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SPILLING OVER AND CROWDING OUT: THE EFFECTS OF PUBLIC SECTOR/PRIVATE SECTOR CONVERGENCE AND COMPETITION, IN THE PROVISION OF PUBLIC GOODS

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Abstract

This paper develops an original model of product differentiation, to contribute to the debate about the regulation and finance of public television. It goes beyond the conventional analysis in this topic, by showing the spill-over effects that a public broadcaster can have upon commercial broadcasters. It shows how the existence of a publicly-financed, free-to-air channel (such as the BBC) can affect the behaviour of advertiser-financed, free-to-air channels (such as the ITV). In particular, it shows what happens if the output of the public channel converges with that offered by private firms, so that it becomes less distinctive; and or it introduces advertising.

These are timely issues, given the extent to which public broadcasters are increasingly criticised for seeking popularity, losing distinctiveness, and in many cases, introducing advertising. These tensions are being felt in the television sectors of virtually every country of the world. To illustrate these and other questions of this nature, we develop a model that clarifies the interplay of the key issues. Moreover, the model has wider parallels to other sectors where services are also offered free at the point of access, but financed by advertising. The most obvious example is the internet.

The following pages therefore develop an original model of product differentiation in two dimensions, following the tradition of Hotelling and Cournot competition. The horizontal product attribute is programme quality or type, and the vertical attribute is level of advertising. Broadcasters compete for viewers by altering their levels of advertising. The second novelty of this model is its pricing scheme, which captures the unusual nature of television advertising markets. Channels sell quantities of airtime to advertisers, the unit price of which is determined by the number of viewers. Relative demand therefore plays the role of price in a Cournot model, except there can be different prices for different channels.We use this model to show that there is a trade-off to be made between distinctiveness and advertising. These trade-offs are not always intuitive. Under the assumptions given, we show that if constraining total television advertising is the social planner's greatest priority, it is best if the public broadcaster has programmes that are identical to commercial broadcasters, but without any advertising. This leads to duplication of programme types, but minimum advertising. However if distinctiveness is the top priority, then we must grasp the uncomfortable conclusion that this brings with it higher levels of advertising on the commercial channels. The worst case occurs when the public broadcaster aims to maximise audience numbers and or advertising revenue: this leads to minimum programme distinctiveness *and* high levels of advertising.

JEL Classification: H, L.

Keywords: spatial competition, product differentiation, television, advertising.

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1. INTRODUCTION[1]:

The most convincing arguments today for publicly financed television are that it provides types of programmes that commercial television would not provide, and/or that it is free of interruptions by advertising. However this traditional gap-filling rational has been wearing increasingly thin, as programmes seem to be more or less the same whatever channel one watches, and as public channels increasingly either sell advertising directly, or devote large amounts of air-time to self-advertising[2]. Public broadcasters do not seem to be especially distinctive, and they seem to be competing with, rather than complementing, commercial broadcasters. The effect is one of convergence, where it is difficult to see real differences between the output of public compared to private broadcasters. Perhaps because of this, there is growing support for abandoning many of the traditions of publicly financed television. Many countries are experimenting with new forms of finance and delivery of public service television, including the establishment of partially competitive quasi-markets, or though increasing use of commercial sources of finance. In the United Kingdom, for example, consumer surveys consistently find about 60% of respondents in favour of financing the BBC through the sale of adverts, rather than the 75-year-old Public Broadcasting Fee[3]. Our question here is, to what extent does this matter?

The importance of gap-filling arguments notwithstanding, this paper aims to add some fresh insights to the debate about television regulation, by focusing instead on the spill-over effects of public broadcasters. We go beyond the usual analysis, to explicitly examine their impact on the behaviour of commercial broadcasters. For example, the existence of a publicly-financed broadcaster may affect the amount of advertising transmitted on commercial television. More subtle effects depend on how distinctively different is the public broadcaster's programme profile, or whether it also sells advertising. As public broadcasters do this, the nature of their output increasingly converges with that offered by commercial broadcasters. We show some of the implications of this. For example, we show that introducing even a small amount of advertising onto the public broadcaster, encourages both less distinctiveness and an escalation of advertising in general. These wider effects give an added rationale for the public broadcaster to complement, rather than to compete against, commercial broadcasters. Given this context, this paper examines the following questions:

i) How does the existence of a publicly funded, free-to-air, channel (such as the BBC) affect the behaviour of advertiser-financed, free-to-air, channels.
ii) What happens if the public channel becomes less distinctive.
iii) What happens if it introduces advertising.
iv) The trade-off between distinctiveness and advertising.

[1] This paper represents part of my PhD research. It has benefited immensely from the encouragement and advice of Professors A.B. Atkinson, Nuffield College, Oxford, and A. Shaked, University of Bonn; and from helpful comments made by M. Thum and others at the CESifo summer workshop on Industrial Organisation, Venice International University, July 20-21, 2001. Any errors remain, of course, my own.

[2] Empirical surveys of this include Blumler (1991), Ishikawa et al (1996), Hillve et al (1997), and Barrowclough (2001).

[3] 'Attitude survey on behalf of BBC Funding Review', April 1999, MORI, UK.

These are timely issues, given the extent to which public broadcasters are increasingly criticised for seeking popularity, losing distinctiveness, and in many cases, introducing advertising. To illustrate these and other questions of this nature, we develop a general and abstract model of product differentiation in two dimensions, following the tradition of Hotelling and Cournot competition. The horizontal product attribute is programme quality or type, and the vertical attribute is level of advertising. Broadcasters compete for viewers by altering their levels of advertising. The second novelty of this model is its pricing scheme, which captures the unusual nature of television advertising markets. Channels sell quantities of airtime to advertisers, the unit price of which is determined by the number of viewers. Relative demand therefore plays the role of price in a Cournot model, except there can be different prices for different channels. (Fuller depiction of the institutional background of this model, with empirical evidence from New Zealand and the United Kingdom, can be found in Barrowclough (1998, 2001).)

We use this model to show that there is a trade-off to be made between distinctiveness and advertising. These trade-offs are not always intuitive. Under the assumptions given, we show that if constraining total advertising is the social planner's greatest priority, it is best if the public broadcaster has programmes that are identical to commercial broadcasters, but without any advertising. This leads to duplication of programme types, but minimum advertising. However if distinctiveness is the top priority, then we must grasp the uncomfortable conclusion that this brings with it higher levels of advertising on the commercial channels. The worst case occurs when the public broadcaster aims to maximise audience numbers and or advertising revenue: this leads to minimum programme distinctiveness *and* high levels of advertising.

2. THE INTUITION.

We begin with a very simple model, which is later expanded. Assume there are two commercial broadcasters, Medium (M) and Low (L), delivering two different types of programmes (medium-brow and low-brow). Their programme type is given, so that M cannot show low-brow programmes, and vice-versa. (The intuition is that programme type is determined by an external regulator, as for example, the United Kingdom's Independent Television Commission). Alongside the programmes, each broadcaster can also deliver advertising. The level of advertising can range from 0 (no advertising) to 1 (a lot of advertising). Advertising is a source of dis-utility to viewers, so that for any programme type everyone prefers less advertising to more.[4]

a) Defining preferences.

[4]The intuition is that of positively-sloped indifference curves, with programme quality or type on the vertical axis, and quantities of advertising on the horizontal axis. Quality must rise as advertising rises, in order to maintain constant utility.

Consumers have preferences over programme type. We measure these preferences in terms of the amount of advertising they must absorb on a favoured programme, until the point where they become indifferent between it and the less favoured programme. The intuition is this: if one loves Medium and hates Low programmes, then utility is only equalised between the two when Medium comes with relatively high amounts of advertising, or Low comes with relatively little or none.

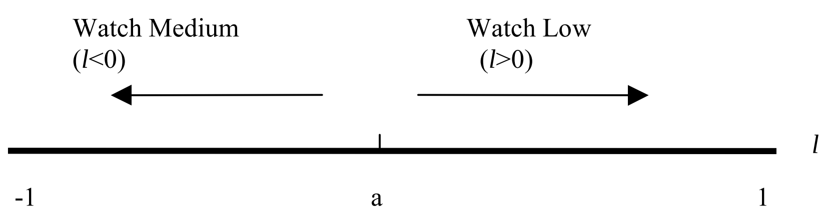
Different individuals have different preferences. Therefore, let the number l describe an individual's marginal rate of substitution between Low and Medium. For each level of advertising a on Medium, utility is equalised where:

$$U(M, a) = U(L, a + l)$$

Where $U(X, y)$ is the utility that the consumer receives from consuming X-type programmes, with advertising of the amount y.

We assume that the distribution of values for l is uniform, along a continuum bound by $-1 \leq l \leq 1$. Non-viewing is not an option. Everyone must watch television, their only question is which programme to watch. As shown in Figure 1, all individuals whose value for l is positive ($l>0$), given a, prefer to watch Low. Those individuals with strongly positive values are located at the far end of the continuum, while those with weakly positive values are located closer to a. By comparison, everyone with a negative value for l given a, ($l<0$) prefers to watch Medium. (One can imagine a population of 1 in each half, and 2 in total).

Figure 1: Distribution of preferences between Medium and Low, where $-1 \leq l \leq 1$.



b) The effect of advertising.

We now extend this to show the interplay that occurs as broadcasters vary their level of advertising. Let Low sell an amount of advertising denoted by λ, and let Medium sell an amount of advertising given by μ. Viewers will choose between channels according to their inherent preference for programme type, mediated by the relative amounts of advertising on each channel. For example, if Low has much more advertising than Medium, individuals who would normally have preferred Low-type programmes may find the dis-utility caused by its advertising sufficient to make them switch to watch

Medium instead. The more advertising shown on Low relative to Medium, the greater the number of viewers attracted to Medium, and vice-versa.

Consumer demand for each of the two channels (M,μ), (L,λ) is determined as shown in Figure 2, which is drawn for the case where Low has more advertising than Medium, so $\lambda > \mu$. As shown in Figure 2, all the individuals located to the right of the point given where $l = \lambda - \mu$, watch Low; those located to its left will watch Medium. The demand for Low, D_L, comprises the individuals whose preference values are located along the length of the distribution given by $1-\lambda+\mu$, indicated by the solid arrow. The demand for Medium, D_M, is given by those located along the length given by $1+\lambda-\mu$, indicated by the dashed arrow. As Low increased its amount of advertising relative to Medium (Figure 2), this moved the pivotal position rightwards, increasing the number of Medium's viewers. If Low then reduced its advertising (Fig. 3), this would move the pivot point leftwards, regaining Low some viewers.

Figure 2: Distribution of viewers given advertising levels λ and μ.

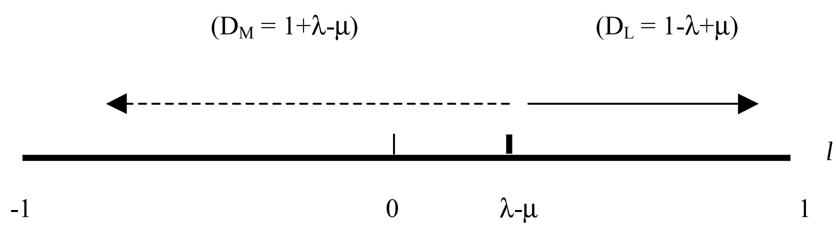
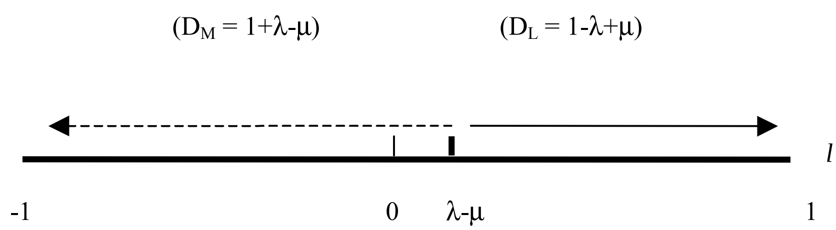


Figure 3: Distribution of viewers as Low decreases its advertising relative to Medium.



c) Broadcaster revenue.

Having determined consumer demand for each channel, we can now calculate broadcaster revenue. The only source of revenue is advertisers, given that television is provided to viewers "free-to-air." Each broadcaster's total advertising revenue is found by multiplying the amount of advertising sold to advertisers by its price, as usual. However a special feature of this model is that the price of each unit of advertising sold is determined by the size of the audience for a particular channel, relative to the total audience. This is a realistic assumption, as television advertisers hope to achieve access to as many consumers as possible and will pay higher prices for access to larger audiences.[5] Each channel's revenue curve is therefore the amount of advertising sold, times its demand.

The broadcaster must therefore calculate the optimal amount and price of advertising in order to maximise revenues, remembering that it loses viewers (and hence unit price of advertising falls) the more its advertising exceeds that sold by the other broadcaster. We assume that each broadcaster takes the other's level of advertising as given, and seeks to find its optimal response. Hence we have a version of the Cournot model of competition, where broadcasters compete in terms of the amount of airtime devoted to advertising. (Clearly we are making the simplifying assumption that costs are the same for each channel.)

The revenue function for Low is therefore D_L times its quantity of advertising: $R_L = (1-\lambda + \mu)\lambda$. Deriving this with respect to λ we obtain:

$$\delta R_L/\delta\lambda = 1 + \mu - 2\lambda = 0$$

So that Low's optimal level of λ, for any μ chosen by Medium is:

$$\lambda^* = (1 + \mu)/2.$$

Medium's best responses are obtained in the same way. Medium's revenue is given by: $R_M = (1 + \lambda - \mu)\mu$. Deriving this with respect to μ, we obtain:

$$\delta R_M/\delta\mu = 1 + \lambda - 2\mu = 0$$

So that Medium's optimal level of advertising for any level chosen by Low, is where:

$$\mu^* = (1 + \lambda)/2$$

These two "best responses" are plotted on the graph below, as in the familiar presentation of Cournot-type models, with which this shares some similarities. The horizontal axis measures Low's levels of advertising λ, ranging from 0 to 1, and the vertical axis shows values for Medium's μ, also from 0 to 1. The upper curve depicts Medium's best responses to Low's choices of any λ, while the lower curve shows Low's best responses to Medium's choices of μ. (When Medium chooses $\mu = 0$, Low's best response is to set $\lambda = ½$, etc. Tables 5a and b show simulated values for Medium's

[5] This does not occur to the same extent in the print media, where marginal costs increase and advertisers are more selective about their target audiences. In addition, there is an implicit assumption here that advertisers' demand to buy airtime is perfectly elastic, as they will buy all the airtime offered, at the going rate. This is justified by observation within current ranges, and is reinforced by the fact that most countries have found it necessary to impose strict upper limits to levels of television advertising, because of unfulfilled demand at the prevailing prices.

responses to Low's chosen advertising level λ, and Low's responses to Medium's chosen μ).

Figure 4: Best responses for Medium and Low.

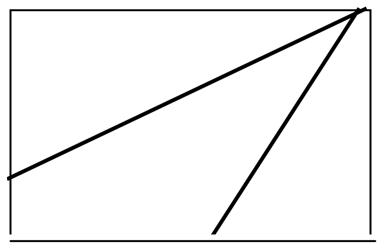


Table 5a: Optimal responses by Medium to Low's given advertising level.

Low's given λ	Medium's optimal μ	Revenue Medium	Total Adverts
0	0.5	0.25	0.50
0.1	0.55	0.30	0.65
0.2	0.6	0.36	0.80
0.3	0.65	0.42	0.95
0.4	0.7	0.49	1.10
0.5	0.75	0.56	1.25
0.6	0.8	0.64	1.40
0.7	0.85	0.72	1.55
0.8	0.9	0.81	1.63
0.9	0.95	0.90	1.85
1.0	1.0	1.0	2.00

Table 5b: Optimal responses by Low to Medium's given advertising level.

Medium's given μ	Low's optimal λ	Revenue Low	Total adverts
0	0.5	0.25	0.50
0.1	0.55	0.30	0.65
0.2	0.6	0.36	0.80
0.3	0.65	0.42	0.95
0.4	0.7	0.49	1.10
0.5	0.75	0.56	1.25
0.6	0.8	0.64	1.40
0.7	0.85	0.72	1.55
0.8	0.9	0.81	1.63
0.9	0.95	0.90	1.85
1.0	1.0	1.0	2.00

In this example, the equilibrium response for both broadcasters occurs where $\mu^*=\lambda^*=1$. Advertising levels are equal, the market is evenly shared, and revenues are maximised. This is not entirely surprising, given the assumptions of uniformly distributed programme preferences, no non-viewers, and only two broadcasters. However it does give a flavour of the problem at hand. Broadcasters must find the level and price of advertising that maximises their revenues, remembering that as advertising levels increase relative to their competitors, viewer numbers fall, causing prices to fall.

The interesting part is what happens next, when we allow the entry of a third broadcaster, called Duplicate, with the same programme profile as Medium's. The intuition here is that we wish to show what happens if a public broadcaster offers a profile that is close to, or even identical, to that offered by another broadcaster. As described above, there is evidence that this is currently occurring in practice, but its effects have not previously been examined in this way.

d) Entry by a Duplicate broadcaster.

If Duplicate enters the market with a programme identical to Medium's, Medium has an extremely limited range of responses. Clearly Medium can never have any more adverts than does Duplicate, because if it did it would lose all its viewers. Why would anyone watch a programme with dis-utility causing advertisements on it, if an identical one is offered elsewhere without them? If Duplicate has zero advertising, so too must Medium. Or if Duplicate has some positive level of advertising, Medium can only match it. Should Medium undercut its level of adverts to somewhere just below Duplicate's, then Duplicate can respond by cutting its level again, and so on. Also, there are further ripple effects, because whenever Medium reduces its levels of advertising, then so too must Low, because otherwise it would lose viewers, in this case to both Medium and Duplicate.

Table 6 below shows how Medium and then Low respond, when Duplicate offers a programme that is identical to Medium, with advertising of the amount given by η. We make no assumption about the motivations of Duplicate: it can choose any level of advertising. The intuition is that it is as if some external regulator decides how much advertising Duplicate is "allowed" to have, as typically occurs in the regulation of television. The point is, that whatever level of ads shown on Duplicate, Medium is best off by responding with exactly the same amount. Low then chooses its optimal level λ, according to Medium's "forced" choice of μ. For example, if Duplicate sets $\eta = 0.5$, μ^* will be 0.5, and Low sets $\lambda^* = (1+ \mu)/2 = 0.75$. There is no change to the revenue for Low previously associated with that level of advertising, but Medium gets only half the revenue it previously earned, at those levels. Also, both broadcasters (Low and Medium) have been forced to accept revenues that are lower than their previously optimal choices, when $\lambda=\mu=1$. If, on the other hand, Duplicate chooses $\eta=1$, then

Medium and Low can still retain their optimal levels λ=μ=1, but Medium must share revenues with Duplicate[6].

The effects of all this on viewers is mixed. In the two broadcaster case, we had an equilibrium with two different programme profiles, delivered with a lot of advertising. In the three broadcaster case, we still have only two different programme choices (two identical channels, plus one different one), but potentially with a large increase in advertising. The only case in which the entry of Duplicate caused total advertising to fall was when it chose levels of advertising that were lower than any of the levels previously chosen, in the two firm case, by Medium or Low (for the range $0<\eta<0.5$.) This is seen by comparing the last colums of tables 5a, 5b and 6. In all other cases, total advertising increased.

Table 6: Advertising, demand and revenues when Duplicate is identical to Medium.

η	μ	λ	Demand Duplicate	Demand Medium	Demand Low	Rev. Duplicate	Rev. Medium	Rev. Low	Total adverts
0.00	0.00	0.50	0.75	0.75	0.50	0.00	0.00	0.25	0.50
0.10	0.10	0.55	0.73	0.73	0.55	0.07	0.07	0.30	0.75
0.20	0.20	0.60	0.70	0.70	0.60	0.14	0.14	0.36	1.00
0.30	0.30	0.65	0.68	0.68	0.65	0.20	0.20	0.42	1.25
0.40	0.40	0.70	0.65	0.65	0.70	0.26	0.26	0.49	1.50
0.50	0.50	0.75	0.63	0.63	0.75	0.31	0.31	0.56	1.75
0.55	0.55	0.78	0.61	0.61	0.78	0.34	0.34	0.60	1.88
0.70	0.70	0.85	0.58	0.58	0.85	0.40	0.40	0.72	2.25
0.80	0.80	0.90	0.55	0.55	0.90	0.44	0.44	0.81	2.50
0.90	0.90	0.95	0.53	0.53	0.95	0.47	0.47	0.90	2.75
1.00	1.00	1.00	0.50	0.50	1.00	0.50	0.50	1.00	3.00

This simple model introduces the intuition behind the way that broadcasters use the control variable of the level of advertising, to determine respective audience size and revenue. We assumed that each broadcaster's programme type was given, and began by letting two broadcasters find their "best response" to each other's given level of advertising, in the tradition of Cournot competition. We then showed what happens when another broadcaster enters, offering a duplicate, rather than diverse, profile: this feature is now expanded considerably below.

3. THE GENERAL MODEL.

Assume there are three television channels, delivering three types of programmes, denoted by *H*, *M*, and *L*. (High-brow programmes, middle-brow and low-brow). As before, alongside the programmes, each channel can also deliver advertising *a,* where we

[6] There is no single equilibrium as in the previous example: here the number of equilibria equals the number of different advertising levels available to Duplicate.

assume $0 \leq a \leq 1$. Advertising is a source of dis-utility to viewers, so that for any programme type everyone prefers less advertising to more.

3.1 Defining preferences:

As before, consumers have different preferences over each program type, and we measure these preferences in terms of the amount of advertising they must absorb on a favoured programme, until the point where they become indifferent between it and a less favoured one.

Therefore, let the numbers h,l describe the preferences of a single consumer, where l describes their marginal rate of substitution between Low and Medium, as in the example above, and h now indicates their marginal rate of substitution between High and Medium. Thus for each level of advertising a on Medium, utility is equalised where:

$$\mathrm{U}\,(M, a) = \mathrm{U}\,(L, a + l)$$

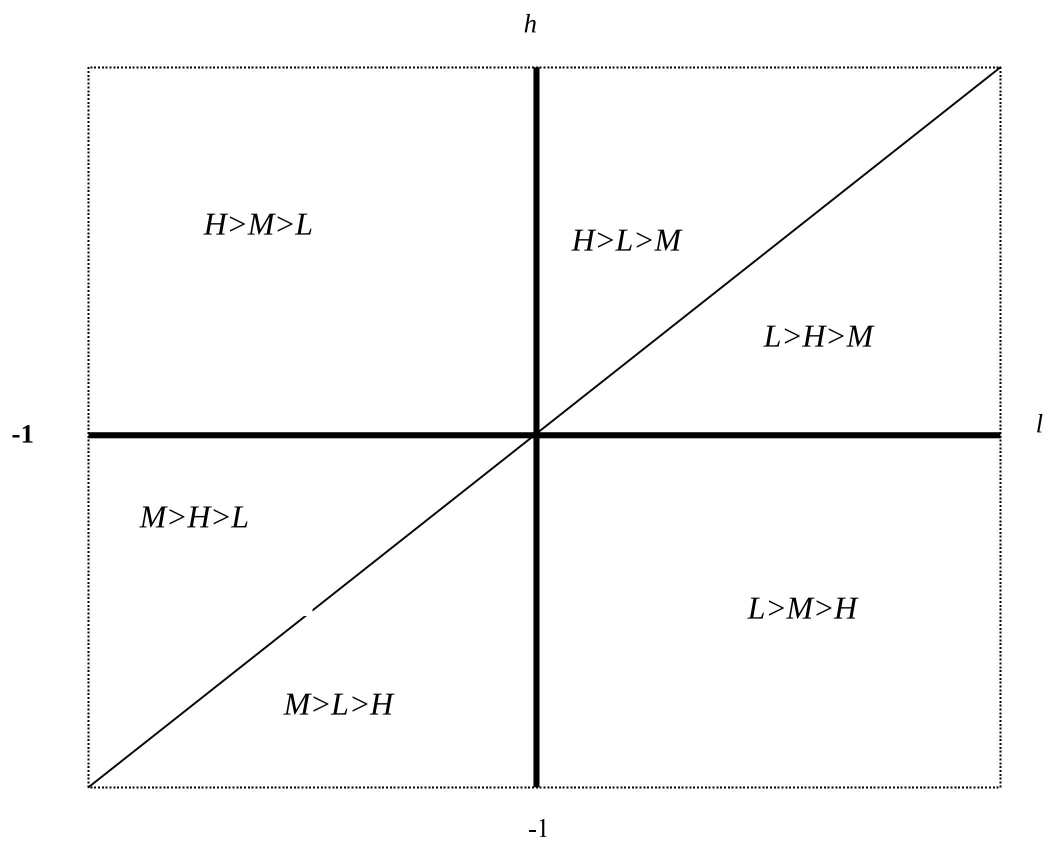
$$\mathrm{U}\,(M, a) = \mathrm{U}\,(H, a + h)$$

Where U (X, y) is the utility that the consumer receives from consuming X-type programmes, with advertising of the amount y. In addition, we assume the limits $-1 \leq l \leq 1$; $-1 \leq h \leq 1$.

These values for h and l are then distributed in the plane shown in Figure 7 below, with l on the horizontal axis and h on the vertical (here drawn as if no broadcaster had any advertising). All individuals with taste values $l > 0 > h$ are located in the south-east quarter. They prefer Low to Middle ($l > 0$), and would hence be willing to bear positive amounts of advertisements on Low, before utility was equalised with Middle. Similarly, since $0 > h$, they prefer Middle to High, meaning they would be willing to bear positive amounts of advertisements on Middle, to make utility equal with High.

Any individual located in the north-west quarter has the preference ranking $H>M>L$, meaning that $l<0$ and $h>0$. In the north-east quarter, both l,h are positive, meaning that both H and L are preferred to M. Splitting the quarter diagonally distinguishes the ranking $H>L>M$ from $L>H>M$. A similar diagonal split in the south-west quarter, where both l,h are negative, separates consumers for whom L was the worst option from those for whom H was worst. Both types preferred M best.

Figure 7: Preferences for High, Medium and Low, with zero advertising.



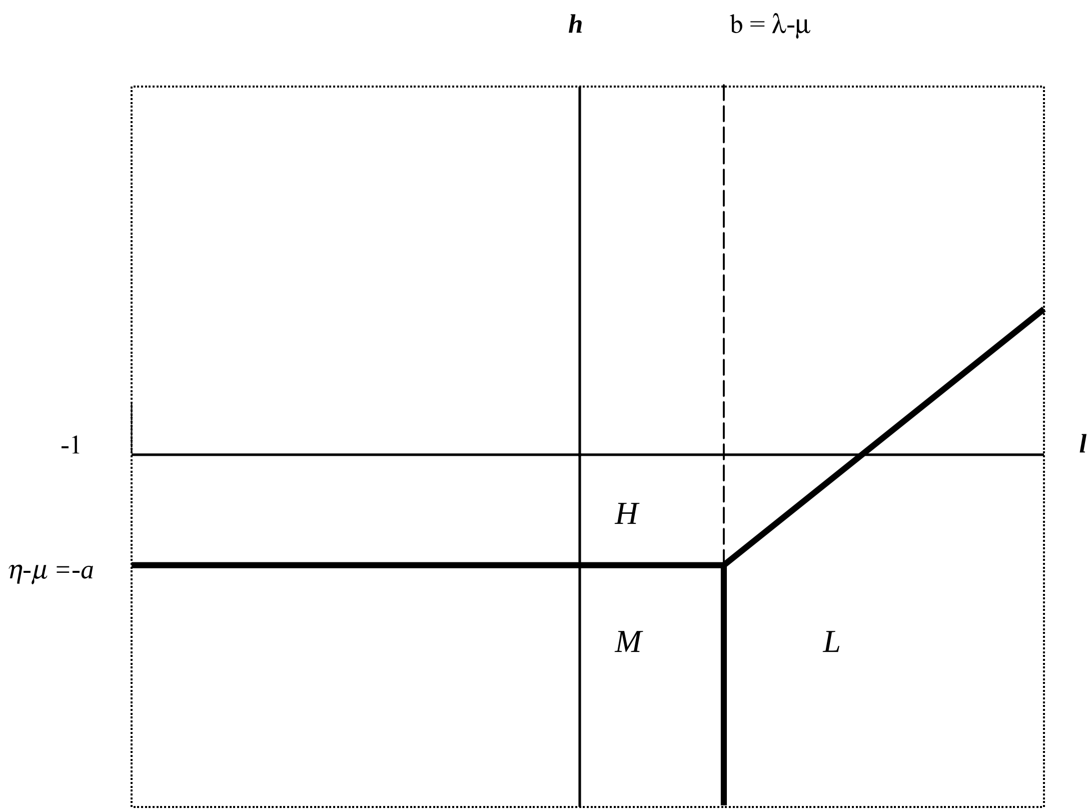
3.2 The effect of advertising.

We now extend Figure 7, to show consumer demand when there is advertising. Our three channels and their respective advertising levels are denoted as (H, η), (M, μ), and (L, λ). Because we are interested in relative advertising, we also define two variables: a = μ - η, the difference in advertising between High and Medium; and b = λ - μ, the difference between Low and Medium's levels of advertising.

The plane above must now be re-drawn to show individuals' values h,l given the advertising levels η, μ, λ, or their relative values given by a and b. Figure 8 shows an example where advertising was greatest on Low, and least on High, so that $\lambda > \mu > \eta$. All individuals with $l >$ b will prefer (L,b) to (M, μ). All individuals with values of $l > h + \lambda - \mu$ prefer (L,b) to (H, η), and so on.

These individual preferences are aggregated to form the demand for each channel. The plane divides geometrically into three audiences, the size of each reflecting the distribution of individuals' initial preferences for each programme type, mediated by their sensitivities to the amounts of advertising. Comparing Figure 8 with Figure 7 shows that, given the levels of advertising depicted, High gains some viewers that previously preferred Medium and Low; while Medium gains some viewers who previously preferred Low. (Because Low increased its level of advertising λ relative to Medium's μ, the dark vertical dividing line moved rightwards, taking with it the little triangle, and giving new viewers to both High and Medium. Similarly, as Medium increased its level of advertising μ relative to High's chosen η, this moved the dark horizontal line downwards (without altering the starting point of the little triangle, on *h* = 0), giving new viewers to High. Further increases by Low relative to Medium would move the line given by b further rightwards: a decrease in advertising by Medium relative to High would move the line given by a upwards, and so on.)

Figure 8: Demand for High, Medium and Low, given η, μ and λ.



3.3 Assumptions about the distribution of values *h,l.*

A number of simplifying assumptions are made about the distribution of taste values, to enable sufficient abstraction to isolate television's key features in a useful way.

i) We assume that individuals are uniformly distributed within the plane. An alternative assumption could have been that taste values were bunched or skewed, perhaps reflecting age or income. However it is not appropriate to make such precise assumptions about peoples' tastes, given the abstract nature of this model.[7]

ii) Non-viewing is not an option. This is a hugely simplifying assumption, as in reality each individual will have some value of *h*,*l* below which they refuse to consume the television offered, but prefer instead any other activity (including sleeping). Determining the effects of these various "exit" levels would be a fruitful avenue for future research, but the "all view" assumption is sufficient for this general and abstract model.

iii) We shall assume that the relative quantities of advertising always preserve the ranking shown in Figure 8 above, where $\lambda > \mu > \eta$. This is a fair approximation of what we usually see in television markets; and it is also a useful simplification for the remainder of the analysis, where we determine channel demands and revenues on the basis of geometry. Any substantial re-structuring of the plane would require re-drawing and re-estimating the demand areas, with little additional insights to be gained. Hence we assume a > 0, and b > 0.

iv) The next assumption focuses our attention on the southern half of the plane. We restrict the domain of consumer preferences, to the lower rectangle of the plane given by the dimensions $-1 \le l \le 1$, $-1 \le h \le 0$; rather than its entire square $-1 \le l \le 1$, $-1 \le h \le 1$. This is equivalent to saying there are very few people with the preference orderings *H*>*M*>*L*; *H*>*L*>*M* ; or *L*>*H*>*M*. Tastes are still distributed uniformly but only within the bottom half of the plane in Figure 7. (Total density therefore is 2, ie. 1+1 in each square).

This makes the analysis more tractable, without being too violent to reality. It is more plausible to remove the top rather than the bottom half of the plane, as observation suggests that fewer people prefer High to Low than vice-versa.[8] Moreover, of those people who do rank Low as their first preference presumably more prefer the orderly ranking *L*>*M*>*H*, (south-east) than the perverse ranking *L*>*H*>*M* (north-east-east).

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[7] This should however be an interesting avenue for future investigation, for example, in the incidence of welfare effects on different social or income groups.

[8] As a digression, one must ask whether High can still mean "Highbrow", if everyone preferred it. For less emotive labels, Low can be defined as "lowest-common-denominator," rather than lowbrow.

Finally, this simplification reflects the fact most of the "action" in the model below concerns responses made by Medium and Low, with respect to strategies chosen by High. Hence we wish to concentrate on the bottom half of the plane. This has the flavour of realism to the extent that one believes the BBC to be loosely like High, the ITV loosely like Medium, and neither like Low. (And one need not fear that focusing on the southern half of the plane undermines High's strategic arsenal, given the powers allowed to High in the final assumption below.)

v) The final assumption concerns the nature of the programmes offered on High, and the subsequent vertical distribution of preference values h. The intuition is as follows. Imagine that Medium and Low are not allowed to change their programme type, or their intrinsic nature (for example, reflecting the strict regulatory environment in which the ITV channels operate in the UK). High however has some flexibility, in the limited sense that it can become more, or less, like Medium. (It cannot become like Low.) The degree of High's similarity to Medium will be measured by a "distinctiveness parameter", α, which has the range $0 \leq \alpha \leq 1$. Where $\alpha = 0$, High's programme is identical to Medium, as in the Duplicate example that opened this chapter. Where $\alpha = 1$, High is distinctively different. Through the use of this distinctiveness parameter, the model thereby illustrates the implications of changing levels of distinctiveness and advertising.

High's ability to alter its nature is connected to assumption (iv) above as follows. As High becomes more similar in nature to Medium, everyone's values for h's become smaller, becoming increasingly concentrated around $h = 0$. At the limit when the two channels are identical ($\alpha = 0$), all the values for h converge to 0. The intuition is clear: why would anyone still have an extreme preference value for h, when there is virtually no difference between the two programmes? Who would endure large amounts of advertising on Medium, when High offers exactly the same programme but without the intrusive adverts? To be precise[9], the new distribution is assumed to be homogeneous between $[0 - \alpha]$ where $0 \leq \alpha \leq 1$, and with the density $1/\alpha$.

As a result of these assumptions, it also follows that $a < \alpha$. If this was not so (for example, if Medium and High profiles were very similar, but Medium had much more advertising) Medium would have no viewers, for the reasons outlined

[9] One can imagine the base of the southern rectangle squashing upwards towards the horizontal axis. The number of individuals has not changed, and they can still have the same broad (horizontal) range of values for l as before. However, rather than being spread within the full depth of the rectangle they are now squashed into a narrower ribbon, that runs along the length of the l axis. The depth of this ribbon depends on the value of α, becoming narrower and narrower as α becomes closer to 0. It runs horizontally along l but vertically becomes increasingly close towards $h = 0$. When $\alpha = 1$ the "ribbon" expands back to the full depth of the original rectangle. (A rough example would be the way that fluid rises up the sides of a container, when a constant volume of water is transferred from a wide container into a narrower one.)

above. It is reasonable to assume that Medium would not choose a level of advertising that produced this situation.

3.4 From preferences to demand.

Once we know everyone's intrinsic preferences for programme types and their sensitivity to advertisements, we can establish the demands for each channel. This can be calculated geometrically using the plane of taste values, remembering that assumptions iv) and v) above mean we now have a distribution of audiences for H,M, and L lying within a box that is 2 units wide, and α units high. Consumer demand for each of the three channels, (H,η), (M,μ), (L,λ), given their relative levels of advertising (described by a = μ - η, and b = λ - μ) is derived from the areas shown in Figure 8:

$$D_H = \frac{1}{\alpha}\left[(1+b)a + \frac{a^2}{2}\right]$$

$$D_M = (1+b) - \frac{(1+b)a}{\alpha}$$

$$D_L = (1-b) - \frac{a^2}{2\alpha}$$

The intuition for finding these areas is as follows. The depth of the bottom half of the plane is given by α, and the density of the distribution within the plane by 1/α. Therefore demand for Low, D_L, consists of all those pairs of values (h,l) found in the rectangle with width (on the l axis) of 1-b and depth of 1 (depth α times density 1/α). It contains 1-b viewers minus those located in the little left-hand corner triangle, $a^2/2\alpha$. Similar geometrical methods are used for the other two audiences[10].

3.5 From demand to revenues.

Each broadcaster's total advertising revenue is found by multiplying the amount of advertising sold by its price. As shown in the introductory model at the start of this chapter, the price of each unit of advertising sold is determined by audience size for a particular channel, relative to the total audience.

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[10] Here the demand for Medium has been found by subtracting High's rectangular demand [(1+b)a]/α from the square [1/α.(1+b).α]. One could just as easily have found the area for Medium by multiplying the length (1+b) by height (α -a), over the density 1/α.

$$R_H = \frac{\eta}{\alpha}\left[(1+b)a + \frac{a^2}{2}\right]$$

$$R_M = \mu\left[(1+b) - \frac{(1+b)a}{\alpha}\right]$$

$$R_L = \lambda\left[(1-b) - \frac{a^2}{2\alpha}\right]$$

First-order conditions for each broadcaster with respect to their level of advertising are[11]:

$$D_H = \frac{\eta}{\alpha}[1+a+b]$$

$$D_M = \mu\left[1+\frac{1}{\alpha}+\frac{b-a}{\alpha}\right]$$

$$D_L = \lambda$$

Given these revenue and first order conditions, the following pages use simulations to show the optimal responses of broadcasters, and their implications, to various choices made by High.

4. THE MODEL IN PRACTICE.

[11] Second order conditions for local maxima are also satisfied. For Low, we find that $\delta^2 R_L/\delta\lambda^2 = -2$, which is clearly negative. For Medium we find that α. $\delta^2 R_M/\delta\mu^2 = -2(\alpha+\eta+1+\lambda) + 6\mu$. Over the relevant range of values, we satisfy the condition that $\delta^2 R_M/\delta\mu^2 < 0$. (See Appendix A for results using simulated values.)

4.1 Partial competition.

In this case, we assume that High moves first, setting its degree of distinctiveness α and level of advertising η. We do not assume any particular motivation on the part of High, but show the effects of a range of values. The intuition is that it is obeying an exogenous regulator, and the point of the analysis is to show how Medium and Low respond, taking High's moves and each other's responses as given, as they seek their revenue-maximising levels of advertising μ and λ given High's first move.

Using the Maple mathematical programme, we find solutions for λ and μ, given High's choice of α and η, which satisfy the first order conditions for Medium and Low. (Maple finds a and b, from which one calculates λ and μ, and then revenue and so on. The results obtained are shown in Tables 9 and 10 below. (For solutions see Appendix B).

Medium. $$(1+b)\left(1-\frac{a}{\alpha}\right)=(a+\eta)\left(1+\frac{1}{\alpha}+\frac{b-a}{\alpha}\right)$$

Low. $$1-\frac{a^2}{2\alpha}=a+2b+\eta$$

$$a=\mu-\eta$$

$$b=\lambda-\mu$$

Where: a > 0, b> 0.

4.2 Intuition behind the results: comparative static examples.

The intuition behind the results obtained can be seen in the three comparative static examples shown below. Three extreme scenarios are described:

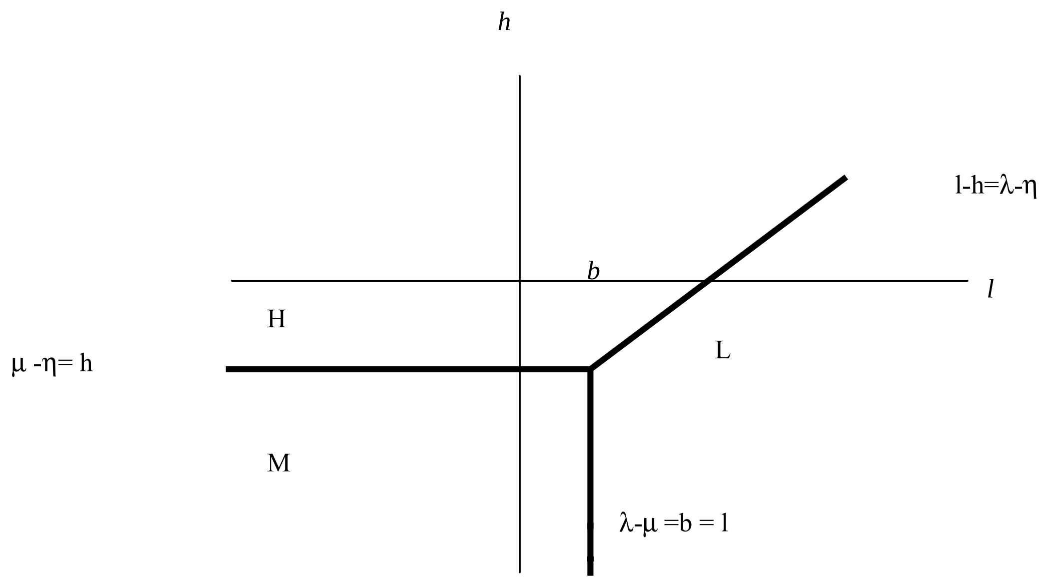
(i) High offers a programme that is extremely different from Medium, with zero advertising.

(ii) High continues to have no advertising, but now offers a programme that is increasingly similar to Medium's.

(iii) High offers a programme that is extremely different from Medium, but now has advertising.

Scenario one:

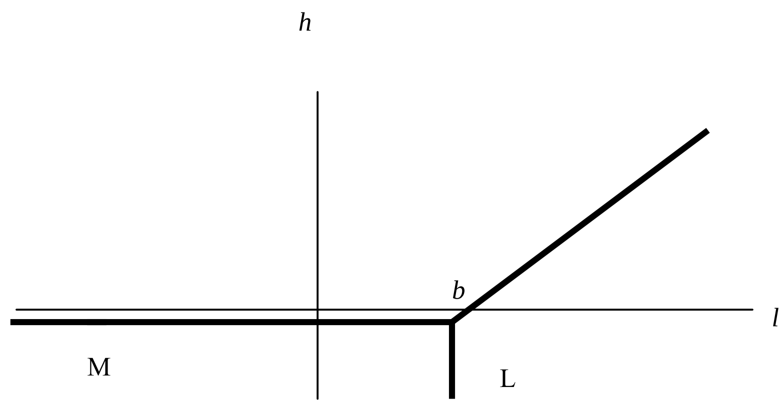
High is totally different from Medium, so $\alpha = 1$. There is no advertising on High, so that $\eta = 0$. The optimal responses found by Maple are for Medium to have advertising levels of $\mu = 0.40$ and Low to have $\lambda = 0.66$. Medium has the biggest audience (0.75), and earns total revenue of 0.30; Low's audience is smaller (0.66), but because it has a lot of advertising it earns more revenue (0.44). High has the smallest audience (0.59) and earns no advertising revenue.



Where: $\alpha = 1$, $\eta=0$, $\mu = 0.4$, $\lambda=0.66$, a = 0.4, b = 0.26, H = 0.59, M = 0.75, L = 0.66.

Scenario two:

We now let High become less distinctive, to the extent that it's programme profile is almost the same as Medium, $\alpha = 0.1$. The distribution has therefore become sharply squeezed into the smaller space given by the southern quadrant's shortened depth: all the *h* values are closely located to $h = 0$, although they continue to stretch along the continuum of *l* values. (We show this by shortening the vertical axis in the diagram). High still has no advertising, so $\eta = 0$. Now the optimal responses for Medium and Low are to reduce their amount of advertising: dramatically so in the case of Medium, and slightly so in the case of Low.



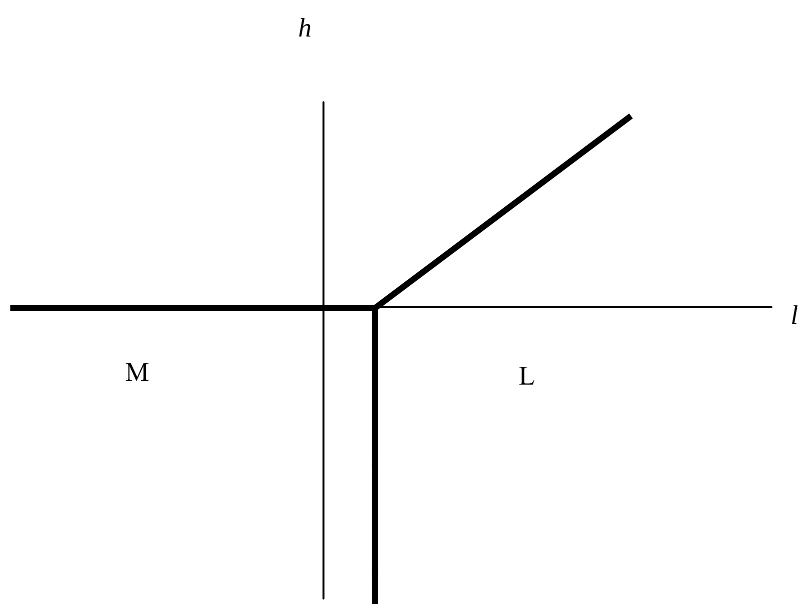
Where: α = 0.1,η = 0, μ = 0.05, λ = 0.52, a = 0.05, b = 0.47, H = 0.73, M = 0.75, L = 0.52.

This is intuitively obvious, but it is nonetheless gratifying to find it exhibited so clearly in the model. Medium's former viewers are no longer prepared to endure the same higher levels of advertising as before, given that High's programme is now so like Medium, and moreover has the advantage of coming without advertisements. And as Medium drops its advertising, in order to stop its viewers fleeing to High, so too must Low, in order to stop marginal viewers fleeing from Low into Medium. Therefore Medium reduces its advertising almost to zero (μ = 0.05) while Low reduces its advertising less dramatically, to λ = 0.52, thereby preserving audiences of 0.75 and 0.52 respectively. Despite their protective moves, High still manages to increase its share of viewers. Low is not affected to the same extent as Medium, who has High breathing down its neck, but it still experiences a decline in viewer numbers and revenue (from 0.44 to 0.27.) Medium's audience has not changed so much, given that its very small amount of advertising has stemmed the flow of viewers into High. However this small quantity of advertising, despite its high price, brings a much smaller revenue (0.04). (One must wonder whether, in reality, Medium could afford to stay in the market in such a situation.)

<u>Scenario three</u>:

High is once again as different from Medium as possible, with α = 1. Assume it is "allowed" advertising, to the level η = 0.55. Under these parameters, High's share of viewers falls sharply, reflecting the fact that there are very few people who find that they gain greater utility from watching High with this much advertising, rather than watching the very different programmes on Medium, with their advertisements. (This was in fact the maximum level of advertising possible on High, as anything above this caused High to lose its viewers totally, as evidenced by the empty cells above $\eta = 0.55$, in Tables 9 and 10.) Therefore it is no surprise to find that Medium can increase advertising to match High, $\mu = 0.55$; and still attract more viewers (1.22). Hence its advertising revenue increases to 0.67. In addition, Low can increase advertising to 0.77, attract more viewers, and increase total revenue to 0.60. By comparison, High now has an extremely small audience of only 0.0005, comprising those individuals located along the horizontal axis, where $0 < h < b$, and making and revenue of 0.0003. There has been a significant loss of viewers, and only a very slight gain in terms of advertising revenue, so it is hard to imagine such a scenario being politically sustainable.

High has suffered dramatically from remaining distinctive in its programme type, and also showing high levels of advertising. This does of course stem from our initial assumption that there are relatively few people who have High as their first preference, but the result should nonetheless offer interesting insights to those critics who call for the introduction of advertising on the BBC. The model shows firstly that if selling advertising is an aim, then High needs to reduce its distinctiveness (advertiser revenue in this model was minimal as the high level of advertising was spread over such a small audience). This may not be the result that the regulator wants. Secondly, for any given level of High's distinctiveness, any increase in advertising by High is matched by increases by Medium and Low. Again, this general escalation of advertising is probably not what the regulator had in mind.



Where: $\alpha = 1$, $\eta = 0.55$, $\mu = 0.55$, $\lambda = 0.775$, a = 0, b = 0.22, H = 0.0005, M = 1.22, L = 0.77.

4.3 Summary of results:

The simulated results shown in Tables 9 and 10 can be summarised as follows:

i) The more distinctive is High's programme compared to Medium, the greater the total amounts of advertising on television. The less distinctive is High, the less advertising there is in total. Thus there is the irony that a reduction of one kind of failure (limited programme choices) increases the other (advertising).

There is one important exception to this. In the special case where High's programme is identical to Medium's, we can get a worst-case result where both kinds of failures are maximised simultaneously – minimum distinctiveness, *and* extremely high levels of advertising.

ii) More generally, for any given level of High's distinctiveness, introducing advertising on High leads the other channels to further increase their own advertising, causing general escalation of advertising. (The horizontal rows of Table 9 show this, as total advertising rises as η rises, for any α.)

Similarly, for any given level of advertising on High, total advertising falls as High's programmes become less distinctive from Medium. The exception is when High is identical to Medium. (Vertical columns of Table 9 show this.)

Table 9. Total advertising on all three channels, given High's choices α, η.

Distinctiveness (α) / Adverts on High (η)	**η = 0**	**η= 0.1**	**η = 0.2**	**η = 0.3**	**η = 0.4**	**η= 0.55**	**η= 1**
α = 1	1.07	1.22	1.38	1.53	1.67	1.88	-
α = 0.7	0.92	1.09	1.25	1.41	1.56	-	-
α = 0.5	0.82	0.99	1.15	1.31	-	-	-
α = 0.3	0.70	0.87	1.04	-	-	-	-
α = 0.1	0.57	-	-	-	-	-	-
α = 0	0.50	0.75	1.00	1.25	1.50	1.75	3.00

Table 10. Levels of advertising (μ,λ), given High's choices α, η.

High's choices of (α) / (η)	**η = 0**	**η= 0.1**	**η = 0.2**	**η = 0.3**	**η = 0.4**	**η= 0.55**	**η= 1.0**
α = 1	0.40, 0.66	0.43, 0.69	0.46, 0.71	0.49, 0.74	0.52, 0.75	0.55, 0.77	-
α = 0.7	0.30, 0.62	0.34, 0.65	0.37, 0.68	0.41, 0.70	0.44, 0.72	-	-
α = 0.5	0.23, 0.59	0.27, 0.62	0.31, 0.65	0.34, 0.67	-	-	-
α = 0.3	0.14, 0.55	0.19, 0.59	0.23, 0.61	-	-	-	-
α = 0.1	0.05, 0.52	-	-	-	-	-	-
α = 0	0.00, 0.50	0.10, 0.55	0.20, 0.60	0.30, 0.65	0.40, 0.70	0.50 0.75	1.00, 1.00

4.4 The model under full competition – the Nash Equilibrium.

In this treatment we assume that High is able to set its levels of advertising competitively, finding its "best response" alongside the competitive decisions made by Medium and Low. We continue to assume however that High's degree of distinctiveness is determined by the regulator, and hence given. We therefore add a third equation to the Maple programme, to find the value of η that satisfies the first order condition for High.

High. $$(1+b)a+\frac{a^2}{2}=\eta(1+a+b)$$

Medium. $$(1+b)\left(1-\frac{a}{\alpha}\right)=(a+\eta)\left(1+\frac{1}{\alpha}+\frac{b-a}{\alpha}\right)$$

Low. $$1-\frac{a^2}{2\alpha}=a+2b+\eta$$

$a=\mu-\eta$
$b=\lambda-\mu$
$a>0$,
$b>0$

As supplied by Maple, the equations above again lead to a cubic equation in *a*, from which we can find the optimal values of η,μ, and λ, for any given α. (For solution, see Appendix B). The results reinforce those gathered in the two-firm competition case above.

* As High's distinctiveness diminishes, there will be less advertising in total. High gets larger audiences, at the expense of Low's audience. (Medium retains its audience by sharply dropping its advertising). As distinctiveness increases, there is more advertising in total, and High gets smaller audiences.

* Generally, revenue for all channels, including High, is maximised when High is very distinctive. High is therefore generally better off with a high degree of distinctiveness and (compared to Medium and Low) relatively small amount of advertising. This also offers consumers the greatest degree of choice, and the least advertising.

* The exception to this is when High is allowed to become completely identical to Medium. In this case, everyone's revenues are maximised at very high levels of advertising. This result means that consumers have the least degree of choice of programme types, and the most advertising.

* These results imply that if High is "allowed" by the regulator to duplicate Medium, it has every incentive to do so. If on the other hand it is required by the regulator to be distinctive, it must also be "allowed" to survive on very small audiences, and relatively low advertiser revenue.

* In summary therefore, the Nash equilibrium results under full competition reinforce the partial competition. Interestingly, they suggest that if High is to be allowed to sell advertising at all, it may be sufficient to let High determine its level of advertising competitively, while maintaining its level of distinctiveness by regulation. With a medium level of distinctiveness, High's Nash level of advertising was rather low, compared to the entire set of possibilities.

<u>Table 11: Nash equilibrium levels of advertising, given High's distinctiveness level α.</u>

Distinctiveness	η	μ	λ	Total Adverts	Audience High	Audience Medium	Audience Low
α = 0.8	0.19	0.40	0.67	1.27	0.36	0.94	0.70
α = 0.7	0.18	0.37	0.66	1.20	0.37	0.94	0.68
α = 0.5	0.14	0.28	0.62	1.04	0.41	0.95	0.64
α = 0.3	0.09	0.18	0.58	0.85	0.44	0.97	0.59
α = 0.1	0.03	0.06	0.53	0.62	0.48	0.99	0.53
α = 0.0	1.00	1.00	1.00	3.00	0.50	0.50	1.00

Table 12: Nash equilibrium revenue, given High's α,

Distinctiveness	Rev H	Rev M	Rev L	Total revenue
$\alpha = 0.8$	0.070	0.379	0.473	0.922
$\alpha = 0.7$	0.066	0.345	0.449	0.860
$\alpha = 0.5$	0.056	0.268	0.397	0.721
$\alpha = 0.3$	0.039	0.175	0.340	0.555
$\alpha = 0.1$	0.015	0.064	0.280	0.360
$\alpha = 0.0$	0.500	0.500	1.000	2.000

7. SUMMARY AND CONCLUSION.

We have developed above a model of product differentiation in two dimensions, to show the effects of broadcaster decisions with respect to programme distinctiveness, and the level of advertising. This is a spatial competition model that follows in the tradition of Hotelling and Cournot: television channels differ in terms of their programme type, and they compete for viewers, by varying their levels of advertising. Relative demand (the relative size of each channel's audience) plays the role of price in a Cournot-type model, except that there can be different prices for each of the three channels. Hence we have combined elements relating to the programme preferences of viewers, their sensitivity to advertising, the broadcaster's chosen level of advertising, and the distinctiveness of the public broadcaster's programe type.

Using this model we are able to show that the existence of a public broadcaster can not only have direct effects, in terms of its programme contribution; but also that it has spillover effects onto the commercial broadcasters that share its environment. This showed some of the trade-offs that have to be made between distinctiveness and advertising. For example, when the public broadcaster had a very distinctive programme profile, and zero advertising, consumers had the benefit of being offered three distinctly different programmes, but with a high amount of advertising on two of them. This occurs because Medium and Low were able to "get away" with higher levels of advertising. If High's programme profile changed to become more like Medium, but without advertising, viewers suffered in the sense that they lost diversity of programme choice, but they also benefited as advertising levels in total fell.

Thirdly,if the public broadcaster has a very distinctive programme profile, but now introduces the sale of advertising, this increases advertising in total, due to a general escalation. Consumers get three different programme choices, but there was more advertising than occurred under the first instance. And finally, if the public broadcaster becames identical to another broadcaster and also has advertising, consumers have only two programme types from which to choose, and high levels of advertising on all three channels.

These results are not always intuitive, showing the usefulness of the abstract methodology. They illustrate the inherent tensions that exist between broadcasting policy makers' aims to encourage distinctiveness and to constrain advertising, because in most situations, the two aims are not compatible:

i) If *constraining advertising* is the social planner's greatest concern, then it is best for the public broadcaster to have minimum programme distinctiveness, and zero advertising. This paradoxically produces the lowest total advertising in the market. The trade-off is that it also produces the least distinctiveness.

ii) Once the public broadcaster introduces advertising, this causes a general escalation of advertising across all broadcasters. This is maximised when the public broadcaster is very distinctive compared to the other broadcasters, and minimised when the public broadcaster becomes less distinctive.

iii) If *encouraging distinctiveness* is the social planner's greatest concern, then it must grasp the uncomfortable conclusion that higher levels of public television distinctiveness go hand in hand with higher levels of total advertising. This occurs irrespective of whether the public broadcaster has advertising or not.

iv) If maximising audiences, and/or maximising advertiser revenue, is the public broadcaster's aim, we end up in a worst-case scenario, marked by minimum programme distinctiveness and high levels of advertising.

This paper therefore offers a new rationale for ensuring that public broadcasters complement, rather than compete with, their commercial counterparts. It also shows the danger of introducing even a little advertising onto the public channel. The biggest problem however is that by definition, a highly distinctive programme profile is also often one that is unpopular, in the sense that it never captures the large audiences that would watch other less distinctive programme types. The small audience may value it very highly, but it is viewer numbers and not the intensity of their preferences that is measured. Most public broadcasters have been unwilling to deal with the tensions that this creates: how does one reconcile the use of public money to provide a service that very few people consume? Most public broadcasters see their mission as a tight-rope act, of providing programmes to as many people as possible, whilst at the same time being reasonably distinctive and high quality. For example, we are told that public television in the UK should "provide something for everybody, making the good popular and the popular good." This inability to resolve the conundrum between distinctiveness and unpopularity is at the heart of many broadcasters' incremental slide towards programme duplication. It is further exacerbated if public broadcasters are also required to supplement shrinking budgets through the sale of advertising.

APPENDIX A: THE SECOND ORDER CONDITION.

The second order condition for local maxima is α. $\delta^2 R_M/\delta\mu^2 = -2(\alpha+\eta+1+\lambda) + 6\mu$.
The requirement that $\delta^2 R_M/\delta\mu^2 < 0$ is satisfied for all our simulated values (from tables 10 and 11).

α	η	μ	λ	-2(α+η+1+λ) +6μ.
1	0	0.4	0.66	-2.92
1	0.1	0.43	0.69	-3
1	0.2	0.46	0.71	-3.06
1	0.3	0.49	0.74	-3.14
1	0.4	0.52	0.76	-3.2
1	0.55	0.55	0.78	-3.36
0.7	0	0.3	0.62	-2.84
0.7	0.1	0.34	0.65	-2.86
0.7	0.2	0.37	0.68	-2.94
0.7	0.3	0.41	0.7	-2.94
0.7	0.4	0.44	0.72	-3
0.5	0	0.23	0.59	-2.8
0.5	0.1	0.27	0.62	-2.82
0.5	0.2	0.31	0.65	-2.84
0.5	0.3	0.34	0.67	-2.9
0.3	0	0.14	0.55	-2.86
0.3	0.1	0.19	0.59	-2.84
0.3	0.2	0.23	0.61	-2.84
0.1	0	0.05	0.52	-2.94
0	0	0	0.5	-3
0	0.1	0.1	0.55	-2.7
0	0.2	0.2	0.6	-2.4
0	0.3	0.3	0.65	-2.1
0	0.4	0.4	0.7	-1.8
0	0.55	0.55	0.75	-1.3
0	1	1	1	0

NASH

α	η	μ	λ	
0.8	0.19	0.4	0.67	-2.92
0.7	0.18	0.37	0.66	-2.86
0.5	0.14	0.28	0.62	-2.84
0.3	0.09	0.18	0.58	-2.86
0.1	0.03	0.06	0.53	-2.96
0	1	1	1	0

APPENDIX B: THE NASH EQUILIBRIUM.

Using Maple we find a, b, η, μ, and λ to the following, given High's level of distinctiveness, α:

$$(1+b)a+\frac{a^2}{2}=\eta(1+a+b)$$

$$(1+b)\left(1-\frac{a}{\alpha}\right)=(a+\eta)\left(1+\frac{1}{\alpha}+\frac{b-a}{\alpha}\right)$$

$$1-\frac{a^2}{2\alpha}=a+2b+\eta$$

$$a=\mu-\eta$$
$$b=\lambda-\mu$$

The solution to this, found by Maple is as follows:

$a=\rho$ is the solution (Z) of:

$$0=12Z^6+Z^5\alpha+\left(-87\alpha^2-72\alpha\right)Z^4+\left(96\alpha^3+27\alpha^2\right)Z^3+\left(39\alpha^3-27\alpha^4+108\alpha^2\right)Z^2+$$

$$+\left(-18\alpha^4-90\alpha^3\right)Z+18\alpha^4$$

$$Z>0$$
$$Z<\alpha$$
$b > 0$

Having found $a=\rho=Z,$ and choosing our various levels of the given α, we now find the rest of the variables:

$$\eta = -3\frac{-\rho^3 - \rho^2\alpha + \rho\alpha^2 + 3\rho\alpha - \alpha^2}{\alpha(-7\rho + 3\alpha)},$$

$$b = \frac{1}{2}\rho\frac{2\alpha + 4\rho^2 + \rho\alpha}{\alpha(-7\rho + 3\alpha)},$$

$$\mu = \frac{-4\rho^2\alpha + 3\rho^3 - 9\rho\alpha + 3\alpha^2}{\alpha(-7\rho + 3\alpha)},$$

$$\lambda = \frac{1}{2}\frac{-16\rho\alpha + 10\rho^3 - 7\rho^2\alpha + 6\alpha^2}{\alpha(-7\rho + 3\alpha)}$$

Results: Nash equilibria levels of advertising on all three channels, given High's distinctiveness, α.

α	η	μ	λ	ρ = a	b.
0.8	0.194	0.403	0.674	0.209	0.271
0.7	0.177	0.366	0.657	0.189	0.291
0.5	0.137	0.281	0.620	0.144	0.339
0.3	0.089	0.181	0.576	0.092	0.395
0.1	0.032	0.065	0.527	0.033	0.462

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