Welfare effects of public service broadcasting in a free-to-air TV market

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Abstract

Viewer's private information consumption generates external benefits for society, because information improves the ability of voters to control politicians. Our study compares two settings in a free-to-air TV market: a differentiated duopoly of private channels and an oligopoly with both private channels and a public service broadcaster broadcasting information as well as entertainment programs. We find that welfare effects of public service broadcasting depend on its program design and cost efficiency, the external benefits of voter's information, and the magnitude of lost rents from the advertising market.

JEL: L82; D72; L32

Keywords: Media, two-sided TV market, information externalities

1 Introduction

Most European countries have a TV market that consists not only of private broadcasters, but also of public service broadcasters, that is, institutions that do not maximize profits but pursue collectively defined aims and which are financed primarily by taxes (Spain) or license fees, levied on households (Sweden) or devices (Germany up to 2012). In Germany, about 20% of channels are public channels, with the two national public service channels ARD and ZDF reaching a viewer market share of over 25%.[1] Recently, European public broadcasters have expanded their activities to the provision of internet content and thereby triggered a new debate about the eligibility of public service broadcasting in a digital world in general (Armstrong, 2005; Hargreaves Heap, 2005; Armstrong and Weeds, 2007; European Commission, 2009).

With regard to analog technology, economists have carved out several justifications for state intervention in the TV market, most of them not applicable to the broadcasting technology available today. However, one argument still applies in a digital world: information consumption does not only generate positive private utility but also external benefits for society (Downs, 1957; Armstrong, 2005; von Hagen and Seabright, 2007). In the Amsterdam Treaty of the European Union (EU) public broadcasting is seen as to be directly related to the "democratic [...] needs of each society" (European Union, 1997, p. 109). Especially politicians who advocate public service broadcasting (European Commission, 2009; Department for Culture Media and Sport, 2006) heavily rely on the effect that a high-quality public broadcaster improves the ability of the citizenship to competently participate in democratic decisions. From an economics point of view, selecting and monitoring politicians can be considered a principal-agent problem with voters as principals and politicians as agents. Media coverage of politicians and policies increases voter information of current issues, which increases the responsiveness of voters to alternative policies, which, in turn, increases the effort and the selection of politicians (Prat and Strömberg, 2011). As a result, voter's information consumption results in better policies.

However, the information consumption through TV channels is a private decision for each voter. A voter considers the private costs of subscribing to a channel, which is zero if it is a free-to-air channel, and the opportunity costs of time for watching the program (and commercial breaks). On the other hand a voter benefits from the entertaining value of the TV program and, if this program is informative, then the additional private benefit he or she derives from voting (and living)

[1] Data available at the MAVISE database: http://mavise.obs.coe.int/ and the Arbeitsgemeinschaft Fernsehforschung (AGF): http://www.agf.de/.

informed. The rational voter does not consider the external (social) benefit of information for all other citizens. Each voter's amount of information consumption is, therefore, socially suboptimal. Public service broadcasting can remedy this market failure through the free provision of informational programs. However, even if an informational program is provided for free, still some voters will not watch it, because this would take the time they like to spend watching a more entertaining program (Armstrong, 2005). Voters who usually do not watch news, but shows and sport, watch news if it is are broadcasted in between the half-time interval of a soccer match or a popular show, similar to how they watch the commercial break on a private TV channel (Rothbauer and Sieg, 2010). To improve consumption of information, a possible strategy might, therefore, be to attract voters through the broadcasting of entertaining programs mixed with informational content.

Against this background, we study the market entry or exit of a public service channel, broadcasting a mix of information and entertainment but no commercials, into or out of a duopoly of free-to-air private TV channels. We calculate the reaction of the private channels and the advertisers in the two-sided TV market and identify the conditions if and when a market entry or exit of the public channel is welfare enhancing.

There are several broadcasting market studies focusing on different market structures and failures. Anderson and Coate (2005) also make a welfare analysis of a broadcasting market, but focus on the market outcome of commercial broadcasting. They are interested in the question as to whether there is an over- or under-provision of advertisements and over- or under-provision of programs. We look at the external effects of the consumption of informational programs, an effect that they do not model. However, we follow the seminal paper of Anderson and Coate (2005) in many aspects.

Choi (2006) analyzes market entry in the broadcasting industry and the aligned market failure. He considers entry decisions of private channels that compete for viewers and commercial revenues. We analyze the market entry of a public service TV channel that is not interested in commercial revenues and does not broadcast commercials. However, the public channel attracts viewers and therefore reduces revenues of the private channels. By assuming free entry and exit of channels Choi (2006) determines the optimal number of channels and detects market failure of over- and under provision of channels. We do not allow for entry and exit of private channels but consider a viable duopoly and analyze entry and exit of a public channel.

Kind et al. (2007) analyze a public service TV channel that can partly correct market distortions. Similar to our approach, they analyze a mixed oligopoly of one pubic channel and two private free-to-air TV channels. However, the aim of the public channel is to correct for the not welfare maximizing level of advertising in the unregulated duopoly of private channels. They do not consider the external effect of information on welfare.

Prat and Strömberg (2005) compare a public monopoly and a mixed duopoly with one public and one private broadcaster. The public channel is journalistically independent, but the government influences the amount of resources that are available to the public broadcaster and whether the broadcaster should tailor its news coverage to specific socio-economic groups in order to improve their re-election probabilities. Whereas Prat and Strömberg (2005) assume that the designs of the incentives of the public broadcaster are driven by re-election efforts of politicians, we do not analyze the objectives of the public broadcaster but instead evaluate the market outcome and the welfare effects of a broad variety of public program policies.

2 Model

We model a free-to-air broadcasting system common in many European countries such as the United Kingdom, Germany, and France.

There are two types of TV programs. First, a TV channel may broadcast entertaining shows, where the broadcasting time of shows is denoted by $t_s \in [0, 1]$. Second, a TV channel may broadcast informational programs such as newscasts, features about science, or economics and so on where the broadcasting time of information programs is denoted by $t_{inf} \in [0, 1]$. Finally, a TV channel may broadcast commercials, where the broadcasting time of commercials is denoted by $t_a \in [0,1]$. Total broadcasting time is normalized to one, such that $t_s+t_{inf}+t_a = 1$. Production costs of all type of programs and commercials do not differ such that broadcasting one unit of time costs c_{pr}.

The number of consumers is normalized to one, and each consumer watches one channel for one unit of time. Voters are heterogeneous in their preferences for shows and information. The preference parameter $\lambda \in [0,1]$ is equally distributed. The utility of voter λ from TV consumption is

$$U_\lambda = \lambda \cdot t_s + (1-\lambda) \cdot t_{inf}. \tag{1}$$

We assume that consumers do not switch channels but watch the utility maximizing TV channel (Anderson and Coate, 2005; Peitz and Valetti, 2008). If channels broadcast the same number of programs, then all consumers with $\lambda < 1/2$ prefer the channel broadcasting more information, whereas all consumers with $\lambda > 1/2$ prefer the channel broadcasting more shows. No voter likes television advertising. We do not consider nuisance cost of advertisements but assume that the utility watching commercials is zero.[2]

[2]This utility function is similar to the function used by Anderson and Coate (2005) considering the special case of nuisance costs $\gamma = 0$ and transport costs $\tau = 1$. Let s denote type 0 and inf denote type 1 in the sense of Anderson and Coate (2005). A consumer watching t_0 channel 0 and t_1 channel one, both broadcasting t_a commercials, gets an Anderson and Coate (2005) utility

$$U_\lambda^{AC} = t_0\left[\beta - \gamma t_a - \tau\lambda\right] + t_1\left[\beta - \gamma t_a - \tau(1-\lambda)\right] \tag{2}$$

Because $t_1 = 1 - t_a - t_0$ and we consider the case $dt_a = 0$ it follows$dt_1 = -dt_0$ and therefore

$$\frac{dU_\lambda^{AC}}{dt_0} = \tau(1-2\lambda) \tag{3}$$

and

$$\frac{dU_\lambda}{dt_0} = -1 + 2\lambda. \tag{4}$$

Therefore, for each consumer $\lambda \in [0,1]$, there is a consumer $\kappa = 1-\lambda \in [0,1]$ such that

$$\frac{dU_\lambda^{AC}}{dt_0} = \frac{dU_\kappa}{dt_0}. \tag{5}$$

Marginal utility of an additional minute of one channel is the same.

We consider advertising that informs consumers about new products they would buy if they knew them (Grossman and Shapiro, 1984). Let, as in Choi (2006, p. 190), the demand for commercials per viewer when the level of advertising is t_a be

$$p(t_a) = a \cdot t_a^{-\beta}. \tag{6}$$

$0 < \beta < 1$ is the constant elasticity, and $a > 0$ represents the benefit that informative advertising provides to advertisers.[3] As in Anderson and Coate (2005), consumer surplus of actually buying the advertised product is assumed to be zero. Revenues per viewer are $R(t_a) = p(t_a) \cdot t_a$. The viewer base v of a channel is not fixed but changes due to the competition from other channels depending on advertising levels and program type.[4] Free-to-air channels maximize profits

$$\Pi(t_a) = p(t_a) \cdot t_a \cdot v - c_{pr}. \tag{7}$$

Since consumers single home, broadcasting stations hold monopoly power over access to their viewers. Advertisers' per viewer surplus from advertising t_a units of time is represented by

$$\int_0^{t_a} p(t)dt. \tag{8}$$

Since consumers do not like commercials, channels may attract rival's audience attention by reducing broadcasting time for commercials. If both channels broadcast the same contents, then the channel with marginally less commercials attracts all viewers. However, a reduction of commercials jeopardizes revenues. Gabszewicz et al. (2004) and Peitz and Valetti (2008) model this kind of programming and advertising competition and show that to mitigate this Bertrand-fashion competition, channels reinforce program differentiation. If viewer dislike commercials, then content duplication does not occur. We do not model programming competition but assume a duopoly of two differentiated TV channels, a show channel

[3] The demand per viewer function used by Anderson and Coate (2005) differs in their special form to the demand function we adopted from Choi (2006, p. 190). However, both functions are log concave with decreasing per viewer marginal revenue.

[4] Since we assume that the market is covert in any case, v can also be interpreted as market share.

that broadcasts entertainment and commercials only and an information channel that does not broadcast entertaining shows, but information programs and commercials.

The consumption of informational programs creates an external effect, because voter information "increases the responsiveness of voters to policy, which increases the effort and selection of politicians, producing better policies," (Prat and Strömberg, 2011, p. 30), an effect that a single voter only partially considers when choosing a TV channel. The external effect is modeled as in Rothbauer and Sieg (2010) by normalizing the pre-TV information of each voter to zero, such that a positive level of information is only reached by watching informational programs on TV. Therefore, a voter who watches channel ch possesses $I_\lambda = t_{inf}^{ch}$ information. We call the output of (better) policies Y and assume that information I is the only factor of production. Due to universal suffrage, each voter equally influences the production of Y through his or her amount of information, that is, two voters, $\lambda, \kappa \in [0, 1]$ who share the same amount of information, $I_\lambda = I_\kappa$, have the same marginal product, $\partial Y/\partial I_\lambda = \partial Y/\partial I_\kappa$. Therefore, there exists a function, $g : [0, 1] \to \mathbb{R}$, such that $Y = \int_0^1 g(I_\lambda)d\lambda$. We assume that marginal information consumption has a nonnegative effect on Y, because policies are better when the citizenry is well informed. Further, we assume a diminishing marginal product of information. A minute of additional information is much more useful for a voter who is quite uninformed than for a voter who already has a large stock of information. We define the social output of information

$$Y = \int_0^1 I_\lambda^\alpha d\lambda \tag{9}$$

where $0 < \alpha < 1$ determines how fast the marginal productivity of information consumption diminishes.

3 Market equilibria

3.1 Duopoly of two private channels

In the Nash equilbrium of the duopoly, both private channels maximize profits (7) through the optimal choice of commercial broadcasting time t_a sold to the advertisers. Private channels sell the time t_a for the price $p(t_a)$ according to (6). The price a channel may charge is independent of the time the competing channel is offering, whereas competition between channels is through the market share of viewers. Increasing the time of commercials decreases the utility a consumer receives from viewing and may let him switch to the other channel. If the show channel broadcasts t_{as} commercials and the information channel t_{ai}, then the viewer $\tilde{\lambda} = (1 - t_{ai})/(2 - t_{ai} - t_{as})$ is indifferent between both channels. Therefore, $v_i = \tilde{\lambda}$ viewers watch the information channel and $v_s = 1 - \tilde{\lambda}$, the show channel. Assuming a given time of commercials of the competing channel, channels maximize profits $\Pi_j = v_j \cdot p(t_{aj}) \cdot t_{aj}$, $j \in \{i, s\}$. The best response function for the information channel is

$$t_{ai}^b = \frac{3 - t_{as}}{2} + \frac{1 - t_{as} - \sqrt{(1 - t_{as})\left(8 - (8 - \beta)\beta - (2 - \beta)^2 t_{as}\right)}}{2(1 - \beta)} = t^b(t_{as}), \quad (10)$$

and for the show channel, analogously, $t_{as}^b = t^b(t_{ai})$.

In the Nash equilibrium of the duopoly, the broadcasting time of commercials is

$$t_{ai}^+ = t_{as}^+ = 1 - \frac{1}{3 - 2\beta}. \quad (11)$$

The broadcasting time of non-commercial programs is

$$t_i^+ = t_s^+ = 1 - t_{aj}^+ = \frac{1}{3 - 2\beta}. \quad (12)$$

The price for commercials is

$$p_i^+ = p_s^+ = a \cdot (t_{aj}^+)^{-\beta} = a \left(1 - \frac{1}{3 - 2\beta}\right)^{-\beta}. \quad (13)$$

As a result, $\tilde{\lambda}^+ = 1/2$, and both channels reach the same market share of $v_i^+ = v_s^+ = 1/2$. Equilibrium profits are

$$\Pi_i^+ = \Pi_s^+ = v_j^+ \cdot p_j^+ \cdot t_{aj}^+ - c_{pr} = a(2 - 2\beta)^{-\beta}(3 - 2\beta)^{-1+\beta}(1 - \beta) - c_{pr}. \quad (14)$$

In this market, consumers earn a surplus of

$$\begin{aligned} CR^+ &= \int_0^{\tilde{\lambda}^+} t_i^+ \cdot (1-\lambda)\, d\lambda + \int_{\tilde{\lambda}^+}^1 t_s^+ \cdot \lambda\, d\lambda \\ &= \frac{3}{12-8\beta}. \end{aligned} \tag{15}$$

The first integral is the consumer surplus from watching the information channel, and the second integral, from watching the show channel. The surplus for the firms that buy commercials is

$$\begin{aligned} R^+ &= v_i^+ \int_0^{t_{ai}^+} a \cdot (t_{ai}^+)^{-\beta} - p_i^+ \, dt_{ai} + v_s^+ \int_0^{t_{as}^+} a \cdot (t_{as}^+)^{-\beta} - p_s^+ \, dt_{as} \\ &= a(1-\beta)^{-\beta} \left(\frac{3}{2} - \beta\right)^{\beta-1} \beta, \end{aligned} \tag{16}$$

where the first term is the surplus of advertisers on the information channel and the second term, from advertisers on the show channel. Since only viewers of the information channel, that is, $\lambda \in [0, \tilde{\lambda}^+]$ consume informational content, the social output of information is

$$Y^+ = \int_0^{\tilde{\lambda}^+} (t_i^+)^\alpha \, d\lambda = \frac{1}{2}(3-2\beta)^{-\alpha}. \tag{17}$$

It is easy to sum up the rents as well as the informational rents to get a welfare of

$$\begin{aligned} W^+ &= \Pi_i^+ + \Pi_s^+ + CR^+ + R^+ + Y^+ \\ &= \frac{\frac{1}{4}\left(2(3-2\beta)^{1-\alpha} + a \cdot 2^{3-\beta}\left(\frac{1}{1-\beta} + 2\right)^\beta + 3\right) + (4\beta - 6)c_{pr}}{3-2\beta}. \end{aligned} \tag{18}$$

3.2 A Public Channel and two private channels

Now we consider an oligopoly of two private and a public channel broadcasting t_p of information and $1 - t_p$ of entertaining shows. Production costs c_p are financed by a non-distorting tax. The public channel acts as a Stackelberg leader deciding to enter the market and to broadcast t_p of information.

The objective of the public broadcaster entering the market is not in the focus of this study. We rather analyze the outcome of entry with a program policy t_p. The objective of the public broadcaster is decided by the government through a political process. Interest groups of this process are private channels that prefer no competition with a public channel at all. When competition occurs, the information channel prefers a low t_p, whereas the show channel prefers a high t_p. Private firms who buy commercials prefer a small public channel, because they are not able to reach consumers who watch the public channel. Politicians may follow these interest groups. Another approach is that politicians try to maximize welfare by establishing a public channel or they could try to maximize Y in order to stabilize democracy. By maximizing Y, they could accept a constraint of not sacrificing welfare for additional Y. However, they could also be willing to reduce overall welfare just to improve Y. We do not analyze the process and the result of this political process but analyze arbitrary policies for the public channel. We ask if and when it is possible to enter the duopoly of private channels with a public channel and improve welfare and Y by not displacing the private channels completely.

The public channel broadcasting entertainment and information attracts viewers of both channels and is, therefore, competing with both channels. However, both private channels are not competing directly anymore. If all channels attract viewers, then a small change of commercial broadcasting time or the public program may induce a viewer of the show channel to switch to the public channel, but this viewer will never switch to the information channel directly. Consumer of type

$$\tilde{\lambda}_i = \frac{t_{ai} + t_p - 1}{t_{ai} + 2(t_p - 1)} \tag{19}$$

is indifferent between the information and the public channel, consumer of type

$$\tilde{\lambda}_s = \frac{t_p}{2t_p - t_{as}} \tag{20}$$

is indifferent between the show and the public channel (see Figure 1).

The private show channel, therefore, only competes with the public channel. To maximize profits, the best response is, therefore, depends only the public program

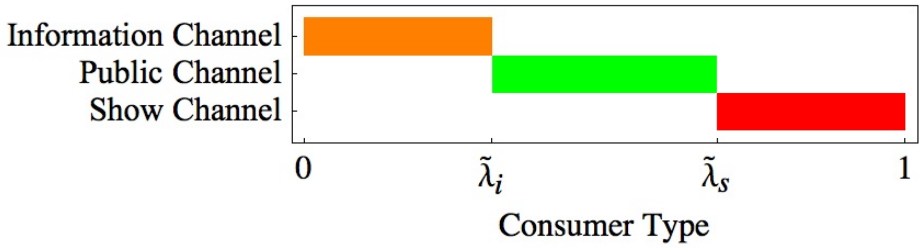

Figure 1: Consumer type and channel choice

policy t_p:

$$t^*_{as}(t_p) = \frac{\hat{\beta}}{2(1-\beta)} \cdot t_p \tag{21}$$

with $\tilde{\beta} = \sqrt{8-(8-\beta)\beta}$ and $\hat{\beta} = 4-3\beta-\tilde{\beta}$. Analogously, the private information channel responds by

$$t^*_{ai}(t_p) = \frac{\hat{\beta}}{2(1-\beta)} \cdot (1-t_p). \tag{22}$$

Using these best-response functions, we can calculate the indifferent viewers and market shares. Interestingly, both do not depend on the public channels program t_p. Indifferent viewers are

$$\tilde{\lambda}^*_i = \frac{t^*_{ai} + t_p - 1}{t^*_{ai} + 2(t_p - 1)} = \frac{1}{4}\left(-\tilde{\beta} - \beta + 4\right) \tag{23}$$

and

$$\tilde{\lambda}^*_s = \frac{t_p}{2t_p - t^*_{as}} = \frac{1}{4}\left(\tilde{\beta} + \beta\right). \tag{24}$$

Thus, the public channel attracts viewers of an amount of

$$v^*_p = \tilde{\lambda}^*_s - \tilde{\lambda}^*_i = \frac{1}{2}\left(\tilde{\beta} + \beta - 2\right) \tag{25}$$

and an amount of

$$v^*_i = \tilde{\lambda}^*_i = v^*_s = (1 - \tilde{\lambda}^*_s) = \frac{1}{4}\left(4 - \tilde{\beta} - \beta\right) \tag{26}$$

viewers stay with their preferred private channel.

Prices for commercials depend on the public channels program t_p. The price for commercials on the information channel is

$$p^*_i = a \cdot (t^*_{ai})^{-\beta} = a \cdot 2^{\beta}\left(\frac{\hat{\beta}(1-t_p)}{1-\beta}\right)^{-\beta} \tag{27}$$

and

$$p_s^* = a \cdot (t_{as}^*)^{-\beta} = a \cdot 2^{\beta} \left(\frac{\hat{\beta} t_p}{1-\beta} \right)^{-\beta} \tag{28}$$

on the show channel.

Now the profits of the private channels are

$$\Pi_i^* = v_i^* \cdot p_i^* \cdot t_{ai}^* - c_{pr} = \frac{a \cdot (1-t_p)^{1-\beta} \bar{\beta} \hat{\beta}^{1-\beta}}{2^{3-\beta}(1-\beta)^{1-\beta}} - c_{pr} \tag{29}$$

with $\bar{\beta} = 4 - \beta - \tilde{\beta}$ and

$$\Pi_s^* = v_s^* \cdot p_s^* \cdot t_{as}^* - c_{pr} = \frac{a \cdot t_p^{1-\beta} \bar{\beta} \tilde{\beta}^{1-\beta}}{2^{3-\beta}(1-\beta)^{1-\beta}} - c_{pr}. \tag{30}$$

Consumers watching the private information channel earn rents

$$CR_i^* = \int_0^{\tilde{\lambda}_i^*} t_i^* \cdot (1-\lambda) d\lambda = \frac{\left(\beta\left(\beta+\tilde{\beta}\right)-2\right)\left(2-\beta-\tilde{\beta}-t_p\hat{\beta}\right)}{2(1-\beta)\left(\beta-\tilde{\beta}\right)^2}. \tag{31}$$

Consumers watching the private show channel earn rents

$$\begin{aligned} CR_s^* &= \int_{\tilde{\lambda}_s^*}^{1} t_s^* \cdot \lambda \, d\lambda \\ &= \frac{2-\beta\left(\beta+\tilde{\beta}\right)}{\left(\beta-\tilde{\beta}\right)^2} - \frac{t_p\left(4-\tilde{\beta}+\beta\left(1-2\tilde{\beta}-2\beta\left(3-\beta-\tilde{\beta}\right)\right)\right)}{(1-\beta)\left(\beta-\tilde{\beta}\right)^2}. \end{aligned} \tag{32}$$

Consumer watching the public channel earn rents

$$CR_p^* = \int_{\tilde{\lambda}_i^*}^{\tilde{\lambda}_s^*} t_p \cdot (1-\lambda) + (1-t_p) \cdot \lambda \, d\lambda = -\frac{1}{2} + \frac{\beta}{4} + \frac{1}{4}\tilde{\beta}. \tag{33}$$

Firms who buy commercials from the private information channel earn rents

$$R_i^* = v_i^* \int_0^{t_{ai}^*} a \cdot (t_{ai}^*)^{-\beta} - p_i^* \, dt_{ai} = \frac{a\beta\bar{\beta}(1-t_p)^{1-\beta}\hat{\beta}^{1-\beta}}{2^{3-\beta}(1-\beta)^{2-\beta}}. \tag{34}$$

Firms who buy commercials from the private show channel earn rents

$$R_s^* = v_s^* \int_0^{t_{as}^*} a \cdot (t_{as}^*)^{-\beta} - p_s^* \, dt_{as} = \frac{a\beta\bar{\beta}t_p^{1-\beta}\hat{\beta}^{1-\beta}}{2^{3-\beta}(1-\beta)^{2-\beta}}. \tag{35}$$

Finally, the output of consumer's information is

$$Y^* = \int_0^{\tilde{\lambda}_i^*} (t_i^*)^\alpha \, d\lambda + \int_{\tilde{\lambda}_i^*}^{\tilde{\lambda}_s^*} t_p^\alpha \, d\lambda = \frac{t_p^\alpha \hat{\beta} - \left(2 - \beta - \tilde{\beta}\right)\left(1 - \frac{(1-t_p)\hat{\beta})}{2(1-\beta)}\right)^\alpha}{-\beta + \tilde{\beta}}. \tag{36}$$

It is easy to sum up these terms to get total welfare

$$W^* = \Pi_i^* + \Pi_s^* + CR_i^* + CR_s^* + CR_p^* + R_i^* + R_s^* + Y^* - c_p \tag{37}$$

which only depends on $(t_p, a, \alpha, \beta, c_{pr}, c_p)$.

4 Welfare comparison

Proposition 1 *For given $(a, \alpha, \beta, c_{pr}, c_p)$, the market entry of a public channel broadcasting t_p of information and $1 - t_p$ of shows does not squeeze the private information channel from the market if*

$$\Pi_i^* = \frac{a(1-t_p)^{1-\beta}\bar{\beta}\hat{\beta}^{1-\beta}}{2^{3-\beta}(1-\beta)^{1-\beta}} - c_{pr} > 0 \tag{38}$$

does not squeeze the private show channel from the market if

$$\Pi_s^* = \frac{a \cdot t_p^{1-\beta}\bar{\beta}\tilde{\beta}^{1-\beta}}{2^{3-\beta}(1-\beta)^{1-\beta}} - c_{pr} > 0, \tag{39}$$

is welfare enhancing if (see also (46) in Appendix A)

$$W^* > W^+ \tag{40}$$

and improves the social output of information if (see also (47) in Appendix A)

$$Y^* > Y^+. \tag{41}$$

Proposition 1 enables the policy maker knowing the parameters $(a, \alpha, \beta, c_{pr}, c_p)$ to check whether a public channel is welfare enhancing, Y enhancing, and whether or not the channel squeezes a private channel out of the market. Figure 2 is a numerical visualization of parameter constellations of welfare-improving public channels with both private channels viable and an enhanced social output of information.

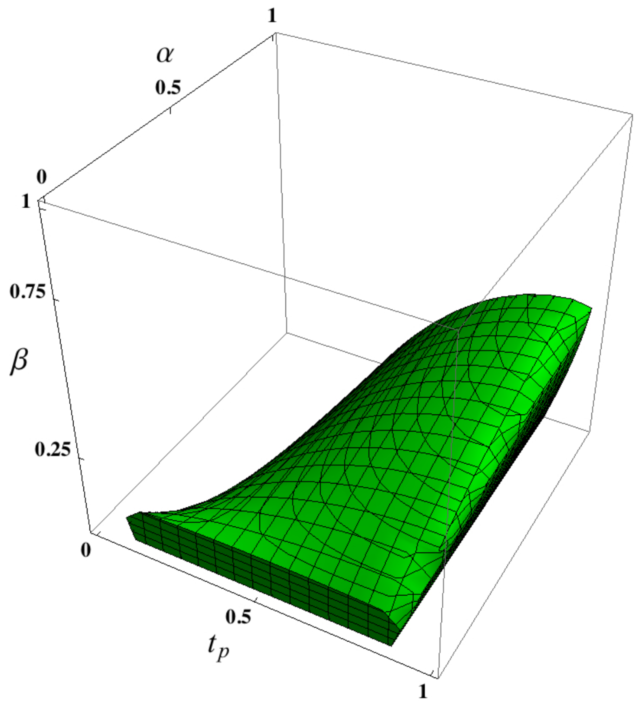

Figure 2: Welfare and Y enhancing parameter combinations with both private channels viable, $c_p = c_{pr} = 0.1, a = 0.5$

We can also analytically prove, that there is a combination of parameters $(a, \alpha, \beta, c_{pr}, c_p)$ and t_p that, indeed, improves welfare and Y and does not squeeze the private channels out of the market. For this purpose, we take a closer look at the symmetric case, where both private channels and the public broadcaster attract a viewer market share of 1/3, and both private channels earn the same profit. The market share of channels is not dependent on the share of information broadcasting time on the public service channel, but is 1/3 whenever $\beta = 1/3$. However, the only case for which profits of private channels are the same is where the public service channel broadcasts entertaining shows for half of the broadcasting time and information programs for the other half, that is, $t_p = 1/2$.[5]

[5]It can be shown that for $\beta = 1/3$ a welfare maximizer chooses $1/2 \leq t_p < 1$ (see Appendix B).

Proposition 2 *Let $\beta = 1/3$ and*

$$c_p < \frac{2}{21} - \frac{1}{2}\left(\frac{3}{7}\right)^{\alpha} + \frac{2^{-\alpha}}{3} + 2^{-2\alpha}3^{-1+\alpha} = \tilde{c}. \tag{42}$$

Then for all

$$a < \frac{-8 - 7 \cdot 2^{2-\alpha} - 7 \cdot 2^{2-2\alpha}3^{\alpha} + 2 \cdot 3^{1+\alpha}7^{1-\alpha} + 84c_p}{21 \cdot 2^{2/3} - 36 \cdot 14^{1/3}} = \tilde{a} \tag{43}$$

and

$$c_{pr} < \frac{4 + 7 \cdot 2^{1-\alpha} + 7 \cdot 2^{1-2\alpha}3^{\alpha} - 3^{1+\alpha}7^{1-\alpha} - 42c_p}{9 \cdot 2^{2/3}\left(-7 \cdot 2^{1/3} + 12 \cdot 7^{1/3}\right)} = \tilde{c}_{pr} \tag{44}$$

a public channel broadcasting $t_p = 1/2$ as well improves welfare as the social output of information by not squeezing a private channel out of the market.

Proof: See Appendix C.

Proposition 2 shows that the costs of the public broadcaster c_p have to be small, so that welfare is improved by market entry of a public service broadcaster. The value of the critical costs of the public service broadcaster $\tilde{c}$ depends on the rate at which the marginal productivity of information α diminishes. This is because the value of α determines the effect of the introduction of public service broadcasting on the social output of information Y, which, in turn, determines the effect on welfare W.

Further, the value of television advertising a has to be small. The intuition behind this result is that the public channel attracts viewers, which would watch private channels in absence of public service broadcasting. In the attempt of not losing too many viewers, private channels decrease their commercial broadcasting time as a reaction of market entry of a public service broadcaster. Although this reaction increases consumer surplus from watching TV, it decreases profits and advertisers surplus. In contrast to consumer surplus, profits and advertisers' surplus depend on the value of television advertising. Therefore, a large value of television advertising, that is, a large a, decreases the chance that public service broadcasting improves welfare.

The critical value of television advertising $\tilde{a}$ again depends on α and additionally on the costs of the public service broadcaster. If the costs of the public service broadcaster are large, then lost advertisers' surplus and lost profits of private channels have to be low to ensure that public service broadcasting is welfare enhancing.

The third inequation ensures that market entry of a public service broadcaster is not only welfare enhancing, but, in addition, that private channels are still profitable. To obtain this result, costs of private channels c_{pr} have to be small. The value of the critical costs of private channels $\tilde{c}_{pr}$ also depend on α and the costs of the public service broadcaster. Imagine an increase in the costs of the public service broadcaster. To still trigger an increase of welfare through the market entry of the public service broadcaster, the value of advertising has to be low. However, a low value of advertising triggers low profits, such that private costs have to be low, to ensure that private channels are still profitable. Thus, with high costs of the public service broadcaster, private costs have to be small to ensure that welfare increases and channels are profitable with a public service channel in the market.

With regard to the change in the social output of information Y, there is no restriction, because in the symmetric case of $\beta = 1/3$ and $t_p = 1/2$, the increase in social output of information is

$$Y^* - Y^+ = \frac{2^{1+\alpha} + 3^\alpha \left(2 - 3\left(4/7\right)^\alpha\right)}{3 \cdot 2^{1+2\alpha}} > 0 \tag{45}$$

for all $0 < \alpha < 1$.

5 Conclusion

The digitalization of the media sector significantly decreased market entry barriers to the broadcasting industry. Market failures based on these barriers, thus, tend to lose their importance. As a result, the question as to whether market intervention through public service broadcasting is justified has to be re-examined. A market failure that still remains in a digital world is that private information consumption ignores the external benefits for society, such that aggregated information consumption is expected to be smaller than socially optimal. To internalize this information externality, a public broadcaster can provide information for free.

However, since viewers still experience opportunity costs of time to consume the information program, some consumers who usually prefer entertaining shows have to be subsidized for information consumption by the offer of more entertaining programs.

We have analyzed a differentiated duopoly in a free-to-air TV market in the absence of a public broadcaster and in the presence of a public service broadcaster broadcasting information as well as entertainment programs and compared both settings for a broad variety of public programs. In the symmetric case, the social output of information is always larger in the presence of a public service broadcaster, but for welfare, the results are ambiguous. Whether a public broadcaster increases welfare depends on its costs and the importance of the advertising industry. If the public broadcaster produces large costs and on the other hand, then the advertising industry generates large rents for society, the chance that welfare is improved by public service broadcasting is small. We also find that large costs of a public broadcaster increase the danger that the public broadcaster replaces private channels. For the European TV markets, this result suggests that (incumbent) public service broadcasting is crowding out private programs.

To summarize, well-designed public service broadcasting may remedy the market failure that is present even today: It is able to improve the information consumption of consumers and, as a result, to improve the quality of voters to control politicians. Whether a public service broadcaster is welfare enhancing crucially depends on its program design and its cost efficiency, the external benefits of voters' information, and the magnitude of lost rents from the advertising market.

Appendix A

$W^* - W^+ > 0 \Longleftrightarrow$

$$2^\beta a \left((1-t_p)^\beta t_p + (1-t_p)t_p^\beta\right) \bar{\beta}\hat{\beta} \left(\frac{(1-t_p)t_p\hat{\beta}}{1-\beta}\right)^{-\beta}$$
$$- \frac{4(1-\beta)}{(\beta-\tilde{\beta})^2}[2\beta - \beta^3 + 2t_p(4+\beta(1-2(3-\beta)\beta)) - 2\tilde{\beta}$$
$$+ 2(1-\beta)\left(1 - \frac{(1-t_p)\hat{\beta}}{2(1-\beta)}\right)^\alpha \left(\beta-\tilde{\beta}\right)\left(-2+\beta+\tilde{\beta}\right)$$
$$+ \tilde{\beta}\left(2t_p(-1-2(1-\beta)\beta) + \beta\tilde{\beta}\right) + \hat{\beta}\left(2t_p^\alpha(1-\beta)\left(\beta-\tilde{\beta}\right) + t_p\left(-2+\beta^2+\beta\tilde{\beta}\right)\right)]$$
$$> \left(8c_p + \frac{2\left(3+2(3-2\beta)^{1-\alpha} + 8a\left(1+\frac{1}{-3+2\beta}\right)^{-\beta}\right)}{3-2\beta}\right)(1-\beta)^2 \tag{46}$$

$$Y^* - Y^+ > 0 \Longleftrightarrow \frac{\left(\tilde{\beta}+\beta-2\right)\left(1-\frac{\hat{\beta}(t_p-1)}{2(\beta-1)}\right)^\alpha + \hat{\beta}{t_p}^\alpha}{\tilde{\beta}-\beta} > \frac{1}{2}(3-2\beta)^{-\alpha} \tag{47}$$

Appendix B

If $\beta = 1/3$, then

$$\Delta W = W^* - W^+ =$$
$$= \frac{1}{84}[8 - 2\ 3^{1+\alpha}7^{1-\alpha} - 84c_p + 3\ 2^{1/3}a\left(-127^{1/3} + 7(1-t_p)^{2/3} + 7t_p^{2/3}\right) +$$
$$28\left(\frac{1}{2}+\frac{t_p}{2}\right)^\alpha + 28t_p^\alpha] \tag{48}$$

with

$$\frac{\partial \Delta W}{\partial t_p} = \frac{1}{6}\left(2^{1/3}a\left(-\frac{1}{(1-t_p)^{1/3}} + \frac{1}{t_p^{1/3}}\right) + \left(\left(\frac{1}{2}+\frac{t_p}{2}\right)^{-1+\alpha} + 2t_p^{-1+\alpha}\right)\alpha\right) \tag{49}$$

and $\lim_{t_p \to 1, t_p < 1} \partial \Delta W / \partial t_p = -\infty$. Further, for $0 < t_p < 1/2$,

$$-\frac{1}{(1-t_p)^{1/3}} + \frac{1}{t_p^{1/3}} > 0 \tag{50}$$

and, therefore, $\partial \Delta W / \partial t_p > 0$ for $0 < t_p < 1/2$. Neither $0 < t_p < 1/2$ nor $t_p = 1$ is optimal.

Appendix C: Proof of Proposition 2

If $\beta = 1/3$ and $t_p = 1/2$, then the difference $W^* - W^+$ is positive if and only if

$$a < \frac{-8 - 7 \cdot 2^{2-\alpha} - 7 \cdot 2^{2-2\alpha} 3^{\alpha} + 2 \cdot 3^{1+\alpha} 7^{1-\alpha} + 84 c_p}{21 \cdot 2^{2/3} - 36 \cdot 14^{1/3}} = \tilde{a} \tag{51}$$

and $\tilde{a} > 0$ if and only if

$$c_p < \frac{2}{21} - \frac{1}{2} \left(\frac{3}{7}\right)^{\alpha} + \frac{2^{-\alpha}}{3} + 2^{-2\alpha} 3^{-1+\alpha} = \tilde{c} \tag{52}$$

If the public channel chooses $1/2 = t_p$, $\Pi_i = \Pi_s$ and to have both channels viable $\Pi_i = \Pi_s \geq 0$ has to hold.

$\Pi_i = \Pi_s \geq 0$ iff

$$c_{pr} \leq \tilde{a}/(6 \cdot 2^{1/3}) = \frac{4 + 7 \cdot 2^{1-\alpha} + 7 \cdot 2^{1-2\alpha} 3^{\alpha} - 3^{1+\alpha} 7^{1-\alpha} - 42 c_p}{9 \cdot 2^{2/3} \left(-7 \cdot 2^{1/3} + 12 \cdot 7^{1/3}\right)} = \tilde{c}_{pr}. \square \tag{53}$$

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