Advertising and Program Content in a Mixed Economy Television Broadcast Industry

Rahul Nilakantan*
Indian Institute of Management Indore
nilakantan@iimidr.ac.in

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Abstract

The data reveals pervasive state ownership of the television media as well as a large share of television audiences for state broadcasters the world over. In spite of this, recent papers dealing with program content and advertising levels have treated the television industry as being purely privately owned. We consider program content and advertising levels in a mixed economy television broadcast industry with Free to Air (FTA) broadcasting technology, where a welfare maximizing state broadcaster competes with a profit maximizing private broadcaster. We find that regardless of advertising profitability, advertising levels on both broadcasters are more optimal, and hence the welfare from advertising is higher under mixed economy. Although welfare from program content is lower under mixed economy, total welfare under mixed economy always exceeds total welfare under private economy. Profits for both private and state broadcasters under mixed economy may exceed or fall below that under private economy depending on the relation between the nuisance level to viewers from advertisements and the profitability of advertising. We provide a welfare argument for the continued existence and operation of loss making state broadcasters.

1 Introduction

Competition between television broadcasters is an example of platform competition in a two sided market. Broadcasters act as platforms through which

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viewers on one side of the market and advertisers on the other interact. Advertisers produce goods, and inform customers about their products through advertising. Viewers receive direct benefits from viewing the programs, and purchase goods from advertisers after seeing their advertisements.

Recent papers[1] on program content and advertising intensity[2] in the television broadcast industry, with the exception of Kind et. al. (2007) and Pan (2009), have modeled platform competition in the context of a purely private economy industry structure (PE), where each broadcaster's sole objective is to maximize profits. We argue that the television industry should be be modeled as a mixed economy industry structure (ME), where state owned broadcasters[3] with possibly non-profit objectives compete with profit maximizing privately owned broadcasters.

State control of television stations is pervasive - Djankov et. al. (2003) find in a sample of 97 countries that the state controls 60% of all television stations. In 43 countries (mostly MENA[4] countries), the state monopolizes television stations with local news programs. However, control of television stations does not ensure that viewers actually watch the television stations. Even so, state broadcasters across the world command a significant market share in terms of television viewers. For example, in the EU alone, state broadcasters in 2007 accounted for an average of 29.23% of all viewers, with a maximum market share of 71.50% in Denmark[5].

State owned broadcasters may have several objectives that may or may not include profit maximization. We abstract from the case where state owned broadcasters serve merely as propaganda vehicles to perpetuate corrupt regimes, and focus on a more benign role for state broadcasters, viz. to provide public service broadcasting (PSB).

Heap (2005) states that PSB objectives are similar the world over, whether fulfilled by state broadcasters acting as dedicated public service broadcasters, or by private broadcasters fulfilling mandatory PSB requirements. He provides an example of PSB objectives within the EU[6], as laid down by the

[1] For example Peitz and Valletti (2008), Anderson and Coate (2005), Nasser et. al. (2007), Gabszewicz et. al (2004) etc.

[2] Advertising intensity is a measure of the amount of advertisements carried per broadcast.

[3] State broadcasters may also be referred to as public broadcasters or public service broadcasters.

[4] MENA stands for Middle East and North Africa

[5] Data on the market share of state broadcasters was obtained from the MAVISE database as on 07/04/09.

[6] Within the UK, Block et. al. (2001) report that the Broadcast Research Unit of the British Film Institute suggested in 1986 the following guidelines for public service broad-

1994 Prague resolution and the 1996 EU Parliament resolution: (1) to aid informed citizenship, (2) to support democratic values, (3) to offer a wide range of quality in all program genres, and (4) to promote social cohesion and the vitality of national cultures.

Although Norris et. al. (2003, pg.48) find cases where dedicated public service broadcasters seem to be more interested in increasing audience shares than in fulfilling their PSB mandates, most state broadcasters adhere to some or all of their PSB objectives. The BBC is an extreme example of adherence to PSB objectives to the exclusion of all other objectives. For example, the BBC's "public purposes" are (1) sustaining citizenship through news, information and analysis of current events and ideas; (2) promoting education and learning, both formal and informal; (3) stimulating creativity and cultural excellence; (4) reflecting the UK's nations, regions and communities; and (5) bringing the world to the UK and UK to the world. According to an internal review of its royal charter, "The BBC exists to deliver public value through these purposes, and for no other reason" (BBC, 2005).

The mixed economy literature in one sided market[7] settings has long recognized the fact that when state owned enterprises with objectives that differ from profit maximization compete with profit maximizing private enterprises, they may have incentives to undertake "anti-competitive" actions that hurt their private enterprise counterparts. Further, even if the objective of the state owned enterprise is welfare maximization, its actions may reduce welfare in equilibrium (Sappington and Sidak, 2003). It is important therefore to see whether such concerns hold good in two sided market settings such as the television broadcast industry.

An example of "anti-competitive" behavior of public service broadcasters comes from private broadcaster complaints to the European Commission. A complaint from Germany highlighted the failure of public service broadcasters to charge "market prices" for granting private broadcasters access to their transmission facilities, thus creating an uneven playing field for private broadcasters (EC, 2007).

State broadcasters have different sources of funding than private broadcasters. State broadcasters may receive budgetary support from the Govern-

casting: (1) geographic universality, (2) universality of appeal, (3) space for minorities, (4) national identity, (5) distance from vested interests, (6) universality of payment, (7) promotion of competition in good programming and (8) guidelines to liberate program makers (see Block et. al. 2001 for a discussion of these objectives).

[7] One sided market here refers to markets where buyers and sellers interact directly i.e. without intermediaries who may charge for the privilege of bringing buyers and sellers together

ment in addition to revenues from advertising, thus loosening the constraints of the profit and loss calculus. This has led to complaints from privately owned competitors of an uneven playing field, with state broadcasters having a competitive advantage on account of being able to tap sources of funds unavailable to their private competitors.

Complaints by private broadcasters to the European Commission against state aid to public service broadcasters typically focus on the excessive levels of such aid. Private broadcasters claim that these aid levels are more than sufficient to provide the given level of public service broadcasting, and thus serve to subsidize the commercial activities of public service broadcasters.

In Germany for example, a complaint highlighted the tendency of public service broadcasters to outbid private broadcasters on lucrative assets like sports telecast rights, which have no relation to public service broadcasting obligations (EC, 2007). This has also been a source of concern to other public service broadcasters in situations where there is more than one public service broadcaster. For example, Channel 4, a commercially funded public service broadcaster in the UK, has complained that the Government's generous support to BBC (another public service broadcaster) in the form of license fees makes it difficult for Channel 4 to compete against the BBC! (Channel 4, 2008)

As we shall show later, it is not always the case that competing with a state broadcaster proves deterimental to the private broadcaster. In certain cases, private broadcasters would actually make greater profits when competing with a state broadcaster than if they were competing with another private broadcaster!

Commercially funded public broadcasters that makes losses face pressure to improve their "bottom lines" or be privatized. For example, in the case of Channel 4 of the UK, anticipated future losses have led to suggestions of merger with a private broadcaster (The Independent, 2009). Privatization pressures may also be driven not just by profit and loss considerations, but also by a belief in the efficiency of markets. We argue that in this particular setting, privatization of state broadcasters would most probably reduce social welfare rather than increase it.

In the present paper, we focus on issues relating to program content and advertising intensity. Since (1) state broadcasters' objectives may vary from profit maximization, and (2) state broadcasters command a significant market share in terms of viewers, it becomes necessary to look at program content and advertising intensity in a ME television broadcasting industry. This paper attempts such an analysis, treating the state broadcaster as a

social welfare maximizer operating in a FTA technology[8] regime.

With regard to competition between advertisers, we consider the homogenous product market case. We treat the choice of program content and advertising intensity as endogenous, and contrast the equilibrium in a ME with that in a PE industry structure.

The rest of the paper is organized as follows. Section 2 summarizes the literature and previews our main results. The model is set up in Section 3. Section 4 discusses the sub-game perfect equilibria under ME and PE and compares ad space decisions, broadcaster profits and social welfare under various levels of profitability of advertising and nuisance level to viewers from advertising. Section 5 summarizes the discussion and concludes.

2 Literature Review and Preview of Main Results

Anderson and Coate (2005) recognized that an FTA television broadcast has public good properties in that viewers derive direct benefits from watching the broadcast, but cannot be excluded from watching the broadcast. Further, advertisers derive indirect benefit from broadcasts by contacting viewers through advertisements, but impose negative externalities on viewers on account of subjecting them to advertising. As a result, there are two sources of market imperfections under FTA broadcasting.

Not surprisingly, Anderson and Coate (2005) found that the decisions of private broadcasters under FTA technology regime in a PE with respect to ad intensity are sub-optimal, since they have no incentive to equate the marginal social cost of advertising (the disutility or nuisance to viewers from ads) with the marginal social benefits of advertising (gains from trade between viewers and advertisers[9]). The tradeoff relevant to the profit maximizing private broadcaster is the revenue gains from carrying more ads versus the loss of audience market share due to carrying more ads. They find that when the viewer nuisance per ad is low (high), there is social under (over) provision of advertisements in a PE.

The question this paper asks is whether prices do a better job of internalizing these externalities when one broadcaster is state owned, and has welfare maximization as its objective. We find that the answer is **yes**. In

[8] Broadcasting technology is usually of two types: Pay TV (PTV) or Free to Air (FTA). PTV broadcasts require viewers to pay for the privilege of watching the broadcast, while FTA broadcasts are free to the viewers.

[9] Advertisers in their model produce goods that are bought by viewers of the advertisements.

our ME setting, the state broadcaster internalizes all the costs and benefits (both private and public) of its ad intensity decision. As a result, competition between the state and the private broadcaster causes the private broadcaster to choose levels of ad intensity that are more optimal than when the private broadcaster competes with another private broadcaster. Since the state broadcaster also chooses more optimal levels of ad intensity than it would if it were privately owned, welfare from advertising is higher under ME than under PE.

When the level of viewer nuisance per ad is low, the state broadcaster refrains from "cut-throat" competition with the private broadcaster, by increasing the number of advertisements it carries, therefore allowing the private broadcaster also to increase the number of advertisements it carries. In this way, both broadcasters can carry a larger number of advertisements under ME than under PE, and thus reduce the extent of social under provision of advertisements. Conversely, when the viewer nuisance per ad is high, the state broadcaster "disciplines" the private broadcaster by sharply reducing the number of advertisements it carries, thus forcing the private broadcaster to follow suit. In this way, both broadcasters carry a smaller number of advertisements under ME than under PE, and thus reduce the extent of social under provision of advertisements. This ability of the state broadcaster to tailor its "aggression" level in competition in accordance with the degree of viewer nuisance per ad is what enables more optimal ad space decisions by both broadcasters under ME.

In the spirit of the present paper, Pan (2009) also compares competition between television broadcaster in the ME and PE settings, but in a situation where the state owned broadcaster maximizes viewer surplus with a binding break even constraint, and the broadcasting technology is PTV. The equilibrium in that model involves under provision of advertisements by both broadcasters under ME and PE. This is because neither broadcaster cares about the welfare of advertisers, nor can they capture all the rent from advertisers even if they wanted to. In contrast to the present model, both advertisers in Pan (2009) choose identical levels of ad space under ME and PE. Given that the broadcasting technology is PTV, the equilibrium involves both broadcasters maximizing joint surplus of broadcaster and viewer, and then using subscription fees to allocate the surplus between broadcaster and viewer. As a result, both broadcasters set the same ad space, but different subscription fees under ME and PE.

Kind et. al. (2007) consider competition between television broadcasters under ME and PE in an oligopoly setting. This is in contrast to the recent literature (including the present paper), which has analyzed compe-

tition between television broadcasters in a duopoly setting. The broadcast technology they consider is FTA, and the state broadcaster is a welfare maximizer. Under PE, they find that ad space is over provided when programs are poor substitutes, but under provided if programs are good substitutes. The intuition behind this result is that broadcasters exploit market power when programs are poor substitutes by carrying more ad space even though this reduces viewer surplus. When programs are poor substitutes however, the state broadcaster reduces its ad space, thus mitigating the problem of over provision of ad space under ME. Unfortunately, Kind et. al. do not analyze the welfare and profit implications of the mitigation of the over provision of advertising under ME.

With regard to progam content, Gal-Or and Dukes (2003) consider the case of a differentiated products market with Nash bargaining on advertising prices between stations and broadcasters. The broadcasting technology is FTA. They find that broadcasters have incentive to minimize content differentiation, which in turn leads producers to advertise less. With less product information available to consumers, producers gain higher margins on product sales, which permits broadcasters to command higher prices for advertisements.

Gabszewicz et. al. (2004) consider the case of a homogeneous products market with advertisers acting as price takers on the advertising market. The broadcasting technology is FTA. They find that when viewer aversion to advertisements is low, broadcasters tend to differentiate content, and vice versa. Differentiating content allows broadcasters to have "niche" markets, carry more advertising and hence make greater revenues. However, the ability to carry more advertising is inversely proportional to the strength of viewer aversion to advertisements. When aversion is high enough, broadcasters prefer content duplication to retain market share since they can carry only limited amounts of advertising.

Peitz and Valletti (2008) consider the case of a quality differentiated products market with advertisers acting as price takers on the advertising market. They consider both FTA and PTV broadcasting technologies. Under the FTA technology regime, they find that the greater the viewer aversion to advertisements, the more broadcasters tend to differentiate program content. This is because content duplication would result in ruinous Bertrand competition in the sense of lowering the number of advertisements (and hence revenues) in an attempt to boost market share. Content differentiation however makes viewers less sensitive to differences in advertising levels across broadcasters, permitting broadcasters to carry more ads and thus make greater revenues.

Pan (2009) finds maximal content differentiation under PE. Under ME, Pan finds intermediate content differentiation, with the state broadcaster close to the mid point of the Hotelling line, and the private broadcaster close to one end. The state broadcaster tends to move closer to the private broadcaster to "squeeze" its profit and therefore increase viewer surplus, while the private broadcaster tends to retreat in order to soften the competition.

In the present paper, we permit only two content choices: maximal content differentiation, and perfect content duplication. By an analogous argument to that in Peitz and Valletti (2008), perfect content duplication would lead to a "race to the bottom" in terms of advertising levels and thus zero advertising revenue. Further, it would lead to a reduction in social welfare on account of lost opportunities for gains from trade between advertisers and viewers, as well as increased viewer transport costs. Therefore, both broadcasters in the present paper prefer content differentiation to content duplication in equilibrium, regardless of broadcasting market structure (ME or PE).

We find that welfare from program content is lower under ME than under PE. Symmetric advertising level choices by identical private broadcasters in a PE cause viewers to choose between programs solely on the basis of which program's content is most preferred. However, in a ME, the advertising level choices of both broadcasters are different. As a result, some viewers under ME watch the program whose content is less preferred on account of its carrying lower advertising levels than the other program. This leads to lower welfare from program content under ME. However, we show that regardless of the profitability of advertising or the nuisance level to viewers from advertising, the welfare gains from more optimal ad space decisions more than outweigh the welfare losses from program content. Therefore, total welfare under ME is always higher than total welfare under PE.

Pan (2009) also finds a welfare improvement under ME. However, unlike in the present model, the source of the welfare improvement is not from more optimal ad space choices since both broadcasters have identical ad space choices under ME and PE. The source of welfare gains is from more optimal program content decisions under ME, since broadcasters no longer maximize content differentiation.

In the present paper, we also contrast profit levels of private broadcasters under ME and PE. We find that both broadcaster make lower profits under ME when the nuisance value of advertising exceeds the profitability of advertising. However, when the profitability of advertising is greater than the nuisance value of advertising, both broadcasters make higher profits under

ME! Thus, it is possible to have a "win-win-win" situation under ME, with both broadcasters as well as society as a whole being better off.

In the case where the profitability of advertising exceeds its nuisance value, competing with a state broadcaster allows the private broadcaster to carry a larger ad space as well as have a larger market share than when competing with another private broadcaster. For a given cost of broadcasting, this gives the private broadcaster greater ad revenues and thus greater profits under an ME. However, in the case where the nuisance value exceeds the profitability of advertising, competing with a state broadcaster forces the private broadcaster to curtail its ad space to a greater extent as well as have a lower marke share than when competing with another private broadcaster. For a given cost of broadcasting, this gives the private broadcaster lower ad revenues and thus lower profits under ME.

Therefore, depending on the level of nuisance from ads and the profitability of advertising, the state broadcaster takes actions that are either to the benefit of, or to the detriment of the private broadcaster (where benefit means profit and detriment means loss). This result is the two sided market analog of the result in Sappington and Sidak (2003, pg.184), who find that a "reduced focus on profit can provide state enterprises with stronger incentives to pursue activities that disadvantage competitors".

Pan (2009) finds that the private broadcaster always makes lower profits under ME than under PE. Since the state broadcaster cares only about viewer surplus (subject to a binding break even constraint), it is a much more aggressive competitor than another private broadcaster, thus lowering the profits of the private broadcaster under ME. Given the binding break even constraint, the state broadcaster is unable to tailor the aggressiveness of its competition depending on the relationship between the profitability and the nuisance value of advertising.

Depending on the nuisance level from advertisements and the cost of broadcasting, the state broadcaster in the present model may incur losses while attempting to carry out its PSB mandate. In such situations, if the deadweight loss incurred in raising public funds to provide budgetary support to the state broadcaster is low enough, a welfare argument can be made for the continued existence and operation of state broadcasters, even if they are loss making.

The results in the present paper on welfare and broadcaster profits go through even if the product market on the advertiser side is modeled as quality differentiated products ala Peitz and Valletti (2008). In that case[10],

[10] These results are available on request.

we do not impose a binding break even constraint ala Pan (2009), but restrict content choice to perfect duplication or maximal differentiation ala Anderson and Coate (2005).

3 The model

This paper adapts the models of Anderson and Coate (2005) and Gabszewicz et. al. (2004) to analyze program content and advertising levels in a mixed economy broadcast industry under a FTA technology regime with homogeneous product markets. Advertising occurs in the setting of a two sided market. Advertisers, who also produce and sell products, on one side of the market and viewers on the other are brought together by broadcasters. Viewers get pleasure from watching programs, but dislike ads. Ads, while distasteful to viewers, inform them of trading opportunities with advertisers. Advertisers pay the broadcasters to carry their ads, which allow them to sell their products to viewers. Viewers need not pay to watch programs since the broadcasting technology is FTA.

The cost of broadcasting is treated as fixed. The private broadcaster (PRITV hereafter) has ad revenue as its sole source of funds. The objective of PRITV is to maximize profits. The state broadcaster (PUBTV hereafter) also has ad revenue as its sole source of funds[11]. The objective of PUBTV is to maximize social welfare. The three participants (viewers, advertisers and broadcasters) together play the following multi-stage game:

1. Broadcasters choose program type
2. After noting each other's program choices, broadcasters choose the level of advertising i.e. ad space, and the price of advertising
3. Advertisers choose which broadcasters to advertise with. Simultaneously, consumers make their viewing choices and goods purchase decisions

We consider the decision problems of each category of participant below.

3.1 Viewers

There is a mass N of viewers. Viewers are distributed uniformly along the unit Hotelling interval, with taste for programs $\beta \sim U[0,1]$. There are two

[11] Therefore, PUBTV in this model is commercially funded.

program types e.g. news and music, indexed by 1 and 2. Producing program 1 is equivalent to the broadcaster choosing a location of 0 on the Hotelling interval. Producing program 2 is equivalent to a broadcaster choosing a location of 1 on the Hotelling interval.

Program choice of PRITV is denoted by distance d_1 from the end of the Hotelling interval indexed by 0, and program choice of PUBTV by distance of d_2 from the end of the Hotelling interval indexed by 1. Thus if both PRITV and PUBTV produced program 1, then $\{d_1, d_2\} = \{0, 1\}$. Similarly, if both PRITV and PUBTV produced program 2, then $\{d_1, d_2\} = \{1, 0\}$. These are the cases where program content is duplicated by broadcasters. If PRITV produced program 1 and PUBTV produced program 2, or vice versa, then $\{d_1, d_2\} = \{0, 0\}$ or $\{d_1, d_2\} = \{1, 1\}$ respectively. These are the cases where program content is differentiated by broadcasters.

With quadratic transportation costs, a viewer located at position β on the Hotelling interval is at a distance β from program 1, and hence incurs a disutility β^2 if she watches program 1. Similarly, she is at a distance of $1-\beta$ from program 2, and hence incurs a disutility of $(1-\beta)^2$ if she watches program 2.

Each viewer gets a pure benefit v from watching a program of length T. Without loss of generality, we set $T = 1$, which is equivalent to having an hour of programming. A fraction a_i of program i consists of advertisements, with the remaining fraction $(1 - a_i)$ consisting of actual programming (say news or music). We call fraction a_i the ad space on program i.

The viewer's distaste for advertisements is measured by the advertising nuisance parameter δ. If the viewed program has ad intensity a_i, then the viewer gets disutility δa_i from watching that program.

We restrict the ad nuisance parameter δ to lie above 1. This restriction ensures that the viewer benefit of watching a program of length 75 minutes that is interrupted by 15 minutes of advertising is less than the viewer benefit of watching an advertisement free program of length one hour.

The viewer's indirect utility from watching program 1 is then $IU_1 = v - \delta a_1 - \beta^2$, while that of watching program 2 is $IU_2 = v - \delta a_2 - (1 - \beta)^2$. If the viewer does not watch TV, her indirect utility is $IU_0 = 0$.

We set v sufficiently large so that both IU_1 and IU_2 are always positive. Thus, every viewer watches TV, and there is full market coverage. Every viewer can watch only one program, and thus chooses the program that gives her higher indirect utility.

Suppose program content is maximally differentiated i.e. both programs are produced. Then, there is a consumer located at b_1 who is indifferent between the two programs. All consumers to the left of b_1 prefer program

1, and all consumers to the right of b_1 prefer program 2. The market share of program 1 is then

$$\begin{aligned} b_1 &= \frac{1}{2} - \frac{\delta(a_1 - a_2)}{2} \\ b_2 &= 1 - b_1 \end{aligned} \tag{1}$$

Total viewership of each program is then Nb_1 for program 1 and Nb_2 for program 2.

Suppose on the other hand that program content is duplicated i.e. both channels produce the same program. Then, market share of program 1 is

$$\begin{aligned} b_1 &= 1 \text{ if } a_1 < a_2 \\ &= \frac{1}{2} \text{ if } a_1 = a_2 \\ &= 0 \text{ if } a_1 > a_2 \end{aligned} \tag{2}$$

As before, market share of program 2 is $b_2 = 1 - b_1$, and total viewership of each program is then Nb_1 for program 1 and Nb_2 for program 2.

3.2 Advertisers

A large number of advertisers (also called producers) costlessly manufacture identical goods. Each advertiser makes a profit of α per viewer when the viewer (also called consumer) buys the product. The advertiser cannot sell to a consumer unless the consumer sees the ad for the good. If a program carries the ad for a particular producer's good, every viewer of that program sees the ad and becomes a consumer. The producer can advertise on none, one or both programs.

Broadcaster i sells a fraction a_i of its broadcasting time to advertisers at a unit price r_i. An advertisement reaches Nb_i viewers, each of whom gives the producer a profit of α. Since producers are price takers on the advertising market, profit maximization by producers implies that $Nb_i\alpha = r_i$ for $i = 1, 2$. As Gabszewicz et. al. (2004) point out, this condition implies that the equilibrium price per viewer is $\frac{r_i}{Nb_i}$ is the same on both chanbels, and is equal to the advertising profit per viewer α.

3.3 Broadcasters

The broadcaster of program i solicits advertisements from producers at price r_i, carries ad intensity a_i, and reaches Nb_i viewers. In a FTA technology

regime, the only source of revenue for a broadcaster carrying program i is ad revenue $a_i r_i$. Ad revenue for broadcaster i is then $N b_i \alpha a_i$. Given an exogenously fixed cost of broadcasting K, the profit of broadcaster i is $\pi_i = N b_i \alpha a_i - K$.

The state broadcaster is concerned with social welfare. Welfare in this economy is the sum of profits of the broadcasters $\left(\pi^{bro}\right)$, profits of the advertisers $\left(\pi^{ad}\right)$, and consumer surplus (CS). We treat the state broadcaster as a social welfare maximizer since we feel that the diverse nature of public service broadcasting objectives can best be captured in a social welfare function. Although it might seem strange to include the profit of the private broadcaster in the state broadcaster's objective function, PSB objectives such as "offering a wide range of quality in all program genres" may not be achieved if the actions of a state broadcaster that is heedless of the effects of its actions on private broadcaster profits results in the private broadcaster being driven out of the market altogether.

In light of the anecdotal evidence that Norris et. al. (2003) provide of some state broadcasters indulging in market share maximization type activities, it is possible to conceive of an objective function that is a weighted combination of profit and social welfare[12]. Given that state broadcaster profit is already included in social welfare, this would amount to reweighting the components of social welfare in favor of state broadcaster profit. However, there is little evidence to suggest that this kind of market share maximization type behavior is widespread enough to justify increasing the weight of own profit in the state broadcaster's objective function.

The components of social welfare are:

$$\begin{aligned}
\pi^{bro} &= \sum_{i=1}^{2} a_i r_i - 2K \\
\pi^{ad} &= N\alpha \sum_{i=1}^{2} b_i a_i - \sum_{i=1}^{2} a_i r_i \\
CS &= N\left[v - \delta \sum_{i=1}^{2} b_i a_i - \sum_{i=1}^{2} \int_0^{b_i} \beta^2 d\beta\right]
\end{aligned}$$

Following Peitz and Valletti (2008), we can rearrange terms to express social welfare as

$$W = Nv + W^{co} + W^{ad} - 2K$$

[12] This approach would be in the spirit of that adopted in the mixed economy literature, where the objective of the state owned enterprise is usually a weighted combination of revenue and profit, in order to account for bureaucratic budget maximization activities.

where W^{co} is the welfare from program content and W^{ad} is the welfare from advertisements:

$$\begin{aligned} W^{co} &= -N\sum_{i=1}^{2}\int_{0}^{b_i}\beta^2 d\beta \\ W^{ad} &= N\sum_{i=1}^{2} b_i a_i\left(\alpha-\delta\right) \end{aligned}$$

The welfare from program content consists of the viewer transport costs incurred from viewing a program whose content is different from that of the viewer's bliss point. As is usual in a Hotelling type model, transport costs are lower under content differentiation than under content duplication, regardless of the viewer shares of the broadcasters. Thus, welfare from program content is higher under content differentiation than under content duplication. The limiting case under content differentiation is when one broadcaster captures the entire market share. In this case, the viewer transport costs are equal under content differentiation and under content duplication.

Welfare from advertisements consists of the gains from trade between consumers (viewers) and producers (advertisers), less the disutility to the viewers from watching advertisements. Clearly, advertising increases social welfare only if the gains from trade exceed the disutility to viewers. Note that the gains from trade accrue completely to the producer. Thus, welfare per ad is positive only if the producer's incremental profit from placing an ad exceeds the incremental disutility to viewers from seeing the ad. Accordingly, welfare from advertisements is highest if all producers advertise when $\alpha > \delta$ and no producers advertise if $\alpha < \delta$.

4 Equilibrium

We look for Sub-game Perfect Nash Equilibria under ME and PE industry structures[13]. The stage 1 choices of PRITV are from the set $A_{PRI} = \{1, 2\}$, and those of PUBTV are from the set $A_{PUB} = \{1, 2\}$, where 1 stands for broadcast program 1, and 2 stands for broadcast program 2.

All terms in the analysis that follows are per-person terms. Since we set v high enough to ensure full coverage of the market, the equilibrium will be the same whether it is calculated using per-person payoffs or gross

[13] All calculations for the equilibria are available on request from the author.

payoffs. The advantage in using per-person payoffs is that we have one less parameter to deal with, namely N.

The only SPNEs that can occur under both ME and PE are those where both broadcasters operate with content differentiation. The private broadcaster prefers content differentiation because because content duplication would lead to Bertrand competition in terms of advertising levels and thus zero advertising revenue. The state broadcaster prefers content differentiation because content duplication would lead to a reduction in welfare on account of lost gains from trade between advertisers (producers) and viewers (consumers), as well as increased viewer transport costs. As a result, both broadcasters prefer content differentiation to content duplication in equilibrium, regardless of broadcasting market structure (ME or PE). We now characterize and compare the SPNEs under ME and PE.

4.1 Private economy

By symmetry of the locations of the two programs on the unit Hotelling interval, the sub-game equilibria when both broadcasters operate yield the same profit levels for PRITV and PUBTV as well as the same level of social welfare regardless of the broadcasters' specific program choices. Therefore, we characterize the sub-game equilibrium assuming that PRITV produces program 1 and PUBTV produces program 2.

Since program content is differentiated, we have $d_1 = d_2 = 0$, and market share for each program is given in equation (1). The problem of broadcaster i is to maximize profit:

$$\max_{a_i \in [0,1]} \pi_i = b_i a_i \alpha - k$$

From the Kuhn-Tucker formulation, the equilibrium choice of ad space by each broadcaster depends on the relationship between the viewer nuisance per ad δ and the advertiser profit per ad α as follows:

For low / intermediate advertising profits i.e. $\alpha \in [0, 1]$, we have

$$\left(a_1^P, a_W, a_2^P\right) = \left(\tfrac{1}{\delta}, 0, \tfrac{1}{\delta}\right) \quad \text{when} \quad \delta \in (1, \infty)$$

For high advertising profits i.e. $\alpha \in (1, \infty)$, we have

$$\left(a_1^P, a_W, a_2^P\right) = \begin{cases} \left(\tfrac{1}{\delta}, 1, \tfrac{1}{\delta}\right) & \text{when} \quad \delta \in (1, \alpha) \\ \\ \left(\tfrac{1}{\delta}, 0, \tfrac{1}{\delta}\right) & \text{when} \quad \delta \in (\alpha, \infty) \end{cases}$$

where superscript P indicates private economy, and $\left(a_1^P, a_W, a_2^P\right)$ are respectively the equilibrium ad space of PRITV, the social welfare maximizing ad space, and the equilibrium ad space of PUBTV. When $\delta = \alpha$, any level of ad space is consistent with welfare maximization since the marginal social benefit of advertising equals the marginal social cost of advertising.

When the viewer nuisance per ad is less than the advertiser profit per ad i.e. when $\delta < \alpha$, welfare maximization requires that all producers be allowed to advertise. Given that there are usually more producers available than programming time, this would require that $a_i = 1$ on each channel. In equilibrium however, both channels under provide ad space since $a_i^P = \frac{1}{\delta} < 1$, given that we restrict $\delta > 1$.

When the viewer nuisance per ad is greater than the advertiser profit per ad i.e. when $\delta > \alpha$, welfare maximization requires that no producer be allowed to advertise i.e. $a_i = 0$ on each channel. In equilibrium however, both channels over provide ad space since $a_i^P = \frac{1}{\delta} > 0$, given that we restrict $\delta > 1$.

As Anderson and Coate (2003) observe, the suboptimal provision of ad space occurs because neither broadcaster has the incentive to equate the marginal social benefit from ads (gains from trade between advertisers and viewers) with the marginal social cost of ads (the viewer disutility or nuisance from ads). The tradeoff relevant to the profit maximizing private broadcaster is the revenue gains from carrying more ads versus the loss of market share due to carrying more ads.

4.2 Mixed economy

By symmetry of the locations of the two programs on the unit Hotelling interval, the sub-game equilibria when both broadcasters operate yield the same profit levels for PRITV and PUBTV as well the same level of social welfare regardless of the broadcasters' specific program choices. Therefore, we characterize the sub-game equilibrium assuming that PRITV produces program 1 and PUBTV produces program 2.

Since program content is differentiated, we have $d_1 = d_2 = 0$, and market share for each program is given in equation (1). PRITV's problem is to maximize profit:

$$\max_{a_1 \in [0,1]} \pi_1 = b_1 a_1 \alpha - k$$

Now, consider the ad space choice of PUBTV. PUBTV's problem is to maximize welfare:

$$\max_{a_2 \in [0,1]} w = v + w^{ad} + w^{co} - 2k$$

From the Kuhn-Tucker formulation, the equilibrium choice of ad space by PRITV and PUBTV depends on the relationship between viewer nuisance per ad δ and advertiser profit per ad α as follows[14]:

For low advertising profits i.e. $\alpha \in \left(\frac{1}{2}, \frac{3}{4}\right]$, we have

$$\left(a_1^M, a_W, a_2^M\right) = \left(\frac{1}{2\delta}, 0, 0\right) \quad \text{when} \quad \delta \in (1, 2\alpha)$$

For intermediate advertising profits i.e. $\alpha \in \left(\frac{3}{4}, 1\right]$, we have

$$\left(a_1^M, a_W, a_2^M\right) = \begin{cases} \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, 0, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right) & \text{when} \quad \delta \in \left(1, \frac{4}{3}\alpha\right] \\ \left(\frac{1}{2\delta}, 0, 0\right) & \text{when} \quad \delta \in \left(\frac{4}{3}\alpha, 2\alpha\right) \end{cases}$$

For high advertising profits i.e. $\alpha \in (1, \infty)$, we have

$$\left(a_1^M, a_W, a_2^M\right) = \begin{cases} \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, 1, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right) & \text{when} \quad \delta \in (1, \alpha) \\ \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, 0, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right) & \text{when} \quad \delta \in \left(\alpha, \frac{4}{3}\alpha\right] \\ \left(\frac{1}{2\delta}, 0, 0\right) & \text{when} \quad \delta \in \left(\frac{4}{3}\alpha, 2\alpha\right) \end{cases}$$

where superscript M indicates mixed economy. $\left(a_1^M, a_W, a_2^M\right)$ are respectively the equilibrium ad space of PRITV, the social welfare maximizing ad space choice, and the equilibrium ad space of PUBTV. When $\delta = \alpha$, any level of ad space is consistent with welfare maximization since the marginal social benefit of advertising equals the marginal social cost of advertising. The second order conditions for welfare maximization require $\delta < 2\alpha$, so comparisons between ME and PE equilibria will be made over the region $(\delta, \alpha) \in (1, 2\alpha) \times \left(\frac{1}{2}, \infty\right)$.

Just like in the PE SPNE, one or both broadcasters over provide ad space when profit per ad exceeds the viewer nuisance per ad i.e. when $\delta < \alpha$, but under provide ad space when the viewer nuisance per ad exceeds profit per ad i.e. when $\delta > \alpha$. However,

[14] No solution exists for $\alpha \leq \frac{1}{2}$.

Proposition 1 *Both broadcasters carry more optimal ad space under ME*

Proof. It follows from the expressions for equilibrium ad space that

$$a_1^P = a_2^P < a_1^M < a_2^M < a_W \quad \text{when} \quad \delta < \alpha$$

$$a_1^P = a_2^P > a_1^M > a_2^M \geq a_W \quad \text{when} \quad \delta > \alpha$$

■

When $\delta < \alpha$, both PUBTV (subscript 2) and PRITV (subscript 1) under provide ad space under ME and PE. When $\delta > \alpha$, PUBTV and / or PRITV over provide ad space under ME and PE. However, the extent of under / over provision of ad space by both broadcasters is lower under ME.

Since PUBTV behaves as a welfare maximizer under ME, it is no surprise that its ad space decisions are more optimal under ME than under PE. What is interesting to note is that PUBTV causes PRITV to make more optimal ad space decisions under ME!

Recall that when viewer nuisance per ad is less than profit per ad, it is optimal to have all producers advertising. Under PE, neither broadcaster cares about the welfare consequences of their actions, hence ad space is under provided. Under ME however, PUBTV cares about the welfare consequences of its actions, and hence carries greater ad space than it would have under PE. This permits PRITV also to carry greater ad space under ME than it would have under PE[15]. The welfare concerns of PUBTV thus permit both broadcasters to carry more ad space under ME, and hence reduce the extent of under provision of ad space.

Similarly, when viewer nuisance per ad is greater than profit per ad, it is optimal to have no producers advertising. Under PE, neither broadcaster cares about the welfare consequences of their actions, hence ad space is over provided. Under ME however, PUBTV cares about the welfare consequences of its actions, and hence carries lower ad space than it would have under PE. This forces PRITV also to carry lower ad space under ME than it would have under PE[16]. The welfare concerns of PUBTV thus force both broadcasters to carry less ad space under ME, and hence reduce the extent of over provision of ad space.

In a sense, the state broadcaster tailors the level of aggressivenes with which it competes with the private broadcaster depending on the relation-

[15] PRITV would carry more ad space if PUBTV also does so, since it would not lose market share, and hence increase its own profits.

[16] PRITV would carry less ad space if PUBTV also does so, since failing to do so would lower its market share, and hence reduce its profits.

ship between the viewer nuisance from ads and the profitability of advertising. When $\delta < \alpha$, PUBTV is a less aggressive competitor under ME, allowing PRITV to carry more ads, and thus ameliorating the under provision of ad space. When $\delta > \alpha$, PUBTV is a more aggressive competitor under ME, "disciplining" PRITV by forcing it to carry fewer ads[17], and thus ameliorating the over provision of ad space.

We now turn our attention to social welfare.

Proposition 2 *Social welfare under ME is always greater than social welfare under PE*

Proof. See Appendix ■

We have already established that the ad space decisions of **both** broadcasters are more optimal under ME than under PE. It follows that welfare from advertising is higher under ME than under PE. However, welfare from program content is lower under ME than under PE.

Symmetric advertising level choices by identical private broadcasters in a PE cause viewers to choose between programs solely on the basis of which program's content is most preferred. However, in a ME, the advertising level choices of both broadcasters are different. As a result, some viewers under ME watch the program whose content is less preferred on account of its carrying lower advertising levels than the other program. This leads to larger viewer transport costs and hence lower welfare from program content under ME.

Nevertheless, it can be shown that the welfare gains from more optimal ad space decisions under ME outweigh the welfare losses from program content **regardless** of the level of viewer nuisance from ads or the profitability of advertising. Since all other components of social welfare[18] are the same under ME and PE, it follows that social welfare under ME is always greater than that under PE. This is the central result of the paper.

We now turn our attention to broadcaster profits under ME.

Proposition 3 *PRITV profit is higher (lower) under ME when* $\delta < (>)\, \alpha$

Proof. See Appendix ■

[17] Shaw (1999, pg. 46) reports that the disciplining role of a public broadcaster was summed up by Michael Grade, formerly of the BBC (a British public broadcaster), as follows: the BBC is there to keep private broadcasters "honest".

[18] The other components of social welfare are the pure viewer benefits of watching TV and costs of broadcasting.

When $\delta < \alpha$, we have $a_1^P = a_2^P < a_1^M < a_2^M < a_W$. Notice that PRITV (subscript 1) carries higher ad space under ME than it does under PE. Moreover, both PRITV and PUBTV have the same ad space under PE, but PUBTV carries greater ad space than PRITV under ME. Thus, PRITV's market share is greater under ME and PE. Greater ad space and greater market share implies greater revenues and hence greater profits for PRITV under ME.

Thus, when the viewer nuisance per ad is less than the profit per ad, the state broadcaster's actions are to the benefit of the private broadcaster, in the sense of allowing the private broadcaster a greater level of profit under ME than under PE. The non-profit focus of the state broadcaster renders it a less aggressive[19] competitor than another private broadcaster.

When $\delta > \alpha$, we have $a_1^P = a_2^P > a_1^M > a_2^M \geq a_W$. Notice that PRITV (subscript 1) carries lower ad space under ME than it does under PE. Moreover, both PRITV and PUBTV have the same ad space under PE, but PRITV carries greater ad space than PUBTV under ME. Thus, PRITV's market share is lower under ME than under PE. Lower ad space and lower market share implies lower revenues and hence lower profits for PRITV under ME.

Thus, when the viewer nuisance per ad is greater than the profit per ad, the state broadcaster's actions are to the detriment of the private broadcaster, in the sense of allowing the private broadcaster a lower level of profit under ME than under PE. The non-profit focus of the state broadcaster renders it a more aggressive[20] competitor than another private broadcaster.

This is the two-sided market analog of the result in Sappington and Sidak (2003, pg.184), who find that a "reduced focus on profit can provide state enterprises with stronger incentives (than profit maximizing firms) to pursue activities that disadvantage competitors". Note that in the two-sided market setting, the state broadcaster is not always a more aggressive competitor than a private broadcaster - when $\delta < \alpha$, the state broadcaster's actions are to the benefit of the private broadcaster in the sense of allowing it a higher profit under ME than it could have got under PE.

In the situation where $\delta > \alpha$, the private broadcaster ends up making lower profits under ME. If the real world situation corresponds to the one where $\delta > \alpha$, then there is some justice to the complaints by private broadcasters of an uneven playing field and overly aggressive competition from

[19] By less aggressive, we mean that the state broadcaster carries more ad space than a private broadcaster would under the same conditions.

[20] By more aggressive, we mean that the state broadcaster carries less ad space than a private broadcaster would under the same conditions.

state broadcasters. How then are we to know whether $\delta > \alpha$, or $\delta < \alpha$?

The model finds that ad space is over provided under ME when $\delta > \alpha$. The common perception is also that ad space is over provided; this is the reason why regulations have been enacted the world over to curb over provision of ad space. If the common perception is correct, we are in a situation where $\delta > \alpha$. In this case, while there may be some justice to the complaints of private broadcasters, no regulatory action is called for since welfare is invariably enhanced by the presence and operation of state broadcasters[21].

Proposition 4 *PUBTV profit is higher (lower) under ME when* $\delta < (>)\, \alpha$

Proof. See Appendix ■

When $\delta < \alpha$, PUBTV carries greater ad space and has lower market share under ME. However, the positive revenue effects of greater ad space outweigh the negative revenue effects of lower market share. For a given cost of broadcasting, this translates into higher PUBTV profits under ME. Thus, it is possible for both broadcasters to make higher profits under ME if the advertising nuisance level is low enough. This is a "win-win-win" situation since both broadcasters make higher profits, and society as a whole is better off.

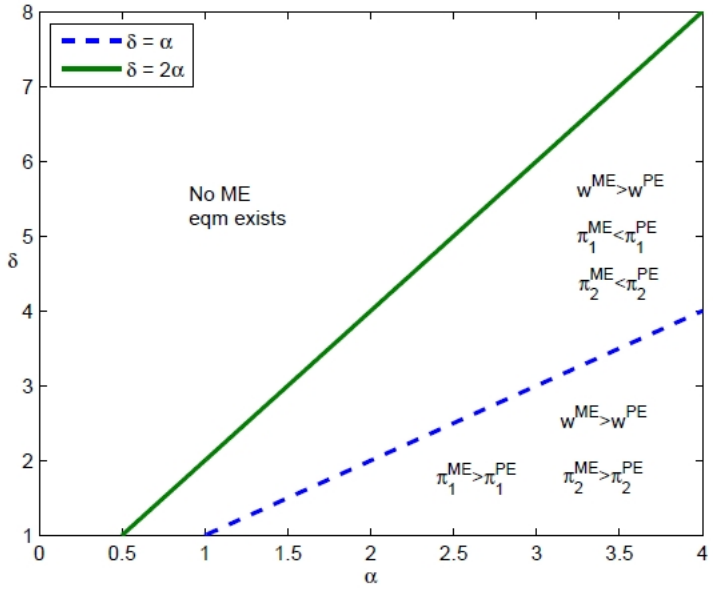
When $\delta > \alpha$, PUBTV carries lower ad space and has higher market share under ME. However, the negative revenue effects of lower ad space outweigh the positive revenue effects of higher market share. For a given cost of broadcasting, this translates into lower PUBTV profits under ME.

In this situation, the welfare gains under ME do not come for free. Whenever the viewer nuisance per ad exceeds the profit per ad, the increased aggression of the state broadcaster in terms of ad space reductions results in welfare improving ad space choices by both state and private broadcasters, but at the cost of the state broadcaster making lower profits under ME than under PE.

When $\delta \in \left(\frac{5}{4}\alpha, \frac{4}{3}\alpha\right)$, the state broadcaster makes lower profits than the private broadcaster under ME. This would tend to support claims that the real world corresponds to the case where $\delta > \alpha$, since it is not uncommon to find that state broadcasters are less profitable than their private sector counterparts.

[21] Of course, even if the common perception is wrong, and we are in a situation where $\delta < \alpha$, no regulatory action is called for since the complaints by private broadcasters could then be dismissed as false.

Figure 1: The main results



When $\delta > \frac{4}{3}\alpha$, the state broadcaster does not carry any ads, and therefore makes losses from operating. Clearly, it would require some form of budgetary support in order to perform its public service mandate. As long as the deadweight losses involved in raising funds to support the state broadcaster do not negate the welfare gains from having an operational state broadcaster, a welfare argument could be made to support the continuing operations of loss making state broadcasters.

Figure 1 depicts the main results of the analysis and the parameter ranges over which they hold, namely:

1. ad space decisions of **both** broadcasters are more optimal under ME than under PE

2. welfare from advertising is higher, welfare from program content is lower, but total welfare is higher under ME regardless of the profitability of advertising or the viewer nuisance level from advertisements

3. profits of **both** broadcasters are higher (lower) under ME if viewer nuisance per ad is lower (higher) than profit per ad

5 Conclusion

In this paper, we consider program content and advertising levels in a mixed economy television broadcast industry under the FTA technology regime, where a welfare maximizing state owned broadcaster competes with a profit maximizing private broadcaster. With regard to competition between advertisers, we consider a homogenous product market structure. We treated the choice of program content and advertising intensity as endogenous, and contrasted the equilibria in a mixed economy with that in a purely private economy industry structure.

With regard to ad space decisions, we found that competition between the state and the private broadcaster causes the private broadcaster to choose levels of ad space that are more optimal than when the private broadcaster competes with another private broadcaster. Since the state broadcaster also chooses more optimal levels of ad space than it would if it were privately owned, welfare from advertising is higher under ME than under PE.

With regard to program content, we find that broadcasters prefer content differentiation to content duplication in equilibrium, regardless of broadcasting market structure (ME or PE). This is because content duplication would lead to a "race to the bottom" in terms of advertising levels and thus zero advertising revenue for both broadcasters, as well as a reduction in social welfare on account of (1) lost opportunities for gains from trade between advertisers and viewers, and (2) increased viewer transport costs.

Welfare from program content is lower under ME than under PE. Symmetric advertising level choices by identical private broadcasters in a PE cause viewers to choose between programs solely on the basis of which program's content is most preferred. However, in a ME, the advertising level choices of both broadcasters are different. As a result, some viewers under ME watch the program whose content is less preferred on account of its carrying lower advertising levels than the other program. This leads to lower welfare from program content under ME. However, we show that the welfare gains from more optimal ad space decisions more than outweigh the welfare losses from program content, regardless of the profitability of advertising or the nuisance value of advertising. Therefore, total welfare under ME is always higher than total welfare under PE.

Private broadcaster profit is lower under ME when the nuisance value of advertising exceeds the profitability of advertising. However, when the profitability of advertising exceeds the nuisance value of advertising, private broadcaster profit is actually higher under ME! Thus, it is possible to have a

"win-win-win"situation under ME, with both broadcasters as well as society as a whole being better off.

When the profitability of advertising exceeds the nuisance value of advertising, competing with a state broadcaster allows the private broadcaster to carry a larger ad space as well as have a greater market share than when competing with another private broadcaster. For a given cost of broadcasting, this gives the private broadcaster greater revenues and thus greater profits under an ME. However, if the nuisance value of advertising exceeds the profitability of advertising, competing with a state broadcaster forces the private broadcaster to curtail its ad space to a greater extent as well as have a lower market share than when competing with another private broadcaster. For a given cost of broadcasting, this gives the private broadcaster lower revenues and thus lower profits under ME.

Therefore, depending on the level of nuisance from ads and the profitability of advertising, the state broadcaster takes actions that are either to the benefit of, or to the detriment of the private broadcaster (where benefit means profit and detriment means loss). This result is the two sided market analog of the result in Sappington and Sidak (2003, pg.184), who find that a "reduced focus on profit can provide state enterprises with stronger incentives to pursue activities that disadvantage competitors". When the nuisance value of advertising exceeds it profitability, there may be some justice to the complaints of private broadcasters of an uneven playing field and overly aggressive competition from state broadcasters, but no regulatory action is called for since welfare is invariably enhanced by the presence and operation of state broadcasters.

Under certain conditions on the nuisance level and profitability of advertising, the state broadcaster may incur losses while attempting to carry out its PSB mandate. In such situations, if the deadweight losses incurred in raising public funds to provide budgetary support to the state broadcaster is low enough, a welfare argument can be made for the continued existence and operation of state broadcasters, even if they are loss making. Privatizing the state broadcaster, although it may result in increased profits for the state broadcaster, would inevitably reduce social welfare on account of less optimal ad space decisions by the privatized entity.

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Appendix

Proof of Proposition 2

Proposition 2 stated that social welfare under ME is always greater than that under PE. The proof is divided into subparts based on the vaues of δ and α as follows:

Low advertising profits case

When $(\delta, \alpha) \in (1, 2\alpha) \times \left(\frac{1}{2}, \frac{3}{4}\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. Evaluating the welfare expressions at these levels of ad space, we have $w^{ME} > w^{PE}$ if $\delta > \frac{14}{13}\alpha$. This is true for all $(\delta, \alpha) \in (1, 2\alpha) \times \left(\frac{1}{2}, \frac{3}{4}\right)$.

Intermediate advertising profits case

When $(\delta, \alpha) \in \left(1, \frac{4}{3}\alpha\right) \times \left[\frac{3}{4}, 1\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. Evaluating the welfare expressions at these levels of ad space, we have $w^{ME} > w^{PE}$ if $\frac{5(\alpha-\delta)^2}{4\delta(2\alpha-\delta)} > 0$. This is true for all $(\delta, \alpha) \in \left(1, \frac{4}{3}\alpha\right) \times \left[\frac{3}{4}, 1\right)$ since the SOC for welfare maximization requires that $\delta < 2\alpha$.

When $(\delta, \alpha) \in \left[\frac{4}{3}\alpha, 2\alpha\right) \times \left[\frac{3}{4}, 1\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. Evaluating the welfare expressions at these levels of ad space, we have $w^{ME} > w^{PE}$ if $\delta > \frac{14}{13}\alpha$. This is true for all $(\delta, \alpha) \in \left[\frac{4}{3}\alpha, 2\alpha\right) \times \left[\frac{3}{4}, 1\right)$.

High advertising profits case

When $(\delta, \alpha) \in \left(1, \frac{4}{3}\alpha\right] \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. Evaluating the welfare expressions at these levels of ad space, we have $w^{ME} > w^{PE}$ if $\frac{5(\alpha-\delta)^2}{4\delta(2\alpha-\delta)} > 0$. This is true for all $(\delta, \alpha) \in (1, \alpha] \times (1, \infty)$ since the SOC for welfare maximization requires that $\delta < 2\alpha$.

When $(\delta, \alpha) \in \left(\frac{4}{3}\alpha, 2\alpha\right) \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. Evaluating the welfare expressions at these levels of ad space, we have $w^{ME} > w^{PE}$ if $\delta > \frac{14}{13}\alpha$. This is true for all $(\delta, \alpha) \in \left(\frac{4}{3}\alpha, 2\alpha\right) \times (1, \infty)$.

All subparts together show that regardless of the values of δ and α, it is always the case that $w^{ME} > w^{PE}$. Thus, Proposition 2 stands proved.

Proof of Proposition 3

Proposition 3 stated that PRITV profit is higher (lower) under ME when $\delta < (>)\, \alpha$. The proof is divided into subparts based on the vaues of δ and

α as follows:

Low advertising profits case

When $(\delta, \alpha) \in (1, 2\alpha) \times \left(\frac{1}{2}, \frac{3}{4}\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $-\frac{3\alpha}{8\delta} < 0$. This is true for all $(\delta, \alpha) \in (1, 2\alpha) \times \left(\frac{1}{2}, \frac{3}{4}\right)$.

Intermediate advertising profits case

When $(\delta, \alpha) \in \left(1, \frac{4}{3}\alpha\right) \times \left[\frac{3}{4}, 1\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $\frac{\alpha(5\alpha-3\delta)(\alpha-\delta)}{2\delta(2\alpha-\delta)^2} < 0$, i.e. if $\delta \in \left(\alpha, \frac{5}{3}\alpha\right)$. This is true for all $(\delta, \alpha) \in \left(1, \frac{4}{3}\alpha\right) \times \left[\frac{3}{4}, 1\right)$.

When $(\delta, \alpha) \in \left[\frac{4}{3}\alpha, 2\alpha\right) \times \left[\frac{3}{4}, 1\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $-\frac{3\alpha}{8\delta} < 0$. This is true for all $(\delta, \alpha) \in \left[\frac{4}{3}\alpha, 2\alpha\right) \times \left[\frac{3}{4}, 1\right)$.

High advertising profits case

When $(\delta, \alpha) \in (1, \alpha) \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. In this range of (δ, α) values we have $\delta < \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} > \pi_1^{PE}$ if $\frac{\alpha(5\alpha-3\delta)(\alpha-\delta)}{2\delta(2\alpha-\delta)^2} > 0$, i.e. if $\delta < \alpha$. This is true for all $(\delta, \alpha) \in (1, \alpha] \times (1, \infty)$.

When $(\delta, \alpha) \in \left(\alpha, \frac{4}{3}\alpha\right] \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $\frac{\alpha(5\alpha-3\delta)(\alpha-\delta)}{2\delta(2\alpha-\delta)^2} < 0$, i.e. if $\delta \in \left(\alpha, \frac{5}{3}\alpha\right)$. This is true for all $(\delta, \alpha) \in \left(\alpha, \frac{4}{3}\alpha\right] \times (1, \infty)$.

When $(\delta, \alpha) \in \left(\frac{4}{3}\alpha, 2\alpha\right) \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $-\frac{3\alpha}{8\delta} < 0$. This is true for all $(\delta, \alpha) \in \left(\frac{4}{3}\alpha, 2\alpha\right) \times (1, \infty)$.

All subparts together show that PRITV profit is higher (lower) under ME when $\delta < (>) \alpha$. Thus, Proposition 3 stands proved.

Proof of Proposition 4

Proposition 4 stated that PUBTV profit is higher (lower) under ME when $\delta < (>)\, \alpha$. The proof is divided into subparts based on the vaues of δ and α as follows:

Low advertising profits case

When $(\delta, \alpha) \in (1, 2\alpha) \times \left(\frac{1}{2}, \frac{3}{4}\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_2^{ME} < \pi_2^{PE}$ if $-\frac{\alpha}{2\delta} < 0$. This is true for all $(\delta, \alpha) \in (1, 2\alpha) \times \left(\frac{1}{2}, \frac{3}{4}\right)$.

Intermediate advertising profits case

When $(\delta, \alpha) \in \left(1, \frac{4}{3}\alpha\right) \times \left[\frac{3}{4}, 1\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $\frac{\alpha(\alpha-\delta)}{2(2\alpha-\delta)^2} < 0$, i.e. if $\delta > \alpha$. This is true for all $(\delta, \alpha) \in \left(1, \frac{4}{3}\alpha\right) \times \left[\frac{3}{4}, 1\right)$.

When $(\delta, \alpha) \in \left[\frac{4}{3}\alpha, 2\alpha\right) \times \left[\frac{3}{4}, 1\right)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $-\frac{\alpha}{2\delta} < 0$. This is true for all $(\delta, \alpha) \in \left[\frac{4}{3}\alpha, 2\alpha\right) \times \left[\frac{3}{4}, 1\right)$.

High advertising profits case

When $(\delta, \alpha) \in (1, \alpha) \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. In this range of (δ, α) values we have $\delta < \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} > \pi_1^{PE}$ if $\frac{\alpha(\alpha-\delta)}{2(2\alpha-\delta)^2} > 0$, i.e. if $\delta < \alpha$. This is true for all $(\delta, \alpha) \in (1, \alpha] \times (1, \infty)$.

When $(\delta, \alpha) \in \left(\alpha, \frac{4}{3}\alpha\right] \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{3\alpha-2\delta}{\delta(2\alpha-\delta)}, \frac{4\alpha-3\delta}{\delta(2\alpha-\delta)}\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $\frac{\alpha(\alpha-\delta)}{2(2\alpha-\delta)^2} < 0$, i.e. if $\delta > \alpha$. This is true for all $(\delta, \alpha) \in \left(\alpha, \frac{4}{3}\alpha\right] \times (1, \infty)$.

When $(\delta, \alpha) \in \left(\frac{4}{3}\alpha, 2\alpha\right) \times (1, \infty)$, we have $\left(a_1^P, a_2^P\right) = \left(\frac{1}{\delta}, \frac{1}{\delta}\right)$ and $\left(a_1^M, a_2^M\right) = \left(\frac{1}{2\delta}, 0\right)$. In this range of (δ, α) values we have $\delta > \alpha$. Evaluating the profit expressions at these levels of ad space, we have $\pi_1^{ME} < \pi_1^{PE}$ if $-\frac{\alpha}{2\delta} < 0$. This is true for all $(\delta, \alpha) \in \left(\frac{4}{3}\alpha, 2\alpha\right) \times (1, \infty)$.

All subparts together show that PUBTV profit is higher (lower) under ME when $\delta < (>) \alpha$. Thus, Proposition 4 stands proved.