NBER WORKING PAPER SERIES

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THE CASE OF BROADCASTING

Simon P. Anderson
Stephen Coate

Working Paper 7513
http://www.nber.org/papers/w7513

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 2000

We thank Tim Besley, John Conley, Simon Cooper, Maxim Engers, and Joel Waldfogel for useful discussions and seminar participants at the Department of Justice and the Universities of Bristol, Caen, California at Berkeley, Cergy-Pontoise, and Illinois for helpful comments. The views expressed herein are those of the author and not necessarily those of the National Bureau of Economic Research.

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JEL No. D43, L13, L82

ABSTRACT

This paper studies the market provision of a specific type of public good: radio and television broadcasts. Its main focus is to explore the ability of the market to provide broadcasting efficiently in a world in which broadcasters earn revenues by selling time to advertisers and advertisements provide information to consumers about new products. The paper shows that market provided broadcasts may feature too few or too many commercials, depending on the relative sizes of their social benefit and their nuisance cost to viewers. In addition, the market may provide too few or too many types of programs, depending on the relative size of viewing benefits and the benefits to advertisers from contacting viewers. The possibility of both under and over-provision of advertisements and programming, means that there are ranges of the parameters for which the market provides broadcasting close to efficiently. The paper also considers whether the market performs better under monopoly or competition and studies how the ability to charge viewers subscription prices impacts market performance.

Simon P. Anderson
Department of Economics
University of Virginia
Charlottesville, VA 22901
sa9w@virginia.edu

Stephen Coate
Department of Economics
Cornell Univesity
Ithaca, NY 14853
and NBER
sc163@cornell.edu

1 Introduction

In public economics textbooks, radio and television broadcasts are often given as examples of pure public goods. For once a broadcast has been transmitted to one household, it may be costlessly received by all other households with the necessary receiving hardware. Moreover, it is quite costly for the provider to exclude others from receiving the broadcast. However, in sharp contrast to the predictions of public economic theory, market provision of both radio and television broadcasting is observed in many countries.

The key feature enabling such provision is that a broadcast is a public good which may be "consumed" by two types of agents. The first type are viewers/listeners who receive a direct benefit from the broadcast. The second type are advertisers who by advertising on the broadcast receive an indirect benefit from contacting potential customers. While the first type of consumer cannot be excluded, the second can. By charging advertisers for accessing their broadcasts, broadcasting firms can earn revenues.

Will such market provision provide broadcasting optimally and, if not, in what ways will it diverge from the optimum? Intuitively, the answer is unclear. Advertisers' consumption of a broadcast imposes an externality on viewers: advertisements take time to watch, and, by their very nature, provide little entertainment value. Thus, optimal provision requires that advertisers face a Pigouvian corrective tax for accessing programming. The price advertisers must pay to broadcasters to advertise on their programs may be thought of as playing this role. Accordingly, the basic structure of market provided broadcasting - free provision to viewers/listeners financed by charges to advertisers - appears similar to that of an optimal structure. The issues are how well equilibrium prices of advertising internalize the externality and whether advertising revenues generate appropriate incentives for the provision of broadcasts.

This paper presents a theory of the market provision of broadcasting and uses it to explore the nature of market failure in the industry. With market provision playing an increasing role in the broadcasting systems of most countries, such an analysis seems timely. The appropriate regulation of commercial broadcasting is an important issue and, to aid policy-makers in this area, there is a need for economic analysis which sheds light on the ability of the market to generate socially desirable outcomes.

Previous work on the market provision of broadcasting (see Owen and Wildman (1992) or Brown and Cave (1992) for reviews) has largely focused on the type of programming that would be produced by the market and the viewer/listener benefits it generates.[1] The literature concludes that the market may provide programming inoptimally: popular program types will be excessively duplicated (Steiner (1952)) and speciality types of programming will tend not to be provided (Spence and Owen (1977)). To illustrate, consider a radio market in which 3/4 of the listening audience like country music and 1/4 like talk, and suppose that the social optimum calls for one station serving each audience type. Then, the literature suggests that the market equilibrium might well involve two stations playing country music. Duplication arises because attracting half of the country listening audience is more profitable than getting all the talk audience. The lack of a talk station arises because capturing 1/4 of the audience does not generate enough advertising revenues to cover operating costs. This may be so even when aggregate benefits to talk listeners exceed operating costs.

While this literature offers some useful insights, its treatment of advertising is problematic. First, advertising levels and prices are assumed fixed. Thus, each program is assumed to carry an exogenously fixed number of advertisements and the revenue raised from each advertisement equals the number of viewers times an exogenously fixed per viewer price (Steiner (1952), Beebe (1977),

[1] The fact that broadcasts are consumed by *both* viewers and advertisers and that the latter also obtain surplus is ignored by most of the literature. One exception is the paper by Masson, Mudambi, and Reynolds (1990) which studies the effect on advertising levels of concentration of ownership of broadcasting stations. A further exception is the empirical study of Berry and Waldfogel (1999a) which clearly distinguishes between the social benefits of additional radio stations stemming from delivering more listeners to advertisers and more programming to listeners.

Spence and Owen (1977) and Doyle (1998)).[2] Second, the social benefits and costs created by advertisers' consumption of broadcasts are not modeled. These features preclude analysis of the basic issue of whether market-provided broadcasts will carry too few or too many advertisements. More fundamentally, since advertising revenues determine the profitability of broadcasts, one cannot understand the nature of the programming the market will provide without understanding the source of advertising revenues. Since these revenues depend on both the prices and levels of advertising, the literature offers an incomplete explanation of advertising revenues and hence its conclusions concerning programming choices are suspect.

The theory developed in this paper provides a detailed treatment of advertising, while preserving the same basic approach to thinking about the market developed in the literature. To enable a proper welfare analysis, the model incorporates the social benefits and costs of advertising. The benefits are that advertising allows producers to inform consumers about new products, facilitating the consummation of mutually beneficial trades.[3] The costs stem from its nuisance value. In addition, the model assumes that broadcasters choose advertising levels taking account

[2] There are a number of exceptions. Assuming that a broadcaster's audience size is reduced by both higher subscription prices and higher advertising levels, Wildman and Owen (1985) compare profit maximizing choices under pure price competition and pure advertising competition and conclude that viewer surplus would be the same in either case. However, theirs is not an equilibrium analysis. Making a similar assumption that viewers are turned off by higher levels of advertisements, Wright (1994) and Vaglio (1995) develop equilibrium models of competition in an advertiser supported system. However, their models are both too ad hoc and too intractable to yield insight into the normative issues. Masson, Mudambi, and Reynolds (1990) develop an equilibrium model of competition by advertiser supported broadcasters in their analysis of the impact of concentration on advertising prices but their model permits neither an analysis of the provision of programming nor a welfare analysis. Hansen and Kyhl (1999) compare pay per view broadcasting with pure advertiser-supported provision of a single event (like a boxing match) under the assumption that the broadcaster chooses advertising levels.

[3] While this is the most obvious role of advertising, not all advertising on radio and television is of this form. Advertisements for new cars, movies and toys fit this model, but advertisements for established soft drinks and beers do not. The advertising literature identifies a number of other possible functions of advertising. An alternative informational perspective is that advertising acts as a *signal*. Consumers are aware of the prices and availability of goods, but cannot observe product quality (Nelson (1974), Kihlstrom and Riordan (1984), Milgrom and Roberts (1986)). Advertising signals high quality, because only a firm that would get repeat business could afford the upfront outlay represented by advertising. Chwe (1997) argues that advertising might solve *coordination* problems. If consumers benefit from consuming the same type of good, advertising can serve as a coordinating device for their consumption decisions. Critics of advertising often argue that its purpose is to persuade rather than to inform. Under this *persuasive* view, advertisements can directly alter consumers' tastes for a product. Even if post-advertising tastes are taken as the correct ones, market determined levels of advertising can be excessive (Dixit and Norman (1978)). Clearly, each of these perspectives implies a different view of the social benefits of advertising. Thus, the results obtained in this paper will be sensitive to the assumed function of advertising.

of their negative effect on the number of viewers and any effect on advertising prices. In this way, advertising revenues and hence program profitability are determined endogenously.

The paper contributes to a large literature on the market provision of public goods (see Cornes and Sandler (1996) for a comprehensive review). The best known strand of this literature is that considering the provision of pure public goods by voluntary contributions from consumers (see, for example, Andreoni (1988) and Bergstrom, Blume and Varian (1986)). Two other strands consider the provision of excludable public goods by firms who charge consumers to consume their production (see the survey by Oakland (1987)) and the provision of club goods by firms who charge consumers to use their facilities (see, for example, Buchanan (1965), Berglas (1976) and Scotchmer (1985)). The distinction between these two strands is that in the club good case consumers wish to belong to at most one club and impose negative crowding externalities on each other.[4]

Broadcasting does not fit into any of these three strands. The pure public good model is not applicable because some consumers (i.e., advertisers) can be excluded. This makes provision by means other than voluntary contributions possible.[5] The excludable public good model is not applicable because some consumers (i.e., viewers) are not excludable. Moreover, advertisers' consumption imposes negative externalities on other consumers, each viewer/listener consumes only one program at any one time and different programs are substitutes. The club good model is not applicable because not all consumers can be excluded and only some consumers impose negative externalities. Furthermore, advertisers wish to consume multiple programs. Broadcasts are thus a distinct type of public good the market provision of which raises new theoretical issues.

The organization of the remainder of the paper is as follows. Section 2 introduces the basic

[4] We include in the club good strand the literature stemming from Tiebout (1956) on local public good provision by planners seeking to maximize the difference between tax receipts and public spending.

[5] The voluntary contributions model might usefully be applied to commercial-free "public" radio and television stations. In the U.S., such stations receive a sizable portion of their revenues from voluntary contributions.

model and section 3 discusses optimal provision of broadcasts. Section 4 explores market provision and compares it with the optimum. Section 5 analyzes two further issues concerning market provision that have been discussed extensively in the broadcasting literature. These are whether market provision produces better outcomes under monopoly or competition and how the possibility of excluding viewers/listeners impacts market performance. Section 6 explains how relaxing the assumption of symmetric viewer groups changes the results and Section 7 concludes with a summary of the main findings and some suggestions for future research.

2 The Model

We are interested in modeling a basic broadcasting system in which channels broadcast programming and viewers/listeners can costlessly access such programming. Thus, we will be assuming that viewers/listeners have the hardware (e.g., televisions and radios) allowing them to receive broadcast signals. Moreover, we assume that broadcasters cannot exclude consumers by, for example, jamming their signals and requiring special decoders, etc.[6]

There are two channels, A and B, each of which can carry one program. There are two types of program, indexed by $t \in \{1, 2\}$. Examples of program types are "top 40" and "country" for radio, and "news" and "sitcom" for television. For concreteness, we focus on the television case and henceforth refer to consumers as viewers. Programs can carry advertisements. Each advertisement takes a fixed amount of time and thus a greater number of advertisements reduces the substantive content of a program. Each program type is equally costly to produce and producing advertisements is no more costly than producing regular programming. The cost of producing either type of program with a advertisements is denoted K.

[6] This is still a reasonable model of radio broadcasting in the U.S.. It is also a reasonable model for television in countries, like the U.K., in which most viewers still pick up television signals via a rooftop antenna. In the U.S., however, the majority of households receive television via cable. The cable company picks up signals and rebroadcasts to households via cable. This yields superior picture quality and permits reception of more channels. For its services, the cable company charges a monthly fee. The cable company can also exclude consumers from viewing certain channels, which permits the use of subscription prices. Our basic model applies in the cable case when all consumers are hooked up and subscription prices are not used.

There are $2N$ potential viewers each of whom watches at most one program. Viewers are distinguished by the type of program they prefer and the degree to which their less preferred program can substitute for their preferred program. Formally, each viewer is characterized by a pair (t, λ) where t represents the viewer's preferred type of program and λ denotes the fraction of the gross viewing benefits he gets from his less preferred type of program. A type (t, λ) viewer obtains a *net viewing benefit* $\beta - \gamma a$ from watching a type t program with a advertisements and a benefit $\lambda\beta - \gamma a$ from watching the other type of program with a advertisements. The parameter γ represents the *nuisance cost* of advertisements and is the same for all viewers.

There are N viewers of type t and, for each group, the parameter λ is distributed uniformly on the interval $[-\varepsilon, 1]$, where $\varepsilon \geq 0$.[7] Not watching any program yields a zero benefit so that if $\lambda < 0$, a viewer finds it costly to watch his less-preferred program. This might be the case, for example, for teenagers watching a public affairs program. The larger is ε, the greater the fraction of viewers in this category.

Advertisements are placed by producers of new goods and inform viewers of the nature and prices of these goods. Having watched an advertisement for a particular new good, a viewer knows his willingness to pay for it and will purchase it if this is no less than its advertised price. There are m producers of new goods, each of which produces at most one good. New goods can be produced at a constant cost per unit, which with no loss of generality we set equal to zero. Each new good is characterized by some type $\sigma \in [0, \overline{\sigma}]$ where $\overline{\sigma} < 1$. New goods with higher types are more likely to be attractive to consumers. Specifically, if a new good is of type σ, then a viewer will have willingness to pay $\omega > 0$ with probability σ and willingness to pay 0 with probability $1 - \sigma$.[8] The fraction of producers with new goods of type less than or equal to σ is (approximately) $\sigma/\overline{\sigma}$.

The assumption that all consumers have a willingness to pay of ω or 0 means that each new

[7] We extend the model to viewer groups of different size in Section 6.

[8] Section 6 describes the additional distortions arising when the two preference types have different willingnesses to pay or different probabilities of liking new goods.

producer will advertise a price of ω. A lower price does not improve the probability of a sale. Thus, a new producer with a good of type σ is willing to pay $\sigma\omega$ to contact a viewer. Accordingly, if p denotes the per-viewer price of an advertisement (i.e., if the advertisement is seen by n viewers it costs np), then the number of firms wishing to advertise is (approximately) $a(p) = m \cdot [1 - p/\omega\overline{\sigma}]$.[9] This represents the *demand curve for advertising*. The corresponding *inverse demand curve* is $p(a) = \omega\overline{\sigma} \cdot [1 - a/m]$.

The fact that each new producer sets a price of ω implies that consumers receive no expected benefits from their purchases of new products: the new producers extract all the surplus from the transaction. This implies that viewers get no *informational benefit* from watching a program with advertisements. Viewers therefore allocate themselves across their various options in such a way as to maximize their net viewing benefits, which greatly simplifies the analysis.[10] We assume that a consumer who is indifferent between watching any two programs is equally likely to watch either.

This completes the description of the model. In the analysis to follow, we maintain the following assumption concerning the values of the parameters:

Assumption 1 *(i)* $\gamma \in [0, 2\beta/m)$ *and (ii)* $\omega\overline{\sigma} \in (0, 4\beta/m)$.

The role of these restrictions will become clear later in the paper.

3 Optimal Provision

This section describes the optimal provision of broadcasts. The two types of programs may be thought of as discrete public goods each of which is consumed by two types of consumers - viewers and advertisers - and each of which costs K to provide. The problem is simply to decide which of

[9] This approximation is designed to circumvent the analytical difficulties created by a step demand function. The larger is m, the better the approximation.

[10] While abstracting from informational benefits seems reasonable, the existence of "infomercials" and networks such as the Home Shopping Network suggest that such benefits are significant for some viewers.

these public goods to provide and who should consume them. We first analyze the desirability of providing one program rather than none, and then consider adding a second program.

Given that the number of viewers of each type is the same, if one program is provided, its type is immaterial. For concreteness, we consider a type 1 program. Following the *Samuelson rule* for the optimal provision of a discrete public good, provision of the program will be desirable if the sum of benefits it generates exceeds its cost. Typically, the aggregate benefit associated with a public good is just the sum of all consumers' willingnesses to pay. However, in the case of broadcasts, we must take account of externalities between the two types of consumers.

More specifically, suppose that the program has $a \leq \beta/\gamma$ advertisements and hence is "consumed" by a new producers.[11] Then, all type 1 viewers will watch the program and obtain a benefit $\beta - \gamma a$. Type 2 viewers for whom $\lambda \geq \frac{\gamma a}{\beta}$ will watch and obtain a benefit $\lambda\beta - \gamma a$. Assuming that the a advertisements are allocated to those new producers who value them the most, the aggregate benefits generated by the program are therefore

$$B_1(a) = N[(\beta - \gamma a) + \int_{\gamma a/\beta}^{1} (\lambda\beta - \gamma a)\frac{d\lambda}{1+\varepsilon}] + N(1 + \frac{1-\gamma a/\beta}{1+\varepsilon}) \int_0^a p(\alpha)d\alpha.$$

The first term represents viewer benefits, while the second measures the benefits to advertisers.

The level of advertising that maximizes theses benefits, denoted a_1^o, satisfies the first order condition[12] :

$$p(a_1^o) \leq \gamma + \frac{\gamma \int_0^{a_1^o} p(\alpha)d\alpha}{\beta(2+\varepsilon) - \gamma a_1^o} \ \textit{with equality if}\ a_1^o > 0.$$

Essentially, this says that the per viewer marginal social benefit of advertising must equal its per viewer marginal social cost. The per viewer marginal social benefit is the marginal advertiser's willingness to pay per viewer, $p(a)$. The per viewer marginal social cost is the consequent decrease in each viewer's utility, γ, plus a term reflecting the losses to existing advertisers resulting from

[11] A level of advertisements in excess of β/γ yields no viewers and hence no benefits to either viewers or advertisers.

[12] It will be shown below that the constraint that a_1^o be no greater than β/γ is not binding.

their advertisements being seen by a smaller audience. Increased advertising drives type 2 viewers from the market meaning that they are not exposed to the existing advertisements and the net social benefits that they engender. Letting $B_1^o = B_1(a_1^o)$ denote maximal aggregate benefits, providing the program is desirable if the operating cost K is less than B_1^o.

The determination of the optimal advertising level with one program is illustrated in Figure 1. The horizontal axis measures the level of advertising, while the vertical axis measures dollars per viewer. The downward sloping line is the inverse demand curve $p(a)$, measuring the willingness to pay of the marginal advertiser to contact a viewer. The horizontal line is simply the nuisance cost γ and the upward sloping line is the graph of the function $\gamma + \gamma \int_0^a p(\alpha)d\alpha/[\beta(2+\varepsilon) - \gamma a]$, which represents the per viewer marginal social cost of advertising. The optimal advertising level is determined by the intersection of the inverse demand curve with the marginal cost curve.

It is natural to interpret the price $p(a_1^o)$ as a *Pigouvian corrective tax*. Each new producer's consumption of the program imposes an externality both on viewers through the nuisance cost and on other advertisers through the loss of audience. Advertisers' consumption of the program should thus be taxed and the optimal tax is $p(a_1^o)$.[13]

Now consider adding a type 2 program. This will be desirable if the increase in aggregate benefits it generates exceeds its cost K. We must therefore find the maximal aggregate benefits when both programs are provided. Note first that advertising levels on the two programs should be the same. Divergent advertising levels cause some viewers to watch a less preferred program and, because all viewers are of equal value to advertisers, this situation is dominated by one in which net aggregate advertising benefits are the same but levels are equalized. If the common

[13] It is also the case that each viewer who chooses to view the program confers an external benefit on the advertisers since he/she might purchase one of their goods. It would therefore be desirable to subsidize viewers to watch. However, we do not consider such subsidies since they would seem difficult to implement. Even if it were possible to monitor use of a radio or television, the difficulty would be making sure that a viewer/listener was actually watching/listening. That said, commercial radio stations sometimes give out prizes to listeners by inviting them to call in if they have the appropriate value of some random characteristic (like a telephone number) and this would seem to serve as a (second best) listener subsidy.

level of advertisements is $a \leq \beta/\gamma$, all viewers will watch their preferred programs and obtain a benefit $\beta - \gamma a$. Assuming that the a advertisements are allocated to those new producers who value them the most,[14] the aggregate benefits from providing both programs are therefore

$$B_2(a) = 2N(\beta - \gamma a) + 2N \int_0^a p(\alpha) d\alpha.$$

The two terms represent viewer and advertiser benefits, respectively.

The level of advertising that maximizes aggregate benefits, denoted a_2^o, satisfies the first order condition:

$$p(a_2^o) \leq \gamma \textit{ with equality if } a_2^o > 0.$$

The per viewer marginal social cost is now simply the nuisance cost, since a marginal increase in advertising causes no viewers to switch off (each viewer is watching his favorite program and hence there are no marginal viewers). The optimal advertising level is illustrated in Figure 1. Using the fact that $p(a) = \omega\overline{\sigma} \cdot [1 - a/m]$, we see that a_2^o equals $m[1 - \gamma/\omega\overline{\sigma}]$ if $\gamma \leq \omega\overline{\sigma}$ and 0 if $\gamma > \omega\overline{\sigma}$.[15]

Letting $B_2^o = B_2(a_2^o)$ denote maximal aggregate benefits, the gain in benefits from the second program is $\Delta B^o = B_2^o - B_1^o$. Accordingly, if K is less than ΔB^o provision of both programs is desirable. Notice that the incremental benefit from broadcasting the second program, ΔB^o, is strictly less than the direct benefits that the second program generates, $B_2^o/2$. This is because the two public goods are substitutes, meaning that some of the benefit of the second one comes at the expense of reducing the benefits generated by the first one. This feature of broadcasts is important to understanding some of the results concerning market provision.

To sum up, if one of the public goods is provided, its aggregate benefits are maximized if it is "consumed" by a_1^o advertisers. If both are provided, they should each be consumed by a_2^o

[14] Notice that the same new producers advertise on both programs. This is because the two programs are watched by different viewers and, since marginal production costs are constant, contacting one set of consumers does not alter the willingness to pay to contact another set.

[15] Note that Assumption 1(ii) guarantees that $a_2^o < \beta/\gamma$ for all γ. Since $a_1^o \leq a_2^o$, Assumption 1(ii) also implies that $a_1^o < \beta/\gamma$. If this Assumption were not satisfied, then for some values of γ, the optimal level of advertising in the two channel case would be such as to leave viewers with no surplus; i.e., $\gamma a_2^o = \beta$.

advertisers. If the operating cost K lies between ΔB^o and B_1^o one program should be provided, while if K is less than ΔB^o, both should be provided. Neither of the public goods should be provided if K exceeds B_1^o.

4 Market Provision

This section considers the market provision of broadcasts. We suppose that the two channels are controlled by firms who make programming and advertising choices to maximize their profits. In standard fashion, we model the interaction between the firms as a two stage game. In Stage 1, each firm chooses whether to operate its channel and what type of program to put on. In Stage 2, given the types of program offered on each channel, each firm chooses a level of advertising. We look for the subgame perfect Nash equilibria of this game. We first characterize market provision and then compare market outcomes with the optimum.

4.1 Characterization of market provision

The equilibria of the game may be solved for in the usual way via backward induction. Taking the firms' Stage 1 choices as given, we solve for advertising levels and revenues in Stage 2. These are then used to determine equilibrium choices in Stage 1.

Suppose first that in Stage 1, only one firm decides to provide a program. Irrespective of the program type it offers, if the firm runs $a \leq \beta/\gamma$ advertisements, its program will be watched by $N(1+\frac{1-\gamma a/\beta}{1+\varepsilon})$ viewers. To sell a advertisements it must set a per-viewer price $p(a)$. Its revenues will thus be given by

$$\pi_1(a) = N(1+\frac{1-\gamma a/\beta}{1+\varepsilon})R(a),$$

where $R(a) = p(a)a$ denotes revenue per viewer. The revenue maximizing level of advertisements is given by a_1^* where

$$R'(a_1^*) = \frac{\gamma R(a_1^*)}{\beta(2+\varepsilon)-\gamma a_1^*}.$$

At advertising level a_1^*, the increase in per viewer revenue from an additional advertisement equals the decrease in revenue from lost viewers measured in per viewer terms. Since $R'(m/2) = 0$, we know that $a_1^* \leq m/2$ and hence $a_1^* < \beta/\gamma$ by Assumption 1(ii).

The profit maximizing advertising level in the one channel case is illustrated in Figure 2. The downward sloping line is marginal revenue per viewer, $R'(a)$, and the lower of the two hump-shaped curves represents the per viewer marginal cost stemming from lost viewers. The revenue maximizing advertising level is determined by the intersection of the two curves. Let $\pi_1^* = \pi_1(a_1^*)$ denote the firm's maximal revenues.

Now suppose that in Stage 1, both channels choose different types of programs. Call the firm operating channel $J \in \{A, B\}$ "firm J" and, for concreteness, suppose that firm A chooses a type 1 program and firm B a type 2. If firm J sets an advertising level a_J it must charge a per viewer price $p(a_J)$. This price is independent of the advertising level of the other channel. The assumption that each viewer watches only one program, means that each channel has a monopoly in delivering its viewers to advertisers. Furthermore, the assumption that each new producer has a constant marginal production cost means that its demand for advertising on one channel is independent of whether it has advertised on the other.[16]

This said, the number of viewers that each firm gets will depend on the advertising level of its competitor. Suppose that each firm chooses an advertising level less than β/γ. If firm A has the lower advertising level, its program is watched by all the type 1 viewers and those type 2 viewers for whom $\lambda\beta - \gamma a_A > \beta - \gamma a_B$. If it has the higher advertising level, then its program is watched by all the type 1 viewers for whom $\beta - \gamma a_A > \lambda\beta - \gamma a_B$. In either case, viewers not watching

[16] This implication of our micro model of advertising demand should be contrasted with the assumptions made concerning inverse demand functions for advertising elsewhere in the literature. Berry and Waldfogel (1999a) assume that the per viewer price received by each radio station is the same and depends only on the total number of listeners; i.e., $p = f(\sum n_J)$. Masson, Mudambi, and Reynolds (1990) assume the per viewer price received by each broadcaster is the same and depends on the total number of "viewer-minutes"; i.e., $p = f(\sum n_J a_J)$. The two formulations are similar since Berry and Waldfogel are implictly assuming that the advertising level of each station is fixed. In light of our results, it would be worth investigating exactly what assumptions on the primitives would generate these formulations.

channel A watch channel B and the two firms' revenues are given by

$$\pi_2^A(a_A, a_B) = N[1 + \frac{\gamma(a_B - a_A)}{\beta(1+\varepsilon)}]R(a_A),$$

and

$$\pi_2^B(a_A, a_B) = N[1 + \frac{\gamma(a_A - a_B)}{\beta(1+\varepsilon)}]R(a_B).$$

Differentiating these revenue functions, we obtain

$$\partial\pi_2^A(a_A, a_B)/\partial a_A = N[1 + \frac{\gamma(a_B - a_A)}{\beta(1+\varepsilon)}]R'(a_A) - N\frac{\gamma}{\beta(1+\varepsilon)}R(a_A),$$

and

$$\partial\pi_2^B(a_A, a_B)/\partial a_B = N[1 + \frac{\gamma(a_A - a_B)}{\beta(1+\varepsilon)}]R'(a_B) - N\frac{\gamma}{\beta(1+\varepsilon)}R(a_B).$$

These expressions reveal two effects of an increase in advertisements. The first term measures the increase in revenues collected from existing viewers. The second term measures the loss in revenues from viewers who switch to the other channel. For each firm J, $\partial^2\pi_2^J/\partial a_J^2 < 0$ and $\partial^2\pi_2^J/\partial a_A \partial a_B > 0$, so that each firm's revenue is a strictly concave function of its own advertising level and the advertising levels are *strategic complements.* A higher expected advertising level from a rival gives a firm more viewers and it will use this advantage to raise its own advertising.

If the equilibrium advertising levels (a_A^*, a_B^*) are less than β/γ, they must be such as to equate the above pair of revenue derivatives to zero. These conditions then imply that $a_A^* = a_B^* = a_2^*$, where a_2^* satisfies

$$R'(a_2^*) = \frac{\gamma}{\beta(1+\varepsilon)}R(a_2^*).$$

Assumption 1(ii) again implies that $a_2^* < \beta/\gamma$. Figure 2 illustrates the determination of this advertising level. The higher of the two hump shaped curves is the graph of lost revenues per viewer, $\frac{\gamma}{\beta(1+\varepsilon)}R(a)$, and a_2^* is determined by the intersection of this curve and the marginal revenue per viewer curve. Let $\pi_2^* = \pi_2^J(a_2^*, a_2^*)$ denote each firm's equilibrium revenues.

Finally, suppose that in Stage 1, both firms choose the same type of program. If advertising is a nuisance ($\gamma > 0$), competition for viewers will drive advertising levels to 0. In the special case in which advertisements are not costly to viewers ($\gamma = 0$), each firm gets $N\frac{2+\varepsilon}{2(1+\varepsilon)}$ viewers, irrespective of its advertising level. Each firm will set an advertising level at which per viewer revenue is maximized; i.e., at which $R'(a) = 0$, which means $m/2$ advertisements. Equilibrium revenues will be $N\frac{2+\varepsilon}{2(1+\varepsilon)}R(m/2)$.

Turning to Stage 1, it is clear that neither firm will provide a program if $K > \pi_1^*$ and only one firm will provide a program if $\pi_1^* > K > \pi_2^*$. If $\pi_2^* > K$, both firms will provide programs. If $\gamma > 0$, these programs will be different, since firms earn no revenue if they show the same type of program. When $\gamma = 0$ the firms will earn positive revenues if they duplicate each other's programs and hence the situation is more complicated. Since $a_2^* = m/2$ when $\gamma = 0$, if the two firms offer different types of programs, they each earn revenues $NR(m/2)$. When $\varepsilon > 0$, these exceed the revenues they would earn if they chose the same type of program (described above). However, when $\varepsilon = 0$, the two revenues are equal because all viewers watch in either case. Thus, when $\gamma = 0$ and $\varepsilon > 0$, the firms will offer different types of programs, but when $\gamma = \varepsilon = 0$ they might also provide the same type.

To sum up, neither firm will find it worthwhile to provide a broadcast if K exceeds π_1^*. One firm will provide a program carrying a_1^* advertisements if K lies between π_1^* and π_2^*. Both firms will provide programs if K is less than π_2^* and each will carry a_2^* advertisements. If either $\gamma > 0$ or $\varepsilon > 0$, the firms will provide different types of programs, but if $\gamma = \varepsilon = 0$ duplication is possible.

4.2 Comparison with optimal provision

We begin with an analysis of the advertising levels carried by market provided broadcasts. Conditional on the market providing one or both of the programs, are the aggregate benefits from these public goods maximized, or will they be consumed by too few or too many advertisers? Consider first the case in which the market provides only one type of program. The market provided advertising level is a_1^*, while the optimal level is a_1^o.[17] The market level may be bigger or smaller than the optimal level, depending on the nuisance cost. If $\gamma = 0$, then $a_1^o = m$ and $a_1^* = m/2$. At the other extreme, if $\gamma \geq \omega\overline{\sigma}$, then $a_1^o = 0$ and $a_1^* > 0$. The possibilities of either over- or under-advertising can be illustrated diagrammatically by combining Figures 1 and 2. Figure 3 illustrates the determination of the two advertising levels in the one program case. In panel (a), the nuisance cost is low and the market level is smaller than the optimal level, while in panel (b) γ is high and the market level is higher.

Similar remarks apply to the case in which the market provides both programs. The market advertising level, a_2^*, can be bigger or smaller than the optimal level, a_2^o, depending on the nuisance cost. In fact, in both cases, there exists a critical nuisance cost such that the market under-provides advertisements when γ is less than this value and over-provides them otherwise.

Proposition 1 *Suppose that the market provides $i \in \{1, 2\}$ types of programs. Then, there exists a critical nuisance cost $\gamma_i \in (0, \omega\overline{\sigma})$ such that the market provided advertising level is lower (higher) than the optimal level as γ is smaller (larger) than γ_i. Moreover, $\gamma_1 < \gamma_2$.*

Another way of phrasing this conclusion is that the market price of advertising will be higher than the Pigouvian corrective tax for low values of the nuisance cost and lower for high values. Thus, while it is possible for the market price of advertising to be "just right", there are no economic forces ensuring the equivalence of the two prices. While the Pigouvian corrective tax reflects the negative externality that advertisers impose on each other and on viewers, the market price of advertising reflects the dictates of revenue maximization. Revenue maximization only accounts for viewers' disutility of advertising to the extent that it induces viewers to switch off or over to another channel.

The most striking thing about the proposition is the possibility that market provided programs

[17] The market provided level is a_1^* even when equilibrium involves both channels providing the same type of program, since $a_1^* = a_2^* = m/2$ when $\gamma = 0$.

may have too few advertisements. While the governments of many countries set ceilings on advertising levels on commercial television and radio (see, for example, Noam (1991)), we are not aware of any governments subsidizing advertising levels![18] In part, under-advertising arises in our model because each broadcaster has a monopoly in delivering its audience to advertisers. This means that broadcasters hold down advertisements in order to keep up the prices that they receive. While this effect might be mitigated if there were alternative ways that advertisers could reach viewers,[19] the possibility of under-provision seems likely to arise in any market system, no matter how it is modeled. For if the nuisance cost imposed by advertisers is small, then efficiency demands that programs be consumed by many advertisers. But the only way this can happen is if the market price is sufficiently low and this will make profitable provision impossible.[20]

We now turn to analyze the programming selected by a market system. The question is will the market provide too few or too many types of program.[21] In principle, under-provision can arise either because an insufficient number of channels operate or because both channels offer the same type of program (duplication). However, our model suggests that duplication is unlikely: it can only arise when viewers are indifferent between watching advertisements and regular programming ($\gamma = 0$) *and* all viewers prefer to watch their least preferred program than nothing ($\varepsilon = 0$). This finding is in sharp contrast to the literature which, following Steiner (1952), has viewed duplication as a major problem with market provision. In our model, for $\gamma > 0$, firms avoid duplicating each

[18] In the U.S., the National Association of Broadcasters, through its industry code, once set an upper limit on the number of commercial minutes per hour and this was implicitly endorsed by the FCC. In 1981, this practice was declared to violate the antitrust laws and no such agreement exists today (Owen and Wildman (1992)).

[19] It would be interesting to explore a model in which viewers watched multiple programs during the day and broadcasters competed for viewers in the various time slots.

[20] The logic is similar to that in the literature on the market provision of excludable public goods. Efficiency demands that all consumers with a positive willingness to pay be able to consume. But this requires a very low price, which is incompatible with profitable operation. Thus, if the market does provide the public good, it must be the case that too few consumers will consume it.

[21] The analysis here compares the number of program types provided by the market with the optimal number. A slightly different problem would be to compare the number of program types provided by the market with the number in an optimal "second-best" system which treated as a constraint the fact that with $i \in \{1, 2\}$ types of programs, the advertising levels would be a_i^*. Similar results to those reported below can be obtained for this problem.

other's programs because duplication leads to ruinous competition in advertising levels. The literature's assumptions of fixed advertising levels and prices disable this logic. Accordingly, the conventional arguments only apply when $\gamma = 0$ in which case advertising levels are effectively fixed at $m/2$ and per viewer prices at $p(m/2)$.

It follows that, outside this case, if the market under-provides programs, it is because too few channels are operating. Recall that both types of programs should be provided if $K < \Delta B^o$, while only one should be provided if $\Delta B^o < K < B_1^o$. The market operates two channels if $K < \pi_2^*$, one if $\pi_2^* < K < \pi_1^*$, and none if $K > \pi_1^*$. In the one channel case, the revenues the firm earns, π_1^*, are less than the gross advertisers' benefits from the program. Accordingly, they must be less than the optimized sum of viewer and advertiser benefits, implying that $\pi_1^* < B_1^o$. Thus, if $\pi_1^* < K < B_1^o$, the market under-provides programs.

It is quite possible that π_1^* is less than the optimized gain in aggregate benefits from adding a second program, ΔB^o. Then, there will be a range of operating costs for which both programs should be provided, while the market provides none! This case arises when the benefits to viewers from watching their preferred programs are large (large β and ε), while the expected benefits from new producers contacting consumers ($\omega\overline{\sigma}$) or the number of new producers (m) are very small. Since broadcasting firms only capture a share of advertiser benefits and these are small relative to viewer benefits, advertising revenues are considerably less than the aggregate benefits of programming. This produces the type of market failure previously identified in the broadcasting literature (see, for example, Spence and Owen (1977)).

With two channels, the revenue each firm earns, π_2^*, is again less than the gross advertisers' benefits from the program it provides, implying that each firm's revenue is less than $B_2^o/2$. However, as was pointed out earlier, ΔB^o is less than $B_2^o/2$ because some of the direct benefits of the second program come at the expense of the first. Moreover, π_2^* includes revenues that are obtained from "stealing" the advertising revenues of the first program. Accordingly, it is unclear whether π_2^* exceeds or is smaller than ΔB^o. In the latter case, the market always under-provides programs. In the former, there exists a range of operating costs for which the optimal number of programs is one, while the market provides two. Programs are then over-provided by the market. Sufficient conditions for under- and over-provision can be obtained by computing π_2^* and ΔB^o.

Proposition 2 *(i) The market does not provide too many types of programs if $\omega\overline{\sigma} < \frac{2\beta(1+2\varepsilon)}{m(1+\varepsilon)}$, and provides too few for some values of K. (ii) The market provides too many types of programs for some values of K if $\omega\overline{\sigma} > \frac{2\beta(1+2\varepsilon)}{m(1-\varepsilon)}$ and γ is sufficiently small.*

Note that over-provision is possible when advertiser benefits from programs (as measured by $\omega\overline{\sigma}$ and m) are large relative to viewer benefits from an additional program (as measured by β and ε).

Since both the broadcasting literature and the literature on market provision of public goods emphasize the problem of under-provision, the possibility of the market over-providing programs established here is particularly interesting.[22] The key feature which permits over-provision is that the social benefit of an additional program is less than the direct benefits that program generates. This is because programs are substitutes for viewers. Although the entering firm's revenues are less than the direct benefits it generates, they may exceed the social benefits since part of its revenues are offset by the reduction in revenues of the incumbent firm. This is a familiar problem with private entry decisions when products are differentiated.

The previous two propositions establish that there is no guarantee that market outcomes are optimal. Nonetheless, since both over- and under-provision of advertising and programs is possible, the market may produce something quite close to the optimum for a range of parameter

[22] Berry and Waldfogel (1999a) discuss the possibility of overprovision of programming in their empirical analysis of U.S. radio broadcasting. In their model, they show that the amount of programming provided by the market will always exceed the amount that maximizes total non-viewer surplus (by non-viewers they mean those agents who are not potential viewers, i.e., broadcast firms and advertisers). In our model, this amounts to the claim that the private gain from the second firm entering, π_2^*, exceeds the gain in gross advertiser benefits. Their result does not hold in our model. For example, when $\gamma = 0$, advertising levels are $m/2$ for each firm and each has half of the viewers, so $\pi_2^* = N\omega\overline{\sigma}m/4$. The gain in gross advertiser benefits comes from the extra $N\varepsilon/(1+\varepsilon)$ viewers who now watch ads that generate benefits of $3\omega\overline{\sigma}m/8$ per viewer, for a total gain of $N\varepsilon 3\omega\overline{\sigma}m/8(1+\varepsilon)$. The latter exceeds π_2^* for ε sufficiently large.

values. To see this, suppose that ΔB^o exceeds K so that the optimum involves providing both programs. From section 3, the Pigouvian corrective tax is γ. Suppose that this tax is sufficiently high that the revenues it would generate are sufficient to finance the provision of both programs; i.e., $N\gamma a_2^o > K$. Then, if γ is close to γ_2, the critical nuisance cost defined in Proposition 1, the market will provide two channels showing different types of programs with an advertising level close to a_2^o. To see this note that, by continuity, a_2^* is close to a_2^o which means that $p(a_2^*)$ is close to γ. This, in turn, implies that $\pi_2^* > K$ which ensures that the market will operate both channels. Accordingly, our theory suggests that there is no a priori reason to believe that the market necessarily provides broadcasting inefficiently.

5 Further Issues concerning Market Provision

In this section, we extend the analysis to address two further questions concerning market provision. The first is whether market provision produces better outcomes under monopoly or competition. This was a central concern of Steiner (1952) and Beebe (1977) and it remains a policy relevant issue today.[23] Steiner argued that monopoly would provide a better mix of programming than competition, because a monopoly would have no incentive to duplicate programs. Beebe challenged this conclusion, pointing out that if there were a "lowest common denominator" program that all viewers would watch, then a monopoly would have no incentive to provide anything else even if viewers had strong and idiosyncratic preferences for other types of programs. Competitive broadcasters, however, would provide variety as they sought to attract each others' viewers.

The second issue is how the possibility of excluding viewers impacts market performance. If broadcasting firms can exclude viewers they can charge subscription prices.[24] The pros and cons

[23] In the U.S., for example, the Telecommunications Act of 1996 relaxed the restriction on ownership of multiple radio stations in a single market. Since then, there has been growing concentration of ownership in the U.S. radio industry (Berry and Waldfogel (1998)). Concern has been expressed that such concentration will lead to higher prices for radio advertisements and less programming (see, for example, Ekelund, Ford, and Jackson (1999)). As we will see, our model suggests that the former concern is misguided.

[24] In Europe, direct broadcast satellite channels like Canal Plus are partially financed by subscription pricing. In

of pricing broadcasting have long been of interest to public good theorists (see Samuelson (1958), (1964) and Minasian (1964)). The issue was the central concern of Spence and Owen (1977) and continues to attract attention in the broadcasting literature (Doyle (1998), Hansen and Kyhl (1999) and Holden (1993)). It is of policy interest because the social desirability of requiring consumers to pay for television that was previously "free" is often a contentious regulatory issue.

5.1 Is monopoly better than competition?

To analyze the issue, suppose that the two channels are owned by a single firm, rather than two separate firms. If the monopoly operates both channels it will show different programs. As Steiner observed, a monopoly will never duplicate programming. Its revenues with a common advertising level a will be $2NR(a)$ and the revenue maximizing level of advertisements is $a = m/2$. Since $p(m/2) = \omega\overline{\sigma}/2$, its maximal revenues are $Nm\omega\overline{\sigma}/2$.

If the monopoly only operates a single channel, its revenue maximizing advertising level will be a_1^* and its revenues π_1^*. Letting $\Delta\pi = N\frac{m\omega\overline{\sigma}}{2} - \pi_1^*$ be the incremental profit from offering the second program, the monopoly will provide both programs if $K < \Delta\pi$, and one program if K is between $\Delta\pi$ and π_1^*. The following proposition can now be established.

Proposition 3 *Suppose that $K < \pi_2^*$. Then, (i) monopoly leads to advertising levels that are at least as high as those under competition and strictly higher if $\gamma > 0$, and (ii) if $\varepsilon = 0$, monopoly provides no more types of programs than competition and strictly less for some values of K.*

The proof of part (i) is straightforward. Recall that both channels operate under competition if $K < \pi_2^*$ and so advertising levels are a_2^* on each channel. If the monopoly operates both channels, it chooses an advertising level $m/2$, which is strictly larger than the competitive level a_2^* except if $\gamma = 0$ in which case the two levels are equal (see Figure 2). If the monopoly operates only one channel, it chooses a_1^* advertisements, which strictly exceeds a_2^* if $\gamma > 0$ (again see Figure 2) and

the U.S., premium cable channels such as HBO and Showtime are often priced individually. Other cable channels, such as ESPN and CNN, are "bundled" and sold as a package (see, for example, Coppejans and Crawford (1999)). However, both cable companies and the cable networks are involved in pricing decisions. Accordingly, a complete analysis of pricing in the U.S. system would require incorporating the behavior of cable companies. We leave this task for future work.

equals a_2^* if $\gamma = 0$. In both cases observed per viewer advertising prices are lower under monopoly! The logic is exactly that of Masson, Mudambi, and Reynolds (1990). Under competition firms compete by reducing advertising levels to render their programs more attractive. A monopoly, by contrast, is only worried about viewers turning off completely and so advertises more. This greater quantity of advertisements sell at a lower per viewer price.[25]

Part (ii) follows from two facts. First, when competition might produce duplication ($\gamma = \varepsilon = 0$) monopoly provides only one program. In this case, all viewers will watch their less preferred program no matter what its advertising level so that $\Delta\pi = 0$. Second, when $\varepsilon = 0$, the monopoly always has less incentive to provide the second program than does a competitive firm; i.e., $\Delta\pi < \pi_2^*$ (this is shown in the Appendix). The result goes against Steiner's claim that monopoly might provide more programming because it avoids duplication. In our model, when duplication might arise, the monopoly responds by simply eliminating the duplication rather than by both eliminating duplication and providing more programs.[26] The result is thus more consonant with Beebe's argument.

As a caveat to part (ii), it is important to note that there is no general logic suggesting that the incentives to provide additional programming are less under monopoly and hence that monopoly will produce fewer programs. Intuitively, it is not clear whether $\Delta\pi$ should be greater or smaller than π_2^*. On the one hand, the monopoly internalizes the business stealing externality; i.e., it takes into account the fact that introducing additional programming means that existing programs will earn less revenue. On the other, the monopoly coordinates across programs and puts more advertisements on the new and old programs which means that each program earns more

[25] Notice, however, that advertiser surplus will not necessarily rise when the monopoly operates only one channel, because fewer viewers will be exposed to advertisements. In this case, the total cost of an advertisement may also be higher under monopoly because each advertisement reaches more viewers. Suppose, for example, that $\gamma = \varepsilon = 0$ and that $K \leq Nm\omega\overline{\sigma}/4$. Then the monopolist provides only one channel with $m/2$ advertisements, while competition produces two channels each with $m/2$ advertisements. Then, the total price of an advertisement is twice as high under monopoly, since twice as many viewers watch the monopolist's single program as watch each competing program.

[26] With viewer groups of different sizes, Steiner's result can hold for $\gamma = 0$ and $\varepsilon > 0$. Section 6 has the details.

revenue than under competition. This second effect has been ignored by the literature because of its assumption of fixed advertising levels. Thus, while $\Delta\pi < \pi_2^*$ when $\varepsilon = 0$, the result is not true for all ε.[27] When $\Delta\pi > \pi_2^*$ and the second effect overwhelms the first, monopoly provides more programs than competition for some values of K.[28]

What can be said about the welfare comparison of monopoly and competition? We focus on the case in which $K < \pi_2^*$ so that both channels are operating under competition. The welfare analysis is straightforward if both channels are operated under monopoly ($K < \Delta\pi$). Monopoly leads to a lower level of aggregate benefits if advertising is over-provided with competition ($\gamma > \gamma_2$). On the other hand, if advertising is under-provided under monopoly ($\gamma < \frac{\omega\overline{\sigma}}{2}$), monopoly does better. If advertising is under-provided with competition and over-provided with monopoly, then the answer depends on the relative magnitudes of the under- and over-provision.

Matters are more complicated when the monopoly operates one channel ($K > \Delta\pi$). If competition involves duplication ($\gamma = \varepsilon = 0$), then surplus (aggregate program benefits minus operating costs) will be higher under monopoly since programming and advertising levels will be unchanged and society simply saves the cost of operating the second channel (K). When competition provides both types of programs, society saves K but aggregate benefits are reduced by an amount $\Delta B^* = B_2(a_2^*) - B_1(a_1^*)$. The latter can be decomposed into a change in viewer benefits and a change in advertiser benefits (gross of payments to broadcasters). Viewer benefits must decrease. Some viewers still have their preferred program but at a higher nuisance cost due to higher advertising levels; others still watch but no longer have their preferred program, while the rest turn off

[27] We have found a counter-example for $\varepsilon = 100$ and $\gamma = 2\beta/m$. This counter-example can be checked by evaluating the function $\Psi(\varepsilon)$ defined in the proof of Proposition 3 at $\varepsilon = 100$ and verifying that it is less than 1/2. As ε rises, both the first effect (cannibalization of existing programs) and the second effect (higher advertising levels) diminish. At $\varepsilon = 100$, it turns out that the second effect dominates the first. Unfortunately, there is no general result which says that this is true for all ε sufficiently large. In the limit as ε tends to infinity, both effects tend to 0 and the monopoly and competitive outcomes coincide.

[28] Berry and Waldfogel (1998) empirically examine the consequences of increased concentration in the U.S. radio broadcasting industry for the variety of programming and the entry of new stations. They find that increased concentration increases variety and reduces entry. They interpret this as possible evidence of strategic preemption. It would be interesting to investigate such strategic effects in a dynamic version of our model.

completely. The effect on advertiser benefits is ambiguous. The per viewer price of advertisements is lower, bringing in a greater range of products advertised and an associated increase in advertiser benefits on that account, but each previously advertised product now reaches a smaller potential market due to viewers who switch off. Conditions under which ΔB^* exceeds or is smaller than K can be derived by carefully considering the determinants of these benefit changes. They are reported in the following proposition.

Proposition 4 *Suppose that $\Delta\pi < K < \pi_2^*$. Then if $\omega\overline{\sigma} < \frac{2\beta(1+2\varepsilon)}{m(1+\varepsilon)}$ aggregate surplus is lower under monopoly if $\gamma \in (\gamma_2, \frac{3\omega\overline{\sigma}}{4})$. However, if $\omega\overline{\sigma} > \frac{2\beta(1+2\varepsilon)}{m(2-\varepsilon)}$ and $K > N[\beta\frac{1+2\varepsilon}{2(1+\varepsilon)} + \frac{\varepsilon 3m\omega\overline{\sigma}}{8(1+\varepsilon)}]$ aggregate surplus is higher under monopoly for γ sufficiently small.*

To sum up, in contrast to standard markets, there is no presumption that monopoly in broadcasting produces worse outcomes than competition. Advertising levels are higher under monopoly, meaning lower advertising prices. However, programming can go either way. On the one hand, a monopoly will take into account the fact that an additional channel draws viewers from others in its stable. On the other, additional channels will carry higher advertising levels than under competition. The welfare comparison between monopoly and competition is complicated by the need to take account of both changes in advertising levels and programming. Even if one knows the direction of these changes, their desirability is uncertain a priori because advertising and programming could be either over- or under-provided under competition.

5.2 Does viewer excludability help?

Characterizing market outcomes when firms can both run advertisements and charge viewers subscription prices is conceptually straightforward but somewhat involved, so we relegate the details to the Appendix. Here we simply summarize the results. When only one channel is operating, the firm will run $a_2^o/2$ advertisements and charge a subscription price

$$s_1^* = \min\{\beta, \beta(1+\frac{\varepsilon}{2}) - \frac{R(\frac{a_2^o}{2}) - \gamma a_2^o/2}{2}\} - \gamma\frac{a_2^o}{2} > 0.$$

The "full price" faced by viewers is the subscription price plus the nuisance cost of advertising, i.e., $s_1^* + \gamma a_2^o/2$ and it is this price that determines the number of viewers the firm gets. A viewer whose less preferred program is being shown will watch if and only if $\lambda\beta$ exceeds $s_1^* + \gamma a_2^o/2$. Accordingly, the firm's revenues will be

$$\pi_{1s}^* = N(1 + \frac{1 - (s_1^* + \gamma a_2^o/2)/\beta}{1+\varepsilon})[s_1^* + R(a_2^o/2)].$$

In the two channel case, the firms will always choose different program types. The possibility of duplication is eliminated even in the special case of $\gamma = \varepsilon = 0$ because Bertrand competition would drive subscription prices to zero. Each firm will run $a_2^o/2$ advertisements and charge a subscription price

$$s_2^* = \min\{\beta, \beta(1+\varepsilon) - [R(\frac{a_2^o}{2}) - \gamma a_2^o/2]\} - \gamma\frac{a_2^o}{2} > 0.$$

Each firm's program will be watched by N viewers and it will earn revenues

$$\pi_{2s}^* = N(s_2^* + R(a_2^o/2)).$$

The two channel case arises when K is less than π_{2s}^*; the one channel case when K is between π_{2s}^* and π_{1s}^*.

Notice that the equilibrium advertising level is the same in both the one and two channel cases and equals one half of the two program optimal level. To understand this, recall that a firm's full price determines the number of viewers it gets. Hence, for any given full price, the firm will choose the advertising level and subscription price that maximize revenue per viewer. More precisely, if the firm is charging a full price r it will choose a and s to maximize $R(a) + s$ subject to the constraint that $\gamma a + s = r$. In both the one and two channel cases, the equilibrium subscription price is positive. If this price were reduced by γ and one more advertisement were transmitted, the full price would stay constant and revenue per viewer would be raised by $R'(a) - \gamma$. Thus, the equilibrium advertising level must satisfy the first order condition $R'(a) \leq \gamma$ with equality if

$a > 0$. Since the linearity of the demand function implies that $R'(a) = p(2a)$, this means that the equilibrium advertising level is $a_2^o/2$ (recall that $p(a_2^o) \leq \gamma$ with equality if $a_2^o > 0$).

In both the one and two channel cases, the equilibrium advertising level is smaller than that selected without excludability as long as γ is positive (the two advertising levels are equal when $\gamma = 0$). This follows from the fact that $a_2^o/2 \leq a_2^* \leq a_1^*$ with the inequalities holding strictly when $\gamma > 0$. Intuitively, excludability allows broadcasters to respond to viewers' dislike of commercials by reducing advertisements and raising subscription prices. Broadcasters will only impose advertising to the point at which the marginal revenue equals the nuisance cost γ. This produces lower advertising levels.

Not surprisingly, it can be shown that equilibrium profits are higher with excludability (i.e., $\pi_{1s}^* > \pi_1^*$ and $\pi_{2s}^* > \pi_2^*$). Pricing allows broadcasters to extract direct payments for their programming and hence makes programs more profitable. This, together with the fact that duplication is not possible with subscription pricing, means that the market provides at least as many programs with subscription pricing.[29] Thus, we have the following proposition.

Proposition 5 *With excludability, the market provides no higher advertising levels than without and strictly lower levels if $\gamma > 0$. Moreover, with excludability the market provides at least as many types of programs as without and strictly more for some values of K.*

Will the market generate a higher level of welfare when viewers are excludable? We first study the cases in which the number of channels operated is the same with and without excludability, starting with the two channel case. We then analyze the case in which excludability increases the number of channels.

Two channels are operated with and without excludability when $K < \pi_2^*$. If $\gamma > 0$, these channels each provide a different type of program and all viewers watch. The only welfare relevant difference in the two regimes is that advertising levels are lower with excludability. This increases viewer benefits but reduces advertiser benefits. The reduction in advertiser benefits will outweigh

[29] The models of Spence and Owen (1977) and Doyle (1998) suggest similar conclusions.

the increase in viewer benefits if advertisements are not much of a nuisance and are already under-provided; i.e., if $\gamma \leq \gamma_2$. The opposite is true for high nuisance costs ($\gamma \geq \omega\overline{\sigma}$), in which case the market delivers the optimal advertising level with excludability. For intermediate nuisance costs ($\gamma_2 < \gamma < \omega\overline{\sigma}$), the switch is from too much advertising without excludability to insufficient advertising with it (since $a_2^o/2 < a_2^o$). Whether aggregate benefits increase or not depends on which distortion is more important.[30]

This discussion belies some interesting distributional consequences of pricing. It is shown in the Appendix (Fact 2) that pricing results in an increase in the full price faced by viewers; i.e., $s_2^* + \gamma a_2^o/2 > a_2^*$. The higher full price implies that viewer surplus must decrease. In addition, the fact that $a_2^* > a_2^o/2$ for all $\gamma > 0$, implies that advertiser surplus is lower. Accordingly, subscription pricing leads to a redistribution of surplus away from viewers and advertisers, towards broadcasting firms.

The market produces one channel with and without excludability when $\pi_{2s}^* < K < \pi_1^*$.[31] The number of viewers is lower with excludability because the full price faced by viewers is higher; i.e., $s_1^* + \gamma a_2^o/2 > a_1^*$ (see the Appendix). However, these viewers are exposed to less advertising, so that viewer benefits may either increase or decrease. Advertiser benefits must decrease as there are less advertisements and these are seen by fewer viewers. If $\gamma \leq \gamma_1$ so that advertising is under-provided without excludability, the reduction in advertiser benefits must exceed any increase in viewer benefits.

[30] If $\gamma = 0$, then since $a_2^* = a_2^o/2 = m/2$, pricing leads to no change in aggregate benefits if the equilibrium without excludability has both firms choosing different programs. However, if it involves duplication, then by destroying this equilibrium, pricing enhances welfare. This advantage of subscription pricing is stressed by Doyle (1998).

[31] The welfare question in this case is formally similar to Hansen and Kyhl's (1999) comparison of pay per view broadcasting and pure advertiser-supported provision of a single event. Their comparison is formally equivalent to comparing the impact of viewer excludability under the assumption that (at most) one program type can be provided. Unlike our analysis, they assume (implicitly) a horizontal demand curve for advertisements. The results they get are ambiguous. On the one hand, pay per view may screen out consumers with positive willingness to pay, on the other it allows the provider to get more surplus and hence increases the probability of provision. They show that pay per view leads to a lower level of advertisements than a pure advertiser supported system and argue that both systems over-provide advertisements.

An example in which viewer benefits increase with excludability and exceed the reduction in advertiser benefits can be constructed when nuisance costs are high ($\gamma \geq \omega\overline{\sigma}$). In this case, with excludability, the advertising level is 0 and the subscription price is β. Thus, only those viewers whose preferred program is provided watch and viewer benefits are $N\beta$. Advertiser benefits are 0. With non-excludability, aggregate benefits from the program are $B_1(a_1^*)$. For sufficiently large ε, $B_1(a_1^*)$ is less than $N\beta$. Intuitively, as ε gets higher, viewer benefits must increase because the costs of excludability in terms of lost viewers become vanishingly small, while the benefits in terms of reduced advertisements remain. These benefits outweigh the reduction in advertiser benefits because $\gamma \geq \omega\overline{\sigma}$.

Excludability increases the number of channels when $\pi_2^* < K < \pi_1^*$ and $K < \pi_{2s}^*$. In this case, the number of viewers is higher with excludability. Viewer benefits must increase, while the effect on advertiser benefits is uncertain. The key question is whether the increase in viewer and advertiser benefits exceeds the social cost of operating the extra channel. While answering this question is difficult in general, there are cases for which clean results are available. Once again these rely on extreme values of the nuisance cost.

When the nuisance cost is high ($\gamma \geq \omega\overline{\sigma}$) the market provides broadcasts optimally with excludability when $K < \Delta B^o$. Accordingly, excludability must improve welfare.[32] At the other extreme, if there are no nuisance costs ($\gamma = 0$), the equilibrium advertising level with excludability remains at $m/2$. Thus, excludability holds constant the advertising level but generates a new program. The extra advertising benefits this produces is that associated with the extra $N\frac{\varepsilon}{1+\varepsilon}$ viewers, and is $N\frac{\varepsilon}{1+\varepsilon}\frac{3\omega\bar{\sigma}m}{8}$. The extra viewing benefits are $N\beta[1 - \frac{1}{2(1+\varepsilon)}]$. Thus, if K is greater

[32] Again, this belies some interesting distributional consequences. Since $s_2^* = \beta$ viewers obtain no surplus under subscription pricing. Indeed, introducing subscription pricing, even though it increases programming, makes no group of viewers better off and makes all those who were watching the status quo programming worse off. Given that regulators cannot costlessly transfer surplus from broadcasters to viewers, regulatory opposition to television pricing seems unsurprising.

than the sum of these two terms, aggregate surplus is lower with excludability.[33]

To sum up, there is no guarantee that the ability to exclude viewers and charge subscription prices will improve market performance. With excludability, the market produces lower advertising levels and more types of programs than without. Broadcasters respond to viewers' dislike of commercials by substituting prices for advertisements, and this strategy makes programming more profitable. Since the market may under-provide advertisements and over-provide programs without excludability, these changes are not necessarily desirable. Pricing also has significant distributional consequences. It leads to viewers paying a higher full price for programs and even when it leads to more programming, it is possible for all viewers to be (weakly) worse off. Advertisers too may be worse off because of the lower volume of advertisements.

6 Asymmetric Viewer Groups

The model so far has assumed that the two groups of viewers are symmetric. In this section, we discuss two different ways of introducing asymmetries and their implications for market performance. We begin by working through the consequences of the two groups being of different size. We then discuss what happens if the two groups are of different value to advertisers.[34]

6.1 Different sized groups

Let N_t denote the number of viewers who prefer type t programs and suppose that N_1 exceeds N_2. This creates an asymmetry between the two types of programs. This asymmetry has relatively minor implications for optimal provision. Naturally, it means that the aggregate benefits from providing a type 1 program are higher than those from a type 2 program. However, the advertising

[33] Using the expressions for π_2^*, π_{2s}^* and π_1^* when $\gamma = 0$, it is straightforward to show that there exist values of K satisfying this inequality that are consistent with the assumptions that $\pi_2^* < K < \pi_1^*$ and $K < \pi_{2s}^*$. For example, when $\varepsilon = 0$, the inequality is $K > N\beta/2$. The condition that $\pi_2^* < K < \pi_1^*$ becomes $\frac{N\omega\overline{\sigma}m}{4} < K < \frac{N\omega\overline{\sigma}m}{2}$ and the condition that $K < \pi_{2s}^*$ becomes $K < N\beta$. Clearly, there is a range of values of K that satisfy these joint conditions.

[34] These are by no means the only two ways of introducing asymmetries. Groups may also vary in how intensely they value consuming programming or in the nuisance cost of advertising they experience. Such asymmetries can be incorporated straightforwardly and we leave the task of exploring their implications to the reader.

level that maximizes these aggregate benefits reflects the same considerations as those underlying the determination of a_1^o. Moreover, when both types of program are provided, aggregate benefits continue to be maximized by having each program show a_2^o advertisements.

The asymmetry has more significant implications for market provision. Consider Stage 2 of the game and suppose that the two firms have chosen different types of programs in Stage 1. For concreteness, suppose that firm A is showing a type 1 program, while firm B is showing a type 2 program. If the two firms choose advertising levels (a_A, a_B) their revenues are given by

$$\pi_{21}^A(a_A, a_B) = \begin{Bmatrix} N_1[1-\widetilde{\gamma}(a_A - a_B)]R(a_A) \text{ if } a_A \geq a_B \\ [N_1 + N_2\widetilde{\gamma}(a_B - a_A)]R(a_A) \text{ otherwise} \end{Bmatrix},$$

and

$$\pi_{22}^B(a_A, a_B; \gamma) = \begin{Bmatrix} [N_2 + N_1\widetilde{\gamma}(a_A - a_B)]R(a_B) \text{ if } a_A \geq a_B \\ N_2[1-\widetilde{\gamma}(a_B - a_A)]R(a_B) \text{ otherwise} \end{Bmatrix},$$

where $\widetilde{\gamma} = \gamma/\beta(1+\varepsilon)$.

It is straightforward to show that the equilibrium advertising levels, denoted a_{21}^* and a_{22}^*, must be such that $a_{21}^* \geq a_{22}^*$ and must satisfy the first order conditions

$$R'(a_{21}^*) = \frac{\widetilde{\gamma}}{1-\widetilde{\gamma}(a_{21}^* - a_{22}^*)} R(a_{21}^*),$$

and

$$R'(a_{22}^*) = \frac{\rho\widetilde{\gamma}}{1+\rho\widetilde{\gamma}(a_{21}^* - a_{22}^*)} R(a_{22}^*),$$

where ρ denotes the ratio of type 1s to type 2s in the population. These imply that $a_{21}^* = a_{22}^* = m/2$ when $\gamma = 0$ and that $m/2 > a_{21}^* > a_{22}^*$ for all $\gamma > 0$ (since R/R' is increasing). Thus the firm serving the smaller group has a lower level of advertising if the nuisance cost is positive.[35]

[35] The above two first order conditions are necessary conditions for a_{21}^* and a_{22}^* to be equilibrium advertising levels. They are not, however, sufficient. It must also be checked that firm B's "equilibrium" revenues π_{22}^* exceed the maximal revenue that it could obtain if it choose a level of advertising larger than a_{21}^*; that is, $\pi_{22}^* > \max\{\pi_{22}^B(a_{21}^*, a_B) : a_B > a_{21}^*\}$. If this condition is not satisfied, there exists no (pure strategy) equilibrium of the advertising game. We have been unable to develop an analytical proof that the above condition is satisfied for all ρ. However, we have been unable to generate a counter example with our simulations.

This means that it serves some of the other firm's natural constituency. However, the first order conditions imply that the firm serving the larger group still retains a larger viewership.

If both firms have chosen the same program in Stage 1, competition for viewers will drive advertising levels to 0, except when $\gamma = 0$. In this special case, if the firms are showing type 1 programs, they each get $[N_1 + N_2/(1+\varepsilon)]/2$ viewers, irrespective of their advertising levels. Each will therefore choose $m/2$ advertisements. If a firm switched to a type 2 program, it would get N_2 viewers and would again choose $m/2$ advertisements. Thus, both firms showing a type 1 program is an equilibrium if $[N_1 + N_2/(1+\varepsilon)]/2 > N_2$ or, equivalently, if $\frac{1+2\varepsilon}{1+\varepsilon}N_2 < N_1$. If $\frac{1+2\varepsilon}{1+\varepsilon}N_2 > N_1$ then one firm would wish to switch to a type 2 program and both firms showing type 1 programs is not an equilibrium. It should be clear that it cannot be an equilibrium for both firms to show the less popular program.

Pulling all this together, we may conclude that if both firms provide programs and either $\gamma > 0$ or $\frac{1+2\varepsilon}{1+\varepsilon}N_2 > N_1$, they will show different types of programs with the type 1 channel showing a_{21}^* advertisements and the type 2 channel showing a_{22}^* advertisements. If $\gamma = 0$ and $\frac{1+2\varepsilon}{1+\varepsilon}N_2 < N_1$ both channels provide type 1 programs with $m/2$ advertisements.

Two new points concerning the difference between market provision and the optimum are worth noting. First, under market provision, if $\gamma > 0$, the advertising level on the program preferred by the minority group is lower than that on the majority-preferred program. Some type 1 viewers end up watching a type 2 program and the allocation of viewers across programs is distorted away from the optimum. This makes it impossible for the market to produce the advertising levels which maximize the aggregate benefits from provision of both types of programs.

Second, if $\gamma = 0$, the market necessarily duplicates the majority preferred program for a broad range of parameter values. Steiner and Beebe's arguments concerning the ability of monopoly to remedy duplication can also be illustrated in this case. When $\gamma = 0$, a monopoly will provide both types of channels if $m\omega\overline{\sigma}\varepsilon N_2/4(1+\varepsilon) > K$ and a single type 1 channel otherwise. When

$\varepsilon = 0$ we are in Beebe's world where consumers of minority programming prefer to watch majority programming than nothing and a monopoly provides no variety. As ε gets large, we move closer to Steiner's world where minority viewers switch off rather than watch majority programming and monopoly does provide variety.

6.2 Groups of different values to advertisers

An important source of group asymmetries in practice is that some groups are more valuable to advertisers than others. To capture this, suppose that if a new good is of type σ, then a type 2 consumer will have willingness to pay ω with probability $\delta\sigma$ and willingness to pay 0 with the residual probability. Thus, the expected benefit of a new producer of type σ contacting a consumer of type 2 is $\delta\sigma\omega$. We assume that $\delta > 1$ in what follows, so that type 2 viewers are more valuable to advertisers than type 1 viewers. This difference between consumers will mean that the demand for reaching viewers of the two types will differ. Let p_t be the price of reaching a single viewer of type t. The inverse demand curves for the two viewer groups are $p_1(a) = \omega\overline{\sigma} \cdot [1 - a/m]$ and $p_2(a) = \delta\omega\overline{\sigma} \cdot [1 - a/m]$. Notice that $p_2(a) = \delta p_1(a) = \delta p(a)$.

The main change in optimal provision is that, when both programs are provided, there should be a higher level of advertisements on the type 2 program. These viewers are more valuable to advertisers and they will optimally be exposed to a higher level of advertisements, even though this causes some misallocation of viewers across channels. Characterizing market provision in this case is made easy by the observation that it is formally identical to a situation in which there are N_1 type 1s, δN_2 type 2s and the two groups are equally valuable to advertisers. The nature of market provision in this case can then be deduced from the results of the previous subsection. In particular, the market involves more advertising on the type 2 program if and only if $\delta N_2 > N_1$.

The main new difference between market provision and the optimum arising in this case is that the market might produce the wrong type of program. To see this, suppose that K is such that only one firm operates in the market solution. If $\delta N_2 > N_1$, this firm will select a type 2 program. However, if $\delta\omega\overline{\sigma} < \gamma$, the optimal type of program is clearly a type 1 program (since $N_1 > N_2$). This distortion simply reflects the well-known point that what matters to broadcasting firms is the value of viewers to advertisers, not the value of the viewing benefits they enjoy.

7 Conclusion

Radio and television broadcasts are public goods with two non-standard features. First, they are consumed by two types of consumers: viewers/listeners and advertisers. The latter's "consumption" creates negative externalities, so that advertisers' access to broadcasts should optimally be restricted via a Pigouvian corrective tax. Second, broadcasts are differentiated products which are substitutes for viewers. This means that the benefits created by an additional program are less than the direct viewing and advertiser benefits it creates. Part of these direct benefits come from attracting viewers of other programs.

Market provision of broadcasting is possible because advertisers are excludable. Moreover, since advertisers' consumption imposes negative externalities, curtailing their consumption via market prices of advertising is not necessarily inefficient. Thus, there is no a priori reason to believe that the market cannot provide broadcasting in at least an approximately efficient way. The question is (i) how well market prices of advertising will reflect the externality created by advertisers and (ii) whether advertising revenues generate appropriate incentives for the provision of programs.

With respect to the first issue, we have demonstrated that the relationship between equilibrium advertising prices and the Pigouvian corrective tax depends on the relative sizes of the nuisance cost and the social benefit of advertisements. With a relatively low nuisance cost, market prices will be too high and viewers will be exposed to too few advertisements. The opposite is true with a relatively high nuisance cost. These findings are particularly interesting in light of the broadcasting literature's neglect of advertising. Notwithstanding the fact that the governments of most countries impose ceilings on advertising levels, the literature has offered no guidance on what the socially optimal level is, let alone the ability of the market to produce it.

With respect to the second issue, we have shown that equilibrium advertising revenues may be such as to generate too few or too many types of programs. A firm's choice of whether to provide a program does not account for the extra viewer and advertiser surpluses generated, nor for the loss of advertising revenue inflicted on competitors. Underprovision will arise when the benefits of programming to viewers are high relative to the benefits to advertisers from contacting viewers. Overprovision can arise when the reverse is true and nuisance costs are low. The existing literature on market provision has largely focused on the underprovision of broadcasting. Moreover, it has emphasized duplication as a key source of underprovision. Our results suggest that, if the nuisance cost of advertising is positive, then broadcasters will avoid duplication because it would lead to cut-throat competition in advertising levels.

While the market is unlikely to provide broadcasting optimally, our results suggest that it may produce something quite close to an optimal system for a range of parameter values. They also suggest that there should be no general presumption of bias in any one particular direction. Empirical investigation of the relevant parameters is therefore necessary to guide the regulation of commercial broadcasting. Such investigation is clearly an important subject for future research.

Two theoretical questions concerning market provision of broadcasting remain for future research. First, does the market provide programs of the right quality and how is this quality impacted by the number of channels providing programming? It is common to hear the argument that the proliferation of channels in the U.S. television market has led to a decline in programming quality. This raises the possibility that technological advances permitting more channels can worsen aggregate surplus. Second, how is market provision impacted by cable or satellite delivery of programming? This introduces an additional agent into the picture, the intermediary service provider, and so an additional possible source of distortion in market choices.

The present framework is also suitable for investigating the role of commercial-free public broadcasting stations. In the literature, the role of public broadcasting is seen as providing socially valuable programming that the market would not provide (Berry and Waldfogel (1999b), Brown (1996)). The increasing diversity of commercial radio and television programming in western countries has led some to question whether public broadcasting continues to be warranted. The analysis of this paper suggests a different argument for public broadcasting; namely, for some (or perhaps all) viewers the nuisance costs of advertising are high relative to its social benefits and public stations not only serve as an outlet for those viewers with high nuisance costs but also help reduce commercial levels on competitor stations.

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8 Appendix

Proof of Proposition 1: We begin with the case in which the market provides one type of program. For clarity, write a_i^o as $a_i^o(\gamma)$ and similarly for a_i^*, $i = 1, 2$. We already know that $a_1^o(0) > a_1^*(0)$, and that $a_1^o(\gamma) < a_1^*(\gamma)$ for all $\gamma \geq \omega\overline{\sigma}$. Thus, by continuity, there exists $\gamma_1 \in (0, \omega\overline{\sigma})$ such that $a_1^o(\gamma_1) = a_1^*(\gamma_1)$. We need to show that this is unique.

We know that if $a_1^o(\gamma) > 0$ then

$$(\beta(2+\varepsilon) - \gamma a_1^o)[p(a_1^o) - \gamma] = \gamma \int_0^{a_1^o} p(\alpha) d\alpha,$$

or, equivalently, using the linear demand specification,

$$(\beta(2+\varepsilon) - \gamma a_1^o)[\omega\overline{\sigma}(1 - \frac{a_1^o}{m}) - \gamma] = \gamma\omega\overline{\sigma}a_1^o(1 - \frac{a_1^o}{2m}).$$

In addition, from the first order conditions that characterize $a_1^*(\gamma)$, we have that

$$(\beta(2+\varepsilon) - \gamma a_1^*)R'(a_1^*) = \gamma R(a_1^*),$$

or, equivalently,

$$(\beta(2+\varepsilon) - \gamma a_1^*)(1 - \frac{2a_1^*}{m}) = \gamma(1 - \frac{a_1^*}{m})a_1^*.$$

Thus, if $a_1^o(\gamma) = a_1^*(\gamma) = a$, we have that

$$\frac{\gamma\omega\overline{\sigma}a(1 - \frac{a}{2m})}{[\omega\overline{\sigma}(1 - \frac{a}{m}) - \gamma]} = \frac{\gamma(1 - \frac{a}{m})a}{(1 - \frac{2a}{m})},$$

which implies, after some simplification, that

$$\frac{a}{m} = \frac{1}{1 + \frac{\omega\overline{\sigma}}{2\gamma}}.$$

We can now establish uniqueness. Suppose, to the contrary, that there exists γ and γ' such that $\gamma < \gamma'$ with the property that $a_1^o(\gamma) = a_1^*(\gamma) = a$ and $a_1^o(\gamma') = a_1^*(\gamma') = a'$. Then, we know that $a > a'$ and hence the above equation implies that

$$\frac{1}{1 + \frac{\omega\overline{\sigma}}{2\gamma}} > \frac{1}{1 + \frac{\omega\overline{\sigma}}{2\gamma'}}.$$

But this is inconsistent with the hypothesis that $\gamma < \gamma'$.

Turning to the case in which the market provides both programs, again since we already know that there exists $\gamma_2 \in (0, \omega\overline{\sigma})$ such that $a_2^o(\gamma_2) = a_2^*(\gamma_2)$, the task is to show that γ_2 is unique. We know that if $a_2^o(\gamma) > 0$, $p(a_2^o) = \gamma$. In addition, from our characterization of $a_2^*(\gamma)$ we have that $\frac{\beta(1+\varepsilon)R'(a_2^*)}{R(a_2^*)} = \gamma$. Thus, if $a_2^o(\gamma) = a_2^*(\gamma) = a$, we have that

$$\frac{\beta(1+\varepsilon)R'(a)}{R(a)} = p(a),$$

or, equivalently,

$$\frac{(1-\frac{2a}{m})}{a(1-\frac{a}{m})} = \frac{\omega\overline{\sigma}(1-\frac{a}{m})}{\beta(1+\varepsilon)}.$$

We will show that this equation has a unique solution for a in the relevant range which, since both $a_2^o(\gamma)$ and $a_2^*(\gamma)$ are decreasing functions, will imply that the solution γ_2 to the equation $a_2^o(\gamma) = a_2^*(\gamma)$ is unique.

Letting $\varsigma = a/m$ and $\Upsilon = \frac{\omega\overline{\sigma}m}{\beta(1+\varepsilon)}$, we may rewrite the above equation as

$$\frac{1-2\varsigma}{1-\varsigma} = \Upsilon\varsigma(1-\varsigma).$$

Since we know that $a_2^*(\gamma) \leq m/2$, the relevant range is $\varsigma \in (0, 1/2)$. The left-hand side is decreasing in ς while the right hand side is increasing in ς over the relevant range, so the solution is unique.

For the final part of the proposition (that $\gamma_2 < \gamma_1$), we simply need to show that $a_2^o(\gamma_1) > a_2^*(\gamma_1)$. Using the diagrammatic arguments from the text, we have that $a_2^o(\gamma_1) > a_1^o(\gamma_1) = a_1^*(\gamma_1) > a_2^*(\gamma_1)$. ■

Proof of Proposition 2: We will need the following useful fact.

Fact 1: For all γ, $\Delta B^o \geq N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}$ with the equality holding strictly if $\gamma \geq \omega\overline{\sigma}$. Moreover, when $\gamma = 0$, $\Delta B^o = N[\beta\frac{1+2\varepsilon}{2(1+\varepsilon)} + \frac{\varepsilon m\omega\overline{\sigma}}{2(1+\varepsilon)}]$.

Proof: It is clear that

$$\Delta B^o \geq B_2(a_1^o) - B_1(a_1^o),$$

so that it suffices to show that

$$B_2(a_1^o) - B_1(a_1^o) \geq N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}.$$

Consider, then, the effect of adding an additional program holding constant the advertising level at a_1^o. Suppose that the existing program is a type 1 program and hence that the additional program is a type 2 program. Type 1 viewers experience no change in their welfare. A type $(2,\lambda)$ viewer enjoys a welfare increase of $(1-\lambda)\beta$ if $\lambda \geq \gamma a_1^o/\beta$ and $\beta - \gamma a_1^o$ otherwise (these gains corresponding to those who were and who were not watching before). Advertisers get an additional $N\frac{\gamma a_1^o/\beta+\varepsilon}{1+\varepsilon}$ viewers and experience a gain of $N[\frac{\gamma a_1^o/\beta+\varepsilon}{1+\varepsilon}]\int_0^{a_1^o} p(a)da$. Aggregating these gains up, we obtain

$$B_2(a_1^o) - B_1(a_1^o) = N[\int_{\frac{\gamma}{\beta}a_1^o}^{1}(1-\lambda)\beta\frac{d\lambda}{1+\varepsilon} + [\frac{\frac{\gamma}{\beta}a_1^o+\varepsilon}{1+\varepsilon}](\beta - \gamma a_1^o + \int_0^{a_1^o} p(a)da)].$$

Since $p(a_1^o) \geq \gamma$, the right hand side is at least as large as

$$N\beta\{\int_{\frac{\gamma}{\beta}a_1^o}^{1}(1-\lambda)\frac{d\lambda}{1+\varepsilon} + [\frac{\frac{\gamma}{\beta}a_1^o+\varepsilon}{1+\varepsilon}]\}.$$

To complete the proof, observe that

$$N\beta\{\int_{\frac{\gamma}{\beta}a_1^o}^{1}(1-\lambda)\frac{d\lambda}{1+\varepsilon} + [\frac{\frac{\gamma}{\beta}a_1^o+\varepsilon}{1+\varepsilon}]\} \geq N\beta\{\int_0^1(1-\lambda)\frac{d\lambda}{1+\varepsilon} + [\frac{\varepsilon}{1+\varepsilon}]\} = N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}.$$

When $\gamma = 0$, we have that $a_1^o = a_2^o = m$, so that then $\Delta B^o = B_2(m) - B_1(m)$. Using the above formula, we obtain

$$B_2(m) - B_1(m) = N[\int_0^1(1-\lambda)\beta\frac{d\lambda}{1+\varepsilon} + [\frac{\varepsilon}{1+\varepsilon}](\beta + \int_0^m p(a)da)] = N[\beta\frac{1+2\varepsilon}{2(1+\varepsilon)} + \frac{\varepsilon m\omega\overline{\sigma}}{2(1+\varepsilon)}].$$

This completes the proof of the Fact. ■

We can now prove the Proposition. (i) If $\omega\overline{\sigma} < \frac{2\beta(1+2\varepsilon)}{m(1+\varepsilon)}$, then $Nm\omega\overline{\sigma}/4 < N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}$. By Fact 1, this implies that $\Delta B^o > \pi_2^*$. In addition, we know that $\pi_1^* < B_1^o$. Hence the market never over-provides programs, and under-provides them for $K \in (\pi_1^*, B_1^o)$ and $K \in (\pi_2^*, \Delta B^o)$. (ii) If $\omega\overline{\sigma} > \frac{2\beta(1+2\varepsilon)}{m(1-\varepsilon)}$ then $Nm\omega\overline{\sigma}/4 > N[\beta\frac{1+2\varepsilon}{2(1+\varepsilon)} + \frac{\varepsilon m\omega\overline{\sigma}}{2(1+\varepsilon)}]$, which by Fact 1 implies $\Delta B^o < \pi_2^*$ for $\gamma = 0$.

Since ΔB^o and π_2^* are clearly continuous functions of γ, there exists $\hat{\gamma} > 0$ such that $\Delta B^o < \pi_2^*$ if $\gamma \in (0, \hat{\gamma})$. The market over-provides programs for $K \in (\Delta B^o, \pi_2^*)$. ■

Proof of Proposition 3: Part (i) is established in the text. For the first claim in part (ii) recall that when $\gamma > 0$, competition provides both types of programs (since $K < \pi_2^*$ by assumption) and hence monopoly cannot provide more programming. When $\gamma = 0$, competition may provide only one type of program, but then $\Delta\pi = 0$ (since $\varepsilon = 0$) and the monopoly operates only one channel. The second claim is an immediate consequence of the fact that $\Delta\pi < \pi_2^*$ for all $\gamma \in [0, 2\beta/m)$ if $\varepsilon = 0$. The remainder of this proof establishes the latter fact.

For $\varepsilon \geq 0$, $\Delta\pi < \pi_2^*$ if and only if $\pi_2^* + \pi_1^* > Nm\omega\overline{\sigma}/2$. Since π_2^* and π_1^* are decreasing in γ, this inequality will hold for all $\gamma \in [0, 2\beta/m)$ if it holds at $\gamma = 2\beta/m$. We can rewrite the above inequality as

$$a_2^*[1 - \frac{a_2^*}{m}] + a_1^*[1 - \frac{a_1^*}{m}][1 + \frac{1 - \gamma a_1^*/\beta}{1 + \varepsilon}] > m/2.$$

We can also readily show that

$$a_1^*(\frac{2\beta}{m}) = m[\frac{2}{3} + \frac{\varepsilon}{6} - \frac{\sqrt{\varepsilon^2 + 4 + 2\varepsilon}}{6}]$$

and that

$$a_2^*(\frac{2\beta}{m}) = m[1 + \frac{\varepsilon}{2} - \frac{\sqrt{\varepsilon^2 + 2 + 2\varepsilon}}{2}].$$

Substituting in the values of $a_1^*(\frac{2\beta}{m})$ and $a_2^*(\frac{2\beta}{m})$, we see that the inequality will hold for all $\gamma \in [0, 2\beta/m)$, if $\Psi(\varepsilon) > 1/2$, where

$$\begin{aligned}\Psi(\varepsilon) \quad = \quad & [1 + \frac{\varepsilon}{2} - \frac{\sqrt{\varepsilon^2 + 2 + 2\varepsilon}}{2}] \cdot [\frac{\sqrt{\varepsilon^2 + 2 + 2\varepsilon}}{2} - \frac{\varepsilon}{2}] \\ & + [\frac{2}{3} + \frac{\varepsilon}{6} - \frac{\sqrt{\varepsilon^2 + 4 + 2\varepsilon}}{6}] \cdot [\frac{\sqrt{\varepsilon^2 + 4 + 2\varepsilon}}{6} + \frac{1}{3} - \frac{\varepsilon}{6}] \cdot [\frac{2}{3} + \frac{\sqrt{\varepsilon^2 + 4 + 2\varepsilon}}{3(1 + \varepsilon)}].\end{aligned}$$

But we have that

$$\Psi(0) = [1 - \frac{\sqrt{2}}{2}] \cdot [\frac{\sqrt{2}}{2}] + [\frac{2}{3} - \frac{\sqrt{4}}{6}] \cdot [\frac{\sqrt{4}}{6} + \frac{1}{3}] \cdot [\frac{2}{3} + \frac{\sqrt{4}}{3}] = 0.5034 > 1/2.$$

■

Proof of Proposition 4: If $K \in (\Delta\pi, \pi_2^*)$ the number of channels is one under monopoly and two under competition. Letting $\Delta B^* = B_2(a_2^*) - B_1(a_1^*)$, social welfare will be lower (higher) under monopoly if $\Delta B^* > (<) K$. Suppose first that $\omega\overline{\sigma} < \frac{2\beta(1+2\varepsilon)}{m(1+\varepsilon)}$; then $\pi_2^* \leq Nm\omega\overline{\sigma}/4 < N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}$, where the former inequality uses the fact that $R(a_2^*) \leq R(m/2)$ and the latter uses Assumption 1 (ii). In addition, if $\gamma \in (\gamma_2, \frac{3\omega\overline{\sigma}}{4})$, we show below that $\Delta B^* > N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}$, implying that $\Delta B^* > K$ and hence that social welfare is lower under monopoly.

To see that $\Delta B^* > N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}$, consider the effect of adding a channel and reducing the advertising level from a_1^* to a_2^*. Suppose that the existing channel is showing a type 1 program and that the additional channel is showing a type 2 program. Type 1 viewers experience a welfare gain of $\gamma(a_1^* - a_2^*)$. A type $(2, \lambda)$ viewer enjoys a welfare increase of $(1-\lambda)\beta + \gamma(a_1^* - a_2^*)$ if $\lambda \geq \gamma a_1^*/\beta$ and $\beta - \gamma a_2^*$ otherwise. Advertisers reach an additional $N\frac{\gamma a_1^*/\beta+\varepsilon}{1+\varepsilon}$ viewers and experience a gain of

$$N[\frac{\gamma a_1^*/\beta + \varepsilon}{1+\varepsilon}]\int_0^{a_2^*} p(a)da - N[1 + \frac{1 - \frac{\gamma a_1^*}{\beta}}{1+\varepsilon}]\int_{a_2^*}^{a_1^*} p(a)da.$$

Aggregating up these gains, we obtain

$$\Delta B^* = N[1 + \frac{1 - \frac{\gamma a_1^*}{\beta}}{1+\varepsilon}]\int_{a_2^*}^{a_1^*}(\gamma - p(a))da + N[\int_{\frac{\gamma}{\beta}a_1^*}^{1}(1-\lambda)\beta\frac{d\lambda}{1+\varepsilon} + (\frac{\frac{\gamma}{\beta}a_1^* + \varepsilon}{1+\varepsilon})(\beta + \int_0^{a_2^*}(p(a) - \gamma)da)].$$

Since $p(a_2^o) \leq \gamma$ and (by Proposition 1) $a_2^* \geq a_2^o$ for all $\gamma \geq \gamma_2$, the first term is positive. Thus, it suffices to show that the second term exceeds $N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}$. Note first that

$$\int_0^{a_2^*}(p(a) - \gamma)da = a_2^*[\omega\overline{\sigma}[1 - \frac{a_2^*}{2m}] - \gamma] > a_2^*[\omega\overline{\sigma}\frac{3}{4} - \gamma],$$

where the inequality follows since $a_2^* < m/2$. This is non-negative for all $\gamma \leq \frac{3}{4}\omega\overline{\sigma}$. Thus the second term is greater than

$$N[\int_{\frac{\gamma}{\beta}a_1^*}^{1}(1-\lambda)\beta\frac{d\lambda}{1+\varepsilon} + (\frac{\frac{\gamma}{\beta}a_1^* + \varepsilon}{1+\varepsilon})\beta]$$

which exceeds $N\beta\frac{1+2\varepsilon}{2(1+\varepsilon)}$.

Now suppose that $\omega\overline{\sigma} > \frac{2\beta(1+2\varepsilon)}{m(2-\varepsilon)}$. Note first that when $\gamma = 0$, $\Delta B^* = N[\beta\frac{1+2\varepsilon}{2(1+\varepsilon)} + \frac{\varepsilon 3m\omega\overline{\sigma}}{8(1+\varepsilon)}]$ and that the condition implies that $\Delta B^* < \pi_2^*$. Since $\Delta B^* < \pi_2^*$ are continuous functions of γ, there exists $\psi > 0$ such that $\Delta B^* < \pi_2^*$ if $\gamma \in (0, \psi)$. Social welfare is therefore higher under monopoly for $K \in (\Delta B^*, \pi_2^*)$. ■

Characterization of Market Outcomes with Excludable Viewers: We amend the game considered in section 4.1 by supposing that in Stage 2 each firm chooses an advertising level and a subscription price. Again, we solve for equilibria via backward induction. To this end, consider the second stage and suppose that in Stage 1, only one firm provides a program. Let $r = \gamma a + s$ denote the *full price* charged to viewers by the firm. If $r \leq \beta$, then its program will be watched by $N(1 + \frac{1-r/\beta}{1+\varepsilon})$ viewers. For any given full price r, the firm will choose the advertising level and subscription price that maximizes revenue per viewer. These are given by

$$(\widehat{a}(r), \widehat{s}(r)) = \arg\max_{(a,s)}\{R(a) + s : \gamma a + s = r,\ a \geq 0, s \geq 0\}.$$

After observing that $R'(\frac{a_2^o}{2}) \leq \gamma$ with equality if $\frac{a_2^o}{2} > 0$ it is easy to show that

$$\widehat{a}(r) = \begin{Bmatrix} r/\gamma & if\ r \leq \gamma a_2^o/2 \\ a_2^o/2 & if\ r > \gamma a_2^o/2 \end{Bmatrix},$$

and

$$\widehat{s}(r) = \begin{Bmatrix} 0 & if\ r \leq \gamma a_2^o/2 \\ r - \gamma a_2^o/2 & if\ r > \gamma a_2^o/2 \end{Bmatrix}.$$

It follows that if $P(r)$ denotes maximal revenue per viewer, then

$$P(r) = \begin{Bmatrix} R(r/\gamma) & if\ r \leq \gamma a_2^o/2 \\ R(\frac{a_2^o}{2}) + r - \gamma a_2^o/2 & if\ r > \gamma a_2^o/2 \end{Bmatrix}.$$

Note that $P(r)$ is continuous and differentiable in $r \in (0, \beta)$. It is also concave.

With this notation, the firm's revenues can be written as

$$\pi_{1s}(r) = N(1 + \frac{1 - r/\beta}{1 + \varepsilon})P(r).$$

The profit maximizing full price is then r_1^*, where r_1^* satisfies the equation

$$P'(r_1^*) \geq \frac{P(r_1^*)}{(2+\varepsilon)\beta - r_1^*} \qquad (\textit{with equality if } r_1^* < \beta).$$

Assuming r_1^* is greater than $\gamma a_2^o/2$, then $P'(r_1^*) = 1$ and the above equation implies that

$$r_1^* = \min\{\beta, \beta(1+\frac{\varepsilon}{2}) - \frac{R(\frac{a_2^o}{2}) - \gamma a_2^o/2}{2}\}.$$

This is consistent with the assumption that r_1^* is greater than $\gamma a_2^o/2$ if $\beta > R(a_2^o/2)/2 + \gamma a_2^o/4$. This follows from Assumption 1 (ii). Thus, we may conclude that the firm sets an advertising level $a_2^o/2$ and a subscription price $s_1^* = r_1^* - \gamma \frac{a_2^o}{2} > 0$. Its maximized revenues can be written as

$$\pi_{1s}^* = N(1 + \frac{1 - (s_1^* + \gamma a_2^o/2)/\beta}{1+\varepsilon})[s_1^* + R(a_2^o/2)].$$

Next suppose that in Stage 1 both firms provide different types of programs, with firm A showing a program of type 1. Let $r_J = \gamma a_J + s_J$ denote the full price charged to viewers by firm J. If $r_A \leq r_B \leq \beta$, then firm A's program is watched by all the type 1 viewers and those type 2 viewers for whom $\lambda\beta - r_A > \beta - r_B$. If $\beta \geq r_A \geq r_B$, firm A's program is watched by all the type 1 viewers for whom $\beta - r_A > \lambda\beta - r_B$. In either case, consumers not watching channel A watch channel B. If either firm charges a full price in excess of β, it will attract no viewers. Using our earlier notation, the two firms' revenues can be written as

$$\pi_{2s}^A(r_A, r_B) = N[1 + \frac{r_B - r_A}{\beta(1+\varepsilon)}]P(r_A)$$

and

$$\pi_{2s}^B(r_A, r_B) = N[1 + \frac{r_A - r_B}{\beta(1+\varepsilon)}]P(r_B).$$

The equilibrium full price levels (r_A^*, r_B^*) satisfy the first order condition

$$N[1 + \frac{r_B^* - r_A^*}{\beta(1+\varepsilon)}]P'(r_A^*) \geq N\frac{1}{\beta(1+\varepsilon)}P(r_A^*) \qquad (\textit{with equality if } r_A^* < \beta)$$

and similarly for firm B (transposing A and B subscripts). The two first order conditions imply that $r_B^* = r_A^* = r_2^*$, where the common full price r_2^* is uniquely defined by the equation

$$P'(r_2^*) \geq \frac{1}{\beta(1+\varepsilon)} P(r_2^*) \qquad (\textit{with equality if } r_2^* < \beta).$$

If r_2^* is greater than $\gamma a_2^o/2$, $P'(r_2^*) = 1$ and the above equation implies that

$$r_2^* = \min\{\beta, \beta(1+\varepsilon) - [R(\frac{a_2^o}{2}) - \gamma a_2^o/2]\}.$$

For this is to be consistent with the supposition that r_2^* is greater than $\gamma a_2^o/2$, we require that $\beta(1+\varepsilon) > R(\frac{a_2^o}{2})$. Since $R(a) \leq R(m/2) = \omega\bar{\sigma}m/4$, this inequality follows from Assumption 1 (ii). Since the function $P(r)$ is concave, then so are the firms' revenue functions, and so r_2^* is indeed the equilibrium full price. We may conclude that the firms choose a common advertising level $a_2^o/2$ and subscription price $s_2^* = r_2^* - \gamma\frac{a_2^o}{2}$ and that each firm earns revenues

$$\pi_{2s}^* = N(s_2^* + R(a_2^o/2)).$$

Finally, suppose that in Stage 1, both firms provide the same type of program. Competition for viewers then drives full price levels to 0, except in the special case in which viewers experience no disutility from advertisements ($\gamma = 0$). In this latter case, each firm will choose $m/2$ advertisements, although prices are still zero. Equilibrium revenues will be $NR(m/2)$.

Turning to Stage 1, neither firm will provide a program if $K > \pi_{1s}^*$ and only one firm will provide a program if $\pi_{1s}^* > K > \pi_{2s}^*$. If $\pi_{2s}^* > K$, both firms will provide programs and they will be of different types. Even when $\gamma = 0$ the firms earn strictly more revenue when they offer different types of programs, than when they duplicate. This is because duplication leads to zero subscription prices.

In summary, then, neither firm will find it worthwhile to provide a broadcast if K exceeds π_{1s}^*. If K lies between π_{1s}^* and π_{2s}^*, one firm will provide a program and it will carry $a_2^o/2$ advertisements and have a subscription price $s_1^* = r_1^* - \gamma\frac{a_1^o}{2}$. If K is less than π_{2s}^*, the two firms will offer different types of programs and each will carry $a_2^o/2$ advertisements and have a subscription price $s_2^* = r_2^* - \gamma\frac{a_2^o}{2}$. ■

Proof of Proposition 5: For the first part, recall from our characterizations and the fact that $a_2^* \leq a_1^*$, that advertising levels with excludability are $a_2^o/2$, while advertising levels with non-excludability are at least a_2^*. It therefore suffices to show that $a_2^o/2 \leq a_2^*$, with strict inequality when $\gamma > 0$. The result follows immediately if $\gamma \geq \omega\overline{\sigma}$ (since $a_2^o/2 = 0 < a_2^*$), so consider $\gamma < \omega\overline{\sigma}$. In this case, $R'(\frac{a_2^o}{2}) = p(a_2^o) = \gamma$. But,

$$R'(a_2^*) = \frac{\gamma}{\beta(1+\varepsilon)}R(a_2^*) \leq \frac{\gamma}{\beta(1+\varepsilon)}R(\frac{m}{2}) = \gamma\frac{m\omega\overline{\sigma}}{4\beta(1+\varepsilon)}.$$

Assumption 1(ii) therefore implies that

$$R'(a_2^*) \leq R'(\frac{a_2^o}{2}) \qquad \textit{with strict inequality if } \gamma > 0.$$

This implies the result.

For the second part, recall that duplication is not possible with excludability. Thus, we need only show that equilibrium revenues are higher with excludability in both the one and two firm cases; i.e., $\pi_1^* < \pi_{1s}^*$ and $\pi_2^* < \pi_{2s}^*$. In the one firm case, this is obvious. With excludability, the firm could always choose to set prices equal to zero and to raise revenue solely through advertising. But, as shown above, the (uniquely) optimal strategy is to reduce advertisements and charge viewers a price $s > 0$. By revealed preference, revenues must be higher with excludability.

In the two firm case, the result is not immediate because the price and advertising levels are determined strategically and firms compete on two fronts rather than one, which might a priori increase competition so much as to reduce equilibrium revenues. We could rule out this possibility if we knew that the full price is higher with excludability. To see this, suppose that $s_2^* + \gamma\frac{a_2^o}{2} > \gamma a_2^*$ and that $\pi_2^* \geq \pi_{2s}^*$. Note that, by symmetry, each firm attracts N viewers with or without excludability. With excludability, each firm has the option of setting the advertising level a_2^* and a subscription price of 0. Since $s_2^* + \gamma \frac{a_2^o}{2} > \gamma a_2^*$ by hypothesis, this would result in strictly more than N viewers and revenues strictly higher than π_2^*. This contradicts the fact that each firm choosing (s_2^*, a_2^*) is an equilibrium. Below, we establish that it is indeed the case that $s_2^* + \gamma \frac{a_2^o}{2} > \gamma a_2^*$. ■

Fact 2: Suppose that the market provides $i \in \{1, 2\}$ types of programs with excludability and non-excludability. Then, the full price faced by viewers is higher with excludability; i.e., $r_i^* = s_i^* + \gamma \frac{a_2^o}{2} > \gamma a_i^*$.

Proof: Suppose first that $i = 1$. It is clear that the result holds if $r_1^* = \beta$, so we assume in what follows that

$$r_1^* = \beta(1 + \frac{\varepsilon}{2}) - \frac{R(\frac{a_2^o}{2}) - \gamma a_2^o/2}{2} < \beta.$$

To prove the desired inequality we follow the proof of a related statement in Hansen and Kyhl (1999). We know that r_1^* satisfies the equation

$$P'(r_1^*) = \frac{P(r_1^*)}{\beta(2 + \varepsilon) - r_1^*}$$

and that a_1^* satisfies the equation

$$R'(a_1^*) = \frac{\gamma R(a_1^*)}{\beta(2 + \varepsilon) - \gamma a_1^*}.$$

Letting $x_s = 1 + \frac{1 - r_1^*/\beta}{1+\varepsilon}$ and $x_a = 1 + \frac{1 - \gamma a_1^*/\beta}{1+\varepsilon}$ denote the fraction of viewers watching with and without excludability, we may rewrite these as

$$2\beta(1 + \varepsilon)(x_s - 1) = R(\frac{a_2^o}{2}) - \gamma \frac{a_2^o}{2} - \varepsilon\beta$$

and

$$2\beta(1 + \varepsilon)(x_a - 1) = \frac{\gamma R(a_1^*)}{R'(a_1^*)} - \gamma a_1^* - \varepsilon\beta.$$

Now let

$$\psi(a) = \frac{\gamma R(a)}{R'(a)} - \gamma a - \varepsilon\beta,$$

Observe that $\psi(a)$ is an increasing function and, since $R'(\frac{a_2^o}{2}) = \gamma$, that $\psi(\frac{a_2^o}{2}) = R(\frac{a_2^o}{2}) - \gamma\frac{a_2^o}{2} - \varepsilon\beta$. Since $\frac{a_2^o}{2} < a_1^*$, it follows that $\psi(a_1^*) > \psi(\frac{a_2^o}{2})$ and hence that

$$2\beta(1+\varepsilon)(x_a - 1) = \psi(a_1^*) > \psi(\frac{a_2^o}{2}) = 2\beta(1+\varepsilon)(x_s - 1).$$

It follows that $x_a > x_s$ which implies that $r_1^* > \gamma a_1^*$.

Now suppose that $i = 2$. It is clear that the result holds if $r_2^* = \beta$. As shown in section 4, Assumption 1 (ii) implies that $\gamma a_2^* < \beta$. Thus, it remains to consider the case in which

$$r_2^* = \beta(1+\varepsilon) - [R(\frac{a_2^o}{2}) - \gamma\frac{a_2^o}{2}] < \beta$$

and hence that $\gamma < \omega\overline{\sigma}$ (otherwise we have $a_2^o = 0$ and a contradiction). Figure 4 depicts the determination of the equilibrium full prices in the two regimes in this case. The equilibrium full price with non-excludability, γa_2^*, is determined by the intersection of the downward sloping line $R'(\frac{r}{\gamma})/\gamma$ and the hump shaped curve $R(\frac{r}{\gamma})/\beta(1+\varepsilon)$. With excludability, the equilibrium full price is determined by $1 = P(r_2^*)/\beta(1+\varepsilon)$, which in the graph is the intersection of the horizontal line emanating from the point $(0,1)$ and the upward sloping curve $\frac{R(\frac{a_2^o}{2}) - \gamma\frac{a_2^o}{2} + r}{\beta(1+\varepsilon)}$. The result will hold if the slope $\frac{1}{\beta(1+\varepsilon)}$ is less than the absolute value of the slope of $R'(\frac{r}{\gamma})/\gamma$ so that $R'(\frac{r}{\gamma})/\gamma$ crosses $R(\frac{r}{\gamma})/\beta(1+\varepsilon)$ (which here is sloping up since $R(a_2^*) > R(\frac{a_2^o}{2})$) before $\frac{R(\frac{a_2^o}{2}) - \gamma\frac{a_2^o}{2} + r}{\beta(1+\varepsilon)}$ crosses the horizontal line emanating from $(0,1)$.

We know that $R'(a) = \omega\overline{\sigma}[1 - \frac{2a}{m}]$ so that $\frac{dR'(\frac{r}{\gamma})/\gamma}{dr} = -\frac{2\omega\overline{\sigma}}{m\gamma^2}$. The required condition is therefore $\beta(1+\varepsilon) > \frac{m\gamma^2}{2\omega\overline{\sigma}}$. But, since $\gamma < \omega\overline{\sigma}$ and, by Assumption 1 (i), $\gamma < 2\beta/m$, we have

$$\frac{m\gamma^2}{2\omega\overline{\sigma}} < \frac{m\gamma}{2} < \beta \leq \beta(1+\varepsilon),$$

as desired. ■

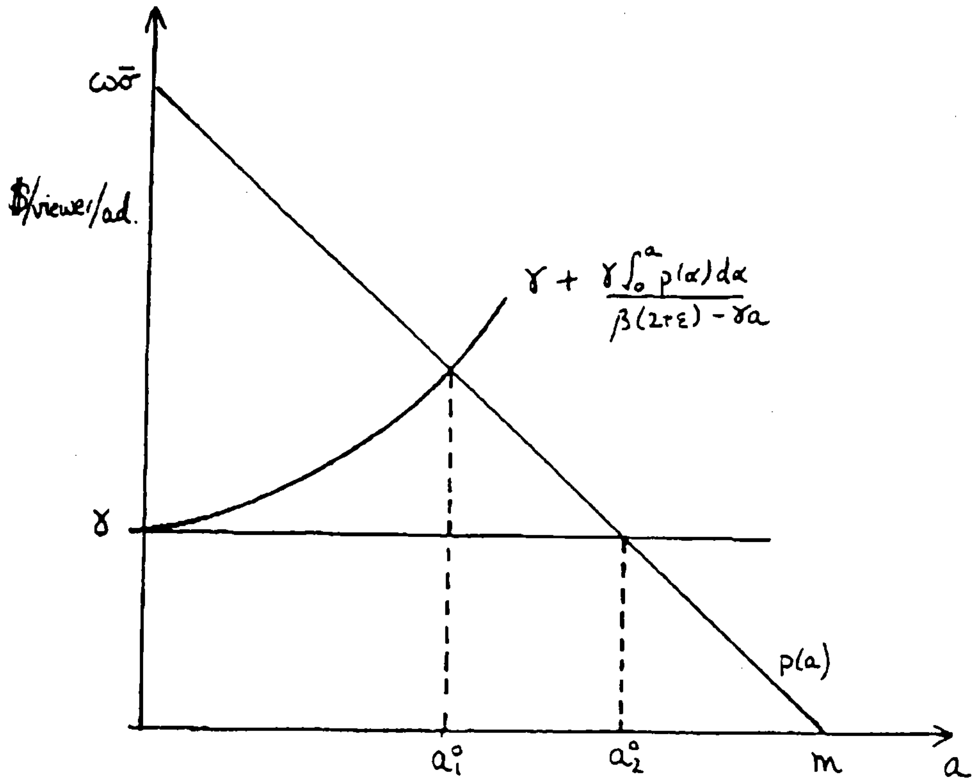


FIGURE 1

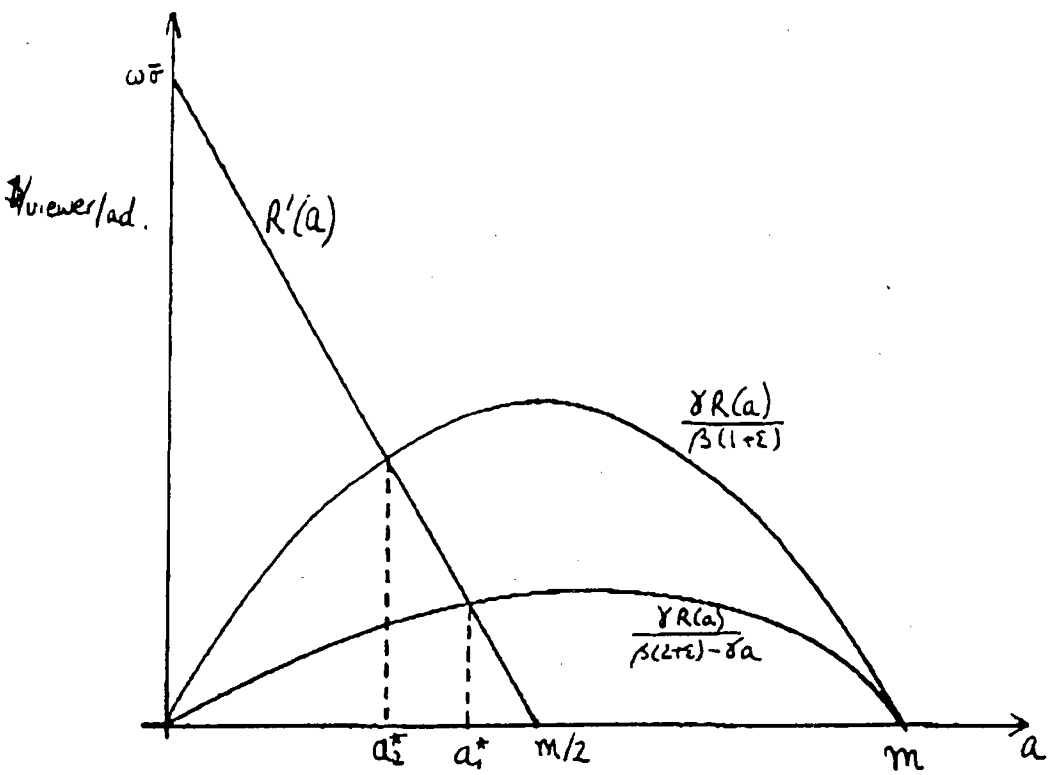
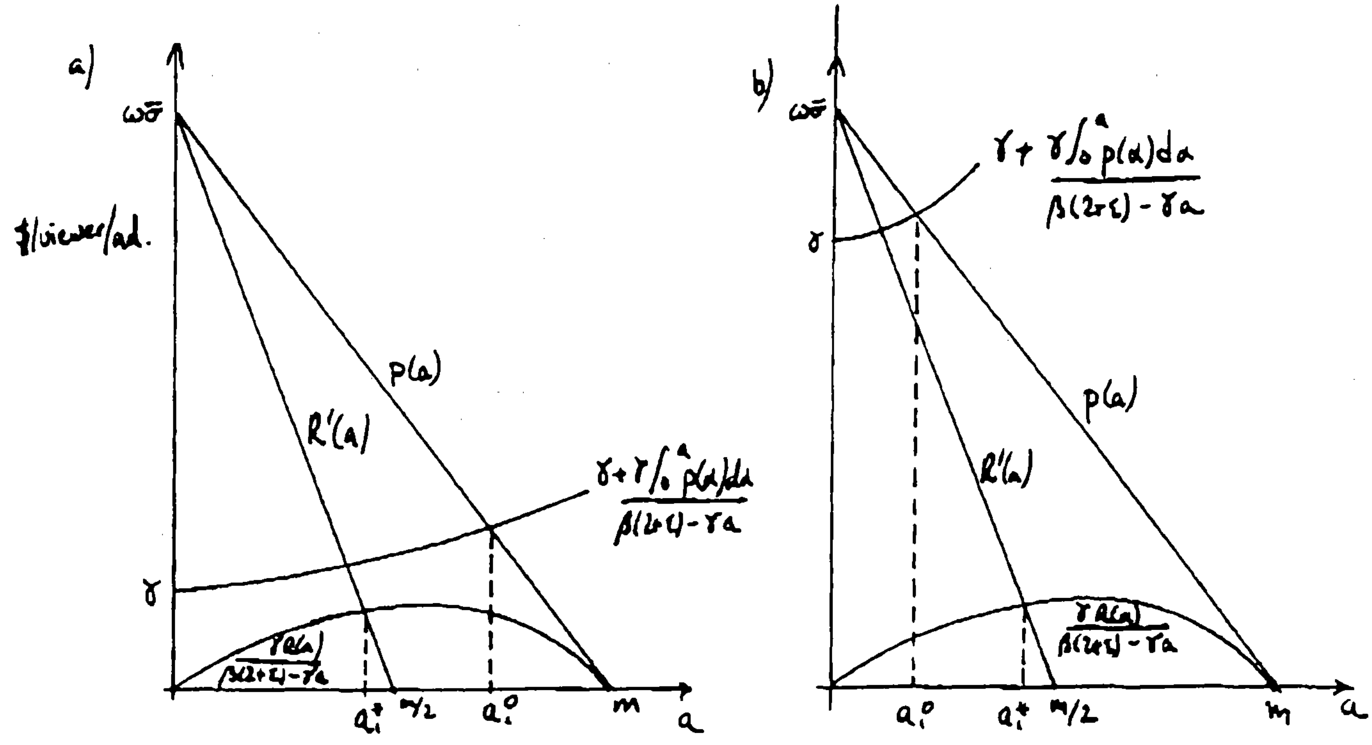


FIGURE 2



(a) FIGURE 3 (b)

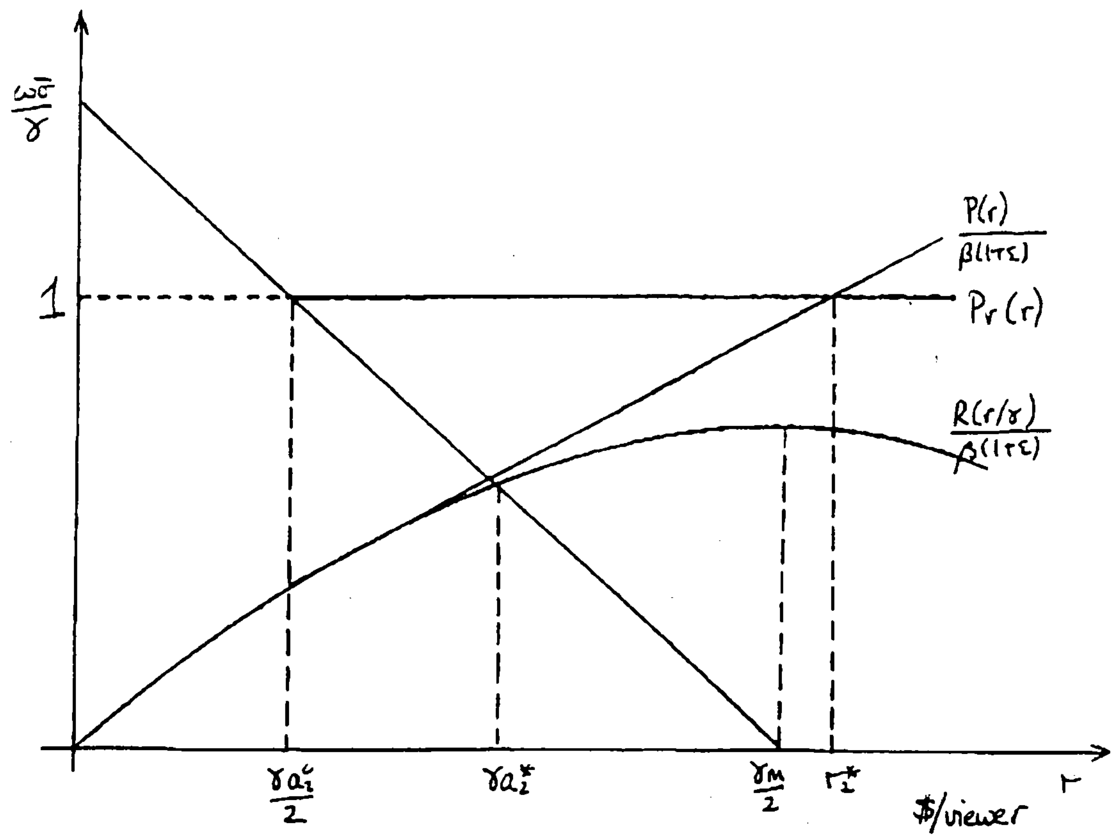


FIGURE 4