Quantity restrictions on advertising, commercial media bias, and welfare☆

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ABSTRACT

We study the welfare effect of a quantity restriction on advertising in free-to-air television (and other advertising financed media) in the presence of commercial media bias. Broadcasters face a trade-off between increasing the number of viewers by sending content that is highly valued by viewers, and increasing the price of advertising by choosing advertiser friendly content. A cap on advertising drives the per-viewer price of ads up; thus, content improves for viewers. Therefore, the cap can be welfare enhancing, even when viewers are not ad averse. Competition among broadcasters makes it more likely that a cap on advertising improves welfare. Thus, there is a complementarity between regulation and competition on this market. We also show that a tax on advertising revenues has quite different effects than a cap on advertising quantity.

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1. Introduction

It is widely agreed that a free and independent media is important for society and democracy. While the independence of media can be endangered from many directions, recent discussions both in academia and policy circles have shown that commercial media bias is an important concern. Commercial media bias arises out of a conflict of interest between advertisers and audiences over media content. Studies from marketing have shown that advertisers prefer lighter content and genres that put consumers in a more advertising receptive mood.[1] Moreover, advertisers may prefer the media not to report critically about their products.[2] There are indications that the topic of commercial media bias has become especially important in recent years. The FCC (2011) has reported worries about the "crumbling ad-edit wall" in broadcast television: due to their difficult financial

[1] For example, Wilbur (2008, p. 373) finds that "advertiser genre preferences are nearly opposite those of viewers" : viewers prefer action and news, while advertisers prefer reality and comedy. A case in point is that Coca-Cola and General Foods have refused to advertise during news broadcasts, as "bad" news might affect consumers' perception of their products (Hawkins and Mothersbaugh, 2009).

[2] For example, tobacco advertisers have pressured media outlets to suppress information concerning the health risks of smoking. Blasco and Sobbrio (2012) provide a survey of the evidence.

situation, media enterprises may be particularly vulnerable to advertisers' pressures.[3]

This paper investigates the welfare effects of limits for the quantity of advertising in a commercial free-to-air television market in the presence of commercial media bias. Since free-to-air broadcasters do not collect direct payments from their audiences, they may be especially susceptible to advertisers' influence. In our model, broadcasters choose the quality of their program for the viewers and the quantity of advertising. The conflict of interest between viewers and advertisers gives rise to a trade-off: making the program more attractive for viewers increases the number of viewers, but lowers the willingness to pay of the advertisers. Ceteris paribus, a cap on advertising quantity will drive the per-viewer price of advertising up since the inverse ad demand is decreasing in quantity. A higher per-viewer price of advertising makes it more profitable for broadcasters to attract additional viewers. Therefore, the non-advertising program content of the media will become more aligned with viewers' preferences.

This result may help to understand cross-country differences in television content. News belong to the viewers' (but not advertisers') most preferred television genres (Wilbur, 2008). We would therefore expect that the supply of news is higher when advertising quantity is restricted, and indeed Aalberg et al. (2010) show that the supply of news and current affairs by the biggest commercial broadcasters during prime time is drastically higher in several European countries, where advertising quantity is restricted, than in the USA, where it is not.[4]

A quantity restriction on advertising increases consumer surplus but decreases producer surplus. We study the conditions under which welfare (which we take to be the sum of consumer surplus and all profits) increases. In particular, due to its effect on media content, a cap may improve welfare even when consumers do not directly suffer from advertising or can easily avoid ads by the use of ad avoidance technologies such as digital video recorders (DVRs).

Competition between many independently owned broadcasters helps overcoming commercial media bias. Surprisingly, it increases at the same time the likelihood that a cap on advertising improves welfare. Therefore, competition and regulation of advertising should not be seen as substitutes; rather, they complement each other. The key reason for the complementarity is as follows. A cap that marginally reduces advertising quantity crowds out the marginal advertisers. The associated loss in producer surplus depends on the willingness to pay of the marginal advertisers, which in equilibrium equals the price of an advertising spot. Competition on the media market decreases this price. Correspondingly, the marginal advertiser has a lower willingness to pay, and the loss in producer surplus from a cap is lower.

The complementarity between regulation and competition is thus tightly linked to the effect of competition on advertising prices. Empirically, it seems that competition on the broadcasting market reduces advertising prices (see Brown and Alexander, 2005). As has been pointed out by Athey et al. (2013, p. 6) and Anderson et al. (2012), this poses a puzzle in media economics since standard models of free TV give the opposite prediction: competition between broadcasters for viewers decreases advertising quantities since viewers are ad averse and thereby *increases* advertising prices. Our model provides a potential explanation for the empirical results. Strong competition among broadcasters leads to low advertising quantities, but also to viewer friendly programs. Other things being equal, the reduction of advertising quantity increases advertising prices, as in the standard models. A more viewer friendly program, however, lowers the advertisers' willingness to pay and thus equilibrium advertising prices. We show that the latter effect dominates the former one.

Our model also contributes to understanding the "crumbling ad-edit wall" diagnosed by some observers of today's media markets. In times of low ad demand, for example, due to advertisers moving online or due to general economic conditions, the price of an ad per viewer is lower. Therefore, attracting viewers is less important for the broadcasters. As a consequence, in equilibrium media content will be more aligned with advertiser preferences.

A cap on advertising lowers broadcasters' profits and may thus induce exit and a higher concentration on the media market. We show, however, that our main results are qualitatively similar when taking endogenous entry into account. In particular, a "local" cap (that slightly reduces advertising quantity) improves consumer surplus and is more likely to be welfare enhancing when competition is fierce. In contrast, a proportional tax on advertising revenues has rather different implications than a cap. The reason is that a cap reduces advertising quantity while a tax increases it in the long run. Marginal costs are zero in television markets. A tax on advertising revenue is therefore a tax on variable profits, and for a given number of broadcasters, equilibrium decisions are unchanged. The tax lowers broadcasters' profits, however, and thus induces exit, and the reduced competition leads to an increase of advertising quantity.

Our paper contributes to two classic topics in public finance, the private provision of public goods, and the comparison of price versus quantity instruments, in the specific setting of advertising financed media. Media markets are of general interest since the working of these markets not only affects their active participants but also generates important externalities, for example, by helping citizens to take well-informed political decisions. For an adequate analysis, the structure of media markets needs to be modelled in more detail than is customary in the theory of public goods. We thus build on modeling tools developed in the economic analysis of advertising and in the theory of two-sided markets, which is a comparatively new topic in public finance.

The paper is organized as follows. The next section provides the background by reviewing (i) the empirical literature on the influence of advertisers on media content, (ii) the conflict of interest between viewers and advertisers, (iii) the regulation of television advertising, and (iv) the related literature. Section 3 gives a simple and highly stylized example that illustrates the main effects in our model. Section 4 introduces the model, briefly mentions its microfoundations (which are presented in detail in Section 2 of the Online Appendix), and discusses the assumptions underlying our welfare analysis. Section 5 characterizes the equilibrium and its welfare properties, investigates the welfare effects of a cap, determines the welfare maximizing cap without and with endogenous entry in the broadcasting market, and discusses advertising taxes. Section 6 studies Pay TV and ad avoidance technologies. Section 7 summarizes our findings, discusses robustness issues and extensions (laid out in detail in the Online Appendix), and briefly mentions the testable predictions of the model. Proofs are relegated to the Appendix, and some lengthy technical proofs to the Online Appendix.

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[3] For example, the FCC (2011) describes the case of a local Fox channel, KBTC-TV, which featured a story on a new electronic rehabilitation system for injured kids. The reporter was introduced to the audience in a way that suggested an independent report by the channel. The reporter did not work for KTBC, however, but for the Cleveland Clinic. Liebermann (2007) reports that this is not an isolated case: "a hybrid of news and marketing (…) has spread to local TV newsrooms all across the country (…). Viewers who think they are getting news are really getting a form of advertising. And critical stories – hospital infection rates, for example, or medical mistakes or poor care – tend not to be covered." Recent academic contributions on commercial media bias include Reuter and Zitzewitz (2006), Ellman and Germano (2009) and Germano and Meier (2013); we review the literature in Section 2. The issue has also recently raised the interest of the FTC, which hosted a workshop on the "blurred lines" between advertising and content in December 2013.

[4] Aalberg et al. (2010) compare the two biggest commercial broadcasters in each of five European countries with the two biggest commercial broadcasters in the USA. During peak hours, in 2007, the biggest two commercial broadcasters in the USA devoted an average of 6 minutes a day on news and current affairs. In comparison, the biggest two commercial broadcasters in Belgium provided 42 minutes, in the Netherlands 20 minutes, in Norway 19 minutes, in Sweden 27 minutes, and in the UK 37 minutes. Of course, there are many differences between these European countries and the USA. The authors stress the higher importance of public service broadcasting in Europe. Within countries, public service broadcasters have a higher news supply than commercial broadcasters; across countries, the biggest public service broadcasters in the European countries show more news during prime time than those in the USA.

2. Background

2.1. Ads influence editors

Many media platforms depend heavily on advertising revenues. For example, the 2014 Pew report on the state of the news media finds that advertising accounts for 69% of US news revenues (Pew Research Center, 2014). At the same time, media reports about firms and their products influence profits.[5] The media's dependence on advertising revenues, combined with its impact on firms' profits, implies that advertisers have economic incentives to influence editorial decisions. Several recent papers have shown econometrically that indeed advertisers systematically influence media content.[6] Advertisers' influence on media content can be expected to be especially strong in solely advertising funded media such as free TV or radio broadcasting. Moreover, the difficult financial situation of the news media today afflicts the quality of news coverage (Pew Research Center, 2013) and has led to a reconsideration of the traditional separation between media companies' news and business divisions (FCC, 2011).

2.2. Conflict of interest between viewers and advertisers

At the center of our model is a conflict of interest between viewers and advertisers over media content. Here we discuss the empirical literature that motivates this assumption. First, there is good evidence that viewers favor different genres than advertisers. Wilbur (2008) estimates a two-sided empirical model of viewer demand for programs and advertiser demand for audiences. In his data, viewers' two most preferred programs are action and news, accounting for 16% of program network hours, whereas advertisers' two most preferred programs are reality and comedy, accounting for 47% of program network hours. His results suggest that advertisers' preferences have a bigger impact on the networks than the viewers' preferences. Similarly, Brown and Cavazos (2005, p. 30) find that "broadcast television programs receive large and statistically significant premia or discounts based on their content, holding constant the number, income, age and gender of the viewers these programs attract. Sitcoms receive large premia, while news shows and police dramas receive large discounts." In their sample, adjusting for the length of these program types, sitcoms aired more than one-and-a-half time more often than news shows and police dramas combined.

A potential explanation for advertisers' genre preferences is provided by the experimental research concerning context effects on advertising effectiveness. Goldberg and Gorn (1987) show that happier program content puts viewers in a more advertising receptive mood. Relatedly, Mathur and Chattopadhyay (1991) find that it improves viewers' message recall as well as their cognitive responses towards the commercials. Advertisers take these issues seriously. Hawkins and Mothersbaugh (2009, p. 298) report that "Coca-Cola and General Foods have refused to advertise some goods during news broadcasts because they believe that 'bad' news affect the interpretation of their products. According to a Coca-Cola spokesman: 'It's a Coca-Cola policy not to advertise on TV news because there is going to be some bad news in there, and Coke is an up-beat, fun product.'"

A second issue is that viewers but not advertisers may favor accurate reporting of any defects, risks, or negative externalities of products (for a review, see Blasco and Sobbrio, 2012, and Online Appendix Section 2). An important and well-documented case in point is the media coverage of the health risks of smoking. Another important case is the media coverage of anthropogenic climate change, where the discourse in the news media has significantly diverged from the scientific consensus. As pointed out by Ellman and Germano (2009), one potential reason behind this biased media coverage is the influence of big advertisers such as car manufacturers or airlines.

2.3. Regulation of TV advertising

The regulation of the quantity of advertising in television differs markedly across countries. In the European Union, for example, the Audiovisual Media Services Directive requires that the "proportion of television advertising spots and teleshopping spots within a given clock hour shall not exceed 20%" (Article 23 § 1.). In contrast, in the United States there are no such rules, except for children's programs. Economic theory has identified two countervailing considerations concerning the welfare effects of limits for the quantity of advertising (Anderson and Coate, 2005): On the one hand, broadcasters are often competitive bottlenecks and have market power over advertisers, suggesting that advertising quantity may be too low from a welfare perspective, for the usual reason why firms with market power restrict quantities below the efficient level. On the other hand, consumers may have a disutility from advertising, suggesting that there may be too much advertising in free TV since the free TV broadcasters cannot perfectly internalize the effect of advertising on their viewers.[7] Indeed, regulation authorities describe protecting consumers as the most important function of the quantity restrictions (e.g. OFCOM, 2011).

Today consumers can, however, avoid contact with annoying advertisements by the use of ad avoidance technologies such as digital video recorders (DVRs). In the EU, about 30% of all households already use such technologies (IP Network, 2013). In the US, 47% of TV households have at least one digital video recorder (Leichtman Research Group, 2013), and about 23% have DVRs on more than one TV set. The average US American watches 25 minutes of DVR playback a day (Nielsen, 2013). The traditional argument for quantity restrictions on advertising may become less compelling under these conditions. Our paper shows that, however, a cap on advertising makes the non-advertising content of the media more aligned with viewers' preferences. Therefore, a cap may increase welfare even if no consumer is directly affected by advertising.

2.4. Related literature

Our paper is related to four strands of the literature. First, broadcasting is a prime example of the private provision of a public good. For this reason, our paper contributes to the broad literature on public good provision (for a review, see Batina and Ihori, 2005). The provision of public goods via advertising is studied in Luski and Wettstein (1994) and Anderson and Coate (2005). Our paper goes beyond these papers by studying advertisers' impact on media content.

Second, our paper contributes to the literature on price versus quantity instruments (Weitzman, 1974), as we compare the welfare implications of a tax on advertising with the effects of a quantity regulation. Our contribution to this literature is to focus on a specific industry, namely, advertising supported media.

Third, we contribute to the growing work on media bias (for a survey, see Prat and Strömberg, 2013). The economics' literature has mainly focussed on political media bias. We focus on advertisers' influence and commercial media bias. Our analysis is closely linked to Ellman and Germano (2009). In their setting, consumers value accurate news, while advertisers value ad-receptive consumers. They show that a monopoly newspaper will underreport news that sufficiently reduces advertiser profits. Interestingly, in a newspaper duopoly, commercial media bias will be eliminated when advertising demand is sufficiently high, unless advertisers are able to commit to withdraw ads from newspapers if they

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[5] See Online Appendix, Section 2, for empirical references.

[6] The seminal contribution is Reuter and Zitzewitz (2006). See Table 1 in the Online Appendix for an overview of econometric evidence. As we describe in Section 1 of the Online Appendix, interviews and surveys of key players in the market also confirm that advertisers influence media content.

[7] Wilbur (2008) estimates that a 10% reduction of advertising quantity in television leads to a 25% increase in audience size.

report too critically. Germano and Meier (2013) study the case of many competing horizontally differentiated media outlets to investigate how media diversity and ownership concentration affect commercial media bias. Blasco et al. (2014) and Spiteri (2015) show that commercial media bias is a concern in particular if all advertisers share the same preferences over media content, as in the tobacco example, where the tobacco industry had a shared interest in eliminating coverage of the health risks of smoking. Otherwise, competition in the product market may help overcome commercial media bias. Blasco and Sobbrio (2012) provide a survey on competition and commercial media bias. However, the quantity of advertising chosen by free TV broadcasters, its interaction with program quality and commercial media bias, and the welfare effects of a cap on advertising, have not been formally studied yet. The present paper attempts to close this gap. We ask how a quantity restriction on advertising influences commercial media bias, analyze its welfare properties, and compare the effects of a quantity restriction with those of a tax on advertising revenues.

Our model also relates to the literature on political media bias and media capture. In some settings, politicians or governments are in fact major advertisers. Politicians that aim to be (re)elected inform the voters on their manifestos via canvassing television ads; they prefer the broadcasters not to report on any scandals or former mistakes that could reduce their chances. Voters, on the other hand, wish to be properly informed about the candidates. Suppressed information on politicians can prevent them from making an appropriate choice and hence lead to distorted political outcomes. Empirical evidence on this mechanism is given by Di Tella and Francescelli (2011), who show in a study of Argentinian newspapers that government advertising is associated with a reduced coverage of the government's corruption scandals. Moreover, as reported above, news are among the most preferred genres of viewers, but not of advertisers. News consumption may have positive externalities by improving citizens' political decisions, and consumers will not internalize the large social gains associated with an informed electorate. Therefore, there could be a demand driven media bias of too little informative news even without any interference from advertisers (Gentzkow and Shapiro, 2008). Commercial media bias against news aggravates this concern.

Fourth, in order to model advertising supported media adequately, we build on the literature on advertising (for a survey, see Bagwell, 2007) and two-sided markets (for a survey, see Anderson and Gabszewicz, 2006). There are three major views in the economic analysis of advertising. According to the informative view, advertising provides customers with information about the existence, price, or qualities of the products. The persuasive view holds that advertising changes consumers' tastes. The complementary view holds that advertising raises the true utility of the advertised goods. The literature has ambiguous results on whether there is too much or too little advertising from a welfare perspective. Moreover, the empirical literature indicates that no single view captures all the relevant aspects (see Bagwell, 2007). In this paper, we aim to show that a cap on advertising improves welfare under some conditions. To make our case strong, we take a rather benign view of advertising and model advertising as informative.[8]

In the theory of two-sided markets, our paper is closely related to the seminal work of Anderson and Coate (2005), who argue that from a welfare perspective equilibrium advertising quantities in a two-sided media market may be too high or too low, mainly depending on consumers' ad aversion. Their model has been extended to a more detailed analysis of horizontal product differentiation by Peitz and Valletti (2008). Our model of entry in two-sided markets is related to Choi (2006) and Crampes et al. (2009). The studies by Ellman and Germano (2009), Germano and Meier (2013), and Blasco et al. (2014) discussed above pioneered using models of two-sided markets for the analysis of commercial media bias. As we compare the welfare

implications of a tax on advertising with the effects of quantity regulation, our work is furthermore related to Kind et al. (2008), who examine taxes in two-sided markets. They study the cases of a monopoly platform, and of perfect competition, assuming that the platforms' marginal costs are strictly positive, and show that taxes can help to accomplish the social optimum if the platform causes overprovision. Our paper, in contrast, focusses on endogenous program quality, and in particular on commercial media bias, in television markets, which are typically oligopolistic. Moreover, in television markets marginal costs are negligible. Thus, revenue taxes are taxes on variable profits and affect entry but cannot be used to fine-tune economic decisions in the short run. Finally, our paper can also be linked to work on ad avoidance technologies (e.g. Anderson and Gans, 2011).

3. Example

In this section, we illustrate the main effects in our model with a simple and highly stylized example, deferring a more detailed discussion of our assumptions to the next section. In the example, a monopoly broadcaster chooses its program quality v and its advertising quantity a. Consumers are uniformly distributed on a Hotelling line [0,1], the broadcaster is located at 0. Consumers have linear travel costs: a viewer who is located at a distance $x \in [0,1]$ from the broadcaster has utility $v–x$ from watching television. Consumers are ad neutral: their utility from watching television is independent of the advertising quantity. A consumer watches television whenever his utility exceeds his outside option of zero. The total number of consumers is normalized to one; thus, the number of viewers is simply equal to the program quality v.

To capture the conflict of interest between advertisers and viewers, we assume that advertisers' willingness to pay for advertising spots decreases in program quality. To be specific, let r denote the per-viewer price of an advertising spot, and suppose that the inverse ad demand per viewer is $r = 1 - v - a$.

The broadcaster is financed by advertising, has zero variable costs, and fixed costs $F > 0$. To ensure viability of the market, let $F < 1/27$. The broadcaster's revenue is equal to the number of viewers, times the prices of an ad per viewer, times the number of ads; its profit is $\pi = v(1 - v - a)a - F$.

For a given advertising quantity $a > 0$, the profit-maximizing program quality v is determined by the first-order condition

$$1 - v - a = v. \tag{1}$$

Eq. (1) illustrates the fundamental trade-off in our model. The left-hand side of Eq. (1) describes the marginal gain of the broadcaster from higher quality, on a per advertising spot basis: higher quality increases the number of viewers, and on each viewer the broadcaster earns the price of an ad per viewer. The right-hand side of Eq. (1) describes the marginal costs of the broadcaster from higher quality, per advertising spot: higher quality decreases the price of an ad per viewer, and the loss of revenue is equal to the number of viewers, which is equal to v in the example.

Solving Eq. (1) for the profit-maximizing program quality gives $v = v^*(a) := (1 - a) / 2$. Substituting $v^*(a)$ into the broadcaster's profit function leads to $\pi = (1 - a)^2 a / 4 - F$. Without a cap on advertising quantity, the profit-maximizing choices of the broadcaster are $a = v = 1/3$, resulting in a profit $1/27 - F > 0$. If there is a cap $\bar{a} < 1/3$, the broadcaster's profit-maximizing choices are $a = \bar{a}$ and $v = v^*(\bar{a})$, as long as the resulting profit is positive; otherwise, the broadcaster shuts down.

Note that the profit-maximizing quality *increases* when a binding cap is introduced. The reason is straightforward to see from the first-order condition Eq. (1): if the advertising quantity is lower due to a cap, ceteris paribus the price of an ad per viewer is higher, and this gives the broadcaster an incentive to increase its quality in order to attract additional viewers.

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[8] Section 4.2 discusses the assumptions underlying our welfare analysis in more detail. In Section 3.1 of the Online Appendix, we also explore the case of misleading advertising.

Now consider the welfare effects of a cap on advertising quantity. We measure consumer surplus by the consumers' aggregate utility from watching television, $CS = \int_0^v (v - x)dx$. Inserting $v^*(a)$ shows that $CS = (1 - \bar{a})^2/8$ is decreasing in $\bar{a}$. Because a cap increases program quality, consumers are better off, even though they are ad neutral in our example. On the other hand, the cap decreases producer surplus, as measured by the area under the per-viewer inverse advertising demand curve multiplied by the number of viewers. To see this, insert $a = \bar{a}$ and $v = v^*(\bar{a})$ into $PS = v\int_0^{\bar{a}}(1 - v - x)dx$ to get $PS = \bar{a}(1 - \bar{a})/4$, which is increasing in $\bar{a}$ in the relevant range $\bar{a} \leq 1/3$. Welfare (the sum of consumer surplus and producer surplus minus fixed costs) is $(1 - \bar{a}^2)/8 - F$ and thus decreasing in $\bar{a}$ in the relevant range. The benefits of the consumers from a cap outweigh the losses of producers. Of course, if the cap is too tight, it will drive the broadcaster out of business, to the detriment of both consumer surplus and producer surplus. The welfare maximizing cap is as tight as possible, subject to the broadcaster breaking even.

4. The model

4.1. Economic agents

There are $N \geq 2$ advertising funded media outlets. Our prime application is to free-to-air television broadcasters, but the model is also applicable to other advertising funded media, such as radio broadcasting. Broadcaster i chooses its program quality $v_i \in \mathbb{R}$ and its quantity of advertising $a_i \in \mathbb{R}_+$.[9] We study a model of a circular town in the spirit of Salop (1979), this is perhaps the best known textbook model that allows for horizontal product differentiation and a flexible number of firms.[10] Broadcasters are evenly spaced on a circle with unit circumference. A mass n of viewers is uniformly distributed on the circle. Viewers single home: each viewer watches only one broadcaster.[11] The utility of a viewer located at a distance x from broadcaster i is

$$w + v_i - \delta a_i - \tau x. \tag{2}$$

Here, $w > 0$ is an exogenous parameter sufficiently big to ensure the market is covered in equilibrium; it represents a viewer's utility from a program located at his ideal point with zero advertising and program quality. The viewers' utility increases in program quality v_i. The parameter $\delta \geq 0$ captures ad aversion; consumers are ad averse when the parameter δ is strictly positive, and ad neutral when $\delta = 0$.[12] Transportation costs are linear with a transportation cost parameter $\tau > 0$, which can be regarded as a measure of the broadcasters' substitutability; the lower τ, the easier it is to substitute for broadcaster i's program.

There is a mass m of producers. Each of them produces and advertises one good at constant marginal costs normalized to zero. We refer to the producers also as the advertisers. Advertising is informative: consumers are initially unaware of the existence of a good, but become informed when watching a channel that is airing an ad for the good.

Producers are characterized by the quality of their goods, denoted by $\tilde{\sigma}$. We assume that $\tilde{\sigma}$ is uniformly distributed on $[0, \sigma]$. The parameter $\sigma > 0$ corresponds to the highest possible quality of a consumption good.

To model the conflict of interest over media content between viewers and advertisers, we assume that a consumer watching a channel with quality v_i is willing to pay up to $\tilde{\sigma} - \beta v_i$ for a product of quality $\tilde{\sigma}$, where $\beta > 0$. High-quality television program reduces the perceived benefits of the products, and thus the consumers' willingness to pay for them. Following Anderson and Coate (2005), we assume that producers capture the willingness to pay of the consumer on the product market. Therefore, the willingness to pay of an advertiser of type $\tilde{\sigma}$ for informing a viewer who watches broadcaster i is $\tilde{\sigma} - \beta v_i$, as well. Thus, viewers' utility increases in v_i, while advertisers' willingness to pay decreases in v_i. In this way, our model captures the conflict of interests over media content between viewers and advertisers.[13] The model combines elements from the classic study of welfare in broadcasting markets by Anderson and Coate (2005) with ideas from the literature on commercial media bias. If program quality is exogenous[14], our model is close to Anderson and Coate (2005).[15] We take from Ellman and Germano (2009) and Germano and Meier (2013) the assumption that program quality decreases the willingness to pay of advertisers.[16]

Advertisers multi-home. Denote the per-viewer price of an ad on broadcaster i by r_i. Assuming $\sigma > \beta v_i + r_i \geq 0$,[17] advertising demand is

$$a_i = m \ \Pr(\tilde{\sigma} - \beta v_i > r_i) = m\left(1 - \frac{\beta v_i + r_i}{\sigma}\right).$$

Solving for r_i gives inverse ad demand per viewer, which is

$$r_i = \sigma - \beta v_i - \frac{a_i \sigma}{m}, \tag{3}$$

whenever $\sigma - \beta v_i \geq a_i \sigma / m$; otherwise, inverse ad demand is zero. The broadcaster's revenue per viewer is $r_i a_i$.

Suppose all broadcasters $j \neq i$ behave symmetrically, and let $u := v_j - \delta a_j$. Moreover, suppose that there is an indifferent viewer located between broadcaster i and its closest competitors.[18] Denote the distance between the indifferent viewer and broadcaster i by $\hat{x}$. Then

$$v_i - \delta a_i - \tau \hat{x} = u - \tau\left(\frac{1}{N} - \hat{x}\right).$$

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[9] We take v_i from the real numbers to avoid corner solutions which are less interesting from an economic point of view.

[10] In Section 4.1 of the Online Appendix, we show that the main results do not hinge on specific features of the Salop circle model. We introduce a more general model of television viewing behavior that nests the Salop model and several other textbook models of discrete choice. We find that the conditions under which a local cap improves welfare are qualitatively similar. The precise quantitative implications, however, depend on the assumed model of television viewing.

[11] Note that the assumption of single homing viewers makes the case for advertising restrictions stronger. Single homing implies that broadcasters have market power on the advertising market and will restrict advertising quantities in order to drive up the price per ad per viewer. Therefore, as argued by Anderson and Coate (2005), equilibrium advertising levels may be too low in equilibrium. If we had competition among broadcasters for advertisers, we would rule out by assumption an important argument why equilibrium advertising quantities may be too low.

[12] In the main model, we assume all viewers dislike ads to the same degree. In order to investigate the impact of ad avoidance technologies, an extension where consumers differ in ad aversion is studied in Section 6.2.

[13] Microfoundations are mentioned in Section 4.3 and discussed in detail in Section 2 of the Online Appendix.

[14] If there is an upper bound $\bar{v}$ on program quality, one can also think of the standard model as the case where $\beta = 0$. Then broadcasters will choose the program quality as high as possible. In the main part of the paper, we assume that the upper bound on quality is not binding. We come back to this issue in Section 6.1.

[15] One remaining difference is that we study a Salop model with a circular town, whereas Anderson and Coate (2005) consider a linear Hotelling specification.

[16] In our main model, we assume that a higher program quality reduces the willingness to pay of all advertisers by the same amount; that is, advertisers have a shared interest in reducing program quality. We study the robustness of our results in two extensions. Section 3.2 in the Online Appendix assumes that only a subset of advertisers has an interest in reducing program quality; this also allows to study sector specific regulation. In Section 4.2 of the Online Appendix, it depends on the quality $\tilde{\sigma}$ of the advertised good how much the willingness to pay changes with television quality. We find that if one plausibly assumes that the willingness to pay of producers of high quality is less affected by program quality, the quality enhancing effect of a cap is reinforced.

[17] The second inequality ensures we can safely ignore corner solutions where every advertiser advertises; this will be the case in equilibrium if $N \geq \beta \tau/(\sigma + m\beta\delta)$.

[18] This is the case if $u - \tau/N < v_i - \delta a_i < u + \tau/N$. If $v_i - \delta a_i < u - \tau/N$, broadcaster i has no viewers. If $v_i - \delta a_i > u + \tau/N$, broadcaster i is said to undercut its rivals, which will not happen in equilibrium. Due to the linear travel costs, the profit of broadcaster i is discontinuous when broadcaster i just undercuts its rivals: if broadcaster i increases its quality and/or reduces its advertising so much that a viewer whose location is at the location of broadcaster $i + 1$ prefers broadcaster i, then broadcaster i gains all the viewers of broadcaster $i + 1$, including those located between $i + 1$ and $i + 2$. This is a standard property of the Salop (1979) model with linear transportation costs. We carefully spell out profits from undercutting in the proofs.

Any viewer with distance less than $\hat{x}$ watches broadcaster i. Therefore, the fraction of viewers watching broadcaster i is

$$2\hat{x} = \frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau}.$$

The profit of broadcaster i is

$$\pi_i = n\left(\frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau}\right)\left(\sigma - \beta v_i - \frac{\sigma a_i}{m}\right)a_i - F, \tag{4}$$

where $F > 0$ are the fixed costs of operation. In Sections 5.1 to 5.3, we consider the case where the number of broadcasters is exogenous and assume that the fixed costs are sufficiently small such that broadcasters make positive profits in equilibrium. Section 5.4 shows that our main results are robust if we study a model with free entry and endogenize the number of broadcasters with a zero profit condition.

4.2. Welfare

In the main part of the paper, our welfare analysis assumes that the willingness to pay of advertisers correctly captures the social benefit of advertisements. As argued by Anderson and Coate (2005), this is a neutral benchmark case, abstracting away from several countervailing considerations (for a review of the economics of advertising, see also Bagwell, 2007). On the one hand, consumers benefit from informative advertising, and when these gains cannot fully be appropriated by the producers, their willingness to pay underestimates the welfare gains of advertising (Shapiro, 1980). On the other hand, if there is competition between producers of products, the advertisers' willingness to pay overestimates the true welfare gains from advertising due to the business stealing effect (Grossman and Shapiro, 1984).

Moreover, persuasive or misleading advertising may make consumers buy products at a price higher than their "true" utility gains from them, which is another reason why advertisers' willingness to pay may overestimate the welfare gains from advertising (Dixit and Norman, 1978). Incorporating these effects would give additional reasons why a cap on advertising can increase welfare. The literature on commercial media bias reviewed in Section 2 has argued that there are empirically large and important externalities from advertising due to such effects, for example, when the advertised products involve health risks and the media do not disseminate this information. We abstract from these considerations in our main model but take them into account in an extension Section 3.1 of the Online Appendix, where we show that they make the case for advertising restrictions stronger.[19]

Our analysis will focus on symmetric equilibria where all broadcasters choose the same quantity a and quality v. Then consumer surplus CS is given by

$$CS = n(w + v - \delta a) - \frac{n\tau}{4N}. \tag{5}$$

Producer surplus PS is the surplus of the broadcasters and the advertisers; in other words, PS equals the sum of advertisers' profits, broadcasters' profits, and fixed costs. In our setting, PS is equal to the total revenue of the advertisers. PS can be calculated as the area under

the per-viewer inverse demand curve for advertising spots, multiplied by the number of viewers:[20]

$$PS = n\int_0^a \left(\sigma - \beta v - \frac{\sigma x}{m}\right)dx. \tag{6}$$

Total revenues of the broadcasters equal $n\left(\sigma - \beta v - \sigma a/m\right)a$, that is, the number of viewers, times the price of an ad per viewer, times the number of ads per broadcaster. The profits of the advertisers are the difference between their revenues and the payments to the broadcasters,

$$n\int_0^a \left(\sigma - \beta v - \frac{\sigma x}{m}\right)dx - n\left(\sigma - \beta v - \frac{\sigma a}{m}\right)a = \frac{1}{2}\frac{a^2}{m}n\sigma. \tag{7}$$

For a given advertising quantity, advertisers' total profits (Eq. (7)) do not depend on program quality. To understand why, note that an increase in program quality implies a parallel downward shift of the inverse ad demand function; for advertising quantity to stay constant, the price of an advertising spot must decrease by the same amount. Moreover, given advertising quantity, advertisers' total profits (Eq. (7)) is independent of the number of broadcasters N.

Using Eq. (7), Eq. (6) can also be written as

$$PS = \underbrace{n\left(\sigma - \beta v - \frac{\sigma a}{m}\right)a}_{\text{Revenues of broadcasters}} + \underbrace{\frac{1}{2}\frac{a^2}{m}n\sigma}_{\text{Profits of advertisers}}. \tag{8}$$

This formulation is helpful in the analysis in Section 5.4, where broadcasters' profits are driven down to zero by free entry, i.e., the revenue of the broadcasters equals their fixed costs NF.

Finally, welfare W is the sum of consumer surplus and total profits of broadcasters and advertisers: $W = CS + PS - NF$.

4.3. Microfoundations

A central assumption of our paper is that the willingness to pay of an advertiser for reaching a consumer decreases in the quality of the program the viewer watches. Four different microfoundations for this assumption can be provided. First, for viewers, high-quality television may be a substitute for consumption, and thus lower their willingness to pay on the product markets. Second, viewers' recall of an ad may depend on the program it is embedded in. Third, the television program may impact the moods of boundedly rational consumers and, thereby, in turn, their purchase behavior. Fourth, high-quality television may contain useful information that counteracts deceptive advertising and thereby lowers consumer demand on the product market. We discuss these microfoundations in more detail in Section 2 of the Online Appendix, where we also provide references to the underlying empirical literature.

These microfoundations are not mutually exclusive. Great television programs may at the same time be substitutes for consumption goods, generate lower attention to and recall of advertisements, influence boundedly rational moods, and inform and counteract deceptive advertising. All these microfoundations imply that there is a conflict of interest between advertisers and viewers over television content, and lead to the same positive predictions of the model.[21] For normative questions,

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[19] Another interesting benchmark is to be agnostic about the value of advertising, and therefore to give it no positive or negative weight in the welfare analysis at all (see Peitz and Valletti, 2008, p. 16). Then welfare is a function of program quality alone. A cap on advertising increases welfare according to this standard if it improves the equilibrium program quality. We show this is the case when the number of broadcasters is exogenous, but need not be the case with free entry.

[20] One way to see this is to calculate the revenues of the advertisers. Recall that the mass m of advertisers is uniformly distributed on $[0,\sigma]$. If a is the number of advertising spots, then the marginal advertiser z is given by $(\sigma - z)m / \sigma = a$, i.e., $z = \sigma - a\sigma / m$. Advertisers with $\tilde{\sigma} > z$ advertise, those with $\sigma \sim < z$ do not. The per-viewer revenue of an advertiser of a type $\tilde{\sigma} > z$ is equal to $\tilde{\sigma} - \beta v$. Thus, advertisers' total revenue is

$$n\int_{\sigma - \frac{a}{m}\sigma}^{\sigma} (\tilde{\sigma} - \beta v)\frac{m}{\sigma}d\tilde{\sigma} = n\int_0^a \left(\sigma - \beta v - \frac{\sigma x}{m}\right)dx.$$

[21] While all the microfoundations are consistent with our assumption that a consumer's willingness to pay for a product of type $\tilde{\sigma}$ is equal to $\tilde{\sigma} - \beta v$, the willingness to pay may also be a nonlinear function. We further discuss this in Section 4.2 of the Online Appendix.

our main model builds on the first two microfoundations, where consumers' willingness to pay for a product accurately captures their true benefits from the product. If boundedly rational moods have an impact on purchase behavior, or advertising is deceptive, consumers may have losses on the product market since their perceived gains from the products are not equal to their true gains. The magnitude of these losses may depend both on advertising quantity and on television program quality. In Section 3.1 of the Online Appendix, we study an extension of our main model that takes these considerations into account.

5. Results

5.1. Equilibrium

For a given advertising quantity $a_i > 0$, the profit-maximizing quality is determined by the first-order condition

$$\underbrace{\frac{n}{\tau}\left(\sigma - \beta v_i - \frac{\sigma a_i}{m}\right)}_{\equiv r_i} = \beta n\left(\frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau}\right). \qquad (9)$$

The left-hand side of Eq. (9) describes the marginal gain of broadcaster i from increasing its program quality, on a per advertising spot basis. Higher quality increases the number of viewers by n / τ, and on each viewer, the broadcaster earns the price of an ad per viewer r_i. The right-hand side of Eq. (9) describes the broadcaster's marginal costs from increasing its quality, per advertising spot. Higher quality decreases the price of an ad per viewer by β, and the loss of revenue is equal to β times the number of viewers.

The first-order condition for the profit-maximizing advertising quantity is

$$\frac{\partial \pi_i}{\partial a_i} = -\frac{n\delta}{\tau}r_i a_i - n\left(\frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau}\right)\frac{\sigma}{m}a_i + n\left(\frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau}\right)r_i = 0. \qquad (10)$$

If broadcaster i shows more ads, he loses viewers because of ad aversion (the first term), achieves a lower per-viewer price of ads (the second term), but generates additional revenue on the additional advertising quantity (the third term). The profit-maximizing quantity balances the marginal benefits and costs. Our first result characterizes the symmetric equilibrium.

Proposition 1. *Suppose there is no quantity restriction on advertising. There is a symmetric equilibrium where for $i = 1,...,N$:*

$$a_i = \frac{m\beta\tau}{N(\sigma + m\beta\delta)}, \qquad (11)$$

$$v_i = \frac{\sigma}{\beta} - \frac{\tau(2\sigma + m\beta\delta)}{N(\sigma + m\beta\delta)}. \qquad (12)$$

Inverse ad demand per viewer is $r_i = \beta\tau / N$. The equilibrium profit of broadcaster i is

$$\pi_i = \frac{nm\beta^2\tau^2}{N^3(\sigma + m\beta\delta)} - F.$$

Eqs. (11) and (12) can easily be drived from the first-order conditions (9) and (10), assuming that all broadcasters behave symmetrically.[22] Proving equilibrium existence is, however, somewhat more challenging

for several interrelated reasons (see Section 5 of the Online Appendix). The profit functions are third-order polynomials in advertising quantity and thus not everywhere concave; global optimality needs to be established. Moreover, in the classic Salop (1979) model, undercutting the rivals leads to a nonpositive profit. In contrast, in our model, undercutting rivals can lead to a positive profit; we thus need to establish that the profit from undercutting is smaller than the equilibrium profit.

Proposition 1 implies that, when N increases or τ decreases, there will be fewer ads and higher program quality. More competition between broadcasters, be it through lower distances between two adjacent broadcasters or due to better substitutability of their programs, makes viewers better off.[23] This is in line with the results in Ellman and Germano (2009) and Germano and Meier (2013).

Higher competition has two countervailing effects on the equilibrium per-viewer price of advertising. On the one hand, it lowers advertising quantity and thereby increases the per-viewer price. On the other hand, it increases program quality and thereby decreases the per-viewer price. Eq. (9) reveals that in any symmetric equilibrium,

$$\frac{nr_i}{\tau} \equiv \frac{n}{\tau}\left(\sigma - \beta v_i - \frac{\sigma a_i}{m}\right) = \frac{n\beta}{N}.$$

Recall that the right-hand side can be interpreted as broadcaster i's marginal costs of program quality and equals β times the number of viewers of the broadcaster. In any symmetric equilibrium, each broadcaster has n/N viewers; thus, the marginal costs of quality decrease in N. At the profit-maximizing quality, the marginal benefit of higher quality, which is proportional to r_i, must therefore also be lower. The model thus predicts that more competition on the media market leads to a lower price of an advertising spot. This prediction is in line with the empirical results of Brown and Alexander (2005), who show that a higher concentration on the media market goes along with higher advertising prices.[24]

In contrast, in models where program quality is exogenous as in Anderson and Coate (2005) or Choi (2006), more competition only leads to a lower advertising quantity, and since inverse demand is falling in quantity, advertising prices increase. As noted, this prediction seems at odds with the empirical evidence, and it is a puzzle in media economics to explain the discrepancy. Anderson et al. (2012) and Athey et al. (2013) propose explanations based on multi-homing viewers. Our model offers a complementary explanation in a model where viewers single home. Broadcasters compete for viewers not only in advertising quantity but also in program quality. More competition on the broadcasting market leads to higher quality, and because of the conflict of interest between viewers and advertisers, higher quality decreases advertising prices.

Proposition 1 also shows that program quality increases in the mass of advertisers m. To understand this result, note that for any given advertising quantity, the profit-maximizing program quality is determined by the trade-off described in Eq. (9): a higher program quality attracts more viewers but leads to a lower price of advertising spots per viewer. When m increases, ceteris paribus the price of an advertising spot per viewer becomes higher; therefore, it pays to attract additional viewers. This fits nicely with the claim of some observers of today's media markets that, as earning money through advertising is more difficult, be it because advertisers move online or simply because of the general economic conditions, advertisers' interests have a bigger impact on media content. The model may thus contribute to explaining

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[22] This argument also shows that the equilibrium is unique in the class of all symmetric equilibria whenever $F > 0$ (see Appendix A.1).

[23] In the classic Salop model, more competition leads to lower prices. In a free TV regime, prices are zero anyhow. However, broadcasters compete in program quality and in advertising time. One can interpret advertising as an implicit price for the program; the result that there is lower advertising in our model is similar to the result that prices are lower in the Salop model.

[24] Brown and Alexander (2005) estimate that a 20% increase in concentration in local broadcast television markets would lead to a 9% increase in the per-viewer price of ads (p. 336).

what is sometimes called the "crumbling ad-edit wall" (for a discussion, see FCC, 2011).[25]

To start the welfare analysis, we investigate whether equilibrium program quality and advertising are too high or too low from a welfare perspective. That is, we consider exogenous changes of either program quality or advertising quantity, marginally changing one while holding the other constant.

Proposition 2. *A small exogenous increase of program quality of all broadcasters, holding the advertising quantities constant, increases consumer surplus and decreases producer surplus. Moreover, welfare increases if and only if*

$$N > \hat{N}_v := \frac{m\beta^2\tau}{\sigma + m\beta\delta}.$$

An increase of program quality means that the program content is more in line with viewers' preferences, which is the reason why consumer surplus increases. Producer surplus, on the other hand, decreases. A higher program quality of broadcaster i has a business stealing effect on the competing broadcasters: it induces viewers to switch from the competitors to broadcaster i. The profit-maximizing quality balances this increase in viewers with the decrease in the prices of advertising (see the discussion of Eq. (9) above). If the quality of all broadcasters is increased simultaneously, as envisioned in Proposition 2, however, viewers do not switch; therefore, the higher quality has only costs but no benefits for the broadcasters. Consequently, broadcasters' profits decrease. In other words, from the point of view of the broadcasters, program quality has a negative externality due to the business stealing effect, and the equilibrium quality is inefficiently high when compared to the quality that maximizes the joint profits of the broadcasters.

The effect of an increase of program quality on consumer surplus does not depend on N. In contrast, its effect on producer surplus is $\partial PS / \partial v = -n\beta a$. Since the equilibrium value of advertising quantity a is decreasing in the number of broadcasters, the effect on producer surplus is less important (smaller in absolute value) when there are many competing broadcasters. This observation explains the result concerning welfare. When there are many independent broadcasters (and similarly when the program substitutability is high), competition for viewers is fierce. Thus, in equilibrium there are relatively few ads, and an increase of program quality does not reduce producer surplus much. Hence the positive effect on consumer surplus dominates. Similarly, if consumers are very ad averse, there are few ads in equilibrium and an increase in quality does not reduce producer surplus much, hence a small exogenous increase of program quality increases welfare.

Towards an understanding of the effect of a cap on advertising quantity, we now consider the effect of a small exogenous decrease of advertising quantity.

Proposition 3. *A small exogenous decrease of advertising quantity of all broadcasters, holding program qualities constant, increases consumer surplus and decreases producer surplus. Moreover, welfare increases if and only if*

$$N > \hat{N}_a := \frac{\beta\tau}{\delta}.$$

Consumer surplus decreases in advertising quantity since consumers are ad averse. Producer surplus is increasing in advertising quantity for the usual reason that a monopolist reduces quantities below the efficient level. Here, since viewers single-home, each broadcaster is in a monopoly position with respect to the attention of his viewers. When consumers are not very ad averse (δ sufficiently small), reducing advertising while keeping program quality v constant reduces welfare. This is in line with the results by Anderson and Coate (2005): when the quality of the broadcasters' content is not at stake, and consumers are not very ad averse, the equilibrium quantity of advertising is too low. Conversely, if ad aversion is severe, there is too much advertising in equilibrium.

Again, the effect on consumer surplus is independent of N, while the effect on producer surplus is less important when competition is high.[26] To understand why, note that the effect of a small exogenous decrease of advertising quantity on producer surplus is that the marginal advertiser is crowded out. The corresponding loss of producer surplus equals the willingness to pay of the marginal advertiser, which in turn equals the equilibrium per-viewer price r of an advertising spot times the number of viewers n. As discussed above, r is decreasing in N and increasing in τ. Therefore, the effect on producer surplus is small in absolute value when competition is high.[27]

5.2. Effects of a cap on advertising

While the program quality may be hard to regulate,[28] advertising can be restricted. As reported in Section 2, many countries impose a cap on the time devoted to ads on free TV. To analyze the effects of such a cap, we need to take into consideration its effect on program quality chosen by the broadcasters.[29] We now consider the effect of a quantity restriction on advertising $\bar{a}$ that constraints all broadcasters to choose $a_i \leq \bar{a}$. The following lemma studies the effect of a binding cap.

Lemma 1. *Suppose that there is a cap*

$$\bar{a} \in \left(0, \frac{m\beta\tau}{N(\sigma + m\beta\delta)}\right)$$

on advertising. Then there is an equilibrium where broadcaster $i = 1, ..., N$ chooses $a_i = \bar{a}$ and

$$v_i = \frac{\sigma}{\beta} - \frac{1}{N}\tau - \frac{1}{m}\frac{\sigma}{\beta}\bar{a}. \tag{13}$$

Profit equals

$$\pi_i = \frac{n\bar{a}\beta\tau}{N^2} - F.$$

As in the absence of a cap, equilibrium program quality is high when competition is high. Moreover, the equilibrium per-viewer price of an ad is decreasing in N and increasing in τ.

Equilibrium quality is decreasing in $\bar{a}$: the more stringent the cap (i.e., the lower $\bar{a}$), the higher program quality. The main reason is that a cap reduces advertising quantity, and thus, since inverse ad demand

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[25] The result is related to the paradox noted by Ellman and Germano (2009) in their model of newspaper competition that increasing the mass of advertisers eventually eliminates commercial media bias. Indeed, it is often argued that advertising revenues help to have independent media (see, e.g., FCC, 2011). As argued above, this is partly reflected in our model since a higher number of advertisers m implies a higher equilibrium program quality. Moreover, it can be shown that in our model a cap makes it easier to bribe the broadcasters to suppress information by bribes that are independent of the advertising quantity. The risk of such political media capture must be traded off against the commercial media bias we focus on.

[26] Formally, $\frac{\partial PS}{\partial a} = n(\sigma - \beta v - \frac{\sigma a}{m})$. Evaluating the derivative at the equilibrium values of a and v gives $\frac{\partial PS}{\partial a} = \frac{n\beta\tau}{N}$.
[27] We point out that this result does not hold in models where program quality is exogenous, such as Anderson and Coate (2005). In these models, an increase in N increases the equilibrium price of advertising. Correspondingly, the loss in producer surplus due to a decrease of advertising quantity is higher when there is fierce competition on the media market.
[28] Moreover, a direct regulation of program quality may raise issues of free speech and media capture by state authorities.
[29] We focus on the effects of a cap on a free TV market. Of course, a cap (and similarly advertising taxes analyzed in Section 5.5) will also change the relative profitability of free TV and pay TV. See Section 6.1 for an analysis of pay TV.

is decreasing in ad quantity, ceteris paribus increases the price of an ad per viewer. Therefore, attracting additional viewers is more profitable for the broadcasters, and thus the equilibrium program content is more in line with viewers' preferences. To understand the logic in more detail, consider Fig. 1, which plots the marginal benefits and costs of quality from Eq. (9) as a function of v_i. A cap shifts the inverse ad demand function upward since the advertising quantity on broadcaster i decreases; ceteris paribus, the price of an ad increases. Simultaneously, the competing broadcasters increase their quality, as predicted by Eq. (13). When broadcaster i leaves its quality unchanged, i has less viewers than before. Therefore, the marginal cost curve shifts downwards. These two reasons imply that broadcaster i has an incentive to increase its program quality. For future reference, note that the effect of the cap $\bar{a}$ on equilibrium program quality is independent of N.

As noted in the introduction, the supply of news and current affairs during peak hours by the biggest commercial broadcasters in several European countries is drastically higher than that of the biggest commercial broadcasters in the USA (Aalberg et al., 2010). This is in line with our result that a cap increases program quality. Advertising quantity is restricted in the European countries, but not in the USA. Other things being equal, our model predicts that television content is more viewer friendly in Europe, and indeed news belong to the viewers' (but not advertisers') most preferred genres (Wilbur, 2008); our model may thus contribute to an explanation of the cross-country differences.

We now analyze the welfare effects of a "local" cap that reduces advertising quantity slightly below the equilibrium level.

Proposition 4. *A local cap on advertising increases consumer surplus but decreases producer surplus. Welfare increases if and only if*

$$N > \hat{N}_{\text{cap}} := \frac{(2\sigma + m\beta\delta)m\beta^2\tau}{(\sigma + m\beta\delta)^2}. \tag{14}$$

The critical values satisfy $\hat{N}_v < \hat{N}_{\text{cap}} < \hat{N}_a$.

The cap reduces advertising and increases program quality; both effects increase consumer surplus and reduce producer surplus. The effect on welfare hinges on the relative importance of these effects. Note that, when $N > \hat{N}_a$, reduced advertising quantity increases welfare, and (since $\hat{N}_a > \hat{N}_v$) an increased program quality does as well; in this case, a cap will surely increase welfare. When this sufficient condition is not satisfied, the direct effect of an advertising cap on welfare is negative; the total effect, however, may nevertheless still be positive.

Proposition 4 implies that, as should be expected, ad aversion makes it more likely that a cap increases welfare. Moreover, whenever inequality (14) holds, the size of the welfare gain through a local cap is increasing in δ. However, even if consumers are not ad averse, a cap on advertising can improve welfare.

Fig. 2 plots the cutoffs as a function of δ. A decrease in advertising quantity, holding program quality constant, increases welfare above $\hat{N}_a$ (the dotted line). Clearly, this can only happen if $\delta > 0$, and the higher
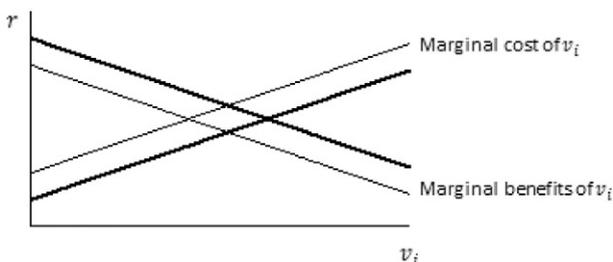

Fig. 2. The critical values as a function of ad aversion δ.

δ, the more likely it is. Above $\hat{N}_v$ (the thin line), an increase in v holding a constant increases welfare. Interestingly, the cutoffs differ most dramatically when δ is small. Fig. 3 plots the cutoffs as a function of m. $\hat{N}_a$ and $\hat{N}_{\text{cap}}$ differ most when m is small. In times where advertisers move online and m decreases, the quality enhancing effect of a cap becomes more relevant.

The most surprising insight from Proposition 4 is that more competition, be it through a higher number of broadcasters (high N) or better substitutability (low τ), makes it *more* likely that a local cap improves welfare. Moreover, the quantitative importance of the welfare gains is greater when there is more competition. This is surprising since, as pointed out above, more competition *increases* equilibrium program quality. Therefore, while competition is helpful to increase program quality, it is not a substitute for regulating the market. Indeed, the marginal welfare gains from a local cap are increasing in N and decreasing in τ; in this sense, there is a complementarity between regulation and competition. Especially in a market with many independent broadcasters, a cap on advertising may improve welfare. A policy implication is that successful competition policy does not automatically make regulation of the advertising quantities dispensable.

To understand the result, recall three observations pointed out above: (i) the effects of a and v on consumer surplus does not depend on N (ii) the effects of a and v on producer surplus gets smaller (in absolute value) when N increases, and (iii) the effect of a cap on equilibrium program quality is independent of N. These observations imply that the negative impact of a cap on producer surplus gets less important

Fig. 1. A broadcaster's marginal costs and benefits from program quality without (thin lines) and with (bold lines) a binding cap.

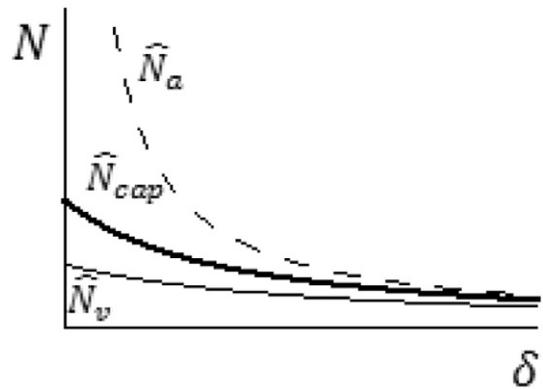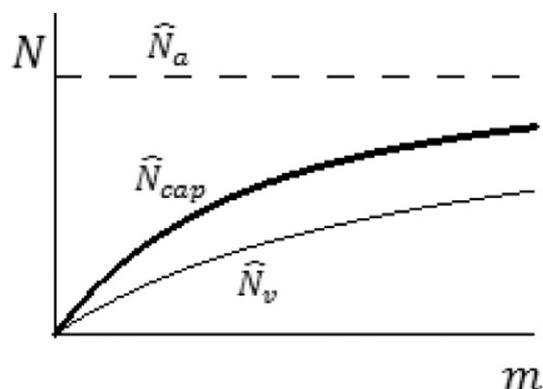**Fig. 3.** The critical values as a function of the mass of advertisers m.

when N increases, while the positive impact on consumer surplus is not affected; hence it is more likely that welfare increases.[30]

5.3. The optimal cap

This section studies the problem to maximize welfare by choosing a cap $\bar{a}$ subject to not changing the number of broadcasters,

$$\max_{\bar{a}} W \text{ s.t. } \pi_i = n\bar{a}\beta\tau/N^2 \geq F.$$

For a given number of broadcasters, welfare is a convex function of $\bar{a}$: consumer surplus is linear in $\bar{a}$, while producer surplus is quadratic in $\bar{a}$ (see (8) in combination with (13)). Therefore, it is either optimal to have no cap on advertising, or a cap that brings profits down to zero, i.e., $\bar{a} = N^2 F/(n\beta\tau)$. In particular, inequality (14) is a sufficient but not a necessary condition for the optimal cap to be binding.

Fig. 4 illustrates. Broadcasters' profits are positive below the zero profit line (in bold); the area above it is ruled out by the assumption that equilibrium profits (absent a cap) are positive. A cap that drives broadcasters' profits to zero is welfare maximizing below the thin line; above it, laissez-faire is optimal. The two lines intersect only once, at $\hat{N}_{\text{cap}}$: on the zero profit line a local cap is a zero profit cap. Fig. 4 also illustrates that a cap can be optimal even when $N<\hat{N}_{\text{cap}}$.

Proposition 5. *There exists a critical value $\hat{N} \leq \hat{N}_{\text{cap}}$ such that the welfare maximizing cap is $\bar{a} = N^2 F/(n\beta\tau)$ if $N>\hat{N}$, and laissez-faire is optimal if $N \leq \hat{N}$. Moreover, $\hat{N}$ increases in F, m, β, and τ; $\hat{N}$ decreases in n, δ, and σ.*

We now compare the results on the optimal cap with our results from Section 5.2 on a local cap. While the welfare gains of a local cap are increasing in N, the same is not everywhere true for the optimal cap. The reason is that, with higher N, the nonnegativity constraint on profits is more stringent.[31] On the other hand, the conditions under which a cap raises welfare are qualitatively similar for a local cap and the optimal cap. In particular, a more competitive broadcasting market, or higher ad aversion, increases the attractiveness of a cap. There are just two differences: the impact of the number of viewers n, and the fixed costs F. For a local cap, these do not matter. For the optimal cap, the higher n, and the lower F, the more stringent a cap can be before inducing exit; therefore, it is more likely that a zero profit cap raises welfare.

The optimal cap is not continuous in the parameters of the model. In Fig. 4, when we cross the thin line from the left, the optimal policy jumps from laissez-faire to a cap that drives profits down to zero. This is somewhat disconcerting since the optimal policy is not robust with respect to small perturbations. The discontinuity disappears, however, once we consider endogenous entry.

5.4. Endogenous number of broadcasters

This section endogenizes the number N of broadcasters by assuming free entry into the broadcasting market. We follow the standard approach to model entry in a two stage game. In stage 1, a large number of potential broadcasters decide whether or not to enter. Upon entry, a broadcaster has to invest the fixed costs F. A broadcaster who stays
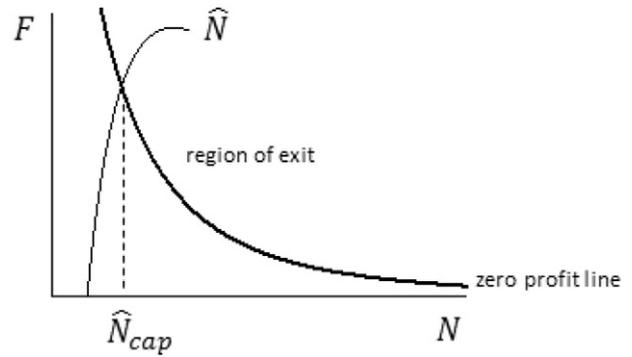

Fig. 4. The critical value for the optimal cap to be binding.

out has a profit of zero. In stage 2, broadcasters that have entered choose their advertising quantity and program quality.

The number of broadcasters is then determined by the condition that the broadcasters' profits (given in Proposition 1 and Lemma 1) equal zero.[32] As shown above, for any fixed number of broadcasters, a cap on advertising lowers the profits of the broadcasters. Therefore, under free entry, a cap will reduce competition on the broadcasting market.

Consider the welfare effects of a cap in the model with free entry. Since the broadcasters' profits equal zero by free entry, total profits equal the profits of the advertisers. A cap reduces advertising quantity, and by (7), advertisers' profits decreases. Hence a cap decreases total profits, as in the model with an exogenous number of broadcasters. Concerning consumer surplus, however, there are additional effects that can reverse our findings above. A cap induces broadcasters to exit, and exit has two negative consequences for consumers. First, ceteris paribus, exit leads to a lower program quality. This counteracts the quality enhancing effect of a cap studied in Section 5.2. The net effect of a cap on program quality depends on the relative strength of these effects. Second, when consumers have fewer broadcasters to choose from, the match between consumers and programs becomes worse (consumers have higher transportation costs). Indeed, a cap that is too stringent decreases consumer surplus. Nevertheless, as our next result shows, a local cap that slightly decreases the advertising quantity below its laissez-faire equilibrium level increases consumer surplus.

Proposition 6. *Consider the model with free entry on the broadcasting market. (i) A local cap increases consumer surplus. (ii) Suppose that*

$$F<\hat{F}_{\text{cap with exit}} := \frac{27n(\sigma + m\beta\delta)^5}{512m^2\sigma^3\beta^4\tau}.$$

Then a local cap increases welfare, and there is a (uniquely defined) optimal cap a^*, which is decreasing in δ and n, and increasing in τ and in F. (iii) If $F \geq \hat{F}_{\text{cap with exit}}$, laissez-faire is optimal.

A comparison of Proposition 6 with Proposition 5 shows that our results that better program substitutability, higher ad aversion, and a larger viewer market increase the attractiveness of a cap, are robust to endogenous entry. Moreover, with endogenous entry, the number of broadcasters depends on the fixed costs: the lower F, the more competition on the broadcasting market. Therefore our result that, with entry, a cap improves welfare if F is sufficiently small, is similar to our result in Section 5.3 that a cap improves welfare if N is sufficiently large.

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[30] We point out that this result hinges on endogenous program quality and a conflict of interest between viewers and advertisers. In models where program quality is exogenous, such as Anderson and Coate (2005) or Choi (2006), more competition implies a higher price of advertising, and correspondingly a larger negative impact of a cap on producer surplus; thus, the marginal welfare gains of a local cap are smaller when competition is intense.

[31] To see this, suppose F is below the point where the two lines cross in Fig. 4. If N is small (to the left of the thin line), a cap lowers welfare. For intermediate values of N (between the thin and the bold line), a cap increases welfare. On the bold line, the zero profit cap is equivalent to no cap at all, and the associated welfare gains are zero. Therefore, the welfare gains from a cap are not monotone in N.

[32] We follow Salop (1979) and assume that, after entry or exit, broadcasters automatically relocate such that they are equidistant. We ignore the integer constraint on N for convenience. When fixed costs are high or the cap on advertising is very stringent, only a monopolist broadcaster may be active, or even all broadcasters may exit. We focus on the case where some competition prevails.

The effects of a cap can be decomposed into the effects for a fixed number of broadcasters, and the effects from the changing number of broadcasters. Holding the number of broadcasters constant, a cap lowers advertising quantity, which directly affects welfare, and induces an increase in program quality that affects welfare, too. In addition to that, a cap on advertising leads to a lower number of broadcasters. A lower N, in turn, affects welfare directly by changing total transportation costs and total fixed costs, and induces a decrease in program quality that affects welfare, too.

Depending on the parameters, endogenous entry can make it more or less likely that a local cap increases welfare.[33] When $\delta > 2\sigma / (3m\beta)$, the exit induced by a cap makes it more likely that a local cap increases welfare.[34] On the other hand, when $\delta < 2\sigma / (3m\beta)$, the exit makes it less likely that a local cap raises welfare. Therefore, with an endogenous number of broadcasters, the case for a cap is stronger when ad aversion is severe, and weaker when viewers are not very ad averse.[35]

It is not surprising that endogenous entry can tilt the desirability of a cap in both ways. While in the classic Salop model, entry is excessive, Choi (2006) has shown that both excessive and insufficient entry are possible in a Salop model of free TV (see also Crampes et al., 2009). Our results indicate a related ambiguity in the present context. The possibility of excess entry on media markets should not be dismissed as purely theoretical, however. Berry and Waldfogel (1999) show empirically that in the U.S. radio market, entry is excessive when evaluated from the point of view of the radio stations and the advertisers. While they cannot give a complete welfare analysis (due to lack of data on the listeners' value of programming), their results indicate that the business stealing effect of entry, which is one reason why entry may be excessive, is quantitatively important.

5.5. The effects of an advertising tax

A tax on advertising seems to be a recurrent policy idea (Rauch, 2013). For example, the states of Iowa and Florida taxed advertising in the late 1980s, and advertising taxes have recently been discussed in Minnesota and Ohio.[36] While many countries impose a cap on advertising quantities, however, Austria (with a tax rate of 10 %) is currently the only OECD country that taxes advertising revenues. In this section, we point out that a proportional tax on advertising revenues has quite different implications than a cap in our model.[37] We assume that the tax revenue is redistributed lump sum to the consumers, and call *net consumer surplus* the consumers' surplus before redistribution of tax revenues, given in Eq. (5). Welfare is the sum of net consumer surplus, tax revenue, and all profits.

Consider first the case of an exogenously given number of broadcasters. Since the marginal costs of broadcasters are equal to zero, a tax on advertising revenue is a tax on variable profits, and does not change the equilibrium advertising quantity or program quality. Advertisers' profits and net consumer surplus are unaffected. The broadcasters bear the burden of the tax since they are monopolists on the advertising markets: due to single homing of consumers, each broadcaster is the only one that can sell access to his viewers. The tax just redistributes from the broadcasters to the government budget, and welfare is constant. In contrast, under the conditions of Proposition 5, a cap raises welfare. Quantity restrictions are a superior instrument to taxes on this market.

With free entry, a tax on advertising revenues leads to exit, and thereby to a higher advertising quantity and lower program quality. Moreover, consumers have fewer broadcasters to choose from, and thus higher transportation costs. These effects decrease net consumer surplus.[38] Interestingly, a tax on advertising increases advertisers' profits (and hence the sum of all profits, too). At first sight, this might be a surprising result; it stems from the two-sidedness of the market. The tax on advertising lowers the number of broadcasters and thus softens the competition for audiences. Therefore, equilibrium advertising quantities are higher and equilibrium program quality is lower. By Eq. (7), advertisers' profits increase. In contrast, a cap decreases advertising quantities and therefore advertisers' profits, as well.

Proposition 7. *With free entry on the broadcasting market, a small tax on advertising decreases net consumer surplus and increases profits. It increases welfare if, and only if,*

$$F > \hat{F}_{\text{tax with exit}} := \frac{729n(\sigma + m\beta\delta)^5}{64m^2\beta^4\tau(4\sigma + 3m\beta\delta)^3}.$$

Moreover, $\hat{F}_{\text{tax with exit}} < \hat{F}_{\text{cap with exit}}$ *if and only if* $\delta > 2\sigma / (3m\beta)$.

While a cap reduces advertising quantity, a tax on ad revenue increases it. Moreover, the cap increases program quality, while the tax reduces it. This explains why a tax decreases net consumer surplus and increases profits, while the effects of a cap are just the other way round. Moreover, the conditions under which these instruments raise welfare are qualitatively quite different. In particular, fixed costs F, program substitutability τ, the viewer market n, and ad aversion δ have the opposite effect on the probability that a tax, or a cap, raise welfare. To understand why, consider, for example, fixed costs F. As explained in Section 5.4 above, an advertising cap raises welfare if and only if F is sufficiently low - just as in the model with exogenous N a local cap raises welfare when N is sufficiently high. The intuition is that the cap raises v and lowers a, and both increases welfare when there is a lot of competition on the broadcasting market (compare Propositions 2 and 3), i.e., when F is low. Proposition 7, in contrast, shows that a tax on advertising revenue raises welfare if and only if F is sufficiently high. The tax increases a and lowers v, which increases welfare when there is not much competition on the broadcasting market, i.e., when F is high. The tax and the cap have in common, however, that they reduce the equilibrium number of broadcasters. As reported above, if $\delta > 2\sigma / (3m\beta)$, exit makes it more likely that a cap raises welfare. In this case $\hat{F}_{\text{tax with exit}}$ is smaller than $\hat{F}_{\text{cap with exit}}$; thus there is a range of parameters where F is between these critical values, and both a cap and a tax raise welfare. Conversely, when $\delta < 2\sigma / (3m\beta)$, exit makes it less likely that welfare increases; then there is a range of parameters where neither the cap nor the tax raises welfare.

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[33] A related but different concern is that content of higher quality may have higher costs. As argued by Anderson (2007), a cap can for this reason reduce program quality.

[34] In the laissez-faire equilibrium with free entry, the effect of a cap for given N can be signed as follows. From Proposition 4, we know that, for given N, a local cap raises welfare if and only if $N > \hat{N}_{\text{cap}}$. Setting N equal to the equilibrium number of broadcasters under free entry, and solving the inequality for F, reveals that the effects of a local cap for a given number of broadcasters increase welfare if and only if $F < \hat{F}_{\text{cap}} := \frac{n(\sigma+m\beta\delta)^5}{m^2\beta^4\tau(2\sigma+m\beta\delta)^3}$. Taking entry into consideration, a cap raises welfare if $F < \hat{F}_{\text{cap with exit}}$. Straightforward calculations show that, $\hat{F}_{\text{cap with exit}} > \hat{F}_{\text{cap}}$ if and only if $\delta > 2\sigma / (3m\beta)$.

[35] The additional effects due to endogenous entry also determine how m affects the probability that a cap raises welfare: $\hat{F}_{\text{cap with exit}}$ decreases in m if and only if $\delta < 2\sigma / (3m\beta)$.

[36] Relatedly, in the discussion on tax reform, U.S. House and Senate Committees introduced proposals to change the tax deductibility of advertising. See Radelat (2013).

[37] An excise tax based on the quantity of advertising, on the other hand, has similar effects as a cap. For given N, an excise tax leads to a lower advertising quantity, and higher program quality; for any cap $\bar{a}$, an equivalent tax rate can be found that leads to the same equilibrium advertising quantities and program qualities. Profits with the tax are lower by the tax revenue than with the cap (unless tax revenues are redistributed lump sum to the broadcasters, in which case the effect of the tax is exactly equal to that of the cap). Therefore, an excise tax on advertising, that is, in the short run (for given N), equivalent to a cap, leads in the long run to higher concentration on the broadcasting market.

[38] Since the tax revenue is redistributed to consumers, these negative effects have to be balanced against the additional income from the redistribution of tax revenue. It can be shown that a small tax on advertising increases the sum of net consumer surplus and tax revenues if and only if $F > 27n(\sigma + m\beta\delta)^2 / (64\, m^2\beta^4\tau)$.

6. Extensions

This section explores two extensions of our model: pay TV, and consumers that differ in ad aversion and use ad avoidance technologies. (Extensions on producers that differ in how far they are affected by television program quality and sector specific regulation, and deceptive advertising are provided in the Online Appendix.) To keep the discussion short, we assume N to be exogenous and focus on the conditions under which a local cap raises welfare, as in Section 5.2 above.

6.1. Pay TV

Our model gives additional support to results by Anderson and Coate (2005) and Peitz and Valletti (2008) that a cap on advertising does *not* improve welfare in a pay TV market. Indeed, in a pay TV market, program quality will not be too low from a welfare perspective. To see this, suppose broadcaster i charges a price p_i. A viewer located at distance x from broadcaster i has utility $w + v_i - \tau x - \delta a_i - p_i$ from watching the broadcaster. The profit of the broadcaster is[39]

$$\pi_i = n\left(\frac{1}{N} + \frac{v_i - \delta a_i - p_i - u}{\tau}\right)\left(p_i + \left(\sigma - \beta v_i - \frac{\sigma a_i}{m}\right)a_i\right) - F,$$

when all other broadcasters $j \neq i$ offer the viewers the same gross of transportation costs utility $u = v_j - \delta a_j - p_j$. Consider the profit-maximizing choice of v_i and p_i for given a_i. Increasing both v_i and p_i by the same amount increases profits if $a_i \beta < 1$. It is natural to assume that there is some upper bound $\bar{v}$ on program quality above which it cannot be improved. Whenever $p_i > 0$ in equilibrium, the broadcaster will increase its program quality as much as possible. This result fits the claim by Brown and Cavazos (2005) that the business strategy of the pay TV broadcaster HBO was to air explicitly darker, advertiser unfriendly material.[40]

6.2. Ad avoidance technologies

As argued in Section 2, viewers can today easily avoid contact with advertisements by using ad avoidance technologies such as ad blockers or digital video recorders. The traditional argument for a cap on advertising thus may seem less compelling: any viewer who is exposed to ads reveals by his behavior that he is not very ad averse. The point made in this paper, that a cap may improve welfare even if viewers do not directly suffer from exposure to ads, however, gets reinforced when there are ad averse viewers who use ad avoidance technologies.

To illustrate this, we consider an extension where there are two types of consumers: a mass n_1 of consumers who are intrinsically ad neutral ($\delta = 0$), and a mass $n_2 = n - n_1$ who are intrinsically ad averse and have a $\delta > 0$. Suppose that ad aversion is independent of the location of a consumer; both ad averse and ad neutral consumers are distributed uniformly on the circle. Moreover, suppose that ad avoidance technologies are freely available. Then viewers with $\delta > 0$ use ad avoidance technologies, and thus effectively *no* consumer is directly negatively affected by ads.

Only those viewers who are intrinsically ad neutral are reached by ads, and only those play a role in the calculations of the media outlets and the advertisers. The other ones are affected, however, by the program quality chosen by the broadcasters. We can model this situation

as above by setting $\delta = 0$, replacing n by n_1 in the formulas for profits and producer surplus, and adding a term $n_2(w + v) - n_2\tau / (4N)$ to the consumer surplus to account for the consumers who use ad avoidance technologies. Thus, as compared to a situation where everyone is intrinsically ad neutral, there is an additional welfare benefit from higher program quality: the consumers using ad avoidance technologies do not figure in the broadcasters' or advertisers' decisions, but enjoy a higher program quality as well. For the welfare comparison in Proposition 4, this implies that the condition for when a local cap improves welfare (14) becomes less strict than when every consumer is intrinsically ad neutral.[41]

7. Conclusion

This paper has argued that a cap on advertising in free-to-air television (or other advertising funded media) drives up the per-viewer price of advertising spots and thus induces the media to choose more viewer friendly program content. Due to this effect on non-advertising content an advertising cap can increase welfare, even when viewers are not directly ad averse or can use ad avoidance technologies. Competition between broadcasters helps overcoming commercial media bias. There is, however, a complementarity between competition and regulation: on a more competitive broadcasting market, the marginal welfare gains from a cap are higher. The paper also shows that endogenous entry into the broadcasting market can tilt the desirability of advertising caps in either way, but does not overturn the main insights from the model. Moreover, the paper compared advertising caps with taxes on advertising revenue, arguing that these two policy instruments are quite different in the present context.

We used the Salop model with linear transportation costs as our model of television viewing behavior. As we show in Section 4.1 of the Online Appendix, however, our results concerning an exogenous number of broadcasters extend to a far more general setting, which comprises other well known discrete choice models such as the Logit model. In particular, the conditions under which a local cap raises welfare are qualitatively similar, and the optimal cap has the same qualitative properties, in these alternative models of television viewing. An interesting question for further research is to generalize the analysis of entry beyond the Salop model.

Our model assumed that higher program quality reduces the willingness to pay of all advertisers by the same amount. We discuss two extensions in the Online Appendix that relax this assumption. First, in Section 3.2 of the Online Appendix, we study an extension where only some advertisers prefer low quality programs, while others are indifferent. If advertising demand from the latter type of advertisers is sufficiently high, the market solves the problem of commercial media bias. Otherwise, however, a cap may raise welfare in a larger set of circumstances, and the welfare gains from a cap may be higher, than in our main model. The reason is that, in the extension, the higher program quality induced by the cap does not decrease the profits of those advertisers who are indifferent over program quality, thus the negative effect of a cap on producer surplus is less important. In addition to that, the extended setting allows to study sector specific regulations such as, for example, a ban on tobacco advertising, and shows they can be even more beneficial.

Second, we discuss an extension where the effect of program quality on advertising demand depends on the quality of the advertised goods. Plausibly, producers of high-quality goods have less to lose from high program quality. An advertising cap implies that the marginal advertiser sells a product of higher quality and thus is less affected by an increase in program quality. We show in Section 4.2 of the Online Appendix that this reinforces the effect of the cap on program quality: with a cap, inverse advertising demand is less sensitive to program quality;

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[39] As above, this implicitly assumes that the market share of broadcaster i is between zero and one, inverse ad demand is positive, and broadcaster i does not undercut its rivals.

[40] Note, however, that the result is driven by the assumption that all viewers have the same marginal rate of substitution between money and program quality. If viewers differ in these respects, the commercial media bias may reappear in equilibrium even in a pay TV regime, as in Ellman and Germano (2009).

[41] Note that the condition does not depend on n, so replacing n by n_1 does not affect it.

therefore, broadcasters will increase quality further. We also discuss other nonlinearities in consumers' utility from watching television, and in the inverse demand for advertising spots.

Our welfare analysis is based on the view that advertising is informative, and on a rational choice model of consumer behavior. Of course, these assumptions are doubtful when purchase decisions are boundedly rational, or when advertising is suggestive or deceptive. In Section 3.1 of the Online Appendix, we study an extension of our model that takes these issues into account and show that deceptive advertising makes the case for an advertising cap stronger.

The size and relative importance of the effects we identify is ultimately an empirical question. The model has several testable empirical implications, such as the comparative static of equilibrium advertising quantity and program quality with respect to competition on the television market, and with respect to the mass of advertisers. A particularly interesting exercise for future research would be to empirically study the effect of an advertising cap on program content. Moreover, our model considered a commercial television market. Public service broadcasters may be less susceptible to commercial media biased insofar as their funding is secured largely independent from advertising revenues. Since public service broadcasters also compete for viewers' attention, their presence may impact the program content of commercial broadcasters as well. Studying these interdependencies is an interesting topic for future research.

Appendix A

A.1. Proof of Proposition 1

Here we show that, for any $F > 0$, if a symmetric equilibrium exists, it is given by Eqs. (11) and (12). In Section 5 of the Online Appendix, we establish that Eqs. (11) and (12) indeed constitute an equilibrium.

Suppose that $F > 0$. In any symmetric equilibrium, $a_i > 0$ for otherwise broadcasters make losses F. Therefore, the first-order conditions (9) and (10) have to hold. By symmetry ($a_i = a_j$ and $v_i = v_j$) these conditions simplify to

$$\frac{1}{\tau}\left(\sigma - \beta v_i - \frac{\sigma a_i}{m}\right) - \frac{\beta}{N} = 0,$$
$$-\frac{\delta}{\tau}\left(\sigma - \beta v_i - \frac{\sigma a_i}{m}\right)a_i - \frac{1}{N}\frac{\sigma}{m}a_i + \frac{1}{N}\left(\sigma - \beta v_i - \frac{\sigma a_i}{m}\right) = 0.$$

It is easily verified that the unique solution to these equations is given by Eqs. (11) and (12).

A.2. Proof of Proposition 2

From Eq. (5),

$$\frac{\partial CS}{\partial v} = n > 0. \tag{15}$$

Moreover, from Eq. (6),

$$\frac{\partial PS}{\partial v} = -n\beta a \tag{16}$$

which is strictly smaller than zero since $a > 0$ in equilibrium.

Finally, consider the marginal effect of v on welfare W,

$$\frac{\partial W}{\partial v} = \frac{\partial CS}{\partial v} + \frac{\partial PS}{\partial v} = n - n\beta a.$$

Inserting the equilibrium value of a gives

$$\frac{\partial W}{\partial v} = n - \frac{nm\beta^2\tau}{N(\sigma + m\beta\delta)},$$

which is strictly positive if and only if $N > \hat{N}_v$.

A.3. Proof of Proposition 3

From Eq. (5),

$$\frac{\partial CS}{\partial a} = -\delta n < 0. \tag{17}$$

Moreover, from Eq. (6),

$$\frac{\partial PS}{\partial a} = n\left(\sigma - \beta v - \frac{\sigma a}{m}\right) > 0, \tag{18}$$

which is strictly positive in equilibrium. The marginal effect of a on welfare is

$$\frac{\partial W}{\partial a} = \frac{\partial CS}{\partial a} + \frac{\partial PS}{\partial a} = -\delta n + n\left(\sigma - \beta v - \frac{\sigma a}{m}\right).$$

Inserting the equilibrium values from Eqs. (11) and (12) gives

$$\frac{\partial W}{\partial a} = -\delta n + \frac{1}{N} n\beta\tau,$$

which is strictly negative if and only if $N > \hat{N}_a$.

A.4. Proof of Lemma 1

The proof is similar to the proof of Proposition 1, and hence omitted.

A.5. Proof of Proposition 4

The marginal effect of $\bar{a}$ on CS is given by

$$\frac{dCS}{d\bar{a}} = \frac{\partial CS}{\partial a} + \frac{\partial CS}{\partial v}\frac{dv}{d\bar{a}}.$$

From Lemma 1 it follows that

$$\frac{dv}{d\bar{a}} = -\frac{1}{m}\frac{\sigma}{\beta}, \qquad (19)$$

so from Eqs. (15), (17), and (19),

$$\frac{dCS}{d\bar{a}} = -\delta n - \frac{\sigma n}{m\beta} < 0.$$

The marginal effect of $\bar{a}$ on the producer surplus PS is given by

$$\frac{dPS}{d\bar{a}} = \frac{\partial PS}{\partial a} + \frac{\partial PS}{\partial v}\frac{dv}{d\bar{a}}.$$

From Eqs. (16), (18), and (19), it follows that

$$\frac{dPS}{d\bar{a}} = n(\sigma - \beta v),$$

which is strictly positive since in equilibrium both inverse ad demand and advertising quantity are strictly positive, i.e., $\sigma - \beta v > \sigma a / m > 0$.
Finally, consider the effect of $\bar{a}$ on welfare W,

$$\frac{dW}{d\bar{a}} = \frac{dCS}{d\bar{a}} + \frac{dPS}{d\bar{a}} = -\delta n - \frac{\sigma n}{m\beta} + n(\sigma - \beta v).$$

From inserting the equilibrium value of v from Proposition 1, it follows that the total effect of $\bar{a}$ on W is

$$\frac{dW}{d\bar{a}} = -\delta n - \frac{\sigma n}{m\beta} + n\beta\frac{\tau(2\sigma + m\beta\delta)}{N(\sigma + m\beta\delta)}$$

which is strictly negative if and only if $N > \hat{N}_{cap}$.

A.6. Proof of Proposition 5

By inserting the equilibrium value of a and v into the welfare function, it follows that the laissez-faire welfare W^{LF}, that is achieved when there is no cap, equals

$$W^{LF} = n\left(w + \frac{\sigma}{\beta} - \frac{\tau(2\sigma + m\beta\delta)}{N(\sigma + m\beta\delta)} - \delta\frac{m\beta\tau}{N(\sigma + m\beta\delta)}\right) - \frac{n\tau}{4N} + n\int_0^{\frac{m\beta\tau}{N(\sigma+m\beta\delta)}}\left(\sigma - \beta\left(\frac{\sigma}{\beta} - \frac{\tau(2\sigma + m\beta\delta)}{N(\sigma + m\beta\delta)}\right) - \frac{\sigma x}{m}\right)dx - NF.$$

With a cap $\bar{a} = N^2 F/(n\beta\tau)$, welfare equals

$$W^{cap} = n\left(w + \frac{\sigma}{\beta} - \frac{1}{N}\tau - \frac{1}{m}\frac{\sigma}{\beta}\frac{N^2 F}{n\beta\tau} - \delta\frac{N^2 F}{n\beta\tau}\right) - \frac{n\tau}{4N} + n\int_0^{\frac{N^2 F}{n\beta\tau}}\left(\sigma - \beta\left(\frac{\sigma}{\beta} - \frac{1}{N}\tau - \frac{1}{m}\frac{\sigma}{\beta}\frac{N^2 F}{n\beta\tau}\right) - \frac{\sigma x}{m}\right)dx - NF.$$

The difference is

$$W^{\text{cap}} - W^{LF} = \frac{\left(FN^3(\sigma + m\beta\delta) - mn\beta^2\tau^2\right)\left(mn\beta^2\tau^2(3\sigma + 2m\beta\delta) + N(\sigma + m\beta\delta)\left(FN^2\sigma - 2n\tau(\sigma + m\beta\delta)\right)\right)}{2N^2 mn\beta^2\tau^2(\sigma + m\beta\delta)^2}.$$

Since by assumption laissez-faire equilibrium profits (given in Proposition 1) are positive, $FN^3(\sigma + m\beta\delta) < mn\beta^2\tau^2$. Therefore, $W^{\text{cap}} > W^{LF}$ if and only if

$$mn\beta^2\tau^2(3\sigma + 2m\beta\delta) + N(\sigma + m\beta\delta)\left(FN^2\sigma - 2n\tau(\sigma + m\beta\delta)\right) < 0$$

or, equivalently,

$$F < \hat{F}(N) := \frac{2Nn\tau(\sigma + m\beta\delta)^2 - mn\beta^2\tau^2(3\sigma + 2m\beta\delta)}{N^3\sigma(\sigma + m\beta\delta)}.$$

For any $N > \hat{N}_{\text{cap}}$, Proposition 4 has already established that a local cap raises welfare and thus clearly $W^{\text{cap}} > W^{LF}$. For the rest of the proof, consider the case where $N \le \hat{N}_{\text{cap}}$.

By differentiating $\hat{F}(N)$ with respect to N, it can be shown that for all $N \le \hat{N}_{\text{cap}}$, $\hat{F}(N)$ is strictly increasing in N. Therefore, for all $N \le \hat{N}_{\text{cap}}$, one can invert $\hat{F}(N)$ to find a strictly increasing function $\hat{N}(F)$ such that $F < \hat{F}(N)$ if and only if $N > \hat{N}(F)$. The remaining properties of $\hat{N}(F)$ can be shown by the implicit function rule, taking into account that, in the relevant range, $\hat{N}(0) \le N \le \hat{N}_{\text{cap}}$.

A.7. Proof of Proposition 6

Without a cap on advertising, the number of firms and quantities of advertising are, in equilibrium,

$$N = N^{LF} := \left(\frac{nm\beta^2\tau^2}{F(\sigma + m\beta\delta)}\right)^{\frac{1}{3}},$$

$$a = a^{LF} := \frac{m\beta\tau}{\left(\frac{nm\beta^2\tau^2}{F(\sigma + m\beta\delta)}\right)^{\frac{1}{3}}(\sigma + m\beta\delta)} = \left(\frac{\beta\tau Fm^2}{n(\sigma + m\beta\delta)^2}\right)^{\frac{1}{3}}.$$

With a binding cap $\bar{a}$, the number of firms equals $N = \sqrt{(n\bar{a}\beta\tau)/F}$.

Substituting v from Lemma 1 in Eq. (5), and inserting the equilibrium number of firms $N = \sqrt{(n\bar{a}\beta\tau)/F}$, shows that consumer surplus is

$$CS(\bar{a}) = n\left(w + \frac{\sigma}{\beta} - \frac{\sigma}{m\beta}\bar{a} - \delta\bar{a}\right) - \frac{5}{4}\frac{\sqrt{n\tau F}}{\sqrt{\bar{a}\beta}}.$$

As noted in the main text, in contrast to the case with a constant number of broadcasters, with free entry a cap on advertising does not necessarily increase CS. Indeed,

$$CS'(\bar{a}) = -\frac{n\sigma}{m\beta} - n\delta + \frac{5}{8}\frac{1}{\bar{a}^{\frac{3}{2}}}\sqrt{\frac{Fn\tau}{\beta}} \tag{20}$$

is positive when $\bar{a}$ is sufficiently small; thus, when a very stringent cap is relaxed, viewers become better off.

To prove part (i) of Proposition 6, evaluate Eq. (20) at the laissez-faire equilibrium value of advertising. After straightforward calculations,

$$CS'(a^{LF}) = -\frac{n\sigma}{m\beta} - n\delta + \frac{5}{8}\frac{n(\sigma + m\beta\delta)}{m\beta} = -\frac{3n(\sigma + m\beta\delta)}{8m\beta} < 0.$$

Therefore, a local cap improves consumer surplus.

It remains prove parts (ii) and (iii). Summing profits and consumer surplus shows that, given a binding cap $\bar{a}$, welfare equals

$$W(\bar{a}) = n\left(w + \frac{\sigma}{\beta} - \frac{\sigma}{m\beta}\bar{a} - \delta\bar{a}\right) - \frac{5}{4}\frac{\sqrt{n\tau F}}{\sqrt{\bar{a}\beta}} + \frac{1}{2}\frac{\bar{a}^2}{m}n\sigma. \tag{21}$$

A welfare maximizing planner maximizes $W(\bar{a})$ by choosing a cap $\bar{a} \le a^{LF}$.[42] Here, choosing $\bar{a} = a^{LF}$ is equivalent to laissez-faire, i.e., imposing no cap at all.

Differentiating Eq. (21),

$$W'(\bar{a}) = -\frac{n\sigma}{m\beta} - n\delta + \frac{5}{8}\frac{1}{\bar{a}^{\frac{3}{2}}}\sqrt{\frac{Fn\tau}{\beta}} + \frac{\bar{a}}{m}n\sigma.$$

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[42] Equation (21) presupposes that $N \ge 2$. Of course, a cap that is too stringent will eliminate competition on the broadcasting market. As stated above, we focus on the case where some competition prevails.

Evaluating $W'(\bar{a})$ at $\bar{a} = a^{LF}$ and rearranging gives

$$W'(a^{LF}) = -\frac{n\sigma}{m\beta} - n\delta + \frac{5}{8}\frac{n(\sigma + m\beta\delta)}{m\beta} + F^{\frac{1}{3}}\frac{(\beta\tau)^{\frac{1}{3}}n^{\frac{2}{3}}\sigma}{(\sigma + m\beta\delta)^{\frac{2}{3}}m^{\frac{1}{3}}},$$

which is strictly negative if and only if

$$F < \left(\frac{\left(\frac{n\sigma}{m\beta} + n\delta - \frac{5}{8}\frac{n(\sigma + m\beta\delta)}{m\beta}\right)(\sigma + m\beta\delta)^{\frac{2}{3}}m^{\frac{1}{3}}}{(\beta\tau)^{\frac{1}{3}}n^{\frac{2}{3}}\sigma}\right)^3 = \hat{F}_{\text{cap with exit}}.$$

This shows that a local cap improves welfare if and only if $F < \hat{F}_{\text{cap with exit}}$.

Note that W fulfills the Inada condition $\lim_{\bar{a} \to 0} W'(\bar{a}) = \infty$; hence, $W'(\bar{a}) > 0$ for sufficiently small $\bar{a}$. If a binding cap $\bar{a} < a^{LF}$ is optimal, it must fulfill the first-order condition $W'(\bar{a}) = 0$. Although W is not necessarily concave on $(0, a^{LF})$; nevertheless, a sufficient second-order condition (called pseudo-concavity) holds:

Lemma 2. *Suppose that $W'(a_0) = 0$ for some $a_0 \in (0, a^{LF})$. Then (i) $W''(a_0) < 0$. Moreover, (ii) $W'(a) > 0$ for all $a < a_0$ and $W'(a) < 0$ whenever $a_0 < a < a^{LF}$.*

Proof. Differentiating $W'(a)$,

$$W''(a) = -\frac{15}{16a^{\frac{5}{2}}}\sqrt{F\frac{n}{\beta}\tau} + \frac{n\sigma}{m}.$$

Suppose that $W'(a_0) = 0$ and $0 < a_0 < a^{LF}$. Then $W''(a_0)$ has the same sign as $g(a_0)$, where

$$g(a) := aW''(a) - W'(a) = -\frac{25}{16a^{\frac{3}{2}}}\sqrt{\frac{Fn\tau}{\beta}} + \frac{n\sigma}{m\beta} + n\delta.$$

Note that $g'(a) > 0$ and

$$g(a^{LF}) = -\frac{25}{16\left(\frac{m\beta\tau}{\left(\frac{nm\beta^2\tau^2}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}(\sigma+m\beta\delta)}\right)^{\frac{3}{2}}}\sqrt{\frac{Fn\tau}{\beta}} + \frac{n\sigma}{m\beta} + n\delta = -\frac{9}{16m}\frac{n}{\beta}(\sigma + m\beta\delta) < 0.$$

It follows that $g(a_0) < 0$ and hence $W''(a_0) < 0$. This establishes (i). Part (ii) is obvious from (i). ∎

To complete the proof of part (ii) of Proposition 6, suppose that $F < \hat{F}_{\text{cap with exit}}$. By the intermediate value theorem since $W'(\bar{a}) > 0$ for sufficiently small $\bar{a}$ and $W'(a^{LF}) < 0$, there exists some $a^* \in (0, a^{LF})$ such that $W'(a^*) = 0$. By Lemma 2, W has a strict global maximum at a^*. For the comparative statics of the optimal cap, recall that $W'(a^*) = 0$ and $W''(a^*) < 0$. By the implicit function rule, the sign of $\frac{da^*}{d\delta}$ is equal to the sign of $\frac{\partial W'(a^*)}{\partial \delta} = -n < 0$. Similarly, $\frac{\partial}{\partial \tau}W'(\bar{a}) > 0$ and $\frac{\partial}{\partial F}W'(\bar{a}) > 0$; thus, a^* is increasing in τ and in F. Moreover,

$$\frac{\partial}{\partial n}W'(\bar{a}) = \frac{\partial}{\partial n}\left(n\left(-\frac{\sigma}{m\beta} - \delta + \frac{5}{8}\frac{1}{\bar{a}^{\frac{3}{2}}}\sqrt{\frac{F\tau}{\beta n}} + \frac{\bar{a}}{m}\sigma\right)\right)$$

$$= \left(-\frac{\sigma}{m\beta} - \delta + \frac{5}{8}\frac{1}{\bar{a}^{\frac{3}{2}}}\sqrt{\frac{F\tau}{\beta n}} + \frac{\bar{a}}{m}\sigma\right) - \frac{5}{16}\frac{1}{\bar{a}^{\frac{3}{2}}}\sqrt{\frac{F\tau}{\beta n}}.$$

Note that the bracket is $W'(\bar{a})/n$ and thus zero when evaluated at a^*. It follows that $\frac{\partial}{\partial n}W'(a^*) < 0$ and a^* is decreasing in n.

To prove part (iii) of Proposition 6, suppose that $F \geq \hat{F}_{\text{cap with exit}}$. Then $W'(a^{LF}) \geq 0$. Lemma 2 implies that $W'(\bar{a}) > 0$ for all $\bar{a} < a^{LF}$. Thus, the optimal policy is laissez-faire.

A.8. Proof of Proposition 7

Suppose there is a tax t on advertising revenue. The profit of broadcaster i equals

$$\pi_i = n\left(\frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau}\right)\left(\sigma - \beta v_i - \frac{\sigma}{m}a_i\right)a_i(1 - t) - F.$$

For given N, the equilibrium advertising quantity a, program quality v, are as given in Proposition 1 above. Inverse ad demand per viewer equals $r = \beta\tau / N$ and net of taxes $(1 - t)\beta\tau / N$. The equilibrium profit of a broadcaster is

$$\pi_i = \frac{nm\beta^2\tau^2}{N^3(\sigma + m\beta\delta)}(1 - t) - F.$$

With endogenous entry, the equilibrium number of broadcasters is

$$N = \left(\frac{nm\beta^2\tau^2(1-t)}{F(\sigma + m\beta\delta)}\right)^{\frac{1}{3}}.$$

Therefore, in equilibrium

$$a = \frac{m\beta\tau}{\left(\frac{nm\beta^2\tau^2(1-t)}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}(\sigma + m\beta\delta)},$$

$$v = \frac{\sigma}{\beta} - \frac{\tau(2\sigma + m\beta\delta)}{\left(\frac{nm\beta^2\tau^2(1-t)}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}(\sigma + m\beta\delta)}.$$

Moreover, net consumer surplus (i.e., before redistribution of tax revenues) is

$$\begin{aligned}
CS_{net} &= n(w + v - \delta a) - \frac{n\tau}{4N} \\
&= nw + \frac{n\sigma}{\beta} - \frac{2\tau n}{\left(\frac{nm\beta^2\tau^2(1-t)}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}} - \frac{n\tau}{4\left(\frac{nm\beta^2\tau^2(1-t)}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}}.
\end{aligned} \tag{22}$$

Thus, CS_{net} is decreasing in t. Advertiser profits equals $a^2 n\sigma / (2m)$ (see Eq. (8)). Inserting the equilibrium value of a gives

$$\frac{1}{2}\frac{a^2}{m}n\sigma = \frac{1}{2}\frac{n\sigma}{m}\left(\frac{m\beta\tau}{\left(\frac{nm\beta^2\tau^2(1-t)}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}(\sigma + m\beta\delta)}\right)^2. \tag{23}$$

Thus, advertiser profits are increasing in t. Tax revenue T is given by $T = nrat$. In equilibrium,

$$T = \frac{nm(\beta\tau)^2 t}{\left(\frac{nm\beta^2\tau^2(1-t)}{F(\sigma+m\beta\delta)}\right)^{\frac{2}{3}}(\sigma + m\beta\delta)}. \tag{24}$$

Welfare is $W = CS_{net} + PS - NF + T$. Note that, because of free entry, $PS - NF$ equals advertisers' profits (23). Inserting Eqs. (22), (23), and (24), into W, differentiating with respect to t, and evaluating at $t = 0$, shows that

$$\frac{\partial W}{\partial t}\Big|_{t=0} = \frac{F\left(\frac{mn\beta^2\tau^2}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}}{12m\beta^2\tau(\sigma+m\beta\delta)}\left(4m\beta^2\tau(4\sigma + 3m\beta\delta) - \left(\frac{mn\beta^2\tau^2}{F(\sigma+m\beta\delta)}\right)^{\frac{1}{3}}9(\sigma + m\beta\delta)^2\right).$$

Therefore, W is increasing in t if and only if $F > \hat{F}_{\text{tax with exit}}$.

To complete the proof, straightforward calculation of $\hat{F}_{\text{cap with exit}} - \hat{F}_{\text{tax with exit}}$ shows that $\hat{F}_{\text{tax with exit}} < \hat{F}_{\text{cap with exit}}$ if and only if $\delta > 2\sigma / (3m\beta)$.

Appendix B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jpubeco.2015.09.004.

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