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Quality choice and advertising regulation in broadcasting markets

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Abstract We consider the role of the endogenous choice of platform quality in a broadcasting duopoly market where competing media platforms also choose their levels of advertising. We compare the equilibrium levels of quality, advertising and welfare under private and mixed duopoly competition. We show that the welfare comparison between the private and mixed duopoly regimes depends crucially on the interplay between the net direct effect of advertising on welfare and the degree of substitutability between platforms. We also consider the effects on quality and welfare of recent policies that tend to eliminate advertising as a source of financing for publicly-owned platforms.

Keywords Endogenous quality · Two-sided markets · Broadcasting duopoly · Publicly-owned platform · Advertising regulation

JEL Classification L11 · L33 · L82 · M37

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1 Introduction

The objective of this paper is to investigate the role of a publicly-owned platform and the regulation of advertising levels in the context of a free-to-air broadcasting industry, assuming an endogenous choice of platforms' quality. As pointed out by Coase (1966), in this industry public policy might have an important role in regulating the quality and diversity of the programming available as well as the level of advertising. However, despite the empirical relevance of the presence of publicly-owned platforms in the media industries of many Western countries, there is a surprising lack of research on this form of public intervention in broadcasting markets. Nevertheless, there are some recent exceptions: On the theoretical side, Kind et al. (2007) consider a mixed broadcasting oligopoly with horizontal differentiation and show that a welfare-maximizing publicly-owned TV channel generates less advertising than private channels if and only if the degree of horizontal differentiation of the TV platforms is sufficiently large. The said authors focus only on the case of horizontal differentiation, but Maestre and Sánchez (2013) consider a mixed duopoly with both horizontal and vertical differentiation but with exogenous qualities, showing the crucial relevance of the quality gap between platforms in the welfare results. On the empirical side, Alcock and Docwra (2005) develop a stochastic oligopoly model for the Australian broadcasting market, and Bel and Domènech (2009) analyze advertising prices in the Spanish broadcasting industry.

Our contribution here is related to recent empirical literature dealing with the importance of platform's quality in television markets. In particular, the work by Beard et al. (2001) estimates that the increase in consumer gains due to a quality increase is almost exactly counterbalanced by reductions due to price increases. Chu (2010) studies the cable television market and finds that satellite entry typically causes cable platforms to raise quality and lower prices. Finally, Imbs et al. (2010) study television prices across European countries and regions. They show that a large fraction of international price gaps corresponds to quality differences. On the theoretical side, advertising in broadcasting media industries with private platforms has been extensively analyzed in recent literature.[1] Most of these earlier papers focus on the combination of advertising and horizontal product differentiation between private platforms in two-sided markets. In particular, Gabszewicz et al. (2004) and Anderson and Coate (2005) consider the influence of platform substitutability on the equilibrium and socially optimal levels of advertising; Gantman and Shy (2007) analyze the profitability of improvements in advertising quality and Peitz and Valletti (2008) compare the levels of advertising intensity and content differentiation under two different scenarios: pay-tv and free-to-air. In a recent paper Lin (2011) considers a private duopoly with endogenous choice of quality by TV platforms, and analyzes different outcomes depending on the presence of free-to-air or pay-TV platforms.

The aim of our paper is twofold:

First, we analyze the combined role of the endogenous choice of platform quality and the presence of a publicly-owned platform in the broadcasting industry. In ear-

[1] See the interesting surveys of advertising in the media by Anderson (2007), Anderson and Gabszewicz (2006).

lier papers (Armstrong 2005) and more recently (Crampes et al. 2009) analyze the effects of endogenous quality improvements in broadcasting industries. In particular, Armstrong compares the equilibrium quality levels between the free-to-air duopoly regime and the case of subscription, while (Crampes et al. 2009) analyze the effects of endogenous quality improvements under free entry. However, these earlier papers assume competition between symmetric private platforms while we consider the case of a publicly-owned platform competing with a private one.[2] We compare the equilibrium levels of platform quality and advertising under private and mixed duopoly competition, and show that the results differ drastically from one scenario to the other.

Second, we also consider the effects on platform quality and welfare of recent policies that tend to eliminate advertising as a source of financing for publicly-owned platforms. This aspect of our analysis is related to some recent controversial policy decisions within the EU. Particularly remarkable is the decision by the French government to eliminate advertising as a way of financing the public TV platform in France. A similar decision was subsequently made by its counterpart in Spain. In both cases the governments have established taxes on the revenues of private TV and telecom platforms as a replacement source of financing. This decision has been investigated by the European Commission but the European Court of Justice eventually ruled that France could continue to apply a special tax on telecoms and media companies to finance public television without advertising.[3] Based on this decision, the European Commission has withdrawn the charges against the Spanish tax system for implementing the same policy.[4]

The rest of the paper is organized as follows: Sect. 2 presents a spatial duopoly market with private platforms and endogenous choice of advertising and quality. Section 3 analyzes a duopoly model where one of the competitors is a publicly-owned platform that maximizes welfare. Section 4 analyzes the controversial policy decisions in the EU by France and Spain to eliminate advertising as a source of financing for their public platforms. Section 5 considers the advertising, platform quality and welfare comparisons between the three regimes and Sect. 6 concludes.

2 The private duopoly model

There are two private platforms, 1 and 2, which are located, respectively, at the extreme left and right of a linear market of length 1. [5] As in the original model developed by

[2] Our work is also related to the paper by Esteban and Hernández (2012): They focus on the role of advertising regulation in a two-sided market where the advertising fee is determined by the interaction between two firms that produce a horizontally-differentiated good and a monopolistic communication platform. By contrast, our paper compares a private and a mixed duopoly in the broadcasting market.

[3] For more details, see the following link on the media: http://www.reuters.com/article/2013/06/27/television-advertising-europe-idUSL5N0F328J20130627.

[4] Regarding advertising regulation, Stühmeier and Wenzel (2012) have recently evaluated the effects of a binding advertising cap on competition for viewers and advertisers in a private duopoly model. They find that regulation of advertising can increase the profits of platforms.

[5] As usual in horizontal differentiation models, the commodity space allows a wide range of interpretations, including ideological preferences or entertainment tastes. The assumption of exogenous platform location at the extremes of the line is a standard simplification in broadcasting duopoly models. One of the few

Hotelling (1929), there is a mass of consumers of measure 1 indexed by $x \in [0, 1]$ and distributed uniformly along this linear market. Each consumer chooses either one unit of good or zero. The utility of consumer x if she/he watches platform i is given by the function

$$u(x) = \begin{cases} V + v_1 - \delta a_1 - tx & \text{if } i = 1, \\ V + v_2 - \delta a_2 - t(1 - x) & \text{if } i = 2, \end{cases} \tag{1}$$

where V is the basic utility from buying a product,[6] v_i is defined as the quality level of platform i which is the extra gross utility from the chosen platform,[7] δ is the parameter representing the disutility or nuisance cost per unit of advertising (denoted by a_i) [8] and t is the transport cost per unit of the distance of moving away from her/his favorite TV platform. Moreover, t can be interpreted as the degree of horizontal differentiation, so a higher t means that platforms are less substitutable.

Denote by x_1 the marginal consumer who is indifferent between watching platforms 1 and 2. Similarly, we define $x_2 = 1 - x_1$. From the utility function (1), the audience share for platform i can be obtained, as:

$$x_i(a_i, a_j) = \frac{v_i - v_j + t - \delta(a_i - a_j)}{2t}, \quad i = 1, 2, \ j \neq i. \tag{2}$$

As in Gabszewicz et al. (2004) the advertising market is considered to be perfectly competitive, so advertisers' profits are zero. We assume that the advertising revenues obtained by platform i are given by $R_i = \gamma a_i x_i$, where γ can be interpreted as the revenue per ad per viewer. On the other hand, the cost of achieving a quality v_i for platform i is given by the quadratic function $C(v_i) = \frac{v_i^2}{2}$. Thus, the profit of platform i is given by:

$$\pi_i = \gamma a_i x_i - \frac{v_i^2}{2}, \quad i = 1, 2, \ i \neq j. \tag{3}$$

By substituting the demand function (2) in the profit function (3), the following is obtained:

$$\pi_i(a_i, a_j) = \gamma a_i \left(\frac{1}{2} + \frac{v_i - v_j - \delta(a_i - a_j)}{2t} \right) - \frac{v_i^2}{2}, \quad i = 1, 2, \ i \neq j. \tag{4}$$

A two-stage game is assumed where the platforms first simultaneously choose their levels of quality and then choose their advertising levels. The Nash equilibrium (NE)

Footnote5 continued
papers dealing with the issue of endogenous location choices is Peitz and Valletti (2008), but they deal only with horizontal differentiation, while we analyze the combined role of horizontal differentiation and the endogenous choice of quality.

[6] In the rest of the paper, it is assumed that V is large enough to ensure that each customer is always willing to watch a platform, i.e. the market is always covered.

[7] As pointed out by Anderson (2007), "the term "quality" is meant in the sense of a positive shift in demand for viewing. This may not necessarily be synonymous with a higher art form."

[8] Our assumption that $\delta > 0$ is consistent with the empirical evidence shown by Wilbur (2008). This author obtains that viewers dislike advertising in the TV industry.

in the levels of advertising at the second stage of the game is now obtained: From the first order conditions, the reaction function of each platform can be obtained as follows:

$$a_i\left(a_j\right) = \frac{v_i - v_j + t}{2\delta} + \frac{a_j}{2}, \quad i = 1, 2,\ i \neq j. \tag{5}$$

Which yields the following NE levels of advertising and market shares at the second stage of the game:

$$a_i = \frac{v_i - v_j + 3t}{3\delta}; \quad x_i = \frac{v_i - v_j + 3t}{6t}; \tag{6}$$

By substituting (6) in (4), the following expression is found for platform i's profit, evaluated at the first stage of the game:

$$\pi_i(v_i, v_j) = \frac{k(v_i - v_j + 3t)^2}{18t} - \frac{v_i^2}{2}, \quad i = 1, 2, i \neq j, \tag{7}$$

where $k \equiv \gamma/\delta$ is the ratio of the revenue per ad per viewer and the nuisance cost. If $k < 1$ ($k > 1$), the negative impact of advertising on consumers' utility is greater (lower) than the positive impact of advertising on the platform's revenue. Therefore, the direct net effect of advertising on welfare is negative (positive) if $k < 1$ ($k > 1$), while $k = 1$ is the case where advertising is neutral from the welfare point of view.

In the following analysis, the following is maintained:

Assumption 1 $k \in (0.8, 1.165)$ and $t > 2.5$.

It is shown in the Appendix that this assumption ensures both the second order conditions of the SPE and positive values for all the endogenous variables at the SPE of all the duopoly regimes considered in the paper.

The first order conditions of profit maximization yield the following reaction functions of platforms, in terms of quality choices:

$$v_i(v_j) = \frac{\left(3t - v_j\right)k}{9t - k}; \quad i = 1, 2, i \neq j. \tag{8}$$

Solving the above equations gives the subgame perfect equilibrium (SPE) levels of qualities, advertising, market shares and profits:

$$v_i^P = \frac{k}{3};\ a_i^P = \frac{t}{\delta};\ x_i^P = \frac{1}{2};\ \pi_i^P = \frac{(9t - k)\,k}{18}, \quad i = 1, 2. \tag{9}$$

As can be seen from (9), in equilibrium both platforms choose the same quality and ads, so that they obtain the same demand and profit. Profits are also found to be increasing in k. This is because the profitability of quality improvement for platforms depends positively on k, which is reflected in the fact that equilibrium qualities are increasing in k. Finally, the level of quality is found not to depend on the degree of substitutability.

Consumer surplus (CS) is calculated as:[9]

[9] Recall that $x_2 = 1 - x_1$.

$$CS = V + v_1 x_1 - \delta a_1 x_1 - t \int_0^{x_1} x dx + v_2(1 - x_1) - \delta a_2(1 - x_1) - t \int_{x_1}^{1} (1 - x) dx. \tag{10}$$

Social welfare (W), defined as the sum of the profits of the platforms ($\pi = \pi_1 + \pi_2$) and the consumer surplus (CS), is now calculated,

$$W = V + (\gamma - \delta)a_2 + (v_1 - v_2 + t + (\gamma - \delta)(a_1 - a_2))x_1 - t x_1^2 + v_2 - \frac{t + v_1^2 + v_2^2}{2}. \tag{11}$$

By using (9) in (11), the social welfare at the SPE in the private duopoly is given by:

$$W^P(k, t) = V + \frac{(36k - 45)\, t - 4\left(k^2 - 3k\right)}{36}. \tag{12}$$

3 The mixed duopoly model

In this section it is assumed that platform 1 is a publicly-owned firm that maximizes social welfare,[10] while platform 2 is a private firm that maximizes its profit. Substituting (2) in (11) and maximizing the resulting welfare function with respect to a_1, the following reaction function is found for the publicly-owned platform 1:

$$a_1(a_2) = a_2 + \frac{k - 1}{\delta(2k - 1)}(v_1 - v_2 + t). \tag{13}$$

Notice that platform 2's reaction function is the same as the one in the previous section since it continues to be a private firm. Thus, from (5) and (13) the second stage NE levels of advertising and market shares in the mixed duopoly can be calculated:

$$\begin{aligned} a_1 &= \frac{(4k - 3)t - (v_1 - v_2)}{\delta(2k - 1)};\ a_2 = \frac{(3k - 2)t - k(v_1 - v_2)}{\delta(2k - 1)} \\ x_1 &= \frac{k(v_1 - v_2 + t)}{2(2k - 1)t};\ x_2 = \frac{(3k - 2)t - k(v_1 - v_2)}{2(2k - 1)t}; \end{aligned} \tag{14}$$

By substituting the NE values of market shares and advertising of platforms 1 and 2 into expressions (3) and (11) the profit function of each firm and the welfare at the first stage of the game are obtained, in terms of the qualities:

[10] In the literature on mixed duopolies, there are more general formulations of the objective function of the publicly-owned firm. In particular, Matsumura (1998) assumes that the publicly-owned firm maximizes a function with positive weight for both welfare and the publicly-owned firm's profit.

$$\pi_1 = \frac{k^2\left((4k-3)t-(v_1-v_2)\right)(v_1-v_2+t)}{2(2k-1)^2 t} - \frac{v_1^2}{2};$$
$$\pi_2 = \frac{k\left((3k-2)t-k(v_1-v_2)\right)^2}{2(2k-1)^2 t} - \frac{v_2^2}{2};$$
$$W = V + \frac{4(k-1)\left((3k-2)t-k(v_1-v_2)\right)t + k^2(v_1-v_2+t)^2}{4(2k-1)t} + v_2 - \frac{t}{2} - \frac{v_1^2}{2} - \frac{v_2^2}{2}. \tag{15}$$

By maximizing the social welfare with respect to v_1, the reaction function of the publicly-owned platform, $v_1(v_2)$, is obtained, and by maximizing platform 2's profit with respect to v_2, the reaction function of the private platform, $v_2(v_1)$ is found. Those functions are given by:

$$v_1(v_2) = \frac{k^2 t + k^2 v_2 - 2kt}{2t - 4kt + k^2};\ v_2(v_1) = -\frac{2k^2 t - 3k^3 t + k^3 v_1}{t + 4k^2 t - 4kt - k^3} \tag{16}$$

Thus, from (16) the SPE levels of quality, advertising, market shares, and platform 2's profit in the mixed duopoly are calculated:

$$v_1^M = \frac{9k^2 t - 12k^3 t + 4k^4 t - 2kt + 2k^5}{2t + 24k^2 t - 16k^3 t - 12kt + k^2 - 6k^3 + 8k^4};$$
$$v_2^M = \frac{2k^5 - 12tk^4 + 14tk^3 - 4tk^2}{2t + 24k^2 t - 16k^3 t - 12kt + k^2 - 6k^3 + 8k^4}.$$
$$a_1^M = \frac{2t(2k-1)\left(k-3t+4kt-2k^2\right)}{2t\delta + k^2\delta - 4k^3\delta - 8kt\delta + 8k^2 t\delta};\ a_2^M = \frac{-2k^3 t + 12k^2 t^2 - 14kt^2 + 4t^2}{2t\delta + k^2\delta - 4k^3\delta - 8kt\delta + 8k^2 t\delta}$$
$$x_1^M = -\frac{kt - 2k^2 t - k^2 + 3k^3}{2t + 8k^2 t - 8kt + k^2 - 4k^3};\ x_2^M = \frac{-k^3 + 6tk^2 - 7tk + 2t}{2t + 8k^2 t - 8kt + k^2 - 4k^3}$$
$$\pi_2^M = \frac{2k\left(-k^3 + 4tk^2 - 4tk + t\right)\left(-k^3 + 6tk^2 - 7tk + 2t\right)^2}{(2k-1)^2\left(2t + 8k^2 t - 8kt + k^2 - 4k^3\right)^2} \tag{17}$$

Substituting (17) in (15) yields the SPE level of welfare in the mixed duopoly, denoted by $W^M(k,t)$. The detailed expression for this function, which is used in the proofs of our welfare results, is relegated to the Appendix.

4 The case of zero advertising commitment by the public platform

This section assesses the consequences of the new TV broadcasting industry regulations introduced by the French and Spanish governments. It is assumed that the publicly-owned platform is committed to setting zero advertising ($a_1 = 0$). Therefore, the timing is similar to the previous game, except that at the advertising stage only the private platform chooses its level of advertising. To simplify the terminology,

in the rest of the paper, the case analyzed in this section is defined as the *zero duopoly regime*.[11]

By substituting the demand function (2) in the definition of profits and taking into account that $a_1 = 0$, the following is obtained:

$$\pi_1 = -\frac{v_1^2}{2}; \quad \pi_2 = \gamma a_2 \frac{v_2 - v_1 + t - \delta a_2}{2t} - \frac{v_2^2}{2}. \tag{18}$$

From maximizing the private platform's profit, the advertising level of private platform can be obtained, so:

$$a_2 = \frac{v_2 - v_1 + t}{2\delta}. \tag{19}$$

By substituting the level of advertising (19) in the profit functions (18) the profit is obtained:

$$\pi_1 = -\frac{v_1^2}{2}; \quad \pi_2 = \frac{k(v_2 - v_1 + t)^2}{8t} - \frac{v_2^2}{2}. \tag{20}$$

The next step is to consider the quality choices of the platforms, so that the publicly-owned platform maximizes social welfare and the private one maximizes its profit. Taking into account that platform 1 does not obtain any revenue from advertising, the social welfare (W) at the first stage is now given by:

$$W = V + v_2 - \frac{t}{2} + \frac{(v_1 - v_2 + 3t)(3(v_1 - v_2) + t)}{16t} + \frac{(k-1)(v_2 - v_1 + t)^2}{8t} - \frac{v_1^2}{2} - \frac{v_2^2}{2}, \tag{21}$$

where the platforms' profits (π) and consumer surplus (CS) are given by:

$$\begin{aligned} \pi &= \pi_1 + \pi_2 = \frac{k(v_2 - v_1 + t)^2}{8t} - \frac{v_1^2}{2} - \frac{v_2^2}{2} \\ CS &= V + v_2 - \frac{t}{2} + \frac{(v_1 - v_2 + 3t)(3(v_1 - v_2) + t)}{16t} - \frac{(v_2 - v_1 + t)^2}{8t} \end{aligned} \tag{22}$$

From the first order conditions in the first stage of the game, the reaction function of each platform can be obtained:

$$v_1(v_2) = \frac{(2k-7)t + (2k+1)v_2}{2k - 8t + 1}; \quad v_2(v_1) = \frac{k(v_1 - t)}{k - 4t}.$$

[11] Apart from eliminating advertising in the publicly-owned platform, the French and Spanish regulations involves a tax on the revenue obtained by private platforms. However, to simplify the exposition of the paper, we assume that the government sets a tax of zero, which is an equilibrium in the game where the government can set a tax on the private platform's revenue. The proof of this result is relegated to the Appendix.

From the intersection of the quality reaction functions of the platforms, the levels of advertising, market shares, profits, and welfare at the SPE of this game are obtained:

$$
\begin{aligned}
v_1^Z &= \frac{2k+(2k-7)\,t}{4k+1-8t};\; v_2^Z = \frac{-2k\,(t-1)}{4k-8t+1};\; a_1^Z = 0;\; a_2^Z = \frac{-4t\,(t-1)}{(1+4k-8t)\,\delta} \\
x_1^Z &= -\frac{6t-4k+1}{4k-8t+1};\; x_2^Z = \frac{-2\,(t-1)}{4k-8t+1} \\
\pi_1^Z &= -\frac{\left(4k^2t^2+8k^2t+4k^2-28kt^2-28kt+49t^2\right)}{2\,(4k-8t+1)^2};\; \pi_2^Z = \frac{2k\,(t-1)^2\,(4t-k)}{(4k-8t+1)^2} \\
W^Z(k,t) &= V + \frac{(1-t)\left(8k^2t+8k^2-16kt^2-44kt+4k+56t^2-7t\right)}{2\,(4k-8t+1)^2}.
\end{aligned}
\tag{23}
$$

5 Comparing the three regimes

This section compares the main variables in the three regimes. To help understand the basic intuitions of our welfare results that are shown in Sect. 5.3, we illustrate graphically some comparative statics regarding quality, advertising and audience shares between the mixed and the zero duopoly in Sect. 5.1, and between the mixed and the private duopoly in Sect. 5.2.

5.1 Mixed versus zero duopoly

Figure 1 compares equilibrium variables in the mixed and zero duopolies for the cases $k = 0.9$ (advertising is harmful), $k = 1$ (advertising is neutral) and $k = 1.1$ (advertising is beneficial).

Note that the pattern followed by the equilibrium levels of the variables is similar in the three cases. Consider the most noteworthy aspects of the comparisons between the two regimes:

Note, first, that the advertising level of the private platform in the zero duopoly is lower than the advertising level of each platform in the mixed duopoly. This is because advertising levels are strategic complements and the public platform does not set advertising in the zero duopoly.

Regarding quality levels, Fig. 1 shows that the sign of the quality gap between the two platforms is reversed when the system shifts from the conventional mixed duopoly to the zero duopoly. In the mixed duopoly the private platform provides higher quality, but in the zero duopoly the opposite result emerges. As a consequence, given that only the private platform provides advertising in this latter case, the public platform obtains a greater market share than the private platform at the SPE. Note also that in the mixed duopoly both gaps are decreasing and very sensitive to t while in the zero duopoly they are almost independent of t.

Intuitively, under the mixed duopoly, advertising by the public platform tends to increase the audience of the private platform, which in turn increases the profitability of its investment in quality. As a result, the quality of the private platform at SPE is greater than the quality chosen by the public platform under this regime. In contrast, under

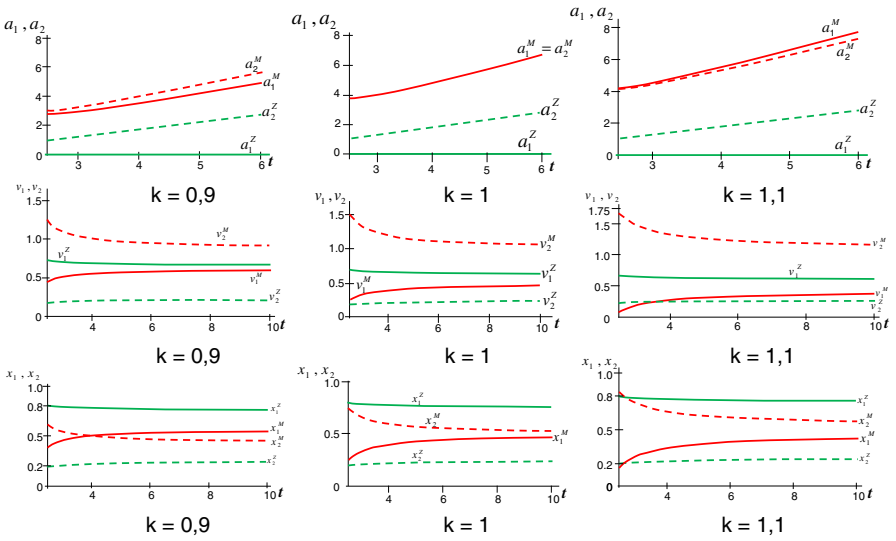

Fig. 1 Comparisons between the mixed and zero duopolies for variables a_i, v_i, and x_i

the zero duopoly the absence of advertising on the public platform tends to reduce the private platform's audience, which reduces its incentive to invest in quality. There is another important aspect: the public platform cares about welfare, which means that higher quality is good news per se, from the point of view of the public firm. The combined effects of these two incentives explain the higher quality of the public platform at the SPE.[12] Notice that the commitment of the publicly-owned platform to set zero ads makes it a tougher competitor for the private platform.

5.2 Mixed versus private duopoly

The comparisons between the mixed and private duopolies is illustrated in Fig. 2. As in the previous subsection, the cases considered are: $k = 0.9$ (advertising is harmful), $k = 1$ (advertising is neutral) and $k = 1.1$ (advertising is beneficial).

First, consider the case where advertising is neutral with respect to welfare ($k = 1$), which is illustrated in the second column of Fig. 2. Note that platform 1 provides

[12] One of the main arguments put forward by the Frech and Spanish governments to justify the elimination of advertising in the public TV platforms had to do with the increase in the quality of TV programming. (For the details in the media, see, for instance: http://news.bbc.co.uk/2/hi/europe/7812747.stm). Interestingly, in our model the public platform increases its quality when it becomes an "advertising free" platform. However the reaction to this policy by the private platform is to decrease its quality. Therefore, from the point of view of the average quality, it is not clear whether this objective is actually achieved. Note also that in our model we refrain from considering competition between public and private televisions to attract announcers. In principle, eliminating advertising on public TV might be good news for the private TV platforms as their bargaining position in regard to advertisers is improved. However, the recent empirical paper by Filistrucchi et al. (2012) on the effects of the advertising ban on French public television appears to indicate that the common expectation that the ban would favour private TV channels has not been confirmed in practice.

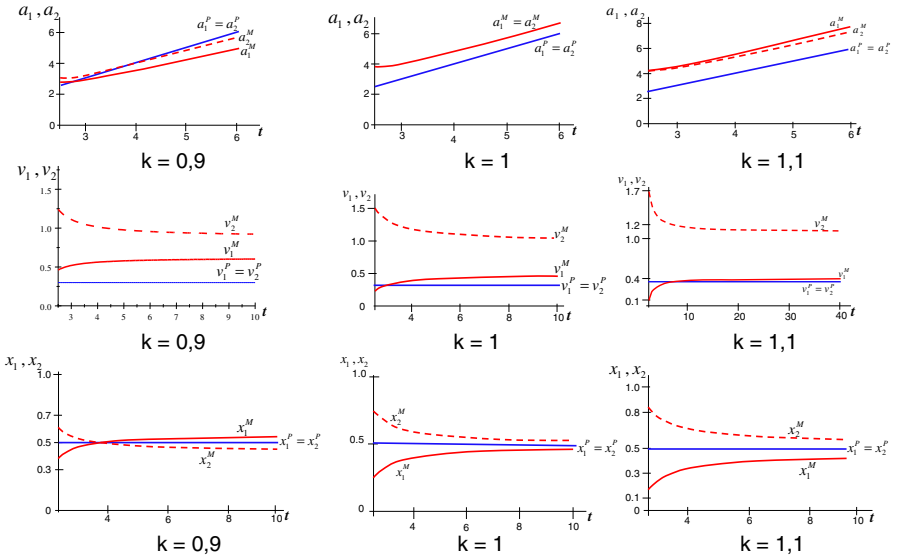

Fig. 2 Comparisons between the mixed and private duopolies for variables a_i, v_i, and x_i

the same level of advertising as platform 2 in both regimes. In addition, this level is similar in the two regimes and is increasing in t. In the private duopoly both platforms provide the same quality and get the same audience share, but in the mixed duopoly the private platform provides higher quality and in consequence it obtains greater audience share. However these differences are decreasing in t. Intuitively, advertising levels are increasing with t because the platforms take advantage of the greater market power associated with greater product differentiation, which in turn is associated with less incentive to provide a high quality gap for platforms in the mixed duopoly.

Now consider the case where advertising is socially harmful. The first column of Fig. 2 illustrates the comparisons between the mixed and private regimes with $k = 0.9$. Note that in contrast with the previous case, the advertising levels are lower in the mixed duopoly for sufficiently large t. Moreover this difference is increasing in t. Note also that the public platform always sets a lower level of advertising than the private platform in the mixed duopoly and that this difference is increasing in t. Intuitively the public platform tends to reduce socially harmful advertising. As a result, for a large t the public platform obtains a bigger audience share than the private one despite the fact that it provides a lower quality level.[13] Note, also that the difference in market shares increases as t increases. This results in higher transportation costs which ceteris paribus tends to hurt welfare. The explanation of this pattern is that the public platform faces a trade-off between two welfare effects: by reducing advertising

[13] Interestingly, a similar effect appears in the oligopoly model considered by Kind et al. (2007). Assuming that advertising is socially harmful, those authors show that a welfare-maximizing publicly-owned channel generates less advertising than private ones if the degree of horizontal differentiation between TV platforms is sufficiently large. However, our approach differs from that of Kind et al. (2007) in that we consider both horizontal and vertical (quality) differentiation. Moreover, quality is endogenous in our model.

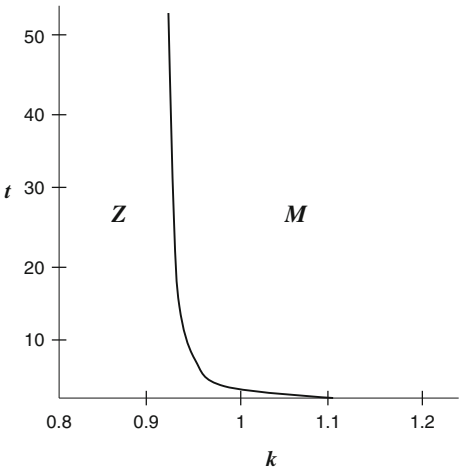

Fig. 3 Welfare comparisons between the mixed and zero-advertising duopolies

it alleviates the harmful effects of this variable but it tends to increase the advertising gap, which in turn tends to increase the difference in market shares. However, the second effect, which is negative, is smaller than the first one, which is positive.

Finally, the third column of Fig. 2 illustrates the above comparisons when advertising is socially beneficial, assuming $k = 1.1$. The main difference with respect to the previous cases is that the advertising levels in the mixed duopoly are higher than in the private one. Moreover the publicly-owned platform provides a higher level of advertising than its private competitor. This pattern is explained by the fact that the public platform tends to increase socially beneficial advertising.

5.3 Welfare comparisons

This subsection compares the social welfare obtained in the three regimes. First, social welfare in the mixed and zero duopolies is compared. This comparison is illustrated in Fig. 3, where $W^Z > W^M$ in region Z and $W^M > W^Z$ in region M.

According to Fig. 3, when advertising is very harmful the zero duopoly is always better than the conventional mixed duopoly from the social welfare point of view. Otherwise, the conventional mixed duopoly may be socially preferred, as stated in the following proposition.

Proposition 1 *In comparisons between mixed and zero duopolies, a critical value of k defined as $k^*(t)$ is found that is decreasing in t, such that for $k \leq k^*(t)$ the zero duopoly is socially better (see region Z) and for $k \geq k^*(t)$ the mixed duopoly is socially better (region M).*

Intuitively, the more harmful advertising is, the more likely it is that government commitment to zero advertising will be the optimal policy. Additionally, when t is small, quality differentiation is more important than horizontal differentiation. Therefore, the smaller t is, the more likely it is that the optimal policy is the government

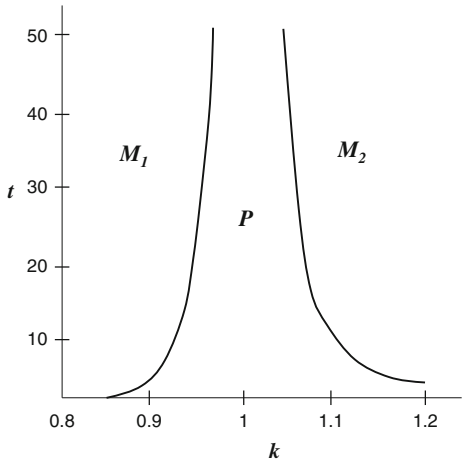

Fig. 4 Welfare comparisons between the mixed and private duopolies

commitment to zero advertising because this ensures a large audience for the TV-platform that provides the highest quality. To see this, note that in the zero duopoly the publicly-owned platform provides the highest quality and obtains a very high audience share (see Fig. 1). Notice that the zero duopoly can be socially better even if advertising is socially desirable (that is, $k > 1$) when the degree of horizontal differentiation is low enough. In particular, if $t < 3.75$, it holds that $k^*(t) > 1$ which implies that $W^Z > W^M$ for some $k > 1$.

An interesting policy implication of this result is that an advertising-free public platform (the zero duopoly) tends to be optimal insofar as its content is sufficiently similar to the content provided by its private competitor (see the low values for t in Fig. 3), except in the cases where the social value of advertising is very high.

The comparison between the mixed and private duopolies is illustrated in Fig. 4, where $W^M > W^P$ in regions M_1 and M_2, while $W^P > W^M$ in region P.

When the mixed and private duopolies are compared it is found that the private duopoly is optimal when advertising is neutral, i.e. when k is near to 1. However, when the negative or positive direct net effect of advertising is large enough this result may be reversed, as illustrated in Fig. 4 and the following proposition.

Proposition 2 *In the comparisons between mixed and private duopolies, the following is obtained:*

(i) for low values of t, the mixed duopoly is socially better if k is low enough, but worse if k is high enough;

(ii) for high values of t, the private duopoly is better for intermediate values of k, but for extreme values of k the mixed duopoly is better.

Note that according to Fig. 4 if advertising is neutral ($k = 1$) the private duopoly is always better than the mixed duopoly.[14] However, when advertising is not neutral, government intervention through the ownership of a TV-platform is desirable if t is

[14] Formally, this particular case resembles the result obtained by Ishibashi and Kaneko (2008), by reinterpreting the advertising levels in our model as the prices levels in their model. However our formulation

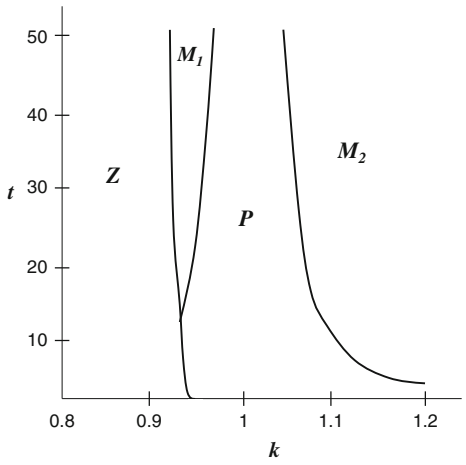

Fig. 5 Welfare comparisons among the mixed, private and zero-advertising duopolies

high enough. Moreover, as t increases, the intermediate interval at which privatization is optimal becomes narrower. The intuition of this result can be explained by comparing the levels of advertising between both regimes. In particular, if advertising is socially harmful ($k < 1$) the mixed duopoly provides lower levels of advertising than the private duopoly for large enough values of t (see the first column of Fig. 2). Therefore, in this case the mixed duopoly is socially better than the private one because it reduces the negative welfare effects of advertising. By a similar argument, if advertising is socially beneficial ($k > 1$), the mixed duopoly is socially better than the private duopoly for a high enough t because in this case the mixed duopoly provides higher levels of advertising (see the third column of Fig. 2). Note also that for a low level of t, the gaps in market shares between platforms are rather large in the mixed duopoly, and this in turn is associated with large quality differences (see the third column of Fig. 2). Therefore, given that in this case advertising levels are similar in the two regimes, welfare is greater in the private duopoly because it achieves an optimal distribution of market shares.

Note that our previous result suggests that those public platforms which offer substantial differences in content with respect to their private competitors are more likely to play a beneficial role from the social welfare perspective. However a privatization policy tends to be optimal if the content provided by the publicly-owned platform is similar to that of its competitors, except when advertising is too harmful.

Now consider the optimal choice out of the three previous regimes. This is handle via the following proposition and illustrated in Fig. 5, where Z, P, M_1 and M_2 indicate the optimal regime in each region.

Proposition 3 *In the comparisons between the three regimes, the following holds:*

(i) for low values of t the optimal regime is the zero duopoly if k is low enough (see region Z) and the private duopoly if k is high enough (see region P);

Footnote14 continued
is more general because k can be different from one, which implies that privatization is not always better than a mixed duopoly. To see this, note that $\delta = \gamma = 1$ must hold for the models to be identical, which means that our model is more general than the one considered in Ishibashi and Kaneko (2008).

(ii) for intermediate values of t the optimal regime is the zero duopoly if k is small (see region Z), the private duopoly for intermediate k (see region P) and mixed duopoly if k is large (see region M_2);

(iii) for high values of t the optimal regime is the zero duopoly if k is small (see region Z), the mixed duopoly for intermediate-low and high levels of k (see regions M_1 and M_2) and the private duopoly for intermediate-high levels of k (see region P).

The basic intuitions behind this result are connected to the above comparisons. In particular, consider case (ii) in Proposition 3. Broadly speaking, the zero duopoly is socially desirable when advertising is sufficiently harmful (region Z) because the absence of advertising by the public firm helps attain two objectives: first, to reduce the nuisance costs associated with advertising, and second to increase the audience of the TV-platform with the highest quality. At the other extreme, when advertising involves a large positive net welfare effect (region M_2), the presence of a public platform is desirable but without the commitment to zero advertising. Finally, when advertising does not generate a large net welfare effect, the optimal policy is privatization (region P).

Note that the results above (Propositions 2 and 3) suggest that those public platforms which offer substantial differences in content with respect to their private competitors are more likely to play a beneficial role from the social welfare perspective. However a privatization policy tends to be optimal if the content provided by the publicly-owned platform is similar to that of its competitors.

6 Conclusions

In this paper we develop a model with a publicly-owned platform and a private one that compete in a free-to-air broadcasting market. The platforms are differentiated in two dimensions: content (horizontal differentiation) and quality (vertical differentiation). Assuming that each platform chooses its advertising and quality levels, we compare the equilibrium levels of quality, advertising and welfare under private and mixed duopoly competition. In this context, we also consider the effects on platform quality and on welfare of recent policies that tend to eliminate advertising in publicly-owned platforms. We show that the results differ substantially depending not only on whether there is a publicly-owned platform but also on the advertising restrictions on such a platform.

One interesting insight from our analysis is that a government commitment to an advertising-free public platform can be socially desirable even if the direct effect of advertising is beneficial from the social welfare point of view (see Proposition 1 and Fig. 3). The explanation underlying this result is that besides the direct effect of advertising on welfare there are also indirect effects associated with endogenous changes in quality and market shares. In particular, our results show that this case is associated with small degrees of horizontal platform differentiation. Thus a policy implication of this result is that an advertising-free public platform tends to be optimal as long as its content is sufficiently similar to the content provided by its competitor. However, eliminating advertising in the public platform can be suboptimal even if

advertising is socially harmful. This case is associated with large levels of horizontal differentiation, as is also shown in Proposition 1. Therefore, the more differentiated the content is, the weaker the case for an advertising-free public platform is.

Our model also suggests some policy implications regarding the optimal choice between privatization and maintaining active public platforms. Basically, our results show that the case for privatization becomes weaker as the degree of horizontal differentiation becomes greater and advertising is not neutral (see Propositions 2 and 3). This suggests that those public platforms which offer substantial differences in content with respect to their competitors are more likely to play a beneficial role from the social welfare perspective.

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Appendix

The model with an endogenous tax on advertising revenues

This subsection incorporates an initial stage in which the government sets a tax on the revenue of the rival private platform to finance the publicly-owned platform. Thus, the revenue obtained by the private platform is considered to consist of its advertising revenue after tax, and the revenue obtained by the publicly-owned platform to consist of the tax revenue collected from the private platform. So profits are given, respectively, by

$$\pi_1 = \tau\gamma a_2 x_2 - \frac{v_1^2}{2}; \quad \pi_2 = (1-\tau)\,\gamma a_2 x_2 - \frac{v_2^2}{2},$$

where τ represents the direct tax on the revenue of the private platform. By substituting the demand function (2) in the definition of profits and taking into account that $a_1 = 0$, the following can be obtained:

$$\pi_1 = \tau\gamma a_2 \frac{v_2 - v_1 + t - \delta a_2}{2t} - \frac{v_1^2}{2}; \quad \pi_2 = (1-\tau)\,\gamma a_2 \frac{v_2 - v_1 + t - \delta a_2}{2t} - \frac{v_2^2}{2}. \tag{24}$$

From maximizing the profit of the private platform, the level of advertising by private platform 2 can be obtained, which is (19). By substituting it in the profit functions (24) the market shares and profits are obtained:

$$x_1 = \frac{v_1 - v_2 + 3t}{4t}; \ \pi_1 = \tau\frac{k\,(v_2 - v_1 + t)^2}{8t} - \frac{v_1^2}{2};$$
$$x_2 = \frac{v_2 - v_1 + t}{4t}; \ \pi_2 = (1-\tau)\,\frac{k\,(v_2 - v_1 + t)^2}{8t} - \frac{v_2^2}{2}.$$

Now consider the quality choice by platforms, so the publicly-owned platform maximizes social welfare and the private one maximizes its profit. Taking into account that the social welfare (W) at the first stage is now given by (21), from the first order conditions in the first stage of the game, the reaction function of each platform can be obtained:

$$v_1(v_2) = \frac{(2k-7)t + (2k+1)v_2}{2k-8t+1};\ v_2(v_1) = \frac{(1-\tau)(t-v_1)k}{4t+k(\tau-1)}.$$

From the intersection of the quality reaction function of the platforms the NE levels of advertising, market shares and profits at the second stage of this game are obtained:

$$\begin{aligned}
v_1(\tau) &= \frac{2k(1-\tau)+(2k-7)t}{2k(2-\tau)+1-8t};\ v_2(\tau) = \frac{2k(\tau-1)(t-1)}{4k-8t-2k\tau+1};\ a_1(\tau) = 0;\ a_2(\tau) = \frac{-4t(t-1)}{(1+2k(2-\tau)-8t)\delta}.\\
x_1(\tau) &= -\frac{6t-4k+2k\tau+1}{4k-8t-2k\tau+1};\ x_2(\tau) = \frac{-2(t-1)}{4k-8t-2k\tau+1};\ \pi_2(\tau) = \frac{2k(1-\tau)(t-1)^2(4t-k+k\tau)}{(4k-8t-2k\tau+1)^2}.\\
\pi_1(\tau) &= -\frac{4k^2t^2-8k^2t\tau+8k^2t+4k^2\tau^2-8k^2\tau+4k^2-16kt^3\tau+32kt^2\tau-28kt^2+12kt\tau-28kt+49t^2}{2(4k-8t-2k\tau+1)^2}\\
W(\tau) &= V - \frac{(t-1)\left(\left(4t\tau^2-8t\tau+8t-8\tau+8\right)k^2-16kt^2+32kt\tau-44kt-4k\tau+4k+56t^2-7t\right)}{2(4k-8t-2k\tau+1)^2}
\end{aligned} \tag{25}$$

By maximizing the welfare function (25) with respect to the tax, the optimal level of the tax is found to be zero.[15]

$$\frac{\partial W(\tau)}{\partial \tau} = -2k(2k\tau+1)(t-1)^2\frac{8t-2k-1}{(8t-2k(2-\tau)-1)^3} < 0$$

Proof of Proposition 1

As explained in the main text, substituting (17) in (15) yields the SPE level of welfare in the mixed duopoly, which is given by

$$W^M(k,t) = -\frac{\Omega(k,t)}{2(2k-1)^2\left(2t+8k^2t-8kt+k^2-4k^3\right)^2}$$

where

$$\Omega(k,t) \equiv \begin{pmatrix} 8k^8\left(98t-(30t+4)k+k^2+108t^2+3\right) \\ -2k^6\left(2k+(460k-249)t+(1608k-2390)t^2+16t^3(26k-113)\right) \\ +k^4t\left(11-124k+(1561-3680k)t+(6480-6560k)t^2\right) \\ -2t^2\left(-10t-653k^2t+1890k^3t+124kt-16k^2+174k^3\right) \end{pmatrix}.$$

Recall that the welfare level at the SPE of the zero duopoly is given by $W^Z(k,t) = V + \frac{(1-t)\left(8k^2t+8k^2-16kt^2-44kt+4k+56t^2-7t\right)}{2(4k-8t+1)^2}$.

[15] We do not consider the possibility of subsidies for the private platform.

Therefore the welfare comparison between the two alternative duopolies is given by the sign of the function $F(k,t) = W^M(k,t) - W^Z(k,t)$. The implicit equation $F(k,t) = 0$ is represented in Fig. 3. From this figure it is easy to obtain the region Z where $F(k,t) = W^M(k,t) - W^Z(k,t) < 0$, and region M, where $F(k,t) = W^M(k,t) - W^Z(k,t) > 0$. Due to the complexity of function $W^M(k,t)$, Fig. 3 is obtained by using the mathematical tools available in Scientific Word 5.5. The technical details needed to obtain Fig. 3 are available upon request.

Proof of Proposition 2

The welfare comparison between the mixed and private duopolies is given by the function $G(k,t) = W^M(k,t) - W^P(k,t)$. The implicit equation $G(k,t) = 0$ is represented in Fig. 4. From this figure the regions M_1 and M_2 are obtained where $G(k,t) = W^M(k,t) - W^P(k,t) > 0$, and the region P where $G(k,t) = W^M(k,t) - W^P(k,t) < 0$. As in the proof of Proposition 1, the technical details needed to obtain Fig. 4 are available upon request.

Proof of Proposition 3

As in the proofs of Propositions 1 and 2, the regions plotted in Fig. 5 are obtained by comparing the functions $W^Z(k,t)$, $W^M(k,t)$, and $W^P(k,t)$. By choosing the appropriate intercepts between these three functions the relevant frontiers plotted in Fig. 5 are obtained. As in the proofs of the two previous propositions, the technical details of this result are available upon request.

Parameter restrictions in the private duopoly

From (4) the Second Order Conditions (SOC) with respect to a_i imply $\frac{\partial^2 \pi_i(a_i,a_j)}{\partial a_i^2} = -\gamma\frac{\delta}{t} < 0$, which is consistent with Assumption 1. Similarly, according to (7), the SOC with respect to v_i imply $\frac{\partial^2 \pi_i(v_i,v_j)}{\partial v_i^2} = \frac{1}{9}\frac{k-9t}{t} < 0$, which is also consistent with Assumption 1. Finally, from (9) it is clear that the SPE levels of a_i, v_i, and x_i are positive.

Parameter restrictions in the mixed duopoly

Note, first, that the SOC of platform 2 with respect to a_2 is the same as in the private duopoly. From (11) the SOC with respect to a_1 implies $\frac{\partial^2 W}{\partial a_1^2} = -\frac{1}{2}\delta\frac{2\gamma-\delta}{t} = -\frac{1}{2}\delta^2\frac{2k-1}{t} < 0 \leftrightarrow k > 0.5$, which is clearly ensured by Assumption 1.

Now, consider the SOC for a SPE with respect to quality levels:

From π_2 and W in (15), the SOC with respect to qualities implies $\frac{\partial^2 W}{\partial v_1^2} = \frac{1}{2}\frac{2t-4kt+k^2}{t(2k-1)} < 0$ and $\frac{\partial^2 \pi_2}{\partial v_2^2} = \frac{-t-4k^2t+4kt+k^3}{t(2k-1)^2} < 0$.

The two inequalities above are satisfied under Assumption 1. The proof is shown by plotting the two above expressions and checking that they are negative for the values of t and k consistent with Assumption 1. The details of this result are available upon request.

Now consider the equilibrium levels for the endogenous variables at expression (17). The proof that all these variables are non-negative under Assumption 1 is shown by plotting each variable as a function of t and k and checking that its value is non-negative for the relevant set of parameter values. Again, the technical details of this proof are available upon request.

Parameter restrictions in the zero duopoly

Note that in this case the SOC with respect to platform 2's advertising is the same as in the mixed duopoly. Therefore this condition satisfies Assumption 1. (Recall that $a_1^Z = 0$, which means that there is no need to consider the SOC with respect to this variable).

Now consider the SOC with respect to quality levels. From (20) and (21) the following is obtained:

$$\frac{\partial^2 \pi_2}{\partial v_2^2} = \frac{1}{4}\frac{k-4t}{t} < 0 \text{ and } \frac{\partial^2 W}{\partial v_1^2} = \frac{1}{8}\frac{2k-8t+1}{t} < 0.$$

The two above inequalities are clearly satisfied under Assumption 1.

Finally, to prove that the SPE levels of the endogenous variables at (23) are positive under Assumption 1, plot each variable as a function of k and t and check that all the functions are non-negative under the restriction imposed by Assumption 1. Again, the technical details of the proof are available upon request.

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