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Market Provision of Public Goods: The Case of Broadcasting*

Abstract

This paper presents a theory of the market provision of broadcasting and uses it to address the nature of market failure in the industry. Advertising levels may be too low or too high, depending on the relative sizes of the nuisance cost to viewers and the expected benefits to advertisers from contacting viewers. Market provision may allocate too few or too many resources to programming and these resources may be used to produce programs of the wrong type. Monopoly may produce a higher level of social surplus than competition and the ability to price programming may reduce social surplus.
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1 Introduction

Individuals in western countries spend a remarkable portion of their lives watching television and listening to radio. In the United States, the average adult spends around four hours a day watching television and three hours a day listening to the radio.[1] Television and radio are also key ways that producers advertise their products. In the United States, television advertising accounted for 23.4% of total advertising expenditures in 1999 and radio accounted for 8%.[2] All of this makes television and radio broadcasting of central economic importance.

In the United States, the bulk of radio and television broadcasting has always been provided by private commercial broadcasters. In Europe and Japan, broadcasting has historically been provided publicly, financed through a mixture of television license fees, appropriations from general taxation, and advertising. Since the 1980s, however, commercial broadcasting has dramatically expanded in these countries. The market now plays a significant role in providing broadcasting in almost all western countries. Despite this, the welfare economics of commercial broadcasting remains obscure. Will market provision lead to excessive advertising levels? Will it allocate too few resources to programming and will these resources be used to produce appropriate programming? How will the ownership structure of broadcasting stations impact market outcomes?

Such questions arise continually in debates about the appropriate regulation of the broadcasting industry. Excessive advertising is an issue in the United States where non-program minutes now exceed 20 minutes per hour on some network television programs and 30 minutes per hour on certain radio programs.[3] In Europe, advertising ceilings are imposed on broadcasters and it is

[1] The Radio Advertising Bureau reports that in 1998 the average weekday time spent listening by adults is 3 hrs and 17 minutes; weekend time spent listening is 5 hrs and 30 mins (http://www.rab.com/station/mgfb99/fac5.html). The Television Advertising Bureau reports that in 1999 the average adult man spent 4 hours and 2 minutes watching television per day, while the average adult woman spent 4 hours and 40 minutes (http://www.tvb.org/tvfacts).

[2] Total advertising expenditures were $215 billion. Other important categories were newspapers (21.7%); magazines (5.3%); direct mail (19.2%) and yellow pages (5.9%) (http://www.tvb.org/tvfacts).

[3] Non-program minutes include commercials, station and networks promos, and public service announcements. The 1999 Television Commercial Monitoring Report indicates that non-program minutes on prime time network

natural to wonder if the United States should follow suit.[4] Concerns about the programming provided by commercial radio led the Federal Communications Commission to announce that it was setting up hundreds of free "low-power" radio stations for non-profit groups across the United States (Leonhardt (2000)). More generally, such concerns are key to the debate about the role for public broadcasting in modern broadcasting systems (see, for example, the Davies Report (1999)). The effect of ownership structure is currently an issue in the United States radio industry which, following the Telecommunications Act of 1996, has seen growing concentration. Concern has been expressed that this will lead to higher prices for advertisers and less programming (see, for example, Ekelund, Ford, and Jackson (1999)).

This paper presents a theory of commercial broadcasting and use it to explore the nature of market failure in the industry. The theory is distinctive in yielding predictions on both the programming and advertising produced by a market system. It therefore permits an analysis of how well commercial broadcasting fulfills its two-sided role of providing programming to viewers/listeners and permitting producers to contact potential customers.

The next section explains how our analysis relates to three different strands of literature: prior work on broadcasting; the classical theory of public goods; and recent work on competition in two-sided markets. Sections 3 and 4 set up the model and explore how market provision of broadcasting differs from optimal provision. Section 5 uses the model to analyze whether market provision produces better outcomes under monopoly or competition and how pricing programming impacts

shows in November 1999 ranged from 12.54 minutes per hour to 21.07 minutes. Commercial minutes ranged from 9.31 minutes to 15.07 minutes. Good information on non-program minutes on radio is more difficult to find. However, in an article about a new technology that allows radio stations to wedge in more commercial minutes by truncating sounds and pauses in talk programs, Kuczynski (2000) reports that commercial minutes exceed 30 minutes per hour on some programs.

[4] The ceilings chosen vary from country to country. In the United Kingdom the limit for private television channels is 7 minutes per hour on average. In France, it is 6 minutes and, in Germany, 9 minutes (Motta and Polo (1997)). In the United States, 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 Federal Communications Commission. In 1981, this practice was declared to violate the antitrust laws and no such agreement exists today (Owen and Wildman (1992)). In 1990, Congress enacted the Children's Programming Act which limits advertising on children's programming to 12 minutes per hour on weekdays and 10 minutes per hour on weekends.

market performance. Section 6 extends the model to discuss duplication and the implications of viewer switching. Section 7 concludes with a summary of the main lessons of the analysis.

2 Relationship to the literature

Previous normative work on the market provision of broadcasting (see Owen and Wildman (1992) or Brown and Cave (1992) for reviews) has focused on the type of programming that would be produced and the viewer/listener benefits it generates.[5] The literature concludes that the market may provide programming sub-optimally: 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 to serve each audience type. Then, the literature suggests that the market equilibrium might well involve two stations playing country music. Duplication arises when attracting half of the country listening audience is more profitable than getting all the talk audience. There is no talk station when capturing 1/4 of the audience does not generate enough advertising revenues to cover operating costs, despite the fact that aggregate benefits to talk listeners exceed operating costs.

While these conclusions are intuitively appealing, the literature's treatment of advertising is unsatisfactory. First, advertising levels and prices are assumed fixed. Each program is assumed to carry an exogenously fixed number of advertisements and the revenue from each advertisement equals the number of viewers times a fixed per viewer price (Steiner (1952), Beebe (1977), Spence and Owen (1977) and Doyle (1998)).[6] Second, the social benefits and costs created by advertisers'

[5] The fact that broadcasting is used by both viewers and advertisers and that the latter also create surplus has been largely ignored. One exception is Berry and Waldfogel's (1999) study of the U.S. radio broadcasting industry, which addresses empirically the question of whether free entry leads to a socially excessive number of radio stations. Their study is distinctive in clearly distinguishing between the social benefits of additional radio stations stemming from delivering more listeners to advertisers and more programming to listeners.

[6] 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

consumption of broadcasts are not considered. 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.[7] The costs stem from its nuisance value. In addition, the model assumes that broadcasters choose advertising levels taking account of their effect on the number of viewers and on advertising prices. In this way, advertising revenues and hence program profitability are determined endogenously.

Since the first version of this paper was completed, a spate of papers on broadcasting have appeared.[8] For our purposes, particularly noteworthy is Hansen and Kyhl's (2001) welfare comparision of pay per view broadcasting with pure advertiser-supported provision of a single event (like a boxing match). Their analysis takes into account both advertiser surplus and the nuisance cost of advertisements to viewers and endogenizes advertising levels. Our analysis of pricing in

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.

[7] While we adopt an informational interpretation, all that is really important for the analysis is that advertising create surplus-enhancing trades. This could alternatively be because advertising might *persuade* consumers that they would like a product that they already knew about (Becker and Murphy (1993)).

[8] A selection of these papers were presented at a recent conference and can be found at http://www.core.ucl.ac.be/media/default.html.

Section 6.2 generalizes their welfare comparison beyond the case of a single monopoly-provided program. Also related are Gabszewicz, Laussel and Sonnac (2001) and Dukes and Gal-Or (2001) who develop spatial models of broadcasting competition in which two broadcasters compete in both programming and advertising levels. Gabszewicz, Laussel and Sonnac argue that advertising ceilings will lead stations to choose more similar programming. Dukes and Gal-Or provide a more detailed treatment of the product market in which advertisers compete and argue that product market competition can lead stations to choose less differentiated programming. While both of these papers develop models that endogenize programming and advertising levels, neither focuses on the welfare issues motivating this paper.

The paper also contributes to the classical theory of public goods (see Cornes and Sandler (1996) for a comprehensive review). It points out that radio and television broadcasts can be thought of as public goods that are "consumed" by two types of agents. The first are viewers/listeners who receive a direct benefit from the broadcast. The second are advertisers who, by advertising on the broadcast, receive an indirect benefit from contacting potential customers. The nuisance to viewers from advertisements means that advertisers' "consumption" of a broadcast imposes an externality on viewers. However, advertisers can be excluded and, by charging advertisers for accessing their broadcasts, broadcasting firms can earn revenues, enabling market provision.

The special features of broadcasts make them a distinct type of public good and their market provision raises interesting theoretical issues. In particular, it is not clear a priori in what ways market provision diverges from optimal provision. Since advertisers' consumption of a broadcast imposes an externality on viewers, 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.

Finally, the paper contributes to the nascent literature on competition in "two-sided markets" (see Armstrong (2002), Tirole and Rochet (2001), and the references therein).[9] A two-sided market is one involving two groups of participants who need to interact via intermediaries. These intermediaries must typically compete for business from both groups. A nice example are dating services. The two groups are single men and women and the intermediaries are the dating agencies. A less colorful (but more economically significant) example is the credit card industry. Here the two groups are shoppers and retailers and the intermediaries are the credit card companies. In a broadcasting context, the two groups are viewers and advertisers and the intermediaries are the broadcasters who must compete both for viewers and advertisers. There are formal similarities between our model and those being developed in this literature and we point these out along the way.

3 The model

We are interested in modeling a basic broadcasting system in which programs are broadcast over the air and viewers/listeners can costlessly access such programming. Thus, we will be assuming that viewers/listeners have the hardware (i.e., televisions and radios) allowing them to receive broadcast signals. Broadcasters cannot exclude consumers by requiring special decoders, etc.[10]

There are two channels, each of which can carry one program. There are two types of program,

[9] Again, this literature has largely developed after the first version of this paper was completed.

[10] This is still a reasonable model of radio broadcasting in the United States. It is also a reasonable model for television in countries, like the United Kingdom, in which most viewers still pick up television signals via a rooftop antenna. In the United States, 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. The cable company charges a monthly fee and can 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. We introduce subscription prices in section 6.2.

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 television and henceforth refer to consumers as viewers. Programs can carry advertisements. Each advertisement takes a fixed amount of time and thus advertisements reduce the substantive content of a program. Each program type is equally costly to make and producing advertisements costs the same as producing regular programming. The cost of producing either type of program with a advertisements is K.[11]

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 $[0, 1]$. Not watching any program yields a zero benefit.[12]

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

[11] The qualitative results below are unaffected if advertisements cost more than programming; i.e., if the cost of producing a program with a advertisements is $K + ca$.

[12] Our model is similar to, but not isomorphic with, a Hotelling-style spatial model. In such a model the $2N$ viewers would be uniformly distributed on the unit interval and the channels would be (exogenously) located at opposite ends of the interval (say, channel A at 0 and B at 1). A viewer located at point $x \in [0, 1]$ would obtain utility $u - Tx - \gamma a_A$ from watching channel A and $u - (1 - T)x - \gamma a_B$ from watching channel B where T is the "transport cost". Assuming that u is large enough, this model implies the same viewer demands as generated by our model when the two channels choose different types of programs and $\beta = T$. With only one channel operating, this model implies the same viewer demands as generated by our model when $T = u = 2\beta$. Thus, in terms of its predictions concerning market provided advertising levels, our model yields similar results to a spatial model *within* regimes (one channel or two channel). However, as we point out below, it yields different conclusions *across* regimes.

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, a viewer has willingness to pay $\omega > 0$ with probability σ for a new good of type σ and willingness to pay 0 with probability $1 - \sigma$. The fraction of producers with new goods of type less than or equal to σ is (approximately) $\sigma/\overline{\sigma}$.

Since a consumer will pay ω or 0, each new 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 the per-viewer price of an advertisement is p (i.e., if the advertisement is seen by n viewers it costs np), then the number of firms wishing to advertise is (approximately) $a(p) = m \cdot [1 - p/\omega\overline{\sigma}]$.[13] This represents the *demand curve for advertising*. The corresponding *inverse demand curve* is $p(a) = \omega\overline{\sigma} \cdot [1 - a/m]$.

Given that each new producer sets a price of ω, 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 viewing options so as to maximize their net viewing benefits.[14] We assume that a consumer who is indifferent between watching any two programs is equally likely to watch either.

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

[14] The model can be extended to incorporate informational benefits by assuming that each consumer's valuation of a new producer of type σ's product is the realization of a random variable ν which is uniformly distributed on $[\underline{\omega}, \overline{\omega}]$ with probability σ and is 0 with probability $1 - \sigma$. Under the assumption that $\underline{\omega} > \frac{\overline{\omega}}{2}$, the type σ new producer's optimal price is $\underline{\omega}$ and, hence, if a consumer watches an advertisement placed by a type σ new producer, he obtains an informational benefit $\sigma\frac{\overline{\omega}-\underline{\omega}}{2}$. The introduction of informational benefits in this way does not change the main conclusions of the paper. In particular, market provided advertising levels can be greater or smaller than optimal levels and the market may over or underprovide programs. Holding constant the social benefit of advertising, increasing the share captured by consumers increases market provided advertising levels. This is because such informational benefits reduce the cost of advertising to viewers. The details of this extension are available in the appendix of the version of the paper available at the web site http://www.people.virginia.edu/~sa9w/.

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.

4 Optimal vs market provision

4.1 Optimal provision

To understand optimal provision, it is helpful to think of the two types of program as discrete public goods each of which costs K to provide and each of which may be consumed by two types of agents - viewers and advertisers. By an advertiser "consuming" a program, we simply mean that its advertisement is placed on that program. The optimality problem is to decide which of 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 the 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 exceed 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, account must be taken 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.[15] 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 $\lambda\beta - \gamma a$. Clearly, the a advertisements should be allocated to those new producers who value them the most, so the

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

aggregate benefits generated by the program are

$$B_1(a) = N[\beta - \gamma a + \int_{\gamma a/\beta}^{1} (\lambda\beta - \gamma a)d\lambda] + N(2 - \gamma a/\beta) \int_0^a p(\alpha)d\alpha.$$

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

The level of advertising that maximizes these benefits, denoted a_1^o, satisfies the first order condition[16] :

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

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 that reflects the losses to existing advertisers resulting from 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 the nuisance cost γ and the upward sloping line is the graph of the function $\gamma + \gamma \int_0^a p(\alpha)d\alpha/[2\beta - \gamma a]$, 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

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

and on other advertisers through the loss of audience. Advertisers' consumption of the program should thus be taxed and the optimal tax is $p(a_1^o)$.[17]

Adding a type 2 program will be desirable if the increase in aggregate benefits it generates exceeds its cost K. When both programs are provided, 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 level of advertisements is $a \leq \beta/\gamma$, all viewers will watch their preferred programs and obtain a benefit $\beta - \gamma a$. Since the a advertisements are allocated to those new producers who value them the most,[18] the aggregate benefits from providing both programs are

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

The two terms represent viewer and advertiser benefits, respectively.

The benefit maximizing advertising level, denoted a_2^o, satisfies the first order condition:

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

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.[19]

[17] 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. 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.

[18] 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.

[19] 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 $\gamma > \omega\overline{\sigma}$. Note that Assumption 1(ii) guarantees that $a_2^o < \beta/\gamma$ for all γ. Since a_1^o is clearly less than a_2^o (see Figure 1), Assumption 1(ii) also implies that $a_1^o < \beta/\gamma$.

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, $B_2^o/2$. Because the two public goods are substitutes, 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 below.

4.2 Market provision

We suppose that the two channels are controlled by broadcasting firms that make programming and advertising choices to maximize their profits. In standard fashion, we model the interaction between the broadcasters 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 broadcaster chooses a level of advertising.[20] We look for the Subgame Perfect Nash equilibrium of this game.

We first solve for advertising levels and revenues in Stage 2, taking the firms' Stage 1 choices as given. Suppose that only one broadcaster decides to provide a program. If the firm runs $a \leq \beta/\gamma$ advertisements, its program will be watched by $N(2 - \gamma a/\beta)$ viewers. To sell a advertisements it must set a per-viewer price $p(a)$ meaning that its revenues will be

$$\pi_1(a) = N(2 - \gamma a/\beta)R(a),$$

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

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

[20] Identical results emerge under the assumption that the two stations simultaneously choose the prices they charge advertisers. This is because each station has a monopoly in delivering its viewers to advertisers.

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.[21] This advertising level 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 at the intersection of the two curves.

If both broadcasters provide programs, they will provide different programs. For if they choose the same type of program, competition for viewers will drive advertising levels and revenues to zero. Call the two broadcasters A and B and suppose that A chooses a type 1 program and B a type 2. If $J \in \{A, B\}$ 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.[22]

This said, the number of viewers that each broadcaster gets will depend on the advertising level of its competitor. If 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 A's program watch B's and the two broadcasters' revenues are given by

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

[21] Since $R'(m/2) = 0$, we know that $a_1^* < m/2$ and hence $a_1^* < \beta/\gamma$ by Assumption 1(ii).

[22] This implication of our micro-founded model of advertising demand should be contrasted with the assumptions made concerning inverse demand functions for advertising elsewhere in the literature. Berry and Waldfogel (1999) assume that the per viewer price received by each radio station is the same and depends only on the total share of the population who are listening; i.e., $p = f(\sum n_J/n)$ where n is the total population and n_J is the number listening to station 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., $p = f(\sum n_J a_J)$. In light of our results, it would be worth uncovering what assumptions on the primitives would generate these formulations.

and

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

At the equilibrium advertising levels (a_A^*, a_B^*), each broadcaster balances the negative effect of higher advertising levels on viewers with the positive effect on revenue per viewer. Using the first order conditions for each firm's optimization, it is straightforward to show that the equilibrium advertising levels (a_A^*, a_B^*) are such that $a_A^* = a_B^* = a_2^*$, where a_2^* satisfies:

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

The left hand side measures the increase in per viewer revenue a firm would earn from an additional advertisement in equilibrium and the right hand side measures the loss in revenue per viewer resulting from lost viewers. 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, $\frac{\gamma}{\beta}R(a)$. It is clear from the Figure that a_1^* exceeds a_2^*, so that advertising levels are lower with two channels. This is because advertising is analagous to a price paid by viewers and more competition leads to lower prices.[23]

Turning to Stage 1, let $\pi_1^* = \pi_1(a_1^*)$ denote the firm's revenues in the one channel case and $\pi_2^* = \pi_2^J(a_2^*, a_2^*)$ each firm's revenues in the two channel case. Since a_1^* exceeds a_2^*, revenues in the one channel case exceeds those with two channels. It follows that neither firm will provide a program if K exceeds π_1^*; one firm will provide a program if K lies between π_1^* and π_2^*; and both firms will provide programs if π_2^* exceeds K.

[23] It is interesting to note that the Hotelling-style spatial model described in footnote 12 implies that advertising levels are higher with two channels than with one, under the assumption that u is sufficiently low that not all viewers watch when only one channel is operating. This is an idiosyncratic feature of the Hotelling model. Indeed, the pricing version of this model with two firms located at either end of the interval implies that the price with only one firm operating is lower than that with both firms operating when buyers' willingness to pay for the good is sufficiently low that not all consumers purchase the good in the one firm case.

4.3 Optimal and market provision compared

Conditional on the market providing one or both of the programs, will they have too few or too many advertisements? When only one broadcaster provides a program, the advertising level (a_1^*) may be bigger or smaller than the optimal level (a_1^o) depending on the nuisance cost. It is clear from Figures 1 and 2 that as γ tends to 0, a_1^o tends to m while a_1^* approaches $m/2$. At the other extreme, if γ exceeds $\omega\overline{\sigma}$, then $a_1^o = 0$ and a_1^* is positive. Similar remarks apply when both firms provide programs. In either case, 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.[24]

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, γ_1 is less than γ_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 may have too few advertisements. While the governments of many countries set ceilings on advertising levels on commercial television and radio, we are not aware of any governments subsidizing

[24] The proofs of this and the subsequent propositions can be found in the Appendix.

advertising levels.[25] Under-advertising arises in our model because, while broadcasters compete for viewers, they have a monopoly in delivering their audience to advertisers.[26] This means that broadcasters hold down advertisements in order to keep up the prices that they receive.[27] It is clear that the fact that each broadcaster has a monopoly in delivering its viewers is partially an artifact of the static nature of our model. In a dynamic world, viewers may be expected to switch between channels, giving advertisers different ways to reach them. Thus, in Section 6 we present a two-period extension of our model to investigate the implications of viewer switching for our conclusions about advertising levels.

Turning to programming, the question is whether the market provides too few or too many types of program.[28] 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 provides both types 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

[25] That said, as noted in the introduction, concern about increasing concentration in the United States radio industry is partly motivated by fears about high advertising prices and hence (presumably) low advertising levels.

[26] In the literature on competition in two-sided markets, this situation is known as a "competitive bottleneck" (Armstrong (2002)). It would also arise, for example, in the newspaper industry when readers only read a single newspaper or in the yellow pages market when people only use a single directory.

[27] If broadcasters could perfectly price discriminate across advertisers, then they would not need to hold down advertising levels to drive up prices and the market outcome is always excessive advertising (see also Hansen and Kyhl (2001)). Note also that there is an interesting parallel between our under-advertising finding and Shapiro (1980) who showed that a monopoly advertiser would undersupply information about its product because it would not capture all the surplus from providing such information. In each case, informative advertising may be under-supplied because the party in charge of the volume of advertising cannot capture all of the surplus. In Shapiro's model, the advertiser itself chooses the volume of advertising and it is the consumer surplus that the advertiser fails to capture. By contrast, in our model, broadcasters choose the volume of advertising and it is the producer surplus that the broadcaster fails to capture. We thank a referee for pointing this out.

[28] The analysis here compares the number of program types provided by the market with the optimal number. A slightly different problem, in the spirit of Mankiw and Whinston (1986), 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^*. Our choice is motivated by the desire to understand if market provision can actually achieve the first best.

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), while the expected benefits from new producers contacting consumers ($m\omega\overline{\sigma}$) are 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 noted 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. The following proposition provides some sufficient conditions for under- and over-provision.

Proposition 2 *(i) If $m\omega\overline{\sigma} < 2\beta$, the market does not overprovide programs, and underprovides them for some values of K. (ii) If $m\omega\overline{\sigma} > 2\beta$, there exist values of K such that the market overprovides programs for γ sufficiently small.*

To understand the result, note that as γ gets small, the equilibrium advertising level a_2^* converges to $\frac{m}{2}$, implying that equilibrium revenues π_2^* converge to $N\frac{m\omega\overline{\sigma}}{4}$. This represents an upper bound, since equilibrium revenues are decreasing in γ. Part (i) of the proposition now follows from the fact (established in the Appendix) that $\Delta B^o \geq N\frac{\beta}{2}$. Part (ii) follows from the fact that ΔB^o converges to $N\frac{\beta}{2}$ as γ gets small. Thus, if the stated inequality holds, π_2^* exceeds ΔB^o for

γ sufficiently small. To see why ΔB^o converges to $N\frac{\beta}{2}$, note that as γ gets small, the optimal advertising levels with one and two programs converge to m. Moreover, all viewers watch even if only one program is provided. Thus, the only gain from providing the second program is the increase in viewing benefits enjoyed by the N viewers who now see their preferred program and this is given by $N\frac{\beta}{2}$.

Since the literature on market provision of public goods emphasizes the problem of under-provision, the possibility of over-provision of broadcasting is noteworthy.[29] The key feature permitting over-provision is that the social benefit of an additional program is less than the direct benefits it 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 decision making when entry is costly (Mankiw and Whinston (1986)).

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 close to the optimum for a range of parameter values.[30]

Accordingly, the model does not suggest that the market *necessarily* provides broadcasting inefficiently.

[29] The possibility of overprovision is also stressed by Berry and Waldfogel (1999). They structurally estimate a model of radio broadcasting based on the work of Mankiw and Whinston (1986). This model implies that the equilibrium number of stations will always exceed the number that maximizes total non-viewer surplus (broadcasting stations plus advertisers) and they quantify the extent of this overprovision. While they are unable to observe viewer surplus, they are able to compute the values of programming that would make the equilibrium optimal.

[30] To see this, suppose that ΔB^o exceeds K so that the optimum involves providing both programs. Suppose further that the Pigouvian corrective tax, γ, 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. 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.

5 Further issues concerning market provision

This section uses the model to address two classic questions concerning the market provision of broadcasting. The first is whether the market produces better outcomes under monopoly or competition. This has been a key question in the literature (see Steiner (1952), Beebe (1977) and Spence and Owen (1977)) and remains a policy relevant issue today, given the current spate of mergers in the broadcasting industry. The second issue is how the possibility of pricing programming impacts market performance. This has 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 (2001) and Holden (1993)). It is of policy interest since, in the television industry, it is becoming increasingly possible to exclude viewers and monitor their viewing choices. This permits the pricing of individual programs as well as access to particular channels.[31]

5.1 Is monopoly better than competition?

To analyze the issue, suppose that the two channels are owned by a single boradcaster, rather than two separate firms. If the monopoly chooses to operate both channels, its revenue maximizing level of advertisements is $a = m/2$ and its revenues will be $2NR(\frac{m}{2})$. If it operates only one channel, its revenue maximizing advertising level will be a_1^* and its revenues π_1^*. Letting $\Delta\pi$ be the incremental profit from offering the second program, the monopoly will provide both programs if K is less than $\Delta\pi$, and one program if K is between $\Delta\pi$ and π_1^*. Assume that K is such that both channels would be operated under competition.

The first point to note is that monopoly produces higher advertising levels than competition.

[31] In Europe, direct broadcast satellite channels like Canal Plus are partially financed by subscription pricing. In the United States, 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. In this case, both cable companies and the cable networks are involved in pricing decisions. In our model, bundling does not make sense because viewers watch at most one program. Obviously, it would be interesting to extend the analysis to incorporate bundling.

Under competition, advertising levels are a_2^* on each channel. If the monopoly operates both channels, it chooses an advertising level $m/2$, which is larger than the competitive level a_2^*. If the monopoly operates only one channel, it chooses a_1^* advertisements, which exceeds a_2^*. In both cases per viewer advertising prices are lower under monopoly, suggesting that concerns about increasing concentration raising prices to advertisers are misguided.[32] 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.[33] This greater quantity of advertisements sells at a lower per viewer price.

The impact of monopoly on programming is more difficult to discern. 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), which favors the provision of less programming. On the other, the monopoly puts on more advertisements implying that each program earns more revenue than under competition. This second effect, which suggests that monopoly will provide more programming, has been ignored by the literature because of its assumption of fixed advertising levels. In our model the first effect dominates the second, yielding the following proposition.

Proposition 3 *Assume that K is such that both channels would be operated under competition. Then monopoly produces higher advertising levels than competition and provides fewer programs*

[32] Notice, however, that advertiser surplus will not necessarily be higher if the monopoly shuts down one channel, because fewer viewers will be exposed to advertisements. In this case, the total price of an advertisement may be higher under monopoly because each advertisement reaches more viewers.

[33] This finding is consonant with the explanation offered by some observers of the United States radio industry that increased concentration of ownership explains increased advertising levels. For example, Duncan's American Radio analysts J.T. Anderton and Thom Moon argue that "As bottom-line pressures increase from publicly-traded owners, the number of commercials on the air has risen. The biggest change when a new owner takes over seems to be the addition of one new stopset per hour. The rationalization offered by most owners is that they limited unit loads because they needed to compete effectively with a direct format competitor: "Fewer commericals gives the listener more reasons to stay with me." Now the reasoning is, "We own the other station they're most likely to change to, so we have them either way. Why limit spot loads?""

for some values of K.

What can be said about the welfare comparison of monopoly and competition? In contrast to standard markets, there is no presumption that monopoly in broadcasting produces worse outcomes than competition. If monopoly leads to the same amount of programming, then the welfare comparison simply depends on relative advertising levels. If advertising levels are too high with competition, then they are even higher with monopoly, so that monopoly must reduce welfare. If they are too low, then monopoly can raise welfare. If monopoly changes the amount of programming, then the welfare analysis needs to take account of both changes in advertising levels and programming. Even if one knows the direction of the changes in programming, welfare comparisons are complicated by the fact that both advertising and programming could be either over- or under-provided under competition.[34]

This analysis of the relative merits of monopoly and competition should be contrasted with the classic discussion in Steiner (1952). In our model, the fact that the monopoly internalizes the business stealing externality is a force working in the direction of less programming. By contrast, in Steiner's analysis it is a force working in favor of monopoly producing more variety. Steiner argued that, while competition would duplicate popular program types, a monopoly would have no incentive to duplicate programs because it would simply be stealing viewers from its own stations. It would, however, have an incentive to also provide less popular programming to the extent that this attracted more viewers.[35] While this argument does not emerge from our basic model, it

[34] If monopoly leads to the loss of a program, 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, but 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. The interested reader can consult Anderson and Coate (2000) for the details.

[35] As Beebe (1977) pointed out, 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.

does in the extension considered in Section 6.

5.2 Does pricing 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. The main point to note is that the equilibrium advertising level is the same whether the market provides one or two programs and equals one half of the two program optimal level. To understand this, note that the number of viewers a firm gets is determined by its "full price"; i.e., the nuisance cost plus subscription price. 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 its advertising level a and subscription price s must maximize $R(a)+s$ subject to the constraint that $\gamma a+s=r$. To see the implications of this, observe that if the subscription 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 $a>0$. The linear advertising demand function implies that $R'(a)=p(2a)$, so that the equilibrium advertising level is $a_2^o/2$.[36]

It follows from this result and the fact (established in the Appendix) that $a_2^o/2<a_2^*<a_1^*$, that pricing reduces advertising levels. Intuitively, pricing allows broadcasters to respond to viewers' dislike of commercials by reducing advertisements and raising subscription prices. Not surprisingly, it can be shown that equilibrium profits are higher with pricing. Pricing allows broadcasters to extract direct payments for their programming and hence makes programs more profitable. This means that the market provides at least as many programs with pricing (see also Spence and Owen (1977) and Doyle (1998)). Thus, we have the following proposition.

[36] With pricing, the model becomes formally similar to that used by Armstrong (2002) to illustrate the general problem of competitive bottlenecks in two-sided markets. The problem of under-advertising is a particular instance of a general distortion arising in the presence of competitive bottlenecks.

Proposition 4 *With pricing, the market provides lower advertising levels than without. Moreover, with pricing 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 with pricing?[37] There are many circumstances in which it will. For example, when $\gamma \geq \omega\overline{\sigma}$ and $K < N\frac{\beta}{2}$, optimal provision involves two programs each of which have no advertising. Without pricing, the market cannot achieve this. With pricing, however, market provision is fully optimal. Viewers are charged a subscription price β and exposed to no advertisements (since $a_2^o/2 = 0$). Each firm earns revenues $N\beta$, more than sufficient to cover operating costs.

However, there are circumstances under which pricing reduces welfare. If pricing leads to no changes in the number of programs provided, it must reduce surplus if advertising levels are already underprovided without pricing. Pricing may also reduce welfare when it increases programs. Suppose that the market provides one program without pricing and two with. If nuisance costs are close to 0, the equilibrium advertising level with and without pricing is almost the same. Thus, pricing holds constant the advertising level but generates a new program. This generates no extra advertising benefits because all viewers are already watching. The extra viewing benefits are $N\frac{\beta}{2}$. Thus, if K is greater than the sum of these two terms, aggregate surplus is lower with pricing.[38]

Pricing also has some interesting distributional consequences. Consider again the case in which $\gamma \geq \omega\overline{\sigma}$ and $K < N\frac{\beta}{2}$ and suppose that the market would provide at least one program without pricing. Then, since viewers would pay a price β and there would be no advertising, introducing pricing would eliminate both viewer and advertiser benefits. All the surplus from the market would be extracted by the two broadcasters!

[37] A more systematic analysis of how pricing impacts welfare can be found in Anderson and Coate (2000).

[38] It is straightforward to show that there exist values of K satisfying this inequality that are consistent with the assumption that one program is provided without pricing and two with.

6 Extensions

This section extends the basic model to address two important questions. First, how are our findings concerning advertising levels impacted by the possibility that, in a dynamic world, viewers may switch between channels? Second, what does our analysis have to say about the problem of duplication of popular program types, which the existing literature has seen as a major problem with market provision.

6.1 Switching viewers

In the basic model, each channel has a monopoly in delivering its viewers to advertisers. Exploitation of this monopoly power is key to the possibility of under-advertising: broadcasters hold down advertising levels to drive up the price of reaching their exclusive viewers. In a dynamic world, viewers are likely to switch between channels, allowing advertisers to reach the same viewers through different channels. Broadcasters' desire to drive up prices is then dampened by the possibility that advertisers might choose to contact viewers via advertising on another channel. This might mitigate the possibility of under-advertising.

To investigate this logic, we extend the model to have two viewing periods, indexed by $\tau \in \{1, 2\}$.[39] Each viewer is now characterized by $\{(t_1, \lambda_1), (t_2, \lambda_2)\}$ where (t_τ, λ_τ) represents the viewer's period τ preferences. As for the static model, we assume that in each period there are N viewers such that $t_\tau = t$ and that, for each group, the parameter λ is distributed uniformly on the interval $[0, 1]$. However, we assume that for a fraction δ of viewers, $t_2 \neq t_1$ with λ_2 being an independent draw from the uniform distribution (hence uncorrelated with λ_1). For the remaining $1-\delta$, $(t_2, \lambda_2) = (t_1, \lambda_1)$. The parameter δ indexes the degree of correlation in the tastes of viewers across the periods.

[39] A dynamic model is necessary given the technological infeasibility of watching two television programs at once. In other examples of advertising markets, such as the yellow pages, magazines, or newspapers, it is possible to introduce competition for advertisers in a static framework. However, even static models of this form prove tricky to analyze (Armstrong (2002)).

To focus cleanly on the impact of competition for advertisers on advertising levels, we take each broadcaster's programming choice as exogenous: channel A shows a type 1 program in each period, while channel B shows a type 2 program.[40] We further assume that each broadcaster runs the same number of advertisments in each period. We study the Nash equilibrium of the game in which each broadcaster simultaneously chooses its advertising level anticipating the impact on the price it can charge and its advertising revenues.[41] We present results for the two extremes in which $\delta = 0$ and $\delta = 1$.[42] When $\delta = 0$, the game is analagous to that studied above - in equilibrium, all viewers watch the same channel in both periods and advertisers must advertise on both channels to contact all viewers. However, when $\delta = 1$, viewers switch between channels and advertisers can reach all viewers *either* by advertising simultaneously on both channels *or* by advertising twice on one channel. Our findings are summarized in:

Proposition 5 *For $\delta \in \{0, 1\}$ there exists a unique equilibrium in which the broadcasters choose an identical advertising level. There exists a critical nuisance cost $\gamma(\delta) \in (0, \omega\overline{\sigma})$ such that the equilibrium advertising level is lower (higher) than the optimal level as γ is smaller (larger) than $\gamma(\delta)$. Moreover, $\gamma(1)$ is less than $\gamma(0)$.*

The key point to note is that while under-advertising is still a possibility when viewers switch between channels, it is less likely than when viewers remain loyal to one channel. Each broadcaster is prevented from lowering its advertising level to increase its price by the credible threat that advertisers will simply switch all their business to its rival. Competition for advertisers therefore mitigates, but does not eliminate, the problem of under-advertising identified in the basic model.

[40] We leave for future work the issue of how broadcasters compete in program scheduling. See Cancian, Bills and Bergstrom (1995) for a discussion of some technical difficulties that may arise in modelling program scheduling.

[41] In this extension, because stations no longer have a monopoly in delivering their viewers to advertisers, it is no longer the case that competition in advertising levels is equivalent to competition in prices. We choose to study competition in advertising levels because it is much more tractable.

[42] A full characterization of equilibrium is well beyond the scope of this paper. This is because for δ sufficiently close to 1 the only equilibrium is in mixed strategies. See the proof of Proposition 5 for the details.

6.2 Duplication

Our basic model is inappropriate for studying duplication because it assumes that both types of programs are equally popular. However, extending the model to allow one program type to be more popular does not generate duplication. If both broadcasters choose the more popular program type, competition for viewers will drive advertising levels and revenues down to zero. Thus, broadcasters will choose not to duplicate even when doing so would increase viewers.

The fierce advertising competition driving this conclusion reflects the strong assumption that two programs of the same type are perfect substitutes for viewers. In reality, there is considerable variation within a type of program: talk programs can discuss current affairs or offer personal advice; country programs can play classics or current hits; etc. Such variation means that programs of the same broad type are not perfect substitutes and hence broadcasters can and do offer programs of the same type. However, the welfare consequences of duplication are then less clear because there is a viewer benefit to having multiple differentiated programs of the same type. Thus, whether the market produces too much duplication is unclear.

This question can be addressed with an extension of the model. Suppose there are two varieties of each program type, denoted i and j. Each viewer is now characterized by a triple (t, k, ξ) where t denotes his preferred type of program, $k \in \{i, j\}$ his preferred variety and ξ the fraction of the gross viewing benefits he gets from his less preferred variety. Thus, a type (t, k, ξ) viewer gets gross viewing benefits β from watching a type t program of his preferred variety k and benefits $\xi\beta$ from his less preferred variety. We assume that viewers receive no benefits from watching either variety of their less preferred type of program.[43]

Suppose there are N_t viewers preferring type t programs and that type 1 programs are more popular (i.e., $N_1 > N_2$). Viewers of each type are evenly split in terms of their preferred variety and

[43] Without this assumption, the model becomes significantly more complicated and analyzing it would require a separate paper.

the parameter ξ is uniformly distributed on the interval $[\underline{\xi}, 1]$. The lower bound $\underline{\xi}$ is a measure of how close substitutes the two varieties are. As $\underline{\xi}$ increases the two varieties become closer substitutes.

When both broadcasters provide programs, there are two possible market outcomes: *duplication* in which the two channels broadcast type 1 programs of different varieties and *diversity* in which they broadcast different types of program. Since a higher value of $\underline{\xi}$ means that the two varieties are closer substitutes, intuition suggests that the market outcome will be diversity for $\underline{\xi}$ sufficiently large and duplication for $\underline{\xi}$ sufficiently small. Indeed, it is straightforward to show that there exists a critical level of $\underline{\xi}$, such that the market outcome will be duplication for $\underline{\xi}$ smaller than this value and diversity for larger $\underline{\xi}$.

If $\underline{\xi}$ is small, providing both varieties of a type 1 program generates significant viewing benefits for type 1 viewers. Since these viewers are more numerous than type 2 viewers, optimal provision may involve duplication in these circumstances. The key question is whether the market generates duplication in circumstances when optimal provision involves diversity. Our next proposition provides sufficient conditions for this to occur.

Proposition 6 *Suppose that K is such that both optimal and market provision involve both channels operating. Then, if $N_2 \in (\frac{N_1}{3}, \frac{N_1}{2})$ and $\underline{\xi} > 0$, market provision involves duplication and optimal provision involves diversity for sufficiently small γ.*

Intuitively, the smaller the minority viewing group (type 2s), the more likely are both market and optimal provision to involve duplication. The question is whether the size of the minority viewing group at which market provision switches from diversity to duplication is smaller than that at which optimal provision switches from diversity to duplication. The proof of the proposition shows that, for sufficiently small γ, optimal provision involves diversity if the minority viewing group (type 2s) is at least 1/3 as big as the majority group. However, market provision involves duplication if the minority group is less than 1/2 as big as the majority group.

It is noteworthy that if the two channels were owned by a single broadcaster (rather than two separate firms).the market outcome would be diversity under the conditions of the proposition. This illustrates the advantage of monopoly stressed by Steiner. Note also that while this proposition restores the conclusion that the market can produce socially inefficient duplication, it does not imply that this is the only possible type of distortion. In principle, there might be conditions under which the market outcome is diversity when optimal provision is duplication. The fiercer competition in advertising levels under duplication may encourage broadcasters to provide diversity before it is socially optimal. We have been unable to rule out this possibility in our model.

7 Conclusion

This paper has presented a theory of the market provision of broadcasting and used it to address the nature of market failure in the industry. Equilibrium advertising levels can be greater or less than socially optimal levels, depending on the relative sizes of the nuisance cost to viewers and the expected benefits to producers from contacting viewers. This reflects a trade off between two factors. On the one hand, broadcasters do not fully internalize the costs of advertisements to viewers - they only care to the extent that they induce viewers to switch off or switch channels. On the other, broadcasters hold down advertising levels in order to drive up advertising prices. The strength of the latter force will depend upon the degree to which broadcasters are able to offer exclusive access to their viewers.

It is perhaps surprising that the analysis does not provide a clear cut case for regulatory limits on advertising levels. Of course, the possibility that advertising levels could actually be too low reflects our assumption that advertising creates surplus-enhancing trades. An alternative perspective is that advertising is simply business-stealing - any benefit of trade between an advertiser and a consumer comes at the expense of the advertiser's competitor. For example, in Grossman and

Shapiro's (1984) elegant analysis of informative advertising, advertisers' payoffs from selling their goods overstate the surplus they generate because their sales come at the expense of their competitors. Such considerations decrease the likelihood of there being too few commercials. Even when the market provides excessive advertising, however, ceilings may be undesirable because of their impact on programming.[44]

Market provision can allocate too few or too many resources to programming. A broadcaster's choice of whether to provide programming 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 advertisers get from contacting viewers. This may explain the prevalence of public broadcasting in the early stages of a country's development when advertising benefits are likely to be low. Overprovision can arise when program benefits are low relative to advertiser benefits and nuisance costs are low.

The market may also misallocate resources across types of programs. In particular, it may provide multiple varieties of a popular program type, when society would be better served by having programs of different types. The problem, once again, is that stations do not take account of the lost advertising revenues to competitors when they choose their format.

With respect to the debate concerning the role of public or not-for-profit broadcasting, the results make clear that there are circumstances under which socially valuable programming will not be provided by the market. However, the possibility of the market overproviding programming means that arguments for public broadcasting should not be made on a priori grounds (as in, for example, the Davies Report (1999)). Any assessment of the case for public broadcasting should also include a consideration of how programming and funding decisions are made in the public

[44] Advertising ceilings reduce advertising revenues and hence may negatively impact the number of programs provided. They may also reduce program quality as argued by Wright (1994) and may reduce program differentiation as argued by Gabszewicz, Laussel, and Sonnac (2001).

sector, an interesting subject for further study.[45]

There should be no presumption that increased concentration in the broadcasting industry is necessarily detrimental to social welfare. Such concentration may be expected to raise advertising levels, but this is not necessarily undesirable. The impact on the amount of resources allocated to programming is (in general) ambiguous, but increased concentration may yield a broader variety of programming. Welfare analysis is complicated by the fact that even if one knows the changes in programming concentration brings, one needs to know whether advertising and programming were over- or under-provided in the status quo.

Finally, the ability to price programming does not necessarily solve the problems associated with market provision. With such pricing, broadcasters can internalize the costs of advertisements to viewers by substituting prices for advertising at the margin. In addition, pricing enables more revenue to be extracted from the market by raising money directly from viewers. However, lower advertising levels and more programming are not necessarily socially desirable. Pricing may also have significant distributional consequences, redistributing surplus away from viewers and advertisers towards broadcasters.

[45] For an entertaining discussion of this issue see Coase (1966).

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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 $a_1^o(\gamma) > a_1^*(\gamma)$ for γ sufficiently small 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

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

or, equivalently, using the linear demand specification,

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

In addition, from the first order conditions that characterize $a_1^*(\gamma)$, we have that $(\beta 2 - \gamma a_1^*) R'(a_1^*) = \gamma R(a_1^*)$ or, equivalently,

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

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 $a_2^o(\gamma) > 0$, then $p(a_2^o) = \gamma$. In addition, from our characterization of $a_2^*(\gamma)$ we have that $\frac{\beta R'(a_2^*)}{R(a_2^*)} = \gamma$. Thus, if $a_2^o(\gamma) = a_2^*(\gamma) = a$, we have that

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

or, equivalently,

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

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 $\Upsilon = \frac{\omega\overline{\sigma}m}{\beta}$, we may rewrite the 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 γ_1 is less than γ_2), we simply need to show that $a_2^o(\gamma_1) > a_2^*(\gamma_1)$. Using Figures 1 and 2, 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: To complete the argument in the text, we need to show that $\Delta B^o \geq N\frac{\beta}{2}$. 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

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

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 $N\gamma a_1^o/\beta$ viewers and experience a gain of $N[\gamma a_1^o/\beta]\int_0^{a_1^o} p(a)da$. Aggregating these gains up, we obtain

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

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

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

To complete the proof, observe that

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

■

Proof of Proposition 3: That monopoly produces higher advertising levels was shown in the text. Thus, we need only show that monopoly provides fewer programs than competition for some values of K. This requires showing that $\Delta\pi < \pi_2^*$ for all $\gamma \in (0, 2\beta/m)$. For then, for any given γ, monopoly provides less programming for $K \in (\Delta\pi, \pi_2^*)$. By definition $\Delta\pi = 2NR(\frac{m}{2}) - \pi_1^*$, so that $\Delta\pi < \pi_2^*$ if and only if $\pi_2^* + \pi_1^* > N\frac{m\omega\overline{\sigma}}{2}$. 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 inequality as

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

Writing a_i^* as $a_i^*(\gamma)$, we can also show that

$$a_1^*(\frac{2\beta}{m}) = m[\frac{1}{3}]$$

and

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

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

$$[1 - \frac{\sqrt{2}}{2}] \cdot [\frac{\sqrt{2}}{2}] + [\frac{1}{3}] \cdot [\frac{2}{3}] \cdot [\frac{4}{3}] > \frac{1}{2}.$$

This is the case because the left-hand side equals 0.5034. ■

Characterization of Market Outcomes with Excludable Viewers: We amend the game considered in section 4.2 by supposing that in Stage 2 each broadcaster 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 broadcaster 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 $N(2 - r/\beta)$ 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 broadcaster's revenues can be written as

$$\pi_{1s}(r) = N(2 - r/\beta)P(r).$$

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

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

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

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

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

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

Now suppose that in Stage 1 both broadcasters provide 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 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 $\beta \geq r_A \geq r_B$, 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

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

and

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

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

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

and similarly for 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

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

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

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

For this is to be consistent with the supposition that r_2^* is greater than $\gamma a_2^o/2$, we require that $\beta > R(\frac{a_2^o}{2})$. Since $R(a) \leq R(m/2) = \omega\overline{\sigma}m/4$, 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

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

Turning to Stage 1, neither broadcaster 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.

In summary, then, neither broadcaster 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 $s_1^* = r_1^* - \gamma\frac{a_2^o}{2}$. 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 4: For the first part, we need to show that $a_2^o/2 < a_2^*$. 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,

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

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, we need only show that equilibrium revenues are higher with pricing in both the one and two channel cases; i.e., $\pi_1^* < \pi_{1s}^*$ and $\pi_2^* < \pi_{2s}^*$. In the one channel case, this is obvious. With pricing, 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 pricing.

In the two channel 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 pricing. To see this, suppose that $r_2^* > \gamma a_2^*$ and that $\pi_2^* \geq \pi_{2s}^*$. Note that, by symmetry, each firm attracts N viewers with or without pricing. With pricing, each firm has the option of setting the advertising level a_2^* and a subscription price of 0. Since $r_2^* > \gamma a_2^*$ 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.

We now establish that it is indeed the case that $r_2^* > \gamma a_2^*$. 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

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

and hence that $\gamma < \omega\overline{\sigma}$ (otherwise we have $a_2^o = 0$). Figure 3 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 $R(\frac{r}{\gamma})/\beta$. With excludability, the equilibrium full price is determined by $1 = P(r_2^*)/\beta$, which in the graph is the intersection of the horizontal line emanating from the point $(0,1)$ and the upward sloping curve $\frac{R(\frac{a_2^o}{2})-\gamma\frac{a_2^o}{2}+r}{\beta}$. The result will hold if the slope $\frac{1}{\beta}$ is less than the absolute value of the slope of $R'(\frac{r}{\gamma})/\gamma$ so that $R'(\frac{r}{\gamma})/\gamma$ crosses $R(\frac{r}{\gamma})/\beta$ (which here is sloping up since $R(a_2^*) > R(\frac{a_2^o}{2})$) before $\frac{R(\frac{a_2^o}{2})-\gamma\frac{a_2^o}{2}+r}{\beta}$ 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 $\beta > \frac{m\gamma^2}{2\omega\overline{\sigma}}$. But, since $\gamma < \omega\overline{\sigma}$ and, by Assumption 1 (i), $\gamma < 2\beta/m$, we have

$$\frac{m\gamma^2}{2\omega\overline{\sigma}} < \frac{m\gamma}{2} < \beta,$$

as desired. ■

Proof of Proposition 5: We start by deriving the demands facing the stations when a fraction δ of viewers switch preferences in the manner described in the text. Suppose that channel J runs a_J advertisements in each period and that channel B's advertising level is at least as high as A's. In addition, assume that $\beta \geq \gamma a_B$ which implies that all consumers watch programming in both periods. In each period, viewers allocate themselves across channels in exactly the same way as in the basic model. Thus, letting V_J denote the number of viewers of channel J in each period, we have that

$$V_A = N[1 + \frac{\gamma}{\beta}(a_B - a_A)],$$

and that

$$V_B = N[1 + \frac{\gamma}{\beta}(a_A - a_B)].$$

For the purposes of understanding advertiser demand, it is important to know the fraction of channel B's viewers that watch B in both periods. A viewer watches channel B in period 1 if $t_1 = 2$ and $\lambda_1 \leq 1 + \frac{\gamma}{\beta}(a_A - a_B)$. That viewer watches channel B in period 2 if $(t_1, \lambda_1) = (t_2, \lambda_2)$

and channel A if $t_2 = 1$. Thus the fraction of channel B's viewers that watch channel B in both periods is the fraction for whom $(t_1, \lambda_1) = (t_2, \lambda_2)$; - namely, $1 - \delta$.

Let p_J be the price for advertising once on channel J. Since channel B has higher advertising levels, p_A must be at least as large as p_B. Consider an advertiser of type σ and suppose first that he can advertise at most once on each channel. Placing an advertisement on channel B would yield an expected payoff of $\sigma\omega V_B - p_B$, while placing an advertisement on channel A would yield $\sigma\omega V_A - p_A$. Placing an advertisement on both channels in the same time period would yield a payoff of $\sigma\omega(V_A + V_B) - p_A - p_B$. This dominates advertising on both channels in different time periods because it guarantees reaching *all* viewers. Observe that the payoff from advertising on either channel is independent of whether the advertiser has advertised on the other channel as long as the advertisements are run in the same time period. Thus, we may conclude that if it was only possible to advertise once on each channel , the advertiser would choose to place an advertisement on channel B if $\sigma \in [\frac{p_B}{\omega V_B}, \overline{\sigma}]$ and one on channel A if $\sigma \in [\frac{p_A}{\omega V_A}, \overline{\sigma}]$. If he advertised on both channels, then he would do so in the same time period.

Now suppose that the advertiser can advertise twice on one channel. Note that it will never pay the advertiser to advertise twice on channel A. This can yield no more viewers than advertising once on both channels at the same time and is more expensive since $p_A \geq p_B$.. However, it might pay to run two advertisements on channel B instead of one on each channel. Placing a second advertisement on channel B will yield an additional payoff of $\sigma\omega\delta V_B - p_B$, reflecting the fact that a fraction $1 - \delta$ of viewers will have already seen the advertisement. This strategy will dominate that of advertising on both channels, if $\sigma\omega\delta V_B - p_B$ exceeds $\sigma\omega V_A - p_A$, which requires that $\sigma \leq \frac{p_A - p_B}{\omega(V_A - \delta V_B)}$. Thus, if $\sigma \in [\frac{p_B}{\omega\delta V_B}, \frac{p_A - p_B}{\omega(V_A - \delta V_B)}]$, the advertiser will choose to advertise twice on channel B. Note that this interval will be non-empty if and only if $p_B V_A < \delta p_A V_B$.

We conclude from this discussion that if $p_B V_A \geq \delta p_A V_B$, advertisers with types in the interval $[\frac{p_B}{\omega V_B}, \overline{\sigma}]$ will place an advertisement on channel B and those with types in the interval $[\frac{p_A}{\omega V_A}, \overline{\sigma}]$ will place an advertisement on channel A. They will be indifferent as to which period the advertisement is shown, as long as it is shown in the same period by both channels. If $p_B V_A < \delta p_A V_B$, advertisers with types in the interval $[\frac{p_B}{\omega V_B}, \frac{p_B}{\omega \delta V_B}]$ will place a single advertisement on channel B. They will be indifferent as to when it is shown. Advertisers with types in the interval $[\frac{p_B}{\omega \delta V_B}, \frac{p_A - p_B}{\omega(V_A - \delta V_B)}]$ will advertise twice on channel B and those with types in the interval $[\frac{p_A - p_B}{\omega(V_A - \delta V_B)}, \overline{\sigma}]$ will advertise on both channels. Again, the latter will want their advertisements run simultaneously.

We may now solve for the demands. For $p_B V_A \geq \delta p_A V_B$, then if prices are to clear the market, the number of advertisements shown each period on channel A is half the mass of types wishing to advertise on both channels, or

$$a_A = \frac{m}{2}[1 - \frac{p_A}{\overline{\sigma}\omega V_A}].$$

Similarly, those who advertise on channel B each period will be

$$a_B = \frac{m}{2}[1 - \frac{p_B}{\overline{\sigma}\omega V_B}].$$

Inverting these two relationships gives the indirect demands as

$$p_A = \overline{\sigma}\omega V_A[1 - \frac{2a_A}{m}],$$

and

$$p_B = \overline{\sigma}\omega V_B[1 - \frac{2a_B}{m}].$$

Notice that $p_B V_A \geq \delta p_A V_B$ if and only if $[1 - \frac{2a_A}{m}] \geq \delta[1 - \frac{2a_B}{m}]$, which requires that $a_B \leq a_A + \frac{m}{2}(1 - \delta)$.

If $a_B > a_A + \frac{m}{2}(1 - \delta)$, then

$$a_A = \frac{m}{2}[1 - \frac{p_A - p_B}{\overline{\sigma}\omega(V_A - \delta V_B)}],$$

and

$$a_B = \frac{m}{2}[1 - \frac{p_B}{\overline{\sigma}\omega V_B}] + \frac{m}{2}[\frac{p_A - p_B}{\overline{\sigma}\omega(V_A - \delta V_B)} - \frac{p_B}{\delta\overline{\sigma}\omega V_B}].$$

Inverting these, we obtain

$$p_A = \frac{2\overline{\sigma}\omega\delta V_B[1-\frac{a_A+a_B}{m}]}{(1+\delta)} + \overline{\sigma}\omega(V_A-\delta V_B)[1-\frac{2a_A}{m}].$$

and

$$p_B = \frac{2\overline{\sigma}\omega\delta V_B[1-\frac{a_A+a_B}{m}]}{(1+\delta)}.$$

When $\delta = 1$, these simplify further to

$$p_A = \overline{\sigma}\omega\{V_A(1-\frac{2a_A}{m}) + V_B(\frac{a_A-a_B}{m})\}$$

and

$$p_B = \overline{\sigma}\omega V_B\{1-\frac{a_A+a_B}{m}\}.$$

We can now derive the symmetric equilibrium for $\delta \in \{0,1\}$. When $\delta = 0$, the situation is basically the same as that studied in section 4.2 except that the number of advertisers is spread over two periods. Thus there are no new issues with the existence of equilibrium. Channel B's profit function is given by

$$\pi_B(a_A, a_B) = 2p_B a_B = 2\overline{\sigma}\omega V_B[1-\frac{2a_B}{m}]a_B.$$

The symmetric equilibrium may be obtained by solving the problem $\max_{a_B} \pi_B(a_A, a_B)$ and imposing symmetry. This yields $a_A = a_B = a^*(0)$ where $a^*(0)$ is implicitly defined by the equation

$$1-\frac{4a^*(0)}{m} = \frac{\gamma}{\beta}a^*(0)(1-\frac{2a^*(0)}{m}). \qquad (A.1)$$

We note here that this solution is also a candidate equilibrium for $\delta \in (0,1)$, since the inverse demand expressions used above hold for similar enough advertising levels. It can be shown that this is indeed an equilibrium for δ small enough; but for δ close to 1, a firm would rather deviate to a higher advertising level and pick up more advertisers by having them advertise twice on its channel.

When $\delta = 1$, we have that

$$\pi_B(a_A, a_B) = \{ \begin{array}{cc} 2\overline{\sigma}\omega V_B\{1 - \frac{a_A + a_B}{m}\}a_B & for\ a_B \geq a_A \\ 2\overline{\sigma}\omega\{V_B(1 - \frac{2a_B}{m}) + V_A(\frac{a_B - a_A}{m})\}a_B & for\ a_B \leq a_A \end{array}.$$

Note that π_B is a continuously differentiable function of a_B and that

$$\frac{\partial \pi_B(a,a)}{\partial a_B} = 2\overline{\sigma}\omega N\{(1 - \frac{3a}{m}) - \frac{\gamma}{\beta}(1 - \frac{2a}{m})a\}.$$

Setting this derivative equal to zero, our candidate symmetric equilibrium is $a_A = a_B = a^*(1)$ where $a^*(1)$ is implicitly defined by the equation

$$1 - \frac{3a^*(1)}{m} = \frac{\gamma}{\beta}a^*(1)(1 - \frac{2a^*(1)}{m}). \qquad (A.2)$$

To show that this is indeed an equilibrium, it is enough to show that $\pi_B(a^*(1), \cdot)$ is quasi-concave. Since $\frac{\partial \pi_B(a^*(1),a^*(1))}{\partial a_B} = 0$ it suffices to show that $\pi_B(a^*(1), \cdot)$ is quasi-concave for $a_B \geq a^*(1)$ and for $a_B \leq a^*(1)$. On the former interval, $\ln \pi_B(a^*(1), \cdot)$ is concave since it is the sum of concave functions (the logs of positive and linear functions of a_B). Thus, $\pi_B(a^*(1), \cdot)$ is log-concave and hence quasi-concave for $a_B \geq a^*(1)$.

The latter interval is more complicated. We need to show that when $\frac{\partial \pi_B(a^*(1),a_B)}{\partial a_B} = 0$, it must be the case that $\frac{\partial^2 \pi_B(a^*(1),a_B)}{\partial a_B^2} < 0$. For this it suffices to show that over the relevant range

$$\frac{\partial^2 p_B(a^*(1), a_B)}{\partial a_B^2} p_B(a^*(1), a_B) - 2(\frac{\partial p_B(a^*(1), a_B)}{\partial a_B})^2 < 0.$$

Note first that using the expressions for V_A and V_B we may write:

$$\begin{aligned} p_B(a^*(1), a_B) &= \overline{\sigma}\omega\{V_B(1 - \frac{2a_B}{m}) + V_A(\frac{a_B - a^*(1)}{m})\} \\ &= N\overline{\sigma}\omega\{1 - \widetilde{a}_B - \widetilde{a}^*(1) + \widetilde{\gamma}(\widetilde{a}^*(1) - \widetilde{a}_B)(1 - 3\widetilde{a}_B + \widetilde{a}^*(1))\}, \end{aligned}$$

where $\widetilde{a}_B = \frac{a_B}{m}$, $\widetilde{a}^*(1) = \frac{a^*(1)}{m}$, and $\widetilde{\gamma} = \frac{\gamma m}{\beta}$. Hence

$$\frac{\partial p_B(a^*(1), a_B)}{\partial a_B} = N\overline{\sigma}\omega\{-1 + \widetilde{\gamma}(6\widetilde{a}_B - 4\widetilde{a}^*(1) - 1)\}$$

and

$$\frac{\partial^2 p_B(a^*(1), a_B)}{\partial a_B^2} = N\overline{\sigma}\omega 6\widetilde{\gamma}.$$

Using these, the required condition is

$$6\widetilde{\gamma}\{1 - \widetilde{a}_B - \widetilde{a}^*(1) + \widetilde{\gamma}(\widetilde{a}^*(1) - \widetilde{a}_B)(1 - 3\widetilde{a}_B + \widetilde{a}^*(1))\} < 2\{-1 + \widetilde{\gamma}(6\widetilde{a}_B - 4\widetilde{a}^*(1) - 1)\}^2.$$

or, equivalently

$$\widetilde{\gamma}(2 + 18\widetilde{a}_B - 22\widetilde{a}^*(1)) < 2 + \widetilde{\gamma}^2\{2(6\widetilde{a}_B - 4\widetilde{a}^*(1) - 1)^2 + 6(\widetilde{a}_B - \widetilde{a}^*(1))(1 - 3\widetilde{a}_B + \widetilde{a}^*(1))\}.$$

This inequality is satisfied if

$$\widetilde{\gamma}(2 + 18\widetilde{a}_B - 22\widetilde{a}^*(1)) < 2$$

and

$$0 < \widetilde{\gamma}^2\{2(6\widetilde{a}_B - 4\widetilde{a}^*(1) - 1)^2 + 6(\widetilde{a}_B - \widetilde{a}^*(1))(1 - 3\widetilde{a}_B + \widetilde{a}^*(1))\}.$$

Since $\widetilde{a}_B \leq \widetilde{a}^*(1)$ the first of these inequalities is satisfied if $\widetilde{\gamma}(1 - 2\widetilde{a}^*(1)) < 1$ but we know from (A.2) that

$$1 - 3\widetilde{a}^*(1) = \widetilde{\gamma}\widetilde{a}^*(1)(1 - 2\widetilde{a}^*(1)).$$

which implies that

$$(1 - 2\widetilde{a}^*(1)) = \frac{1 - 3\widetilde{a}^*(1)}{\widetilde{\gamma}\widetilde{a}^*(1)}$$

Thus, this inequality is satisfied if $\frac{1}{4} < \widetilde{a}^*(1)$ which follows from Assumption 1(i) and $(A.2)$. For the second inequality, note that

$$\begin{aligned} & \{2(6\widetilde{a}_B - 4\widetilde{a}^*(1) - 1)^2 + 6(\widetilde{a}_B - \widetilde{a}^*(1))(1 - 3\widetilde{a}_B + \widetilde{a}^*(1))\} \\ = \quad & 54\widetilde{a}_B^2 - 72\widetilde{a}_B\widetilde{a}^*(1) - 18\widetilde{a}_B + 26\widetilde{a}^*(1)^2 + 10\widetilde{a}^*(1) + 2. \end{aligned}$$

This is minimized at

$$\widetilde{a}_B = \frac{4\widetilde{a}^*(1) + 1}{6}$$

at which value the inequality boils down to

$$2\widetilde{a}^*(1)^2 - 2\widetilde{a}^*(1) + \frac{1}{2} > 0.$$

This is satisfied because the left hand side equals $(\frac{1}{\sqrt{2}} - \widetilde{a}^*(1)\sqrt{2})^2$.

To complete the proof, we must establish that there exists a critical nuisance cost $\gamma(\delta) \in (0, \omega\overline{\sigma})$ such that the equilibrium advertising level is lower (higher) than the optimal level as γ is smaller (larger) than $\gamma(\delta)$ and that $\gamma(1)$ is less than $\gamma(0)$. Note first that the optimal level is independent of δ and solves the problem

$$\max 4N(\beta - \gamma a) + 2N \int_0^{2a} p(\alpha)d\alpha.$$

This implies that the optimal level, denoted a^o, satisfies the first order condition:

$$p(2a^o) \leq \gamma \textit{ with equality if } a^o > 0.$$

The difference between this and the basic model just reflects the fact that with two periods twice the number of advertisers can contact viewers. We can now use similar arguments to those used to establish Proposition 1 to show that for $\delta \in \{0, 1\}$ there exists $\gamma(\delta) \in (0, \omega\overline{\sigma})$ such that the equilibrium advertising level is lower (higher) than the optimal level as γ is smaller (larger) than $\gamma(\delta)$. Since $a^*(1)$ exceeds $a^*(0)$, we have that $\gamma(1)$ is less than $\gamma(0)$. ■

Proof of Proposition 6: In the case of duplication, the two broadcasters compete for viewers via their choice of advertising levels in the same way as discussed in section 4.2. Following an analagous argument, it can be shown that the equilibrium advertising level under duplication, denoted a_d^*, satisfies

$$R'(a_d^*) = \frac{\gamma}{\beta(1 - \underline{\xi})} R(a_d^*),$$

and equilibrium revenue for each firm is $\frac{N_1}{2} R(a_d^*)$. Under diversity, the assumption that viewers will not watch either variety of their less preferred type of program implies that each broadcaster is a monopoly with respect to its viewers. Thus, the situation is analagous to the one firm case in section 4.2. Following the same logic, the equilibrium advertising level under diversity, denoted a_v^*, satisfies[46]

$$R'(a_v^*) = \frac{\gamma}{\beta(2 - \underline{\xi}) - \gamma a_v^*} R(a_v^*).$$

The firm serving type t viewers will obtain revenues

$$\pi_t^v = \frac{N_t}{2}[1 + \frac{1 - \gamma a_v^*/\beta}{1 - \underline{\xi}}]R(a_v^*).$$

The market outcome will be duplication if $\frac{N_1}{2}R(a_d^*) > \pi_2^v$ and diversity otherwise.

To prove the proposition, note that equilibrium advertising levels under both duplication and diversity converge to $\frac{m}{2}$ as γ becomes small. Moreover, since $\underline{\xi} > 0$, under diversity, all type t citizens would watch the type t channel. Thus, the market outcome will be duplication if $\frac{N_1}{2} > N_2$. With optimal provision, advertising levels under duplication and diversity converge to m as γ becomes small and, under diversity, all type t citizens would watch the type t channel. Moving from duplication to diversity would create new viewing benefits of $\frac{N_2}{2}\beta[1 + \frac{1+\underline{\xi}}{2}]$ for type 2 viewers and lead to a loss of viewing benefits of $\frac{N_1}{2}\beta[\frac{1-\underline{\xi}}{2}]$ for type 1 viewers. The gain is bigger than the loss if $N_2 > \frac{N_1}{3}$. Since the total viewing audience is greater under diversity ($N_1 + N_2$ vs N_1), advertisers must also be better off and hence diversity dominates duplication from a welfare standpoint. ■

[46] This equation holds for $\underline{\xi}$ less than $\widehat{\underline{\xi}}$ where $R'(\beta\widehat{\underline{\xi}}/\gamma) = \gamma R(\beta\widehat{\underline{\xi}}/\gamma)/2\beta(1 - \widehat{\underline{\xi}})$. If $\underline{\xi}$ lies between $\widehat{\underline{\xi}}$ and $\gamma m/2\beta$ the solution to the firm's problem is to set $a_\nu^* = \beta\underline{\xi}/\gamma$, while if $\underline{\xi}$ exceeds $\gamma m/2\beta$ then the firm should set $a_\nu^* = m/2$. In these latter two ranges, the solution involves all type t viewers watching the type t program. The existence of these ranges requires that $\underline{\xi}$ be significantly bigger than 0.