A MODEL OF DEBATES: MODERATION VS FREE SPEECH

Tymofiy Mylovanov and Andriy Zapechelnyuk

Abstract. This paper provides a framework to study communication conflicts, such as political debates, using a novel model of competition in Bayesian persuasion. Debating parties can frame their arguments for maximal impact. They also can spam the discussion to distract the audience from the opponent's arguments. We find that spamming is more detrimental than framing. Truth discovery requires moderation by restricting on the number of arguments that parties can make. When the parties are allowed to speak freely, spamming can kill truth discovery and make communication completely uninformative. By contrast, framing is disciplined by competition. If the conflict between the parties is strong and the number of arguments is restricted, the parties reveal the truth.

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Mylovanov: University of Pittsburgh, Department of Economics, 4714 Posvar Hall, 230 South Bouquet Street, Pittsburgh, PA 15260, USA. *E-mail:* mylovanov@gmail.com.
Zapechelnyuk: School of Economics and Finance, University of St Andrews, Castlecliffe, the Scores, St Andrews KY16 9AR, UK. *E-mail:* az48@st-andrews.ac.uk.

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1. Introduction

> The proper response to a charge that you beat your wife is *not* to explain that you don't beat your wife and are in fact an ardent feminist: it's to point out that throwing around accusations without evidence makes your opponent a piece of garbage.
>
> Ben Shapiro, "How to Debate Leftists and Destroy Them"

On June 4th, 2021 Tymofiy Mylovanov, a coauthor of this paper, was preparing for a debate on national television. A fortnight earlier a prominent journalist accused Tymofiy – without evidence – of accepting a bribe.

Just before the accusation, Tymofiy was appointed the chairman of the supervisory board of the Ukrainian Defense Industry Consortium, a holding of over a hundred of state-owned enterprises that produce military equipment in Ukraine. A day before the appointment, the Consortium made public (as required by law) a research contract with Kyiv School of Economics, where Tymofiy is the president. The journalist stated that this contract is a bribe to Tymofiy for agreeing to serve on the board. A public communication crisis ensued.

What was Tymofiy supposed to do? Issue a public rebuttal? Write a post on his (popular, well-followed) social network page? Appear on a prominent TV show? Reach out to the journalist and convince him that there was no impropriety? Tymofiy was worried that all of it would be futile. Any response would be perceived as defensive and the truth would be lost in the noise of the social media and TV. After all, who's got the patience nowadays to get to the bottom of the issue?

Tymofiy did not explain the facts. Instead, he challenged the journalist to a debate on national television. It took a week to bargain over the format and find a suitable national TV show. The debate was 1 hour long split in two parts. In each part one party made statements or posed questions and the opponent responded. Then the roles switched. After the debate, the audience seemed to be convinced that the scandalous aspect of the accusation – the bribe – had no substance. The public interest in the topic vanished and the communication crisis was over.

This paper provides a formal framework to study communication conflicts, such as the one described above. We focus on two competing forces. First, each party can frame its arguments for maximal impact. Second, it can spam the discussion to distract the audience from the opponent's arguments.

In our model, spamming turns out to be more detrimental than framing. Truth discovery requires restricting the number of arguments that parties are allowed to make. Spamming can kill truth discovery and make communication completely uninformative. By contrast, framing is disciplined by competition. If the conflict between the accuser and the defendant is strong and the number of arguments is restricted, the parties will reveal the truth.

Before we describe the model, let us note several applications in addition to the one of a response to a public accusation. *Freedom of speech.* In democracy it enables informed citizens. But what if opinion leaders manipulate citizens through framing and distraction? *Social media.* They provide everyone with an opportunity to speak. But special interest groups have learned to abuse social media to frame, polarize, and confuse. *Public hearings.* Congressional hearings used to be the golden standard of truth discovery. Think of the Truman commission. Nowadays, they are more likely to be shouting matches. *Debates.* The same holds for political debates. In the second Biden-Trump debate, the organizers were compelled to the rule that mutes the microphone of the candidate unless it is his turn to speak.

In our model, there are two parties: an accuser and a defendant. The parties appeal to an audience that consists of a continuum of citizens. A citizen supports the accuser if there is sufficient truth to the accusation. Otherwise she supports the defendant. Formally, the truth is an unobserved state of the world. A citizen supports the accuser if the expected state is above the citizen's private threshold. Citizens's thresholds differ reflecting their sympathy to the defendant, political stance, preferences, or biases. Each party maximizes an increasing function of the citizens' total support.

The parties invite several (potentially) informed agents to make arguments. Citizens observe the arguments and then choose whether to support the accuser or the defendant. Each citizen can only observe and mentally process up to a given number of arguments. If the number of arguments exceeds the limit, the citizen takes into account only a random sample of them.

The agents who make arguments are classified into experts, activists, and bots. Experts are instruments of *informational framing.* They reveal information about the state according to their expertise. An expertise is described by an information structure that divides the state space into intervals (categories) and reveals which category the state belongs to. The experts cannot lie, as their expertise is valuable only as long as it is credible. There is a large pool of such experts with a variety of expertise. The parties choose framing by selection of an appropriate type of experts.[1]

Activists and bots capture the idea that the parties cannot control all sources of information. While the accuser and the defendant control information they provide through experts, they can also distract from the information provided by their opponent (and, perhaps, by their own expert) by inviting activists and bots to speak. Activists are partially and independently informed participants who make (binary) arguments in support or against the accusation. Bots make uninformative arguments in support of either the accuser or the defendant. Because citizens have limited attention, bots distract citizens from informative arguments, thus serving as instruments of *spamming*.

We compare three discussion formats. The first format is an *information monopoly*, where the defendant refrains from responding, so the accuser is the only party that controls information disclosure. The other two formats are called *free debate* and *moderated debate*. A debate has an exogenous capacity for the number of arguments. Each party can invite agents to make arguments as long as the capacity is not exceeded. In a free debate, the capacity is large and exceeds the citizens' attention limit. So a large, potentially unlimited number of opinions can be voiced, as in discussion threads on Facebook and Twitter. Each citizen can only observe a sample of all the arguments made in a free debate. In contrast, in a moderated debate, a small number of invited participants are allowed to speak, as in TV debates and Clubhouse meetings. The capacity is smaller than a citizen's attention limit, so the citizens can observe all the arguments made in the debate.

We obtain a few insights using this model. Let us briefly discuss them.

An obvious merit a free debate is that it allows everybody to have a say. Freedom of speech is a fundamental value of democracy, in particular, because it leads to informed citizens and informed voters. However, we show that when the participation and agenda of debates are controlled by the interested parties, there is little or no information disclosure in a free debate. The information aggregation from a large number of independent information sources does not occur. There is a simple reason for this. Each party has an incentive to substitute activists, who are uncontrolled sources of information, with fully controlled bots. The debate becomes spammed. A

[1]In some applications, as in the one motivating this paper, the accuser and the defendant can themselves be the experts and make arguments on their own behalf.

representative citizen, who can only observe a sample of the arguments due to her attention constraint, is likely to observe nothing but noise.

In comparison to free debates, moderated debates reveal more information. In such debates, disclosure comes through expertise. The restriction on the number of arguments ensures that the citizens (who have limited attention) never miss the experts' arguments. Despite the parties choosing their experts strategically, the competition between them leads to substantial informational gains for citizens, greater than those under information monopoly or free debate. In fact, the state of the world is fully revealed if the conflict between the parties is strong enough, for example, if their utilities are zero-sum, or if they are linear in the citizens' total support.

This leads to a somewhat controversial conclusion. It is reasonable to think that citizens would prefer two centrist parties who have a lot in common and can find compromises to work for the good of the society, as opposed to having two extremist parties who consider the win of one as the loss of the other, and compromise on nothing. It might seem that when there is a scope for compromise, there will be more incentives to reveal information. Our model shows that this need not be the case. The parties have interest in increasing the public support by manipulating information. They reveal more than they would like to only when pressured by the competition.

We also establish how the public ranks the discussion formats, in terms of how much information they reveal. Moderated debates reveal more than information monopolies, and free debates reveal the least. We also find that, for the defendant who is initially at disadvantage, moderated debates are preferred to both free debates and the accuser's information monopoly, whereas, obviously, the accuser always prefers his own information monopoly.

Do our result imply that the society should regulate the freedom of speech to mitigate spamming? This is a scary proposition in practice. Who will be the judge of what is considered spam? The government? An appointed committee? The answer is outside of our formal model, but we hope that technological innovation driven by competition among social platforms will eventually take care of this. A recent (albeit fleeting) popularity of audio social networks such as Clubhouse or Audio Telegram provide an example. In audio social networks, discussions are moderated, often moderators allow one person to speak at a time, spammers are removed, speakers are allowed to respond to accusations and comments, and interaction happens in real time with the audience present and focused on the speakers. On these platforms, competition appears to be among the moderators rather than the speakers, and the audience flocks to the audio rooms that are better moderated and have more informative discussions.

Finally, as a theoretical contribution, we show that our moderated debate can be represented as a novel model of the competition in Bayesian persuasion between two senders, with a vanishing cost of information disclosure. This model is an extension of a single-sender model of Kolotilin, Mylovanov, and Zapechelnyuk (2021), which corresponds to the information monopoly. We characterize and prove uniqueness of the equilibrium outcome in our model, compare it with that in the single-sender model, and find the necessary and sufficient condition for full disclosure.

Related Literature. The term *debate* refer to a decision procedure that formalizes rhetoric and argumentation, where informed but biased parties choose arguments, and an uninformed listener reaches a conclusion based on these arguments. Glazer and Rubinstein (2001) study an abstract model where the state is a string of 0's and 1's, and the listener wants to know whether there are more 1's than 0's. They adopt a mechanism design approach: To elicit information from two informed parties, the listener designs a sequential communication protocol subject to a constraint on its complexity. Spiegler (2006) studies a different setting where two parties debate on two issues at the same time. He uses an axiomatic approach to derive a solution that describes how arguments should be selected and how winners should be chosen. In our paper, we adopt a more pragmatic model of a debate. It is a public information exchange between biased parties with the purpose of providing information to citizens.

In some public economics and political science literature, the term *debate* appears with a different meaning. It refers to a pre-play cheap talk communication of asymmetrically informed legislators tasked to agree on a public decision. This communication is simultaneous in Austen-Smith (1990) and sequential in Ottaviani and Sørensen (2001). In Spector (2000) this communication precedes each decision-making round in an infinitely repeated interaction of legislators.

We adopt the Bayesian persuasion approach to modeling experts. Methodologically our paper is built upon a single-expert Bayesian persuasion model of Kolotilin, Mylovanov, and Zapechelnyuk (2021), which we extend to a game between two competing experts with a vanishing cost of information disclosure, and characterize the equilibrium of this game.

Our paper is closely related to the literature on competition in Bayesian persuasion where senders commit to information disclosure protocols before learning the state of the world, as in Gentzkow and Kamenica (2017a,b) and Li and Norman (2018).[2] The results in these papers use the property that if each sender reveals some bit of information, then no sender can profitably deviate by concealing it, because the receiver will learn it from the other sender anyway. In particular, there is always a fully revealing equilibrium where each sender reveals the state. Notice, however, that if information disclosure was costly, then each sender *could* have profitably deviated by not revealing the information that is anticipated to be revealed by the competitor. The crucial difference of our paper from Gentzkow and Kamenica (2017a,b) and Li and Norman (2018) is that we assume an arbitrarily small cost of information disclosure. We thus eliminate the equilibria that rely on zero-cost disclosure and obtain the unique equilibrium outcome. Our model has substantially more structure, and our equilibrium characterization is not immediately generalizable to the settings of Gentzkow and Kamenica (2017a,b) and Li and Norman (2018).

Our paper also contributes to the literature on competitive expertise and informational lobbying, in which two or more biased experts consult a policy maker or legislator. The main focus of this literature is on whether consulting more than one expert can improve the information disclosure to the policy maker, and if so, whether full disclosure can be achieved. The majority of this literature assumes that experts' communication is cheap talk. In Gilligan and Krehbiel (1989), Krishna and Morgan (2001a,b), Battaglini (2002), Ambrus and Takahashi (2008), Li (2010), and Mylovanov and Zapechelnyuk (2013a,b) the experts are fully informed about the state of the world, so the inclusion of more than one expert has no informational role, but it can improve the incentives for information disclosure. In Austen-Smith (1993), Wolinsky (2002), Battaglini (2004), Levy and Razin (2007), and Ambrus and Lu (2014), the experts are imperfectly informed, so multiple experts can improve the informational content of cheap talk. In contrast, Li (2010) shows that more experts can lead to less information disclosure.[3] In addition to cheap talk communication, the literature considers other types of communication of the experts. The experts can collude in their information disclosure strategies, as in Zapechelnyuk (2013). The experts can strategically choose the amount of information obtained through i.i.d. random processes, as in Brocas, Carrillo, and Palfrey (2012) and Gul and Pesendorfer (2012). The effects of the order in which the experts present their arguments are explored in Krishna and Morgan (2001b) and D'Agostino and Seidmann (2021).

[2]A different model of competition in Bayesian persuasion, where multiple senders disclose independent pieces of private information, is studied in Au and Kawai (2020).

[3]A similar result is shown by Li and Norman (2018) in a Bayesian persuasion setting.

In this paper we allow for a potentially large number of *activists* who report their noisy i.i.d. information about the state of the world. Our paper is thus related to the literature on strategic voting and information aggregation in elections and polls (Austen-Smith and Banks, 1996; Feddersen and Pesendorfer, 1997; Razin, 2003; Morgan and Stocken, 2008). The highlight of this literature is that the aggregation of disperse information does not always occur in polls. We also obtain this result, but for a different reason. Unlike the above literature, in our paper the set of poll participants is endogenous and strategically chosen by the interested parties. In equilibrium only uninformative participants (bots) are chosen, thus no information aggregation occurs.

2. Model

2.1. **Preliminaries.** Two parties are engaged in a public debate on some issue relevant to the public, for example, whether some economic policy should be implemented, or whether an accusation against one of the parties is true and that party should face a political defeat. As per the latter interpretation, the two parties are called an *accuser* (A) and a *defendant* (D) and labeled by A and D. The truth about the issue is summarized by a random unobserved state of the world $\omega \in [0, 1]$. The public consists of a continuum of citizens indexed by type $\theta \in [0, 1]$ that captures the heterogeneity of the citizens' attitudes towards the issue. The utility of each citizen with type θ is given by $\omega - \theta$ if the citizen decides to support party A on this issue, and it is equal to 0 if the citizen decides to support party D.

The state ω and the type θ are distributed independently, according to prior probability distribution functions F and G that have continuous and strictly positive densities f and g, respectively.

2.2. **Debate.** Citizens are informed about the state ω through a debate. In a debate, a few participants make arguments that are potentially informative about ω. A debate has a given capacity of N participants, with at least one participant for each party, so $N \geq 2$. We will also consider a special case of the information monopoly with a single participant, $N = 1$.

Each debate participant makes a single argument, so there are N arguments in total. Citizens have an attention limit. Each citizen can only observe up to L arguments, where $L \geq 2$ is exogenously given. So, if $N \leq L$, then each citizen observes all N arguments. However, if $N > L$, then each citizen observes a random sample of size L from the profile of N arguments, where each argument in the profile is equally likely to be observed. As a result, each citizen observes her type θ and a sample $\hat{m}$ of the arguments (with the sample size of $\min\{L, N\}$), derives a posterior expected state $\mathbb{E}[\omega|\hat{m}]$ using Bayes' rule, and then supports party A if and only if $\mathbb{E}[\omega|\hat{m}] \geq \theta$.[4]

The participants of the debate are classified into *experts*, *activists*, and *bots*. We now describe each class of participants in detail.

Experts are participants who are partially informed about the state. Each party $i = A, D$ invites a single expert. An expert invited by party i is endowed with a *disclosure rule* that describes this expert's expertise, that is, what this expert can find out and reveal about ω. Each expert's disclosure rule is fixed and publicly known: the expert has a reputation to maintain and must reveal her information when providing expertise. We assume that there is a large pool of such experts with a variety of disclosure rules. Each party can invite any expert from this pool.

A disclosure rule of an expert i is a *monotone partitional signal* defined as a right-continuous, weakly increasing function $\sigma_i : [0,1] \to [0,1]$ that associates with each state ω a message $\sigma_i(\omega)$. Informally, σ_i divides the state space $[0,1]$ into intervals (categories) and reveals the category that the state belongs to. As standard in the persuasion literature (e.g., Kamenica and Gentzkow, 2011), we normalize each message $m_i = \sigma_i(\omega)$ to be equal to the expected state conditional on that message,

$$\sigma_i(\omega) = \mathbb{E}[\omega|m_i = \sigma_i(\omega)].$$

For example, the *full disclosure rule* is $\sigma_i(\omega) = \omega$, and *no disclosure rule* is constant and equal to the prior expectation of ω, so $\sigma_i(\omega) = \mathbb{E}[\omega]$. Let Σ be the set of all monotone partitional signals. Thus, Σ is the pool of experts that the parties choose from.

Unlike the experts who can make complex arguments, activists and bots are participants who make binary arguments, $m \in \{A, D\}$, where $m = i$ indicates the support of party i.

Activists are participants who have a noisy information about ω. Each activist j sends message $m_j = A$ with a given probability $p(\omega) = \Pr(m_j = A|\omega)$, and message $m_j = D$ with the complementary probability, independently of the other participants. The function $p(\omega)$ is assumed to be strictly increasing in ω. Activists are not invited, they turn up on their own until the capacity of the debate is filled.

[4]It is immaterial how a tie is resolved, because it is a zero probability event.

Bots are participants invited by the parties to make uninformative arguments in support of the inviter. Each bot invited by party $i = A, D$ always sends the message that supports the inviting party.

When observing arguments made by the participants, citizens can identify the experts. However, citizens cannot distinguish activists from bots, so they treat their arguments symmetrically.[5]

The debate protocol is as follows. First, each party $i = A, D$ invites a single expert with a disclosure rule σ_i chosen from the set of monotone partitional signals Σ. At the same time, each party i invites n_i bots, $0 \le n_i \le N-2$. If $n_A + n_D > N-2$, then bots are proportionally rationed to capacity.[6] If $n_A + n_D < N-2$, then the remaining capacity of $N-2-n_A-n_D$ is filled with activists. Finally, a state ω realizes, and the participants simultaneously make their arguments conditional on the state.

2.3. **Payoffs.** The parties are expected utility maximizers. Their preferences are as follows. Let q_i be an expected fraction of citizens who support party $i = A, D$, so $q_A + q_D = 1$. Each party $i = A, D$ obtains the utility $u_i(q_i)$, which is strictly increasing in q_i. For example, the parties can be interested in maximizing their public support on the debated issue, so the utilities are linear, $u_i(q_i) = q_i$. For another example, the parties can be interested in reaching the support by the simple majority, so each u_i smoothly approximates the step function $\psi_{1/2}$ given by $\psi_{1/2}(q_i) = 0$ when $q_i < 1/2$ and $\psi_{1/2}(q_i) = 1$ when $q_i > 1/2$.

In addition, the parties incur costs for inviting participants. Each bot has a flat cost $\kappa > 0$. The experts are assumed to have the entropy-based cost function as in the rational inattention literature (e.g., Matějka and McKay, 2015). The cost $\phi(\sigma)$ of an expert with a disclosure rule σ is the expected reduction in the entropy relative to the prior distribution. Formally,

$$\phi(\sigma) = \mathcal{H}(F) - \mathbb{E}_\sigma\big[\mathcal{H}(F_\sigma(\cdot|m)\big],$$

where $\mathcal{H}(\cdot)$ is the entropy function, F is the prior distribution of ω, and $F_\sigma(\cdot|m)$ is the posterior distribution of ω conditional on message m of disclosure rule σ. Thus, party i that invites n_i bots and the expert with a disclosure rule σ_i incurs the cost

$$c\big(\kappa n_i + \phi(\sigma_i))\big),$$

[5]This assumption simplifies exposition, but, as discussed in Section 4.1, it is unimportant as long as there is a positive probability of confusing activists with bots.

[6]The exact rationing rule is unimportant as long as it is monotone, because the parties do not exceed the capacity in equilibrium.

where $c > 0$ is a cost scaling parameter.

2.4. **Equilibirum.** We analyze the game between the two parties. Each party i's strategy is a pair $s_i = (n_i, \sigma_i)$ that consists of a number of bots n_i and a choice of an expert's disclosure rule σ_i, where $0 \leq n_i \leq N-2$ and $\sigma_i \in \Sigma$. The subsequent choices of the debate participants and the citizens are as described above. Let $U_i(s_A, s_D)$ be the expected payoff of party i as a function of the parties' strategies. This is the expected utility from the citizens' support net of the costs. The solution concept is Nash equilibrium in pure strategies.

Each pair of strategies $s = ((n_A, \sigma_A),\ (n_D, \sigma_D))$ induces a probability distribution H_s over the posterior expected state observed by a representative citizen. We will refer to this probability distribution as the *outcome* of strategy profile s. In words, the outcome summarizes the information disclosed to a representative citizen through the debate.

2.5. **Assumptions.** For the remainder of the paper, we maintain the following assumptions:

$$\text{density } g \text{ of type } \theta \text{ is strictly log-concave on } [0,1]; \tag{A$_1$}$$

$$\text{marginal utilities } u'_A \text{ and } u'_D \text{ are log-concave on } [0,1]; \tag{A$_2$}$$

$$D \text{ prefers full disclosure to no disclosure;} \tag{A$_3$}$$

$$\text{the cost is vanishing, } c \to 0. \tag{A$_4$}$$

Log-concavity[7] is a common assumption in a variety of economic applications, such as voting, signalling, and monopoly pricing (see Section 7 in Bagnoli and Bergstrom, 2005). Log-concave densities exhibit nice properties, such as unimodality and hazard rate monotonicity. Many familiar probability density functions are log-concave (see Table 1 in Bagnoli and Bergstrom, 2005). Log-concave marginal utility functions are monotone (e.g., decreasing marginal utility) or single-peaked. Thus, we can include the case relevant in political applications in which the parties care more about obtaining the support of the citizens near the median of the population distribution and less about those at the extremes (e.g., obtaining the support of the simple majority).

Assumption (A_3) formalizes the idea that the defendant is initially at a disadvantage. That is, the initial situation where the public is uninformed is less favorable for the defendant than the situation where the public learns the truth. This is consistent with our story, as in practice accusations come at the time when the accused is

[7]A function $h(x)$ is (strictly) log-concave if $\ln h(x)$ is (strictly) concave.

vulnerable. This assumption is made for the ease of interpretation. It plays no role in the equilibrium analysis.

By Assumption (A_4), throughout the paper we analyze the parties' optimal behavior when there is no cost to invite participants, but this optimum is robust to the introduction of a small cost. Essentially, this means that the parties lexicographically prefer fewer bots and less informative experts whenever the citizens' choices are unaffected.

3. Formats

We analyse and compare three discussion formats: an information monopoly, a free debate, and a moderated debate.

An *information monopoly* of a party is the format where only the specified party provides information to the public by inviting a single expert, $N = 1$.

A *moderated debate* is one with a small capacity, so that the number of participants does not exceed the limit of the citizen's attention, $2 \leq N \leq L$. In a moderated debate, every citizen observes all the arguments of the debate.

A *free debate* is one with no upper bound on the number of participants. We will consider an approximation of the free debate by assuming a bounded capacity as it tends to infinity, $N \to \infty$.

3.1. Information Monopoly.

To set a benchmark, we first consider the case of the information monopoly, where one of the two parties monopolizes the information disclosure to the public.

A party $i \in \{A, D\}$ is the *information monopoly* if it chooses a single expert, and each citizen is informed about the state ω only by observing messages of the disclosure rule σ_i of that expert.

We now find for each party $i = A, D$ the optimal disclosure rule σ_i^M when this party is the information monopoly.

Proposition 1. *Let party $i \in \{A, D\}$ be the information monopoly. The optimal disclosure rule σ_i^M is unique and satisfies the following properties:*

(i) Let $i = A$. There exists a threshold x_A^M such that σ_A^M reveals the state when $\omega \in [0, x_A^M]$ and pools the states in $(x_A^M, 1]$.

(ii) Let $i = D$. There exists a threshold x_D^M such that σ_D^M reveals the state when $\omega \in (x_D^M, 1]$ and pools the states in $[0, x_D^M]$.

This proposition follows from Theorem 1 in Kolotilin, Mylovanov, and Zapechelnyuk (2021), whose conditions are satisfied under our assumptions. Using their terminology, rule σ_A^M is referred to as *upper censorship*, and rule σ_D^M is referred to as *lower censorship*. The formal proof Proposition 1 is in Appendix A.2.

To gain the intuition for why such disclosure rules are optimal, imagine that there are three states: bad, average, and good (for the defendant). Suppose that the citizens initially believe the expected state is average. Also suppose that the majority of the citizens will support the defendant if they believe that the state is above average. The defendant never gets the support of the majority if it provides no information, and only gets it in the high state if it fully reveals the state. However, the defendant can get the support of the majority in the average and high states if she pools these states (by sending the same message in both) and reveals the low state. So, giving away bad news is instrumental to credibly improve the posterior beliefs when the news is not bad.

3.2. **Optimal Number of Bots.** In this section we consider debates in both free and moderated formats. We show that, in equilibrium, either the state is fully revealed, or the parties fill the debate capacity with bots and leave no room to activists.

Proposition 2. *Consider a debate with capacity $N \geq 2$. For every Nash equilibrium $s^* = ((n_A^*, \sigma_A^*), (n_D^*, \sigma_D^*))$ at least one of the following properties must hold:*

(i) the equilibrium outcome is full disclosure;

(ii) $n_A^* + n_D^* = N - 2$.

The proof is in Appendix A.3.

Intuitively, if there are activists among the debate participants, each party i has an incentive to deviate from its strategy (n_i^*, σ_i^*) by adding a friendly bot. This deviation is undetected by the citizens, because they cannot distinguish bots and activists. So, with a strictly positive probability, each citizen observes one less argument from an activist and one more argument from party i's bot, which strictly benefits party i. Put simply, the parties have incentives to substitute activists, who are uncontrolled sources of information, with controlled bots.

The main conclusion from Proposition 2 is that in debates where the participation and agenda are controlled by the interested parties, activists play no role. Either the state is fully revealed by the experts, in which case the information provided by activists is redundant, or the entire capacity is filled with two experts and $N-2$ bots, and no activists are present at all. Thus, crowdsourcing of information by combining a large number of independent, imperfectly informative arguments does not occur in such debates.

3.3. **Informativeness.** Let us compare how much information is revealed to the public in different discussion formats.

We compare the value of different formats to the citizens by Blackwell informativeness of their equilibrium outcomes. We say that a probability distribution H is *more Blackwell-informative* than a probability distribution $\tilde{H}$ if H is a mean-preserving spread of $\tilde{H}$ (Blackwell, 1953).

An outcome of a strategy profile s is *interval censorship* if there is a pair of thresholds (x', x'') with $0 \leq x' \leq x'' \leq 1$ such that the state ω is revealed if $\omega \in [0, x']$ and $\omega \in (x'', 1]$, and the states are pooled (i.e., the same pooling message is sent) when they belong to the interval $\omega \in (x', x'']$.

Two special cases of interval censorship are full disclosure and no disclosure. An outcome is *full disclosure* if the state is fully revealed, so $H_s(\omega) = F_s(\omega)$. It is *no disclosure* if no information about the state is revealed, so $H_s(\omega)$ has the unit mass on the prior expected state $\mathbb{E}[\omega]$.

Our first main result finds the equilibrium disclosure in the free and moderated formats.

Theorem 1. *Consider a debate with a capacity $N \geq 2$. Let $L \geq 2$ be a citizen's attention limit.*

(Moderated Debate) If $N \leq L$, then the unique Nash equilibrium outcome is an interval censorship. This outcome is more Blackwell-informative than optimal disclosure under the information monopoly of either party.

(Free Debate) In every Nash equilibrium, at least the fraction $1-2L/N$ of the citizens remain completely uninformed. As $N \to \infty$, the limit Nash equilibrium outcome is no disclosure.

The proof is in Appendix A.4.

Theorem 1 shows that, when the debate is moderated, the unique equilibrium outcome is interval censorship. Importantly, this outcome reveals more information to the citizens than the optimal interval censorships under the information monopoly of either party A or D.

In contrast, when the debate capacity N is large, the citizens get to sample and observe the experts' arguments exceedingly rarely. A representative citizen samples only bots with the probability at least $1 - 2L/N$. Because bots are uninformative (and the citizens know that there are no activists in equilibrium), the mass of at least $1 - 2L/N$ of the citizens remains uninformed. In the free debate, as $N \to \infty$, every equilibrium outcome approaches no disclosure.

Using Theorem 1, we can compare the informativeness of different discussion formats for the public.

Corollary 1. *A moderated debate is more Blackwell-informative than an information monopoly of either party, which is more Blackwell-informative than a free debate.*

The conclusion is that moderated debates are helpful as they reveal more information than the information monopolies. In contrast, even when it is in the interest of each party to optimally reveal some information, this interest is eroded and the information gets spammed when the debate is free.

3.4. **Comparison of Discussion Formats for Defendant.** Let us compare the discussion formats from the perspective of the defendant. Following our story, the defendant can choose one of three formats. First, she can refrain from making any discussion, thus granting the information monopoly to the accuser. Second, she can choose a free debate format which is a stylized approximation of an endless exchange of arguments. Third, she can challenge the accuser to a moderated debate, such as a debate on TV.

Corollary 2. *The defendant prefers a moderated debate to both a free debate and the accuser's information monopoly.*

Intuitively, the defendant has a better control over information in a moderated debate than in the accuser's information monopoly. Also the defendant prefers the equilibrium outcome of a moderated debate to full disclosure, because she has an option to fully disclose the state in a moderated debate. Finally, by our assumption (A_3), the defendant prefers full disclosure to no disclosure, which is the outcome of a free debate.

Notice that the comparison of the same formats from the accuser's perspective is obvious. The accuser will prefer his own information monopoly, as this is the format where he has the best control over the information disclosure.

3.5. **Equilibrium in Moderated Debate.** Our main result, Theorem 1, relies on Proposition 3 below that characterizes the equilibrium strategies of the parties in a moderated debate. In addition, it allows us to determine the conditions under which the competition of the parties for the public support leads to full disclosure of the state in moderated debates.

Before stating the proposition, we introduce some notation and prove an auxiliary lemma. Let x be a posterior expected state conditional on some message from σ_i. A citizen supports the policy if and only if her type θ does not exceed x. Thus, the citizen with type $\theta = x$ is indifferent between supporting and opposing the policy, and the fraction of the population that supports the policy is $G(x)$. Define

$$V_A(x) = u_A(G(x)) \quad \text{and} \quad V_D(x) = u_D(1 - G(x)). \tag{1}$$

So, $V_i(x)$ is party i's utility when the indifferent citizen has type x. Note that $V_A(x)$ is strictly increasing and $V_D(x)$ is decreasing in x. We will refer to $V_i(x)$ as party i's *indirect utility*.

We now show that, under the assumptions of this paper, the indirect utilities have specific shapes. Namely, $V_A(x)$ is *strictly S-shaped*, that is, it is first strictly convex, and then strictly concave. Symmetrically, $V_D(x)$ is *strictly inverted S-shaped*, that is, it is first strictly concave, and then strictly convex.

Lemma 1. *There exists $\tau_A, \tau_D \in [0, 1]$ such that*

(i) $V_A(x)$ is strictly convex for $x < \tau_A$ and strictly concave for $x > \tau_A$;

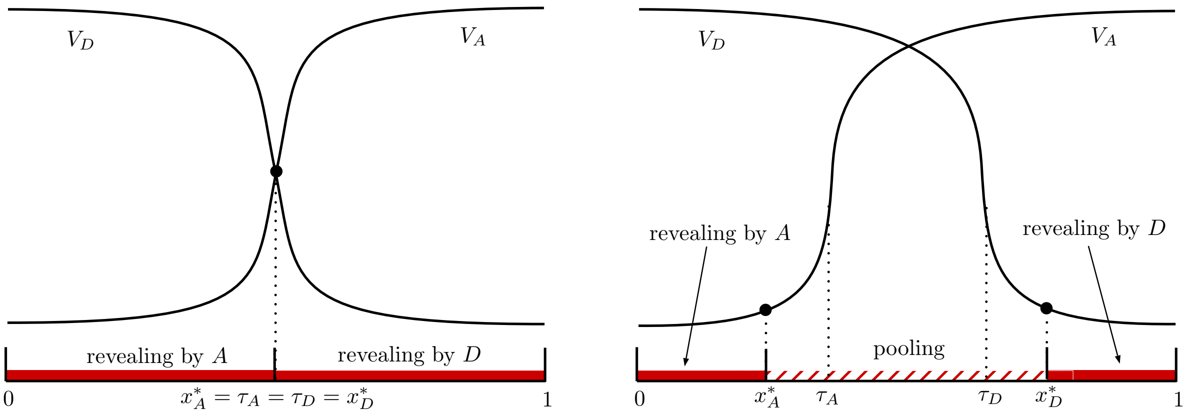
(ii) $V_D(x)$ is strictly concave for $x < \tau_D$ and strictly convex for $x > \tau_D$.

The proof is in Appendix A.5.

We denote by τ_i the inflection point of party i's indirect utility. If $\tau_A = 0$ and $\tau_D = 1$ then $V_A(x)$ and $V_D(x)$ are globally concave, so the value of every additional citizen that supports party $i = A, D$ diminishes. Similarly, if $\tau_A = 1$ and $\tau_D = 0$ then $V_A(x)$ and $V_D(x)$ are globally convex, so the value of every additional citizen that supports party $i = A, D$ increases.

Recall that x_i^M denotes the threshold of the optimal interval censorship under the information monopoly of party i (see Proposition 1).

Proposition 3. *Consider a debate with a capacity $2 \leq N \leq L$. Every Nash equilibrium $s^* = ((n_A^*, \sigma_A^*), (n_D^*, \sigma_D^*))$ induces the same outcome.*



(a) The case of $\tau_A = \tau_D$

(b) The case of $\tau_A < \tau_D$

FIGURE 1. Equilibrium disclosure for different τ_A and τ_D.

(i) If $\tau_A \geq \tau_D$, then there exists a threshold $x^* \in [0,1]$ such that σ_A^* reveals the states in $\omega \in [0, x^*]$ and pools the states in $(x^*, 1]$, whereas σ_D^* reveals the states in $\omega \in (x^*, 1]$ and pools the states in $[0, x^*]$.

(ii) If $\tau_A < \tau_D$, then there exists a unique pair of thresholds $0 \leq x_A^* < x_D^* \leq 1$ such that σ_A^* reveals the states in $\omega \in [0, x_A^*]$ and pools the states in $(x_A^*, 1]$, whereas σ_D^* reveals the states in $\omega \in (x_D^*, 1]$ and pools the states in $[0, x_D^*]$. Moreover,

$$x_A^M \leq x_A^* < x_D^* \leq x_D^M. \tag{2}$$

The proof is in Appendix A.6.

Besides characterizing the structure of the equilbrium disclosure outcomes, Proposition 3 delivers two insights.

The first insight is that in a moderated debate the Nash equilibrium outcome fully discloses the state if and only if $\tau_A \geq \tau_D$. To gain intuition, consider Figure 1. The horizontal axis shows the position x of the citizen who is indifferent between supporting parties A and D. As x increases, more citizens support party A and fewer support party D. Solid curves depict the indirect utilities of the parties, V_A is the increasing curve and V_D is the decreasing curve.

Figure 1(a) shows the case of strong competition, $\tau_A = \tau_D$. Up to the intersection in the middle, both parties have increasing marginal utilities from swaying the indifferent citizen to their side. Given party D disclosing the state on $[1/2, 1]$, V_A is convex on $[0, 1/2]$, so party A is risk loving, and thus it optimally reveals the state on that interval, which induces the riskiest lottery over the states. Symmetrically, given party A disclosing the state on $[0, 1/2]$, party D optimally reveals the state on interval $[1/2, 1]$. We thus obtain full disclosure by the two parties.

In Figure 1(b), where $\tau_A < \tau_D$, the situation is different. Both parties have decreasing marginal utilities from swaying the indifferent citizen x to their side when x is between τ_A and τ_D. The utilities of the parties are concave on that interval, so the parties are risk averse and benefit from pooling some states in the middle. The equilibrium cutoffs are as shown in Figure 1(b) for an appropriately chosen distribution of the state.

Note the condition $\tau_A \geq \tau_D$ is satisfied as equality if the parties have zero-sum or constant-sum utilities, or if their utilities are linear in the fraction of citizens who support them. In these special cases we obtain full disclosure of the state. We summarize the above in a corollary.

Corollary 3. *A moderated debate fully reveals the state if and only if the preferences of A and D are sufficiently conflicting, $\tau_A \geq \tau_D$. In particular, $\tau_A = \tau_D$ if*

(i) the parties' utilities are constant sum, so $u_A(q) + u_D(1-q) = c$ for some $c \in \mathbb{R}$;

(ii) the parties' utilities are linear, so $u_i(q) = \alpha_i + \beta_i q$ for some $\alpha_i \in \mathbb{R}$ and $\beta_i > 0$, $i = A, D$.

The second insight from Proposition 3 is that a moderated debate reveals more information that an information monopoly for two reasons. First, each information monopoly alone reveals the states on one end of the spectrum (as follows from Proposition 1), but the two parties together reveal the states on both ends of the spectrum, thus making the citizens fully informed whenever the states are extreme. Second, as follows from full disclosure in the case of $\tau_A \geq \tau_D$, and from the inequality (2) in the case of $\tau_A < \tau_D$, the competition makes each party reveal the state on a larger interval (e.g., $[0, x_A^*]$ for the accuser) as compared to what it would optimally do the under information monopoly ($[0, x_A^M]$ for the accuser).

4. Discussion

In this section we discuss several modeling assumptions and comment on some variations of the model.

4.1. Assumptions.

We outline the roles of various assumptions in our model.

In our debates, each party can invite only one expert. Expanding this to more than one expert makes no difference, as long as the set of experts is rich, in the sense that the available expertise includes all monotone partitional signals. This is because any such information structure communicated by multiple experts can be communicated by a single expert.

We assume that citizens cannot distinguish activists and bots. In reality, however, sometimes it is possible to suspect that certain participants are bots, and sometimes to be rather sure of that. However, this does not change our results. No party can use activists as information disclosure devices to its advantage, provided the set of experts is rich. So, as long as there is a strictly positive probability of confusing a bot with an activist, and the cost of bots is small enough, the parties still have incentives to invite bots in order to crowd out activists.

Next, we assume that when a debate has capacity that remains unfilled by invited participants, this capacity is filled by activists. This assumption is unimportant. For example, suppose instead that activists arrive according to a Poisson process and join the debate up to the capacity. As long as the cost of bots is small enough, the parties still have incentives to invite bots to fill the capacity and leave no room for activists to join.

Consider the assumptions that each citizen has the same attention limit L and that a uniformly random sample of L observations is observed when $N > L$. The key consequence of these assumptions is that a representative citizen samples an expert with a probability that approaches zero as $N \to \infty$. Clearly these assumptions can be substantially relaxed while retaining this consequence.

As usual in the Bayesian persuasion literature, the assumption that experts commit to their disclosure strategies is crucial. Our justification for this commitment is that the experts do not know the state, they simply reveal the results of their expertise. However, this does not preclude the possibility that a party bribes an expert to falsify the results of the expertise. We assume that this does not happen, as the experts have their reputation to maintain. The model of partial commitment in Bayesian persuasion is explored in Lipnowski, Ravid, and Shishkin (2019), Guo and Shmaya (2021), and Min (2021). Their findings demonstrate continuity with respect to small departures from commitment, thus suggesting that our results are robust in this regard.

In our model, the distribution of the citizens' types and the marginal utilities of the parties are assumed to be logconcave. While this is a rather common assumption, as we pointed out in Section 2.5, one may ask, for example, what happens if we assume monotone or single-peaked functions instead. As follows from Kolotilin, Mylovanov, and Zapechelnyuk (2021), the logconcavity assumption is sufficient for our Proposition 1, but not necessary. So there is a scope for the extension of our result to a larger set of primitives of the model. We leave this question for future research.

4.2. **Optimal Capacity.** Suppose that the regulator representing the defendant, the public, or the society as a whole can choose the capacity N of the debate. The optimal capacity is $N = 2$. That is, the optimal debate is the moderated debate that includes experts only. This is because in equilibrium there are no activists. Any excess capacity over $N = 2$ is filled with bots, which is a waste of resources from the perspective of the defendant and a waste of attention from the perspective of the public.

4.3. **Competing Events.** Suppose that instead of holding a moderated debate, each party hosts its own event (e.g., a press conference). This event has the same format as a debate with a given capacity $N \leq L$, but only the organizing party is allowed to invite participants. Suppose further that each citizen has to choose how to spread her attention L between the two events. In particular, a citizen can choose to focus her attention on a single event.

The equilibrium information disclosure of this game is the same as that in Theorem 1. The reason is as follows. First, notice that each party will fill the capacity of its event with bots, for the same reason as in the moderated debate. So the equilibrium disclosure is determined by the expertise. Second, because citizens can choose where to focus their attention, there will be self-selection with the full focus on a single event. Specifically, there will be a cutoff type θ^* such that types below θ^* will observe the event orgainized by the accuser, and types above θ^* will observe the event organized by the defendant. By the argument in Kolotilin, Mylovanov, Zapechelnyuk, and Li (2017, Proposition 2), this is equivalent to them observing both events simultaneously, which is the same as observing a moderated debate.

Appendix

A.1. **Auxiliary Lemma.** To prove our results, we will use an auxiliary lemma stated below. This lemma directly follows from Kolotilin, Mylovanov, and Zapechelnyuk (2021) under the assumptions of this paper.

Consider a problem of information monopoly when the state ω is restricted to some interval $[a,b]\subset[0,1]$ and distributed according to the conditional density $f(\omega)/(F(b)-F(a))$. Let $\Sigma_{[a,b]}$ the set of monotone partitional disclosure rules on $[a,b]$ of the information monopolist $i=A,D$.

Let $\sigma_i\in\Sigma_{[a,b]}$. Let x be a posterior expected state conditional on some message from σ_i. Because a citizen supports the accuser if and only if her type θ does not exceed x, we can also interpret x as the type of the indifferent citizen. For each $x\in[a,b]$ let

$$r_A(x)=V_A(x)-V_A(m_{[x,b]})-V_A'(m_{[x,b]})(x-m_{[x,b]}), \tag{3}$$

$$r_D(x)=-V_D(x)+V_D(m_{[a,x]})+V_D'(m_{[a,x]})(x-m_{[a,x]}), \tag{4}$$

where V_A and V_D are given by (1), and we use the notation

$$m_{[x',x'']}=\mathbb{E}\big[\omega\big|\omega\in[x',x'']\big].$$

By Lemma 1 in Section 3.5, there exist $(\tau_A,\tau_D)\in[0,1]^2$ such that $V_A(x)$ is strictly convex on $[0,\tau_A]$ and strictly concave on $[\tau_A,1]$, and $V_D(x)$ is strictly concave on $[0,\tau_D]$ and strictly convex on $[\tau_D,1]$. So τ_A and τ_D are the inflection points of V_A and V_D.

Lemma 2. *Let $\omega\in[a,b]\subset[0,1]$ be distributed with density $f(\omega)/(F(b)-F(a))$. Let party $i\in\{0,1\}$ be the information monopoly. There is a unique optimal disclosure rule $\sigma_i'\in\Sigma_{[a,b]}$. It is described as follows.*

Let $\tilde{x}_i$ be the unique point in $[a,b]$ that satisfies

$$r_i(x)>(<)\,0 \text{ whenever } x<(>)\,\tilde{x}_i.$$

(i) Let $i=A$. Then σ_A' reveals the state in $[a,\tilde{x}_A]$ and pools the states in $(\tilde{x}_A,b]$. Moreover, if $\tau_A\geq b$, then $\tilde{x}_A=b$ (so σ_A' is full disclosure); if $\tau_A<b$, then

$$a\leq\tilde{x}_A<\tau_A<m_{[\tilde{x}_A,b]}<b, \tag{5}$$

and

$$V_A'(m_{[\tilde{x}_A,b]})>V_A'(\tilde{x}_A) \quad \text{and} \quad V_A''(m_{[\tilde{x}_A,b]})<0. \tag{6}$$

(ii) Let $i = D$. Then σ'_D reveals the state in $(\tilde{x}_D, b]$ and pools the states in $[0, \tilde{x}_D]$. Moreover, if $\tau_D \le a$, then $\tilde{x}_D = a$ (so σ'_D is full disclosure); if $\tau_D > a$, then

$$a < m_{[a,\tilde{x}_D]} < \tau_D < \tilde{x}_D \le b, \tag{7}$$

and

$$V'_D(m_{[a,\tilde{x}_D]}) < V'_D(\tilde{x}_D) \quad \text{and} \quad V''_D(m_{[a,\tilde{x}_D]}) < 0. \tag{8}$$

Proof. Under Assumptions A_1–A_2, by Lemma 1 in Section 3.5, V_A is S-shaped (first convex and then concave) and V_D is inverted S-shaped (first concave and then convex). For $c = 0$, the existence and uniqueness of the disclosure rule stated in Lemma 2 follows from Theorem 1 in Kolotilin, Mylovanov, and Zapechelnyuk (2021) (thereafter, KMZ). Inequalities (5) and (7) follow from Lemma 2 in KMZ. Inequalities (6) and (8) follow from the property that $r_i(x)$ is single-crossing from above by Lemma 1 in KMZ, and that this crossing point is exactly $\tilde{x}_i$. Finally, by Gentzkow and Kamenica (2014), party i's expected utility is continuous in c when $c > 0$, so any optimal disclosure rule converges to σ'_i as $c \to 0$. □

A.2. **Proof of Proposition 1.** Proposition 1 follows immediately from Lemma 2 with $[a, b] = [0, 1]$. □

A.3. **Proof of Proposition 2.** Let $s^* = ((n^*_A, \sigma^*_A), (n^*_D, \sigma^*_D))$ be a Nash equilibrium whose outcome is not fully informative. To prove part (ii), we show that if there are activists, so $n^*_A + n^*_D < N - 2$, then one of the firms strictly prefers add one more bot, thus contradicting the assumption that s^* is a Nash equilibrium.

Let $n^*_A + n^*_D < N - 2$ and consider $i = A$ (the argument for $i = D$ is symmetric). The deviation from (n^*_A, σ^*_A) to $(n^*_A + 1, \sigma^*_A)$ changes the participant positioned at $j^* = 2 + n^*_A + n^*_A + 1$, from an activist who reports $m_{j^*} = A$ with probability $p(\omega)$ to a bot who reports $m_{j^*} = A$ with certainty. A representative citizen samples the argument of participant j^* with a strictly positive probability, $\min\{L, N\}/N > 0$.

Let $\hat{m}$ be a sample from the participants' arguments that contains the argument of participant j^* and does not fully reveal the state. The probability of drawing such a sample is strictly positive, because the outcome is not fully informative by assumption. Note that $\hat{m}$ may contain both, either, or none of the two experts. (Obviously, $\hat{m}$ always contains both experts if $N \le L$, and at least one if $N = L + 1$.) Because the experts that are contained in $\hat{m}$ (if any) do not fully reveal the state, there exists at least one interval $(\omega', \omega''] \subset [0, 1]$ such that, conditional on the arguments of the experts' contained in $\hat{m}$, the posterior state is pooled for each $\omega \in (\omega', \omega'']$. Because the density f of the state is strictly positive, this event occurs with a strictly positive probability, $F(\omega'') - F(\omega')$, leading to a nondegenerate posterior distribution with support on $(\omega', \omega'']$ and density $f(\omega)/(F(\omega'') - F(\omega'))$.

Recall that citizens cannot distinguish bots and activists, they only see argument A or D from every such participant in the samples they observe. Also recall that the activists' arguments are independent from each other, and the probability of $m_j = A$ is a strictly increasing function $p(\omega)$. Let $\hat{n}$ be the number of regular participants in the sample $\hat{m}$, and let $\hat{k} \in \{0, ..., \hat{n}\}$ be the number of arguments $m_j = A$ among these participants. Because the citizens believe that there is a strictly positive number of activists in total, $N-2-n_A^*-n_D^* > 0$, the posterior expected state $\mathbb{E}[\omega|\hat{m}, \omega \in (\omega', \omega'']]$ is strictly increasing in $\hat{k}$.

Thus, when $\omega \in (\omega', \omega'')$, changing the report of participant j^* from $m_{j^*} = A$ with probability $p(\omega) < 1$ to $m_{j^*} = A$ with certainty strictly increases the posterior expected state in each sample that contains participant j^* and is not fully revealing. It follows that a representative citizen's posterior expected state is never smaller, and with a strictly positive probability it is strictly greater. Thus, the deviation from (n_A^*, σ_A^*) to $(n_A^* + 1, \sigma_A^*)$ strictly increases the expected payoff of party A for each sufficiently small cost $c > 0$. □

A.4. **Proof of Theorem 1.** *Part 1 (Moderated Debate).* Let $N \leq L$. By Proposition 3 (see Section 3.4), the Nash equilibrium outcome is unique.

Let $s^* = ((n_A^*, \sigma_A^*), (n_D^*, \sigma_D^*))$ be a Nash equilibrium. If the outcome of s^* is full disclosure, then it is a special case of interval censorship. Obviously, it is more Blackwell-informative than any other outcome, in particular, those induced by σ_A^M and σ_D^M.

If the outcome of s^* is not full disclosure, then, by part (ii) in Proposition 3, σ_A^* and σ_D^* together reveal the state on $[0, x_A^*]$ and $(x_D^*, 1]$, and pool the states on $(x_A^*, x_D^*]$, where $x_A^* < x_D^*$. Moreover, by Proposition 2, $n_A^* + n_D^* = N - 2$. Consequently, the outcome of s^* is interval censorship with thresholds (x_A^*, x_D^*). Moreover, by Proposition 3, $x_A^M \leq x_A^* < x_D^* \leq x_D^M$. This means that the outcome of s^* reveals the state on a weakly larger set of states than either σ_A^M or σ_D^M (see Proposition 1), thus being more Blackwell informative.

Part 2 (Free Debate). The statement is vacuous for $N \leq 2L$. Let $N > 2L$, and let $s^* = ((n_A^*, \sigma_A^*), (n_D^*, \sigma_D^*))$ be a Nash equilibrium. The outcome of s^* cannot be full disclosure, because a citizen's sample contains no experts with a strictly positive probability:

$$\frac{N-2}{N}\cdot\frac{N-3}{N-1}\cdot\ldots\cdot\frac{N-L}{N-L+2}\cdot\frac{N-L-1}{N-L+1}=\frac{(N-L)(N-L-1)}{N(N-1)}\geq 1-\frac{2L}{N}>0.$$

We can thus conclude by Proposition 2 that $n_A^*+n_D^*=N-2$. It follows that with probability at least $1-2L/N$ a citizen samples only bots, thus receiving no information about the state. It follows that the mass of uninformed citizens is at least $1-2L/N$, which approaches 1 as $N\to\infty$. □

A.5. **Proof of Lemma 1.** We prove the lemma for $i=A$ (the proof is symmetric for $i=D$). By (1),

$$\begin{aligned}V_A''(x)&=\frac{\mathrm{d}^2}{\mathrm{d}x^2}u_A(G(x))=u_A''(G(x))\,(g(x))^2+u_A'(G(x))g'(x)\\&=u_A'(G(x))\,(g(x))^2\left(\frac{u_A''(G(x))}{u_A'(G(x))}+\frac{g'(x)}{(g(x))^2}\right).\end{aligned}$$

By assumption, u_A' and g are strictly positive, so $u_A'(G(x))\,(g(x))^2>0$. Because u_A' is log-concave and G is strictly increasing, $u_A''(G(x))/u_A'(G(x))$ is decreasing. Because g is strictly log-concave, we have $g''(x)g(x)<(g'(x))^2$. Therefore,

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{g'(x)}{(g(x))^2}\right)&=\frac{g''(x)(g(x))^2-2g(x)(g'(x))^2}{(g(x))^4}<\frac{(g'(x))^2g(x)-2g(x)(g'(x))^2}{(g(x))^4}\\&=-\frac{(g'(x))^2}{(g(x))^3}\leq 0.\end{aligned}$$

Thus, g'/g^2 is strictly decreasing. We have proved that $V_A''(x)$ crosses the horizontal axis at most once and from above, which implies the statement of Lemma 1. □

A.6. **Proof of Proposition 3.** We first show that if there is a Nash equilibrium outcome for $N>2$, then the same outcome is obtained in a Nash equilibrium for $N=2$. To prove this claim, let $s^*=((n_A^*,\sigma_A^*),(n_D^*,\sigma_D^*))$ be a Nash equilibrium for $N>2$. By Proposition 2, either (σ_A^*,σ_D^*) fully disclose the state, or $n_A^*+n_D^*=N+2$, so non-expert participants are all bots, and thus the pair (σ_A^*,σ_D^*) determines the outcome. We wish to show that for $N=2$, the strategy profile $\tilde{s}^*=((0,\sigma_A^*),(0,\sigma_D^*))$ that induces the same outcome must also be a Nash equilibrium. Suppose by contradiction that this is not the case, so at $\tilde{s}$ some party i has a strictly profitable deviation to some strategy $(0,\hat{\sigma}_i^*)$. But then the deviation to $(\hat{n}_i,\hat{\sigma}_i)=(N+2,\hat{\sigma}_i^*)$ when playing s^* for $N>2$ would also lead to a strict improvement in the payoff, provided the cost c is small enough. We thus have reached a contradiction to the assumption that s^* is a Nash equilibrium.

We thus conclude that Proposition 3 for $N > 2$ follows from Proposition 3 for $N = 2$, which we prove now. The proof for the case of $N = 2$ is divided into three steps. Step 1 derives a unique best reply of each party i. Steps 2 and 3 use Step 1 to establish Parts (i) and (ii) of Proposition 3, respectively.

Let $N = 2$, so the two experts are the only debate participants. A strategy of each party i reduces to a choice of a disclosure rule $\sigma_i \in \Sigma$. In what follows, we drop $n_A = n_D = 0$ from the notation.

Recall that τ_i is the inflection point of the expected utility V_i of each party i, as defined in Appendix A.1.

Step 1. For each party $i = A, D$ and each strategy $\sigma_i \in \Sigma$ of that party, the other party $j \neq i$ has a unique (up to a measure zero of states) best reply $BR_j(\sigma_i) \in \Sigma$. This best reply is fully described by a threshold $\tilde{x}_i \in [0, 1]$ as follows:

(a) $BR_A(\sigma_D)$ reveals each state in $[0, \tilde{x}_A]$ whenever it is not already revealed by σ_D, and pools the rest of the states into the largest possible intervals. Moreover, $\tilde{x}_A \leq \tau_A$.

(b) $BR_D(\sigma_A)$ reveals each state in $(\tilde{x}_D, 1]$ whenever it is not already revealed by σ_A, and pools the rest of the states into the largest possible intervals. Moreover, $\tilde{x}_D \geq \tau_D$.

Proof of Step 1. We provide the proof for $i = A$ (the proof is analogous for $i = D$). Let $\sigma_D \in \Sigma$. Because σ_D is a monotone partition, it can be described by a set of intervals I_P where the states are pooled and a set of intervals I_R where the states are revealed. Specifically, I_P contains the largest disjoint intervals $(a, b]$ on which the states are pooled by σ_D, so for each each $(a, b] \in I_P$ and each $\omega \in (a, b]$ we have $\sigma_D(\omega) = \mathbb{E}[\omega | \omega \in (a, b]]$. Also, I_R contains the largest disjoint intervals $(a', b']$ on which the states are revealed by σ_D, so for each each $(a', b'] \in I_R$ and each $\omega \in (a', b']$ we have $\sigma_D(\omega) = \omega$.

Suppose that $\tau_A = 0$. Then by Lemma 2 it is optimal for party A to pool all the states in $[0, 1]$, so $BR_A(\sigma_D)$ satisfies (a) with $\tilde{x}_A = 0$.

Alternatively, suppose that $\tau_A > 0$. Then there exists a unique interval $(a^*, b^*] \in I_R \cup I_P$ that contains τ_A. Conditional on the state being in $(a^*, b^*]$, by Lemma 2 there exists a unique $\tilde{x}_A < \tau_A$ such that it is optimal to reveal the states in $[a^*, \tilde{x}_A]$ and to pool the states in $(\tilde{x}_A, b^*]$.[8] For each interval $(a, b] \in I_R \cup I_P$ to the right of b^*, so $\tau_A \leq a$, by Lemma 2, it is optimal to pool the states. For each interval $(a, b] \in I_R \cup I_P$ to the left of a^*, so $\tau_A \geq b$, by Lemma 2, it is optimal to reveal

[8]Note that it does not make any difference whether an isolated point $\omega = a^*$ is revealed or pooled with an adjacent interval, because the distribution function F has no atoms by assumption.

the states. Consequently, $\sigma_A = BR_A(\sigma_D) \in \Sigma$ pools the states in $(\tilde{x}_A, 1]$ and reveals all the states in $[0, \tilde{x}_A]$ that are not already revealed by σ_D. Note that because less informative rules are cheaper when $c > 0$, this means that $\sigma_A = BR_A(\sigma_D) \in \Sigma$ pools the states that are already revealed by σ_D, i.e, in each interval $(a, b] \in I_R$ where $b < \tau_A$. □

Step 2. Let $\tau_A \geq \tau_D$. Then Part (i) in Proposition 3 holds for the case of $N = 2$.

Proof of Step 2. If (σ_A^*, σ_D^*) are mutual best replies, then by Step 1, there exist $(\tilde{x}_A, \tilde{x}_D)$ with $\tilde{x}_A \leq \tau_A$ and $\tilde{x}_D \geq \tau_D$ such that σ_D^* reveals all the states in $(\tilde{x}_D, 1]$ that are not already revealed by σ_A^*, and σ_A^* reveals all the states in $[0, \tilde{x}_A]$ that are not already revealed by σ_D^*.

We now show that $\tilde{x}_A = \tilde{x}_D$.

To rule out $\tilde{x}_A > \tilde{x}_D$, observe that in this case both parties reveal the state in $(x_D, x_A]$, so each party has a profitable deviation by using a less informative rule that does not reveal the state in that interval.

To rule out $\tilde{x}_A < \tilde{x}_D$, observe that in this case the state is pooled in the interval $(\tilde{x}_A, \tilde{x}_D]$, with the expected value

$$m_{(\tilde{x}_A, \tilde{x}_D]} = \mathbb{E}[\omega | \omega \in (\tilde{x}_A, \tilde{x}_D]].$$

But by Lemma 2 applied to $[a, b] = [0, \tilde{x}_D]$, given that the state is in $[0, \tilde{x}_D]$, the optimal threshold $\tilde{x}_A$ for party A must satisfy

$$\tilde{x}_A \leq \tau_A < m_{(\tilde{x}_A, \tilde{x}_D]}.$$

Similarly, by Lemma 2 applied to $[a, b] = [\tilde{x}_A, 1]$, given that the state is in $[\tilde{x}_A, 1]$, the optimal threshold $\tilde{x}_D$ for party D must satisfy

$$m_{(\tilde{x}_A, \tilde{x}_D]} < \tau_D \leq \tilde{x}_D.$$

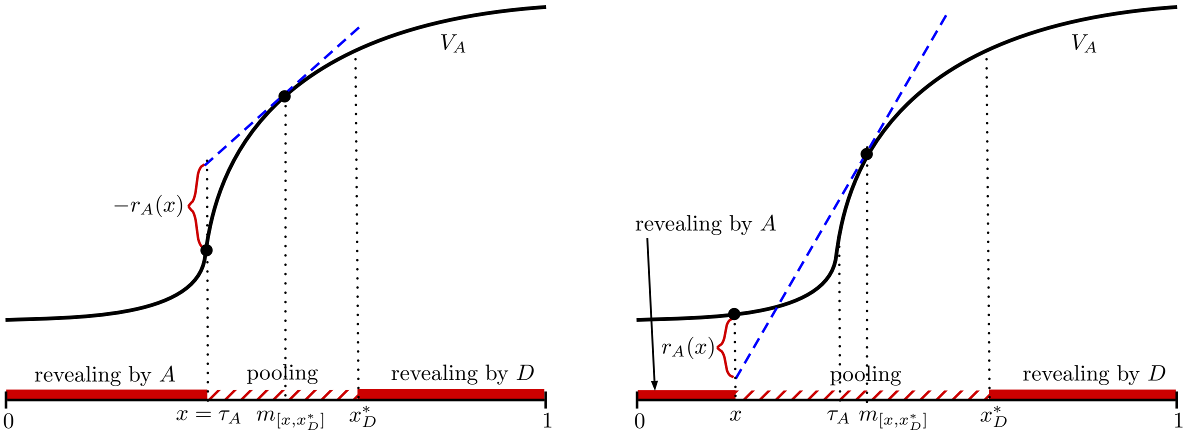
It follows that $\tau_A < m_{(\tilde{x}_A, \tilde{x}_D]} < \tau_D$, which is a contradiction to the assumption that $\tau_A \geq \tau_D$. We thus conclude that $\tilde{x}_A = \tilde{x}_D$, and all states in $[0, 1]$ are revealed by (σ_A^*, σ_D^*), so the outcome is full disclosure. □

Step 3. Let $\tau_A < \tau_D$. Then Part (ii) in Proposition 3 holds for the case of $N = 2$.

Proof of Step 3. If (σ_A^*, σ_D^*) are mutual best replies, then by Step 1, there exists a pair (x_A^*, x_D^*) with

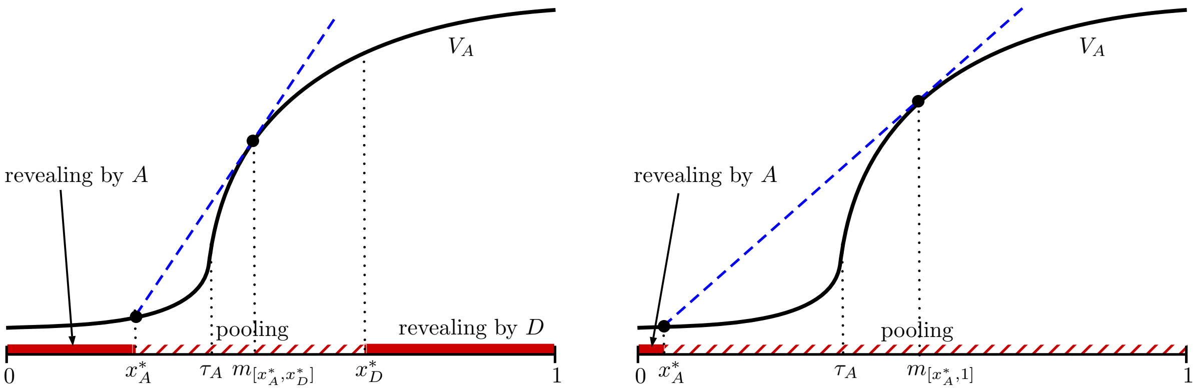
$$0 \leq x_A^* \leq \tau_A < \tau_D \leq x_D^* \leq 1$$

such that σ_A^* reveals the state when $\omega \in [0, x_A^*]$ and pools the states in $(x_A^*, 1]$, whereas σ_D^* reveals the state when $\omega \in (x_D^*, 1]$ and pools the states in $[0, x_D^*]$. It remains to



(a) The case of $r_A(x) < 0$, so $x_A^* < x$ (b) The case of $r_A(x) > 0$, so $x_A^* > x$

FIGURE 2. A choice of cutoff x by party A for a given x_D^*.



(a) Optimal x_A^* on the interval $[0, x_D^*]$ (b) Optimal x_A^* on the interval $[0, 1]$

FIGURE 3. Optimal cutoff x_A^* for party A.

prove that the equilibrium pair (x_A^*, x_D^*) is unique and to show that inequality (2) holds.

Let (σ_A^*, σ_D^*) be a Nash equilibrium as described above, and let (x_A^*, x_D^*) be the associated pair of thresholds. By (3) and Lemma 2 applied to $[a, b] = [0, x_D^*]$ (the interval where the state is pooled by party D), party A's best-reply threshold must satisfy

$$r_A(x) = V_A(x) - V_A(m_{[x,x_D^*]}) - V_A'(m_{[x,x_D^*]})(x - m_{[x,x_D^*]}) > (<)\, 0 \quad \text{if} \quad x < (>)\, x_A^*. \quad (9)$$

For illustration consider Figure 2. Party A chooses a cutoff x, so that the state is revealed when in $[0, x]$ and pooled when in $(x, x_D^*]$. Party A's indirect utility V_A (depicted by the solid curve) is S-shaped, and τ_A is its inflection point. Function

$r_A(x)$ can be seen as the difference at point x between V_A and the dashed line that is tangent to V_A at the expected state $m_{[x,x_D^*]}$ of the pooling interval $(x, x_D^*]$. Figure 2(a) shows the case where $x = \tau_A$ is too high, so $r_A(x) < 0$, and thus the optimal cutoff must be below x. Figure 2(b) shows the opposite case where x is too low, so $r_A(x) > 0$, and thus the optimal cutoff must be above x. Figure 3(a) shows the optimal cutoff x_A^* at the place where the dashed tangency line crosses V_A, and thus $r(x_A^*) = 0$.

Similarly to (9), by (4) and Lemma 2 applied to $[a, b] = [x_A^*, 1]$ (the interval where the state is pooled by party A), party D's best-reply threshold must satisfy

$$r_D(y) = V_D(m_{[x_A^*,y]}) + V_D'(m_{[x_A^*,y]})(x - m_{[x_A^*,y]}) - V_D(y), > (<)\, 0 \ \text{ if } \ y < (>)\, x_D^*. \quad (10)$$

We now show that $r_A(x)$ is strictly decreasing on $[0, x_D^*]$ under the constraint that x_D^* is endogenously determined as the unique best-reply threshold, i.e., $x_D^* = x_D^*(y)$ satisfies (9). It will then follow that there exists a unique pair (x_A^*, x_D^*) that satisfies both (9) and (10). Because V_A is strictly S-shaped by Lemma 1, it follows that $r_A(\tau_A) < 0$, as illustrated in Figure 2(a). Thus, we only need to consider $x \in [0, \tau_A)$.

Fix an arbitrary $x \in [0, \tau_A)$. Observe that, as follows from Lemma 2, $r_D(y)$ is strictly single-crossing from above on $[a, b] = [x, 1]$. So there is a unique $x_D^* = x_D^*(x) \in [x, 1]$ that satisfies (10). We have assumed $\tau_A < \tau_D$, so $x < \tau_D$. Thus, by Lemma 2 with $[a, b] = [x, 1]$, either $r_D(y) \geq 0$ for all $y \in [x, 1]$, so $x_D^*(x) = 1$, or $x_D^*(x)$ solves $r_D(y) = 0$. Moreover,

$$x < m_{[x,x_D^*(x)]} < \tau_D \leq x_D^*(x). \quad (11)$$

We are now ready to prove that $r_A(x)$ is strictly decreasing in $x \in [0, \tau_A)$ when $x_D^* = x_D^*(x)$ as defined above. By (9) we have

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}x} r_A(x) &= V_A'(x) - V_A'(m_{[x,x_D^*]}) \\ &\quad + V_A''(m_{[x,x_D^*]})(m_{[x,x_D^*]} - x)\left(\frac{\partial m_{[x,x_D^*]}}{\partial x} + \frac{\partial m_{[x,x_D^*]}}{\partial x_D^*}\frac{\mathrm{d}x_D^*}{\mathrm{d}x}\right),\end{aligned}$$

Using Lemma 2 applied to the interval $[a, b] = [0, x_D^*]$, by (6) we have

$$V_A'(x) - V_A'(m_{[x,x_D^*]}) < 0 \quad \text{and} \quad V_A''(m_{[x,x_D^*]}) < 0.$$

Next, because $m_{[x,x_D^*]} = \mathbb{E}[\omega | \omega \in [x, x_D^*]]$, we have

$$\frac{\partial m_{[x,x_D^*]}}{\partial x} = \frac{f(x)(m_{[x,x_D^*]} - x)}{F(x_D^*) - F(x)} > 0 \text{ and } \frac{\partial m_{[x,x_D^*]}}{\partial x_D^*} = \frac{f(x_D^*)(x_D^* - m_{[x,x_D^*]})}{F(x_D^*) - F(x)} > 0, \quad (12)$$

where the inequalities are by (11) and the assumption that f is strictly positive. Thus it remains to establish that

$$1+\frac{\frac{\partial}{\partial x_D^*}m_{[x,x_D^*]}}{\frac{\partial}{\partial x}m_{[x,x_D^*]}}\cdot\frac{\mathrm{d}x_D^*}{\mathrm{d}x}\geq 0.$$

If $x_D^*=x_D^*(x)=1$, then $\mathrm{d}x_D^*/\mathrm{d}x=0$. We thus obtain $\mathrm{d}r_A(x)/\mathrm{d}x<0$.

Alternatively, suppose that $x_D^*=x_D^*(x)$ solves $r_D(x_D^*)=0$ on $[x,1]$. Taking the full differential of $r_D(x_D^*)$, by (10) we have

$$\left(V_D'(m_{[x,x_D^*]})-V_D'(x_D^*)+V_D''(m_{[x,x_D^*]})(x_D^*-m_{[x,x_D^*]})\frac{\partial m_{[x,x_D^*]}}{\partial x_D^*}\right)\mathrm{d}x_D^*$$
$$+V_D''(m_{[x,x_D^*]})(x_D^*-m_{[x,x_D^*]})\frac{\mathrm{d}m_{[x,x_D^*]}}{\mathrm{d}x}\mathrm{d}x=0$$

Thus,

$$\frac{\mathrm{d}x_D^*}{\mathrm{d}x}=-\frac{V_D''(m_{[x,x_D^*]})(x_D^*-m_{[x,x_D^*]})\frac{\partial}{\partial x}m_{[x,x_D^*]}}{V_D'(m_{[x,x_D^*]})-V_D'(x_D^*)+V_D''(m_{[x,x_D^*]})(x_D^*-m_{[x,x_D^*]})\frac{\partial}{\partial x_D^*}m_{[x,x_D^*]}}<0. \tag{13}$$

To see why $\frac{\mathrm{d}x_D^*}{\mathrm{d}x}<0$, observe that by (8) in Lemma 2 applied to the interval $[a,b]=[x,1]$ we have $V_D'(m_{[x,x_D^*]})<V_D'(x_D^*)$ and $V_D''(m_{[x,x_D^*]})<0$. By (11), $x_D^*-m_{[x,x_D^*]}>0$. By (12), $\partial m_{[x,x_D^*]}/\partial x>0$ and $\partial m_{[x,x_D^*]}/\partial x_D^*>0$. We thus obtain $\frac{\mathrm{d}x_D^*}{\mathrm{d}x}<0$. Now, using (12) and (13), we obtain

$$\begin{aligned}1+&\frac{\frac{\partial}{\partial x_D^*}m_{[x,x_D^*]}}{\frac{\partial}{\partial x}m_{[x,x_D^*]}}\cdot\frac{\mathrm{d}x_D^*}{\mathrm{d}x}\\&=1-\frac{\partial m_{[x,x_D^*]}}{\partial x_D^*}\cdot\frac{V_D''(m_{[x,x_D^*]})(x_D^*-m_{[x,x_D^*]})}{V_D'(m_{[x,x_D^*]})-V_D'(x_D^*)+V_D''(m_{[x,x_D^*]})(x_D^*-m_{[x,x_D^*]})\frac{\partial}{\partial x_D^*}m_{[x,x_D^*]}}\\&=\frac{V_D'(m_{[x,x_D^*]})-V_D'(x_D^*)}{V_D'(m_{[x,x_D^*]})-V_D'(x_D^*)+V_D''(m_{[x,x_D^*]})(x_D^*-m_{[x,x_D^*]})\frac{\partial}{\partial x_D^*}m_{[x,x_D^*]}}>0,\end{aligned}$$

where the inequality is by both the numerator and the denominator being negative. We thus have shown that $\mathrm{d}r_A(x)/\mathrm{d}x<0$.

We now show inequality (2). By (13), when $x_D^*(x)$ is in the interior, it is strictly decreasing in x. As follows from the first-order condition (10), when $x_D^*(x)$ is at the boundary, $x_D^*(x)=1$, then it is locally constant. That is, if party A chooses a higher cutoff $x=x_A^*$, the best reply of party D is to choose a weakly lower cutoff x_D^*. The symmetric argument applies to establish that $x_A^*(y)$ is weakly decreasing in $y=x_D^*$. Observe that the information monopoly of party A is equivalent to the debate where

D's strategy is *no disclosure*, so $x_D^* = 1$. We thus obtain $x_A^*(x_D^*) \geq x_A^*(1)$ for $x_D^* < 1$. That is, party A reveals the state on a larger interval when it is competing with party D than when it holds the information monopoly. This is illustrated in Figure 3. Pane (a) shows the optimal cutoff x_A^* when party D reveals the state in the interval $(x_D^*, 1]$. Pane (b) shows the optimal cutoff x_A^* when party D is uninformative, so party A is the information monopolist. The symmetric argument holds for the best reply of party D. □

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