Information or Opinion? Media Bias as Product Differentiation

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Two aspects of media bias are important empirically. First, bias is persistent: it does not seem to disappear even when the media is under scrutiny. Second, bias is conflicting: different people often perceive bias in the same media outlet to be of opposite signs. We build a model in which both empirical characteristics of bias are observed in equilibrium. The key assumptions are that the information contained in the facts about a news event may not always be fully verifiable, and consumers have heterogeneous prior views ("ideologies") about the news event. Based on these ingredients of the model, we build a location model with entry to characterize firms' reports in equilibrium, and the nature of bias. When a news item comprises only fully verifiable facts, firms report these as such, so that there is no bias and the market looks like any market for information*. When a news item comprises information that is mostly nonverifiable, however, then consumers may care both about opinion and editorials, and a firm's report will contain both these aspects—in which case the market resembles any* differentiated product market*. Thus, the appearance of bias is a result of equilibrium product differentiation when some facts are nonverifiable. We use the model to address several questions, including the impact of competition on bias, the incentives to report unpopular news, and the impact of owner ideology*

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on bias. In general, competition does not lead to a reduction in bias unless this is accompanied by an increase in verifiability or a smaller dispersion of prior beliefs.

1. Introduction

The possibility that there is bias in the media has excited politicians and public opinion ever since the political impact of the media was recognized. In his famous Des Moines speech, US Vice President Spiro Agnew argued that "[. . .] a little group of men [. . .] wield a free hand in selecting, presenting and interpreting the great issues of our Nation."[1] Because the media industry supplies most of the information that viewers have on issues that they do not directly experience, claims of bias deserve serious attention. For example, if information is contaminated democracy could be less reliable and reductions in welfare could follow. In this paper, we provide a simple model of the industrial organization of the media that can be used to examine the nature of bias and other outstanding issues in the field.

Two aspects of media bias seem to be important empirically. First, media bias does not seem to disappear even when the media is under scrutiny—in other words, bias is persistent. In a classic 1965 study, Merril described how *Time* magazine stereotyped three US presidents. The Merrill study finds a strong positive bias on Eisenhower and strong negative bias on Truman, whereas a balanced picture of Kennedy emerged. Severin and Tankard (1992) report that the editors of *Time* have insisted that their magazine has become fairer over time and the *Wall Street Journal* has reported that "[. . .] even critics concede that *Time*'s political coverage now is more balanced than in its anti-Truman and pro-Eisenhower days." Yet, they also report that a later study by Fedler et al. (1979) found a similar pattern of bias in 1979, a period over which the magazine's circulation increased by 40%. Anecdotal evidence is also consistent with the idea that bias does not diminish under scrutiny. For example, despite being the lightning rod for recent debates about bias in television news coverage, *Fox News*' coverage remains essentially unchanged during the past few years. Network executives even concede that accusations of bias actually help them, and the channel's dramatic growth in ratings are consistent with this view.

A second empirical aspect of bias is that different people invariably perceive bias in the media to be of *opposite* signs (i.e., the direction of bias is conflicting). Recently, for example, Goldberg (2002) and Coulter (2002) claim that there is a liberal bias in the media while Krugman

1. Cited in Loury (1971).

(2002) and Alterman (2003) claim that there is a conservative bias. In addition, observers frequently disagree on the direction of bias by the same media outlet: for example, some argue that CNN has a liberal bent, whereas those on the left perceive it to be right-of-center. The key point, however, raised by conflicting bias is that the phenomenon of bias in the media appears to be quite different than, say, a statistician's notion of bias—because bias lies in the eyes of the beholder (or consumer).

Persistent media bias suggests that it is appropriate to examine whether bias can emerge as an equilibrium phenomenon, rather than some transitory outcome that will eventually disappear. Conflicting bias, on the other hand, implies that it appears to be less an objectively verifiable phenomenon, and perhaps reflects differences in opinion.

We build a model where bias is both persistent and conflicting. The central assumption in our model is that the information contained in the "facts" about any news event may not always be fully verifiable. Verification of information is central to the media.[2] At the same time, full verifiability is the exception rather than the rule.[3] To accommodate the possibility of imperfect verifiability, and to examine its consequences for media bias, a key aspect of our model is that we allow news events to vary according to their degree of verifiability. This turns out to have important consequences for how the media market behaves. For example, one can think of firms as reporting about a news event that contain verifiable and nonverifiable facts. Their report to consumers is a bundle of facts plus opinion (editorials).[4] Based on these ingredients,

2. For example, in *The Elements of Journalism*, Kovach and Rosensteil (2001) note simply that "The essence of journalism is the discipline of verification."

3. The challenges confronted in verifying information about news events are described as early as the fifth century B.C., in Thucydides' introduction to his account of the Peleponnesian War: "With regard to my factual reporting of events . . . I have made it a principle not to write down the first story that came my way, and not even to be guided by my own general impressions; either I was present myself at the events which I have described or else heard of them from eyewitnesses whose reports I have checked with as much thoroughness as possible. Not that even so the truth was easy to discover: different eyewitnesses have different accounts of the same events, speaking out of partiality from one side or the other, or else from imperfect memories." Kovach and Rosensteil (2001) note how this account alludes to the basic challenges in any task of "nonfiction: How do you sift through the rumor, the gossip, the failed memory, the manipulative agendas, and try to capture something as accurately as possible, subject to revision in light of new information and perspective? How do you overcome your own limits of perception, your own experience, and come to an account that more people will recognize as reliable?" As they note, the difficulties posed in this task have resulted not only in journalists rejecting the term objectivity as an illusion, "but in various legal opinions, which declared objectivity impossible."

4. Crucially, these attributes cannot be unbundled. The model therefore would also apply to a world without editorials but where opinion slips into news reports in the guise of context or analysis. We provide some justifications for this in Section 2.2., but for now simply note that it is often technically hard to present news without some (reasonable) form of opinion. In practice, bias can take many forms. First, there is the issue of selecting what

we build a location model with entry to characterize firms' reports in equilibrium. When a news item comprises only fully verifiable facts, consumers only care about that, and firms report it as such—so that the media market looks like any *market for information*. When a news item comprises information that is mostly nonverifiable, however, then consumers may care both about opinion and editorials, and a firm's report will contain both these aspects—in which case the market resembles any *differentiated product market*. The key point is that both firms' incentives and consumer preferences are a function of the characteristic of news. And this characteristic, rather than any intrinsic preference for bias by consumers or owners, is the key driver of media coverage and bias.

An interesting aspect of the model is that, ultimately, there is no biased reporting to consumers of the verifiable facts that media firms receive. The appearance of bias is simply a result of equilibrium product differentiation when some facts are nonverifiable. Indeed, because consumer ideologies are different, and facts are nonverifiable, consumers' preferred reports end up being different from each other. The resulting heterogeneity in reports *mimics* a "preference for bias" even though it is, at its root, a taste for opinion.

The simplicity of the model allows us to define an intuitive measure of media bias, and to study its behavior when the environment changes. We address a set of basic questions on media bias, including: What are the characteristics of equilibrium bias? What is the impact of competition on bias? What happens when viewers give less emphasis to the truth (as in a war)?; do cross ownership limitations increase bias?

Our main result about competition is that free entry does not always eliminate bias. To see why, recall that when news is not fully verifiable, firms produce reports to cater to viewers with tastes for different opinions. Intuitively, the combination of partial verifiability and heterogeneous tastes make information behave similarly to any differentiated product, so one could argue that a free press does not eliminate bias for similar reasons that a free market does not lead to one color of cars.

Interestingly, the same logic suggests that a free press deviates from the truth when viewers behave as fanatics (i.e., people who put a low weight on the truth, and whose ideologies exhibit a lot of similarities).

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to report and what not to report, as stressed in the Agnew quote above. There could also be bias in the way news is reported. Severin and Tankard (1992) describe the six categories of bias pointed out in Merrill (1965). These are attribution bias (for example, "Truman snapped"), adjective bias (Eisenhower's "warm manner of speaking"), adverbial bias ("Truman said curtly"), outright opinion (for example "seldom has a more unpopular man fired a more popular one"), contextual bias (bias in whole sentences or paragraphs) and photographical bias ("how is the president presented in the picture-dignified, undignified; angry, happy; calm, nervous; etc.").

This explains why news reporting by a free press within a country during a war may appear more biased. Furthermore, a free press does not report all news items in the same way. Specifically, it is less likely to report truth that is unpopular (there is a natural suppression of unpopular extremes).

The model can be used to shed light on the role of owner ideology on media bias. One might ask how owner ideology can play any role in shaping bias in a competitive market with free entry? The reason is that competition does not completely pin down the location of reports in equilibrium. Specifically, the incentives to avoid losses and deter entry are necessary, but not sufficient, conditions to characterize the equilibrium (in other words, multiple equilibria exist). This, in turn, creates room for owner ideology to influence reporting. At the same time, a general theme is that consumer preferences and competition from potential entrants constrain owner ideology.

The economics literature on media bias is relatively scarce. Some recent papers (discussed below) offer explanations for why one should see biased reporting by firms in equilibrium. Each of these studies takes as given the existence of bias as an empirical phenomenon. A logical antecedent to this line of inquiry is to ask whether bias in fact exists in the media. The model here offers a mechanism where firms' reports give the appearance of bias although there is none. Thus, firms provide unbiased reports when information is fully verifiable, and provide opinion (that has the appearance of bias) when information is nonverifiable—in either case, no information distortion occurs.

An important theme in the literature and in public debates about bias is what kind of market structure allows bias to exist.[5] Mullainathan and Shleifer (2002) deal directly with this problem. In their model each firm observes a signal of a news event. A preference for bias implies that firms' reports are different, and this leads to product differentiation. But while bias occurs in equilibrium, a "conscientious reader" can eliminate it by watching many different reports and averaging them out—this is a version of the law of large numbers, as the aggregation of signals eliminates noise.

In our model, by contrast, the key driver of bias is that part of the content of a piece of news that is nonverifiable. Indeed, both consumer preferences and firms' reports are a function of this characteristic of news—so that the same market can appear to be biased when reporting certain news stories and objective in reporting others. This not only implies within-market variation in bias, but also generates sharp testable

5. In related work, Djankov et al. (2001) and Besley and Prat (2006) investigate how ownership of the media affects economic and political outcomes across countries. Stromberg (2001) and Besley and Burgess (2002) examine how the presence of the media influences government actions.

predictions over what kinds of stories this variation in bias occurs. This difference also expresses itself in other ways, most notably predictions about how competition affects bias. In contrast to Mullainathan and Shleifer, in our model there is no adding up result. This stems from information being not fully verifiable and for a taste for opinion. Adding up reports does not yield an unbiased aggregate for the same reason that a blue car plus a yellow car do not yield a green car.

Baron (2004) points out a general challenge for models with bias in equilibrium: viewers should understand the incentives of firms to distort the news and rationally recover the unbiased news report. Nevertheless, he shows that bias can still arise when a media firm obtains information on a news event (from third parties or by investing in a search technology) and has discretion to report or omit this news event. Intuitively, when the firm reports that it does not have news, consumers cannot conclude that news is not favorable to the firm. The firm could either have gotten hard news that was unfavorable, but the stochastic search technology may not have generated any hard news at all. Baron (2006) presents a reated supply-side model of persistent bias originating with journalists who have career interests and are willing to sacrifice current wages for future opportunities. Finally, Gentzkow and Shapiro (2005) study a market where no actor has an intrinsic preference for bias but where biased reports are still generated as a result of firm's desire to preserve a reputation for accuracy.

Our model can shed light on empirical work on media bias. One of the few such studies is Groseclose and Milyo (2005). They calculate a measure of media bias by estimating ideological scores for media outlets in two steps. First, they calculate the left–right score of all think tanks and policy groups in the US by counting the number of times politicians on either side of the political spectrum rely on the publications of these organizations in their speeches. Second, they assign a score to a media outlet depending on the score of the think tanks and policy groups that they cite. They find that news outlets have very different scores. In our model, this finding might be considered either (1) a failure to report verifiable facts, or (2) that some facts are nonverifiable, and outlets cater to the preferences of consumers in reporting these nonverifiable facts. As shown here, the latter interpretation is consistent with equilibrium behavior.

In addition to the finding on "relative bias" described above (where the bias of news outlets differs in relation to each other), Groseclose and Milyo find an *overall* liberal bias in the news content (i.e., excluding editorials, letters to the editor, or book reviews) because the average ideological score of all media outlets is to the left of the average member of Congress. In our model as well, average bias can exist in equilibrium when fixed costs are large because media outlets then have considerable discretion in locating without inviting entry.[6] An alternative is that the observed aggregate bias is an out-of-equilibrium phenomenon that should invite entry of right-wing outlets. Indeed, the period covered by Groseclose and Milyo experiences entry on the right by Fox News.[7]

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 characterizes market equilibria. Section 4 develops the main implications, while Section 5 studies several applications. Section 6 concludes.

2. The Model

We start by describing consumer preferences. Accusations of media bias involve some form of misrepresentation. But, how is it possible that a media outlet can defend biased news if these can be disproven by the facts? Two premises are central to our analysis. First, a "fact" may be either verifiable or nonverifiable. Nonverifiable facts admit differing interpretations which cannot be *proven* wrong. Thus, any piece of news can be characterized by its degree of verifiability.[8] The second premise is that consumer attitudes towards facts differ according to their verifiablity. A consumer is less willing to accept a lie when a fact is verifiable, even if the lie corresponds to a world that is *closer* to her ideology.

Note that we are assuming that a set of rational agents simultaneously hold different views concerning a single news event. Piketty (1995), Benabou and Tirole (2002), and Rotemberg (2002), make a similar assumption regarding the structure of beliefs—in their cases concerning the role of individual effort in economic success. They justify such dispersion by invoking high costs of experimentation. In our case, such dispersion arises from the noise content of news events and the differences in taste of consumers. Noise arises because part of the issues (e.g., Bill Clinton's effectiveness as a President) are not verifiable. Of course, given enough time, money and effort many nonverifiable pieces of information might be verified, and then there would be less dispersion in views. But in practice many facts remain unverifiable over the relevant time horizon and there is room for ideology and interpretation.

6. Note that Groseclose and Milyo (2005) estimate absolute average bias (for news outlets) as the distance from the average ideological score of politicians. In our case, absolute bias is the distance of reports from the facts.

7. A recent paper by Della Vigna and Kaplan (2005) examines the effect of entry by Fox News on popular votes.

8. Here, we take the degree of verifiability λ as a primitive of the model. Alternatively, one could view it as a consequence of how many resources are devoted to verifying or fact-checking.

In what follows, we present a model to systematically study the implications of these premises.

2.1 Information and Viewer Preferences

Information and news reports. The basic object of interest is a news event, described by the real number $\tilde{\theta}$, which we call the "truth." This event generates a piece of news, which is a composite of, on the one hand, verifiable facts and, on the other hand, nonverifiable facts that need to be interpreted. When this piece of news is communicated by a firm we call it a report. Parameter $\lambda \in [0, 1]$ is the fraction of facts which are verifiable, which is common knowledge.[9] Media firm f observes $\tilde{\theta}$ and chooses a report θ_f.

Viewer preferences. Viewers care about two things, ideology and "truth." Viewer v's ideological preference is described by the real number θ_v. There is a continuum of viewers of mass 1 with taste parameter θ_i uniformly distributed in the interval $[\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}]$ with $\alpha \in (-\infty, \infty)$ and $\beta \in (0, 1]$. Because there is a mass 1 of viewers, the c.d.f. is

$$\frac{1}{\beta}\int_{\alpha-\frac{\beta}{2}}^{\theta_i} d\theta = \frac{1}{\beta}\left[\theta_i - \left(\alpha - \frac{\beta}{2}\right)\right].$$

Note that α measures the mean ideology; β, on the other hand, parametrizes ideological dispersion.

The second part of viewer preferences regards truthfulness in reporting. We assume that, on the one hand, the utility of viewing report θ_f falls with its distance to "truth" $\tilde{\theta}$. On the other hand, utility also falls with the distance of report θ_f to the viewer's ideology, θ_v. Because, in general, $\tilde{\theta} \neq \theta_v$ and media firm f must choose where to locate one report θ_f, it follows that there is a tradeoff between "truth" and ideology.

The terms of this tradeoff depend on viewer preferences for truth in the following manner: the higher the fraction λ of verifiable facts, the more a viewer values closeness to the "truth." Hence, the utility that viewer v obtains with report θ_f is

$$U_{vf} = -\lambda(\theta_f - \tilde{\theta})^2 - (1 - \lambda)(\theta_f - \theta_v)^2. \quad (1)$$

9. In the journalism literature the precise definition of λ is "verisimilitude," for example, Williams and Carpini (2002). Specifically: "...[V]erisimilitude is meant to acknowledge the inherent contestability of concepts like truth and objectivity while avoiding the slippery slope of pure relativism. For that reason, we use the word "verisimilitude" not in its meaning as the appearance or illusion of truth (though that definition should always be kept in mind), but rather to suggest the likelihood or probability of truth. As such, *it is a term that nods to the uncertainty of things while at the same time affirming the importance of seeking the truth.*" [emphasis added]

In other words, people like to be told the truth, but they also like to hear news that confirms their views of the world.[10] For example, a Democrat would prefer a report on corporate accounting scandals that also stresses company links to an incumbent Republican president, than a report on the same scandals that argues companies tend to provide large contributions to both political parties.

There is by now ample empirical evidence in support of the assumption that people prefer to consume stories that are consistent with their beliefs. Mullainathan and Shleifer (2005), who base their model on a similar assumption, cite research by Bartlett (1932) where people remember better such stories. A celebrated paper by Lord et al. (1979, and subsequent research on "confirmatory bias" shows that people tend to interpret ambiguous data as supportive of their prior beliefs, as well as to find more credible data that is consistent with their priors (see Matthew Rabin and Joel Schrag, 1999, and the references cited therein).[11] The key point in our model is that the relative weights that viewers put on "truth" and ideology depend on what extent news are based on verifiable information. In other words, viewers only value ideological reports when the truth is not fully verifiable; when the truth is incontrovertible, they accept it.[12]

To simplify, one can normalize $\tilde{\theta} = 0$. Then preferences can be rewritten as

$$U_{vf} = [\theta_f - (1-\lambda)\theta_v]^2 + \xi_v, \tag{2}$$

where $\xi_v \equiv \lambda(1-\lambda)\theta_v^2$. Note that ξ_v is simply a viewer "fixed effect" that does not affect the relative valuation of firms with different locations.

One aspect of the preferences in (2) is worth noting here. On the one hand, dispersion in θ_v implies that our model behaves like any standard horizontal location model (e.g., Salop, 1979). Here people differ over which θ_f maximizes their utility. On the other hand, our model is like a standard vertical differentiation model because people prefer θ_f that are closer to the truth. The twist is that viewers have a combination of

10. One could describe a Bayesian model that provides more explicit microfoundations for this utility structure. In such a model, viewers receive information about a news event from two sources: (a) "prior" signals of information with heterogeneous mean across consumers and given precision p_v, and (b) reports from firms, that (may be unbiased, that is, mean equal to the truth, and) have exogenous variance p_f. Updating occurs in a standard Bayesian fashion, so that the mean of posterior beliefs resembles (1), where the weights assigned to prior beliefs and firms' information reports, λ and $(1-\lambda)$ respectively, depend on the precision of each source of information (see DeGroot, 1970).

11. Mullainathan and Shleifer also cite Graber (1984), and Klayman (1995) as providing evidence that people seek stories that confirm their prior beliefs.

12. Notice that the case where viewers place weight on ideology even when the truth is fully verifiable (the case of "fanatics") is a special case of this model, and is studied in application 5.1.

both location preferences and vertical preferences over what in the end is the same attribute.[13] Of course, the more verifiable information is, the more important the vertical attribute becomes.

Interpretation. A simple interpretation of the set up is that when individuals make a consumption decision their utility depends both on the report's informational content and the interpretation it carries. The root assumption of the model is that individuals particularly like those messages that are closest to their own ideology, but that this tendency is tempered by the extent to which the content of the piece of news they are watching is verifiable. In other words, a report by a media firm can be interpreted as providing some coaching on how to interpret the "truth" $\tilde{\theta}$ if you are of type θ_v, with this message being less and less useful the further away θ_f is from θ_v.

As an example of what we have in mind consider the news event "Bill Clinton's performance as president" and the news report "Bill Clinton lied concerning having had sex with an intern."[14] But what does this episode tell about his effectiveness as a president? At least two interpretations seem possible:

- "Bill Clinton may have had sex with an intern, but that is neither here nor there for assesing how good a president he is, particularly given that they had already investigated him for Whitewater and found nothing and this ridiculous line of personal questions would have never been allowed in France."
- "Bill Clinton lied under oath and it is well known that people who lie on one issue are likely to lie on other issues, and besides, these activities make him less effective as president given that he has less authority."

Our root assumption suggests that people who have Democratic leanings liked to hear the first interpretation, perhaps because they now had an argument to defend the President. On the other hand, conservatives probably did like the second interpretation, perhaps because they could use the line about how lying is a pattern and how important it is to have authority to be an effective president. In general, rather than choose any media firm to obtain information, individuals prefer to tune in to firms that produce an analysis of the news that is closer to their ideology.

13. When people value interpretation and have a dispersion of beliefs information is similar to a market for cars where each individual wants a different color, but all individuals prefer lighter colors (as they are more easily visible from afar).

14. Note that the verifiability of the report changed over time, particularly when President Clinton acknowledged the episode.

2.2 Media Firms

We now state the objectives of media firms. Firm f chooses θ_f to maximize its profits that are given by

$$\pi_f(\theta_f;\theta_1,\ldots,\theta_n) = P\cdot\eta_f(\theta_1,\ldots,\theta_n) - s,$$

where η_f is firm f's market share.[15] We assume that revenues only depend on market share (or "ratings"), and normalize P to 1 in what follows.[16]

Media owners are thus assumed to be non ideological. That is, firms care only about ratings; they neither have an intrinsic preference for truthful reporting nor do they have ideological tastes.[17] We relax both assumptions later.

There is a sunk entry cost s into the market, and the marginal cost of a news report is zero.

2.3 Timeline

The timing of actions is as follows:

1. A news event $\tilde{\theta} = 0$ takes place, and media firms observe it.
2. Media firms $f \in \{1, 2, \ldots\}$ decide whether to enter. To enter, a firm must sink cost $s \in [0, 1)$.
3. The N firms that enter sink s and report θ_f. That choice describes their "location".
4. Taking locations of firms $\{1, 2, \ldots, N\}$ as given, firms $\{N+1, N+2, \ldots\}$ simultaneously decide whether they sink cost s and enter. If they enter they choose their location θ_f.
5. Individuals make viewing decisions. Given locations, market shares are determined and the game ends.

For convenience, we make the following assumption.

15. θ_j can be interpreted as firm j's choice of "brand identity" that signifies how ideological or balanced a firm will be in its news reports. For example, NPR might be thought to provide generally balanced coverage, while Fox News may have a conservative identity.

16. Note that price competition is not relevant for non-excludable goods like broadcast TV and radio. For other forms of media, one might wonder what would happen if firms compete in prices. The standard effect of price competition in location games is to drive firms to differentiate their products. In this sense, its effect reinforces the entry-deterrence forces at work (described in Section 3.1).

17. Accounts of how ratings impact firm's decisions on what news to report abound. For example, Downie and Kaiser (2002) note that the future of a news director at a local television station "depends on his ability to preserve or improve those profits . . . News directors aren't fired for putting on lousy news programs, they're fired for getting lower ratings than their competitors—and in the television business, they are fired regularly."

Assumption 1: *If a last-stage entrant is indifferent between entering and remaining outside, then it enters.*

3. Market Equilibrium

We begin by characterizing equilibria with viewers that do not value truth. This is a useful benchmark because, as it turns out, equilibria when viewers do value truth are isomorphic.

In the rest of the paper, we use the following notation. θ_f denotes firm f's location after second-stage entry. Without loss of generality, let $\theta_1 \leq \theta_2 \leq \cdots \leq \theta_N$. Call vector $[\theta_1, \theta_2, \ldots, \theta_N]$ a *configuration of media firms*. Firm f's market share is denoted as η_f.

We can now derive two basic properties of market shares that follow directly from the uniform distribution of viewer tastes. The first result is due to Schmalensee (1978).

Result 1 (Market shares): *If $\theta_{f+1} > \theta_{f-1}$, then for all $\theta_f \in (\theta_{f-1}, \theta_{f+1})$, $\eta_f = \frac{\theta_{f+1} - \theta_{f-1}}{2\beta}$.*

That is, the market share of a firm located between two others does not depend on its location. Next, note that for firms θ_1 and θ_N which locate next to the extremes,

$$\eta_1 = \frac{1}{\beta}\left[\frac{\theta_1 + \theta_2}{2} - \left(\alpha - \frac{\beta}{2}\right)\right]$$

and

$$\eta_N = \frac{1}{\beta}\left[\left(\alpha + \frac{\beta}{2}\right) - \frac{\theta_{N-1} + \theta_N}{2}\right].$$

3.1 Equilibria When Viewers Do Not Care About Truth ($\lambda = 0$)

Any equilibrium configuration must satisfy two natural necessary conditions which are described below. Then, we state the main result of this section: these necessary conditions are also sufficient. However, because these conditions are not enough to pin down the exact equilibrium location of media firms, there will typically be multiple equilibria.

The first two necessary conditions imply the central tension in our model. On the one hand, media firms cannot locate too close to each other, else their market shares are not large enough to cover the sunk cost s. On the other hand, media firms cannot locate too far apart in equilibrium, else there is room for entry.

LEMMA 1 (Survival): *In any equilibrium with $N \geq 3$ and $\theta_{f+1} > \theta_f > \theta_{f-1}$, $\theta_{f+1} - \theta_{f-1} \geq 2s \cdot \beta$.*

LEMMA 2 (Entry deterrence 1): *In any equilibrium with $N \geq 2$, $\theta_f - \theta_{f-1} < 2s \cdot \beta$.*

As seen, taste dispersion, as measured by $\beta \in (0, 1]$, influences how close to each other media firms locate. When taste dispersion falls media firms tend to locate closer to each other. For one, with a smaller β more viewers are located in a given interval. For another, entry deterrence forces firms to do so in equilibrium—otherwise there would be room for profitable entry.

Entry deterrence yields two additional conditions. First, it implies that firms cannot mimic each other in equilibrium.

LEMMA 3 (Entry deterrence 2): *In any equilibrium with $N \geq 3$, $\theta_1 < \theta_2 < \cdots < \theta_N$.*

The intuition is simple: if two firms locate on the same spot, then their neighbours would need to locate far enough for both to capture a combined market share of at least $2s/\beta$—that is, at a distance of at least $4s/\beta$. But then there is room for profitable second-stage entry because an entrant would grab a market share of at least $2s$. Thus, firms must differentiate in equilibrium.

Last, entry deterrence in the second-stage implies the following necessary condition:

LEMMA 4 (Entry deterrence 3): *If $s \leq \frac{1}{2}$, then $\theta_1 = \alpha - \beta(\frac{1}{2} - s)$ and $\theta_N = \alpha + \beta(\frac{1}{2} - s)$.*

In other words, if 'extreme' media firms locate too close to the center of the taste distribution, then there is room for profitable second-stage entry. Note that second-stage entry implies that the "principle of minimum differentiation" does not operate: firms cannot bunch at the center of the distribution in equilibrium.

Proposition 1 states that *any* configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ that satisfies these necessary conditions can be sustained as the outcome of a subgame perfect equilibrium. That is, these conditions are also sufficient.

PROPOSITION 1 (Sufficient conditions for an equilibrium configuration): *Any configuration satisfying 'survival,' and the three entry deterrence conditions above can be sustained as the outcome of a subgame perfect equilibrium.*

Proof. See Appendix A. □

Proposition 1 can be used to derive a useful result. Specifically, consider a benchmark taste distribution where $\alpha = 0$ (the distribution is centered on the truth) and $\beta = 1$. Lemma 5 shows that the set of equilibria in this case is isomorphic to the set of equilibria of the general case where the distribution of tastes is centered anywhere on the line, $\alpha = \hat{\alpha} \neq 0$, or viewers are bunched closer together, $\beta = \hat{\beta} \in (0, 1)$.

Lemma 5: *$[\theta_1, \theta_2, \ldots, \theta_N]$ is an equilibrium configuration in the market with $\alpha = 0$ and $\beta = 1$ if and only if $[\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_N]$ is an equilibrium configuration in the market with either $\alpha = \hat{\alpha} \neq 0$ or $\beta = \hat{\beta} < 1$, with $\hat{\theta}_f \equiv \hat{\alpha} + \hat{\beta}\theta_f$ for all f.*

Proof. Proposition 1 implies that we just have to check that configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ satisfies the four conditions (Survival; Entry deterrence conditions 1, 2, and 3) if and only if $[\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_N]$ does.

Survival: $\theta_{f+1} - \theta_{f-1} \geq 2s$ iff $\hat{\alpha} + \hat{\beta}\theta_{f+1} - \hat{\alpha} - \hat{\beta}\theta_{f-1} = \hat{\beta}(\theta_{f+1} - \theta_{f-1}) \geq 2s \cdot \hat{\beta}$.

Entry deterrence 1: $\theta_f - \theta_{f-1} < 2s$ iff $\hat{\alpha} + \hat{\beta}\theta_f - \hat{\alpha} - \hat{\beta}\theta_{f-1} = \hat{\beta}(\theta_f - \theta_{f-1}) < 2s \cdot \hat{\beta}$; and $\theta_1 \leq -\frac{1}{2} + s$ iff $\hat{\alpha} + \hat{\beta}\theta_1 \leq \hat{\alpha} + \hat{\beta}(-\frac{1}{2} + s)$ (the equivalence for θ_N is analogous)

Entry deterrence 2: $\theta_1 < \theta_2 < \cdots < \theta_N$ iff $\hat{\alpha} + \hat{\beta}\theta_1 < \hat{\alpha} + \hat{\beta}\theta_2 < \cdots < \hat{\alpha} + \hat{\beta}\theta_N$.

Entry deterrence 3: It follows directly from entry deterrence 1. □

3.2 Equilibria When Viewers Value Truth ($\lambda \neq 0$)

Recall, from equation (2), that a viewer with taste parameter θ_v who watches a media firm located at θ_f gets utility

$$[\theta_f - (1 - \lambda)\theta_v]^2 + \xi_v.$$

Because ξ_v is a fixed effect, we ignore it in what follows. Moreover, defining $\theta'_v \equiv (1 - \lambda)\theta_v$, one can redefine each viewer's utility function as

$$(\theta_f - \theta'_v)^2,$$

with viewer preferences uniformly distributed on the interval $[(1 - \lambda) \times (\alpha - \frac{\beta}{2}), (1 - \lambda)(\alpha + \frac{\beta}{2})]$.

What is the effect of the taste for "truth," as parametrized by λ? Technically, parameter λ compresses the distribution, an effect very similar to parameter β. Nevertheless, while the effect on the distribution is similar, the economic interpretation is different. β describes how homogeneous are consumer preferences, whereas λ describes how ideological they are.

In Appendix B, we show that when viewers value truth, the analogues of the four Lemmas (survival, and the entry-deterrence conditions 1–3) are also necessary and sufficient. Thus, any model with $\lambda \neq 0$ is just a transformation of the model with $\lambda = 0$. And, the following lemma (the analogue of Lemma 5) holds:

Lemma 6: *$[\theta_1, \theta, \ldots, \theta_N]$ is an equilibrium configuration of media firms when $\lambda = 0$, with α and β taking arbitrary values if and only if $(1 - \lambda)[\theta_1, \theta_2, \ldots, \theta_N] \equiv [\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_N]$ is an equilibrium configuration in the game with $\lambda \in (0, 1)$.*

Proof. See Appendix B. □

3.3 Taking Stock

Before proceding it is useful to summarize what we have done so far.

First, parameters α, β, and λ completely describe preferences. Moreover, once the entry cost s is known, the complete set of equilibria is determined by the four necessary and sufficient conditions (Proposition 1 and Lemmas 1–4 when $\lambda = 0$; and their analogues when $\lambda \in (0, 1)$). Hence, we can speak of a 'market' $(\alpha, \beta, \lambda, s)$ and there is an equilibrium set-valued function which returns the set of equilibrium configurations for each market $(\alpha, \beta, \lambda, s)$.

We also know from Lemmas 5 and 6 that the set of equilibria of market $(\alpha, \beta, \lambda, s)$ is isomorphic to that of market $(0, \frac{1}{2}, 0, s)$. This is useful, because for a given s one can obtain the set of equilibria for an arbitrary market just from a linear transformation of each equilibrium configuration of the market $(0, \frac{1}{2}, 0, s)$. We will use this in what follows.

4. Implications

4.1 Bias and Diversity

One can now introduce measures of bias and diversity of opinion. To do so, it is useful to add the following notation. Consider an arbitrary configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ in a market $(\alpha, \beta, \lambda, s)$ (note that this is not necessarily an equilibrium configuration). Given this arbitrary configuration, market shares are determined by result 1 and we denote them by $[\eta_1, \eta_2, \ldots, \eta_N]$. Then we define the following:

Definition 1: *$\bar{\theta}_J \equiv \frac{1}{N} \sum_j \theta_j$ is the average firm location given configuration $[\theta_1, \theta_2, \ldots, \theta_N]$. Next $\bar{\theta}_V \equiv \sum_f \eta_f \theta_f$ is the average broadcast watched by viewers given configuration $[\theta_1, \theta_2, \ldots, \theta_N]$.*

4.1.1 Bias

Perhaps the most natural measure of bias comes from the following thought experiment: given configuration $[\theta_1, \theta_2, \ldots, \theta_N]$, what is the expected bias if we pick a broadcast at random? It equals the bias of the average broadcast, viz.

$$\mathcal{B}_F = \frac{1}{N}\sum_f |\theta_f|, \tag{3}$$

which henceforth we will call *firm bias* (recall that 'truth' is arbitrarily located at 0).[18]

We can now use these measures to obtain some general results about how equilibrium bias depends on taste parameters, α, β, and λ. To proceed, consider a configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ that is an equilibrium in market $(0, \frac{1}{2}, 0, s)$. From Lemmas 5 and 6 we know that for such an equilibrium configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ in market $(0, \frac{1}{2}, 0, s)$ there exists an equilibrium configuration $[\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_N] = (1-\lambda)[\alpha + \beta\theta_1, \alpha + \beta\theta_2, \ldots, \alpha + \beta\theta_N]$ in market $(\alpha, \beta, \lambda, s)$. This allows us to study the change in bias as parameters α, β, and λ change. Of course, multiplicity of equilibria implies that all our statements are about the set of equilibria. Thus, we can make statements like "as parameters α, β or λ change, bias (in all equivalent equilibria) change uniformly in a given direction," but we cannot say much about how the particular equilibria of a given market would change after parameters change—multiplicity does not allow it.

Specifically, consider the measure of firm bias:

$$\begin{aligned}\mathcal{B}_F(\alpha, \beta, \lambda) &= \frac{1}{N}\sum_f |(1-\lambda)(\alpha + \beta\theta_f)| \\ &= \frac{1}{N}(1-\lambda)\left[\sum_{\alpha+\beta\theta_f \geq 0}(\alpha + \beta\theta_f) - \sum_{\alpha+\beta\theta_f < 0}(\alpha + \beta\theta_f)\right].\end{aligned}$$

This immediately gives the following result:[19]

Result 2: *Bias falls as viewers value truth more intensely. It disappears when $\lambda = 1$, that is, when viewers only value "truth."*

4.1.2 Diversity

Diversity of opinion differs from bias in one key respect: it does not depend on where "truth" is located. The reason is that diversity only

18. A related measure comes from the following thought experiment: given allocation $[\theta_1, \theta_2, \ldots, \theta_N]$ what is the expected bias viewed by a viewer picked at random? For a given configuration market shares η_j can be straightforwardly computed, and the expected bias is $\mathcal{B}_V = \sum_f \eta_f |\theta_f|$, which one can refer to as "viewer bias."

19. A similar result holds if one considers the measure of viewer bias.

has to do with the horizontal dimension of preferences and is affected by "truth" only insofar as a preference for it affects the equilibrium location of media firms. A natural measure of diversity is the variance of reports by firms,[20] viz.

$$\mathcal{D}_F = \frac{1}{N}\sum_f (\theta_f - \bar{\theta}_F)^2. \tag{4}$$

Another measure of diversity is useful when analyzing the media industry. A source of concern of advocacy groups is that there will be a suppression of opinions, particularly when few persons own the media. In such a case, it is natural to consider a measure of the *range of opinions* that can be seen in a given market, captured by the difference between the locations of the "most extreme" media firms, viz.

$$\Delta = \theta_N - \theta_1. \tag{5}$$

4.1.3 Results

Because diversity measures are not affected by the location of "truth," this implies, formally, that $\mathcal{D}_F$ and Δ do not depend on α, but only on β and λ. Consider firm diversity:

$$\begin{aligned}\mathcal{D}_F(\alpha, \beta, \lambda) &= \frac{1}{N}\sum_f [(1-\lambda)(\alpha + \beta\theta_f) - (1-\lambda)(\alpha + \beta\bar{\theta}_F]^2 \\ &= \frac{1}{N}(1-\lambda)^2\beta^2 \sum_f (\theta_f - \bar{\theta}_F)^2 \\ &= (1-\lambda)^2\beta^2\mathcal{D}_F\left(0, \frac{1}{2}, 0\right).\end{aligned}$$

and for the range of opinions:[21]

$$\Delta(\alpha, \beta, \lambda) = (1-\lambda)\beta\Delta\left(0, \frac{1}{2}, 0\right).$$

Thus, regardless of how ones measures diversity, the following results follow:

Result 3: *Diversity does not depend on the average bias α of the distribution of viewer tastes.*

20. Relatedly, one can compute the variance of the reports viewed by a random viewer, $\mathcal{D}_V = \sum_f \eta_f(\theta_f - \bar{\theta}_V)^2$.

21. Proof: $\Delta(\alpha, \beta, \lambda) = (1-\lambda)(\alpha + \beta\theta_N) - (1-\lambda)(\alpha + \beta\theta_1) = (1-\lambda)\beta(\theta_N - \theta_1) = (1-\lambda)\beta\Delta(0, \frac{1}{2}, 0)$.

Result 4: *Diversity falls as viewers value truth more intensely or they are less diverse (as measured by parameter β).*

Together with the earlier result (1), this highlights a tradeoff between unbiasedness and diversity in the media: one would neither like media firms to always offer the same reports (lack of diversity) nor always different reports (bias).

4.2 Competition and Bias

We now study how competition affects bias.[22] First, we show that average firm bias does not disappear when entry is costless ($s = 0$) and competition is maximal. Next we explain why this result also holds as $s > 0$.

4.2.1 A Market with Costless Entry

As in a standard IO model of this type, consumer preferences drive firm location here. But the distribution of preferences will not be replicated in the market because sunk costs s prevent each viewer from getting her preferred report. In contrast, in markets $(\alpha, \beta, \lambda, 0)$ there will be a continuum of firms in equilibrium, and every viewer receives her most preferred report—media firms perfectly follow and replicate preferences. The following proposition characterizes bias in a market with no entry cost:

Proposition 2 (Equilibrium bias with costless entry): *In market* $(\alpha, \beta, \lambda, 0)$

$$\mathcal{B}(\alpha, \beta, \lambda, 0) = \begin{cases} \alpha(1-\lambda) & \text{if } \alpha - \beta/2 \geq 0 \\ -\alpha(1-\lambda) & \text{if } \alpha + \beta/2 \leq 0 \\ \dfrac{(1-\lambda)}{2\beta}(2\alpha^2 + \beta^2/2) & \text{if } \alpha - \beta/2 < 0 < \alpha + \beta/2. \end{cases}$$

Proof. It follows from straightforward computations using the uniform distribution of preferences. □

$\alpha(1-\lambda)$ is equal to the preference of the average viewer. Thus the proposition says that when preferences are such that all viewers are to the left or the right of "truth," and there are no entry costs, bias equals the preference of the average viewer and viewer diversity, as measured by β, does not affect bias. The reason is that in this case, a smaller β reduces bias for those located far away from "truth," but tends to drive

22. In a pure location model like this where prices do not play any role, "competition" is equivalent to "number of firms."

away from "truth" those who are nearer to it: both effects cancel out exactly. When viewers are located on both sides of the "truth," reducing β reduces bias because it tends to concentrate viewers towards "truth." (Any increase of α in absolute value will, not surprisingly, increase equilibrium bias). Note that in a benchmark market $(0, 1, 0, 0)$, where viewers do not care about truth, average firm bias equals $\frac{1}{4}$.

These results have the following central implication about the impact of competition on bias:

Corollary 1: *Costless entry does not eliminate bias.*

The reason is that firms' reports will be different in a world where news are not fully verifiable and consumers value opinion. If not, there will be profitable entry opportunities. Thus, bias does not disappear even when entry is not only free but costless.

4.2.2 Bias When Entry is Costly

The direct consequence of a nonnegligible entry cost is that most viewers will not get their most preferred broadcast. But, an additional implication of $s > 0$ is that multiplicity of equilibria will emerge. Multiplicity implies that one ought to study upper and lower bounds to bias and study how it varies as s varies in [0, 1]. Such an exploration shows that firm bias is always strictly positive and does not disappear as s falls and N grows. In fact, it can be shown that in the limit both the upper and lower bounds to bias converge to $\frac{1}{4}$, which equals bias when $s = 0$.

Appendix C characterizes competition with $s > 0$ by studying the relation between the number of firms N and entry costs s in equilibrium. We then derive a lower bound on average firm bias for any number of firms N, and show that it does not disappear as s falls and N grows. The economics are as follows. On the one hand, a lower entry cost s allows firms to move toward the center, because each needs less market share to cover the entry cost s. This tends to reduce bias. On the other hand, a lower entry cost pulls θ_1 and θ_N further to the extremes. To prevent third stage entry in equilibrium, more firms enter at the extremes. This tends to increase bias. As shown in the appendix, neither effect dominates. This discussion can be summarized in the following result:

Result 5: *Bias does not disappear as s falls and competition grows.*

Diversity, on the other hand, increases as entry costs fall. Thus in markets with smaller entry costs extreme viewers receive more attention. The reason is simple: as s falls, the entry deterrence conditions becomes stricter because $\frac{1}{2}(1 - s)$ falls. Then some firms locate farther to the extremes to prevent entry.

The main insight behind these results is that a change in the number of firms neither changes the verifiability of news, nor the heterogeneity in consumer tastes. Instead, its primary effect is to "fill in the gaps" in the market so that more viewers now receive their preferred report. Thus, bias does not change unless accompanied by a change in verifiability. At the same time and for the same reason, more extreme voices will be heard as s falls and competition increases. Thus, competition is good for diversity.[23]

Remark 1: Note that the same holds, *mutatis mutandis*, for larger markets.

5. Applications

We now use our model to address some issues of frequent interest about the media industry.

5.1 Fanatic, Ideological and Upright Viewers

Section 2 described how consumer preferences–specifically, the weight that consumers attach to truthful reporting—are a function of the verifiability of news. In this application, we examine viewer preferences where λ is exogenous, that is, it does not depend on the characteristic (verifiability) of news. The model can give straightforward definitions to three types of viewer preferences—fanatical, ideological and upright—and examine their consequences on equilibrium bias and diversity.

First, consider a market where $\lambda = \beta = 0$ and thus viewers are both uninterested in the truth and display no diversity in their preferences—in other words, a market of *fanatics*. Second, consider a market where $\lambda = 0$, $\beta > 0$, that is, viewers are uninterested in "truth" but still display diversity in their opinions. One might refer to this as a market for ideologues, because viewers behave as if the news in question were unverifiable. Last, consider a market where viewers only care about the "truth," that is, $\lambda = 1$ and all viewers are *upright*. The following results follow:

Result 6: *In a market with ideologues bias and diversity are maximal.*

Result 7: *In a market with fanatics bias equals α, but there is no diversity.*

Result 8: *In a market with upright viewers bias disappears but there is no diversity.*

23. Consistent with this result is the increase in diversity brought about by cable and the Internet. As *The Economist* noted when ABC's Peter Jennings passed away: "Mr Jennings's success at ABC was set against the decline not just of network news (the average age of ABC's audience is now 60) but also of the journalism he enjoyed. Impartiality has given way to the stridency of Fox News and the Internet bloggers." ("Style and Substance," August 11th, 2005).

A standard complaint about some media markets is that viewers do not get a wide enough spectrum of opinion and it appears that "voices are suppressed" by firms. The previous results suggest a reverse causality behind this empirical observation. For example, in either markets with fanatics or those with upright viewers, viewers do not have differences of opinion and diversity offered by media firms is restrained because it is not profitable. In other words, "viewers get what they deserve." In contrast, although reports are also biased when viewers are ideologues, media firms do offer a diverse range of opinion.

These cases also highlight a basic tension between bias and diversity.[24] If all media outlets always offered exactly the same report (e.g., upright viewers), there would be no diversity in the press. On the other hand, if media outlets always offered different reports (even on the same issues and where news was verifiable, as with a market of ideologues), then one can argue that the press displays bias. Last, a market of fanatics displays both bias and a lack of diversity.

An example of news for fanatics is news concerning an enemy nation. In extreme cases, for example during war, a story concerning a flying ace, or an act of bravery, would be less likely to be scrutinized for accuracy. And it would be even more unlikely that the news story concerns an enemy flying ace, or acts of bravery by those behind enemy lines. This is consistent with the findings in Herman (1985). He compares the coverage in the *New York Times* of the 1984 elections in El Salvador—a country with official US support—against Nicaragua, an official enemy of the United States. During 1984, there were 28 articles on the El Salvador elections and 21 on those in Nicaragua. The articles on El Salvador emphasized democratic aspects of the process while those on Nicaragua did the opposite. For example, human rights violations in Nicaragua were emphasized, when in fact they were more severe in El Salvador.

As an example of news reporting for ideologues, one might look at news reports on the virtues of free market reforms in Latin America. Or, reports on a purely demagogical piece of information, such as "a day in the life of a local football star"—where viewers are only interested in the local athlete, even if athletes from other towns or countries are far

24. As it stands, the model yields a tension between bias and diversity that may be argued to be of little consequences because, ultimately, firms produce what consumers want. That is, bias arises in equilibrium when people do not value the truth; but, if they don't, then why is the truth desirable? However, this apparent lack of tension is simply a consequences of not analyzing more fully how information is used by consumers. In a more developed model, where one specified the use of information (for example, its use in voting or in social debates), the tension would arise naturally. Relatedly, Della Vigna and Kaplan (2005) is one of the few studies that directly examines the impact of media reports on outcomes (in their case, voting).

worthier of glorification. The same logic explains why news coverage is invariably "local."

An extension of this section is to allow some weight on the "truth" so that viewers behave as if news were somewhat verifiable. In that case, media coverage will vary according to the characteristics of the news (and in turn consumer ideologies). As a recent example, discussed in earlier versions of Mullainathan and Shleifer (2005), consider the reporting on the Iverson case (a professional basketball player investigated for violent behavior) and the Summers-West dispute (whereby Harvard President Larry Summers criticised African American Professor Cornel West for grade inflation). Reporting on the Iverson case was mistaken (in that it presumed guilt) but uniform, whereas reporting on the Summers-West dispute differed across news outlets in ideologically predictable ways. One possibility is that the more balanced reporting in the second case was a consequence of the involvement of ideological public figures (Reverend Al Sharpton and Jesse Jackson became involved on behalf of Cornel West). But, the model presented here suggests that the difference in coverage could be traced simply to differences in the distribution of viewer beliefs in the two cases: whereas most people's priors in the Iverson case is that professional athletes misbehave, in the Summers-West case there is a left–right divide on priors wherein people on the left are less concerned about grade inflation than about diversity, and people on the right are more focused on academic excellence.

5.2 Unpopular Truth and Bias

Some observers claim that the media in general displays bias in reporting, rather than simply a certain media outlet. But, interestingly, while some claim that the media has a conservative bias, others argue that the bias is liberal.[25] As an example of this particular case, consider the argument by Goldberg (2002) concerning the reports on the homeless in the media: "In the 1980s, I started noticing that the homeless people we showed on the news didn't look very much like the homeless people I was tripping over on the sidewalk.[. . .] They looked like us—they *were* like us! On NBC, Tom Brokaw said that the homeless are 'people you know'."[26] The "liberal" ideology behind this type of biased reporting, at

25. Lee and Solomon (1992) is an example of the first, while Goldberg (2002) is an example of the second.

26. Goldberg goes on to say: "Before I started showing the real homeless on the evening news, I made my bosses very happy by going to a soup kitchen in New York where I found a very atypical, blond-haired, blue eyed family."

Luttmer (2000) presents survey evidence showing that people support welfare more when welfare recipients have a similar racial origin to the respondents. Alesina et al. (1999) show that the share of spending on public goods in US cities is inversely related to city's ethnic fragmentation.

least as expressed in Goldberg (2002), is that anybody could become one of the homeless if luck turns sufficiently against them. A liberal slant to the news reports (even when the "truth" about the homeless may be quite different) is therefore more conducive to government policies in support of the homeless.

To assess claims like these, we can define a situation when truth is "unpopular" as the case where $\alpha < 0$ or $\alpha > 0$, that is where a majority of viewers believe otherwise. (In extreme versions of this, one of the ideological extremes is located nearest to the "truth," that is when either $\alpha < 0$ and $\alpha + \beta/2 \leq 0$ or $\alpha > 0$ and $\alpha - \beta/2 \geq 0$. Then, result 9 follows:

RESULT 9 (The incentive to suppress unpopular truth in a free press): *Suppose $\alpha \neq 0$. Then bias increases with $|\alpha|$.*

This result says that bias is greater as the truth becomes more unpopular. As an example, suppose that the most careful scientific study revealed that more liberal gun laws reduce crime. The model suggests that reporting by a free press on such a news event is likely to be different than on events that are closer to the ideology of the median viewer. In other words, even though the truth may not be in the middle, the news report generally is.

EXAMPLE: Consider a market $(\alpha, 1, \frac{1}{2}, \frac{1}{4})$. Because $s = \frac{1}{4}$, it follows that $N = 3$. When $\alpha = 0$ the maximum bias occurs when firms are located at $-\frac{1}{8}, \frac{1}{8} - \varepsilon$, and $\frac{1}{8}$, so that $\mathcal{B}_F = \frac{1}{8} - \frac{\varepsilon}{3}$. In contrast, if $\alpha = \frac{1}{2}$, then the left-extreme of the distribution is at 0 and all viewers are to the right of "truth." Now the equilibrium that maximizes bias is when firms locate at $\frac{1}{8}, \frac{3}{8} - \varepsilon$, and $\frac{3}{8}$, and then $\mathcal{B}_F = \frac{7}{24} - \frac{\varepsilon}{3}$.

Why should there be more biased reporting when the truth is at an ideological extreme? When $\alpha = 0$ viewers distribute uniformly on $[-\frac{1}{4}, \frac{1}{4}]$ and no viewer is located more than $\frac{1}{4}$ away from 0. In contrast, when $\alpha = \frac{1}{2}$, viewers distribute on $[0, \frac{1}{2}]$ and half of them have ideal points that are more than $\frac{1}{4}$ away from "truth." To cater to these viewers, the reports of some firms will be disproportionately to the right of the truth. □

An interesting implication is that a free press would tend to bias reports if the truth on a piece of news happened to be at an ideological extreme—regardless of which extreme it was. In other words, the incentive of media firms to bias reports does not stem from any ideological sympathy. Instead, bias results purely from the assumption that firms are profit-maximizing that is, they only care about ratings and not intrinsically where the truth is. Consequently, because the median viewer is located far away from where the truth happens to be, so will news reports by some firms.

Goldberg acknowledges the role of profit-maximization behind the tendency of the media to bias news coverage: "And that's exactly why they are in television so much, even if they made up only a tiny fraction of the homeless population in America. In a word, we put them on TV for the reason television people do almost everything—ratings (it). Ratings are the God that network executives and their acolytes worship. We know who our viewers are." In terms of our model, the news (the exact composition of the homeless population, taken as a proxy for probability that any individual viewer becomes one of the homeless) is not verifiable. Thus, there is still room for the networks to tailor the news to cater to its (liberal) viewers, even if the truth happened to coincide with the beliefs of people at one end of the ideological spectrum (the conservatives). The key point, however, is that if the truth was at the opposite (liberal) extreme, the media's position would end up being biased in the opposite direction—that is, to be more conservative than the truth.

This result also highlights the differences between viewers and voters on media coverage. Indeed, one example of truth suppression may occur in developing countries with unequal distribution of income. In those countries ratings by poor people do not matter much because these groups are not interesting for advertisers. Thus the relevant audience may be overwhelmingly composed of higher income individuals whose political preferences may be uniformly biased towards the right. Our model predicts that in those cases media firms will optimally bias their reports and suppress truths unpopular for higher income groups.[27]

5.3 Is Owner Ideology Relevant in a Free Market?

A standard concern with media organizations is that they may serve as vehicles for their owners to express their own ideology, or that ideologies common to rich media owners can get more airtime than ideologies that more fully reflect the views in the population. Because owners of media companies tend to maintain high profiles and often identify with specific causes, this is used to explain media bias.[28]

27. A similar point is made in Stromberg (2004). In his model, an increasing-returns-to-scale cost structure and advertiser financing results in media outlets catering to interests of large groups and groups that are valuable to advertisers. He examines how the resulting news bias introduces a bias in public policy.

28. The examples of Ted Turner identified with liberal causes and of Rupert Murdoch identified with conservative ideas are often mentioned because they are the owners of the two dominant cable news networks in the United States. Indeed, in describing the operation of his company's newspapers, Murdoch is on record as saying that he is in

One can model a preference for ideology in at least two ways: on the one hand, the ideological owner may want to ensure that his particular view is aired, regardless of the rating it attains. On the other hand, an ideological owner may want to strategically influence *viewer* bias towards his preference—he cares that viewers are exposed to news as close as possible to his bias. The latter is the type of influence we will study in this application.[29]

We begin by considering the impact of owner ideology on media bias in a benchmark case: when $s = 0$. In such a market, all viewers receive their preferred broadcast and owner ideology *cannot* play any role because in equilibrium no owner can induce any viewer to watch something that is not exactly her most preferred broadcast. In that case, bias and diversity just reflect the underlying distribution of viewer tastes. This clarifies that owner ideology may play a role only because of sunk costs because then viewers may watch firms that do not air their most preferred broadcast. One can state this in the following result:

Result 10 (Possibility of owner ideology affecting media bias): *Owner ideology may matter only because of sunk entry costs.*

If $s = 0$ any media firm that gives preference to its owner's ideology will be watched only by viewers who have exactly that ideology. Hence media owners cannot influence what viewers watch in equilibrium.

Before going to the case of $s > 0$ it is useful to consider the other case where owner ideology cannot play any role. The next proposition shows that some ideological *viewers* are necessary for owner ideology to matter.

Result 11 (Owner ideology matters only if consumers have ideologies themselves): *If $\lambda = 1$ (all viewers are upright) then ideological owners cannot survive in equilibrium.*

When $\lambda = 1$ any firm that deviates from the truth gets no customers, hence makes losses. So, in any equilibrium, a firm's location choice will not be influenced by the ideology of its owner. For the same reason, as λ grows owner ideology must become less important *ceteris paribus*.

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charge of editorial policy: "The buck stops at my desk. My editors have input but I make final decisions."

29. Another recent paper that studies the impact of owner ideology in the media is Balan, DeGraba, and Wickelgren (2004). One focus of their work is the interaction between owners of different ideologies: for example, if a conservative owner starts buying media, this may trigger a response by liberal owners to acquire media.

Consider now $s > 0$, and assume initially that ideological owners cannot lose money.[30] Extend the model to include a group of N_I "ideological" firms in addition to the non-ideological firms. Describe owner ideologies by a vector $(\rho_1, \ldots, \rho_{N_I})$. These firms may be willing to sacrifice profits but not to lose money, and they want to bring bias in the market as close as possible to their ideology ρ_i. Otherwise, the game is the same as before.

It is straightforward to see that Lemmas A.2, A.3, A.6 still are necessary for any configuration to be an equilibrium. Essentially, ideological owners cannot change the fact that in any equilibrium media firms must be far enough to cover their sunk entry cost, but close enough to make further entry unprofitable; and they cannot mimic each other.

Now consider an equilibrium configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ in the model without ideological firms, and then substitute an ideological owner ρ_j for a non-ideological media firm located at θ_i. Is the configuration still an equilibrium? In general, it will not be, for the ideological owner will want to deviate to increase bias towards his preference. Now clearly any deviation to locate between firms other than θ_{i-1} and θ_{i+1} leaves losses. But in general, there will be multiple locations between θ_{i-1} and θ_{i+1} such that the ideological firm captures exactly the same rating. Now if ρ_j is not in the interval $(\theta_{i-1}, \theta_{i+1})$, it is easy to see that the firm's optimal deviation, call it $\tilde{\theta}_i$, is to locate as close as possible to θ_{i-1} if $\rho_j \le \theta_{i-1}$; or as close as possible to θ_{i+1} if $\rho_j \ge \theta_{i-1}$, subject to the constraint of not making second-stage entry profitable (we are examining deviations assuming optimal play in the third stage). If, on the contrary, $\rho_j \in (\theta_{i-1}, \theta_{i+1})$, then the optimal deviation is to locate as close to ρ_j as long as second-stage entry is not profitable. Now configuration $[\theta_1, \theta_2, \ldots, \theta_{i-1}, \tilde{\theta}_i, \theta_{i+1}, \ldots, \theta_N]$ can be sustained as a subgame perfect equilibrium provided it satisfies Lemmas 1–3. This reasoning leads to the following result:

Result 12: *In any equilibrium with ideological owners who cannot lose money, they locate as close to their preference as entry deterrence will admit.*

It follows that the size of the effect of owner ideology on bias is *local* in the sense that it depends on s (or, equivalently, on the size of the market). If the cost is large relative to market size then ideological owners can affect bias substantially. But as the market becomes large relative to s this effect is small. The following example suggests how owner ideology can affect bias.

30. This is still a deviation from the profit maximization assumption—ideological owners may prefer a location that yields lower profits but still meets the self-financing constraint.

Example: Consider again a market where $\alpha = 0, \beta = 1, \lambda = \frac{1}{2}$, and $s = \frac{1}{4}$, so that $N^* = 3$ in equilibrium. We know that $\theta_1 = -\frac{1}{8}$ and $\theta_3 = \frac{1}{8}$. Moreover, $\inf \eta_1 = \inf \eta_3 = \frac{1}{2}$ and $\eta_2 = \frac{\theta_3 - \theta_1}{2} = \frac{1}{8}$ for any θ_2 in $[-\frac{1}{8}, \frac{1}{8}]$, therefore firm 2 is indifferent between all such locations. Last, given any such θ_2, firms 1 and 3 will not deviate and there will be no entry.

Because θ_2 can lie anywhere between θ_1 and θ_3 in an equilibrium with no ideological owners, it follows that the ideology of firm 2's owner can pin down the specific choice of location by that firm, thus influencing bias and diversity as measured by $\mathcal{D}_F$ and $\mathcal{D}_V$. □

The possibility that owner ideology may affect bias follows from the fact that conditions Survival (Lemma 1) and Entry Deterrence (Lemma 2) need not be binding in an equilibrium with non-ideological firms, and therefore the locations of firms are not uniquely pinned down in equilibrium. The resulting multiplicity of equilibria creates room for owners' ideologies to influence news reports. The reason is that, once competitors' locations are fixed in an equilibrium, a firm can typically choose different "locations" for its news reports that generate equivalent profits but cater to different ideologies. This also allows owner ideology to influence news coverage in equilibrium.

Does competition somehow discipline ideological owners? Our result indeed suggests that if there are many firms in the market in equilibrium, owner bias will not be very relevant. But, competition restrains owner ideology not by forcing them to report the truth (except when $\lambda = 1$) and thereby restraining owner ideology, but rather, by making it redundant: with more firms in the market, there is already greater "ideological variety" in news reports, hence the ideology of media owners will be less relevant. The discussion here also emphasizes the central role of fixed costs. When the market is large relative to s, then owner ideology is less important because then the tastes of viewers are replicated more closely by the location of other firms. On the other hand, owner ideology can play a greater role in small markets because when s is large relative to the size of the market, catering closely to the tastes of most viewers is neither feasible nor necessary.

Last, the distribution of viewer ideologies also constrain owners with ideological tastes, as seen here. In this context, Shawcross (1997, p. 411) makes it clear that Rupert Murdoch sees ideological differentiation as a business opportunity. He states that "[Murdoch] had long made it clear that he thought the opportunity to challenge CNN lay in offering more conservative content. He believed that audiences were falling because of the "growing disconnect" between news broadcasters and their viewers. He thought that a more conservative news channel would attract more viewers. He said that while 45% of the

American public described itself as conservative, only 5% of journalists did."[31]

We conclude this section by briefly examining the following question: what happens if ideological owners are willing to lose money to peddle their ideology? Formally, the willingness to lose money is equivalent to having a lower sunk cost s. To simplify the discussion take the extreme case where ideological owners have deep pockets, whch is equivalent to $s = 0$. It is apparent that in that case the following occurs:

Result 13: *If ideological owner i has deep pockets it enters in equilibrium and locates exactly on* ρ_i.

Any other location cannot be an equilibrium, because the owner with deep pockets would increase his payoff by deviating and locating exactly on ρ_i. But other than that, little would change compared with the analysis when owners are unprincipled. Again, the extent to which owner ideology can affect bias is largely determined by viewer taste dispersion and entry cost s.

In fact, assuming many ideological owners with deep pockets are willing to lose money implies:

Result 14: *If there are many ideological owners with different tastes and deep pockets then owner ideology is close to irrelevant.*

The intuition should be clear from the earlier discussion: if there are many ideological owners with deep pockets, the model is similar to having many firms with $s = 0$—in which case, as we have seen, owner ideology is irrelevant.

Cross-ownership and the suppression of diversity. A related concern is that allowing cross-ownership of media firms will allow some owners excessive control over which news are aired and which are suppressed. For example, in the late 1980s twelve large conglomerates controlled almost half of the US newspaper circulation, and many of them were also involved in broadcasting, cable or other media.[32] In a paper which is often cited in journalism, Gormley (1977) reports evidence that common ownership of newspaper and a television station in the same city contributes to news homogeneity in the sense of reducing the number of stories available to the public. Might cross ownership amplify the impact of an owner's ideology by allowing it to suppress voices?

Certain considerations that impact cross-ownership are not considered here. For example, one central question has to do with whether

31. To compete with CNN, he had once said, "We may have to develop another expert source on Cuba other than CNN's bureau chief, Fidel Castro."

32. Busterna (1988), cited in Severin and Tankard (1992).

different media outlets are substitutes or complements in consumption (see Waldfogel, 2002). At the same time, the simple model developed here allows one to shed some light on other issues: how does competition impact ideological owners who own multiple media outlets? How is the answer affected by whether cross-owned firms enjoyed economies of scale or scope as well?

To begin, one might consider two plausible reasons why cross ownership leads to fewer voices. First, ideological owners may locate firms nearer to their own ideology. Second, cross-owned firms may enjoy economies of scale or scope. Our model suggests important caveats to each of these arguments, and the central role of fixed costs in any such debate.

Note that owning more than one firm just allows its owner to move them towards her ideology, but only in as much it leaves no room for entry: the ability to do so is constrained again by s. Thus, cross ownership *per se* does not give much more room to peddle the owner's ideology, for the simple reason that suppressing a voice leaves a market voice that can be filled by an entrant.

Next consider scale or scope economies. Formally, these are equivalent to ideological owners that do not mind losing money. Thus consider the extreme case where these are so large that they imply $s = 0$. As we have seen in the previous section, in that case the ideological owner would locate at least one of her firms exacly on her ideological preference. But the second firm will not be located on the owner's preference, because it would simply result in "business stealing" (taking away viewers from her own firm already located there). Moreover, if the ideological owner decides to abandon a market segment whose ideology he dislikes, it would leave room for an entrant. In summary, the scope to affect bias is again limited by s.

Anecdotal accounts of cross-owned media firms often bring attention to the fact that this results in a "homogenization" of viewpoints. But, understanding the impact of cross-ownership also forces one to confront the question of when and why diversity in views persists in firms that are cross-owned. Another part of Shawcross (1997, p. 98) is relevant for this discussion of cross ownership. It seems that Murdoch has bought media companies that are identified with a liberal audience. An example is his acquisition of the *Village Voice* in January 1977. Shawcross describes Murdoch's initial decision to try and have editor Marianne Partridge replaced, despite a previous commitment that he would not do so, and how this inflamed some of the *Voice* 's most valuable columnists, including Alexander Cockburn. He then mentions "he understood that the paper's radical views were essential to its success and he did not seek to impose a conservative editor. Instead, he chose David Schneiderman, a journalist from the *New York Times*, who remained editor until Murdoch eventually sold the paper in 1985. The *Voice* ran frequent attacks on Murdoch and the *New York Post*, particularly in Cockburn's "Press Clips" column. For the most part Murdoch ignored them. Schneiderman received the occasional irate telephone call, protesting against the more savage criticisms, but otherwise Murdoch left the *Village Voice* alone. Its massive classified advertising base grew and the paper thrived." [33,34]

5.4 Complex News: Bias When There are Conflicting Stereotypes

News issues are often multidimensional. One can think of each piece of news as a composite of multiple underlying attributes. Thus, for example, one's views on whether or not to relax entry restrictions on Mexican immigrants into the US depends on personal views concerning illegal immigration but also the economic impact if one owned a small business employing such workers. Similarly, views on political relations with another country may depend on whether or not it is a safe haven for criminals but also whether it owns vast oil reserves. The model can be used to examine how the media covers "simple" versus "complex" issues. The prediction is that while coverage is biased on simple issues, it may be more objective on complex ones.

To see why, we first ask where do viewer beliefs come from. A natural starting point is that a viewer's preference or belief about a particular piece of news is a composite of her preferences over the range of underlying attributes that define this piece of news. As an example, let viewer i's belief over a piece of news z be constructed as the weighted sum of her beliefs over two underlying attributes x and y as

$$z_i = \eta x_i + (1 - \eta) y_i,$$

where the distribution of viewer tastes over x and y $f(x)$ and $g(y)$, is each a uniform$(-\frac{1}{2}, \frac{1}{2})$ variable, and $\eta \in [0, 1]$ is the relative importance of each attribute in shaping the viewer's belief about the piece of news. When both attributes are equally important, $\eta = \frac{1}{2}$. Now, the distribution of beliefs, $h(z)$, over z, can be easily derived, and will depend on whether viewer tastes over the two attributes x and y are positively or negatively

33. An interesing case, cited in Severin and Tankard (1992), is that of Senator Jesse Helms of North Carolina, who has accused *CBS News* of liberal bias. They also mention that *Fairness in Media*, a group he is affiliated with, indicated that it was attempting to buy controlling stock in CBS.

34. The more general point suggested by this example is that for a more systematic treatment of how coverage is shaped by viewer tastes on the one hand (the profit-making motive) versus owner ideology on the other (the ideological motive), one might compare media coverage by a single firm of a common event across different markets.

correlated. As an example, let $y = xp + (1 - p)(1 - x)$. Then, both y and z are $U(-\frac{1}{2}, \frac{1}{2})$ random variables as well, and p parametrizes the correlation in tastes over the two attributes, where this correlation is simply $(2p - 1)$.

Now, define a "complex" issue as one where viewer's tastes over the underlying attributes are perfectly negatively correlated. In that case, $h(z) = 1$ if $z = 0$ and 0 everywhere else—so that all viewers have the same beliefs about the piece of news z. By the results in Section 5.1, media reports on z will then display no bias. On the other hand, suppose that $p = 1$ so that $z = x$ and there is large ideological dispersion. This will result in maximum bias in equilibrium.

Result 15: *In a free press, news coverage of "complex" issues (that is, on which viewer preferences over underlying attributes conflict) will be less biased than coverage of "simple" issues (where preferences do not conflict).*

The intuition behind this result is straightforward—complex issues are characterized by there being very few viewers "at the extremes," consequently news reports display less bias. On the other hand, the preference distribution over a "simple" issue is equally dense everywhere, resulting in greater bias in reports.

Consider, for example, an African American judge who favors limits on abortion and is against affirmative action. Consumers who favor affirmative action may support the nomination of such a candidate on grounds of race but oppose it due to the the candidate's conservative philosophy. Their "composite" preference on whether to nominate such a candidate may therefore end up being not too different from viewers who oppose affirmative action but line up with the candidate's conservative beliefs. Consequently, the dispersion of beliefs on whether to favor or oppose nomination is likely to be small. (On the other hand, one might expect more intense support and opposition for a white conservative judge.) These examples, and Proposition 3, can be used to shed light on two prominent cases of coverage of African Americans in the 1990s, the supreme court nomination hearings of Clarence Thomas and the murder trial of O.J. Simpson. Surveys of the coverage of those events shows that the media coverage of the hearings on Clarence Thomas (a conservative African American) was generally considered to be less biased than coverage in the media on the trial of O.J. Simpson (an African American being tried for murder).

6. Conclusions

The overwhelming majority of the information that people use to make decisions in political markets is produced by the media industry.

Politicians, journalists and academics have repeatedly argued that the media is biased. There are two striking empirical characteristics of bias. First, bias does not disappear under scrutiny. *Fox News*, for example, is accused of a conservative bias on a recurrent basis, while its ratings continue to climb. A second characteristic of bias is that people agree on its existence, but disagree on the sign (see, for example, Alterman, 2003; Coulter, 2003; Goldberg, 2003; and Krugman, 2002). Our paper contributes to this growing literature by developing a model where bias can arise in equilibrium and where both empirical characteristics are observed.

The novel feature of our model is that the relative weight that consumers place on the vertical attribute (information) and the horizontal attribute (opinion) varies according to the characteristics of the product (verifiability of news). This allows us to characterize a variety of situations relevant to the discussions of media bias. For example, the quality of reporting can appear to oscillate: sometimes it is unbiased and resembles a classic market for information, other times it can appear biased and resembles a market for opinion. A key implication is that the view of "a free press" being a biased one misses a basic point. That is, the same press can end up being extremely objective in its coverage of one piece of news, and extremely biased when it comes to reporting on another piece of news. In other words, a free press can appear to be both objective at times and biased at others. As another example, consider two markets that each have a free press with exactly the same cost structure, but where viewers in the two markets have largely opposing beliefs on a particular piece of news. Then, the press in each market will appear to be biased to viewers in the other.

Each of these phenomena stems from the fact that information is not always fully verifiable. Partial verifiability and heterogeneous tastes results in a market for opinion (a taste for diversity) that gives the appearance of bias.

More competition does not change these results, as there is no reason to expect that the extent of verifiability inherent in the news event will change, or that it will affect the distribution of tastes. A basic prediction of our model is that as fixed costs fall (or as demand rises), more extreme voices should be part of the equilibrium. This is consistent with the often-made observation that radio programs can be more extreme than TV or newspapers, and that the TV industry has become more extreme as costs have fallen and more firms have entered the industry.[35]

35. See, for example, the article "Right-Wing Media: It Pays to be Right," *The Economist*, December 7, 2002, p. 60. It argues that Fox's "success reflects a business as much

Several aspects of the theory are empirically testable. Specifically, the model emphasizes how the extent of bias is influenced by the verifiability of the news report and by viewers' tastes. For example, the more verifiable a news item becomes—for example, when evidence emerges on a corporate scandal or on presidential misconduct—the less biased will news coverage be. Similarly, coverage of a news item where viewer preferences are one-sided—for example, of a popular war—will be more homogeneous than for a news item where viewers sharply disagree.

Last, our model may be used to understand the standard argument that the amount of media bias is evidenced by the public's increasing lack of faith in journalists.[36] But for the majority of viewers, lack of faith in journalism is exactly what you expect in a standard location model. As long as the news item in question is not fully verifiable, customers will observe how different media firms reach drastically different conclusions (editorials), starting from the same piece of information. Not surprisingly, viewers will find suspect what most journalists have to say, with the exception of the one he/she usually watches. Thus, simply asking people in general about the media is hardly the way to infer bias.

The central premise of this paper is that information is not always fully verifiable. But, in this paper we take the verifiability parameter as a primitive. One could relax this assumption. Indeed, one can imagine that whether or not a piece of news is verifiable is impacted by how many resources are devoted by firms to "finding out the facts." This, in turn, will be impacted by market structure: for exampe, the incentives to gather information and impact verifiability might be linked to a firm's ability to gain rents by "being first" in breaking a news story. Examining a model where verifiability is endogenous to market structure is one promising avenue for further research.

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as a political strategy. With the proliferation of cable-news channels—CNN, MSNBC, Fox News, CNBC, Bloomberg—the market in America has become more segmented. Mr Murdoch spied a niche for a snappier, noisier form of in-your-face TV news that would outshine the increasingly staid formats used by CNN—and serve viewers fed up with liberal leanings."

36. "Good public debate must not only be accessible to, but also assessable by, its audiences. The press are skilled at making material accessible, but erratic about making it assessable. This may be why opinion polls and social surveys now show that the public in the UK claim that they trust newspaper journalists less than any other profession." Reported in "Shoot the messenger: The media are always calling for transparency, but who are they accountable to?," by Onora O'Neill, Tuesday April 30 2002, *The Guardian*, UK.

Appendix A: The Model with $\lambda = 0$

A.1 Time Line of the Game

The timing of actions is presented in Section 2.3.

A.2 Market Shares

Notation A1: *Let θ_f denote firm f's location after second-stage entry. Then without loss of generality let $\theta_1 \leq \theta_2 \leq \cdots \leq \theta_N$. Call vector $[\theta_1, \theta_2, \ldots, \theta_N]$ a* configuration of media firms.

Notation A2: *Let η_f be firm's f market share.*

Let $G(\theta_v)$ be the number of viewers with taste parameter $\theta \leq \theta_v$, with G defined on support $[\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}]$ with $\alpha \in (-\infty, \infty)$ and $\beta \in (0, 1]$, differentiable with $g \equiv G'$ and $G(\alpha + \frac{\beta}{2}) = 1$. Then, assuming $\theta_1 < \theta_2 < \cdots < \theta_N$ and $N \geq 2$,

$$\eta_1 = \int_{\alpha - \frac{\beta}{2}}^{\frac{\theta_1 + \theta_2}{2}} g(\theta)\, d\theta; \tag{A1}$$

$$\eta_N = \int_{\frac{\theta_{N-1} + \theta_N}{2}}^{\alpha + \frac{\beta}{2}} g(\theta)\, d\theta; \tag{A2}$$

and for $1 < f < N$

$$\eta_f = \int_{\frac{\theta_{f-1} + \theta_f}{2}}^{\frac{\theta_f + \theta_{f+1}}{2}} g(\theta)\, d\theta. \tag{A3}$$

To proceed we make the following simplifying assumptions:

Assumption A1: *n firms located on the same spot share viewers equally.*

Assumption A2: *G is the uniform distribution, that is $G(\theta_v) = \frac{1}{\beta}[\theta_v - (\alpha - \frac{\beta}{2})]$.*

Then the following lemma follows:

Lemma A1 (Schmalensee, 1978): *If $\theta_{f+1} > \theta_f > \theta_{f-1}$ then for all $\theta_f \in (\theta_{f-1}, \theta_{f+1})$, $\eta_f = \frac{\theta_{f+1} - \theta_{f-1}}{2\beta}$.*

Proof. It follows directly from (A3) when G is the uniform distribution. □

A.3 Strategies

A history of the game after stage 1 is a vector $h_1 = [\sigma_1, \sigma_2, \ldots, \sigma_M]$, with $\sigma_k \in [\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}]$; also, without loss of generality, choose labels so that $\sigma_1 \leq \sigma_2 \leq \cdots \leq \sigma_M$. The set of histories after stage 1 is the union $\cup_{M=0}^{\infty} \times_{\ell=0}^{M} [\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}]$.[37]

Remark A1: Vector $[\sigma_1, \sigma_2, \ldots, \sigma_M]$, with $\sigma_k \in [\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}]$, summarizes locations after first-stage entry.

Firm k's strategy is a function $\mathbf{S}_k$ that selects an action after any history. After the initial history $\emptyset$ the action set of media firm k is

$$A_k^1 = \left[\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}\right] \cup \{\infty\};$$

Either firm k sinks cost s, enters and locates on a point in the interval $[\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}]$, or it remains ouside the market, an action we denote by ∞.

After history h_1, the action set is $\{\infty\}$ for any firm k such that $A_k^1 \in [\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}]$. For those firms such that $A_k^1 = \infty$, the action set is

$$A_k^2 = \left[\alpha - \frac{\beta}{2}, \alpha + \frac{\beta}{2}\right] \cup \{\infty\}.$$

A Nash equilibrium in the subgame that begins after history h_1 is a strategy combination $(S_k^2)_{k=1}^{\infty}$ such that no media firm can gain by unilaterally changing her decision. A subgame perfect equilibrium is a strategy combination $(\mathbf{S}_k)_{k=1}^{\infty}$ such that it is a Nash equilibrium of the game, and induces a Nash equilibrium in any subgame.

A.4 Necessary Conditions for an Equilibrium Configuration

The following conditions must be satisfied by any equilibrium configuration:

Lemma A2 (Survival): *In any equilibrium with $N \geq 3$ and $\theta_{f+1} > \theta_f > \theta_{f-1}$, $\theta_{f+1} - \theta_{f-1} \geq 2s \cdot \beta$.*

Proof. Suppose not, then $\eta_f = \frac{\theta_{f+1} - \theta_{f-1}}{2\beta} < s$ for some f, which cannot be in equilibrium. $\square$

37. The final allocation we denote using θ_j's; the allocation after first-stage entry we denote using σ_j's.

Lemma A3 (Entry deterrence): *In any equilibrium with* $N \geq 2, \theta_f - \theta_{f-1} < 2s \cdot \beta$ *for all* $f \in \{2, 3, \ldots, N-1\}, \theta_1 \leq \alpha - \frac{\beta}{2} + \beta s$ *and* $\theta_N \geq \alpha + \frac{\beta}{2} - \beta s$.

Proof. If a last-stage entrant locates anywhere in (θ_{f-1}, θ_f) and $\theta_f - \theta_{f-1} \geq 2s \cdot \beta$, then Lemma A1 implies that he can get a market share of $\frac{\theta_f - \theta_{f-1}}{2\beta} \geq s$.

Next suppose $\theta_1 > \alpha - \frac{\beta}{2} + \beta s$. Then a firm could enter in the last stage, locate at $\theta = \alpha - \frac{\beta}{2} + \beta s + \beta \varepsilon$ and get a market share of at least $\frac{1}{\beta}[\alpha - \frac{\beta}{2} + \beta s + \beta \varepsilon - (\alpha - \frac{\beta}{2})] = s + \varepsilon > s$. The proof for θ_N is analogous. □

Note that the second part of the lemma implies that extremes always get some attention.

Lemma A4 (Upper bound on the number of media firms): *In any equilibrium* $1 \geq Ns$.

Proof. It is apparent that for all N, $\max \min \eta_f = \frac{1}{N}$, which obtains when all firms have equal market shares. Hence $\min \eta_f \leq \frac{1}{N}$. Now suppose $1 < Ns$. Then $s > \frac{1}{N} \geq \min \eta_f$. Hence f loses money which cannot happen in equilibrium. □

Lemma A5 (Lower bound on the number of media firms): *In any equilibrium* $N > \frac{1}{2s}$.

Proof. It is apparent that for all N, $\min \max \eta_f = \frac{1}{N}$, which obtains when all firms have equal market shares. Hence a last-stage entrant can always get a market share of at least $\frac{1}{2N}$ by locating at the same spot than the firm with the largest market share. Hence, in equilibrium it must be the case that $\frac{1}{2N} < s$, from which the lemma follows. □

Corollary A1: *In any equilibrium* $\frac{1}{2s} < N \leq \frac{1}{s}$.

A.5 Minimal Differentiation and Competition

The following conditions, which must also be satisfied by any equilibrium configuration, characterize differentiation in equilibrium:

Lemma A6 (No media firm is like any other): *In any equilibrium with* $N \geq 3, \theta_1 < \theta_2 < \cdots < \theta_N$.

Proof. To begin suppose, by way of contradiction, that there exists $\theta_1 < \theta_f = \theta_{f+1} < \theta_N$. Then we know that $\eta_f + \eta_{f+1} = 2\eta_f = \frac{\theta_{f+2} - \theta_{f-1}}{2\beta} \geq 2s$. It follows that $\theta_{f+2} - \theta_{f-1} \geq 4s \cdot \beta$. Now $\max\{\theta_f - \theta_{f-1}, \theta_{f+2} - \theta_f\} \geq 2s \cdot \beta$, hence an entrant would grab a market share of at least s and last-stage entry would be profitable. If more than two media firms bunch, then space in between must be even larger.

Next suppose that $\theta_1 = \theta_2 < \theta_3$. Because $\theta_1 \leq \alpha - \frac{\beta}{2} + \beta s$ (otherwise last-stage entry would be profitable), this can be an equilibrium only if $\theta_3 - \theta_2 \geq 2s \cdot \beta$. To see this, note that firms 1 and 2 get all viewers in $[\alpha - \frac{\beta}{2}, \theta_1]$ and half of those between them and θ_3; furthermore, θ_1 and θ_2 share viewers equally, and the total number of viewers in $[\alpha - \frac{\beta}{2}, \theta_1]$ is at most s. It follows that the number of viewers to the right of θ_1 who watch θ_1 and θ_2 must be at least s, hence firm 3 must be located at a distance of at least $2s \cdot \beta$. But if that is the case, then there is room for a last-stage entrant between θ_1 and θ_3. □

Corollary A2 (No minimal differentiation): *Assume $s < \frac{1}{2}$. Then minimal differentiation cannot be an equilibrium.*

Proof. If $s < \frac{1}{2}$ then $N = 1$ cannot be an equilibrium. Suppose thus that $N \geq 2$ in equilibrium. Lemma A6 implies that $\theta_1 < \theta_N$: bunching would leave an opportunity for profitable last-stage entry. □

Lemma A7 (Entry costs pin down the location of extremes): *If $s \leq \frac{1}{2}$, then $\theta_1 = \alpha - \frac{\beta}{2} + \beta s$ and $\theta_N = \alpha + \frac{\beta}{2} - \beta s$.*

Proof. Suppose that $\theta_1 < \alpha - \frac{\beta}{2} + \beta s$. Lemma A6 also implies that $\theta_2 > \theta_1$. If $\theta_2 \leq \alpha - \frac{\beta}{2} + \beta s$ firm 1 loses money; on the other hand, if $\theta_2 > \alpha - \frac{\beta}{2} + \beta s$, firm 1 could select $\theta_1 = \alpha - \frac{\beta}{2} + \beta s$ and increase profits. □

A.6 A Sufficient Condition for an Equilibrium Configuration

Proposition A1 (Sufficient conditions for an equilibrium configuration): *Any configuration satisfying survival (Lemma A2), entry deterrence (Lemma A3), no media firm is like any other (Lemma A6) and entry costs pin down the location of extremes (Lemma A7) can be sustained as the outcome of a subgame perfect equilibrium.*

Proof. Consider a strategy combination $(\mathbf{S}_k)_{k=1}^{\infty}$ such that (a) the outcome of the strategy combination is a configuration that satisfies the hypothesis of the Proposition; (b) induces a Nash equilibrium in any subgame not reached by the play of the game; (c) all entry occurs in the first stage. We now show that this strategy combination is a subgame perfect equilibrium.

This is a dynamic game with finite horizon. The one-shot deviation principle implies it suffices to check that each strategy is unimprovable by a one-shot deviation after any history (see, for example, Hendon et al., 1996).

Because all entry occurs by hypothesis on stage 1, a deviation in the second stage can only consist in a media firm that unilaterally changes her decision and enters. Moreover, also because all entry occurs in the first stage, $M = N$ and $[\sigma_1, \sigma_2, \ldots, \sigma_M] = [\theta_1, \theta_2, \ldots, \theta_N]$. Thus second–stage entry must leave losses because the configuration satisfies entry deterrence.

Entry deterrence also implies that a unilateral deviation of a firm that did not enter in the first stage leaves losses, no matter where it locates (note that entry deterrence implies that entry by a deviant would lead to a subgame with a Nash equilibrium such that no firm enters in the second stage). On the other hand, a firm who entered in stage 1 locating on θ_f either makes profits or brakes even, so she does not want to change her decision to enter. Moreover, if $1 < f < N$, then she is indifferent among any location in $(\theta_{f-1}, \theta_{f+1})$, and entry deterrence implies that it is not profitable to locate in between any other firms, or at the extremes. If the firm is located at the extremes, then it does neither want to move toward the edges, because it would only reduce its market share; nor away from them, because it would prompt second-stage entry. Hence, there is no profitable deviation for firms that entered on stage 1 either.

Last, any deviation on a subgame that is not reached by the play of the game does not improve payoffs in the subgame because strategies induce a Nash equilibrium in any subgame. Hence we have shown that strategy combination $(\mathbf{S}_k)_{k=1}^{\infty}$ is unimprovable after any history. □

Appendix B: The Model When Viewers Value Truth

We continue to work with the same uniform distribution as in the previous appendix, and assume that "truth" is located on $\theta = 0$. As shown in Section 2, when viewers value "truth" their utility function is

$$U_v(\theta_f) = [\theta_f - (1-\lambda)\theta_v]^2 + \xi_v.$$

Defining $(1-\lambda)\theta_v \equiv \theta_v'$, we can redefine the viewer's utility function as,

$$U_v'(\theta_f) = (\theta_f - \theta_v')^2$$

with viewer preferences uniformly distributed on the inteval $[-(1-\lambda)(\alpha - \frac{\beta}{2}), (1-\lambda)(\alpha + \frac{\beta}{2})]$. For an arbitrary configuration of media firms $[\theta_1, \theta_2, \ldots, \theta_N]$, market shares are now

$$\eta_1 = \frac{1}{\beta(1-\lambda)} \int_{-(1-\lambda)(\alpha-\frac{\beta}{2})}^{\frac{\theta_1+\theta_2}{2}} d\theta = \frac{1}{\beta}\left(\alpha - \frac{\beta}{2}\right) + \frac{\theta_1+\theta_2}{2\beta(1-\lambda)}; \tag{B1}$$

$$\eta_N = \frac{1}{\beta(1-\lambda)} \int_{\frac{\theta_{N-1}+\theta_N}{2}}^{(1-\lambda)(\alpha+\frac{\beta}{2})} d\theta = \frac{1}{\beta}\left(\alpha + \frac{\beta}{2}\right) - \frac{\theta_{N-1}+\theta_N}{2\beta(1-\lambda)}; \tag{B2}$$

and for $1 < f < N$

$$\eta_f = \frac{1}{\beta(1-\lambda)} \int_{\frac{\theta_{f-1}+\theta_f}{2}}^{\frac{\theta_f+\theta_{f+1}}{2}} d\theta = \frac{\theta_{f+1}-\theta_{f-1}}{2\beta(1-\lambda)}. \tag{B3}$$

We can now show that Lemmas A2, A3, A6, and A7 have their analogues when $\lambda \in (0, 1)$.

Lemma B1: *In any equilibrium with $N \geq 3$ and $\theta_{f+1} > \theta_f > \theta_{f-1}, \theta_{f+1} - \theta_{f-1} \geq 2s \cdot \beta(1-\lambda)$.*

Proof. Suppose not, then $\eta_f = \frac{\theta_{f+1}-\theta_{f-1}}{2\beta(1-\lambda)} < s$ for some f, which cannot occur in equilibrium. □

Lemma B2: *In any equilibrium with $N \geq 2, \theta_f - \theta_{f-1} < 2s \cdot \beta(1-\lambda)$ for all $f \in \{2, 3, \ldots, N\}, \theta_1 \geq (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$ and $\theta_N \leq (1-\lambda)(\alpha + \frac{\beta}{2} - \beta s.)$.*

Proof. If a last-stage entrant locates anywhere in (θ_{f-1}, θ_f) and $\theta_f - \theta_{f-1} \geq 2s \cdot \beta(1-\lambda)$, then an entrant located in-between can can get a market share $\frac{\theta_f - \theta_{f-1}}{2\beta(1-\lambda)} \geq s$.

Next suppose $\theta_1 > (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$. Then a firm could enter in the last stage, locate at $\theta = (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s) + (1-\lambda)\beta\varepsilon$ and get a market share of at least $s + \varepsilon > s$. The proof for θ_N is analogous. □

Lemma B3: In any equilibrium with $N \geq 3, \theta_1 < \theta_2 < \cdots < \theta_N$.

Proof. To begin suppose, by way of contradiction, that there exists $\theta_1 < \theta_f = \theta_{f+1} < \theta_N$. Then we know that $\eta_f + \eta_{f+1} = 2\eta_f = \frac{\theta_{f+2}-\theta_{f-1}}{2\beta(1-\lambda)} \geq 2s$. It follows that $\frac{\theta_{f+2}-\theta_{f-1}}{\beta(1-\lambda)} \geq 4s$. Now $\max\{\frac{\theta_f-\theta_{f-1}}{1-\lambda}, \frac{\theta_{f+2}-\theta_f}{1-\lambda}\} \geq 2s$, hence an entrant would grab a market share of at least s and last-stage entry would be profitable. If more than two media firms bunch, then they must keep even more space in between.

Next suppose that $\theta_1 = \theta_2 < \theta_3$. because $\theta_1 \leq (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$ (otherwise last-stage entry would be profitable), this can be an equilibrium only if $\frac{\theta_3-\theta_2}{\beta(1-\lambda)} \geq 2s$. To see this, note that firms 1 and 2 get all viewers in $[(1-\lambda)(\alpha - \frac{\beta}{2}), \theta_1]$ and half of those between them and θ_3; furthermore, 1 and 2 share viewers equally, and the total number of viewers between $[(1-\lambda)(\alpha - \frac{\beta}{2}), \theta_1]$ is at most s. It follows that the number of viewers to the right of θ_1 who watch θ_1 or θ_2 must be at least s, hence firm 3 must locate at least on $2s(1-\lambda)$. But then there is room for a last-stage entrant between θ_1 and θ_3. □

Lemma B4: *If* $s \leq \frac{1}{2}$, *then* $\theta_1 = (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$ *and* $\theta_N = (1-\lambda) \times (\alpha + \frac{\beta}{2} - \beta s)$.

Proof. Suppose that $\theta_1 < (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$. Because $\theta_2 > \theta_1$, this would imply that firm 1 is not maximizing profits: if $\theta_2 \leq (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$ firm 1 would lose money; on the other hand, if $\theta_2 > (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$, firm 1 could select $\theta_1 = (1-\lambda)(\alpha - \frac{\beta}{2} + \beta s)$ and increase profits. □

The following important results follow. The first states necessary and sufficient condition for an configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ to be an equilibrium with $\lambda \in (0, 1)$

Proposition B1: *Any configuration satisfying survival (Lemma A2), entry deterrence (Lemma A3), no firm is like any other (Lemma A6) and entry costs pin down the location of extremes (Lemma A7) can be sustained as the outcome of a subgame perfect equilibrium.*

Proof. The proof is, *mutatis mutandis*, the same of Proposition A1. □

The next result shows that, formally, nothing fundamental changes when $\lambda \in (0, 1)$:

Lemma B5: $[\theta_1, \theta_2, \ldots, \theta_N]$ *is an equilibrium configuration of media firms when* $\lambda = 0$ *if and only if* $(1-\lambda)[\theta_1, \theta_2, \ldots, \theta_N] \equiv [\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_N]$ *is an equilibrium configuration in the game with* $\lambda \in (0, 1)$.

Proof. To prove the equivalence we just have to show that configuration $[\theta_1, \theta_2, \ldots, \theta_N]$ satisfies Lemmas A2, A3, A6, and A7 if and only if $(1-\lambda)[\theta_1, \theta_2, \ldots, \theta_N] \equiv [\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_N]$ satisfies Lemmas B1–B4.

To begin, note that

$$\theta_1 < \theta_2 < \cdots < \theta_N \Leftrightarrow (1-\lambda)\theta_1 \equiv \hat{\theta}_1 < (1-\lambda)\theta_2 \equiv \hat{\theta}_2 < \cdots < (1-\lambda)\theta_N \equiv \hat{\theta}_N;$$

$$\theta_1 = \alpha - \frac{\beta}{2} + \beta s \Leftrightarrow (1-\lambda)\theta_1 \equiv \hat{\theta}_1 = (1-\lambda)\left(\alpha - \frac{\beta}{2} + \beta s\right);$$

$$\theta_N = \left(\alpha + \frac{\beta}{2} - \beta s\right) \Leftrightarrow (1-\lambda)\theta_N \equiv \hat{\theta}_N = (1-\lambda)\left(\alpha + \frac{\beta}{2} - \beta s\right).$$

Hence, Lemmas A7 and A6 are satisfied if and only if Lemmas B3 and B4 are satisfied.

Next, from the survival condition (Lemma A2)

$$\theta_{f+1} - \theta_{f-1} \geq 2s \cdot \beta \Leftrightarrow (1-\lambda)(\theta_{f+1} - \theta_{f-1}) \geq (1-\lambda)2s \cdot \beta$$
$$\Leftrightarrow \hat{\theta}_{f+1} - \hat{\theta}_{f-1} \geq (1-\lambda)2s \cdot \beta.$$

In addtion, from the entry deterrence condition (Lemma A3) $\theta_f - \theta_{f-1} < 2s \cdot \beta$ for all $f \in \{2, \ldots, N-1\}$. Moreover

$$\theta_f - \theta_{f-1} < 2s \cdot \beta \Leftrightarrow (1-\lambda)(\theta_f - \theta_{f-1}) < (1-\lambda)2s \cdot \beta$$
$$\Leftrightarrow \hat{\theta}_{f+1} - \hat{\theta}_{f-1} \geq 2s \cdot \beta(1-\lambda).$$

This completes the proof. □

The last result characterizes equilibrium when $\lambda = 1$.

Proposition B2: *Let $\lambda = 1$. Then $N = \text{integer } \frac{1}{s}$ and $\theta_1 = \theta_N = 0$ is the unique equilibrium configuration.*

Proof. Straightforward. □

Appendix C: Bias and Competition

In this appendix we formally show that there is a strictly positive lower bound for firm bias whenever $s < \frac{1}{2}$. Moreover, this lower bound tends to $\frac{1}{4}$ as $s \to 0$ and $N \to \infty$. We begin by studying the relation between s and N.

C.1 The Relation Between N and s

The following lemma characterizes the relation between N and s.

Lemma C1: *(i) There exists equilibria with $N = 1$ iff $s > \frac{1}{2}$. (ii) There exist equilibria with $N = 2$ iff $s \in (\frac{1}{4}, \frac{1}{2}]$. (iii) Fix $N \geq 3$ odd. Then there exists an equilibrium with N firms iff $s \in (\frac{1}{2N}, \frac{1}{N+1}]$. (iv) Fix $N \geq 4$ even. Then there exists equilibria with N firms iff $s \in (\frac{1}{2N}, \frac{1}{N})$.*

Proof. (*i*) is straightforward. To prove (*iii*), note first that the location of extreme firms is always pinned down, and leaves slightly less than $1 - 2s$ for firms $\theta_2, \theta_3, \ldots, \theta_{N-1}$. Now without loss of generality fix the middle firm, $\theta_{\frac{N+1}{2}}$, at 0. This firm needs at least $2s$ of space between $\theta_{\frac{N+1}{2}-1}$ and $\theta_{\frac{N+1}{2}+1}$. Hence, firm $\theta_{\frac{N+1}{2}-1}$ can locate at most at $-s$. In turn, firm $\theta_{\frac{N+1}{2}-2}$ can locate at most at $-2s$; and so on. Now consider firm θ_2. To meet the self-financing constraint, there must be at least $2s$ betwen θ_1 and θ_3. Because θ_3 is located at most at $-(\frac{N-1}{2} - 2)s$, it follows that

$$-\left(\frac{N-1}{2}-2\right)s-\left(-\frac{1}{2}+s\right)\geq 2s,$$

from which the upper bound follows.

Now as s falls, firms must spread out, otherwise they would leave space for third-stage entry. By spreading apart slightly less than $2s$, $N-2$ firms can jointly cover slightly less than

$$(1-2s)-(N-2)\cdot 2s < 2s.$$

After manipulation this yields $s > \frac{1}{2N}$.

To prove (*iv*), note that the $N-2$ firms other than θ_1 and θ_N have slightly less than $1-2s$ if θ_2 locates very close to θ_2 and θ_{N-1} locates very close to θ_N. Now if these $N-2$ firms are located in bunches of two firms, each bunch located at distance $2s$ of each other, they obtain a market share large enough to cover entry cost s. Hence the upper bound on N must be such that

$$\frac{1-2s}{N-2} > s,$$

that is, each firm has enough space to pay the entry cost s. After manipulation this yields $s < \frac{1}{N}$. (Of course, two firms cannot locate at exctly the same spot in equilibrium. This is why the interval is open.) To obtain the lower bound, proceed exactly as in (*iii*).

Last, to prove (*ii*) proceed exactly as in (*iv*) but note, in addition that if $s=\frac{1}{2}$, then both firms can cover their cost and any different location would leave losses. □

C.2 A Lower Bound on Bias

To show formally that competition does not eliminate we proceed as follows. First we find a general expression that gives a lower bound on bias for each N. That is, for each N, we find an s in $(\frac{1}{2N}, \frac{1}{N+1}]$ or $(\frac{1}{2N}, \frac{1}{N})$ as the case may be such that bias cannot be smaller. Then we show that this expression is always strictly positive and tends to $\frac{1}{4}$ as N tends to infinity.

C.2.1 Bias in the Limit When N is Odd

An Example: To explain the logic of the proof that follows, we start with an example where we derive the lower bound for bias. Assume $N=9$ and that $s=\frac{1}{10}$. We know that $\theta_1=-\frac{1}{2}+\frac{1}{10}$ and $\theta_9=\frac{1}{2}-\frac{1}{10}$. Furthermore, to minimize bias, it is clearly necessary for θ_5, the middle firm, to locate exactly at 0. And it is also necessary to locate θ_4 at $-\frac{1}{10}$. What next?

We know that θ_2 must be located at least $\frac{2}{10}$ further to the left of θ_4. Thus, to minimize bias it is necessary to locate it exactly at $-\frac{3}{10}$. Now consider where to locate θ_3. Because θ_3 is indifferent where to locate in the interval $(-\frac{3}{10}, -\frac{1}{10})$, it should locate as close to θ_4 as possible. But θ_3 must be located at least $\frac{2}{10}$ further to the left of θ_5, so that θ_4 can break even. It follows that $\theta_3 = -\frac{2}{10}$. Symmetry then implies that firm bias cannot be lower than

$$\frac{2}{9} \cdot \left[\left(\frac{5}{10} - \frac{1}{10} \right) + \left(\frac{3}{10} \right) + \left(\frac{2}{10} \right) + \left(\frac{1}{10} \right) \right] = \frac{20}{90} = \frac{2}{9}$$

(symmetry implies that bias is twice the sum of bias for firms located to the left of θ_5; and one must divide by 9 firms to obtain firm bias).

Now consider what happens if s starts to fall. On the one hand, θ_1 must move further to the extreme. On the other hand, θ_2, θ_3, and θ_4 are pulled towards the center. Firm bias is then

$$\frac{2}{9} \cdot \left[\left(\frac{1}{2} - s \right) + 3s + 2s + s \right] = \frac{1}{9}(1 + 10s). \tag{C1}$$

Thus, bias falls with s. But this can go on only as long as the difference between θ_1 and θ_2 is smaller than $\frac{2}{10}$. For when s becomes small enough, θ_2 cannot move further to the center, because it would leave enough room for profitable third-stage entry. The critical s is such that

$$-3s + \frac{1}{2} - s = 2s$$

or $s = \frac{1}{12}$. From then on the location of θ_2 is equal to $\theta_1 + 2s = -\frac{1}{2} + 3s$, and average bias is

$$\frac{2}{9} \cdot \left[\left(\frac{1}{2} - s \right) + \left(\frac{1}{2} - 3s \right) + 2s + s \right] = \frac{2}{9} \cdot (1 - s) . \tag{C2}$$

Now bias increases as s falls. Because $\frac{1}{9}(1 + 10s) = \frac{2}{9} \cdot (1 - s)$ when $s = \frac{1}{12}$, it is clear that for $N = 9$ bias is minimized when $s = \frac{1}{12}$.

Generalizing the example. In general, for larger N the equilibrium configuration will look exactly the same. On the one hand, a group of firms $\theta_2, \theta_3, \ldots, \theta_i$ will be pulled to the edge toward θ_1 to prevent third stage entry; these firms enter the bias calculation with terms the like of $(\frac{1}{2} - ks)$, $k = 1, 3, \ldots, i$. For these terms, bias increases as s falls. On the other hand, a second group of firms, $\theta_{i+1}, \theta_{i+2}, \ldots, \theta_{\frac{N-1}{2}-1}$ will pull to the center; these firms enter the bias calculation with terms the like of ks, $k = 1, 2, \ldots, \frac{N-1}{2} - i$. For these terms, bias falls as s falls. Minimum bias will be found for the lowest i such that the difference

$$\left(1+2+3+\cdots+\left[\frac{N-1}{2}-i\right]\right)s-(1+3+5+\cdots+[2i-1])s$$
$$=\frac{1}{2}\left(\frac{N-1}{2}-i\right)\left(\frac{N-1}{2}-i-1\right)s-i^2s \tag{C3}$$

is still positive. Call this the optimal i. Then, for optimal i, average firm bias will be equal to

$$\frac{2}{N}\left\{\left[\left(\frac{1}{2}-s\right)+\left(\frac{1}{2}-3s\right)+\cdots+\left(\frac{1}{2}-is\right)\right]\right.$$
$$\left.+\left[1+2+3+\cdots+\left(\frac{N-1}{2}-i\right)\right]s\right\}$$
$$=\frac{1}{N}\left\{i\,(1-2is)+\left(\frac{N-1}{2}-i\right)\left(\frac{N-1}{2}-i-1\right)s\right\}. \tag{C4}$$

Bias in the limit when N is odd. We can now calculate bias in the limit as $N\to\infty$. To do so, first we obtain s such that bias is minimized as a function of N and i. One does not know what i minimizes bias until one solves expression (C3). Nevertheless, we do know that the optimal i must satisfy the following condition:

$$\theta_{i+1}-\theta_i=-(2i-1)s-\left[\frac{1}{2}-\left(\frac{N-1}{2}-i\right)s\right]=2s,$$

which yields

$$s(i,N)=\frac{1}{N+1+2i}. \tag{C5}$$

As said, we do not know what the optimal i is. Fortunately, instead of solving (C3), we can still express i as a function of N by defining z such that $i\equiv\frac{N-1}{2}-z$, with $z=1,2,\ldots,\frac{N-1}{2}$. Indirectly, doing so enables us to calculate average firm bias for any i, including that which solves problem (C3) and is optimal.

Substituting $i\equiv\frac{N-1}{2}-z$ and (C5) into (C4) yields that average firm bias equals

$$\frac{1}{N}\left[\left(\frac{N-1}{2}-z\right)\left(1-\frac{N-1-2z}{2(N-z)}\right)+\frac{z\,(z-1)}{2(N-z)}\right]$$
$$=\left(\frac{1}{2}-\frac{1}{2N}-\frac{z}{N}\right)\left(1-\frac{1}{2\left(1-\frac{z}{N}\right)}-\frac{1+2z}{2(N-z)}\right)+\frac{z\,(z-1)}{2N(N-z)}$$

for a given z. Now this expression is always strictly positive for each z. Moreover,

$$\lim_{N\to\infty}\left\{\left(\frac{1}{2}-\frac{1}{2N}-\frac{z}{N}\right)\left(1-\frac{1}{2\left(1-\frac{z}{N}\right)}-\frac{1+2z}{2(N-z)}\right)+\frac{z\,(z-1)}{2N(N-z)}\right\}$$
$$=\frac{1}{2}\left(1-\frac{1}{2}\right)=\frac{1}{4}.$$

Thus we have shown that for any N odd, bias does not disappear as N grows.

C.2.2 Bias in the Limit When N is Even

Expressions for minimum average firm bias when N is even are derived following a similar logic. Here we just show the expressions and show that in the limit they converge to $\frac{1}{4}$. It turns out that the exact expression depends on whether $\frac{N}{2}$ is even or odd.

Case 1: *N even and $\frac{N}{2}$ odd.* Some tedious algebra shows that with N even, but $\frac{N}{2}$ odd, average firm bias equals

$$\frac{1}{n}\left\{i\,(1-2is)+\left(\frac{N}{2}-i\right)^2 s\right\}. \tag{C6}$$

In addition,

$$s(i,n)=\frac{1}{N+2(1+i)}. \tag{C7}$$

Last, let $i\equiv\frac{N}{2}-z$ and substitute this and (C7) into (C6), to obtain

$$\frac{1}{N}\left[\left(\frac{N}{2}-z\right)\left(1-\frac{N-2z}{2(N-z+1)}\right)+\frac{z^2}{2(N-z+1)}\right]$$
$$=\left(\frac{1}{2}-\frac{z}{N}\right)\left(1-\frac{1}{2\left(1-\frac{z}{N}+\frac{1}{N}\right)}-\frac{2z}{2\left(1-\frac{z}{N}+\frac{1}{N}\right)}\right)$$
$$+\frac{z^2}{2(N-z+1)}$$

for a given z. Now this expression is always strictly positive for each z. Moreover,

$$\lim_{N\to\infty}\left\{\left(\frac{1}{2}-\frac{z}{N}\right)\left(1-\frac{1}{2\left(1-\frac{z}{N}+\frac{1}{N}\right)}-\frac{2z}{2\left(1-\frac{z}{N}+\frac{1}{N}\right)}\right)\right.$$
$$\left.+\frac{z^2}{2(N-z+1)}\right\}=\frac{1}{4}.$$

Case 2: *N even and $\frac{N}{2}$ even.* Some tedious algebra shows that with N even, but $\frac{N}{2}$ even, average firm bias equals

$$\frac{1}{N}\left\{i\,(1-2is)+\left[\left(\frac{N}{2}-i-1\right)^2+2\left(\frac{N}{2}-i\right)\right]s\right\}. \tag{C8}$$

Also,

$$s(i,n)=\frac{1}{N+2(i-1)}. \tag{C9}$$

Last, let $i\equiv\frac{N}{2}-z$ and substitute this and (C9) into (C8), to obtain

$$\frac{1}{N}\left[\left(\frac{N}{2}-z\right)\left(1-\frac{N-2z}{2(N-z-1)}\right)+\frac{(z-1)^2+2z}{2(N-z-1)}\right]$$
$$=\left(\frac{1}{2}-\frac{z}{N}\right)\left(1-\frac{1}{2\left(1-\frac{z}{N}-\frac{1}{N}\right)}+\frac{2z}{2(N-z-1)}\right)+\frac{(z-1)^2+2z}{2(N-z-1)}$$

for a given z. Now this expression is always strictly positive for each z. Moreover,

$$\lim_{N\to\infty}\left\{\left(\frac{1}{2}-\frac{z}{N}\right)\left(1-\frac{1}{2\left(1-\frac{z}{N}-\frac{1}{N}\right)}+\frac{2z}{2(N-z-1)}\right)\right.$$
$$\left.+\frac{(z-1)^2+2z}{2(N-z-1)}\right\}=\frac{1}{4}.$$

Remark 3: Similarly, one can calculate maximum bias for each N and show that it also converges to $\frac{1}{4}$ in the limit.

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