ON COMMERCIAL MEDIA BIAS

Fabrizio Germano*
Departament d'Economia i Empresa
Universitat Pompeu Fabra
Ramon Trias Fargas 25-27
08005 Barcelona, Spain
fabrizio.germano@upf.edu

April 2009

Abstract

Within the spokes model of Chen and Riordan (2007) that allows for non-localized competition among arbitrary numbers of media outlets, I analyze the effect of concentration of ownership on quality and bias of media content. Too few commercial outlets, or better, too few separate owners of commercial outlets can lead to substantial bias in equilibrium. Increasing the number of outlets – commercial and non-commercial – tends to bring down the bias; but the strongest effect occurs when the number of owners is increased. Analyzing free entry provides lower bounds on fixed costs above which significant bias appears unavoidable in equilibrium. The paper allows to draw policy conclusion concerning the role of concentration and public funding of media markets.

Keywords: Commercial media; concentration and consolidation; media bias; self-censorship; ownership structure. *JEL Classification*: L13; L82.

*I am grateful to Nicola Gennaioli, Manfred Kops, Maria Petrova, Kurt Schmidheiny, Helen Weeds, and seminar participants in Heidelberg and at the 6th Workshop on Media Economics in Zurich for insightful comments and conversations. Financial support from the Spanish Ministry of Science and Technology, Grant SEJ2007-64340, from the Fundación Ramón Areces, as well as the Barcelona GSE Research Network, and the Generalitat de Catalunya is gratefully acknowledged. All errors are my own.

"Papa, what is the moon supposed to advertise?"

Carl Sandburg, THE PEOPLE, YES, 1936

(cited from Barnouw, 1978, p. 3)

1 Introduction

Motivated by the recent media policy debate in the United States and ongoing attempts by the Federal Communications Commission (FCC) to loosen ownership rules there (see e.g., McChesney, 2004, for a description of the events around the 2003 attempt; another such episode occurred in 2007), we develop a model of media competition that allows for a somewhat detailed study of the quality and bias of media content for a number of different ownership structures. The analysis builds on the spokes model of Chen and Riordan (2007), which is a Hotelling type model of spatial competition that allows for arbitrary numbers of media firms and outlets (commercial and non-commercial) that compete against each other in a non-localized fashion.

We show that excessively concentrated media markets, beyond a certain cut-off, can result in substantial bias of media content. Increasing the number of separately owned media firms in the market helps towards reducing the bias; increasing the number of commercial outlets, while keeping the number of owners fixed, can also help, but clearly to a lesser extent.[1]

The channel through which the bias occurs in our model is through the funding of commercial media outlets by advertisers and the internalization of the effect of the media outlets' content on the advertisers' sales and advertising budgets. A motivating example for our analysis is the coverage of tobacco related health hazards in the US. For decades, despite hundreds of thousands of deaths a year, serious statistics and medical information about the health hazards of smoking were kept away from mainstream commercial media (see e.g., Baker, 1994, and Bagdikian, 2004, for chronologies as well as references documenting the statistical impact of advertising on the coverage

[1] In a companion paper (see Germano and Meier, 2008) we study a variant where increasing the number of commercial outlets, while keeping the number of owners fixed, actually deepens the bias albeit slightly.

of tobacco related health hazards; see also Ellman and Germano, 2009, for further discussion and references). Bagdikian (2004, pp. 250-252) summarizes "there were still more stories in the daily press about the causes of influenza, polio, and tuberculosis than about the cause of one in every seven deaths in the United States," so that, in the 1980's, some "64 million Americans, obviously already addicted, smoked an average of 26 cigarettes a day" with surveys indicating that half the general and two-thirds the smoking population did not think smoking made a great difference in life expectancy, Baker (1994, p. 51).[2] Our model claims that alongside advertising, concentration in the media markets plays an important role in explaining such bias.

Model. The basic model is structured as follows. There are n (≥ 2) commercial media outlets and a mass one of consumers. Media outlets are located at the endpoints (one for each outlet) of a spokes network that has $N \geq n$ potential locations. Commercial media are assumed to maximize profits which are derived from advertising and payments from the audience minus the costs of producing the programming. Later in Section 3.4, we consider the important case where commercial media firms can own multiple ($\kappa \geq 1$) outlets, in which case the κn total outlets are located at κn different endpoints of a spokes network with $N \geq \kappa n$ endpoints; and finally in Section 4 we also allow for the possibility of m (≥ 0) non-commercial media outlets (funded by viewer fees or by an exogenously given budget) to be in the market, again each one located at a different endpoint of a network with $N \geq \kappa n + m$ endpoints.

Consumers are uniformly distributed along the N spokes of the network. Transportation (or switching) costs reflect different costs consumers may have of switching from a most preferred to a second most preferred outlet. As in Chen and Riordan (2007), consumers have a preference for only two of the N potential outlets. This guarantees continuity and simplicity of demands. One interpretation is that beyond the second most preferred outlet consumers prefer a non-media outside option. If $N > \kappa n$ (or $N > \kappa n + m$) then there

[2] In 2007, according to the Center for Disease Control and Prevention of the US Department of Health and Human Services, cigarette smoking remained the leading preventable cause of death in the US, accounting for approximately 1 of every 5 deaths (= 438,000 people) per year.

are some consumers who are interested in consuming exactly two, one or zero of the κn (or $\kappa n + m$) actual outlets.

Assumptions. Besides the assumptions implicit in the framework, the analysis relies on three key assumptions: (A1) Advertisers advertise with all commercial media outlets proportionally to their audience share ($s_i \geq 0$); (A2) advertisers spend a constant fraction ($\eta > 0$) of their final sales on ads; (A3) advertisers' final sales can be written as $C(\mathbf{x}) = \varphi(\mathbf{x})C_0$, where φ is a decreasing function of the sensitive information variable $\mathbf{x}$ and C_0 is an exogenously given level of base consumption of the advertised products. Assumptions (A1)-(A3) combined imply that any media outlet i's advertising revenues can be written as $s_i \, \eta \, C(\mathbf{x})$.

(A1) assumes advertisers value consumers equally, and essentially abstracts from issues of targeting, whereby advertisers strategically target audiences of particular interest to them (see e.g., George and Waldfogel, 2003, Hamilton, 2004, and Strömberg, 2004, for models of targeting and their effects). (A2) is an approximation; Schmalensee (1972) derives that spending a constant fraction of final sales on advertising can actually be an optimal rule in many circumstances and also provides some empirical support for such behavior; Baghestani (1991), Jung and Seldon (1995), Elliott (2001) provide further empirical evidence; but see also Esteve and Requena (2006) for some qualifications.

(A3) is probably the more critical of the three assumptions. One can view the information variable $\mathbf{x}$ as being essentially *defined* through this assumption and therefore interpret it as representing any "generic" variable measuring programming content that has a decreasing net effect on aggregate demand (or on aggregate advertising revenues).[3] Generally speaking this is content that affects consumption of advertised products; for example it can be information sensitive to advertisers whose products fail to meet basic

[3] Peter Duersch has suggested a micromodel of this whereby advertisers whose products do not comply with certain basic standards spend more on advertising, making them relatively more attractive to media outlets (if not the media might not mind too much reporting information sensitive to them); if this is the case then it is easy to see that reporting sensitive information on such products would lead to a net decrease of aggregate advertising revenues, which is what is really needed for our results.

standards. Clearly what $\mathbf{x}$ represents more concretely can vary over time, and an implication of our analysis is that with excessively concentrated media, the time lags of shifting production to higher standard products can be prolonged due to deficient coverage of the issue. Further interpretations of the variable $\mathbf{x}$ follow below.[4] The main object of the present paper can also be seen as studying the implications of assumption (A3) on programming content within a location model of product differentiation.

Results. Given these assumptions, we derive a cut-off number $\bar{n}$ such that if there are fewer outlets in the market, then in equilibrium sensitive information can be completely suppressed ($\mathbf{x} = \mathbf{0}$); on the other hand, a sufficiently large number of outlets will always guarantee no suppression or maximum accuracy ($\mathbf{x} = \mathbf{1}$) (Proposition 1). The result is robust to further ownership structures, like allowing media firms to own multiple outlets (Proposition 5) or to adding non-commercial ones (Proposition 8). While audience-funded commercial media tend to be more informative, the possibility of drawing revenues from advertisers can undo this potential effect (Propositions 3 and 4).

Moreover, if there is free entry and fixed costs are high, the market may not support sufficiently many separate firms in equilibrium to ensure full accuracy. Introducing non-commercial outlets can bring down the critical number $\bar{n}$ of commercial firms or outlets needed to avoid substantial bias (Proposition 8), but clearly their ability to attract sufficient audiences relies on non-negligible budgets.

Finally, the framework also allows media outlets to choose a further quality variable (y) that is separate from the mentioned accuracy variable $\mathbf{x}$. We show that essentially only the audience funded media achieve the efficient amount of this quality variable (Proposition 3). The propositions and structural claims about media content and quality obtained can in principle be tested empirically.

[4]For a concrete example of how media content can affect viewers' behavior at a deep level, see La Ferrara et al. (2008), who suggest that the fertility rates of Brazilian women were significantly affected by the introduction of the *Rede Globo* TV channel in their region. Baker and George (2008) suggest that TV access in the US may have affected household indebtedness in the 1950's.

Evidence and notion of bias. The information variable $\mathbf{x}$ is at the center of our model. At a first level it measures the amount of information provided on "sensitive" topics (defined implicitly by assumption (A3) through the effect on $C(\mathbf{x})$), so that $\mathbf{x} = \mathbf{0}$ corresponds to what we call minimum accuracy or substantial bias (also full suppression or self-censorship), while at the other end, $\mathbf{x} = \mathbf{1}$ corresponds to maximum accuracy or absence of suppression (no censorship). But more concretely, the variable $\mathbf{x}$ can represent a variety of things. For example, it could represent information that a product or a family of products does direct harm to a consumer (as in the case of tobacco; or also dangerous or "unhealthy" toys, cars, fattening foods or drinks; pharmaceutical products with potentially serious side effects,[5] etc.); it could be information that products are made in a possibly non-desirable way (e.g., with genetically modified organisms, or with toxic materials) or under non-desirable conditions (e.g., that are in violation of basic standards such as the Ethical Trading Initiative, environmental standards, etc.). In each case, repeated exposure to sensitive information may put off some consumers from buying certain products and hence may decrease the total amount of the "generic" advertised good demanded. According to our model, a main reason for suppressing coverage on, say, tobacco and climate change is the presence of large advertisers[6]

Two well-documented examples are the coverage of health hazards of smoking, mentioned above, and of anthropogenic climate change.[7] Both are examples where inadequate reporting has highly nontrivial consequences, individual or global.

[5]There is a sizeable literature appearing in medical journals on how to limit advertisers, particularly pharmaceutical sponsors, from interfering with the medical content of the scientific articles (see e.g. Lexchin and Light, 2006).

[6]Tobacco companies such as *Brown & Williamson* (part of *British American Tobacco*) or *Philip Morris* (previously part of *Altria Group*) as well as for instance car manufacturers such as *General Motors* or *Ford* have consistently been top advertisers in the US at different points in time (e.g., Baker, 1994, and Advertising Age, 2007).

[7]E.g., while Oreskes (2004) finds that *none* of the 928 scientific papers published between 1993-2003 disagree with the "scientific consensus position" that "most of the observed global warming over the last 50 years is due to the greenhouse gas concentration," Boykoff and Boykoff (2004) find that *over half* of a random sample of articles published between 1988-2002 in the *New York Times, Washington Post, Los Angeles Times, Wall Street Journal*, give equal attention to the scientific consensus position and to the industry-supported view that "natural fluctuations suffice to explain global warming."

A further interpretation of the variable $\mathbf{x}$ – probably more pertinent to TV outlets – is the amount of "critical" programming in the sense of the inverse of "dumbed down" content. The latter appears to improve the effectiveness of advertising on the reception and eventual consumption of advertised products. Barnouw (1978), Baker (1994, 2007), Bagdikian (2004), McChesney (2004), and Hamilton (2004) among others present evidence suggesting an increase in "dumbed down" content in the US over the last decades; which in view of the increased concentration of the media is not inconsistent with our model. Clearly, a rigorous and empirical analysis of the relationship still needs to be carried out.[8]

Related literature. Particularly relevant is Ellman and Germano (2009), who study the effect of advertiser influence on media content by explicitly modeling advertisers and consumers, besides the usual media outlets. Instead, the present paper simplifies the analysis, focuses on media outlets as the main players and introduces transportation costs in order to quantify the effect of different ownership structures on media content variables. In particular, it should be emphasized that the present paper underestimates the effect of (large) advertisers on media content as it does not model direct threats by advertisers to withdraw their ads from individual media outlets. This is an important additional channel in Ellman and Germano (2009) that can be effective even when competition between outlets is strong. We refer to that paper for further discussion also of related literature.

Also closely related is Armstrong and Weeds (2007) who use a Hotelling model (for the case $n = 2$) and a Salop model (when $n \geq 2$) to evaluate the role of public broadcasting and pay TV on the quality of programming (see also e.g., Anderson and Coate, 2005, and Peitz and Valletti, 2008). Their focus with advertising concerns the quality of programming and the disutility from having to watch ads. To their analysis our paper adds that

[8]Another related aspect concerns the amount of educational, social, or "public interest" content of commercial media. For example, Putnam (2000) attributes a substantial part of the civil disengagement he documents in the United States to TV and other electronic media, and goes on to state that "[n]o sector of American Society will have more influence on the future state of our social capital than the electronic mass media[..]" (p. 410). Testing the commercial media's performance in this respect seems worthwhile. Prat and Strömberg (2005) and Gentzkow and Shapiro (2008b) have some partial results on this.

advertising may not only affect viewers through the disutility of watching ads but also through the interference of advertisers with content. As is clear from our examples, this may lead to substantial externalities and welfare effects that should be taken into account when computing the “efficient” amount of advertising.

Besley and Prat (2006) and Petrova (2008) model political influence in the media through models of bribes or lobbying and obtain that competition in the media sector can be effective in reducing the influence on media content. By contrast, in the targeting models of George and Waldfogel (2003) or Strömberg (2004), but also in the model of Mullanaithan and Shleifer (2005), competition in the media need not always help to reduce biased content as the bias here is ultimately driven by consumer preferences. For the purpose of this paper we ignore these types of biases and focus instead on aspects of advertiser driven (or commercial) media bias.

Gentzkow and Shapiro (2006) study political slant in newspapers and, while they find slant at the individual newspaper level, they do not find significant evidence that newspaper ownership really matters in explaining the individual papers’ biases. Our analysis suggests that it might be worth carrying out a similar type of test with respect to commercial bias of given media firms’ different outlets. Reuter and Zitzewitz (2006) provides empirical evidence of bias favoring advertisers in certain financial publications. Wilbur (2008) uses a two-sided market framework to show that TV network program choices are influenced more by advertiser preferences than by viewer preferences.

The paper is organized as follows. Section 2 sets out the basic model used throughout the paper. Sections 3 studies environments with only commercial outlets in some detail and Section 4 introduces non-commercial outlets and also studies mixed environments with both commercial and non-commercial outlets. Section 5 studies free entry and Section 6 concludes. Most proofs and derivations are contained in an appendix.

2 The basic framework

We work with the spokes model of Chen and Riordan (2007) that allows for an arbitrary number of media outlets to compete for audience in a non-localized fashion. The model we develop shares important features with a number of other papers in the media literature that have worked with the Hotelling model (when $n = 2$) or the Salop model (when $n \geq 2$), see for example, Anderson and Coate (2005), Armstrong and Weeds (2007), Peitz and Valletti (2008), and Weeds (2009).

There are n (≥ 2) commercial media outlets located at the endpoints (one for each outlet) of a spokes network that has $N \geq n$ potential locations. Any two endpoints have distance 1 from each other (and each endpoint therefore has distance $\frac{1}{2}$ to the center of the network). Commercial media outlets are assumed to maximize profits which are derived from advertising and payments from the audience minus the costs of producing the programming.

There is a mass one of consumers uniformly distributed along the N spokes of the network. Transportation (or switching) costs are the same for all consumers in the sense that there is a constant cost $t > 0$ to "travel" a unit distance (or to "switch" to another outlet).[9] As in Chen and Riordan (2007), consumers have a preference for only two of the N potential outlets, namely, the outlet corresponding to the spoke the consumer is located on and another one chosen at random with uniform probability from all the remaining $N-1$ potential outlets. This guarantees continuity and significantly simplifies the analysis. When $N > n$ this means that there are some consumers who are interested in consuming exactly two, one or zero of the n actual outlets.[10]

There are N potential outlets and n actual ones. Each consumer has a preference for (at most) two potential outlets so that if $N > n$ some consumers may have a preference for one or zero actual outlets.Consumers are

[9]Transportation costs are between 0 and t depending on the location of the consumer. A consumer located at the endpoint of a spoke incurs a transportation cost of 0 for consuming the outlet located at the same endpoint and incurs a cost of t for consuming his second most preferred outlet instead. By contrast a consumer located at the center of the network is indifferent between his two most preferred outlets and incurs the same cost $\frac{t}{2}$ for consuming either one.

[10]In Germano and Meier (2008), we study the particular case where $N = n$, so the market is "covered" and each consumer has a preference for exactly two actual outlets.

therefore indifferent or close to indifferent between the two brands, both of which are available on the market. Any two firms compete for such consumers that are approximately indifferent between their products, while at the same time competing with other firms for other consumers. Notice that this simultaneous competition on several fronts is what distinguishes this spokes model with Salop's (1979) model, where a given firm competes essentially with its two neighbors.

There is an exogenous degree of horizontal product differentiation between the media outlets. Shares are determined by the equation

$$s_i = \frac{n-1}{N(N-1)} + \frac{1}{N(N-1)} \sum_{j \neq i} s_{ij} + \frac{2(N-n)}{N(N-1)}\,,$$

where s_{ij} is the share of viewers on j's spoke that i appropriates from j,

$$s_{ij} = \begin{cases} -1 & \text{if } u_i - u_j < -t \\ \frac{u_i - u_j}{t} & \text{if } \mid u_i - u_j \mid \leq t \\ 1 & \text{if } u_i - u_j > t \end{cases}\,,$$

where $t > 0$ is a transportation cost, and where outlet i's utility is given by

$$u_i = v + \alpha x_i + \beta y_i - p_i\,.$$

and where $v \gg \alpha + \beta$ is the exogenous valuation of consuming the media; $\alpha, \beta \geq 0$ are parameters; $x_i, y_i \in [0,1]$, where x_i is the level of information reported on sensitive topics; y_i is an endogenous measure of quality, separated from the x_i's; $p_i \geq 0$ is the price charged by i. Define $\bar{u} = \frac{1}{n} \sum_i u_i$. Assuming $\mid u_i - u_j \mid \leq t$, which we assume throughout unless otherwise stated, the share equation reduces to

$$\begin{aligned} s_i &= \frac{n-1}{N(N-1)} + \frac{1}{N(N-1)t} \sum_{j \neq i} (u_i - u_j) + \frac{2(N-n)}{N(N-1)} \\ &= \frac{A_n}{n} + \frac{n(u_i - \bar{u})}{N(N-1)t}\,, \end{aligned}$$

where, given our assumption on the exogenous values $v >> 0$, we can define total audience reached by the n actual outlets in a market with N potential outlets as

$$A_n = n \left(\frac{n-1}{N(N-1)} + \frac{2(N-n)}{N(N-1)} \right) = \frac{n(2N-n-1)}{N(N-1)}\,, \tag{1}$$

Aggregate demand for the advertisers' products is given by

$$C(\mathbf{x}) = C_0 \cdot e^{-\psi \sum_{i=1}^{n} s_i x_i} \tag{2}$$

where $\mathbf{x} = (x_1, \ldots, x_n)$ is the vector of information on sensitive topics reported, (recall that x_i represents outlet i's level), and $\psi \in [0, 1]$ is a constant representing the marginal effect on final consumption of the information available to the audience.

Implicitly Eq. (2) assumes that there is a generic information variable that depresses consumption of advertised products at a decreasing rate. The functional form is chosen mainly for analytic tractability. (In Germano and Meier, 2008, we work with a linear version, and obtain qualitatively comparable results with respect to our main results). As discussed in the introduction, we interpret $\mathbf{x}$ as representing a variety of different things; but strictly speaking we take Eq. (2) as the defining characteristic of the variable $\mathbf{x}$; a reader that believes that such a generic variable cannot seriously affect aggregate branded consumption will tend to believe in a low value of ψ. We also sometimes speak of "substantial bias" or "self-censorship" when the value of x_i is set to zero. As mentioned in the introduction, the topics or issues that are subject to such bias or censorship can easily shift over time.

3 Commercial media

We assume commercial media maximize profits, which consist of revenues from advertising and from fees paid by the audience minus the costs of producing the programming. Specifically, a given commercial media outlet i maximizes profits given by,

$$\pi_i = s_i \eta C + s_i p_i - \frac{\delta}{2} y_i^2,$$

where, since we assume a mass one of consumers, C is at the same time total and per capita consumption of the advertised products; p_i is the revenue from all consumers as well as the price paid by an individual consumer to access outlet i; y_i is the level of quality of the programming that is accessed equally by all consumers who have access to the outlet; $0 < \eta < 1$, $\delta > \frac{\eta C_0}{n}$ are fixed parameters, where the assumption on δ ensures that $y_i \in [0, 1]$. The first and second expressions represent revenues from advertising and from the audience respectively. As discussed in the introduction, we assume that advertising revenues are a fixed share of total sales of the advertised products weighted by the audience share of the outlet. The third expression represents the costs of producing quality of programming. This can be viewed as a fixed cost to produce a programming of quality y_i; for simplicity we also assume that providing information x_i is costless.

From the cost and utility functions described above, we can compute the socially efficient levels of x_i^* and y_i^* that a media outlet should supply, namely, $x_i^* = 1$ and $y_i^* = \frac{\beta}{\delta} s_i$, which, in the symmetric benchmarks we consider below, become

$$x^* = 1 \quad \text{and} \quad y^* = \frac{\beta}{\delta} \frac{A_n}{n} = \frac{\beta}{\delta} \frac{2N - n - 1}{N(N-1)} \,. \tag{3}$$

As we will see in the following sections, too few media outlets can lead to substantial deviations from the socially efficient level of the information variable (x^*), whereas the quality variable (y^*) is relatively less affected by this.

3.1 Advertising funded media

We first consider purely advertising funded media where by assumption prices are zero ($p_i = 0$). By inspection of the marginal profits with respect to x_i

$$\frac{\partial \pi_i}{\partial x_i} = \left(\frac{\alpha(n-1)}{N(N-1)t} - \frac{\psi A_n^2}{n^2} \right) \eta C_0 e^{-\psi A_n x}$$

we see that profits are increasing whenever $\frac{\alpha(n-1)}{N(N-1)t} > \frac{\psi A_n^2}{n^2}$ and decreasing whenever $\frac{\alpha(n-1)}{N(N-1)t} \leq \frac{\psi A_n^2}{n^2}$, so that, when the first inequality holds, it is best to set the maximum level of accuracy ($x = 1$), while it is best to set the minimum level ($x = 0$) whenever the second inequality holds. In other words, solving

$$\frac{\alpha(n-1)}{N(N-1)t} = \frac{\psi A_n^2}{n^2}$$

with respect to n and using Eq. (1) defining A_n, gives the critical number of media outlets

$$\bar{n} = 2N - 1 + \frac{\alpha N(N-1)}{2\psi t} - \frac{\sqrt{\alpha N(N-1)^2(\alpha N + 8\psi t)}}{2\psi t}, \tag{4}$$

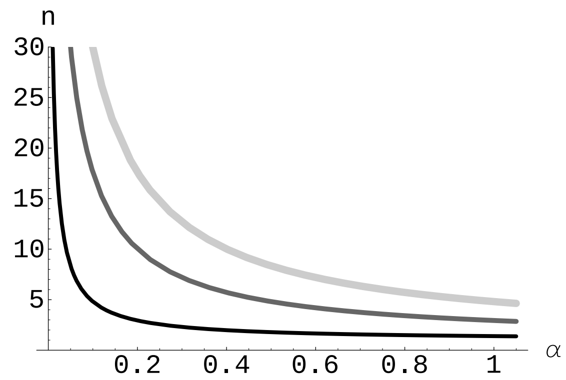

Figure 1: Plots of the cut-off number of outlets $\bar{n}$ needed to guarantee full accuracy ($x = 1$) as a function of preference parameter α for transportation costs $t = 1$ (black), $t = 5$ (dark grey) and $t = 10$ (light grey) and $[N = 100, \psi = .1]$; the areas above the $\bar{n}$–curves are at the same time the combinations of (α, n) that avoid censorship ($x = 0$), (for $t = 1, 5, 10$).

at which the optimal strategy switches from minimum to maximum accuracy.[11] It can further be shown that for $n < \bar{n}$ we have that $x = 0$ is the unique symmetric equilibrium; while for $n > \bar{n}$ we have $x = 1$. This leads to the first main result.

Proposition 1 *In a market with N potential media outlets and $n < N$ actual purely advertising funded outlets there is a unique symmetric equilibrium with minimum accuracy ($x = 0$) whenever $n \leq \bar{n}$, and with maximum accuracy ($x = 1$) whenever $n > \bar{n}$, where $\bar{n}$ is given in Eq. (4) above.*

This shows that media markets that are too heavily concentrated or that have too few outlets ($n \leq \bar{n}$) have substantial bias ($x = 0$). A larger number of outlets provides an incentive to report more accurately for two main reasons: a competition effect and an externality effect. The competition effect derives from the marginal effect of increasing accuracy on a firm's own

[11] The discontinuity of the equilibrium accuracy ($\mathbf{x}$) at $\bar{n}$ (see Figure 2) is due to the exponential form of the function $C(\mathbf{x})$. This eliminates the variable $\mathbf{x}$ from the FOC so that the optimal values are determined by the bounds 0 and 1. Using other functional forms typically gives a region where $\mathbf{x}$ is increasing, but most of the time it is also determined by the bounds 0 and 1 (see e.g., Germano and Meier, 2008, for the linear case). Notice that marginal benefits from reporting a positive $\mathbf{x}$ at $\mathbf{x} = 0$ are always bounded which is why equilibrium accuracy is zero for low values of n.

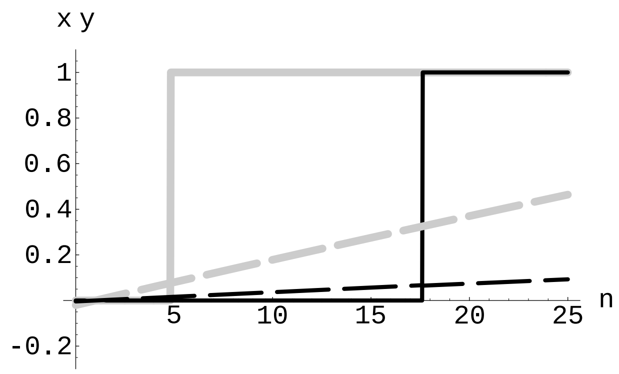

Figure 2: Plots of accuracy (x, solid) and quality (y, dashed) as functions of the number of outlets n for $t = 1$ (grey) and $t = 5$ (black) and $[N = 100, \beta = 1, \psi = .1]$; higher transportation costs (t) reduce accuracy and quality.

share, $(\frac{\partial s_i}{\partial x_i})$, which increases with the number of outlets; the externality effect derives from the marginal effect of increasing accuracy on total advertising revenues, $(\eta \frac{\partial C}{\partial x_i})$, which decreases as the number of outlets increases. Lower transportation costs (t) and a low marginal effect of sensitive information on consumption (ψ) tend to relax the constraint on the number of outlets needed to avoid substantial bias (see Figure 1), while a lower preference parameter on sensitive issues (α), which might in turn be induced by low "awareness" of these issues, tightens the constraint.

The first order condition for the optimal quality gives,

$$\frac{\partial \pi_i}{\partial y_i} = \eta \left(\frac{\beta(n-1)}{N(N-1)t} C_0 e^{-\psi A_n x} \right) - \delta y = 0,$$

which implies

$$y = \frac{\eta \beta(n-1)}{\delta N(N-1)t} C_0 e^{-\psi A_n x} .$$

We can state the following.

Proposition 2 *Under the conditions of Proposition 1, the optimal quality levels are given by*

$$y = \frac{\beta(n-1)}{\delta N(N-1)t} \eta C_0 \text{ if } n \leq \bar{n} \quad \text{and} \quad y = \frac{\beta(n-1)}{\delta N(N-1)t} \eta C_0 e^{-\psi A_n} \text{ if } n > \bar{n},$$

where A_n is defined in Eq. (1).

In particular, in both cases, the level of quality (y) is increasing in the number of actual media outlets (n) and in the preference parameter for quality (β), and is decreasing in the transportation costs (t). Comparing these quality levels with the socially efficient one given in Eq. (3) it is easy to see that also here too few media outlets may lead to an inefficiently low level of quality. Clearly, the advertising revenues (ηC) play a key positive role here, so that unlike with the accuracy variable (x), the number of outlets are relatively less important here. This will play a role when comparing commercial and non-commercial media.

3.2 Audience funded media

Next consider media outlets funded exclusively by the audience who pay a fee p_i for accessing media outlet i and assume (for now) $\eta = 0$. From the symmetric FOC's we immediately get $x = 1$ and, for the quality and price, we get

$$\frac{\partial \pi}{\partial y_i} = p\frac{\beta(n-1)}{N(N-1)t} - \delta y = 0\,, \quad \frac{\partial \pi}{\partial p_i} = \frac{A_n}{n} - p\frac{n-1}{N(N-1)t} = 0,$$

with A_n defined in Eq. (1), which gives

$$p = \frac{(2N-n-1)t}{n-1} \quad \text{and} \quad y = \frac{\beta}{\delta}\frac{(2N-n-1)}{N(N-1)}$$

as the equilibrium price and quality.

Proposition 3 *In a market with N potential media outlets and $2 \leq n < N$ actual purely audience funded media outlets, there is a unique symmetric equilibrium where maximum accuracy ($x = 1$) and the socially efficient level of quality ($y = y^*$) are supplied at positive prices.*

Essentially, the costs incurred by the outlets for providing quality do not depend on the audience size whereas revenues do; both accuracy and quality provided will coincide with the socially efficient levels obtained in Eq. (3) above. Armstrong and Weeds (2007) get a similar result for the standard Hotelling model.

3.3 Audience and advertising funded media

Before considering multiple ownership, we briefly consider the general case where outlets can obtain revenues from both advertising and directly from the audience. Solving for equilibria where all media outlets choose simultaneously accuracy on the sensitive topic x_i, quality y_i, and prices charged p_i, we obtain from the FOC's, after imposing symmetry,

$$p = \left[\frac{(2N-n-1)t}{n-1} - \eta C_0 e^{-\psi A_n x}\right]^+ \quad \text{and} \quad y = \frac{\beta(n-1)}{\delta N(N-1)t}\eta C_0 e^{-\psi A_n x}.$$

From here we see that whenever transportation costs are not too large, $t \leq \frac{n-1}{2N-n-1}\eta C_0 e^{-\psi A_n}$, prices are automatically set to zero, in which case the equilibria reduce to the ones studied in Section 3.1.

Proposition 4 *If transportation costs are not excessively large, namely,* $t \leq \frac{n-1}{2N-n-1}\eta C_0 e^{-\psi A_n}$*, then the media outlets will choose not to charge their audience* ($p = 0$) *and so will be exclusively advertising funded. The equilibrium levels of bias and quality will coincide with the ones of Propositions 1 and 2.*

We interpret this as saying that unless there are very large transportation costs (as can occur e.g., with a live event such as a soccer or football match) or very small contributions from advertising (e.g., when η or C_0 are very small) media outlets refrain from charging their audiences (in fact, when $t < \frac{n-1}{2N-n-1}\eta C_0 e^{-\psi A_n}$ outlets might even be willing to pay the audiences for consuming their outlet). We take the zero price case as the more relevant one for the purposes of this paper and do not pursue the case of positive (nor negative) audience fees. At the same time, we implicitly take the view that audience funded outlets, while socially efficient will be cast aside (by commercial outlets) whenever sizable advertising revenues are available.

3.4 Multiple ownership

In practice many media conglomerates own more than one media outlet in the same market.[12] We therefore turn to the important case where media

[12]For example, in 2008 *Clear Channel* owned over 1200 radio stations in the US; in many areas multiple *Clear Channel* stations were in competition with each other (see Columbia Journalism Review, 2008).

firms can own multiple subsidiary outlets. Let n now denote the total number of owners, and suppose for simplicity that each owner owns the same number $\kappa \geq 1$ of actual media outlets. The owner's profits are then

$$\pi_i = \sum_{\kappa_i^{'}=1}^{\kappa_i} \left(s_{\kappa_i^{'}} \eta C - \frac{\delta}{2} y_{\kappa_i^{'}}^2 \right) \,,$$

where total consumption is $C = C_0 \cdot e^{-\psi \sum_{i=1}^{n} \sum_{\kappa_i^{'}=1}^{\kappa_i} s_{\kappa_i^{'}} x_{\kappa_i^{'}}}$. Defining total audience reached as

$$A_{\kappa n} = \frac{(2N - \kappa n - 1)\kappa n}{N(N-1)} \,,$$

we can compute firm i's marginal profits with respect to $x_{\kappa_i^{''}}$ as

$$\frac{\partial \pi}{\partial x_{\kappa_i^{''}}} = \left(\frac{\alpha \kappa (n-1)}{N(N-1)t} - \frac{\psi A_{\kappa n}^2}{\kappa n^2} \right) \eta C_0 e^{-\psi A_{\kappa n} x} \,.$$

Again, these are either positive or negative depending on whether the number of separately owned firms n is smaller or greater than the critical value $\bar{n}(\kappa)$ given by

$$\begin{aligned} \bar{n}(\kappa) &= \frac{2N-1}{\kappa} + \frac{\alpha N(N-1)}{2\psi \kappa^2 t} \\ &\quad - \frac{\sqrt{(\alpha N(N-1))^2 + 4\alpha \psi \kappa t N(N-1)(2N-\kappa-1)}}{2\psi \kappa^2 t} \end{aligned} \tag{5}$$

While the function $\bar{n}(\kappa)$ is a decreasing function of κ, it is strictly increasing when multiplied by κ, indicating that what matters in terms of avoiding substantial bias is not just the number of total media outlets but also the number of separately owned media firms.[13] Figure 3 plots $\bar{n}(\kappa)$ together with the maximum number of owners possible $\frac{N}{k}$. The intersection point gives simultaneously the minimum number of separate owners $\bar{n}_{min}$ $(= \frac{N}{\bar{\kappa}_{max}})$ necessary to avoid the substantial bias as well as the maximum number of

[13] It is worth noting here that in the "covered" version of Chen and Riordan (2007), where $\kappa n = N$ and where increasing the number of outlets directly increases the total number of spokes, the function $\bar{n}(\kappa)$ actually *increases* with κ. This means that adding additional outlets actually *increases* the chances of having substatial bias. See Germano and Meier (2008) for the details.

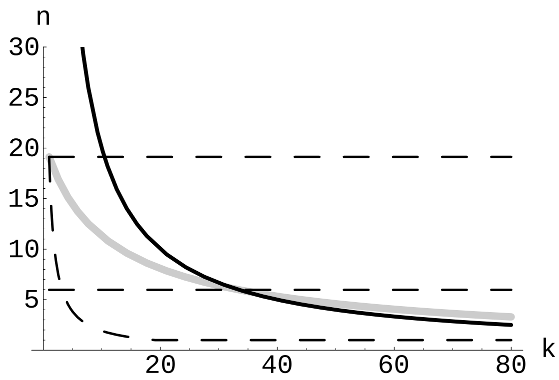

Figure 3: Plot of $\bar{n}(\kappa)$ (grey), $\frac{N}{\kappa}$ (black) and $\frac{\bar{n}(1)}{\kappa}$ (dashed) as a function of the number of subsidiary outlets owned κ for $[t = 5,\ N = 200, \alpha = \psi = .1]$ as well as $\bar{n}(1) \approx 20$ and $\bar{n}_{min} \approx 6$ (both dashed); the area above $\bar{n}(\kappa)$ (grey) and below $\frac{N}{\kappa}$ (black) are all the feasible combinations that avoid censorship ($x = 0$); they intersect at $(\bar{\kappa}_{max}, \bar{n}_{min}) \approx (33, 6)$.

media outlets $\bar{\kappa}_{max}$ that can be owned, analytically,

$$\bar{n}_{min} = 1 + \frac{\psi t}{\alpha}\frac{N-1}{N} \qquad \text{and} \qquad \bar{\kappa}_{max} = \frac{\alpha N^2}{\alpha N + \psi(N-1)t}\,. \tag{6}$$

Depending on the values of the parameters α, ψ and t, the number $\bar{\kappa}_{max}$ can be substantially below N, which is the maximum number of outlets a media firm can own while avoiding the censorship problem, if what mattered were only the total number of outlets; similarly $\bar{n}_{min}$ is substantially above 1. Let $\bar{n} = \bar{n}(1)$, then we can state our second main result.

Proposition 5 *In a market with N potential media outlets, $n \geq 2$ media firms, each of which owns the same number $\kappa \geq 1$ of purely advertising funded media outlets, and where $\kappa n < N$, there is a unique symmetric equilibrium with minimum accuracy ($x = 0$) whenever $n \leq \bar{n}(\kappa)$ and with maximum accuracy ($x = 1$) whenever $n > \bar{n}(\kappa)$, where $\bar{n}(\kappa)$ is given in Eq. (5) and satisfies $\bar{n}(\kappa) \geq \frac{\bar{n}(1)}{\kappa}$ with strict inequality whenever $\kappa > 1$.*

Moreover, a minimum of $\bar{n}_{min} > 1$ separate media owners (with $\bar{\kappa}_{max}$ outlets each) are necessary to avoid minimum accuracy, where $\bar{n}_{min}$ (and $\bar{\kappa}_{max}$) are defined in Eq. (6).

This is the multiple ownership version of Proposition 1. It states that allowing media firms to own multiple media outlets can help but does not necessarily avoid the problem of substantial bias. This is best seen in Figure 3, where the grey curve ($\bar{n}(\kappa)$) plots the number of owners necessary to avoid it.

The result also shows that the cut-off $\bar{n}(\kappa)$ is to an important extent about the number of owners rather than the number of media outlets. To see the extent, see again Figure 3, and compare the grey curve representing $\bar{n}(\kappa)$ with the dashed curve representing $\frac{N}{\kappa}$ which is the benchmark where what matters is the total number of actual media outlets. The discrepancy becomes larger for smaller values of α or larger values of t. The intuition for the difference is essentially due to the fact that, media firms with multiple outlets have additional monopoly power as they have more "captured" viewers,[14] and the effect of raising accuracy on their overall market share is also lower.

From the FOC's, using symmetry, we compute,

$$\begin{aligned}\frac{\partial \pi}{\partial y_{\kappa_i''}} &= \frac{\beta\kappa(n-1)}{N(N-1)t}\left(\eta C_0 e^{-\psi A_{\kappa n} x} + p\right) - \delta y_{\kappa_i''}\\ \frac{\partial \pi}{\partial p_{\kappa_i''}} &= \frac{A_{\kappa n}}{\kappa n} - \frac{\kappa(n-1)}{N(N-1)t}\eta C_0 e^{-\psi A_{\kappa n} x} - \frac{\kappa(n-1)}{N(N-1)t}p\,,\end{aligned}$$

which leads to the equilibrium prices and quality levels,

$$p = \left[\frac{(2N-\kappa n-1)t}{\kappa(n-1)} - \eta C_0 e^{-\psi A_{\kappa n} x}\right]^+ = 0\,, \quad y = \frac{\beta\kappa(n-1)}{\delta N(N-1)t}\eta C_0 e^{-\psi A_{\kappa n} x}\,.$$

Again, increasing the number of owners (n) or of subsidiary outlets per owner (κ) increases the quality (y) and decreases the price (p) chosen in equilibrium.

Proposition 6 *In a market with $n \geq 2$ media firms, each of which owns $\kappa \geq 1$ purely advertising funded media outlets, the level of quality is relatively lower and prices are relatively higher than if there were κn separate firms.*

As to be expected, due to the increasing monopoly power, if there are n firms with $\kappa > 1$ outlets rather than κn separate firms, then the level of quality

[14] Notice that with n owners each of which owns κ media outlets, the share of consumers that are "trapped" between two firms of a single owner is $\frac{\kappa-1}{N-1}$, which goes from 0 to $\frac{N-n}{N-1}\frac{1}{n}$ as κ goes from 1 up to $\frac{N}{n}$.

(y) becomes relatively lower, and, in the cases where prices are positive, they are relatively higher. In the remainder of the paper, to simplify, we treat the case $\kappa = 1$.

4 Adding a non-commercial sector

In order to capture the role of media outlets such as non-profit radio stations, TV stations, newspapers, and also increasingly important internet websites and weblogs, some of which are in direct competition with other mainstream outlets, we next consider a second type of media outlet, which we refer to as non-commercial.[15] Before studying the case of mixed markets with commercial and non-commercial media outlets, we first briefly consider the case with only non-commercial outlets.

4.1 Non-commercial media

We assume non-commercial media maximize the utility provided to their audience, u_i, and operate under a given budget $B_i \geq 0$. While we do not intend to model public broadcasting in this paper (see e.g., Armstrong, 2005, and Armstrong and Weeds, 2005, 2007, on this), we do not exclude that this type of modeling may in fact capture the behavior of some public media outlets.[16]

The optimization problem of a non-commercial outlet is

$$\max_{x_i, y_i, p_i} u_i \qquad \text{subject to} \qquad \frac{\delta}{2} y_i^2 \leq B_i + s_i p_i,$$

where $B_i \geq 0$ is the outlet's budget. The solution to this is given by

$$x_i = 1, y_i = \sqrt{\frac{2(B_i + s_i p_i)}{\delta}}, p_i = \left[\frac{\beta^2 s_i}{2\delta} - \frac{B_i}{s_i}\right]^+,$$

[15] See e.g., Curran (2000), Hallin and Mancini (2004), Baker (2007) and Kops (2007) for discussions of different types of media sectors and outlets and how they affect the overall media system. What we model here is closest to what some of these authors call non-profit media (or even public media as opposed to state media).

[16] Since market shares are determined as $s_i = \frac{A_m}{m} + \frac{1}{N(N-1)t} \sum_{j \neq i}(u_i - u_j)$ where A_m is defined just as in Eq. (1), they can be written as $s_i = \phi_0 + \phi_1 u_i$, for $\phi_0, \phi_1 > 0$ constant as far as i's optimization problem is concerned, and taking the level of utility of the other outlets as given, we see that maximizing u_i is equivalent to maximizing its market share s_i.

where the optimal fee charged is computed from the corresponding FOC,

$$\frac{\partial u_i}{\partial p_i} = \frac{\beta s_i}{2\delta} \frac{1}{\sqrt{\frac{2(B_i+s_i p_i)}{\delta}}} - 1 = 0.$$

In particular, assuming a situation where media outlets are all symmetric and non-commercial, we get

$$x = 1, y = \sqrt{\frac{2(B+sp)}{\delta}}, p = \left[\frac{\beta^2 s}{2\delta} - \frac{B}{s}\right]^+,$$

where here $s = \frac{A_m}{m} = \frac{2N-m-1}{N(N-1)}$. We summarize this as follows.

Proposition 7 *In a market with* N *potential media outlets and* $m < N$ *symmetric purely non-commercial media outlets (with no commercial outlets) there is a unique symmetric equilibrium with maximum accuracy (*$x = 1$*) for any* $m \geq 1$*. The allocated budget and audience revenue (when these are positive) are spent entirely on providing quality,* $y = \sqrt{\frac{2(B+sp)}{\delta}}$*, and prices are given by* $p = \left[\frac{\beta^2 s}{2\delta} - \frac{B}{s}\right]^+$*.*

When prices are zero, the quality level is independent of the number (and strategies) of the other non-commercial outlets and a budget of $B = \frac{\delta}{2} y^{*2}$ is required to achieve the socially efficient quality level (y^*), whereas, if prices are positive, we can write the equilibrium quality level as

$$y = \sqrt{\frac{B}{\delta} + \frac{1}{2}\left(\frac{\beta(2N-m-1)}{\delta N(N-1)}\right)^2}.$$

Attempting to achieve the socially efficient quality level in this case would require a budget of $B = \frac{\delta^2}{2} y^{*2}$ which is inconsistent with positive prices.

4.2 Mixed media markets

Most media markets have commercial and non-commercial media outlets operating simultaneously. We next derive equilibria where the commercial and non-commercial outlets just studied act symmetrically relative to their type. We also characterize actual equilibrium shares of commercial vs. non-commercial media. For simplicity, we do not allow media firms to own more than one outlet.

There are N potential outlets of which $n \geq 2$ are commercial and $m \geq 0$ are non-commercial and where $n + m < N$ such that there are $N - n - m > 0$ potential firms that are not present in the market. Commercial outlets are indexed by $i = 1, \ldots, n$, as before, non-commercial ones are indexed by $i = n+1, \ldots, n+m$, and potential ones not present in the market by $i = n+m+1, \ldots, N$. We maintain the assumption $|\, u_i - u_j \,| \leq t$, for all $i, j = 1, \ldots, N - n - m$,[17] so that, letting A_{n+m} denote the total share of the commercial and non-commercial outlets' audience, we can write

$$A_{n+m} = \frac{2N - n - m - 1}{N(N-1)}(n+m)\,. \tag{7}$$

Let $\sigma = \sum_{i=1}^{n} s_i \in [0, A_{n+m}]$ be the actual share of consumers that access commercial media outlets from among all consumers, so that $A_{n+m} - \sigma$ is the share that access non-commercial ones.

The assumption that viewers have a preference for only two outlets directly implies that $0 \leq \frac{(N-m)(N-m-1)}{N(N-1)} \leq \sigma \leq 1 - \frac{(N-n)((N-n-1)}{N(N-1)} \leq 1$.

From Section 4, assuming budgets are not too small or that there are sufficiently many non-commercial outlets, we have $p_{NC} = 0$. The optimal strategy of the non-commercial media is

$$x_{NC} = 1, y_{NC} = \sqrt{\frac{2B}{\delta}}, p_{NC} = 0,$$

and we can write the profit of the commercial media, for as

$$\pi_i = s_i \eta C + s_i p_i - \frac{\delta}{2} y_i^2, \text{ for } i = 1, \ldots, n,$$

where, since $x_{NC} = 1$, we have, $C = C_0 \cdot e^{-\psi\left(\sum_{j=1}^{n} s_j x_j + \sum_{j=n+1}^{n+m} s_j\right)}$. Recall that, for $i = 1, \ldots, n$,

$$\begin{aligned} s_i &= \frac{n+m-1}{N(N-1)} + \frac{1}{N(N-1)t}\sum_{j \neq i}(u_i - u_j) + \frac{2(N-n-m)}{N(N-1)} \\ &= \frac{A_{n+m}}{n+m} + \frac{n(u_i - \bar{u}_C)}{N(N-1)t} + \frac{m(u_i - \bar{u}_{NC})}{N(N-1)t}\,. \end{aligned}$$

[17] This assumption implies that all media outlets have similar budgets for their exogenous positioning.

Computing marginal profits, assuming type-symmetry, and taking into account that σ depends on the shares of all firms (and cannot therefore be treated as a constant), gives from the FOC's, solving for x_C,

$$x_C = 1 + \frac{(n+m-1)n}{\sigma\psi m} - \frac{\sigma t N(N-1)}{\alpha n m}. \tag{8}$$

Further solving for (y_C, p_C),

$$\begin{aligned} p_C &= \left[\frac{\sigma N(N-1)t}{n(n+m-1)} - \left(1 + \frac{\sigma\psi m(1-x)}{n(n+m-1)}\right)\eta C_0 e^{-\psi(A_{nm}-\sigma(1-x))}\right]^+ = 0 \\ y_C &= \frac{\beta}{\delta N(N-1)t}\left(n+m-1+\frac{\sigma\psi m(1-x)}{n}\right)\eta C_0 e^{-\psi(A_{nm}-\sigma(1-x))}, \end{aligned}$$

where it can be checked that again both SOC's are satisfied.

Fixed and symmetric shares. To get a first idea of the effect of adding non-commercial outlets to a given set of existing commercial outlets assume for simplicity that the share σ is proportional to the number of commercial outlets, $\sigma = \frac{nA_{n+m}}{n+m}$, for given m. Implicitly this assumes that each non-commercial outlet has a sufficiently large budget to exogenously position itself so as to potentially attract the same number of consumers as a commercial outlet. Then it is easy to see that Eq. (8) above reduces to

$$x_C = 1 + \frac{(n+m-1)N(N-1)}{\psi m(2N-n-m-1)} - \frac{(2N-n-m-1)t}{\alpha m},$$

which is increasing in n. Solving for the cut-off at which x_C equals 1 gives

$$\bar{n}_m = 2N - m - 1 + \frac{\alpha N(N-1)}{2\psi t} - \frac{\sqrt{\alpha N(N-1)^2(\alpha N + 8\psi t)}}{2\psi t}, \tag{9}$$

which is equal to $\bar{n} - m$, where $\bar{n}$ is the cut-off obtained in Eq. (4) with only commercial outlets. This suggests that there is a one-to-one trade off between commercial outlets and non-commercial outlets in terms of achieving the cut-off number of outlets $\bar{n}_m$ that avoid substantial bias.[18] Therefore,

[18]Solving for the cut-off where $x_C = 0$ gives a number smaller but close to $\bar{n}_m$. The reason for the one-to-one trade off is due to the fact that of the three channels through which m affects the commercial firms' reporting strategy, namely, through the competitive, the externality effect and through the effect on the share σ, given the assumption of a fixed share σ and since the cut-off is computed for $x_C = 1$, only the competition effect remains which has a one-to-one tradeoff between m and n. This is clear from the FOC's.

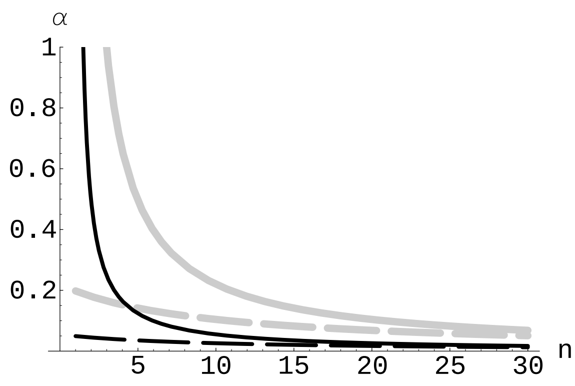

Figure 4: Plot of bounds Λ_0 (black) and Λ_1 (grey) as a function of n for $m = 0$ (solid lines) and for $m = 10$ (dashed lines) with $[t = 5,\ N = 100, \psi = .1]$; the areas above the curves Λ_1 (grey and dashed grey) are combinations with full accuracy ($x = 1$), (for $m = 0$ and 10), whereas the areas below Λ_0 (black and dashed black) cannot avoid censorship ($x = 0$).

the real difference between commercial and non-commercial outlets in terms of reaching the cut-off $\bar{n}_m$ (from a situation where $n < \bar{n}_m$) is that non-commercial outlets always report $x_{NC} = 1$ which over time may lead to a higher α (through higher awareness of sensitive issues amongst the population) and also to a greater chance of achieving the relevant cut-off ($\bar{n}_m$) when adding outlets. Since we do not endogenize the preference parameter α here, we leave a formal analysis for future research.

Endogenous shares. Next we turn to the more general case where the share of the audience captured by commercial media is endogenous. From Eq. (8) and assuming the bounds $\frac{n}{N} \leq \sigma \leq \frac{2n}{N}$, the following expressions

$$\Lambda_0(\psi, t, m, n, N) = \frac{\psi t(N-1)}{2\psi m + (n+m-1)N}$$

and

$$\Lambda_1(\psi, t, m, n, N) = \frac{4\psi t(N-1)}{(n+m-1)N}$$

act respectively as upper and lower bounds for α such that the following three cases can be distinguished (see Figure 4),[19]

[19]Since σ is not (yet) determined and depends in an important way on n, we cannot solve for n directly, but rather for α which we bound using the functions Λ_0 and Λ_1.

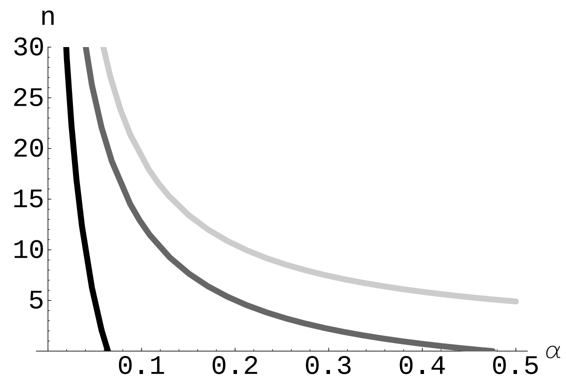

Figure 5: Plot of $\bar{n}_m$ as function of α for $m = 0$ (light grey), $m = 5$ (dark grey) and $m = 20$ (black) and $[N = 100, \beta = 1, \psi = .1]$; the areas above the curves $\bar{n}_m$ are combinations (α, n) with full accuracy $(x = 1)$, (for $m = 0, 5$, and 20).

CASE 1: $x_C = 0$ occurring when $\alpha \leq \Lambda_0(\psi, t, m, n, N)$;
CASE 2: $x_C \in [0, 1]$ occurring when $\Lambda_0(\psi, t, m, n, N) < \alpha < \Lambda_1(\psi, t, m, n, N)$;
CASE 3: $x_C = 1$ occurring when $\alpha \geq \Lambda_1(\psi, t, m, n, N)$.

Depending on the values of the parameters, any of the three cases can occur. But it is clear, already from Eq. (8), that, given α and the other parameters, larger values of n, m tend to increase x_C and also tend to make the conditions for full accuracy (CASE 3 where $x_C = 1$) more likely to be satisfied. Similarly, when solving the model for the equilibrium σ and then for the corresponding cut-off $\bar{n}_m$ one obtains that the more non-commercial media outlets there are, the smaller $\bar{n}_m$ is (see Figure 5); moreover, the trade off between n and m in reaching $\bar{n}_m$ is close to the fixed share case where it is exactly equal to one.

We can summarize as follows.

Proposition 8 *In a market with N potential media outlets of which n are commercial and m are non-commercial, and where $N > n + m$, everything else equal, increasing C_0 or η increases the equilibrium share of commercial media (σ), while increasing B decreases it. Moreover, accuracy and quality of the commercial media (respectively x_C and y_C) tend to increase with higher values of α, m, and n and tend to decrease with ψ, N, and t.*

Overall, the analysis indicates that even with relatively low budgets, non-commercial media can have beneficial effects for both accuracy (x_C) and quality (y_C) within the commercial media. We should stress that our spokes model has an exogenous symmetry in terms of the positioning of the (actual and potential) outlets, giving symmetric (exogenous) audience to commercial and non-commercial outlets (implicitly this is an assumption about the outlets' budgets). While there are clearly very many non-commercial websites that might qualify as a "media outlet", only a small portion have the capacity and visibility to count as an actual "media outlet" in our underlying spokes model. Moreover, clearly, an increase in base consumption (C_0) of advertised products can partially crowd out non-commercial media, while an increase in the budget allocated to non-commercial media (B) can partially crowd out commercial media.

Finally, an aspect that is only partially captured by the present model is the relative advantage of non-commercial media to bring down the cut-off $\bar{n}_m$ through their efficient reporting of the sensitive information variable ($\mathbf{x}_{NC} = 1$). In an expanded model, this can be shown to raise awareness and therefore also interest in accuracy by increasing the preference parameter α and thereby (significantly) reducing $\bar{n}_m$ (see Figure 5). This aspect plays an even more important role when modeling the internet and other low-budget non-commercial media, but is left for future research, as we here take α to be fixed.

5 Free entry

To allow for free entry into the above markets, consider for simplicity the setting of Section 3 with N potential firms and $n < N$ actual firms which are all commercial firms and have one outlet each ($\kappa = 1$) so that there are no non-commercial firms. Assume each outlet requires fixed costs $K > 0$ to operate[20] and solve for the lower bound level of fixed costs $\bar{K}$ that supports fully informative equilibria. In other words solve for the level of fixed costs

[20]Fixed costs are crucial to understanding media market. Here we treat the issue in a very simple way and leave a more detailed discussion, especially within the context of multiple ownership and non-commercial media to future research. Weeds (2009) provides a promising framework to analyze some of the open questions.

$\bar{K}$ such that actual fixed costs need to be below or equal to this lower bound, then there will be full accuracy ($x = 1$).

Recall, that in the case of purely commercial outlets with $n \geq \bar{n}$, we have, $x = 1, y = \frac{\beta(n-1)}{N(N-1)t}\eta C_0 e^{-\psi A}, p = 0$. Therefore, as the lower bound for the fixed costs supporting fully informative equilibria, we get

$$\begin{aligned}\bar{K} &= \frac{A}{\bar{n}}\eta C_0 e^{-\psi A} - \frac{\delta}{2}\left(\frac{\beta(\bar{n}-1)}{\delta N(N-1)t}\eta C_0 e^{-\psi A}\right)^2 \\ &= \frac{\eta C_0 e^{-\psi A}}{N(N-1)}\left(2N - \bar{n} - 1 - \frac{\beta^2(\bar{n}-1)^2}{2\delta t^2}\eta C_0 e^{-\psi A}\right),\end{aligned}$$

where from Eq. (4), $\bar{n} = 2N - 1 + \frac{\alpha N(N-1)}{2\psi t} - \frac{\sqrt{\alpha N(N-1)^2(\alpha N + 8\psi t)}}{2\psi t}$. If actual fixed costs are substantially above the lower bound $\bar{K}$, then, using Proposition 1, fully informative equilibria (with $x = 1$) will not be supported. Clearly, the larger $\bar{n}$ the smaller $\bar{K}$ will have to be, and the less likely the case that a fully informative market structure can be supported will be. In principle, the formulas obtained for $\bar{K}$ give a further tool to empirically check the possibilities for substantial bias in mainstream commercial outlets. They can easily be extended to the cases studied above with multiple ownership and noncommercial outlets.

6 Conclusion

The results have clear implications for the debate on the optimal ownership structure in media markets. This has become particularly important in the US recently where the FCC has tried twice (in 2003 and 2007) to relax ownership rules to allow for media conglomerates to eventually own more outlets. At the same time, the media market in the US is fairly and increasingly concentrated already.[21] Our results show that excessive concentration

[21] According to Bagdikian, 2004, *five* media conglomerates (*Time Warner, Disney, News Corporation, Viacom,* and *Bertelsman*) produce more than half of all of US media consumption; a number that was around *fifty* in the early 1980's, see Bagdikian (1983). Compaine and Gomery (2000) contains several qualifications of such figures; an important question concerns the notion of the "relevant" market; see also Baker (2007). The current crisis appears to be accelerating the trend towards further concentration and consolidation of media ownership.

of ownership can lead to substantial bias in areas sensitive to advertisers, and, moreover, the numbers we obtain as thresholds for the occurrence of substantial bias in equilibrium are potentially alarming. On the other hand, for example, Gentzkow and Shapiro (2008a) conclude their survey on the role of competition in the market for news by saying that "we think it unlikely that the existing level of concentration at the national level [in the US] significantly limits the production of truth." Our analysis potentially challenges such a viewpoint at some level. Clearly, more empirical work is needed to validate the picture sketched by our model; several of the stylized facts and insights derived can in principle be tested by the data. Essentially this involves, identifying a relevant media market, quantifying the relevant information variable and its marginal impact on advertising revenues, and linking these variables also with a measure of concentration of ownership in the media market. The case of the reporting on anthropogenic climate change over the last few decades might be a good place to start.

Appendix

Proofs of Propositions 1–4. Before going into the individual proofs we first derive some general expressions. Compute for $i \neq j$,

$$\frac{\partial s_i}{\partial x_i} = \frac{\alpha(n-1)}{N(N-1)t}, \quad \frac{\partial s_i}{\partial y_i} = \frac{\beta(n-1)}{N(N-1)t}, \quad \frac{\partial s_i}{\partial p_i} = -\frac{n-1}{N(N-1)t},$$

$$\frac{\partial s_j}{\partial x_i} = -\frac{\alpha}{N(N-1)t}, \quad \frac{\partial s_j}{\partial y_i} = -\frac{\beta}{N(N-1)t}, \quad \frac{\partial s_j}{\partial p_i} = \frac{1}{N(N-1)t},$$

$$\begin{aligned}\frac{\partial C}{\partial x_i} &= \left(s_i + \frac{\partial s_i}{\partial x_i}x_i + \sum_{j\neq i}\frac{\partial s_j}{\partial x_i}x_j\right)(-\psi)C_0 e^{-\psi\sum_{i=1}^n s_i x_i} \\ &= \left(s_i + \frac{\alpha(n-1)}{N(N-1)t}x_i - \sum_{j\neq i}\frac{\alpha}{N(N-1)t}x_j\right)(-\psi)C_0 e^{-\psi\sum_{i=1}^n s_i x_i},\end{aligned}$$

and also $\frac{\partial C}{\partial y_i} = \frac{\partial C}{\partial p_i} = 0$. Assuming symmetric equilibrium with $x_i = x, y_i = y, p_i = p$ for all i, we can write,

$$\frac{\partial C}{\partial x_i} = \frac{A_n}{n}(-\psi)C_0 e^{-\psi A_n x} = \frac{2N-n-1}{N(N-1)}(-\psi)C_0 e^{-\psi\frac{2N-n-1}{N(N-1)}nx}.$$

Marginal profits under symmetry are

$$\begin{aligned}
\frac{\partial \pi_i}{\partial x_i} &= \eta \left(\frac{\partial s_i}{\partial x_i} C + s_i \frac{\partial C}{\partial x_i} \right) + p_i \frac{\partial s_i}{\partial x_i} \\
&= \eta \left(\frac{\alpha(n-1)}{N(N-1)t} C_0 e^{-\psi A_n x} + \frac{A_n}{n} \frac{A_n}{n} (-\psi) C_0 e^{-\psi A_n x} \right) + p \frac{\alpha(n-1)}{N(N-1)t} \\
&= \left(\frac{\alpha(n-1)}{N(N-1)t} - \frac{\psi A_n^2}{n^2} \right) \eta C_0 e^{-\psi A_n x} + p \frac{\alpha(n-1)}{N(N-1)t}
\end{aligned}$$

$$\begin{aligned}
\frac{\partial \pi_i}{\partial y_i} &= \eta \left(\frac{\partial s_i}{\partial y_i} C + s_i \frac{\partial C}{\partial y_i} \right) + p_i \frac{\partial s_i}{\partial y_i} - \delta y_i \\
&= \eta \frac{\beta(n-1)}{N(N-1)t} C_0 e^{-\psi A_n x} + p \frac{\beta(n-1)}{N(N-1)t} - \delta y \\
\frac{\partial \pi_i}{\partial p_i} &= \eta \left(\frac{\partial s_i}{\partial p_i} C + s_i \frac{\partial C}{\partial p_i} \right) + \left(s_i + p_i \frac{\partial s_i}{\partial p_i} \right) \\
&= \eta \frac{(-(n-1))}{N(N-1)t} C_0 e^{-\psi A_n x} + \left(\frac{A_n}{n} + p \frac{(-(n-1))}{N(N-1)t} \right) \\
&= -\eta \frac{n-1}{N(N-1)t} C_0 e^{-\psi A_n x} + \frac{A_n}{n} - p \frac{n-1}{N(N-1)t} .
\end{aligned}$$

Proof of Proposition 1. By inspection of the marginal profits with respect to x_i, and assuming $p_i = 0$, we have that profits are increasing whenever $\alpha(n-1) > \frac{\psi t(2N-n-1)^2}{N(N-1)}$ and decreasing whenever $\alpha(n-1) < \frac{\psi t(2N-n-1)^2}{N(N-1)}$. This means that when the first inequality holds, then it is best to set the maximum level of accuracy ($x = 1$), while it is best to set the minimum level ($x = 0$) whenever the second inequality holds. In other words, solving for the equality

$$\frac{\alpha(n-1)}{N(N-1)t} = \frac{\psi A_n^2}{n^2} \Leftrightarrow \frac{\alpha(n-1)}{t} = \frac{\psi(2N-n-1)^2}{N(N-1)}$$

for n, gives us the number (of media outlets)

$$\begin{aligned}
\bar{n} &= 2N - 1 + \frac{\alpha N(N-1)}{2\psi t} - \frac{\sqrt{\alpha N(N-1)^2(\alpha N + 8\psi t)}}{2\psi t} \\
&= 2N - 1 - \frac{N-1}{2\psi t} \left(\sqrt{(\alpha N)^2 + \alpha N 8\psi t} - \alpha N \right),
\end{aligned}$$

at which the optimal strategy switches from minimum to maximum accuracy. It can be shown that for $n < \bar{n}$ we have $x = 0$ as the unique symmetric solution; while for $n > \bar{n}$ we have $x = 1$ as the unique symmetric solution.

Proof of Proposition 3. Since $\eta = 0$, we immediately get $x = 1$ and for the quality and price we have as the symmetric FOC's,

$$\frac{\partial \pi}{\partial y_i} = p\frac{\beta(n-1)}{N(N-1)t} - \delta y = 0\,, \quad \frac{\partial \pi}{\partial p_i} = \frac{A_n}{n} - p\frac{n-1}{N(N-1)t} = 0,$$

where A_n is defined in Eq. (1). Solving for p then for y, leads to

$$p = \frac{A_n N(N-1)t}{n(n-1)} = \frac{(2N-n-1)t}{n-1} \quad , \quad y = \frac{\beta(2N-n-1)}{\delta N(N-1)}\,.$$

Proof of Proposition 4. Solving the general, symmetric FOC's for (x, y, p) yields,

$$p = \left[\frac{(2N-n-1)t}{n-1} - \eta C_0 e^{-\psi A_n x}\right]^+ \quad , \quad y = \frac{\beta(n-1)}{\delta N(N-1)t}\eta C_0 e^{-\psi A_n x}$$

as the unique symmetric equilibrium levels of price and quality. From here, it is easy to see that if $\frac{(2N-n-1)t}{n-1} < \eta C_0 e^{-\psi A_n x}$, which is the case pursued in the paper, then the level of accuracy coincides with the one in Proposition 1.

Proof of Proposition 5. Defining total audience reached as

$$A_{\kappa n} = \frac{(2N-\kappa n-1)\kappa n}{N(N-1)}\,,$$

we can write for $j \neq \kappa_i^{''}$,

$$\frac{\partial s_{\kappa_i^{''}}}{\partial x_{\kappa_i^{''}}} = \frac{\alpha(n\kappa-1)}{N(N-1)t}\,, \quad \frac{\partial s_{\kappa_i^{''}}}{\partial y_{\kappa_i^{''}}} = \frac{\beta(n\kappa-1)}{N(N-1)t}\,, \quad \frac{\partial s_{\kappa_i^{''}}}{\partial p_{\kappa_i^{''}}} = -\frac{n\kappa-1}{N(N-1)t}\,,$$

$$\frac{\partial s_j}{\partial x_{\kappa_i^{''}}} = -\frac{\alpha}{N(N-1)t}\,, \quad \frac{\partial s_j}{\partial y_{\kappa_i^{''}}} = -\frac{\beta}{N(N-1)t}\,, \quad \frac{\partial s_j}{\partial p_{\kappa_i^{''}}} = \frac{1}{N(N-1)t}\,,$$

$$\begin{aligned}\frac{\partial C}{\partial x_{\kappa_i^{''}}} &= \left(s_{\kappa_i^{''}} + \frac{\partial s_{\kappa_i^{''}}}{\partial x_{\kappa_i^{''}}}x_{\kappa_i^{''}} + \sum_{j\neq\kappa_i^{''}} \frac{\partial s_j}{\partial x_{\kappa_i^{''}}}x_j\right)(-\psi)C_0 \cdot e^{-\psi\sum_{i=1}^{n}\sum_{\kappa_i^{'}=1}^{\kappa_i} s_{\kappa_i^{'}}x_{\kappa_i^{'}}} \\ &= \left(s_{\kappa_i^{''}} + \frac{\alpha(\kappa n-1)}{N(N-1)t}x_{\kappa_i^{''}} - \sum_{j\neq\kappa_i^{''}} \frac{\alpha}{N(N-1)t}x_j\right)(-\psi)C_0 \cdot e^{-\psi\sum_{i=1}^{n}\sum_{\kappa_i^{'}=1}^{\kappa_i} s_{\kappa_i^{'}}x_{\kappa_i^{'}}}\,.\end{aligned}$$

Notice also that $\frac{\partial C}{\partial y_{\kappa_i''}} = \frac{\partial C}{\partial p_{\kappa_i''}} = 0$. Computing marginal profits we have,

$$\begin{aligned}
\frac{\partial \pi}{\partial x_{\kappa_i''}} &= \frac{\partial}{\partial x_{\kappa_i''}}\left(s_{i''}\eta C - \frac{\delta}{2}y_{\kappa_i''}^2\right) + \sum_{\kappa_i' \neq \kappa_i''} \frac{\partial}{\partial x_{\kappa_i''}}\left(s_{\kappa_i'}\eta C - \frac{\delta}{2}y_{\kappa_i'}^2\right) \\
&= \eta\left(\frac{\partial s_{\kappa_i''}}{\partial x_{\kappa_i''}}C + s_{\kappa_i''}\frac{\partial C}{\partial x_{\kappa_i''}}\right) + \sum_{\kappa_i' \neq \kappa_i''} \eta\left(\frac{\partial s_{\kappa_i'}}{\partial x_{\kappa_i''}}C + s_{\kappa_i'}\frac{\partial C}{\partial x_{\kappa_i''}}\right) \\
&= \eta\left(\frac{\alpha(n\kappa - 1)}{N(N-1)t} + \frac{A_{\kappa n}}{\kappa n}(-\psi)\frac{A_{\kappa n}}{\kappa n}\right) C_0 e^{-\psi A_{\kappa n} x} \\
&\quad + \sum_{\kappa_i' \neq \kappa_i''} \eta\left(\frac{(-\alpha)}{N(N-1)t} + \frac{A_{\kappa n}}{\kappa n}(-\psi)\frac{A_{\kappa n}}{\kappa n}\right) C_0 e^{-\psi A_{\kappa n} x} \\
&= \left(\frac{\alpha\kappa(n-1)}{N(N-1)t} - \frac{\psi A_{\kappa n}^2}{\kappa n^2}\right)\eta C_0 e^{-\psi A_{\kappa n} x}.
\end{aligned}$$

Again, this expression is either positive or negative depending on whether n is smaller or greater than $\bar{n}(\kappa)$ given by,

$$\begin{aligned}
\bar{n}(\kappa) &= \frac{2N-1}{\kappa} + \frac{\alpha N(N-1)}{2\psi\kappa^2 t} - \frac{\sqrt{\alpha N(N-1)(\alpha N(N-1) + 4\psi\kappa(2N-\kappa-1)t)}}{2\psi\kappa^2 t} \\
&= \frac{2N-1}{\kappa} - \frac{\sqrt{(\alpha N(N-1))^2 + 4\psi\kappa t\alpha N(N-1)(2N-\kappa-1)} - \alpha N(N-1)}{2\psi\kappa^2 t}.
\end{aligned}$$

Proof of Proposition 6. As before we have, $\frac{\partial C}{\partial y_{\kappa_i''}} = \frac{\partial C}{\partial p_{\kappa_i''}} = 0$ from which we can compute,

$$\begin{aligned}
\frac{\partial \pi}{\partial y_{\kappa_i''}} &= \frac{\partial}{\partial y_{\kappa_i''}}\left(s_{\kappa_i''}\eta C + s_{\kappa_i''}p_{\kappa_i''} - \frac{\delta}{2}y_{\kappa_i''}^2\right) + \sum_{\kappa_i' \neq \kappa_i''} \frac{\partial}{\partial y_{\kappa_i''}}\left(s_{\kappa_i'}\eta C + s_{\kappa_i'}p_{\kappa_i'} - \frac{\delta}{2}y_{\kappa_i'}^2\right) \\
&= \left(\frac{\partial s_{\kappa_i''}}{\partial y_{\kappa_i''}}(\eta C + p_{\kappa_i''}) + \eta s_{\kappa_i''}\frac{\partial C}{\partial y_{\kappa_i''}} - \delta y_{\kappa_i''}\right) + \sum_{\kappa_i' \neq \kappa_i''}\left(\frac{\partial s_{\kappa_i'}}{\partial y_{\kappa_i''}}(\eta C + p_{\kappa_i'}) + \eta s_{\kappa_i'}\frac{\partial C}{\partial y_{\kappa_i''}}\right) \\
&= \left(\frac{\beta(\kappa n - 1)}{N(N-1)t} + \sum_{\kappa_i' \neq \kappa_i''}\frac{(-\beta)}{N(N-1)t}\right)\left(\eta C_0 e^{-\psi A_{\kappa n} x} + p\right) - \delta y_{\kappa_i''} \\
&= \frac{\beta\kappa(n-1)}{N(N-1)t}\left(\eta C_0 e^{-\psi A_{\kappa n} x} + p\right) - \delta y_{\kappa_i''},
\end{aligned}$$

$$
\begin{aligned}
\frac{\partial \pi}{\partial p_{\kappa_i''}} &= \frac{\partial}{\partial p_{\kappa_i''}} \left(s_{\kappa_i''} \eta C + s_{\kappa_i''} p_{\kappa_i''} - \frac{\delta}{2} y_{\kappa_i''}^2 \right) + \sum_{\kappa_i' \neq \kappa_i''} \frac{\partial}{\partial p_{\kappa_i''}} \left(s_{\kappa_i'} \eta C + s_{\kappa_i'} p_{\kappa_i'} - \frac{\delta}{2} y_{\kappa_i'}^2 \right) \\
&= \left(s_{\kappa_i''} + \frac{\partial s_{\kappa_i''}}{\partial p_{\kappa_i''}} (\eta C + p_{\kappa_i''}) + \eta s_{\kappa_i''} \frac{\partial C}{\partial p_{\kappa_i''}} \right) + \sum_{\kappa_i' \neq \kappa_i''} \left(\frac{\partial s_{\kappa_i'}}{\partial p_{\kappa_i''}} (\eta C + p_{\kappa_i'}) + \eta s_{\kappa_i'} \frac{\partial C}{\partial p_{\kappa_i''}} \right) \\
&= \frac{A_{\kappa n}}{\kappa n} - \frac{\kappa(n-1)}{N(N-1)t} \eta C_0 e^{-\psi A_{\kappa n} x} - \frac{\kappa n - 1}{N(N-1)t} p_{\kappa_i''} + \sum_{\kappa_i' \neq \kappa_i''} \frac{1}{N(N-1)t} p_{\kappa_i'} \,.
\end{aligned}
$$

Assuming symmetry, setting equal to zero, and solving for (p, y) gives,

$$
p = \left[\frac{(2N - \kappa n - 1)t}{\kappa(n-1)} - \eta C_0 e^{-\psi A_{\kappa n} x} \right]^+ = 0 \,, \qquad y = \frac{\beta \kappa (n-1)}{\delta N(N-1)t} \eta C_0 e^{-\psi A_{\kappa n} x} \,.
$$

Proof of Proposition 8. We need to compute the equilibrium strategies for the commercial outlets. Recall, for $i = 1, \ldots, n$,

$$
\begin{aligned}
s_i &= \frac{n+m-1}{N(N-1)} + \frac{1}{N(N-1)t} \sum_{j \neq i} (u_i - u_j) + \frac{2(N-n-m)}{N(N-1)} \\
&= \frac{A_{n+m}}{n+m} + \frac{n(u_i - \bar{u}_C)}{N(N-1)t} + \frac{m(u_i - \bar{u}_{NC})}{N(N-1)t} \,.
\end{aligned}
$$

Moreover, for $i \neq j$,

$$
\frac{\partial s_i}{\partial x_i} = \frac{\alpha(n+m-1)}{N(N-1)t} \,, \qquad \frac{\partial s_i}{\partial y_i} = \frac{\beta(n+m-1)}{N(N-1)t} \,, \qquad \frac{\partial s_i}{\partial p_i} = -\frac{n+m-1}{N(N-1)t} \,,
$$

$$
\frac{\partial s_j}{\partial x_i} = -\frac{\alpha}{N(N-1)t} \,, \qquad \frac{\partial s_j}{\partial y_i} = -\frac{\beta}{N(N-1)t} \,, \qquad \frac{\partial s_j}{\partial p_i} = \frac{1}{N(N-1)t} \,,
$$

$$
\begin{aligned}
\frac{\partial C}{\partial x_i} &= \left(s_i + \frac{\partial s_i}{\partial x_i} x_i + \sum_{j \neq i, j=1}^{n} \frac{\partial s_j}{\partial x_i} x_j + \sum_{j=n+1}^{n+m} \frac{\partial s_j}{\partial x_i} \right) (-\psi) C_0 e^{-\psi \left(\sum_{i=1}^{n} s_i x_i + \sum_{i=n+1}^{n+m} s_i \right)} \\
&= \left(s_i + \frac{\alpha(n+m-1)}{N(N-1)t} x_i - \sum_{j \neq i, j=1}^{n} \frac{\alpha}{N(N-1)t} x_j - \frac{m\alpha}{N(N-1)t} \right) (-\psi) C_0 e^{-\psi \left(\sum_{i=1}^{n} s_i x_i + \sum_{i=}^{n+} \right.}
\end{aligned}
$$

and assuming type-symmetry, where $x_i = x_C$ for all $i = 1, \ldots, n$,

$$
\begin{aligned}
\frac{\partial C}{\partial x_i} &= \left(\frac{2N - n - m - 1}{N(N-1)} + \frac{m(\bar{u}_C - \bar{u}_{NC})}{N(N-1)t} - \frac{\alpha m (1 - x_C)}{N(N-1)t} \right) (-\psi) C_0 e^{-\psi(\sigma x_C + 1 - \sigma)} \\
&= \left(\frac{\sigma}{n} - \frac{\alpha m (1 - x_C)}{N(N-1)t} \right) (-\psi) C_0 e^{-\psi (A_{nm} - \sigma(1 - x_C))} \,,
\end{aligned}
$$

where it can be checked that $\frac{\sigma}{n} = \frac{1}{N} + \frac{m(\bar{u}_C - \bar{u}_{NC})}{N(N-1)t}$. Also,

$$\begin{aligned}
\frac{\partial C}{\partial y_i} &= \left(\frac{\partial s_i}{\partial y_i} x_i + \sum_{j \neq i, j=1}^{n} \frac{\partial s_j}{\partial y_i} x_j + \sum_{j=n+1}^{n+m} \frac{\partial s_j}{\partial y_i} \right) (-\psi) C_0 e^{-\psi\left(\sum_{i=1}^{n} s_i x_i + \sum_{i=n+1}^{n+m} s_i\right)} \\
&= \frac{\beta m(1-x_C)}{N(N-1)t} \psi C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))}
\end{aligned}$$

$$\begin{aligned}
\frac{\partial C}{\partial p_i} &= \left(\frac{\partial s_i}{\partial p_i} x_i + \sum_{j \neq i, j=1}^{n} \frac{\partial s_j}{\partial p_i} x_j + \sum_{j=n+1}^{n+m} \frac{\partial s_j}{\partial p_i} \right) (-\psi) C_0 e^{-\psi\left(\sum_{i=1}^{n} s_i x_i + \sum_{i=n+1}^{n+m} s_i\right)} \\
&= -\frac{m(1-x_C)}{N(N-1)t} \psi C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))} .
\end{aligned}$$

Notice that, if $x = 1$, then $\frac{\partial C}{\partial y_i} = \frac{\partial C}{\partial p_i} = 0$, otherwise, $\frac{\partial C}{\partial y_i} > 0$, $\frac{\partial C}{\partial p_i} < 0$.

Computing marginal profits, assuming type-symmetry, gives,

$$\begin{aligned}
\frac{\partial \pi}{\partial x_i} &= \eta \left(\frac{\partial s_i}{\partial x_i} C + s_i \frac{\partial C}{\partial x_i} \right) + p_i \frac{\partial s_i}{\partial x_i} \\
&= \left(\frac{\alpha(n+m-1)}{N(N-1)t} - \frac{\psi\sigma}{n} \left(\frac{\sigma}{n} - \frac{\alpha m(1-x_C)}{N(N-1)t} \right) \right) \eta C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))} + \frac{\alpha(n+m-1)}{N(N-1)t} p_C \\
\frac{\partial \pi}{\partial y_i} &= \eta \left(\frac{\partial s_i}{\partial y_i} C + s_i \frac{\partial C}{\partial y_i} \right) + p_i \frac{\partial s_i}{\partial y_i} - \delta y_i \\
&= \left(\frac{\beta(n+m-1)}{N(N-1)t} + \frac{\psi\sigma}{n} \frac{\beta m(1-x_C)}{N(N-1)t} \right) \eta C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))} + \frac{\beta(n+m-1)}{N(N-1)t} p_C - \delta y_C \\
\frac{\partial \pi}{\partial p_i} &= \eta \left(\frac{\partial s_i}{\partial p_i} C + s_i \frac{\partial C}{\partial p_i} \right) + s_i + p_i \frac{\partial s_i}{\partial p_i} \\
&= -\left(\frac{n+m-1}{N(N-1)t} + \frac{\psi\sigma}{n} \frac{m(1-x_C)}{N(N-1)t} \right) \eta C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))} + \frac{\sigma}{n} - \frac{n+m-1}{N(N-1)t} p_C
\end{aligned}$$

Solving for x_C yields

$$x_C = 1 + \frac{(n+m-1)n}{\sigma\psi m} - \frac{\sigma t N(N-1)}{\alpha n m} . \tag{8}$$

Writing $\frac{\partial C}{\partial x_i} = E(-\psi) C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))}$, where $E = \left(\frac{\sigma}{n} - \frac{\alpha m(1-x_C)}{N(N-1)t} \right)$, the

SOC's give

$$
\begin{aligned}
\frac{\partial^2 \pi}{\partial x_i^2} &= \eta \left(\frac{\partial^2 s_i}{\partial x_i^2} C + 2 \frac{\partial s_i}{\partial x_i} \frac{\partial C}{\partial x_i} + s_i \frac{\partial^2 C}{\partial x_i^2} \right) \\
&= \left(0 + \frac{2\alpha(n+m-1)}{N(N-1)t} E(-\psi) + \frac{\sigma}{n} (E^2(-\psi)^2 + \frac{\partial E}{\partial x_i}(-\psi)) \right) \eta C_0 e^{-\psi(A_{nm} - \sigma(1-x))} \\
&= \left(-\frac{2\alpha(n+m-1)\psi}{N(N-1)t} E + \frac{\sigma}{n} (E^2\psi^2 - \frac{\partial E}{\partial x_i}\psi) \right) \eta C_0 e^{-\psi(A_{nm} - \sigma(1-x))} < 0
\end{aligned}
$$

since $\frac{n}{N} \leq \sigma \leq \frac{2n}{N}$. This means that Eq. (8) gives the unconstrained profit-maximizing level of accuracy for the commercial media. (It can be checked that $\frac{\partial x_C}{\partial n}, \frac{\partial x_C}{\partial m}, \frac{\partial x_C}{\partial N}, \frac{\partial x_C}{\partial \alpha} \geq 0$ while $\frac{\partial x_C}{\partial t} \leq 0$.) Further solving for (y_C, p_C) yields

$$
\begin{aligned}
p_C &= \left[\frac{\sigma N(N-1)t}{n(n+m-1)} - \left(1 + \frac{\sigma\psi m(1-x_C)}{n(n+m-1)} \right) \eta C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))} \right]^+ = 0 \\
y_C &= \frac{\beta}{\delta N(N-1)t} \left(n+m-1 + \frac{\sigma\psi m(1-x_C)}{n} \right) \eta C_0 e^{-\psi(A_{nm} - \sigma(1-x_C))},
\end{aligned}
$$

where it can be checked that again both SOC's are satisfied. Solving Eq. (8) with respect to α at $x_C = 0$ and at $x_C = 1$ gives respectively $\frac{\sigma^2\psi t N(N-1)}{n(\sigma\psi m + n(n+m-1))}$ and $\frac{\sigma^2\psi t N(N-1)}{n^2(n+m-1)}$, so that, assuming the bounds $\frac{n}{N} \leq \sigma \leq \frac{2n}{N}$, we can define,

$$
\Lambda_0(\psi, t, m, n, N) = \frac{\psi t(N-1)}{2\psi m + (n+m-1)N} \left(\leq \frac{\sigma^2\psi t N(N-1)}{n(\sigma\psi m + n(n+m-1))} \right)
$$

and

$$
\Lambda_1(\psi, t, m, n, N) = \frac{4\psi t(N-1)}{(n+m-1)N} \left(\geq \frac{\sigma^2\psi t N(N-1)}{n^2(n+m-1)} \right)
$$

as upper and lower bounds for α. (Since σ is not (yet) determined and depends in an important way on n, we do not yet solve for n, but rather for α which we bound by the functions Λ_0 and Λ_1). We distinguish the following three cases,

CASE 1: $x = 0$ occurring when $\alpha \leq \Lambda_0(\psi, t, m, n, N)$;
CASE 2: $x \in [0, 1]$ occurring when $\Lambda_0(\psi, t, m, n, N) < \alpha < \Lambda_1(\psi, t, m, n, N)$;
CASE 3: $x = 1$ occurring when $\alpha \geq \Lambda_1(\psi, t, m, n, N)$.

Depending on the values of the parameters, any of the three cases can occur. It is clear, already from Eq. (8), that larger values of n, m tend to increase x.

Also, given α and the other parameters, larger values of n, m tend to make the conditions for CASE 3 (where $x = 1$) more likely to be satisfied. Hence, more commercial and non-commercial outlets in the market tend to increase the level of accuracy.

We next consider CASES 1 and 3. We omit CASE 2 as it is tedious to analyze and is anyways intermediate between the other two.

CASE 1: $x = 0$. Here we have

$$x_C = 0, y_C = \frac{\beta\eta C_0 e^{-\psi(A_{nm}-\sigma)}}{\delta N(N-1)t}\left(n + m - 1 + \frac{\sigma\psi m}{n}\right), p_C = 0$$

and

$$x_{NC} = 1, y_{NC} = \sqrt{\frac{2B}{\delta}}, p_{NC} = 0.$$

Which leads to

$$u_C = \beta y_C \text{ and } u_{NC} = \alpha + \beta y_{NC}$$

so that, with $\frac{\sigma}{n} = \frac{2N-n-m-1}{N(N-1)} + \frac{m(\bar{u}_C - \bar{u}_{NC})}{N(N-1)t}$, we can compute the equilibrium share σ from

$$\frac{\sigma}{n} = \frac{2N - n - m - 1}{N(N-1)} + \frac{\beta m(y_C - y_{NC}) - \alpha m}{N(N-1)t}. \tag{10}$$

CASE 3: $x = 1$. Here we have

$$x_C = 1, y_C = \frac{\beta\eta(n + m - 1)C_0 e^{-\psi A_{nm}}}{\delta N(N-1)t}, p_C = 0$$

and

$$x_{NC} = 1, y_{NC} = \sqrt{\frac{2B}{\delta}}, p_{NC} = 0.$$

This leads to

$$u_C = \alpha + \beta y_C \text{ and } u_{NC} = \alpha + \beta y_{NC}$$

so that, with $\frac{\sigma}{n} = \frac{2N-n-m-1}{N(N-1)} + \frac{m(\bar{u}_C - \bar{u}_{NC})}{N(N-1)t}$, we can compute the equilibrium share σ from

$$\frac{\sigma}{n} = \frac{2N - n - m - 1}{N(N-1)} + \frac{\beta m(y_C - y_{NC})}{N(N-1)t}. \tag{11}$$

Finally, substituting the expression for σ into Eq. (8) above and solving for n gives a new expression for $\bar{n}_m$, the number of (separately owned) commercial media outlets that guarantee that there will be no censorship given that there are m non-commercial media outlets in the market. The effect of changing B and C_0 on σ follow directly from Eqs. (10), (11); the effect of α, m, n, ψ, N, t on $\bar{n}_m$ follows from the derived $\bar{n}_m$ or from Eqs. (10), (11).

References

[1] Advertising Age (2007) *Leading National Advertisers: Marketer Profiles Yearbook*, (B. Johnson *et al.*, eds.), New York: The Ad Age Group.

[2] Anderson, S., and S. Coate (2005) "Market Provision of Broadcasting: A Welfare Analysis," *Review of Economic Studies*, **72**, 947-972.

[3] Armstrong, M., and H. Weeds (2007) "Programme Quality in Subscription and Advertising-Funded Television," Mimeo, University College London and University of Essex.

[4] Bagdikian, B.H. (2004) *The New Media Monopoly*, Beacon Press, Boston

[5] Baghestani, H. (1991) "Cointegration Analysis of the Advertising-Sales Relationship," *Journal of Industrial Economics,* **39**: 671-681.

[6] Baker, C.E. (1994) *Advertising and a Democratic Press*, Princeton University Press, Princeton.

[7] Baker, C.E. (2007) *Media Concentration and Democracy: Why Ownership Matters*, Cambridge University Press, Cambridge.

[8] Baker, M.J., and L.M. George (2008) "The Role of Television in Rising Household Debt: Evidence from the 1950's," Conference presentation at the 6th Workshop on Media Economics in Zurich.

[9] Barnouw, E. (1978) *The Sponsor*, Oxford University Press, Oxford.

[10] Besley, T., and A. Prat (2006) "Handcuffs for the Grabbing Hand? Media Capture and Government Accountability," *American Economic Review*, **96**: 720-736.

[11] Boykoff, M.T., and J.M. Boykoff (2004) "Balance as Bias: Global Warming and the US Prestige Press," *Global Environmental Change*, **14**, 125-136.

[12] Chen, Y., and M.H. Riordan (2007) "Price and Variety in the Spokes Model," *Economic Journal*, **117**: 897-921.

[13] Columbia Journalism Review (2008) *Resources: Who Owns What*, New York. (http://www.cjr.org/resources/index.php?c=clearchannel)

[14] Compaine, B.M., and D. Gomery (2000) "Who Owns the Media?: Competition and Concentration in the Mass Media Industry, 3rd ed., Lawrence Erlbaum Associates, Mahwah, New Jersey.

[15] Curran, J. (2000) "Rethinking Media and Democracy," in J. Curran and M. Gurevitch (eds.) *Mass Media and Society*, 3rd ed., Arnold Publishers, London.

[16] Elliott, C. (2001) "A Cointegration Analysis of Advertising and Sales Data," *Review of Industrial Organization*, **18**: 417-426.

[17] Ellman, M., and F. Germano (2009) "What Do the Papers Sell? A Model of Advertising and Media Bias," *Economic Journal*, **114**: 680-704.

[18] Esteve, V., and F. Requena (2006) "A Cointegration Analysis of Car Advertising and Sales Data in the Presence of Structural Change," *International Journal of the Economics of Business*, **13**: 111-128.

[19] Gentzkow, M., and J.M. Shapiro (2006) "What Drives Media Slant? Evidence from U.S. Daily Newspapers" National Bureau of Economic research Working Paper 12707.

[20] Gentzkow, M., and J.M. Shapiro (2008a) "Competition and Truth in the Market for News" *Journal of Economic Perspectives*, **22**: 133-154.

[21] Gentzkow, M., and J.M. Shapiro (2008b) "Competition and Truth in the Market for News" *Quarterly Journal of Economics*, **123**: 279-323.

[22] George, L.M., and J. Waldfogel (2003) "Who Affects Whom in Daily Newspaper Markets?" *Journal of Political Economy*, **11**: 765-785.

[23] Germano, F., and M. Meier (2008) "Concentration and Self-Censorship in Commercial Media," Mimeo, Universitat Pompeu Fabra and IAE-CSIC.

[24] Hallin, D.C., and P. Mancini (2004) *Comparing Media Systems: Three Models of Media and Politics*, Cambridge University Press, Cambridge.

[25] Hamilton, J.T. (2004) *All the News That's Fit to Sell*, Princeton University Press, Princeton.

[26] Jung, C., and B.J. Seldon (1995) "The Macroeconomic Relationship between Advertising and Consumption," *Southern Economic Journal*, **61**: 577-587.

[27] Kops, M. (2007) "A Revenue-Based Methodology for the Classification and Comparison of Broadcasting Systems," Working Paper 223e, Institute for Broadcasting Economics, Cologne.

[28] La Ferrara, E., Chong, A., and S. Dureya (2008) "Soap Operas and Fertility: Evidence from Barzil," Mimeo, Bocconi University and Inter-American Development Bank.

[29] Lexchin, J., and D.W. Light (2006) "Commercial Influence and the Content of Medical Journals," *BMJ*, **332**: 1444-1447.

[30] McChesney, R.W. (2004) *The Problem of the Media: U.S. Communication Politics in the 21st Century*, Monthly Review Press, New York.

[31] Oreskes, N. (2004) "Beyond the Ivory Tower: The Scientific Consensus on Climate Change," *Science*, **306**, 1686.

[32] Peitz, M., and T. Valletti (2008) "Content and Advertising in the Media: Pay-TV versus Free-to-Air," *International Journal of Industrial Organization*, **26**: 949-965.

[33] Petrova, M. (2008) "Inequality and Media Capture," *Journal of Public Economics*, **92**: 183-212.

[34] Prat, A., and D. Strömberg (2005) "Commercial Television and Voter Information," Mimeo, LSE and Stockholm University.

[35] Putnam, R.D. (2000) *Bowling Alone: The Collapse and Revival of American Community*, Simon & Schuster, New York.

[36] Reuter, J., and E. Zitzewitz (2006) "Do Ads Influence Editors? Advertising and Bias in the Financial Media," *Quarterly Journal of Economics*, **121**: 197-227.

[37] Salop, S. (1979) "Monopolistic Competition with Outside Goods," *Bell Journal of Economics,* **10**: 141-156.

[38] Schmalensee, R. (1972) *The Economics of Advertising*, North-Holland, Amsterdam.

[39] Strömberg, D. (2004) "Mass Media Competition, Political Competition, and Public Policy," *Review of Economic Studies*, **71** , 265-284.

[40] Weeds, H. (2009) "Superstars and the Long Tail: The Impact of Technology on Market Structure in Media Industries," University of Essex, Discussion Paper 669.

[41] Wilbur, K.C. (2008) "A Two-Sided, Empirical Model of Television Advertising and Viewing Markets," *Marketing Science*, **23** , 356-378.