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Biased media in an unbiased market

Graham Beattie
University of Pittsburgh

Abstract

It is well documented that biased media coverage can arise because of biases on the part of consumers, media outlets, or advertisers. I present a model in which neither media outlets nor their consumers are biased. I show that biased coverage can occur if information is costly for media outlets to acquire.

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Contact: Graham Beattie - grb57@pitt.edu.
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1 Introduction

There is consensus that the media play a crucial role in a functioning democracy. However, previous work has shown media coverage is often biased (Gentzkow and Shapiro, 2010). This bias may be supply-driven, when media owners align themselves with a particular political cause (Besley and Prat, 2006) or journalists want to advance their political careers (Baron, 2006). It may also be demand-driven, as consumers may prefer coverage which aligns with their own biases (Mullainathan and Shleifer, 2005), find coverage from a media outlet which has similar bias more informative for decision-making (Chan and Suen, 2008), or judge media outlets which provide both sides of a story to be more credible (Shapiro, 2016). Finally, advertisers might dictate positive coverage for their products (Ellman and Germano, 2009) or coverage which attracts their target audience (Strömberg, 2004).

This note analyzes media bias from a novel perspective. I present a model in which no agents have biased prior beliefs or have preferences for biased or inaccurate coverage. In the model, journalistic investigation to learn reportable facts is costly. There are two types of facts, left-wing and right-wing, and the orientation of a news story is given by the number of each type of fact. A media outlet chooses how many facts to investigate and which of the facts it learns to reveal in its reporting. The decision to investigate depends on the facts it already knows, and the probability it will learn each type of fact if it investigates. The media outlet maximizes its profits by presenting a story that conforms to the expectations of consumers, as this leads consumers to believe it is more likely to be operating based on journalistic integrity. I show through a simple example that this setting can lead to biased media coverage – the expected orientation of a news story may differ from the expected orientation of the event being covered.

Aside from the absence of biased players, the basic mechanics of the model are standard to the literature. For example, Sobbrio (2014) explores costly investigation and Gentzkow and Shapiro (2006) use a model where consumers use a media outlet's coverage to judge whether it is acting strategically or is motivated by journalistic integrity. However, in previous work, media bias has been a result of bias on the part of players in the model. This paper is the first, to my knowledge, to show that biased media coverage can occur absent bias anywhere else in the model.

2 Model

The game presented in this paper consists of two types of agents: a set of consumers and a media outlet. The media outlet can either be sincere or strategic.

A news event is drawn by nature, consisting of N facts, each of which are independent binary variables with prior probability p. Values of 1 are defined as 'right-wing' and values of 0 are defined as 'left-wing'. The orientation of the news event is the proportion ($\hat{p}$) of the realized facts which are right-wing. Since the event consists of a finite number of facts, $\hat{p}N$ is a random draw from a binomial distribution parameterized by N and p. Both consumers and the media outlet know p, and neither has preferences over p or $\hat{p}$, preferences over other players' beliefs, or preferences over reporting aside from a preference for accuracy. According to any standard definition of bias from the literature, both consumers and the media outlet are unbiased.

After the realization of the news event, the media outlet receives a signal that consists of a subset of the facts that comprise the news event and makes a report to consumers. Because of space or time constraints, the outlet is not able to report all of the facts that comprise the news event – they report a fixed number $M < N$ facts. The orientation of a report can be described by the number of right-wing facts reported, $k \in \{0, 1, ..., M\}$.

If the outlet is sincere, it is motivated by journalistic integrity, so its payoff increases in the accuracy of its reports and is independent of its profit. It will pay to learn all N facts and report an unbiased subsample of size M, so the proportion of right-wing facts in its report is as close as possible to the proportion of right-wing facts in the realized news event and the ex-ante expectation of its report k is equal to pM. The probability that a sincere outlet makes report k is denoted $\beta_T(k)$.

If the outlet is strategic, it is motivated by profits. Initially, a strategic outlet learns M of the N facts in the news event, the number of facts required to make a report. At this point, it chooses between paying cost c to investigate one additional fact and making a report. If it makes a report, the game ends. If it investigates, it learns another fact – a random draw from the set of facts in the news event that it has not learned yet.

If the outlet reports after having learned additional facts the reporting decision is more complicated. The outlet knows more than M facts, and it can choose any subset consisting of M known facts to report.

The game continues until the outlet chooses to stop investigating and makes a report. The strategy of a strategic outlet induces a distribution of reports, where each report k is made with probability $\beta_S(k)$.

Consumers have a choice whether or not to consume the media outlet, a choice that is a function of their beliefs about the outlet's type. They prefer consuming the outlet if they believe it is sincere, as only this type of outlet reports $\hat{p}$ accurately with certainty. Consumers use the current period's report to update their prior beliefs about the outlet's type, and use their updated beliefs to make consumption decisions in subsequent periods. This posterior belief is strictly increasing in the likelihood ratio $\frac{\beta_T(k)}{\beta_S(k)}$, and thus the outlet's discounted future revenues are strictly increasing in this ratio as well. To simplify the exposition, I do not provide explicit functions for consumers' payoff functions or consumption choices. Instead, I just use the likelihood ratio $\frac{\beta_T(k)}{\beta_S(k)}$ as the outlet's revenue function.[1] Because $\beta_T(k)$ is simply a function of p, the revenue that the outlet receives after making report k is strictly decreasing in $\beta_S(k)$.

I employ a Perfect Bayesian equilibrium concept. The strategies of consumers and the outlet, if it is sincere, are described above, so equilibrium depends on the strategy of the outlet if it is strategic and the beliefs of the consumers.

Definition A strategy σ_S is an equilibrium if and only if *(i)* the outlet's revenue function is consistent with the probabilities $\beta_S(k)$ induced by σ_S and *(ii)* given this revenue function, the reporting and investigation decisions in σ_S are profit maximizing.

[1]The main results and intuition are not sensitive to this particular choice. Similar results can be derived for other revenue functions that are strictly increasing in $\frac{\beta_T(k)}{\beta_S(k)}$.

It is useful to note that the model does not actually rely on the possibility that the outlet is sincere. It is equally consistent with a situation in which the outlet is strategic but consumers believe there is a possibility that it is sincere. The model can be understood to be a model of a profit-maximizing media outlet attempting to appear like it is motivated only by journalistic integrity in order to attract consumers.

3 Bias

In the previous section, a game was defined in which neither the media outlet nor its consumers were biased. All players have accurate prior beliefs about the orientation of the story, consumers want to learn the true realization of the story, and the media outlet does not have an incentive to bias coverage to persuade consumers. However, as this section will illustrate, the equilibrium of this game can still involve biased reporting by the media outlet – the expected report of the outlet may not be equal to the expected orientation of the news event.

This bias arises from the asymmetric investigation problem which arises if $p \neq \frac{1}{2}$. If the media outlet receives an initial draw that is different from the expected news event, it has an incentive to investigate further to learn more facts. If $p > \frac{1}{2}$, the probability an unknown fact is right-wing is greater than the probability it is left-wing. Investigating with the goal of learning more right-wing facts is more likely to succeed than investigating to learn more left-wing facts. Since the outlet's investigation problem is not symmetric, the outlet's optimal strategy may not be symmetric either, creating biased reporting.

In this section I sketch an outline of the equilibrium in a simple example of the game. A formal derivation is left for the appendix.

3.1 A simple example

In a simple example of the game there are four facts ($N = 4$). and the outlet reports two ($M = 2$).

A complete equilibrium strategy consists of investigation and reporting decisions for every possible combination of facts the outlet might know. If the outlet is strategic, any equilibrium strategy involves making report $k = 1$, a report with one right-wing and one left-wing fact, if this report is available when the outlet stops investigating. This arises because the initial draw of facts that the outlet receives if it is sincere consists of fewer draws from the same binomial distribution as the draw of facts that it would receive if it were sincere. This smaller draw will have greater variance, so a strategic outlet is more likely to receives 'extreme' draws of only left-wing facts or only right-wing facts. As a result, reports containing only one type of fact are a signal the outlet is more likely to be strategic.

If investigation costs are positive and the outlet is able to make a profit-maximizing report, it is always optimal to stop investigating and make this report, so in an equilibrium strategy the outlet never investigates if it already knows at least one of each type of fact. Investigation can only occur when the outlet has learned only one type of fact.

Consider an outlet that knows only left-wing facts, and does not know all N facts. This outlet investigates if and only if

$$c \leq p\Big(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(0)}{\beta_S(0)}\Big) \tag{1}$$

This expression holds if the cost of investigating (c) is less than the expected return from investigating – the probability of learning a right-wing fact (p) multiplied by the increase in profits from making the mixed report over the left-wing fact only report ($\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(0)}{\beta_S(0)}$). Similarly, an outlet that knows only right-wing facts investigates if and only if

$$c \leq (1-p)\Big(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(2)}{\beta_S(2)}\Big) \tag{2}$$

If it is optimal for the outlet to investigate, increasing the amount of investigation increases the probability that a strategic outlet makes a mixed report and decreases the probability it makes a report of two facts of the same type. This decreases $\frac{\beta_T(1)}{\beta_S(1)}$ and increases $\frac{\beta_T(0)}{\beta_S(0)}$ or $\frac{\beta_T(2)}{\beta_S(2)}$, thereby decreasing the return to investigation. If some investigation is optimal, there is an amount of investigation such equations (1) and (2) hold with equality and the outlet is indifferent between investigating and not investigating, so any probability of investigation is optimal. An equilibrium strategy will involve this amount of investigation. On the other hand, if equation (1) (or equation (2)) never holds – for example, if p (or $(1-p)$) is sufficiently low – then it is never optimal for the outlet to investigate if it knows only left-wing facts (or only right-wing facts). These two factors create a unique equilibrium distribution of reports by a strategic outlet.[2]

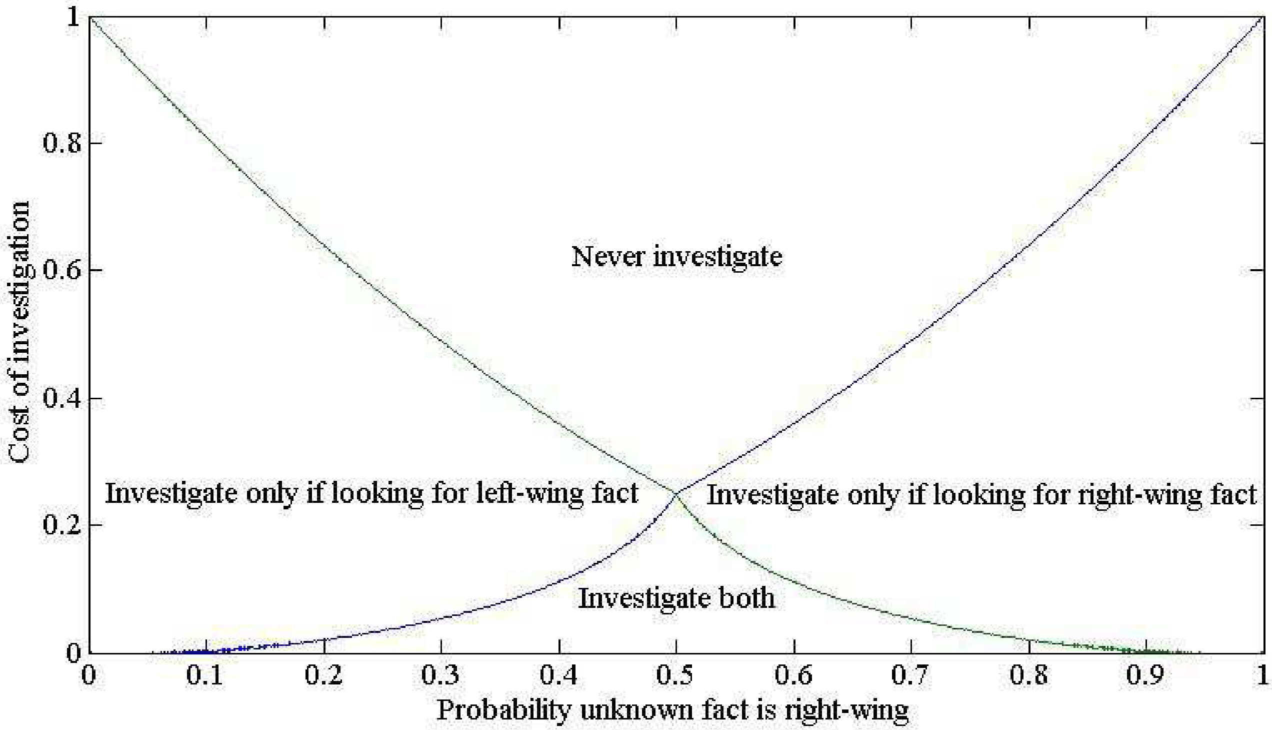
3.2 Equilibrium bias

The equilibrium distribution of reports may be biased. To illustrate this, Figure 1 shows investigation component of an equilibrium strategy if the outlet is strategic. The outlet investigates if the cost of investigation is sufficiently low and if the likelihood of learning the type of fact it wants to learn is sufficiently high. If $p \neq \frac{1}{2}$, this is not a symmetric problem, so the outlet's decision whether or not to investigate to try to learn a right-wing fact is different from its decision whether to try to learn a left-wing fact.

Figure 1 contains four regions. If the cost of investigation is sufficiently high, the outlet never investigates. If the probability that an unknown fact is right-wing is sufficiently high the outlet will investigate if it only knows left-wing facts and is looking for a right-wing fact. However, if the outlet has only learned right-wing facts and wants to learn a left-wing fact it will not investigate. The probability of learning a left-wing fact and thus the expected return to investigating is low, so equation (2) never holds. Similarly, if the probability an unknown fact is right-wing is sufficiently low, the outlet will investigate only if it is looking for a left-wing fact. Finally, if investigation cost is low and the probability that an unknown fact is right-wing is sufficiently close to $\frac{1}{2}$ the outlet investigates with positive probability if it is looking for either type of fact.

[2] A more complete derivation of this result is shown in the appendix.

Figure 1: Equilibrium investigation for simple example



The parameter ranges in which the outlet only investigates to learn one type of fact provide the simplest illustration of how bias can arise. Note that if the outlet never investigates it reports two random draws from a binomial distribution – a report which is unbiased. Consider an outlet that investigates if it only knows left-wing facts and is looking for a right-wing fact, but not when it only knows right-wing facts and is looking for a left-wing fact. It will make report $k = 1$ after an initial draw of only left-wing facts with positive probability. After any other initial draw the outlet does not investigate and reports its initial draw. Therefore,

$$\beta_S(0) < \beta_S^{NI}(0)$$
$$\beta_S(1) > \beta_S^{NI}(1)$$
$$\beta_S(2) = \beta_S^{NI}(2)$$

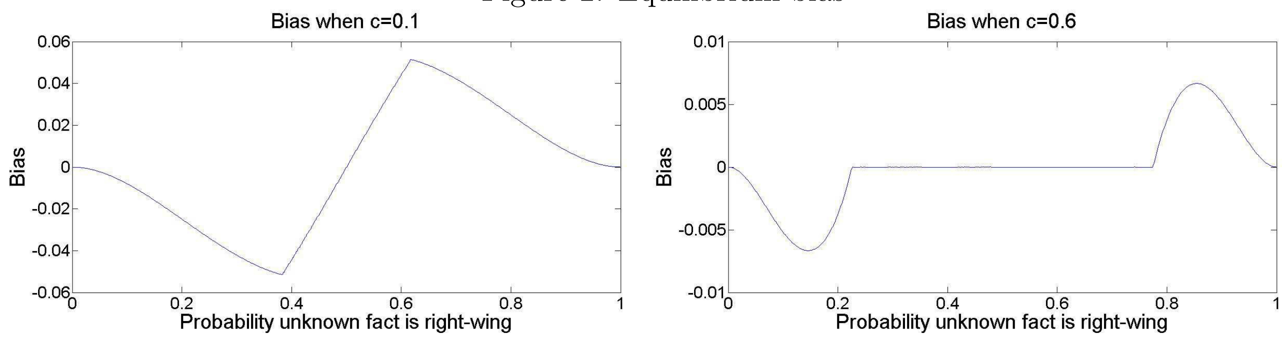
where $\beta_S^{NI}(k)$ denotes the probability that an outlet that never investigates makes report k.

The equilibrium distribution of reports by the strategic outlet first order stochastically dominates the distribution of reports of an outlet which never investigates, so the expected value of a report is higher. Since an outlet that never investigates makes an unbiased report, the strategic outlet makes a biased report in equilibrium.

A more formal version of this intuitive definition of bias is:

$$\text{Bias} = 0 \cdot \beta_S(0) + 1 \cdot \beta_S(1) + 2 \cdot \beta_S(2) - 2p$$

Figure 2: Equilibrium bias



Bias is defined as the difference between the expected report of a strategic outlet and the expected orientation of two randomly drawn facts.[3] A negative value indicates reporting is biased to the left, and a positive value indicates reporting is biased to the right. Using this definition, Figure 2 provides an illustration of how bias varies with the probability an unknown fact is right-wing, for different investigation costs. Coverage is biased to the left when an unknown fact is more likely to be left-wing and to the right when an unknown fact is more likely to be right-wing.

The intuition behind this bias is straightforward. The probability that a strategic outlet receives extreme draws with only one type of fact is higher than the probability that a sincere outlet makes an extreme report with only one type of fact. After receiving these draws, a strategic outlet has an incentive to 'correct' them and try to make a balanced report through investigation. This incentive, which is the return to investigation, is larger if it is more likely to draw the type of fact it wants. Therefore, if p is high an outlet that wants to find a right-wing fact investigates with a higher probability than an outlet that wants to find a left-wing fact. Since it is also more likely to find the right-wing fact, it reports more right-wing facts than are in its initial draw more often than it reports more left-wing facts than are in its initial draw. This biases its reporting to the right. Similarly, if p is low, reporting is biased to the left.

3.3 Extensions

This paper posits a model with a set of consumers and one media outlet, and shows that if investigation is costly and uncertain, reporting might be biased. There are several factors that can affect the amount of bias.

As the previous subsection discusses, bias is a function of the investigation cost and the probability an unknown fact is right-wing. Similarly, the number of facts that the outlet includes in a report can affect the level of bias. As M approaches N, the outlet is not able to bias its reports as much, as it must report a larger share of the available facts. Further, if the outlet is able to target particular types of unknown facts – for example, specifically searching for right-wing facts – then it would be able to imitate a sincere outlet at a lower cost so its reports would be less biased in expectation.

[3] Since $0 \cdot (1-p)^2 + 1 \cdot p(1-p) + 2 \cdot p^2 = 2p$, the expected report of an outlet that never investigated would be $2p$.

Gentzkow and Shapiro (2006) discuss how competition and verifiable reporting can reduce media bias, and their intuition applies to this setting as well. If consumers are able to learn the true value of the news event, then the media outlet has an incentive to investigate and report it accurately.

4 Conclusion

This paper posits a model of investigation and reporting by a media outlet. A strategic media outlet learns facts about a news event one at a time, paying an investigation cost each time it learns a fact. In order to appeal to consumers, it tries to imitate an outlet that has journalistic integrity and is fully informed about the news event.

Previous literature about media bias begins with the assumption that either outlets or consumers are biased, and uses this to show that these biases will affect the reports the outlet makes. My analysis takes a different approach, as the model assumes that both the media outlet and consumers are informed and unbiased prior to the news event. I show that this can still lead to biased coverage.

The bias illustrated in this paper arises from two factors: costly, uncertain investigation and asymmetric prior probabilities. If the media outlet does not have the facts necessary in order to make a report that conforms to consumers' expectations, it may choose to investigate to learn more facts to be able to make a more right- or left-leaning report. If the probability an unknown fact is right-wing is not $\frac{1}{2}$, this problem is not symmetric, and this asymmetry may cause the outlet to make a report that differs in expectation from the news event it is reporting.

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A Derivation of equilibrium properties

This appendix contains a formal characterization of the equilibrium sketched in the text for the case when $M = 2$ and $N = 4$. I provide expressions for investigation decisions, which are functions of the facts the outlet already knows, and show that these investigation decisions lead to a unique equilibrium distribution of reports. I use the notation a_n to represent the number of right-wing facts the outlet learns among the first n facts it receives and the notation $d(a, b)$ to represent the investigation decision of an outlet which has learned a facts, b of which are right-wing

The reporting decisions are trivial. When the outlet only knows one type of fact, it only has one report available. As shown in the following lemma and proposition, an equilibrium strategy always involves the outlet reporting $k = 1$ when it knows at least one of each type of fact,

Lemma 1. *In equilibrium, report $k = 1$ has the highest value of $\frac{\beta_T(k)}{\beta_S(k)}$. When $c > 0$, it is the unique revenue maximizing report.*

Proof. Define γ as the prior probability that the outlet is sincere, and $\alpha(k)$ as the posterior probability an outlet that makes report k is sincere. Revenue is strictly increasing in $\alpha(k)$. Note that after receiving signal $a_2 = x$, the outlet is always able to make report $k = x$. Thus any report made after this signal must yield at least as high revenue as $k = x$.

A sincere outlet learns $\hat{p}$, which can take values $\hat{p} \in \{0, \frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\}$. If $\hat{p} \in \{0, \frac{1}{2}, 1\}$, then $\hat{p}M$ is an integer, and a sincere outlet makes the report $k = \hat{p}M$. If $\hat{p} = \frac{1}{4}$, the rounding rule specifies that a sincere outlet randomizes between report $k = 0$ and report $k = 1$ and if $\hat{p} = \frac{3}{4}$ it randomizes between report $k = 1$ and $k = 2$. It randomizes in order to ensure that its expected report is equal to the expected orientation of the news event. Thus each fact it reports has expected value p and the expected value of its report of 2 facts is $2p$. Thus it chooses x to satisfy [4]

$$\begin{aligned} 0 \cdot \big(\text{Bin}(0,4,p) + x\text{Bin}(0,4,p)\big) + 1 \cdot \big((1-x)\text{Bin}(1,4,p) + \text{Bin}(2,4,p) + x\text{Bin}(3,4,p)\big) \\ +2 \cdot \big((1-x)\text{Bin}(3,4,p) + \text{Bin}(4,4,p)\big) = 2p \end{aligned}$$

The left hand side of this equation is the expected value of its report if it chooses the lower of the two reports (e.g. report $k = 0$ when randomizing between $k = 0$ and $k = 1$) with probability x and the higher of the two reports with probability $1-x$. This expression yields the value $x = \frac{1}{2}$ for any value of p, so a sincere outlet makes report $k = 0$ with probability

$$\beta_T(0) = (1-p)^4 + \frac{1}{2} \cdot 4 \cdot p(1-p)^3 = (1-p)^3(1+p)$$

[4] $\text{Bin}(i, j, p)$ denotes the probability of a realization i from a binomial distribution where j draws are performed which each have a probability of success p

This is always less than the probability that a strategic outlet's initial draw is $a_2 = 0$, which is $(1-p)^2$. If a strategic outlet were never to investigate, it reports $k = 0$ with a higher probability than a sincere outlet, so posterior beliefs following a report of 0 would be less than γ. Denote this belief $\alpha^{NI}(0)$. Similarly, $\alpha^{NI}(2) < \gamma$ and $\alpha^{NI}(1) > \gamma$.

The rest of the proof proceeds as follows. I show that $\alpha(0) > \alpha(1)$ always leads to a contradiction, and by symmetry $\alpha(2) > \alpha(1)$ does as well. This implies that report $k = 1$ always maximizes posterior beliefs, and thus revenue. I begin by dividing $\alpha(0) > \alpha(1)$ into three exhaustive cases.

Case 1: $\alpha(0) \leq \alpha^{NI}(0)$

Recall that the posterior probability $\alpha(k)$ is strictly decreasing in the probability a strategic outlet makes report k. In order for $\alpha(0) \leq \alpha^{NI}(0)$, the probability that a strategic outlet makes report $k = 0$ must be weakly greater than the probability that it receives an initial draw $a_2 = 0$. Since

$$\alpha(1) < \alpha(0) \leq \alpha^{NI}(0) < \gamma < \alpha^{NI}(1)$$

we know that $\alpha(1) < \alpha^{NI}(1)$, so the probability that a strategic outlet makes report $k = 1$ must be strictly greater than the probability that it receives an initial draw $a_2 = 1$. Combined, reports $k = 0$ and $k = 1$ are made strictly more often than they are initially drawn, so some initial draws of $a_2 = 2$ must end up being reported as $k = 1$ or $k = 0$. Since a strategic outlet never makes a report which is less profitable than another report available to it, $\alpha(2) \leq \max\{\alpha(0), \alpha(1)\}$. Given that $\alpha(1), \alpha(0) < \gamma$, this requires that $\alpha(k) < \gamma$ for all values of k, which is a contradiction.

Case 2: $\alpha(0) > \alpha^{NI}(0)$ *and* $\alpha(2) < \alpha(0)$

In this case, a strategic outlet must report $k \neq 0$ with positive probability after an initial draw $a_2 = 0$, Since $\alpha(2), \alpha(1) < \alpha(0)$, reports $k = 1$ and $k = 2$ are less profitable than report $k = 0$, so this is not optimal.

Case 3: $\alpha(0) > \alpha^{NI}(0)$ *and* $\alpha(2) \geq \alpha(0)$

If $\alpha(2) \geq \alpha(0) > \alpha(1)$, $k = 2$ is a revenue maximizing report, so it must be the case that $\alpha(2) > \gamma$. Since $\alpha^{NI}(2) < \gamma$, it must also be the case that the probability a strategic outlet makes report $k = 2$ is strictly less than the probability it receives an initial draw $a_2 = 2$. Further, given that $\alpha(0) > \alpha^{NI}(0)$, the probability it makes report $k = 0$ is strictly less than the probability it receives an initial draw $a_2 = 0$. This requires that $\beta_S(1|a_2 = 0) > 0$, or that $\beta_S(2|a_2 = 0) > 0$ and $\beta_S(1|a_2 = 2) > 0$. Since a strategic outlet never makes a report which is less profitable than another report available to it, we know that $\alpha(0) \leq \alpha(1)$, which given that I began with the assumption $\alpha(0) > \alpha(1)$, is a contradiction.

Therefore $\alpha(0) > \alpha(1)$ always leads to a contradiction. An equivalent analysis shows that $\alpha(2) > \alpha(1)$ leads to a contradiction as well. This proves the first part of the claim, that $k = 1$ is always a revenue maximizing report.

To show the second part of the claim, that $k = 1$ is the unique revenue maximizing report if $c > 0$, suppose that $c > 0$ and $k = 0$ is a revenue maximizing report. Note that $\alpha(k) \geq \gamma$ for any revenue maximizing k. As shown above, since $\alpha^{NI}(0) < \gamma$, then $\beta_S(1|a_2 = 0) > 0$ or $\beta_S(2|a_2 = 0) > 0$. A strategic outlet is paying cost c to investigate when it is able to make a revenue maximizing report. This is not optimal if $c > 0$. The analogous case where $c > 0$ and $k = 2$ is revenue maximizing leads to a similar contradiction and completes the proof. $\square$

The following proposition follows directly from Lemma 1.

Proposition 1. *If $c > 0$ and the outlet has learned at least one right-wing and one left-wing fact, the outlet does not investigate and reports $k = 1$.*

A sequentially rational strategy must satisfy Proposition 1. If the outlet is strategic, it always reports $k = 1$ if it knows at least one of each type of fact. Further, if it decides to report when it only knows one type of fact, it must report two facts of that type. The outlet outlet would never pay to investigate if it already knows one fact of each type, since the revenue-maximizing report is already available. Therefore an equilibrium strategy can be completely characterized by the four investigation decisions that are made when report $k = 1$ is not available.

By investigating after learning 3 left-wing facts, the outlet gives itself a chance of reporting $k = 1$ instead of $k = 0$. The cost of the investigation is c. Given beliefs, the outlet maximizes profits after receiving a signal $a_3 = 0$ by choosing $d(3, 0)$ so that

$$d(3,0) \in \underset{d(3,0)\in[0,1]}{\operatorname{argmax}}\ d(3,0)\left[p\frac{\beta_T(1)}{\beta_S(1)} + (1-p)\frac{\beta_T(0)}{\beta_S(0)} - c\right] + (1-d(3,0))\left[\frac{\beta_T(0)}{\beta_S(0)}\right] \tag{3}$$

This expression is linear in $d(3, 0)$, so

$$d(3,0) = \begin{cases} 0 & \text{if } c > p\left(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(0)}{\beta_S(0)}\right) \\ 1 & \text{if } c < p\left(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(0)}{\beta_S(0)}\right) \end{cases} \tag{4}$$

If $c = p\left(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(0)}{\beta_S(0)}\right)$ then $d(3, 0)$ can take any value.

The solution to this optimization problem determines $C(3, 0)$, the expected profit for an outlet which has learned 3 left-wing facts and 0 right-wing facts. The outlet's investigation decision after learning 2 left-wing facts is given by

$$d(2,0) \in \underset{d(2,0)\in[0,1]}{\operatorname{argmax}}\ d(2,0)\left[p\frac{\beta_T(1)}{\beta_S(1)} + (1-p)C(3,0) - c\right] + (1-d(2,0))\left[\frac{\beta_T(0)}{\beta_S(0)}\right] \tag{5}$$

Because the optimization problem for $d(3, 0)$ is linear, either $C(3, 0) = p\frac{\beta_T(1)}{\beta_S(1)} + (1 - p)\frac{\beta_T(0)}{\beta_S(0)} - c$ or $C(3, 0) = \frac{\beta_T(0)}{\beta_S(0)}$ (or both). Substituting either of these values into (5) gives conditions identical to those for $d(3, 0)$, so

$$d(2,0), d(3,0) = \begin{cases} 0 & \text{if } c > p\left(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(0)}{\beta_S(0)}\right) \\ 1 & \text{if } c < p\left(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(0)}{\beta_S(0)}\right) \end{cases} \tag{6}$$

An equivalent analysis can be done to determine an outlet's optimal actions after learning only right-wing facts. The probability of learning a left-wing fact and being able to report $k = 1$ is $(1 - p)$, so

$$d(2,2), d(3,3) = \begin{cases} 0 & \text{if } c > (1-p)\Big(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(2)}{\beta_S(2)}\Big) \\ 1 & \text{if } c < (1-p)\Big(\frac{\beta_T(1)}{\beta_S(1)} - \frac{\beta_T(2)}{\beta_S(2)})\Big) \end{cases} \tag{7}$$

The actions described in (6) and (7) generate a distribution of reports. For example, the probability a strategic outlet makes report $k = 1$ is given by

$$\begin{aligned} \beta_S(0) =& (1-p)^2\Big((1 - d(2,0)) + d(2,0)(1-p)(1-d(3,0)) \\ &+ d(2,0)d(3,0)(1-p)^2\Big) \\ =& (1-p)^2\Big(1 - d(2,0)p - d(2,0)d(3,0)p(1-p)\Big) \end{aligned} \tag{8}$$

The first term in this expression is the probability that the initial draw contains two left-wing facts, which is necessary for $k = 0$ to be reported.[5] The second term is the probability that report $k = 0$ is conditional on this initial draw. This term can be decomposed into three expressions; the probability that no investigation occurs $(1 - d(2,0))$, the probability one more fact is investigated, found to be left-wing, and no further investigation takes place $(d(2,0)(1-p)(1-d(3,0))$, and the probability that two more facts are investigated and both are found to be left-wing $(d(2,0)d(3,0)(1-p)^2)$.

Similarly,

$$\begin{aligned} \beta_S(2) &= p^2\Big((1 - d(2,2)) + d(2,2)p(1-d(3,3)) + d(2,2)d(3,3)p^2\Big) \\ &= p^2\Big(1 - d(2,2)(1-p) - d(2,2)d(3,3)p(1-p)\Big) \end{aligned} \tag{9}$$

And

$$\begin{aligned} \beta_S(1) =& 1 - \beta_S(0) - \beta_S(2) \\ =& 1 - (1-p)^2\Big(1 - d(2,0)p - d(2,0)d(3,0)p(1-p)\Big) \\ &- p^2\Big(1 - d(2,2)(1-p) - d(2,2)d(3,3)p(1-p)\Big) \end{aligned} \tag{10}$$

A Perfect Bayesian Equilibrium exists if a strategy is sequentially rational for beliefs which are consistent given the strategy. A set of values for $d(2,0)$, $d(3,0)$, $d(2,2)$ and $d(3,3)$ are part of a Perfect Bayesian Equilibrium if and only if the investigation decisions in (6) and (7) are optimal given the values of $\beta_S(0)$, $\beta_S(1)$ and $\beta_S(2)$ in (8), (9) and (10) and the values of $\beta_S(0)$, $\beta_S(1)$ and $\beta_S(2)$ in these equations are consistent with the investigation decisions.

[5] As a consequence of Proposition 1, report $k = 0$ is only made after initial draw $a_2 = 0$. If the initial draw is $a_2 \neq 0$, and report $k = 0$ is in the set of available reports, then report $k = 1$ is in the set of available reports as well, and is made with probability 1.

Since the revenue from making report k decreases with the probability a strategic outlet makes report k, $\frac{\beta_T(0)}{\beta_S(0)}$ and $\frac{\beta_T(2)}{\beta_S(2)}$ are strictly increasing in the amount of investigation while $\frac{\beta_T(1)}{\beta_S(1)}$ is strictly decreasing. Investigation reduces the return from investigating, so there is a unique distribution of equilibrium beliefs and reports.