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

Anna Kerkhof†  Johannes Münster‡

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Abstract

We study the welfare effect of a quantity restriction on advertising in free-to-air television 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 the traditional argument for an advertising cap based on viewers’ ad aversion does not apply. 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 also show that a tax on advertising revenues has quite different effects than a cap on advertising quantity.

Key words: media bias, advertising, quantity restriction, taxes, two-sided markets

JEL codes: H23, H25, L13, L51, L82

1 Introduction

It is widely agreed that a free and independent media is important to 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.\textsuperscript{1} Moreover, advertisers may prefer the media not to report critically about their products.\textsuperscript{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 situation, media enterprises may be particularly vulnerable to advertisers’ pressures.\textsuperscript{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 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 2008a). 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.\textsuperscript{4}

\textsuperscript{1}For example, Wilbur (2008a, p. 373) finds that “advertiser genre preferences are nearly opposite those of viewers”: viewers prefer actions 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, since “bad” news might affect consumers’ perception of their products (Hawkins and Mothersbaugh 2010). We review the evidence in Section 2.

\textsuperscript{2}For example, tobacco advertisers have pressured media outlets to suppress information concerning the health risks of smoking (see Bagdikian 2004, Warner and Goldenhar 1989, Warner et al. 1992).

\textsuperscript{3}For example, the FCC (2011) describes the case of a local Fox channel, KBTC-TV, that 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”. See Germano and Meier (2013) for a recent contribution on commercial media bias, Blasco and Sobribo (2012) for a survey, and the references given in Section 2 below. 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.

\textsuperscript{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 US. 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, in the Netherlands 20, in Norway 19, in Sweden 27, and in the UK 37 minutes. Of course, there are many important differences between these European countries and the US. Aarlberg et al. (2010) stress the higher importance of public service broadcasting in Europe. Within
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 and producer surplus) 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. 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 affects not only 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, presents its microfoundations, 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. Several economically interesting extensions such as Pay TV, usage of ad avoidance technologies, sector specific regulation, and deceptive advertising are analyzed in Section 6. Section 7 shows that our main results are robust with respect to different assumptions on the television viewing behavior and discusses limitations of our model. Section 8 briefly mentions the testable predictions of the model and its relation to public service broadcasting. All proofs are relegated to the Appendix.

2 Background

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. At the same time, media reports about firms and their products influence their profits.\textsuperscript{5} The media’s dependence on advertising revenues, combined with its

\textsuperscript{5}For example, when the New York Times reported about a potential breakthrough in cancer research in its Sunday edition, it induced a permanent rise in share prices of EntreMed, a biotechnology company with licensing rights to the breakthrough - even though the information had already been published in Nature, and various newspapers, several month earlier (Huberman and Regev 2001). Similarly, Engelberg and Parsons (2011) show that media reporting has a causal effect on investor behavior, and Liu et al. (2014) show that media coverage of IPOs has long-run effects on the stock’s value. Media reporting may also bring public scrutiny to sensitive issues and lead to regulatory threats to firms. For example, Erble and McMillan (1990) show that during the 1979 oil crisis, television reports on the oil crises influenced home heating oil price ratios, but not residual fuel oil price
impact on firms’ profits, implies that advertisers have economic incentives to influence editorial decisions. Media scholars have documented many cases of advertisers’ influence on media content (Baker 1994, Bagdikian 2004, Herman and Chomsky 1988).

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<td>* Reuter 2009</td>
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<td>wine publications</td>
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<td>“Wine Spectator appears largely to insulate reviewers from the influence of advertisers” (p. 125)</td>
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Table 1: Evidence on advertisers’ influence on media content

Several recent papers have shown econometrically that advertisers systematically influence media content, see Table 1 for an overview. These papers compare advertiser spending with media coverage or slant. An empirical challenge is to identify whether there is a causal effect of advertising on media content. The recent literature has used state-of the art instrumental variable techniques and natural experiments to overcome this challenge (e.g. Gurun and Butler 2012). Interviews and surveys of key players in the market also confirm that advertisers influence media content. An early survey by Soley and Craig (1992) on newspaper editors found that almost 9 out of 10 of their correspondents claim that advertisers have attempted to take influence on editorial decisions. In a survey of journalists by the Pew Research center (2000), a third of the journalists stated an “intrusion of commercial interests” into editorial decisions (p. 3). Similarly, ratios, and argue that the different reactions are explained by the threat of government intervention.
An and Bergen’s survey (2007) on 219 advertising directors at US daily newspapers reports frequent conflicts between the journalism side and the business side of newspapers. Further evidence of advertisers’ influence comes from a content analysis of ostensibly noncommercial newscasts (Upshaw et al. 2007): 90% of the stations studied contained at least one instance per newscast of commercial messages outside regular commercial blocks.

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 2008, 2013). Media relying on ad revenues currently face an aggravating “ethical dilemma” (Upshaw et al. 2007, p. 71), and financial difficulties have led to a reconsideration of the traditional separation between media companies’ news and business divisions (FCC 2011, Basen 2012).

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 (2008a) 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 on context effects on advertising effectiveness. Goldberg and Gorn (1987) show in an experiment that happier program content in television puts viewers in a more advertising receptive mood. They observe that happy programs cause higher effectiveness of the commercials, better recall of the advertising messages as well as more positive cognitive responses of the ads. Goldberg and Gorn conclude that if a program is dark or serious, advertisements are often viewed as inappropriate, while with happy and light programs, advertisements are perceived as better fitting. Relatedly, Mathur and Chattopadhyay (1991) conduct an experiment on the impact of program generated moods, and find that light programs improve 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, and maybe even more delicate, issue is that viewers but not advertisers may favor accurate reporting of any defects, risks, or negative externalities of products (see Blasco and Sobbrio 2012 for a recent review). Several studies have shown that critical media reports indeed impact consumer behavior. Niederdeppe and Frosch (2009) provide evidence that news coverage on trans fat reduced sales of trans-fat-products. Schlenker and Villas-Boas (2009) find a significant decrease in beef sales following reports on mad cow disease. Wakefield et al. (2003) show that antismoking messages can lower youth smoking rates. Laugesen and Meads (1991) find that doubling the coverage of smoking issues in newspapers lowers cigarette consumption as much as a 10% price increase.

Reporting about the health risks of smoking is an important and well-documented case of commercial media bias. The tobacco industry is a major advertiser. The tobacco industry has suppressed reports on health risks of smoking, and induced media platforms to merely reprint statements claiming that there was no proven evidence for smoking inflicting health (Bagdikian 2004). For example, when the magazine *Mother Jones* published an article on smoking and health, the tobacco companies withdrew their ads and “made clear that *Mother Jones* would never get cigarette advertising again” (Whelan et. al 1981 p. 34). Warner and Goldenhar (1989) and Warner et al. (1992) provide strong statistical evidence that cigarette advertising in magazines relates to less coverage of the health risks of smoking.

News coverage of anthropogenic climate change is an issue of global importance. Global warming imperatively requires an accurately informed public. The broad scientific consensus is that human activities affect the climate (Oreskes 2004). The discourse in the news media, however, has significantly diverged from the scientific consensus, particularly in the US. Boykoff and Boykoff (2004) study the US prestige-press coverage of global warming between 1988 and 2002. They find that 53% of the investigated articles gives equal weight to the scientific consensus opinion and the view that human activities are a negligible factor in overall changes in the climate. The difference between US television news coverage and the scientific consensus is even more severe: from 1996 to 2004, 70% of the television broadcasts on climate change provided a balanced view on its causes (Boykoff 2008, p.6). 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.

Critical media reporting also has an important role to counteract misleading advertising. Again, tobacco is a case in point: cigarette advertising has often downplayed the associated

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6According to the WHO (2013, p.22), “the tobacco industry spends tens of billions of US dollars worldwide each year on tobacco advertising, promotion and sponsorship (TAPS). In the United States alone, the tobacco industry spends more than US$ 10 billion annually on TAPS activities“.


8See also Blasco and Sobbrio (2012) and Germano and Meier (2013).
health risks (see Glaeser and Ujhelyi 2010). Arguably, deceptive advertising, combined with tobacco advertisers’ influence on media content, explains why public awareness of the health risks lagged decades behind their scientific discovery. For example, in Gallup polls from 1980 every second woman did not know that smoking during pregnancy increases the risk of stillbirth and miscarriage (Bagdikian 2004). Similarly, the WHO (2011) report on the global tobacco epidemic points out that many smokers do not fully understand the health risks of smoking. The WHO (2011) also mentions that the news media are a key source of health information, and emphasizes the importance of media reporting on tobacco control.

Another well documented example is advertising for medical drugs. Faerber and Kreling (2013) find that 2/3 of claims in ads for prescription and non-prescription drugs are potentially misleading or even false. They also report that consumers may see up to 30 hours of television drug advertising each year; in contrast, they spend 15 to 20 minutes at an average visit with their primary care physician. Misleading advertising may thus seriously impair consumers’ ability to take well informed decisions (Brody and Light 2011). Critical media reporting on medical drugs, on the other hand, will improve consumers’ information. Not surprisingly, drug advertisers have tried to influence media content, even in the case of scientific medical journals (Lexchin and Light 2006).

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. 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). For example, the Audiovisual

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9For the present paper, nonprescription drugs seem particularly relevant, as they directly target consumers as opposed to their physicians. Faerber and Kreling (2013, table 4) find that the majority of claims in ads for nonprescription drugs is misleading (61%), less than one quarter (23%) is objectively true, and some (17%) are outright false.

10Wilbur (2008a) estimates that a 10% reduction of advertising quantity in television leads to a 25% increase in audience size.
Media Services Directive argues there are “increased possibilities for viewers to avoid advertising through the use of new technologies such as digital personal video recorders and increased choice of channels”. In the EU, about 30 percent 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 restriction of 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.

There exist certain sector specific bans in television advertising. In the United States, broadcasters are not allowed to send commercials on tobacco by the Public Health Cigarette Smoking Act (1970). The rules in the European Union are similar. The Audiovisual Media Services Direction (2010) bans commercials on cigarettes and other tobacco products, medicinal products and medicinal treatment available only on prescription. The advertisements for alcoholic beverages shall not be aimed specifically at minors and shall not encourage immoderate consumption (Article 9). The restrictions can be more stringent in the member states. In Germany, gambling must not be advertised and commercials for alcohol must not appeal to children or teenagers (Seufert and Gundlach 2012). We give a new rationale for sector specific regulations based on their impact on non-advertising media content in Section 6.3.

**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 (see Batina and Ihori 2005 for a review). 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 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 (see Prat and Strömberg 2013 for a survey). The economics’ literature has mainly focussed on political media bias.\(^\text{11}\) We focus on advertisers’ influence and commercial media bias. Our analysis is closely linked to Ellman and

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\(^\text{11}\)Consumers’ demand for politically slanted news can result in a demand driven political media bias (Mullainathan and Shleifer 2005, Gentzkow and Shapiro 2006). On the other hand, a distortion can also stem from the supply side: from owners (Djankov et al. 2003; Anderson and McLaren 2011), governments (Besley and Prat 2006, Gehlbach and Sonin 2014), lobbies (Petrova 2008), or journalists themselves (Baron 2006). Empirical evidence is given by Groseclose and Milyo (2005), Gentzkow and Shapiro (2010), and Puglisi and Snyder (2011); Groeling (2013) provides a survey.
Germano (2009). In their setting, consumers value news accuracy. Advertisers, however, value ad-receptive consumers, and can threaten to withdraw their ads from the media platform in case it reports on sensitive topics. They can thereby impose economic pressure as media platforms are typically dependent on advertising revenues. Similarly, Germano and Meier (2013) develop a model of self-censorship where ad-funded media platforms internalize the effect of how accurately different issues are covered on advertisers. Blasco et al. (2014) show that competition among advertisers can reduce commercial media bias if advertisers influence media content in opposite directions. 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 influence commercial media bias and 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. Moreover, 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, and news consumption may have positive externalities by improving citizens’ political decisions. As argued by Downs (1957), Coase (1974), and Posner (1986), consumers may not internalize 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 (see Bagwell 2007 for a survey) and two-sided markets (Rochet and Tirole 2003, 2006, Armstrong 2006, Weyl 2010). 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.\footnote{Section 4.2 discusses the assumptions underlying our welfare analysis in more detail.}

Another strand in the literature, however, has shown that advertising is sometimes misleading or false. For example, Faerber and Kreling (2013) classify more than one half of all major claims in prescription and non-prescription drug ads on US television during 2008-2010 as potentially misleading. Sharp evidence on deceptive advertising is provided by Zinman and Zitzewitz (2012), who show that ski resorts report 23% more fresh snow during weekends, when potential skiers are more flexible to react on snow conditions. Glaeser and Ujhelyi (2010) survey the available evidence. Nagler (1993) and Glaeser and Ujhelyi (2010) explore theoretical implications of misleading advertising, and study optimal policy responses. We show in an extension in Section 6.4 that misleading advertising strengthens the case for a cap on advertising.

Naturally, the literature on advertising is closely entwined with the literature on advertising in media markets (see Anderson and Gabszewicz 2006 for a survey). In their seminal work, Anderson and Coate (2005) 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 the consumers’ ad aversion. Their model has been extended to a more detailed analysis of horizontal product differentiation by Peitz and Valletti (2008) and vertical product differentiation by Armstrong and Weeds (2007). Similar to Anderson and Coate, Kind et al. (2007) propose that the question of under- or overprovision depends on the programs’ substitutability. Anderson (2007) points out that ad revenues are necessary for product quality and thereby offers an additional argument for underprovision.

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, 2011) who examine taxes in two-sided markets. Kind et al. (2008) 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, focuses 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. Our paper can also be linked to work on ad avoidance technologies (Wilbur 2008b, Anderson and Gans 2010). We point out that a cap on advertising can improve welfare even when viewers can easily avoid being afflicted by advertisements.
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 $r = \frac{1}{v} a$. 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

$$1 - v - a = v.$$  (1)

Equation (1) illustrates the fundamental trade-off in our model. The left hand side of (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 (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 equation (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 (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.

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 \( v^* (a) \) into \( PS = v \int_0^a (1 - v - x) \, dx \) 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 produces 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 \( a_i \in \mathbb{R}_+ \). We study a model of a circular town in the spirit of Salop (1979), this is perhaps the most well known textbook model that allows for horizontal product differentiation and a flexible number of firms. (Section 7.1 shows that the main results are robust to other specifications of TV-viewing behavior.) 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.\(^{13}\) 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 \( \delta \) is strictly

\(^{13}\) 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.
positive, and ad neutral when \( \delta = 0 \).\(^{14}\) Transportation costs are linear with a transportation cost parameter \( \tau > 0 \) and can be regarded as a measure of the broadcasters’ substitutability; the lower \( \tau \), 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; we discuss the microfoundations in Section 4.3. 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\(^{15}\), our model is close to Anderson and Coate (2005).\(^{16}\) We take from Ellman and Germano (2009) and Germano and Meier (2013) the assumption that program quality decreases the willingness to pay of advertisers.\(^{17}\)

Advertisers multi-home. Denote the per-viewer price of an ad on broadcaster \( i \) by \( r_i \). Assuming \( \sigma > \beta v_i + r_i \geq 0 \),\(^{18}\) advertising demand is

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

\(^{14}\)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.

\(^{15}\)If there is an upper bound \( \tilde{\theta} \) 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.

\(^{16}\)One remaining difference is that we study a Salop model with a circular town, whereas Anderson and Coate (2005) consider a linear Hotelling specification.

\(^{17}\)In our main model, we assume that the parameter \( \beta \) is the same for all producers; that is, advertisers have a shared interest in reducing program quality. To investigate the robustness of our results, and in order to study sector specific regulations of advertising, we explore an extension in Section 6.3 where only a subset of advertisers has an interest in reducing program quality.

\(^{18}\)The second inequality ensures we can safely ignore corner solutions where every advertiser advertises; this will be the case in equilibrium if \( N \geq \beta \tau / (\sigma + m \beta \delta) \).
Solving for $r_i$ gives inverse ad demand per viewer, which is

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

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.\(^{19}\) Denote the distance between the indifferent viewer and broadcaster $i$ by $\hat{x}$. Then

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

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

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

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 (see also Bagwell 2007 for a review of the economics of advertising). On the one hand, consumers benefit from informative advertising, and when these gains cannot fully be appropriated by the producers, the producers’ willingness to pay underestimates the welfare gains

\(^{19}\)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 undercut 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, see for example Anderson et al. (1992) or Vogel (2008). We carefully spell out profits from undercutting in the proofs.
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, Nagler 1993, Glaeser and Ujhelyi 2010). 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 in Section 6.4, where we show that they make the case for advertising restrictions stronger; see also Section 4.3 below.

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

\[
CS = n (w + v - \delta a) - \frac{4n\tau}{N}.
\]

Produce 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:\n
\[
PS = n \int_0^a \left( \sigma - \beta v - \frac{\sigma x}{m} \right) dx.
\]

Total revenues of the broadcasters equal \( n (\sigma - \beta v - \sigma a/m) a \), 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,

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

\(^{20}\) 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.

\(^{21}\) 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 \( \tilde{\sigma} < z \) 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

\[
n \int_{\tilde{\sigma} - \frac{a}{m}}^\sigma (\tilde{\sigma} - \beta v) \frac{m}{\sigma} \tilde{\sigma} d\tilde{\sigma} = n \int_0^a \left( \sigma - \beta v - \frac{\sigma x}{m} \right) dx.
\]
For a given advertising quantity, advertisers’ total profits \( (7) \) 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 \( (7) \) is independent of the number of broadcasters \( N \).

With \( (7) \), equation \((6)\) can also be written as

\[
PS = n \left( \sigma - \beta v - \frac{\sigma a}{m} \right) a + \frac{1}{2} \frac{a^2}{m} n \sigma.  
\]

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 \( v \) of the program the viewer watches. This section discusses possible microfoundations.

One possible interpretation of the variable \( v \) is that it corresponds to a genre preferred by viewers. The empirical results by Wilbur (2008a) and Brown and Cavazos (2005) indicate that advertisers’ preferences over genres differ from viewers’ preferences: advertisers prefer lighter content. Similarly, experimental evidence from Goldberg and Gorn (1987) shows that happier program types put viewers in a more advertising receptive mood.

The implications for consumer welfare depend on the mechanism how program content impacts on advertising effectiveness. One potential reason is that television genres preferred by consumers are substitutes for consumption goods; therefore, the better the quality of the television program, the lower the willingness to pay for goods. In other words, viewing advertiser friendly genres is a complement for consumption, i.e. it raises the utility of the viewer from consuming goods. We call this the complementary microfoundation.\(^{22}\)

Consumers have stable preferences defined over consumption and advertising. Television program quality enters their utility function directly, and it moreover affects the utility they gain from consumption goods. In particular, we assume that the gross utility gain of a consumer from buying a product of quality \( \tilde{\sigma} \) is equal to \( \tilde{\sigma} - \beta v \). If in addition producers capture all the gains on the product mar-

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\(^{22}\)This microfoundation is similar to the complementary view of advertising (Stigler and Becker 1977, Becker and Murphy 1993; for a survey see Bagwell 2007, esp. Section 2.4). While this view claims that advertising is a complement for the advertised consumption good, we claim here that television content may be both a complement and a substitute to consumption goods. We point out that our model of advertising itself is also consistent with the complementary view of advertising.
ket, the willingness to pay of a producer of type $\bar{\sigma}$ for an advertising slot is also $\bar{\sigma} - \beta v$. In this microfoundation, consumers are rational, and the willingness to pay of consumers for goods indicates their true welfare gains from consumption.

Another reason why television content may have an impact on advertising effectiveness is that consumers’ recall of an ad depends on the program it is embedded in. Mathur and Chattopadhyay (1991) show in an experiment that viewers recall an ad better if it is shown in the context of a program that puts the viewers in a happy mood. This finding inspires our a second microfoundation, the recall microfoundation.

Suppose that some consumers recall an ad after seeing it, while others forget it. The probability that a consumer forgets an ad for a product of type $\bar{\sigma}$ placed in a program of quality $v$ is $p(v, \bar{\sigma})$. Plausibly, $p$ is increasing in $v$, and decreasing in $\bar{\sigma}$: the better the television program, and the lower the product’s quality, the more likely the consumer is to forget the product. Moreover, recall of better products (i.e. those with a high $\bar{\sigma}$) might be less affected by television genre. A functional form consistent with these properties is $p(v, \bar{\sigma}) = \beta v / \bar{\sigma}$. A consumer who saw an ad for a product, but doesn’t recall it, does not buy the product; just as consumers who do not know the product exists. Consumers make rational decisions given their information.23 As in the complementary microfoundation, the willingness to pay of an informed consumer captures the true welfare gains from consumption. The willingness to pay of an advertiser of type $\bar{\sigma}$ for showing an ad to a consumer is $(1 - p(v, \bar{\sigma})) \bar{\sigma}$. Note this is decreasing in program quality $v$. Moreover, if $p(v, \bar{\sigma}) = \beta v / \bar{\sigma}$, the willingness to pay of the advertiser is $\bar{\sigma} - \beta v$, as in our model.

Television genre may also impact advertising effectiveness since it influences the moods of boundedly rational consumers. For an example, recall the case of Coca-Cola refusing to advertise during news broadcasts out of a concern that “bad” news might counteract its positioning of Coke as an “up-beat, fun product”. There is good empirical evidence that consumers’ moods impact their economic decisions. Harlé and Sanfey (2007) experimentally induce different moods by showing short movie clips to their subjects prior to an ultimatum game experiment. Incidental sad moods result in lower acceptance rates of unfair offers. Harlé et al. (2012) confirm this finding and study the underlying neural mechanisms in an fMRI study. Consumers have also been found in field data to be more likely to engage in impulse buying when they are in a positive mood (Beatty and Ferell 1998, Flight et al. 2012, see Faber and Fohs 2013 for a survey). Television induced moods may thus affect advertising effectiveness and purchase behavior, even when the “true” utility from consumption is not affected by television genre.24 We call this the moods microfoundation. In such a situation, consumers’ willingness to pay cannot simply be equated with their true utility gains from the products. If some genres put consumers in a spending happy mood such that they overestimate the true utility gains of the products, the welfare

23Moreover, if producers capture all the rents on the product market as in our model, consumers have no incentive to remember the ads; forgetting is a form of rational ignorance.

24See also DellaVigna (2009) and Lerner et al. (2015) who survey the growing literature on the role of emotions in economic decisions.
analysis has to take this into account; we do this in Section 6.4.

A second possible interpretation of the variable $v$ is that a high quality corresponds to more accurate and critical reporting over products, for example over any risks involved in the consumption. A program of higher quality can then be interpreted as containing more information that helps consumers making well-informed decisions. Good television programs may also contain information about the advertiser or producer, and any externalities that the products may have. An example is the case of government advertising and reporting of corruption scandals investigated by Di Tella and Francescelli (2011).

Following Nagler (1993) and Glaeser and Ujhelyi (2010), this interpretation can be used to develop another microfoundation, the deceptive advertising microfoundation. They argue that advertising sometimes is misleading and makes consumers underestimate costs involved in the consumption of their products. Key cases are advertising for medicines, cigarettes, and fast food; see also the discussion in Section 2. Following Glaeser and Ujhelyi (2010), suppose that consumption of a product has health costs $c$, so the true gain of consumers from consuming a product of type $\sigma$ is $\sigma - c$. Consumers’ perception of these costs may differ from the true costs. We assume that the perceived costs depend on how accurate reporting on television is; the better the program quality, the higher the perceived costs. Suppose that perceived costs are equal $\beta v_i$, and that, in the relevant range, consumers underestimate the costs, i.e. $c > \beta v_i$. Thus, the better the program, the smaller consumers’ errors. Under these assumptions, a consumer is willing to pay pay up to $\sigma - \beta v_i$ for a product of quality $\sigma$. As above, we assume that the producer can completely capture these perceived benefits. Therefore, the willingness to pay of the producer for informing the consumer is equal to $\sigma - \beta v_i$, as well. Consumers are aware that a better program quality helps them making better decisions, and thus perceive a benefit $v_i$ from watching the program. They are not aware that the products involve any health costs beyond $\beta v_i$. Therefore, their perceived benefit from watching the broadcaster is as given in (2). In the welfare analysis, however, we need to take into account that consumers do not correctly perceive the costs involved in the consumption decisions on the product market.

The microfoundations discussed above are not mutually exclusive. Great television programs may at the same time be substitutes for consumption goods, influence boundedly rational moods, 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. For normative questions, our main model builds on the

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25 Another difference between our setup and Glaeser and Ujhelyi (2010) is that, in our model, all consumers watching the same broadcaster are identical and have single unit demand. Therefore, even though each producer is a monopolist, consumption is efficient if and only if consumers perceive the health cost correctly, and there is no efficiency enhancing role for misinformation.

26 While all the microfoundations are consistent with our assumption that a consumer’s willingness to pay for a product of type $\sigma$ is equal to $\sigma - \beta v$, the willingness to pay may also be a nonlinear function. We discuss this in Section 7.2.
complementarity microfoundation or the recall microfoundation, where consumers’ willingness to pay for a product accurately captures their true benefits from the product. The moods microfoundation and the deceptive advertising microfoundation, on the other hand, show that 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. Section 6.4 studies 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

\[
\frac{n}{\tau} \left( \frac{\sigma - \beta v_i - \frac{\sigma a_i}{m}}{n} \right) = \beta n \left( \frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau} \right).
\]

The left hand side of equation (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 \( n/\tau \), and on each viewer the broadcaster earns the price of an ad per viewer \( r_i \). The right hand side of equation (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 \( \beta \), and the loss of revenue is equal to \( \beta \) times the number of viewers.

The first order condition for the profit maximizing advertising quantity is

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

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 \( i = 1, ..., N \) :

\[
a_i = \frac{m \beta \tau}{N (\sigma + m \beta \delta)},
\]

\[
v_i = \frac{\sigma}{\beta} \frac{\tau (2 \sigma + m \beta \delta)}{N (\sigma + m \beta \delta)}.
\]
Inverse ad demand per viewer is \( r_i = \frac{\beta \tau}{N} \). The equilibrium profit of broadcaster \( i \) is

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

Equations (11) and (12) can easily be derived from the first order conditions (9) and (10), assuming that all broadcasters behave symmetrically.\(^{27}\) Proving equilibrium existence is, however, somewhat more challenging for several interrelated reasons. 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 (Anderson, de Palma, and Thisse 1992, Section 6.3.2). 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 \( \tau \) 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.\(^{28}\) 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 price per ad per viewer. On the one hand, it lowers advertising quantity and thereby increases the per viewer price. On the other hand, it increases the program quality and thereby decreases the per viewer price. Equation (9) reveals that in any symmetric equilibrium,

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

Recall that the right hand side can be interpreted as broadcaster \( i \)'s marginal costs of program quality, and equals \( \beta \) times the number of viewers of the broadcaster. In any symmetric equilibrium, each broadcaster has \( 1/N \) 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.\(^{29}\)

\(^{27}\)This argument also shows that the equilibrium is unique in the class of all symmetric equilibria whenever \( F > 0 \) (see Appendix A.1.1).

\(^{28}\)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.

\(^{29}\)Brown and Alexander (2005) estimate that a 20% increase in concentration local broadcast television markets would lead to a 9% increase in the per-viewer price of ads (p.336).
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. (2014) 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 (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 what is sometimes called the “crumbling ad-edit wall” (see FCC 2011 for discussion).\(^{30}\)

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

\[
N > \hat{N}_e := \frac{m\beta^2 \tau}{\sigma + m\beta \delta}.
\]

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. The broadcasters do not fully internalize the negative effect of program

\(^{30}\)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. Besley & Prat 2006, Petrova 2011, 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.
quality on the advertisers’ profits: a broadcaster will choose the program quality such that a marginal change will not influence its own profit; however a marginal increase lowers advertisers’ profits. Moreover, 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 equation (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 decreases. 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

$$\frac{\partial PS}{\partial v} = n \int_0^a (-\beta) \, dx = -n\beta a.$$  

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 accuracies 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 ($\delta$ 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 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.\textsuperscript{31} To see this, 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 $\tau$. Therefore, the effect on producer surplus is small in absolute value when competition is high.\textsuperscript{32}

5.2 Effects of a cap on advertising

While the program quality may be hard to regulate, advertising can be restricted. As reported in the 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.\textsuperscript{33} We now consider the effect of a quantity restriction on advertising $\bar{a}$ that constrains 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

$$v_i = \frac{\sigma}{\beta} - \frac{1}{N^\tau} - \frac{1}{m \beta} \bar{a}. \quad (13)$$

Profit equals

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

\textsuperscript{31}Formally, $\frac{\partial PS}{\partial a} = n \left(\sigma - \beta v - \frac{a \beta}{m} \right)$. Evaluating the derivative at the equilibrium values of $a$ and $v$ gives $\frac{\partial PS}{\partial a} = \frac{n \bar{a} \beta}{\bar{a}}$.

\textsuperscript{32}We point out that this result does not hold in models where program quality is exogenous, such as Anderson and Coate (2005) or Choi (2006). As discussed above, 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.

\textsuperscript{33}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.
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 \( \tau \).

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 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 Figure 1, which plots the marginal benefits and costs of quality from equation (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 (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 \( N \).

![Figure 1: The effect of a cap on program quality. The thin lines are the marginal costs and benefits of program quality given the equilibrium advertising quantity absent a cap; in bold with a binding cap.](image)

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 (Aarlberg 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. Moreover, the comparison we are referring to is between commercial broadcasters only, thus our model applies. Other things being equal, the 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 2008a); our model may thus contribute to an explanation of the cross-country differences.\(^{34}\)

\(^{34}\)Of course, other things are not equal; in particular, Aalberg et al. (2010) stress the stronger public service orientation in European television.
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

\[ N > \hat{N}_{\text{cap}} := \frac{(2\sigma + m\beta)\sigma m^2\tau}{(\sigma + m\beta)^2}. \]  

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

Figure 2 illustrates. A decrease in advertising quantity, holding program quality constant, increases welfare above the dotted line, which plots \( \hat{N}_v \). Clearly, this can only happen if \( \delta > 0 \), and the higher ad aversion, the more likely it is. Above the thin line, which plots \( \hat{N}_v \), an increase in \( v \) holding \( a \) constant increases welfare. The bold line is the cutoff \( \hat{N}_{\text{cap}} \). Interestingly, the cutoffs \( \hat{N}_a \) and \( \hat{N}_{\text{cap}} \) differ most dramatically when ad aversion is small. Similarly, Figure 3 plots the cutoffs as a function of \( m \). The cutoffs \( \hat{N}_a \) and \( \hat{N}_{\text{cap}} \) differ most when \( m \) is small. In times where advertisers move online and thus \( m \) decreases, the quality enhancing effect of a cap pointed out in our paper 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 \( \tau \)), 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 \( \tau \); 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 when \( N \) increases, while the positive impact on consumer surplus is not affected; hence it is more likely that welfare increases.\(^{35}\)

### 5.3 The optimal cap

This section studies the welfare maximizing cap. Consider the problem to maximize welfare by choosing a cap \( \bar{a} \) subject to not changing the number of broadcasters,\(^{36}\)

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

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 (7) 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. \( \bar{a} = N^2F/(n\beta\tau) \). In particular, if inequality (14) holds, the optimal cap is such that broadcasters make zero profits. Moreover, (14) is a sufficient but not a necessary condition for the optimal cap to increase welfare.

Figure 4 illustrates. Profits are positive below the bold line; 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 \( \bar{N}_{cap} \): on the zero profit line a local cap is a zero profit cap. Figure 4 also illustrates that a cap can be optimal even when \( N < \bar{N}_{cap} \).

\(^{35}\)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.\(^{36}\)We consider a model with free entry and an endogenous number of broadcasters in Section 5.4.
Figure 4: On the bold line, broadcasters’ equilibrium profits (absent a cap) are zero; above it there would be exit. Below the thin line, a cap that drives broadcasters’ profits to zero maximizes welfare. The welfare gains from the optimal cap are not everywhere monotone in $N$, for example along the dotted line.

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

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. 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 Figure 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 (see, for example, Mas-Colell, Whinston, and Green 1995, Chap. 12 E). 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 out has a profit of zero. In stage 2, broadcasters that have entered choose their advertising quantity and program quality.

\footnote{For example, suppose $F$ is as indicated by the horizontal dotted line in Figure 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 $N$.}
The number of broadcasters is then determined by the condition that the broadcasters’ profits (given in Proposition 1 and Lemma 1) equal zero.\textsuperscript{38} 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

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

Then a local cap increases welfare, and there is a (uniquely defined) optimal cap \(a^*\), which is decreasing in \(\delta\) and \(n\), and increasing in \(\tau\) and in \(F\). (iii) If \(F \geq \hat{F}_{\text{capwithexit}}\), 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.

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. The left panel in Figure 5 illustrates. The bold lines correspond the effects for a given number of broadcasters familiar from Section 5.2\textsuperscript{38}

\textsuperscript{38}We follow Salop (1979) and the textbook literature (e.g. Belleflamme & Peitz 2010, Chap. 4.2) and assume that, after entry or exit, broadcasters automatically relocate such that they are equidistant. We ignore the integer constraint on \(N\) for convenience. We also ignore the issue that, 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.
above. The thin lines represent the additional effects due to endogenous entry: the cap changes the number of broadcasters, which in turn affects welfare directly (by changing of consumers’ transportation costs and broadcasters’ fixed costs) and indirectly (since for any given advertising quantity, program quality depends on $N$).

![Figure 5: The effects of a cap (left panel), and a tax (right panel) on welfare.](image)

Depending on the parameters, endogenous entry can make it more or less likely that a local cap increases welfare.\(^{39}\) When $\delta > 2\sigma / (3m\beta)$, the exit induced by a cap makes it more likely that a local cap increases welfare.\(^{40}\) 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.\(^{41}\)

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 (see also Berry et al. 2014).

\(^{39}\)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.

\(^{40}\)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 $N > N_{\text{cap}}$. 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 $F < F_{\text{cap}} := \frac{n(\sigma + m\beta)^2}{m^2 n^2 + (2m + n\beta)^2}$. Taking entry into consideration, a cap raises welfare if $F < F_{\text{cap with exit}}$. Straightforward calculations show that, $F_{\text{cap with exit}} > F_{\text{cap}}$ if and only if $\delta > 2\sigma / (3m\beta)$.

\(^{41}\)The additional effects due to endogenous entry also determine how $m$ affects the probability that a cap raises welfare: $F_{\text{cap with exit}}$ decreases in $m$ if and only if $\delta < 2\sigma / (3m\beta)$.
5.5 The effects of an advertising tax

A tax on advertising revenue is sometimes advocated as a measure to overcome commercial media bias (Baker 1994). Indeed, a tax on advertising seems to be a recurrent policy idea (Rauch 2013). For example, the states Iowa and Florida taxed advertising in the late 1980s, and advertising taxes have recently been discussed in Minnesota and Ohio.\(^{42}\) 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.\(^{43}\) We assume that the tax revenue is redistributed lump sum to the consumers. To clarify our terminology, we call net consumer surplus the consumers’ surplus before redistribution of tax revenues, given in (5), and take welfare to be the sum of net consumer surplus, tax revenue, and all profits.

Consider first the case of an exogenous 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. When the tax revenue is redistributed to consumers, these negative effects have to be balanced against the additional income from the redistribution of tax revenue.\(^{44}\) 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 comes from the two-sidedness of the market. The tax on advertising lowers the number of broadcasters. Thus there is less competition for audiences, which implies that equilibrium advertising quantities are higher. By (7), advertisers’ profits

\(^{42}\) Relatedly, in the discussion on tax reform, U.S. House and Senate Committees introduced proposals to change the tax deductibility of advertising. See AdvertisingAge, March 12, 2013 and Adweek, February 26, 2014.

\(^{43}\) 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 \(a\), 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.

\(^{44}\) It can be shown that a small tax on advertising increases the sum of net consumer surplus and tax revenues if and only if \(F > \frac{27n (\sigma + m\beta)^2}{(64\beta^2\sigma^4)}\).
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. This explains why a cap increases consumer surplus and decreases profits, while the effects of the tax 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 \(\tau\), the viewer market \(n\), and ad aversion \(\delta\) have the opposite effect on the probability that a tax, or a cap, raise welfare. The tax and the cap have in common, however, that they reduce the equilibrium number of broadcasters. In turn, exit has both a direct effect on welfare, and an indirect effect (since for given advertising quantity, program quality depends on \(N\)). These common effects of a cap and a tax are represented by the dotted lines in Figure 5. As reported above, when \(\delta > 2\sigma/(3m\beta)\), these effects make it more likely that a cap raises welfare; then there is a range of parameters where both a cap and a small tax increase welfare (see Figure 6). Conversely, when \(\delta < 2\sigma/(3m\beta)\), the effects common to a cap and a tax make it less likely that welfare increases; then there is a range of parameters where neither the cap nor the tax raises welfare.

![Figure 6](image_url)

**6 Extensions**

This section explores four extensions of our model: pay TV, consumers that differ in ad aversion and use ad avoidance technologies, producers that differ in how far they are affected by television program quality and sector specific regulation, and deceptive advertising. 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), Armstrong and Weeds (2007), 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

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

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 $\tilde{v}$ 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.\footnote{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).}

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 essentially free. Then viewers with $\delta > 0$ use ad avoidance technologies, and thus effectively no consumer is directly negatively affected by ads.\footnote{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.}

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 \( n_2 (w + v) - n_2 \sigma / (4N) \) 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.\(^{47}\)

### 6.3 Sector specific regulation

Our model above assumed that advertisers have a shared interest in low program quality. This may be appropriate for specific industries where the qualities of the products sold are highly correlated. For example, all producers in the tobacco industry may suffer from an increased awareness of the health risks of smoking. In other industries, however, broadcasters may be less hostile to accurate reporting. As argued by Ellman and Germano (2009) and Germano and Meier (2013), and modelled in detail by Blasco, Pin, and Sobbrio (2012), competition on the product market can ameliorate commercial media bias when advertisers have opposing interests.

In this section, we study an extensions of where advertisers are interested in low program quality in some industries, but not in others. To keep the discussion short, we focus on the case where \( \delta = 0 \). Suppose there is a mass \( m_1 \) of type 1 advertisers characterized by \( \beta = 0 \). These advertisers are not interested in dumbing down media content. Moreover, there is a mass \( m_2 = m - m_1 \) of type 2 advertisers with \( \beta > 0 \); these advertisers prefer lower program quality. Suppose that the quality \( \tilde{\sigma} \) of the product of any advertiser is drawn from the uniform distribution on \([0, \sigma]\); thus type 1 and type 2 advertisers do not differ in this respect (see also Section 7.2). Advertising demand of broadcaster \( i \) then is

\[
a_i = m_1 \Pr (\tilde{\sigma} > r_i) + m_2 \Pr (\tilde{\sigma} - \beta v_i > r_i)
\]

\[
= \begin{cases} 
    m_1 \left( 1 - \frac{r_i}{\sigma} \right) + m_2 \left( 1 - \frac{r_i + \beta v_i}{\sigma} \right), & \text{if } 0 \leq r_i < \tilde{\sigma} - \beta v_i, \\
    m_1 \left( 1 - \frac{r_i}{\sigma} \right), & \text{if } \tilde{\sigma} - \beta v_i \leq r_i < \sigma.
\end{cases}
\]

Inverse ad demand per viewer is

\[
r_i = \begin{cases} 
    \sigma - \sigma \frac{m_1}{m_1}, & \text{if } a_i < \frac{m_1 \beta v_i}{\sigma}, \\
    \sigma - \frac{m_2 \beta v_i}{m_1} - \sigma \frac{a_i}{m_1}, & \text{if } \frac{m_1 \beta v_i}{\sigma} \leq a_i < \frac{1}{\sigma} (m \sigma - \beta m_2 v_i).
\end{cases}
\]

If \( m_1 \) is sufficiently big, then only the type 1 advertisers are advertising in equilibrium, since the willingness to pay of type 2 advertisers is lower. In this case the market solves the problem of

\(^{47}\)Note that the condition does not depend on \( n \), so replacing \( n \) by \( n_1 \) does not affect them.
commercial media bias. If \( m_1 \) is sufficiently small, however, there exist a symmetric equilibrium where both type-1 and type-2 advertisers are served.\(^{48}\) In this case, the profit of broadcaster \( i \) is

\[
\pi_i = n \left( \frac{1}{N} + \frac{v_i - \delta a_i - u}{\tau} \right) \left( \sigma - \beta_2 v_i - \frac{\sigma a_i}{m} \right) a_i
\]

where \( \beta_2 := m_2 \beta / m < \beta \). The equilibrium values of program quality and advertising quantity can be found by replacing \( \beta \) by \( \beta_2 \) in the formulas in Proposition 1 and Lemma 1.\(^{49}\)

Consumer surplus can be calculated as in (5) above. To calculate producer surplus, we need to take the two different types of advertisers into account:

\[
PS = n \int_0^{m_1 v \sigma} \left( \sigma - \frac{\sigma x}{m_1} \right) dx + n \int_{m_1 v \sigma}^{a \sigma} \left( \sigma - \frac{m_2 \beta}{m} v - \frac{\sigma x}{m} \right) dx.
\]

We now consider the effect of a general cap that applies to the quantity of all advertising by type 1 and type 2 producers.

**Proposition 8** Consider the extension where there is a mass \( m_1 \) of advertisers with \( \beta = 0 \) and a mass \( m_2 = m - m_1 \) of advertisers with \( \beta > 0 \). Let \( \delta = 0 \). If both types of advertisers are served in equilibrium, a local cap on advertising increases welfare if and only if

\[
N > \hat{N}_{\text{cap}2} := \frac{2 \beta^2 \tau m_2}{\sigma (\beta (m - m_2) + 1)}.
\]

To compare this with our main model, first note that when \( m_2 \to m \), we get the same condition as (14) for the case \( \delta = 0 \). Moreover, \( \hat{N}_{\text{cap}2} \) is increasing in \( m_2 \), the more likely it is that a cap improves welfare. Therefore, in the extension considered in Proposition 8, it is more likely than in our main model that a cap improves welfare. The intuition is that, since only some broadcasters suffer from higher program quality, the loss of producer surplus due to a cap is not as important as in our main model.

As reported in the introduction, many countries impose bans on advertising for specific sectors or products, for example tobacco or alcohol. To see the implications in our model, consider a sector specific advertising ban that excludes all type 2 advertisers. Then for the broadcasters there is no drawback from choosing high program quality; thus in equilibrium program quality will be equal to its highest possible level \( \bar{v} \). If \( \bar{v} \) is sufficiently high, a sector specific advertising ban leads to a higher welfare than laissez faire, or a local cap on all advertising. While most rationales for regulating the content of advertising are built on bounded consumer rationality,
this argument identifies conditions such that regulating advertising content is justifiable for the reason it decreases commercial media bias, even when consumers are perfectly rational.

6.4 Deceptive advertising

Our main model assumed that a consumer’s willingness to pay for a product accurately captures the consumer’s benefits from the product. As argued Section 4.3, this assumption is doubtful when purchase decisions are boundedly rational, or when advertising is suggestive or deceptive. Then, consumers may take suboptimal decisions (for themselves) on the product markets. Moreover, the corresponding losses of the consumers will depend on television program quality. This section investigates how taking these considerations into account modifies our main results.

As in the main model, we assume that a television program with quality $v$ reduces the willingness to pay for a product of type $\tilde{\sigma}$ to $\tilde{\sigma} - \beta v$. However, here we assume that one part, $\gamma \beta v$, of the reduction comes from consumers making smaller errors, and the remaining part $(1 - \gamma) \beta v$ comes from good television being a substitute for consumption, where $0 \leq \gamma \leq 1$. Following Glaeser and Ujhelyi (2010), suppose that consumption of a product has a health costs $\gamma c$, so the true gain of consumers from buying a product of type $\tilde{\sigma}$ is $\tilde{\sigma} - (1 - \gamma) \beta v - \gamma c$. The consumer perceives the costs to be $\gamma \beta v$; we assume that in the relevant range, consumers underestimate the costs, i.e. $c > \beta v$. We scale both the true costs and the perceived costs with the same parameter $\gamma$ in order to have one single parameter that captures the importance of deceptive advertising. The case where $\gamma = 0$ corresponds to our main model. The case $\gamma = 1$ corresponds to the deceptive advertising microfoundation discussed in Section 4.3. When $0 < \gamma < 1$, higher television quality both reduces the true utility of consumption, and informs consumers so that they have a more accurate estimate of the costs.

As above, we assume that the producer can capture all the perceived benefits from the product by charging the price $\tilde{\sigma} - \beta v$. The net utility gain of a consumer from consuming a good of type $\tilde{\sigma}$ is then $\tilde{\sigma} - (1 - \gamma) \beta v - \gamma c - (\tilde{\sigma} - \beta v) = \gamma (\beta v - c)$. The consumer is informed about, and consumes, in total $a$ such products, thus the consumer’s loss on the product market equals $a \gamma (c - \beta v)$. Consumers are aware that a better program quality helps to make better decisions, and perceive a benefit $v$ from watching the program. They are not aware that the products advertised on television involve any health costs beyond $\gamma \beta v$. Thus the consumers perceived benefit from watching a broadcaster is given by (2), as in the main model. Consumer surplus, however, also has to take into account consumers’ losses on the product market:

$$CS = n (v - \delta a) - \frac{nt}{4N} - na \gamma (c - \beta v). \quad (15)$$

Producer surplus is, as in the main model, given by equation (6). Note that consumption of a product of type $\tilde{\sigma}$ raises welfare if and only if $\tilde{\sigma} > \gamma c$. Thus consumption of high-quality goods is welfare enhancing in our setting.
For the positive analysis, this model generates the same predictions as our main model. A cap on advertising, however, now has additional benefits for the consumers: it improves their decisions on the product market, both by reducing the number of ads and by improving the program quality. Thus the welfare gains due to a cap are higher than in our main model. To see this formally, note that the effects of lower advertising quantity, and higher program quality, on consumer surplus are

\[ \frac{\partial CS}{\partial a} = \delta n + n\gamma (c - \beta v), \]
\[ \frac{\partial CS}{\partial v} = n + na\gamma \beta. \]

Thus both the direct (less advertising) and the indirect (higher program quality) effect of a cap on consumer surplus are more important when \( \gamma > 0 \). It is therefore more likely that the cap’s positive effects on consumer surplus outweigh the negative effects on producer surplus.

Deceptive advertising thus makes the case for a cap stronger. It modifies, however, our result on the complementarity between competition and regulation. When there are many independent broadcasters, consumers’ errors are small since program quality is high and advertising quantities are low; thus consumers’ gains from a cap are smaller. This works against the complementarity between competition and regulation. Indeed, if \( \gamma \) is close to 1, competition and regulation are no longer local complements. We show in Appendix A.10, however, that the local complementarity between competition and regulation holds whenever \( \gamma < (2\sigma + m\beta\delta) / (3\sigma + m\beta\delta) \); a sufficient condition is \( \gamma < 2/3 \).

7 Robustness

7.1 Television viewing behavior

This section probes the robustness of our results with respect to the model television viewing behavior, focussing on the case where the number of broadcasters is exogenous. One limitation of our results comes from the assumption that everyone watches television. If the number of viewers is endogenous, and viewers are ad averse, a cap on advertising will ceteris paribus increase the total number of viewers. This means that increasing \( v \) has higher costs for a broadcaster, because he loses \( \beta a \) on every viewer he has, countervailing the quality improving effects of a cap discussed above.\(^{50}\)

Our results do not hinge, however, on specific features of the Salop circle model. To show this, we introduce a more general model of television viewing behavior that nests the Salop model and several other textbook models of discrete choice. Suppose that, if all broadcasters

\(^{50}\)Indeed, if ad aversion is strong, a cap may decrease equilibrium program quality. The simplest way to see this is to reconsider the example from Section 3, and to introduce ad aversion \( \delta > 0 \). Then a cap will increase program quality whenever \( \delta < 1 \), but it will decrease quality when \( \delta > 1 \).
\( j \neq i \) behave symmetrically, the fraction of viewers who watch broadcaster \( i \) depends only on the difference between the utility \( v_i - \delta a_i \) offered by broadcaster \( i \), and the utility offered by the competitors, scaled by a factor \( 1/\tau \). The share is given by \( s \left( \frac{v_i - \delta a_i - u}{\tau} \right) \), where \( u := v_j - \delta a_j \), and \( s \) is a strictly increasing function with \( s(0) = 1/N \). In general, the function \( s \) will depend on \( N \); we assume it to be independent of the other exogenous parameters of the model. We assume that the function \( s \) is sufficiently well behaved such that a symmetric equilibrium in pure strategies exists and can be characterized by the relevant first order conditions. This model nests the Salop model with linear transportation costs studied in Section 5 (given undercutting is not an issue), the Salop model with any convex (e.g. quadratic) transportation costs, the Logit model (see, for example, Anderson, de Palma, and Thisse 1992), and the covered Spokes model introduced by Chen and Riordan (2007) and used in a study of commercial media bias by Germano and Meier (2013).

Appendix A.11 substantiates these claims, and A.12 characterizes the symmetric equilibrium with and without a cap. A cap increases program quality, and indeed \( d\tilde{v}/(d\tilde{a}) = -\sigma/\beta m \) exactly as above, see equation (13). The comparative statics of the equilibrium depends on the behavior of \( Ns'(0) \). The advertising quantity \( a \) is decreasing in \( N \), and quality \( v \) is increasing in \( N \), if and only if \( Ns'(0) \) is increasing in \( N \). Similarly, the price of an advertising spot per viewer \( r \) is decreasing in \( N \) if and only if \( Ns'(0) \) is increasing in \( N \). As discussed above, this seems to be the empirically plausible case. The Salop model with linear or strictly convex transportation costs, and the Logit model share this property that \( Ns'(0) \) is increasing in \( N \). The Spokes model is a limit case where \( Ns'(0) \) is independent of \( N \).

For the welfare analysis, we assume that, for a given number of broadcasters \( N \), welfare is given by

\[
W = n(w + v - \delta a) + n \int_0^a \left( \sigma - \beta v - \frac{\sigma}{m} x \right) dx - NF + C(N),
\]

where \( C(N) \) is independent of \( a \) and \( v \). This is the case in all the discrete choice models mentioned above (e.g. in the Salop model, \( C(N) \) equals aggregate transportation costs). As in our main model, a cap increases consumer surplus, and decreases producer surplus. Moreover, the welfare analysis of a local cap is quite similar to our main model. A local cap improves welfare if and only if \( Ns'(0) > \tilde{N}_{cap} \). This is, in addition, a sufficient but not necessary condition for the optimal cap subject to the constraint that profits are nonnegative to be binding. The optimal policy is either to choose a cap that drives profits down to zero, i.e. \( \tilde{a} = FN^2s'(0)/(n\beta \tau) \), or laissez-faire.

As seen above, many standard discrete choice models imply that \( Ns'(0) \) is increasing in \( N \). Moreover, if \( Ns'(0) \) is increasing in \( N \), then the comparative statics of equilibrium advertising quantity, program quality, and price per ad per viewer go in empirically plausible directions. It is exactly this property that also gives rise to the complementarity between competition and regulation: If \( Ns'(0) \) is increasing in \( N \), then an increase in \( N \) makes it more likely that a local cap raises welfare.
Since $s(\cdot)$ is independent of the remaining parameters of the model, their impact is exactly as in the linear Salop model considered in Section 5. Table 2 lists the market share, the condition under which a local cap improves welfare, and the optimal cap (if binding) for several discrete choice models nested in our general model. It shows that the conditions under which a local cap improves welfare are qualitatively similar. Moreover, the optimal cap has the same qualitative properties under these models. The table also shows, however, that the precise quantitative implications depend on the assumed model of television viewing.

<table>
<thead>
<tr>
<th>Model</th>
<th>$s\left(\frac{u_i-u}{\tau}\right)$</th>
<th>$Ns'(0)$</th>
<th>local cap improves $W$ iff</th>
<th>zero-profit cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salop linear</td>
<td>$\frac{1}{N} + \frac{u_i-u}{\tau}$</td>
<td>$N$</td>
<td>$N &gt; \hat{N}_{cap}$</td>
<td>$\frac{FN^2}{n\beta\tau}$</td>
</tr>
<tr>
<td>Salop quadratic</td>
<td>$\frac{1}{N} + \frac{N(u_i-u)}{\tau}$</td>
<td>$N^2$</td>
<td>$N^2 &gt; \hat{N}_{cap}$</td>
<td>$\frac{FN^3}{n\beta\tau}$</td>
</tr>
<tr>
<td>Spokes</td>
<td>$\frac{1}{N} + \frac{u_i-u}{\tau}$</td>
<td>$1$</td>
<td>$1 &gt; \hat{N}_{cap}$</td>
<td>$\frac{FN}{n\beta\tau}$</td>
</tr>
<tr>
<td>Logit</td>
<td>$\frac{e^{u_i/\tau}}{e^{u_i/\tau}+(N-1)e^{u_i/\tau}}\frac{N-1}{N}$</td>
<td>$\frac{N-1}{N} &gt; \hat{N}_{cap}$</td>
<td>$\frac{F(N-1)}{n\beta\tau}$</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Different assumptions on television viewing behavior. Salop linear (quadratic) refers to the Salop model with linear (quadratic) transportation costs.

7.2 Advertising demand

Our model assumed that a higher program quality reduces the willingness to pay of all advertisers by the same amount. In a diagram with advertising quantity on the horizontal axis, and the price of and ad per viewer on the vertical axis, the inverse demand curve for advertising spots is linear, and a higher program quality leads to a parallel downward shift of the inverse demand curve; see the left hand side of Figure 8. The reduction of the willingness to pay, however, may depend on the quality of the good. It seems plausible to assume that the willingness to pay of producers of high (rather than low) quality goods is less affected by program quality. Moreover, there might be nonlinearities in the inverse advertising demand curve. For example, advertisers may have increasing marginal costs from program quality, or similarly, viewers’ marginal utility from program quality may be decreasing.

To study potential implications, suppose that the inverse demand for advertising is given by a function $r(a, v)$, which is decreasing in $a$ and in $v$. While a complete analysis is beyond the scope of this paper, we show that the plausible assumption that producers of high quality goods have little to lose from program quality strengthens the mechanism by which a cap increases program quality. Formally, the assumption means that the cross-partial derivative

---

51 Note that even in the Spokes model a lower $\tau$, i.e. a more competitive broadcasting market since viewers are more homogenous, makes a cap more likely to be welfare enhancing.

52 Note this can also capture decreasing marginal utility of the viewers. Suppose a viewer’s utility is given by $f(v_i) - \delta a_i - \tau x$, where $f'(v) > 0 > f''(v)$, instead of equation (2), and $r_i$ is as given in (3). Then we can equivalently think of the broadcaster choosing $\hat{v}_i := f(v_i)$; then viewers utility from watching is $\hat{v}_i - \delta a_i - \tau x$ as in (2), but $r_i = \sigma - \beta f^{-1}(\hat{v}_i) - \sigma a_i/m$, thus the advertisers have increasing marginal costs from program quality.

39
$r_{va} := \frac{\partial^2 r}{\partial v \partial a}$ is negative. In terms of the right hand side of Figure 8, an increase in quality makes the inverse ad demand curve steeper.

Consider the profit maximization problem of broadcaster $i$, given a binding cap $\bar{a}$:

$$\max_{v_i} ns \left( \frac{v_i - \delta \bar{a} - u}{\tau} \right) r(\bar{a}, v_i) \bar{a} - F$$

where $u = v_j - \delta \bar{a}$ for all $j \neq i$. Setting up the first order condition for the profit maximizing program quality, and then using symmetry, one obtains

$$\frac{s'(0)}{\tau} r(\bar{a}, v) + \frac{1}{N} r_v(\bar{a}, v) = 0$$

where $r_v$ is the partial derivative $\partial r / \partial v$. Consider how the equilibrium value of $v$ changes when the cap $\bar{a}$ changes. From the implicit function rule,

$$\frac{dv}{d\bar{a}} = -\frac{s'(0) r_\bar{a} + \frac{1}{N} r_{va}}{s'(0) r_v + \frac{1}{N} r_{vv}}, \quad (16)$$

where as above subscripts indicate partial derivatives. The denominator is negative by the second order condition, and $r_\bar{a} < 0 < s'(0)$ by assumption. Therefore, if $r_{va} = 0$, then $dv/d\bar{a} < 0$, and a cap improves program quality as in our main model; the sign of the second order partial derivatives $r_{vv}$ and $r_{aa}$ does not matter for this result.53 As can be seen from (16), $r_{va} < 0$ reinforces the quality enhancing effect of the cap. The economics behind this is as follows. A tighter cap implies that the marginal advertiser has a better product. When $r_{va} < 0$, it follows that the willingness to pay of the marginal advertiser decreases less in program quality. Therefore, broadcasters have an additional reason to increase their program quality. Similarly, any reason why the marginal advertiser has a lower stake in program quality works in the same direction. On the other hand, when the marginal advertiser has a higher stake in program quality (perhaps because of the advertisers’ cost structure), this works against the quality enhancing effect of a cap.

53While the curvature of $r$ in $v$ does not matter for the sign of $dv/d\bar{a}$, it influences its absolute value. This can change the results on the desirability of a cap and on the local complementarity between competition and regulation. To see this, consider the case where there is some upper bound $\tilde{v}$ on quality. Such an upper bound might endogenously arise as the result of viewers’ utility being increasing in $v$ only up to $\tilde{v}$, or from advertisers’ willingness to pay dropping rapidly when quality exceeds $\tilde{v}$. Then, enough competition on the media market can be sufficient to ensure that equilibrium program quality is $\tilde{v}$, and thus as high as it possibly can be. If, in addition, ad aversion is small, a cap on advertising will be detrimental to welfare.
8 Conclusion

This paper has argued that a cap on advertising in commercial free-to-air television drives up the per viewer price of advertising spots and thus induces broadcasters to air 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 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.

A Appendix

A.1 Proof of Proposition 1

In Section A.1.1, we show that, for any $F > 0$, if a symmetric equilibrium exists, it is given by (11) and (12). In A.1.2 we establish that (11) and (12) indeed constitute an equilibrium.
A.1.1 Uniqueness

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

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

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

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

A.1.2 Existence

We suppose all broadcasters $j \neq i$ behave as indicated in the Proposition and show that broadcaster $i$ has no incentive to deviate. Since the proof is somewhat lengthy, we break it down into steps, for which we first briefly sketch the intuition. Step 1 assumes that broadcaster $i$ does not undercut and shows that, under this assumption, broadcaster $i$ has no incentive to deviate. The remaining steps consider deviations that involve undercutting. Step 2 prepares the ground by describing the range of $a_i$ and $v_i$ leading to undercutting. From here, it is straightforward to show that undercutting more than two rivals is not profitable: it leads to zero inverse ad demand and hence to a profit of zero (Step 3). The remaining steps consider undercutting two rivals. Step 4 considers the case of $N = 3$. Here, by undercutting two rivals, broadcaster $i$ captures all the market. It will choose $v_i$ such that it just undercuts its two rivals since this is sufficient to make all viewers watch broadcaster $i$. We show that the resulting profit is smaller than the equilibrium profit. Steps 5 and 6 consider undercutting two rivals in case of $N > 3$. Here, by undercutting two rivals, broadcaster $i$ does not capture all viewers. Step 5 shows that broadcaster $i$ will not increase its program quality more than necessary to just undercut two rivals. The intuition is that at the equilibrium broadcaster $i$ is already indifferent whether or not to increase its program quality a bit, thereby winning viewers but gaining a lower price for ads. At the considered deviation, broadcaster $i$ already has more viewers than in equilibrium, and thus prefers not to increase its program quality any more. Step 6 shows that the deviation profit from just undercutting two rivals is smaller than the equilibrium profit.

**Step 1:** Find the profit maximizing decisions of broadcaster $i$ assuming that broadcaster $i$ does not undercut any rival.

Suppose all broadcasters $j \neq i$ behave as indicated. Then

$$u = v_j - \delta a_j = \frac{\sigma}{\beta} - \frac{2\tau}{N}.$$
The profit of broadcaster $i$ is

$$\pi_i = n \left( \frac{1}{N} + \frac{v_i - \delta a_i - \left( \frac{\sigma}{\beta} - \frac{2\tau}{N} \right)}{\tau} \right) \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) a_i$$

whenever

$$\left( 1 - \frac{a_i}{m} \right) \frac{\sigma}{\beta} > v_i > \delta a_i + \left( \frac{\sigma}{\beta} - \frac{2\tau}{N} \right) - \frac{\tau}{N}. $$

Otherwise, profit is zero: if the first inequality does not hold, inverse ad demand is zero, if the second inequality does not hold, broadcaster $i$ has no viewers. Therefore, broadcaster $i$ will choose an $a_i > 0$ such that

$$\frac{3\tau}{N \left( \frac{\sigma}{\beta m} + \delta \right)} > a_i > 0.$$ (17)

We first consider the profit maximizing $v_i$ for a given $a_i$ satisfying (17). Note that $\pi_i$ is strictly concave in $v_i$. Solving the first order condition

$$\frac{\partial \pi_i}{\partial v_i} = \frac{n}{\tau} \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) a_i - \beta n \left( \frac{1}{N} + \frac{v_i - \delta a_i - \left( \frac{\sigma}{\beta} - \frac{2\tau}{N} \right)}{\tau} \right) a_i = 0$$

for $v_i$ shows that the profit maximizing program quality is

$$v_i^* (a_i) = \frac{1}{2} \left( \left( 1 - \frac{a_i}{m} \right) \frac{\sigma}{\beta} + \delta a_i + \left( \frac{\sigma}{\beta} - \frac{2\tau}{N} \right) - \frac{\tau}{N} \right).$$

Substituting $v_i^* (a_i)$ into the profit of broadcaster $i$ gives

$$\pi_i (a_i, v_i^* (a_i)) = \frac{nb}{4\tau} \left( \frac{3\tau}{N} - a_i \left( \frac{\sigma}{\beta m} + \delta \right) \right)^2 a_i.$$ 

The first order condition

$$\frac{d}{da_i} \pi_i (a_i, v_i^* (a_i)) = 0$$

has the solutions

$$a_{i1} = \frac{3\tau}{N \left( \frac{\sigma}{\beta m} + \delta \right)}$$

corresponding to the upper bound on $a_i$ in (17), and

$$a_{i2} = \frac{a_{i1}}{3} = \frac{m\beta\tau}{N \left( \sigma + m\beta \delta \right)}$$

which is (11). Moreover, it is straightforward to show that $\pi_i (a_i, v_i^* (a_i))$ as a function of $a_i$ is: zero at $a_i = 0$, strictly concave when $a_i < 2a_{i1}/3$, strictly convex when $2a_{i1}/3 < a_i < a_{i1}$, and
zero at $a_i = a_{i1}$. It follows that $a_{i2}$ maximizes profit. Noting that $v^*_i(a_{i2})$ is the value of $v_i$ given in the Proposition completes step 1.

**Step 2: Describe the range of $a_i$ and $v_i$ leading to undercutting.**

Suppose broadcaster $j$ is a distance $k/N$ away from broadcaster $i$. A consumer with ideal point at the location of broadcaster $j$ is indifferent between the products of broadcasters $i$ and $j$ if

$$v_i - \delta a_i - \frac{k\tau}{N} = v_j - \delta a_j.$$ 

Consider a unilateral deviation of broadcaster $i$, while all broadcasters except $i$ stick to the equilibrium strategies, i.e. $v_j - \delta a_j = \frac{\sigma}{\beta} - \frac{2\tau}{N}$. Thus, the consumer is indifferent if

$$v_i - \delta a_i = \frac{\sigma}{\beta} - \frac{2\tau}{N} + \frac{k\tau}{N}.$$ 

For $k = 1, 2, ..., \ldots$, the values of $(a_i, v_i)$ satisfying this equation are the points of discontinuity of the demand of broadcaster $i$. Note that the discontinuity at $k = 1, 2, ..., \ldots$ corresponds to just undercutting $2k$ rivals. For simplicity and w.l.o.g., we break all ties in favor of broadcaster $i$, i.e. we assume that if a broadcaster deviates then any consumer that is indifferent between the deviating and another broadcaster watches the deviating broadcaster.

To summarize, broadcaster $i$ undercuts no rival if

$$v_i - \delta a_i < \frac{\sigma}{\beta} - \frac{2\tau}{N} + \frac{\tau}{N}.$$ 

Broadcaster $i$ undercuts exactly $2k$ rivals, $k = 1, 2, ..., \ldots$, if

$$\frac{\sigma}{\beta} - \frac{2\tau}{N} + \frac{k\tau}{N} \leq v_i - \delta a_i < \frac{\sigma}{\beta} - \frac{2\tau}{N} + \frac{(k + 1)\tau}{N}.$$ 

**Step 3: Broadcaster $i$ cannot make a positive profit by undercutting more than 2 broadcasters.**

By the symmetry of the behavior of broadcasters $j \neq i$, if broadcaster $i$ undercuts more than 2 broadcasters, it undercuts 4 or more broadcasters. To undercut 4 or more broadcasters, the program quality of broadcaster $i$ needs to be $v_i \geq \sigma/\beta + \delta a_i$. However, then $\sigma - \beta v_i - \sigma a_i/m < 0$, thus inverse ad demand is zero.

**Step 4: Undercutting two rivals: the case $N = 3$.**

Suppose that broadcaster $i$ undercuts exactly 2 rivals. That is,

$$\frac{\sigma}{\beta} - \frac{\tau}{N} \leq v_i - \delta a_i < \frac{\sigma}{\beta}.$$
If \( N = 3 \), this means broadcaster \( i \) has a market share of 1. The profit of broadcaster \( i \) is then
\[
\pi_i \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) a_i.
\] (18)

Note this is strictly decreasing in \( v_i \), therefore, the optimal undercutting of two rivals satisfies
\[
\frac{\sigma}{\beta} - \frac{\tau}{3} = v_i - \delta a_i.
\]

Solving for \( v_i \) gives
\[
v_i = \hat{v}_i (a_i) := \frac{\sigma}{\beta} - \frac{\tau}{3} + \delta a_i,
\]

substituting in (18) shows that the profit is
\[
\pi_i^{\text{dev}} (a_i, \hat{v}_i (a_i)) = n \left( \sigma - \beta \left( \frac{\sigma}{\beta} - \frac{\tau}{3} + \delta a_i \right) - \frac{\sigma a_i}{m} \right) a_i.
\]

Note \( \pi (a_i, v_i^* (a_i)) \) is strictly concave in \( a_i \). The first order condition
\[
\frac{d}{da_i} \pi_i^{\text{dev}} (a_i, \hat{v}_i (a_i)) = 0
\]
has the unique solution
\[
a_i^{\text{dev}} = \frac{m \beta \tau}{6 (\sigma + m \beta \delta)}.
\]

Moreover,
\[
\hat{v}_i \left( a_i^{\text{dev}} \right) = \frac{\sigma}{\beta} - \frac{\tau}{3} + \delta \frac{m \beta \tau}{6 (\sigma + m \beta \delta)}.
\]

The profit from the deviation is
\[
\pi_i^{\text{dev}} \left( a_i^{\text{dev}}, \hat{v}_i \left( a_i^{\text{dev}} \right) \right) = \frac{3}{4} \frac{nm \beta^2 \tau^2}{27 (\sigma + m \beta \delta)},
\]
which is \( 3/4 \) of the equilibrium profit given in the Proposition.

It follows that in case \( N = 3 \), broadcaster \( i \) has no incentive to undercut two rivals.

**Step 5:** In case \( N > 3 \), from all strategies involving undercutting two rivals, the best strategy is at a point of discontinuity of demand.

Suppose broadcaster \( i \) undercuts exactly 2 rivals:
\[
\frac{\sigma}{\beta} - \frac{\tau}{N} \leq v_i - \delta a_i < \frac{\sigma}{\beta}.
\]
If $N > 3$, broadcaster $i$ has a market share of

$$\frac{3}{N} + \frac{v_i - \delta a_i - \left(\frac{\sigma}{\beta} - \frac{\tau}{N}\right)}{\tau}.$$ 

Profit is

$$\pi_i^{Dev}(a_i, v_i) = n \left( \frac{3}{N} + \frac{v_i - \delta a_i - \left(\frac{\sigma}{\beta} - \frac{\tau}{N}\right)}{\tau} \right) \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) a_i.$$ 

We will show that this profit is maximal whenever $i$ just undercuts two rivals, i.e. when

$$\frac{\sigma}{\beta} - \frac{\tau}{N} = v_i - \delta a_i. \quad (19)$$

To see this, suppose that broadcaster $i$ undercuts 2 rivals, and

$$\frac{\sigma}{\beta} - \frac{\tau}{N} < v_i - \delta a_i < \frac{\sigma}{\beta}.$$ 

For a fixed $a_i$,

$$\frac{\partial}{\partial v_i} \pi_i^{Dev} = \left( \frac{1}{\tau} \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) - \beta \left( \frac{3}{N} + \frac{v_i - \delta a_i - \left(\frac{\sigma}{\beta} - \frac{\tau}{N}\right)}{\tau} \right) \right) na_i.$$ 

Note that $\pi_i^{Dev}$ is strictly concave in $v_i$. Moreover, at $v_i = \frac{\sigma}{\beta} - \frac{\tau}{N} + \delta a_i$, we have

$$\left. \frac{\partial}{\partial v_i} \pi_i^{Dev} \right|_{v_i = \left(\frac{\sigma}{\beta} - \frac{\tau}{N} + \delta a_i\right)} = \left( \frac{1}{\tau} \left( \beta \frac{3}{N} - \delta a_i - \frac{\sigma a_i}{m} \right) - \beta \frac{3}{N} \right) na_i$$

$$= - \left( \frac{1}{\tau} \left( \beta \frac{\delta a_i}{m} + \frac{\sigma a_i}{m} \right) + \beta \frac{2}{N} \right) na_i < 0.$$ 

Therefore, in the relevant range $\pi_i^{Dev}$ is strictly decreasing in $v_i$ for fixed $a_i$. It follows that the best strategy involving undercutting two rivals must satisfy equation (19).

**Step 6: In case $N > 3$, broadcaster $i$ has no incentive to just undercut 2 rivals.**

Suppose broadcaster $i$ just undercuts 2 rivals, i.e. equation (19) holds. Then

$$\pi_i^{Dev} = n \left( \frac{3}{N} \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) a_i.$$ 

Solve equation (19) for $v_i = \frac{\sigma}{\beta} - \frac{\tau}{N} + \delta a_i$ and substitute into $\pi_i^{Dev}$ to get

$$\pi_i^{Dev} = n \left( \sigma - \beta \left( \frac{\sigma}{\beta} - \frac{\tau}{N} + \delta a_i \right) - \frac{\sigma a_i}{m} \right) a_i.$$
Note that this is a strictly concave function of $a_i$. The first order condition
\[
\frac{\partial}{\partial a_i} \pi_i^{Dev} = 0
\]
has the unique solution
\[
a_i = \frac{1}{2N} m \beta \frac{\tau}{\sigma + m \beta \delta}.
\]
Inserting this into $\pi_i^{Dev}$ gives
\[
\pi_i^{dev} = \frac{3}{4} \frac{nm \beta^2 \tau^2}{N^3 (\sigma + m \beta \delta)}
\]
which is $3/4$ of equilibrium profit. It follows that broadcaster $i$ has no incentive to just undercut two rivals.

### A.2 Proof of Proposition 2

From (5),
\[
\frac{\partial CS}{\partial v} = n > 0.
\]
Moreover, from (6),
\[
\frac{\partial PS}{\partial v} = -n \beta a
\]
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 iff $N > \bar{N}_v$.

### A.3 Proof of Proposition 3

From (5),
\[
\frac{\partial CS}{\partial a} = -\delta n < 0.
\]
Moreover, from (6),
\[
\frac{\partial PS}{\partial a} = n \left( \sigma - \beta v - \frac{\sigma a}{m} \right) > 0,
\]
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 (11) and (12) gives

\[
\frac{\partial W}{\partial a} = -\delta n + \frac{1}{N} n \beta \tau,
\]
which is strictly negative iff \( N > \hat{N}_a \).

### 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

\[
\frac{dv}{d\bar{a}} = -\frac{1}{m \beta},
\]

so from (22), (20), and (24),

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

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 (21), (23), and (24) 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 \( a \) on \( W \) is
\[
\frac{dW}{da} = -\delta n - \frac{\sigma n}{m_\beta} + \frac{n_\beta \tau (2\sigma + m_\beta \delta)}{N (\sigma + m_\beta \delta)}
\]
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
\[
W^{LF} = n \left( w + \frac{\sigma}{\beta} - \frac{\tau (2\sigma + m_\beta \delta)}{N (\sigma + m_\beta \delta)} - \frac{\delta}{N} \frac{m_\beta \tau}{(\sigma + m_\beta \delta)} \right) - \frac{n \tau}{4N} + n \int_0^{\frac{m_\beta \tau}{N(\sigma + m_\beta \delta)}} \left( \sigma - \beta \left( \frac{\sigma}{\beta} - \frac{\tau (2\sigma + m_\beta \delta)}{N (\sigma + m_\beta \delta)} \right) - \frac{\sigma x}{m} \right) dx - NF.
\]

With a cap \( \bar{a} = N^2 F / (n_\beta \tau) \), welfare equals
\[
W^{cap} = n \left( w + \frac{\sigma}{\beta} - \frac{1}{N} \tau - \frac{1}{m_\beta \beta} \frac{\sigma N^2 F}{n_\beta \tau} - \frac{\delta N^2 F}{n_\beta \tau} \right) - \frac{n \tau}{4N} + n \int_0^{\frac{N^2 F}{n_\beta \tau \beta}} \left( \sigma - \beta \left( \frac{\sigma}{\beta} - \frac{1}{N} \tau - \frac{1}{m_\beta \beta} \frac{\sigma N^2 F}{n_\beta \tau} \right) - \frac{\sigma x}{m} \right) dx - NF.
\]

The difference is
\[
W^{cap} - W^{LF} = \frac{FN^3 (\sigma + m_\beta \delta) - mn_\beta^2 \tau^2}{2N^2 mn_\beta^2 \tau^2 (\sigma + m_\beta \delta)^2} \left( mn_\beta^2 \tau^2 (3\sigma + 2m_\beta \delta) + N (\sigma + m_\beta \delta) (FN^2 \sigma - 2n \tau (\sigma + m_\beta \delta)) \right).
\]

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, \( W^{cap} > W^{LF} \) if and only if
\[
mn_\beta^2 \tau^2 (3\sigma + 2m_\beta \delta) + N (\sigma + m_\beta \delta) (FN^2 \sigma - 2n \tau (\sigma + m_\beta \delta)) < 0
\]
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 \( N > \hat{N}_{cap} \), Proposition 4 has already established that a local cap raises welfare and thus clearly \( W^{cap} > W^{LF} \). For the rest of the proof, consider the case where \( N \leq \hat{N}_{cap} \).

By differentiating \( \hat{F} (N) \) with respect to \( N \), it can be shown that for all \( N \leq \hat{N}_{cap} \), \( \hat{F} (N) \) is strictly increasing in \( N \). Therefore, for all \( N \leq \hat{N}_{cap} \), 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, $\hat{N}(0) \leq N \leq \hat{N}_{\text{cap}}$.

**A.7 Proof of Proposition 6**

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

$$N = N^{LF} := \left( \frac{nm\beta^2 + 2}{F(\sigma + m\beta \delta)} \right)^{\frac{1}{4}},$$

$$a = a^{LF} := \frac{m\beta \tau}{\left( \frac{nm\beta^2 + 2}{F(\sigma + m\beta \delta)} \right)^{\frac{1}{4}} (\sigma + m\beta \delta)} = \left( \frac{\beta \tau m^2}{n (\sigma + m\beta \delta)^2} \right)^{\frac{1}{4}}.$$

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 equation (5), and inserting the equilibrium number of firms $N = \sqrt{(n\bar{a}\beta \tau)/F}$, shows that consumer surplus is

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

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,

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

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 (25) 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

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

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

Differentiating (26),

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

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

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

which is strictly negative if and only if

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

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

Note $W$ fulfills the Inada condition $\lim_{a \to 0} W'(\bar{a}) = \infty$, 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 $W'(a)$,

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

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

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

Equation (26) presupposes that $N \geq 2$. 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.
Note that $g'(a) > 0$ and

$$g(a_{LF}) = -\frac{25}{16}\left(\frac{\frac{m\beta\tau}{\tau(\sigma+m\beta\delta)}}{\frac{\frac{m\beta\tau}{\tau(\sigma+m\beta\delta)}}{\frac{m\beta\tau}{\tau(\sigma+m\beta\delta)}}}\right)^{1\over 2} \sqrt{\frac{Fn\tau}{\beta}} + \frac{n\sigma}{m\beta} + n\delta$$

$$= -\frac{9}{16m\beta} (\sigma + m\beta\delta) < 0.$$  

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 $F < \hat{F}_{capwithexit}$. By the intermediate value theorem, since $W'(\tilde{a}) > 0$ for sufficiently small $\tilde{a}$ 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 $\frac{\partial a}{\partial \tau}$ is equal to the sign of $\frac{\partial W'(a^*)}{\partial \beta} = -n < 0$. Similarly, $\frac{\partial a}{\partial F} > 0$ and $\frac{\partial a}{\partial W'(\tilde{a})} > 0$, thus $a^*$ is increasing in $\tau$ and in $F$. Moreover,

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

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

Note the bracket is $W'(\tilde{a}) / n$ 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 $F \geq \hat{F}_{capwithexit}$. Then $W'(a_{LF}) \geq 0$. Lemma 2 implies that $W'(\tilde{a}) > 0$ for all $\tilde{a} < a_{LF}$. 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
\[ CS_{\text{net}} = n(\omega + v - da) - \frac{n\tau}{4N}. \]
\[ = nw + \frac{n\sigma}{\beta} - \frac{n\tau}{4 \left( \frac{nm\beta^2 \tau^2 (1 - t)}{F(\sigma + m\beta\delta)} \right)^{\frac{1}{3}}}. \]  
\[ (27) \]

Thus, \( CS_{\text{net}} \) is decreasing in \( t \).

Advertiser profits equals \( a^2 n\sigma / (2m) \) (see equation (8)). Inserting the equilibrium value of \( a \) gives
\[ \frac{1}{2} a^2 n\sigma = \frac{1}{2} \frac{n\sigma}{m} \left( \frac{m\beta\tau}{\left( \frac{nm\beta^2 \tau^2 (1 - t)}{F(\sigma + m\beta\delta)} \right)^{\frac{1}{3}} (\sigma + m\beta\delta)} \right)^{2}. \]  
\[ (28) \]

Thus, advertiser profits are increasing in \( t \).

Tax revenue \( T \) is given by \( T = n\sigma \gamma / t \). In equilibrium,
\[ T = \frac{nm (\beta\gamma)^2 t}{\left( \frac{nm\beta^2 \tau^2 (1 - t)}{F(\sigma + m\beta\delta)} \right)^{\frac{2}{3}} (\sigma + m\beta\delta)}. \]  
\[ (29) \]

Welfare is
\[ W = CS_{\text{net}} + PS - NF + T. \]

Because of free entry, \( PS - NF \) equals advertisers’ profits (28).

Inserting (27), (28), and (29), into \( W \), differentiating with respect to \( t \), and evaluating at \( t = 0 \), shows that
\[ \frac{\partial W}{\partial t} \bigg|_{t=0} = \frac{F \left( \frac{nm\beta^2 \tau^2}{F(\sigma + m\beta\delta)} \right)^{\frac{1}{3}}}{12m\beta^2 \tau (\sigma + m\beta\delta)} \left( 4m\beta^2 \tau (4\sigma + 3m\beta\delta) - \left( \frac{nm\beta^2 \tau^2}{F(\sigma + m\beta\delta)} \right)^{\frac{1}{3}} 9 (\sigma + m\beta\delta)^2 \right). \]  
53
Therefore, $W$ is increasing in $t$ if and only if
\[ 4m\beta^2 \tau (4\sigma + 3m\delta) > \left( \frac{mn\beta^2 \tau^2}{F(\sigma + m\delta)} \right)^{\frac{1}{3}} 9(\sigma + m\delta)^2 \]
or equivalently,
\[ F > \frac{mn\beta^2 \tau^2}{(\sigma + m\delta)} \left( \frac{9(\sigma + m\delta)^2}{4m\beta^2 \tau (4\sigma + 3m\delta)} \right)^{3} = \hat{F}_{\text{taxwithexit}}. \]

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

### A.9 Proof of Proposition 8

Since by assumption $\delta = 0$,
\[ W = nv + n \int_{0}^{m_1 \beta v} \left( \sigma - \sigma \frac{x}{m_1} \right) dx + n \int_{a}^{m_2 \beta v} \left( \sigma - \frac{m_2 \beta v}{m} - \sigma \frac{x}{m} \right) dx - \frac{nt}{4N}. \]

The effect of a cap on welfare is
\[ \frac{dW}{da} = \frac{\partial W}{\partial a} + \frac{dv}{da} \frac{\partial W}{\partial v}, \]
where
\begin{align*}
\frac{\partial W}{\partial a} &= n \left( \sigma - \frac{m_2 \beta}{m} v - \frac{\sigma a}{m} \right), \\
\frac{\partial W}{\partial v} &= n - n \frac{m_2 \beta}{m} \left( a - \frac{m_1 \beta v}{\sigma} \right).
\end{align*}

Moreover, from Lemma 1, replacing $\beta$ by $\beta_2$, we have
\[ \frac{dv}{da} = -\frac{1}{m} \frac{\sigma}{\beta m_2} = -\frac{\sigma}{\beta m_2}. \]

Thus
\[ \frac{dW}{da} = n \left( \sigma - \frac{m_2 \beta}{m} v - \frac{\sigma a}{m} \right) - \frac{\sigma}{\beta m_2} \left( n - n \frac{m_2 \beta}{m} \left( a - \frac{m_1 \beta v}{\sigma} \right) \right). \quad (30) \]
The equilibrium values of \(a\) and \(v\) can be found from Proposition 1, replacing \(\beta\) by \(\beta_2\) and setting \(\delta = 0\):

\[
\begin{align*}
a &= \frac{m \beta_2 \tau}{N \sigma} = \frac{\beta \tau m_2}{N \sigma}, \\
v &= \frac{\sigma}{\beta_2} - \frac{2 \tau}{N} = \frac{m \sigma}{m_2 \beta} - \frac{2 \tau}{N}.
\end{align*}
\]

Inserting these into equation (30) shows that the effect of a local cap is

\[
\frac{dW}{da} = \frac{n \beta \tau m_2}{Nm} - \frac{\sigma}{\beta m_2} \left( n - n \frac{m_2 \beta}{m} \left( \frac{\beta \tau m_2}{N \sigma} - \frac{m_1 \beta}{\sigma} \left( \frac{m \sigma}{m_2 \beta} - \frac{2 \tau}{N} \right) \right) \right)
= \frac{n \beta m_2}{Nm} - \frac{\sigma}{m_2 \beta} \left( n + n \beta \left( m_1 - \beta \tau \frac{m_2^2 + 2 m_1 m_2}{Nm \sigma} \right) \right).
\]

This is strictly negative if and only if

\[
\frac{\beta \tau m_2}{Nm} < \frac{\sigma}{m_2 \beta} \left( 1 + \beta \left( m_1 - \beta \tau \frac{m_2^2 + 2 m_1 m_2}{Nm \sigma} \right) \right).
\]

or, equivalently (since \(m = m_1 + m_2\), \(N > \hat{N}_{\text{cap2}}\).

A.10 Complementarity between competition and regulation with deceptive ads

Competition and regulation are local complements if the marginal welfare gains from a cap, \(-\frac{dW}{da}\), are increasing in \(N\). Here, \(W = CS + PS - NF\), \(CS\) is given in (15), \(PS\) in (6). Substituting \(v\) from Lemma 1 into these expressions, and differentiating, on obtains

\[
\frac{\partial}{\partial N} \left( -\frac{dW}{da} \right) = n \beta \tau \frac{2 \sigma - 3 \sigma \gamma + m \beta \delta - m \beta \gamma \delta}{N^2 (\sigma + m \beta \delta)},
\]

which is strictly positive if and only if \(\gamma < (2 \sigma + m \beta \delta) / (3 \sigma + m \beta \delta)\).

A.11 General model of television viewing behavior

A.11.1 Salop model with convex transportation costs

Suppose that the transportation costs of a viewer located at a distance \(x\) from the broadcaster equals \(\tau l (x)\), where \(l\) is strictly increasing, strictly convex, and satisfies \(l (0) = 0\). Let \(u_i = v_i - \delta a_i\), and \(u = v_j - \delta a_j\) for all \(j \neq i\). Assuming that there is an indifferent viewer between broadcaster \(i\) and its closest competitors, the distance \(x\) between this viewers and broadcaster \(i\) solves

\[
u_i - \tau l (x) = u - \tau l \left( \frac{1}{N} - x \right),\]

55
or equivalently
\[
\frac{u_i - u}{\tau} = l(x) - l\left(\frac{1}{N} - x\right).
\]

Let \(\lambda(x, N) = l(x) - l\left(\frac{1}{N} - x\right)\). Since \(\lambda\) is strictly increasing in \(x\), holding \(N\) fixed, an inverse function \(\lambda^{-1} (\cdot, N)\) exists, and
\[
\lambda^{-1}\left(\frac{u_i - u}{\tau}, N\right) = x.
\]

Therefore, the market share of \(i\) is
\[
s\left(\frac{u_i - u}{\tau}\right) = 2x = 2\lambda^{-1}\left(\frac{u_i - u}{\tau}, N\right).
\]

Thus
\[
s'(\frac{u_i - u}{\tau}) = \frac{2}{\lambda'(\lambda^{-1}\left(\frac{u_i - u}{\tau}, N\right))} = \frac{2}{l'(x) + l'\left(\frac{1}{N} - x\right)}.
\]

When \(u_i - u = 0\), \(x = 1/(2N)\). Thus
\[
Ns'(0) = \frac{N}{l'(\frac{1}{2N})}.
\]

Therefore
\[
\frac{d}{dN} (Ns'(0)) = \frac{l'(\frac{1}{2N}) + l''\left(\frac{1}{2N}\right)\frac{1}{2N}}{l'(\frac{1}{2N})^2} > 0.
\]

Thus \(Ns'(0)\) is increasing in \(N\).

It remains to establish that the first order conditions are sufficient for a maximum. Given the convex transportation costs, undercutting is not an issue. To show that any critical point is a global maximum, we now show that the variable profit, \(\pi_i + F\), is log-concave in \((a_i, v_i)\).

We begin by establishing that \(\ln s\left(\frac{u_i - u}{\tau}\right)\) is strictly concave in \(u_i\).

\[
\frac{\partial^2}{\partial u_i^2} \left( \ln s\left(\frac{u_i - u}{\tau}\right) \right) = \frac{1}{\tau^2 s\left(\frac{u_i - u}{\tau}\right)^2} \left( s\left(\frac{u_i - u}{\tau}\right) s''\left(\frac{u_i - u}{\tau}\right) - \left( s'\left(\frac{u_i - u}{\tau}\right) \right)^2 \right)
\]
is strictly smaller zero if, and only if,
\[
s\left(\frac{u_i - u}{\tau}\right) s''\left(\frac{u_i - u}{\tau}\right) < \left( s'\left(\frac{u_i - u}{\tau}\right) \right)^2.
\]

Here, this inequality is equivalent to
\[
1 + \lambda^{-1}\left(\frac{u_i - u}{\tau}, N\right) \frac{\lambda''\left(\lambda^{-1}\left(\frac{u_i - u}{\tau}, N\right)\right)}{\lambda'\left(\lambda^{-1}\left(\frac{u_i - u}{\tau}, N\right)\right)} > 0
\]
which is true since \(\lambda^{-1} > 0\), \(\lambda' > 0\) and \(\lambda'' > 0\).
It follows that
\[ \ln (\pi_i + F) = \ln s \left( \frac{u_i - u}{\tau} \right) + \ln \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) + \ln a_i \]

is the sum of three functions, each of them being weakly concave in \((a_i, v_i)\). Moreover, the first of these functions is strictly concave in \((a_i, v_i)\) except along the line where \(v_i - \delta a_i\) is constant; the second is strictly concave except along the line where \(\beta v_i + \frac{\sigma a_i}{m}\) is constant. It follows that \(\ln (\pi_i + F)\) is strictly concave in \((a_i, v_i)\).

### A.11.2 Logit

In the logit model, the market share of broadcaster \(i\) is
\[ s \left( \frac{u_i - u}{\tau} \right) = \frac{e^{u_i/\tau}}{e^{u_i/\tau} + (N - 1)e^{u_i/\tau}} \]
(see, for example, Anderson, de Palma, and Thisse 1992). It is straightforward to calculate that
\[ N s'(0) = \frac{N - 1}{N} \]
Moreover, it can be shown that the variable profit \((\pi_i + F)\) is log-concave in \((a_i, v_i)\). Therefore, the first order conditions are sufficient for a maximum.

### A.11.3 Spokes

In the covered Spokes model introduced by Chen and Riordan (2007) and used in Germano and Meier (2013),
\[ s_i \left( \frac{u_i - u}{\tau} \right) = \frac{1}{N} + \frac{1}{N} \left( \frac{u_i - u}{\tau} \right) \]
Then \(N s'(0) = 1\) is independent of \(N\). Again, the variable profit is log-concave in \((a_i, v_i)\) and therefore the first order conditions are sufficient for a maximum.

### A.12 Equilibrium characterization and welfare effects of a cap

The profit of broadcaster \(i\) is
\[ \pi_i = ns \left( \frac{v_i - \delta a_i - u}{\tau} \right) \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) a_i - F. \]
The first order condition
\[ \frac{\partial \pi_i}{\partial v_i} = s' \left( \frac{v_i - \delta a_i - u}{\tau} \right) \frac{1}{\tau} n \left( \sigma - \beta v_i - \frac{\sigma a_i}{m} \right) a_i - \beta ns \left( \frac{v_i - \delta a_i - u}{\tau} \right) a_i = 0 \]
simplifies to, assuming symmetry,

\[ r \equiv \sigma - \beta v - \frac{\sigma}{m} a = \frac{\beta \tau}{Ns'}(0). \]

Consider the case without a cap. The first order condition

\[
\frac{\partial \pi_i}{\partial a_i} = ns' \left( \frac{v_i - \delta a_i - u}{\tau} \right) \left( \frac{\delta'}{\tau} \right) \left( -\beta \frac{\sigma v_i - \frac{\sigma}{m} a_i}{m} a_i + ns \left( \frac{v_i - \delta a_i - u}{\tau} \right) \left( \frac{\sigma}{m} a_i \right) \right) \\
+ ns \left( \frac{v_i - \delta a_i - u}{\tau} \right) \left( \sigma - \beta v_i - \frac{\sigma}{m} a_i \right) = 0
\]

simplifies, in any symmetric equilibrium, to

\[-\frac{\delta}{\tau} s'(0) ra - \frac{1}{N} \frac{\sigma}{m} a + \frac{r}{N} = 0.\]

Inserting \( r = \beta \tau / (Ns'(0)) \) and solving for \( a \) gives

\[ a = \frac{\beta}{Ns'(0)} \frac{m \tau}{\sigma + m \beta \delta}. \]

Moreover,

\[ v = \frac{\sigma}{\beta} - \frac{\tau}{Ns'(0)} \frac{2 \sigma + m \beta \delta}{\sigma + m \beta \delta}. \]

If there is a binding cap \( \bar{a} \), then in any symmetric equilibrium

\[ v = \frac{\sigma}{\beta} - \frac{\sigma}{\beta m} \bar{a} - \frac{\tau}{Ns'(0)}. \]

Inserting the equilibrium value of \( v \) into the welfare function, we get

\[
W(\bar{a}) = n \left( w + \frac{\sigma}{\beta} - \frac{\sigma}{\beta m} \bar{a} - \frac{\tau}{Ns'(0)} - \delta \bar{a} \right) + n \int_0^{\bar{a}} \left( \beta \left( \frac{\sigma}{\beta m} \bar{a} + \frac{\tau}{Ns'(0)} \right) - \frac{\sigma}{m} x \right) dx - NF + C
\]

\[ = n \left( -\frac{\sigma}{\beta m} \bar{a} - \delta \bar{a} \right) + \frac{n \sigma}{2m} \bar{a}^2 + \frac{n \beta a \tau}{Ns'(0)} + \text{terms independent of } \bar{a}. \]

Consider the problem to maximize \( W(\bar{a}) \) by choosing \( a \), subject to the constraint that profits are nonnegative:

\[ \pi_i = n \frac{\beta \tau}{N Ns'(0)} \bar{a} - F \geq 0. \]

Since \( W(\bar{a}) \) is convex in \( \bar{a} \), either the optimal cap is driving profits to zero, or it is not binding. Moreover,

\[ \frac{dW}{d\bar{a}} = n \left( -\frac{\sigma}{\beta m} - \delta \right) + n \frac{\bar{a}}{m} + \frac{n \beta \tau}{Ns'(0)}. \]
Evaluating this at the equilibrium level of $a$ (absent a cap) gives

$$\frac{dW}{da} = \left( -\frac{\sigma}{\beta m} - \delta \right) + \frac{n\beta}{Ns'(0)} \frac{m}{\sigma + m\beta} - \frac{n\beta \tau}{Ns'(0)}$$

which can be written as

$$\frac{dW}{da} = \left( -\frac{\sigma}{\beta m} - \delta \right) + \frac{n\beta \tau}{Ns'(0)} \frac{2\sigma + m\beta \delta}{\sigma + m\beta \delta}.$$

Rearranging shows that this is strictly negative if and only if

$$Ns'(0) > \frac{(2\sigma + m\beta \delta)(\beta m^2\tau)}{(\sigma + m\beta \delta)^2} = \hat{N}_{\text{cap}}.$$

Thus a local cap raises welfare if and only if $Ns'(0) > \hat{N}_{\text{cap}}$.

References


[86] OFCOM. "Regulating the quantity of advertising on television". OFCOM Statement (2011).


