i^m > 0 \end{cases}$$

where i denotes the number of networks, X_i^s the study station fraction of prime time devoted to the i^{th} network and X_i^m the same for a station which is multi-affiliate. "G measures the maximum understatement of duplication afforded by D".

N_1 is measured as the number of households in a station audience area which watch that station at least one a week and N_2 as all subscribers to CATV carrying a local station.

To show the effects of each variable on A, we write the F-F's basic regression:

$$A = 1926 + N_1(.5322 - .3466 \log (1 + Q) + 1.535\ C + .4943\ I + .0707\ D_1) + N_2(.7574 - .6898\ D_2 - 1.2285\ G) \text{ with } R^2 = .9468$$

Some results

From the basic regression F-F conclude:

1) CATV's economic impact on station revenues is substantial,

2) A significant number of existing stations cannot withstand a relatively small increase in CATV penetration without concommittant cost reduction, and

3) A significant number of potential new stations, i.e. UHF, are lifely to be discouraged from entry by a relative small increase in CATV penetration.

* Quarterly Journal of Economics, May, 1966

THE INVISIBLE RESOURCE

USE AND REGULATION OF THE RADIO SPECTRUM*

HARVEY J. LEVIN

This book is divied into four section:

i) American spectrum system

ii) Principles and practice of spectrum allocation

iii) The level of spectrum development, and

iv) The interrelated tasks of competition and regulation

We will review (ii), (iii) and (iv).

The absence of market prices for spectrum is the source of most of the management problems. Section (ii) shows new management criteria and tools through which the behaviour of the users can be rationalized. Levin proposes the following spectrum allocation alternatives:

A) FREELY TRANSFERABLE RIGHTS. Rights are created by the courts or by the government. These rights are freely transferable.

B) AUCTIONS OF GOVERNMENT'S DESIGNATED RADIATION RIGHTS.

C) CHARGES TO USERS. Charges are applied according to the frequency, location and size of the reception area and time of broadcast. Rates might be derived from auction values, shadow prices or fixed at an arbitrary flat dollar rate.

D) SHADOW PRICES. Prices derived from maximum sums that current spectrum users will be willing to pay rather than do without some marginal amount of spectrum.

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* The John Hopkins Press, Baltimore, 1971

E) NEW ADMINISTRATIVE TECHNIQUES. 1) a greater control of government users, 2) the right to borrow frequencies and 3) control of spectrum managers who override economic considerations.

For Levin the freely transferable rights is the best system from an economic viewpoint. Nevertheless that implies a radical change of the current real-world customs which is not going to be accepted. Levin selects shadow prices (D), user charges (C) and intrals and auction values (B) as the best approaches given "current real-world practicalities".

Two examples on how to determine the shadow prices are given. The first example postulates competing claims on a band microwave frequencies by space satellite and terrestrial microwave system. The second postulates rival claims by land mobile and T.V. broadcast systems on a portion of the VHF spectrum. In both cases, the maximum price the rival claimants are presumed to be willing to pay rather than do without the frequencies are calculated.

With respect to the above calculations we quote Levin:

> "Because the practical difficulties are great, much carfeul effort is needed before proceeding with this approach".

Once the shadow prices are calculated, their values could be used to design a rental charge schedule. The need for rental charges comes primarily from the incumbent broadcaster lack of incentive to economize. Another rental charge proposed is the one derived from "efficient" spectrum usage E_s:

$$E_s = \frac{V_i B_i T_i}{\Sigma_j V_{dj}\ B_{dj}\ T_{dj}}$$

where V_i B_i and T_i = volume of physical space, bandwidth and time ideally required; V_d, B_d and T_d = the same derived to others.

Section (iii) concentrates in spectrum scarcity and frequency development. Levin claims that in the absence of organized spectrum markets, frequency congestion and spectrum scarcity may provide inducement to economize. To support his claim he shows how the increase of land mobile radio users has induced the development of equipment to use the higher banks with a reduction of bandwidth and band spacing.

With a multiple regression, Levin shows that the increase in channel loading, i.e. congestion, is better explained by population growth that by the number of channels, i.e. supply.

In the AM broadcast service congestion he also generated technological changes, i.e. improved antennaes. Nevertheless, this process of accommodation is not optimum from a welfare viewpoint due to the fact that latercomers have to bear the bulk of the extra cost of the entry.

IN T.V. and FM broadcasting the allocation of spectrum has been generous so no incentive has existed to "push" technical progress. For example, with present technology bandwith could be reduced by a factor of 10-100 if T.V. broadcasters could be induced to adopt a system that would "store video images and transmit only the changes in consecutive pictures, not the whole picture". Obviously, congestion is one of the incentives to economize spectrum by adopting new technologies.

As the access to the T.V. and FM spectrum is artificially restricted and the demand exceeds supply economic rents do exist. This economic fact is reflected by the premiums TV. buyers pay to station owners. That indicates another way of pricing spectrum.

Levin's thesis is explained in section (iv). He argues that while a full-fledged market would have theoretical advantages, more could be obtained with a regulated market-type system with prices. The obstacles to a pure market-type system are of practical and economic nature. Practical obstacles are the rigidities that arise from the existing incumbent's spectrum properly rights and from the political and government institutions in charge of managing the existent regulated type-system. Economic obstacles are the inefficiencies caused by the fact that broadcast signals are public and merit goods and that the broadcasters generate technical and pecunary externalities.

Levin's propositions can be reduced to two:

1) Pricing will reduce the stringencies in the use of the spectrum, and
2) Newcomer broadcasters should be granted similar rights then the incumbents in the evaluation of regulatory changes. Their investments must be considered in phasing in the new and phasing out the old. Using opportunity costs in spectrum utilization will help to correct actual imbalances in regard of the newcomer's potential rights and the incumbent's de facto property rights.

Management of the Frequency Spectrum*

William H. Meckling

Meckling believes that any effort to improve the efficiency of the frequency management must be built on the recognition that the spectrum is similar to most of the resources available to society and therefore it can be allocated through the market system.

The spectrum is by tradition managed in an odd and sometimes contradictory way. The Government defines and then gives away all use rights. The recipients of those rights are not allowed to seel any portion of them and so there is no incentive to economize. The efficiency problem is compounded by the fact that the rights to the spectrum are divided and alloted to specific services and no transfer is permitted between services, i.e., land-mobile and broadcasting. Furthermore, significant parts of the spectrum are allocated to services where the number of users are not limited and so part of the spectrum is transformed in a free good with all the implied inefficiencies. And last but not least since the government completely control the spectrum, government agencies get first consideration in its distribution and again at no cost.

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* Washington University Law Quarterly, Spring 1968.

The Criterion Problem

The policies more frequently cited in spectrum management are:

i) Allocated the spectrum to minimize interference

ii) Allocated the spectrum to maximize the utilization of frequencies

iii) Allocated the spectrum simulating the market system, and

iv) Let the market to allocate.

The criteria (i) and (ii) are clearly in direct conflict: to minimize interference is necessary to prohibite all but one individual to radiate, and the way to maximize utilization is to let everybody to radiate.

Criterion (iii) according to Meckling presents three main problems:

a) "If the FCC is to assign frequencies in accord with potential price, it must know how much prospective users would be willing to bid for rights".

b) What to do about the rights that have already been granted? and

c) It will be very difficult for a frequency authority to take away and reasign rights to those users who valued them more highly.

In (iv) Meckling proposes a straight market for frequencies. His main idea, like in Coase (1959), is simply that individual frequency rights should "be transferable in whole or in part, and in term of the three dimensions of band with, geographic location, and time". There are several objections to the proposition:

a) It would not correct the "congestion" problem in some frequencies

b) Monopoly in broadcasting and communication industries will be increased

c) Some users like amateurs, science, ambulances, fire and police departments ought to have frequencies free

d) Government should retain control of frequencies in order to control the quality of broadcasting.

Meckling defends the market system from those four criticisms as follows. Congestion of the spectrum (a), will actually diminish because as Coase (1959) "has proven", in the portion of the spectrum that is overused some users will buy-out others reducing the level of interference. With respect to (b) Meckling notes that the actual situation in U.S. cannot be worse, i.e., four networks, and furthermore that there exist anti-trust laws specifically designed to handle the monopoly problem. Objection (c) is ruled out on the ground that neither amateur broadcasters nor firemen, police and science, are given free equipment so there is no reason why "they shouldn't be forced to take into account the opportunity costs of frequency spectrum just as they are forced to take cn account other costs". Meckling answers to the fourth criticism with one question: "Would any are seriously suggest that printing presses or newsprint should be controlled by the government to control the quality of newspapers?"

Conclusions

Meckling believes that only the market system can "improve" the actual situation. Nevertheless it is almost impossible to get the policital support to undo the mistakes that have been made in the past. On the other hand it is very difficult to realize the steps that can be taken within the actual system to improve the spectrum utilization.

Meckling does not make clear in this paper how the problems attributed to the market simulation can be avoided with the introduction of the market system.

R.H. Coase, "The Federal Communications Commission", Journal of Law and Economics, 1, 1959.

ECONOMIC ASPECTS OF TELEVISION REGULATIONS

ROGER G. NOLL, MERTON J. PECK AND J. MCGOWAN*

The aim of this book is a critical examination of the public policies that determine the structure of the TV industry in U.S.A. Three major issues are treated: the demand for television, the economics of TV stations, and the analysis of regulatory behavior.

The Demand for Television

A model of viewer behavior must describe how viewers value different programs. The main evidence about viewer preferences comes from "free" television, subscription television, and cable television.

"Free" Televison Evidence: Free television according to NPM gives very little evidence about viewer preferences. NPM argue as follows: Since the price of TV watching is zero viewers will seek to watch a program type until its marginal benefit to them is zero. On the other hand networks will have no incentive to broadcast programs that provide benefits to the viewer more than incrementally above zero since no increase in revenue will be implied. "This arrangement implies that a large number of viewers regard the benefits from an increment to viewing time in general as negligible, but regard the benefits of additional hours of certain type of programming as very great". (NPM, p. 28)

So since zero price does not measure the marginal cost of programs the fact that the benefits of more programming of a particular type exceed zero is not sufficient evidence that more of it should be produced. A final statement about the composition of TV programming and a social optimum will finally depend upon a comparison of the marginal costs and the benefits of more programs.

There are three basic flaws in the above arguments. First nothing has been said about the competition among networks to increase their viewer shares. Second it seems that in the real world networks will try to increase the benefit to viewers until the cost of attracting a new viewer will be equal to the advertising reveune generated by the marginal viewer. And third it is not clear why "the benefits from increment to viewing time in general (are) negligible".

Suscription Televison Evidence: NPM associate suscription television with a voting system with proportional representation since different prices are paid for different kind of programs. In theory that implies that "individuals by concentrating their dollar votes ... overcome the unpopularity of their tastes". Price elasticity will therefore be the critical factor that would permit to measure the intensity of demand against the number of viewers at a going price. NPM state that even if price elasticities differ among programs, "networks would be unlikely to set prices accordingly", (NPM, p. 131). That statement is based upon two assumptions: (a) the popularity of a new program cannot be predicted at the beginning of a season, and (b) the popularity of a program is likely to change during a season. Hence given those uncertainties, the best strategy might be to avoid price premiums on the popular programs. The implication of such a price policy will be that free television will pick the same program mix than subscritpion television and that the TV price will be positive instead of zero, allowing networks to increase their profits significantly.

From the above arguments it is not clear why programs that would maximize audience at zero price will also maximize audience at a positive price and consequently the argument that networks will increase their profits is not necessarily true.

The Cable Television Evidence: To NPM Cable or Community Antenna (CATV) constitutes the only means through which individuals can express the intensity of their demand for viewing options by their willingness to pay for the opportunity to expand the number or increase the quality of television signals they can receive, (NPM, Appendix "A").

NPM build a model of cable television demand using a Cobb-Dougals utility function as follows. Let Y be the income of a representative potential subscriber to a given CATV, s the cost of television quality and Q an index of TV viewing quality. The utility-function of a CATV typical subscriber is assumed to be

$$U_c = A(Y - S)^{\lambda} Q_c^{\beta}$$

If he does not subscribe his ability from free television will be

$$U_f = AY^{\lambda} Q_f^{\beta}$$

given the fact that S vanishes.

The maximum subscription fee S* the viewer will be willing to pay is the fee that equates U_c and U_f

$$S^* = Y\left(1 - \left(\frac{Q_c}{Q_f}\right)^{-\gamma}\right)$$

so that

(1)

$$-\gamma = \frac{l_n\ (1 - S^*/Y)}{l_n\left(\frac{Q_c}{Q_f}\right)}$$

The distribution of potential subscribers to any CATV is assumed to be

$$f(\gamma) = \mu e^{-\mu\gamma} d\gamma$$

Letting N_s be the number of actual subscribers and N_p the

$$N_p - N_s = N_{p_\delta}{}^{\gamma} \mu e^{-\mu\gamma} d\gamma$$

number of potential subscribers
evaluating the integral and taking logarithms gives

$$-\gamma = \frac{1}{\mu} \ln \left(\frac{N_s}{N_p}\right) \qquad \text{so}$$

with (1) it gives

(2) $$\frac{\ln(1 - S^*/Y)}{\ln\left(\frac{N_s}{N_p}\right)} = \frac{1}{\mu} \ln \frac{Q_c}{Q_f}$$

where only the left hand side variables are observable

NPM derive the estimating equation

$$\frac{\ln(1 - S^*/Y)}{\ln\left(\frac{N_s}{N_p}\right)} = R_o + \sum R_i \ln X_i + \sum_j G_j D_j$$

where X_i is a proxy for quality of service

$$X_i = \frac{1 + N_i{}^c}{1 + N_i{}^f}$$

N_1 = the number of primary network alternatives

N_2 = the numbef of independent stations

N_3 = the number of education television

N_4 = the number of duplicate network-affiliated stations

and the D_j's are dummy variables

Finally writing

$$\frac{\ln (1-S/y)}{\ln (\frac{N_s}{N_p})} = \theta$$

and rearranging gives the penetration index

$$\frac{N_s}{N_p} = (1 - S/Y)^{\frac{1}{\theta}}$$

(see comanor Mitchell)

The main conclusions of NPM estimations are that in areas where homes are unable to receive all the three U.S. networks, one half of the households will be willing to pay a monthly fee of $5.00 to receive all the networks, and that the average household would be willing to pay 5% of his income rather than do without the network television services.

The Economics of TV Stations

In this section NPM provide a formal analysis of the economic relationships among networks, affiliates and program suppliers. Two assumptions are made (a) The value of audience for a given broadcaster is the same for all programs within some block of time, and (b) The programs offered to or produced by the broadcasters have associated an expected audience and a given price.

The expected net revenue r generated by broadcast of any program unit is defined by

$$r = va\ (1 - e), \quad e = f/va$$

where v is revenue per viewer, a the expected audience size and f the cost of the program to the broadcaster.

If a network owns broadcast rights to m programs and broadcast over a nationwide system, it will attract audiences a_i, i:1,..., m with a gross revenue of

$$\Sigma_i\ va_i$$

The network must make its programs economically attractive to its affiliated by sharing revenues. In order to induce affiliates to carry the full network lineup it should be true that

$$c_i \geq (1 - \eta_i)\ (\alpha_i/a_i)$$

where c_i is the share of the revenue from the i^{th} program the network gives up to its affiliates, α_i the expected audiences of nounetwork programs, i:1,...,n, and η_i the revenue demanded by the supplier of program i.

Clearly a network can reduce affiliate share of revenues by maximizing the expected audience a_i of its own programs.

NPM also study the relation between program owners, networks and affiliates. If the ith program owner withdraws his program from the network lineup, the network will replace it with say a program with expected audience a_r. Affiliates will carry the new program if their net revenue from carrying it is at least as great as the revenue derived from the with-drawn program, i.e.

$$c_m v a_r \geq (1 - \eta_i)\, v a_i$$

where c_m is the maximum share the network gives up to affiliates. Rearranging

$$\eta_i \leq 1 - c_m \frac{a_r}{a_i}$$

where η_i is the maximum share in broadcast revenue a program owner could stract in syndication.

Distributors charge a share of the gross revenue for their services. The maximum share a program owner could extract from a network is therefore bounded by

$$e_i \leq (1 - d)\,(1 - c_m \frac{a_r}{a_i})$$

NPM also deal with the uncertainty that surrounds the potential audiences that will follow a new program. One of the devices to test potential audiences is the production of a <u>pilots</u> for new series. NPM assume that producers will invest in new pilots only if the present value of expected returns is at least as great as the cost of pilot production. Their basic model is

$$(1 - t)\ \theta_n (e_n V_n - (1 - p)\ \theta_r e_r V_r - K_n > P$$

where V_n: present value of expected broadcast revenue of an accepted pilot during the network run

V_r: present value of expected broadcast revenue of an accpeted pilot in off-network syndication.

K_n: present value of the opportunity cost of producing the expected number of eposidoes of an accepted pilot.

P : cost of producing a pilot

e_n: program owner's share in broadcast revenue from network run.

e_s: program owner's share in revenue from off-network syndication broadcast after payment of distributor's fee

t : profits tax rate

θ_n: probability a pilot will be accepted by networks

θ_s: probability that an accepted pilot will be released into off-network syndication

p : network's share in profits from off-network syndication

From the above expression it follows that the optimal value for e_n is given by

$$e_n^o = \left(1 + \frac{\mu}{\theta_n(1 - t)}\right) \frac{K_n}{V_n} - (1 - p)\ \theta_s e_s \frac{V_s}{V_n}$$

where $\mu = \frac{P}{K_n}$

The <u>expected network profits</u> from a new program is defined by

$$\P_n = (1 - \bar{c})\ V_n - e_n^o V_n - p\theta_s e_s V_s$$

where $\bar{c}$ is the average share of broadcast revenue given up to affiliates. Substitution of e_n^o gives

$$\P_n = (1 - \bar{c})\ V_n - \theta_s e_s V_s - \left(1 - \frac{\mu}{\theta_n(1 - t)}\ K_n\right)$$

NPM estimate values of the parameters of the above Network - Packager equations and conclude

"it appears that the networks have been able to bargain rather effectively in procuring entertainment series programming. Nevertheless, this analysis suggests that a considerable proportion of the payments they make to program owners -- as much as 20% of the total in recent years -- constitute rents". (NPM, 313).

NPM were use this observation to argue throughout the book that additional resources available to TV will have very little effect on programming volume. Further increases in the expected rate of return are unlikely to draw additional resources into the program production industry.

The Analysis of Regulatory Behavior

Most of the conclusions reached in the final chapter of Economic Aspects of Television Regulation are not directly related to the above analysis. They could have been obtained independently from the previous chapters. The authors point out that the U.S. Federal Communication Commission is determined to undermine consumer sovereignity in order to protect the wealth of the network or station owners. They find that the U.S. - FCC instead of establishing the "rules of the games" leaving the outcome to the market forces tries to regulate the industry up to the minimal detail.

They call for substantial deregulation of television, for competition from new communication technologies, for an expansion of viewing choice and for divesting the U.S. - FCC from control over program content. (NPM, p. 274-276).

* The Brooking Institution, Washington, D.C., 1973.

William S. Comanor and Bridger M. Mitchell, "Cable Television and the Impact of Regulations", Bell Journal of Economics and Management Sciences, Vol. 2 (Spring 1972), pp. 154 - 212.

Television: Old Theories, Current Facts, and Future Policies

The Growth of Cable T.V. and Its Problems Impact on Over-The-Air Broadcasting*

By

Rollad Edward Park

INTRODUCTION

Cable may provide more diverse programming for its subscribers, but at the cost of reducing the amount of programming produced by over-the-air television for non-subscribers. Over-the-air stations may be forced to reduce the quality of their programs and even be forced off the air.

To control this problem the U.S. Federal Communications Commission has restricted cable growth in the top 100 markets while allowing growth in smaller markets to promote diversity.

In a free market diversity follows from competition among a large number of broadcast stations. That is possible in the case of Radio. In the case of T.V. no more than seven stations can be allowed in VHF. the 1952 allocation of UHF frequencies to T.V. has only increased marginally the number of stations.

CABLE IMPACT

This paper reports Park's attempt to build a model to measure the impact of unrestricted cable growth. The model is constructed from four estimated pieces:

1) Estimates of cable penetration are based on the hypotehsis that the penetration tends to be higher: a) for systems carrying a greater number of signals and b) for systems operating in areas with fewer signals.

2) To determine what share of the audience will watch distant

signals and what share will continue watching local ones attractiveness indices are attached to signals so that audience shares are proportional to those indexes, e.g. the attractiveness index of UHF is one half the index from the same signal broadcast by VHF.

3) From 1) and 2) the station audience can be calculated. Relationships that transform audience into revenue are then estimated. Two results are of interest: i) an additional household is worth less to a large station than to small one, and ii) a distant audience is worth less than a closer one.

4) The relation between local and public service programming on the one hand and station revenue on the other is estimated. As 15-21 cents of each marginal revenue dollar is spent on local programming, cable adverse impact on local station revenue will imply a decrease in local programming.

This paper provides the following results about the percentage change in Revenue due to cable in a 1970's environment.

TYPE OF STATION	MARKET RANK				
	1-50	51-100	101-150	151-200	1-200
Network VHF	-17	-24	-31	-55	-20
Network UHF	+12	-18	-15	-	-14
Independent VHF	-11	-	-	-	-11
Independent UHF	+20	+20	-	-	+19
All	-15	-23	-30	-56	-18

COMMENTS

It is clear from the above table that:

i) Overall station revenue is reduced 18% by cable

ii) Stations in smaller markets are harder hit than those in larger markets, and

iii) UHF stations are less harmed ... some are benefitted by cable than are VHF stations.

* Papers and Proccedings of the American Economic Association, May 1970

New Television Networks which are the Prospects for New Networks in United States?*

Rolla Edward Park

In this paper Park uses a model of television network competitive behavior to explore the prospects for new networks in U.S. His conclusion is that the chances for a fourth commercial network are slim. <u>This result contradicts Noll, Peck, and McGowan findings</u>!

<u>The model</u>. Park's model is a variant of Crandall's[2]. There are J networks indexed by j or i. Let r_j be the annual revenue produced by an individual watching j; A_j the average number of households watching, pj the expenditure in programs and F_j a fixed cost. The profit of j is

$$\Pi_j = r_j A_j - p_j - F_j$$

where $r_j = r_j(A)$ and $A_j = A_j(p_1,\ldots,p_J)$

The first order condition for profit maximization gives

$$\left[r_j + A_j \frac{dr_j}{dA_j}\right]\left[\frac{\delta A_j}{\delta p_j} \quad \sum_{i\neq j} \frac{\delta A_j}{\delta p_j} \frac{dp_i}{dp_j}\right] = 1$$

<u>Park takes programming expenditure as a network's decision variable while Crandall treats individual factor inputs to program production as decision variables</u>.

<u>Assumptions</u>

1) There are K subsets of television households k:1,...,K.

2) The j^{th} networks share of audience in k is given by

$$S_{jk} = \frac{m_{jk}\, a_j}{\Sigma_i m_{ik} a_i}$$

where M_{jk} denotes the terms on which network j competes in household subset k, and a_j a measure of attractiveness.

3) The attractiveness is an increasing function of P_i

$$a_i = \lambda p_i \beta, \quad \lambda \text{ and } \beta > 0$$

4) Changes in program supply produces changes in λ.

5) Total audience in k, N_k, depends only on the number of networks serving k.

6) Advertising revenue is constant for each Network

$$\frac{dr_j}{dA_j} = 0$$

7) Cournot's assumption. Each network expects the others will not reach to changes in its programming expenditure.

$$\frac{dp_i}{dp_i} = 0 \quad i \neq j$$

From 1-7, the first order condition for profit maximization becomes $\beta r_j \Sigma_k N_k S_{jk}(1 - S_{jk}) = p_j$

Park assumes the three U.S. commercial Networks compete with each other on equal terms in all reas of the country, $P_1 = P_2 = P_3 = \$288$ M and r = \$46. Those assumptions together with the above equation give β = .77

One of the figures that the model calculate is the excess revenue over program expenditure i.e. "income". Clearly "income" for a new network must be high enough to cover fixed costs F_j. Financial data give estimates of the fixed cost of national network operation between \$100M and \$200M per year.

The fourth network example is "feeded" into the model as follows: Park assumes the fourth network competes on equal terms with the existing three in 21M households, subject to UHF handicap in 16M and does not reach 24M at all. He assumes that 65% of those who receive the four networks watch, compared to 60% of those that receive three. Applying those percentage to k: 1,2,3, he get

$$|N| = (13.65 \quad 10.4 \quad 14.4) \times 10M)$$

the m_{jk} are estimated to reflect UHF competition and the competitive position of the fourth network in the three subsets of television households. The p_i, i:1,...,4 are calculated from the first order condition equation.

The final result is that the fourth network excess of revenue over program expenditure are 51M, 27M and 8M for 0.67, 0.77 and 0.87 as alternative values of

As the propective incomes are less than $100M the fourth network will not be organized.

* "The Bell Journal of Economics", Autumn 1975.

1) Economic Aspects of Television Regulation Washington, D.C.: The Brooking Institution, 1973, p. 30

2) "FCC Regulation, Monopsony, and Network Television Program Costs". The Bell Journal of Economics and Management Science, Autumn 1972.

PROGRAM PATTERNS AND PREFERENCES, AND THE WORKABILITY OF COMPETITION IN RADIO BROADCASTING*

BY

PETER O. STEINER

In this article, Steiner assumes that individuals would listen only to their program type and that stations seek to maximize their audience size. These assumptions together with the welfare criterion that as many persons as possible should receive the programs they are willing to listen to leads to programming duplication.

The three main sections of this paper are:

1. Criteria for the appraisal of workability,
2. The one period model, and
3. The model over time

1) CRITERIA FOR APPRAISAL OF WORKABILITY

Stations sell time to advertisers according to privately established rates but station time is valuable only if there are listeners. People .. who are the customers of the product advertised .. are induced to listen by means of Programs.

For Steiner the Public Interest lies in "the nature and quality of the patterns of programs that emerges", and his Welfare Criterion is the satisfaction of the largest number of listener-hours. He assumes that a person is satisfied in every period in which he finds a program to which he will listen and that a person's decision to listen is entirely determined by the programs available.

2) THE ONE PERIOD MODEL

Assumptions:

1. A period is at 15 minutes interval;
2. The cost of a program is independent of the number of listeners;
3. There is a minimum size of audience for every program;
4. Rates per period and per program depend upon the average audience of the station;
5. The program is a free good to the listener;
6. There is one market;
7. Each station strives in every period to maximize the number of its listeners;
8. Programs are of indentifiable types and there are a determinate number of listeners per type;
9. Individual preferences are independent of programs presented;
10. For any given program type the second individual choice is non-listening;
11. If some stations simultaneously produce the same program they will equally share the audience.

Assumptions 6-11 can be relaxed.

NOTATION:

Let $P_1, P_2, \ldots P_j, \ldots, P_k, \ldots, P_i$

and

$L_1, L_2, \ldots, L_j, \ldots, L_k, \ldots L_i$

respectively be a list of program types and their number of listeners per period. The index refers to any program, j to any program being produced, and k to the unproduced program with the greatest potential number of listeners. Steiner assumes $L_1 > L_2 > \ldots > L_{i-1}$

By definition the number of program types produced at any time is $k - 1 = P$

The order of the <u>duplication</u> is defined as $D^{th} = X - P$ where $X = \Sigma x_j$, and x_j is the number of stations producing the j^{th} program.

According to the previous assumptions and definitions, the welfare criterion established before, is satisfied <u>if each station produces a different program type and if the types with the largest number are produced</u>.

On the other hand, each station will choose the program that will maximize its audience, i.e. will maximize $L_i/(x_i - 1)$. What implies that a station will <u>duplicate</u> an existing program if the share it can get of the audience by duplicating a program is greater than the total audience it will get from the unproduced one. There will be a D^{th} order duplication as soon as the number of stations is $D - k - 1$ and either $L_1/(D - 1)$, $L_2/D, \ldots,$ $L_j/(D - j - 2)$, ..., or $L_D/2$ are greater than L_k.

<u>Clearly social welfare conflicts with individual station interest</u>.

3) <u>THE MODEL OVERTIME</u>

In this case, Steiner chooses the socially optimal program pattern .. welfare criterion .. in terms of the maximization of the number of listener-hours over the total time span.

If "preferences" .. the sizes of the L's .. are constant overtime, the single period model will apply repetively.

The available listening audience L_i, for a particular program P_i may change overtime. L_i may chance according to the period in which P_i is broadcasted. Steiner says that preferences are shiftable if listeners are satisfied by listening a certain program at any period within a sequence of successive periods, and that preferences are non- shiftable if that is not the case.

Steiner examines the programs patterns related to shiftability. Here we review the two polar cases: (a) Complete non-shiftability and (b) Complete shiftability of preferences.

(a) COMPLETE NON-SHIFTABILITY

Steiner characterizes this problem as follows: a station is supposed to choose among several program-types P_i. A program-type is composed of T similar programs to be broad-casted over a sequence of periods t:1,...,T. An entry L_{ti} of a matrix L indicates the number of listeners of the program t of type i. The station is supposed to choose the program-type that maximizes $L_i = \Sigma_t L_{ti}$ subject to the constraint that each L_{ti} should be equal or greater than the minimum number of listener required by a program i to be salable at t. The salability constraint obviously leads away from the coincidence of social and station optima.

(b) COMPLETE SHIFTABILITY

For two or more stations operating over a time span the number of programs .. not program-types .. will be equal to the number of stations times the number of periods in that span. The total audience for a particular program will be divided as many times as the program is reproduced. Clearly an already produced program-type will be reproduced if the share of its audience will be greater than the total audience of an unproduced type. The k^{th} program will be first produced in the station period

$$\sum_{j=1}^{j=k-1} [(\Sigma_t L_j)/(\Sigma_t L_k)] - 1)$$

where [ ] symbolizes "the whole number contained therein".

The conclusion is that even with perfect shiftability, there will still be a substancial number of duplications and agin social and station optima will not coincide.

Pilkington and the Theory of Value*

P. Wiles

This is a study of the 1960 Pilkington Report on British broadcasting.

Wiles agrees with Pilkington's conclusion that duopoly in TV is worse than monopoly and disagrees with the conclusion that polypoly in sound broadcasting is worse than monopoly.

Wiles' main propositions are:

(1) "Atomic competition in broadcasting, when technically possible, can do under the profit motive most of what a public spirited monopoly can do". This proposition is verified empirically. Wiles compares the high program diversity in the Boston and New York radio broadcastings and the restricted range of B.B.C. programming.

Wiles argues that neither maximum nor minimum differentiation on programs is a tendency under *laissez-faire*, but only the most profitable degree of differentiation. If the minimum is the most profitable then only mass programs are produced. That brings Wiles' second proposition:

(2) "Under the relationships between cost and revenue obtaining for TV, minimum differentiation is most profitable to an oligopoly or monopoly, maximum differentiation to a polypole".

To prove this proposition, Wiles uses some "imaginary"

2

figures. He assumes: (i) Six different types of programs: One unprofitable, four profitable and an indefinite number of "mass programs". (ii) Community satisfaction is measured by the consumers willingness to pay. (iii) Consumers will rather watch mass programs than nothing, but minority audiences always watch their special programs if possible. (iv) Programs are financed in any chosen way, and "profit" is a notional concept, the difference between what people are willing to pay and the cost of the product.

Cost, ratings, willing to pay a price, potential profit and "monetary" satisfaction are described in a table for each of the TV programs broadcasted by four different organizations.

1) A "satisfaction" - maximising monopoly with five channels where the unprofitable program is not put on.

11) A "profit" - maximising monopoly with five channels producing only one mass program, so that four channels go unused.

111) A "profit" - maximiser duopoly with two channels, each broadcasting mass programs, and

1V) A 10-poly "profit" - maximiser with ten available channels: four for "profitable" programs and six for mass programs.

The figures show that the satisfaction in sterling pounds are for the four cases 1): 94,000; 11): 60,000; 111): 62,000; and 1V): 100,000. So the duopoly produces less satisfaction than the "profit" - maximising polypoly and the "satisfaction" -

maximising monopoly.

From the above table Wiles also "proves" that the maximisation of ratings is a very poor substitute for the maximisation of profits or satisfaction if more balanced programs are desired. That implies that TV financing based upon ratings do distort the "public wishes".

Wiles' article is an attempt to improve Steiner's model. In his article he allows for differences in the value that viewers place on different programs, and for different monopolistic and oligopolistic organizations. Nevertheless, his conclusions are rather tautological, they are almost identical to the "assumptions" of his model. Even if that were not true some of his hypothesis are too arbitrary: "*Faute de mieux*, then the prices are invented". (p. 200).

* *The Economic Journal*, June 1963.

THE ECONOMIC VALUE OF THE SPECTRUM RESOURCE IN BROADCASTING AND LAND MOBILES -- Perrakis, S.