Similarity of Information and Collective Action

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We study a canonical collective action game with incomplete information. Individuals attempt to coordinate to achieve a shared goal, while also facing a temptation to free-ride. More similar information can help them coordinate, but it can also exacerbate free-riding. Our main result shows that more similar information facilitates (impedes) achieving the common goal when it is sufficiently challenging (easy). We apply this insight to show why less powerful authoritarian governments may face larger protests if they restrict press freedom, when committee diversity is beneficial in costly voting, and when a more diverse community contributes more to public good provision.

I. Introduction

This paper addresses the following question: When does increased similarity of information among participants help or harm participation in collective action?

A collective action problem is a situation in which individuals want to achieve a common goal but face a temptation to free-ride (see Tullock (1971), Olson (1965)), because reaching the goal requires a sufficient number of people to take a costly action, while the benefit accrues to all.[1] We consider collective action problems under incomplete information, in which individuals face uncertainty about the benefits of reaching the goal, and can privately learn about it. In such situations, an individual may not take the costly action even after learning that reaching the goal is socially beneficial. This is because her decision depends not only on what her private information tells her about the state (fundamental uncertainty),

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[1]Examples of collective action problems are ubiquitous: protests, regime changes, boycotts, or voting in committees. See Palfrey and Rosenthal (1985), Taylor and Ward (1982), Goeree and Holt (2005), Myatt and Wallace (2008), Diermeier and Van Mieghem (2008), Shadmehr (2021), Dziuda, Gitmez and Shadmehr (2021) for some examples.

but also on what it tells her about the information that others have and thus what they will do (strategic uncertainty). For instance, an individual's private information may make her believe, at the same time, that reaching the goal is beneficial, but that others do not intend to take the costly action, rendering her own costly action ineffective. We investigate what happens to participation in collective action when information becomes more similar, in the sense that agents know that others have private information with content similar to their own.

Understanding the effects of changing similarity of information in strategic environments is particularly important against the backdrop of the extraordinary changes in how information is disseminated and consumed in recent years. Algorithms steer individuals to news or video content based on personal characteristics, resulting in like-minded people accessing the same information from the same source. A plausible conjecture is that if people with the same objectives now access the same information, it may be easier for them to predict each other's actions and attain better outcomes.

Our central observation is that greater similarity of information among agents, *even those with identical preferences*, can serve as a double-edged sword in collective action games. On the one hand, if people believe that others are more likely to have the same information as them, they may be able to coordinate better to reach the common goal. On the other hand, the temptation to free-ride may be exacerbated: if an agent knows that others have the same information and predicts that they will take action, then she does not need to take a costly action herself. Both these opposing effects have been observed separately in empirical work on protests, an archetypal collective action game. Enikolopov, Makarin and Petrova (2020) find, using Russian data, that in cities where individuals accessed news from the same media platform, it led to more protests, and cities in which people were not all on the same platform faced fewer protests. However, in an experiment on protests in Hong Kong, Cantoni et al. (2019) show essentially the opposite: knowledge of others' participation led to a stronger temptation to free-ride for potential participants. Such mixed evidence motivates our research question: when is information similarity helpful and when is it harmful in collective action games? Our main results characterize when increased information similarity helps or harms participation in a canonical regime-change game of incomplete information. To illustrate the main forces, let us start with a simple example.

Example: Abe and Bob are working on a project that is of high ($\boldsymbol{\theta} = 1$) or mediocre ($\boldsymbol{\theta} = 0$) quality with equal probability. They do not know the project quality, but each receives a private, binary signal about it. For simplicity, we assume that a player never mistakes a mediocre project for a high-quality one but may mistake a high-quality project for a mediocre one. Formally, each player i receives a binary signal $\mathbf{S}_i$, such that if $\boldsymbol{\theta} = 0$ then $\mathbf{S}_i = 0$ with probability 1, and if $\boldsymbol{\theta} = 1$, then the signals are drawn from some *joint* distribution. Importantly, the signals might not be conditionally independent.

After observing their own private signal, each player decides (independently and simultaneously) whether to work or shirk. Working entails a cost of c. The project is completed with certainty if both players work, and completed with probability q if only one works. If a high-quality project is completed, the players enjoy a benefit of 1 each. If the project is mediocre or unfinished, they both get 0. Table 1 specifies the payoffs. For simplicity, suppose that c is high enough that players will never work after receiving signal $\mathbf{S}_i = 0$.

		Bob: work	Bob: shirk
Abe	work	$\theta - c, \theta - c$	$q\theta - c, q\theta$
	shirk	$q\theta, q\theta - c$	$0, 0$

Table 1—: Payoff matrix

Notice that this is not a pure coordination game[2]: while both players enjoy the benefit from the completion of a high-quality project, each player may have an incentive to free-ride even if he believes the project is of high quality. We ask first whether there is a symmetric, pure-strategy equilibrium in which a player works whenever $\mathbf{S}_i = 1$, i.e., when he knows the project is of high quality. Then we ask, what happens if the realized private signals that Abe and Bob observe become more similar, in the sense that each player knows that his private signal is now a better predictor of the other player's signal (and his consequent action choice).

For a player to be willing to work after observing $\mathbf{S}_i = 1$, we need

$$(1) \qquad (1-q)Pr\left(\mathbf{S}_{-i} = 1 \middle| \mathbf{S}_i = 1\right) + q\left(1 - Pr\left(\mathbf{S}_{-i} = 1 \middle| \mathbf{S}_i = 1\right)\right) \geqslant c.$$

Intuitively, conditional on observing $\mathbf{S}_i = 1$, player i works only if he believes his effort is pivotal (makes a difference) with high-enough probability. If a player works, then his marginal contribution to the completion of the project is $(1-q)$ if the other player also works, and q if the other player does not work. The marginal benefit from effort depends on two primitives: (i) the extent to which individual effort can make a difference, measured by q, and (ii) a player's conditional belief about his opponent's signal (and implied equilibrium action). It is easy to obtain c, q and a joint distribution such that, we have an equilibrium wherein both the agents work when they receive a signal 1.[3]

What happens when Abe's and Bob's signals become *more similar?* More similar signals simply means that there is a higher likelihood that Abe and Bob see the same signal while their marginal distribution remains unchanged. That is, when

[2]See Shadmehr and Bernhardt (2011) for a similar payoff structure.
[3]Proposition 13 in the online appendix (Section B6) contains a complete analysis with the parameter configurations supporting the results.

the project is high quality ($\boldsymbol{\theta} = 1$), the probability that any agent receives a signal 1 is unchanged. However, the probability that they both receive the same signal increases by α, and the probability that they receive different signals decreases by α.[4] How does this increased similarity in the realized private signals affect players' incentives to work in equilibrium? The answer depends on the value of q. From (1) above, a player works after receiving signal 1 if

$$(1-q)\underbrace{Pr\left(\mathbf{S}_{-i}=1\middle|\mathbf{S}_i=1\right)}_{\uparrow\text{ with more similarity}}+q\underbrace{\left(1-Pr\left(\mathbf{S}_{-i}=1\middle|\mathbf{S}_i=1\right)\right)}_{\downarrow\text{ with more similarity}}\geqslant c.$$

With increased similarity of information, the conditional probability that $\mathbf{S}_{-i} = 1$ given that $\mathbf{S}_i = 1$ increases. When q is sufficiently high ($> \frac{1}{2}$) the left-hand side of the above constraint decreases. Intuitively, with high likelihood, one player's effort suffices for project completion. So, after observing $\mathbf{S}_i = 1$, a player i is less likely to be pivotal compared to before and has a stronger incentive to free-ride. Analogously, when q is sufficiently low ($< \frac{1}{2}$), the left-hand side of the above constraint increases. After observing $\mathbf{S}_i = 1$, a player i assigns a higher probability to being pivotal and has a stronger incentive to work. These arguments yield the following result.

Increasing similarity of information impedes participation if $q > \frac{1}{2}$, and facilitates participation if $q < \frac{1}{2}$.

More concretely, we can find two joint distributions, one more similar than the other, such that, for high enough q, both agents working after learning the project is high-quality constitutes an equilibrium under the less similar distribution, but not under the more similar one. Conversely, for low enough q, both agents working after learning the project is high-quality constitutes an equilibrium under the more similar distribution, but not under the less similar one.

Intuitively, a low value of q captures environments in which not achieving coordination is the primary obstacle to collective action. In these settings, increasing information similarity proves beneficial for effort incentives. A high value of q captures environments in which free-riding is the primary obstacle to collective action. In these settings, increasing information similarity may be harmful for effort incentives.

Of course this example has several simplifying features. With binary signals, it was straightforward to define what it means to have more similar information. Moreover, the parameter q is a mechanical way of quantifying the relative importance of coordination (versus preventing free-riding). Finally, strategies are quite

[4]As before, they receive signal 0 when $\boldsymbol{\theta} = 0$.

simple with binary signals, and given no agent participates after a signal 0. But it turns out that the essential insights from this example generalize.

In the baseline model, we consider a canonical regime-change game. There are two states of the world: one in which regime change is beneficial for society, and one in which it is not. There are two geographically dispersed groups, who have identical preferences but have access to different information about the state. Each group receives a signal about the state, drawn from a finite set. Each individual sees only the signal of their own group and decides whether to participate in an action aimed to bring about regime change. Regime change is successful only if a threshold number of agents participate. We call this required threshold participation the *resilience* of the regime. Agents are uncertain about the resilience of the regime. The benefit of a successful regime change is public, but the cost of participation is borne only by the participants. In this canonical setting, we ask whether increased similarity of groups' signals increases or decreases participation.

First, we need a notion that allows us to compare similarity between information structures. We use an order of information similarity, analogous to the one in the example above. We say information is *more similar* or has a *higher concentration along diagonal* (CAD) when, conditional on observing signal realization s, an agent believes it is more likely that others also observed the signal realization s and less likely that others observed a signal realization different from s.[5]

We then show that, analogous to low and high values of q in the example, it is possible to cleanly partition the general setting into *encouragement environments*, in which greater aggregate participation encourages participation by making it more likely that an individual can make a difference, and *discouragement environments*, in which greater aggregate participation discourages participation by making it less likely that an agent can make a difference.

Our main results establish that more similar information in the CAD order increases participation in encouragement environments but can reduce participation in discouragement environments. Formally, for any strategy profile, we define the participation (nonparticipation) set as the set of signals for which agents participate (do not participate). Given any information structure, our game can admit multiple equilibria, including, possibly equilibria with strategies that are non-monotonic in signals. We prove that more similar information enlarges the participation set in the equilibrium with maximal participation in encouragement environments (Theorem 1), but can shrink it in discouragement environments (Theorem 2).

Notice that participation is costly for an agent but generates no benefit when regime change is not beneficial for society, or when the agent's participation is not

[5] For two-dimensional signals, our CAD order is equivalent to one proposed by Meyer (1990). Like her, we require that the two signals have the same marginal distribution over signals.

pivotal. In these events, in principle, increasing participation can be detrimental to total social welfare. Theorem 3 shows that if the distribution of a regime's resilience is single-peaked, then maximal welfare unambiguously increases in the encouragement environment. At the same time, much like maximal participation, even maximal welfare can decrease in the discouragement environment.

We apply our methods to three applications. First, we study mass protests (as in Shadmehr, 2021), and ask when we see encouragement and discouragement environments in practice. Specializing to an environment where the resilience of the regime is drawn from a Poisson distribution we show that sufficiently resilient regimes—requiring a large number of participants for regime change—are encouragement environments. So the effect of changing information similarity is qualitatively different based on the resilience of regimes: Increased similarity of information facilitates greater participation in a mass protest when the regimes are hard to change (high expected resilience), but can hurt participation in protests against weaker regimes. We show that this is true also about the likelihood of a successful protest: Increased information similarity increases (can decrease) maximal equilibrium probability of successful regime change against sufficiently (insufficiently) resilient regimes. Recall the mixed empirical evidence regarding how modern information technology has affected protests. Our results imply that increased similarity of information may have facilitated greater participation in collective action against regimes previously thought to be impregnable but, at the same time, hindered movements with ex-ante easier goals. These findings also speak to the effectiveness of censorship under different regimes. When authoritarian governments curb press freedoms, they effectively reduce the similarity of information across individuals. Our results suggest that it is precisely the resilient authoritarian governments that benefit more from doing this. Less powerful regimes may face larger protests and a higher likelihood of being overthrown when attempting to restrict press freedom.

Second, we apply our framework to a setting of costly voting in a committee (as in Palfrey and Rosenthal, 1985). We consider a monetary policy committee with more than two members who must vote on whether to raise interest rates. A rate increase is implemented only if a threshold number of members vote for it. Public opinion is against any rate increases, and committee member votes are observed ex post, making it costly for any member to vote in favor of a rate increase. Committee members base their decision on their private information about whether a rate increase is warranted based on the state of the economy. Their information can be more or less similar depending on their backgrounds—academic backgrounds or areas of expertise that makes them focus on different aspects of the available evidence. How do changes in member diversity affect the voting outcome? In this setting, there is no uncertainty about the vote threshold. But importantly, with multiple members, we need to develop an analog of the CAD order to compare multivariate binary signals. With this new CAD order, we can establish results analogous to Theorems 1 and 2. We show that conditional on the rate increase being warranted, a more diverse committee (with less similar information) strengthens the incentive to vote correctly and increases the maximal equilibrium number of votes in favor of a rate increase if fewer votes are required for a rate hike. Conversely, if more votes are required for a rate hike, a more diverse committee weakens the incentive to vote correctly. We also examine how changes in information similarity influence the optimal voting threshold rule.

In our final application, we consider a public good provision problem in a "private-value setting". There are two groups of N agents each. Each agent simultaneously decides whether or not to contribute to a public good, and the public good is provided if at least a certain minimum number agents contribute. Unlike in our baseline model, there is no fundamental uncertainty. Rather, it is commonly known that the public good is beneficial for society, but the costs of contribution are private. Agents make contribution decisions after they observe their own private costs. So agents face only strategic uncertainty. We examine whether greater similarity in costs across agents leads to higher contributions to the public good, and derive analogs of our main results.

We conclude by discussing other extensions and limitations of our model.

A. Related Literature

A large literature going back to at least Hirshleifer (1971) studies how exogenous changes in the information environment affect agents' incentives in strategic environments. More recently, Morris and Shin (2002), Angeletos and Pavan (2007), Bergemann and Morris (2013), Jensen (2018), and Mekonnen and Vizcaíno (2022) have studied this question in a class of games with pure complementarity or substitutability. This literature provides insights about how changes in the exogenous information structure affect the monotone equilibria and welfare. Van Zandt and Vives (2007) have shown that in games of strategic complementarity, the extremal equilibria are in monotone strategies. Our canonical collective action game is not a game of pure complementarity, and best responses to monotone strategies may not be monotone, making the established tools unsuitable. Moreover, much of the literature focuses on the effect of new public information. Three notable exceptions are Morris and Shin (2007), de Mesquita and Shadmehr (2023) and Angeletos and Lian (2016). Like us, these papers vary the correlation of information across agents in a coordination game while keeping the belief about fundamentals unchanged. Morris and Shin (2007) make the partition of agents that receive the same signals coarser: this indeed is a way to increase CAD-similarity. Angeletos and Lian (2016) introduce a common noise with private signals in a Gaussian set-up: Here, the increase in correlation implies an increase in CAD-similarity only if the state has uniform prior. de Mesquita and Shadmehr (2023) compare a combination of a public and private signal with only a private signal, making the information structures not CAD-comparable because the information structures have different signal spaces.

We consider an arbitrary signal structure and propose CAD as a natural order of information similarity. The existing literature contains other measures of interdependence of joint distributions (for example, Müller and Stoyan (2002), Meyer and Strulovici (2012)), but none are appropriate for comparing the *conditional* belief distributions that arise in strategic settings with incomplete information. For the bivariate case (the focus of this paper), the CAD order is the same as that in Meyer (1990). Like her, we consider multivariate random variables with fixed marginal distributions while changing the joint distribution. Clemen and Winkler (1985) and Cheng and Borgers (2024) study how such changes impact the value of information and show that informational diversity may be valuable. These papers also consider an information structure with fixed marginals and vary the correlation structure. de Oliveira, Ishii and Lin (2023) consider an environment with known marginal distributions but unknown joint distribution to obtain the robustly optimal policy in a class of decision problems. Awaya and Krishna (2022) study the effect of the interdependence of signals on common learning as do Cripps et al. (2008). They show that essentially any interdependence obstructs common learning.

We also contribute to the sizable literature on protests and voting. The majority of the theoretical work on protest focuses on the coordination aspect. However, some recent papers—for example, Shadmehr (2021), Dziuda, Gitmez and Shadmehr (2021), and Park and Smyrniotis (2022)—incorporate free-riding and construct cutoff equilibria. Dziuda, Gitmez and Shadmehr (2021) show that a lower required participation threshold for success might not increase the likelihood of a successful completion of a project. Mutluer (2024) shows that a higher cost of participation may lead to larger protest. These papers do not consider changing information environments, which is our focus. Some recent empirical papers have studied the effect of modern communication technologies on the size of protests. Manacorda and Tesei (2020) show empirical evidence that mobile phones facilitated protests in Africa, and Enikolopov, Makarin and Petrova (2020) show that the diffusion of an online social network increased protest turnout in Russia. In contrast, Cantoni et al. (2019) demonstrate, in an experiment about mass protesters in Hong Kong, that the knowledge of others' participation led to a stronger temptation to free-ride for potential participants. These ambiguous empirical results underscore the importance of our research question. We provide a characterization of when information similarity helps and when it hurts. Our results have implications for the effect of press freedom on protests. Edmond (2013) considers a game of protest in which the regime can manipulate information. However, in this game, the agents only have the coordination motive and no free-riding motive. In a voting application, we study how informational diversity affects voting incentives. Taylor and Yildirim (2010) and Roesler (2022) study similar questions. In these papers, an agent can always get her desired outcome by voting, if no one else votes. In contrast, in our setup, an agent cannot get her desired outcome by being the only vote. Chemmanur and Fedaseyeu (2018) present a model of voting on a corporate board that closely resembles our application. Kattwinkel and Winter (2023) characterize the optimal voting rule under conditionally independent signals. We consider only simple threshold voting rules but show how information similarity affects the optimal voting rule.

II. A Regime-Change Game

There are two states of the world: $\boldsymbol{\theta} \in \Theta = \{0, 1\}$. In $\boldsymbol{\theta} = 1$, it is socially beneficial to change the regime. In $\boldsymbol{\theta} = 0$, it is not socially beneficial to change the regime. Society consists of $G = 2$ groups, and each group comprises N agents. Each agent makes a binary action choice of whether or not to participate $a \in \{0, 1\}$. Participating (choosing $a = 1$) costs $c > 0$, while not participating (choosing $a = 0$) is costless. Regime change occurs if and only if enough agents participate. Agents are uncertain about the threshold participation required to change the regime, denoted by $\bar{\boldsymbol{n}} + 1$. We assume that $\bar{\boldsymbol{n}} + 1$ is an $\mathbb{N} \backslash \{1\}$-valued random variable, where $\bar{\boldsymbol{n}}$ follows probability mass function $\psi(\cdot)$ and cumulative mass function $\Psi(\cdot)$.[6] We call $\bar{\boldsymbol{n}}$ the *resilience* of the regime. We assume that $\boldsymbol{\theta}$ and $\bar{\boldsymbol{n}}$ are independent. We summarize the payoffs in the matrix below, in which $\bar{n} + 1$ is the realized threshold and A denotes the number of agents who participate.

	$A \geqslant \bar{n} + 1$	$A \leqslant \bar{n}$
$a = 1$	$\theta - c$	$-c$
$a = 0$	θ	0

Table 2—: Payoffs

This regime change game captures the tradeoff between coordination and free-riding in a collective action problem in a parsimonious way. Later in the paper, we consider variations of the model to fit different applications: in a committee voting application, we consider a fixed threshold (voting rule) and more than two committee members (no groups). In a public good contribution setting, we consider heterogeneous private costs and no common state.[7]

A. *Information Structure*

Before deciding whether to participate, agents receive information about the state of the world. There is a fixed, finite set of signals $\mathcal{S}$. Each group $g \in \{1, 2\}$ receives

[6] $\bar{\boldsymbol{n}} + 1 \geqslant 2$ means that at least two participating agents are required to change the regime.

[7] Section VIII contains several other extensions. For instance, we allow group sizes to be uncertain and unobserved. We let the state reflect the attainability of regime change rather than the desirability of regime change. We study more general payoff with more than two states, and a possible "warm glow effect" from participation when the regime changes. Also, Section B2 in the online appendix provides a detailed comparison of our model with others in the literature.

a signal $\mathbf{S}_g$ drawn from $\mathcal{S}$, and every agent in group g observes only the signal received by their own group. Let $\mathbf{S} := (\mathbf{S}_1, \mathbf{S}_2)$. We denote the joint distribution of $(\boldsymbol{\theta}, \mathbf{S})$ by $\mathcal{P}(\cdot) \in \Delta(\Theta \times \mathcal{S}^2)$, and the distribution of $\mathbf{S}$ conditional on $\boldsymbol{\theta} = \theta$ by $\mathcal{P}^\theta \in \Delta(\mathcal{S}^2)$. As we will describe in Section II.C, similarity of information in our context will simply be a measure of interdependence of $\mathbf{S}$.

We assume that $\mathbf{S}_1, \mathbf{S}_2$ are independent of $\bar{\boldsymbol{n}}$, i.e., a signal conveys no information about the resilience of the regime. Let $\mu := \mathcal{P}(\{\boldsymbol{\theta} = 1\})$. For each $g \in \{1, 2\}$, we denote the marginal distribution of $\mathbf{S}_g$ in state θ by $\mathbb{P}_g^\theta \in \Delta(\mathcal{S})$. We assume that the distribution of $\mathcal{P}^\theta(\cdot)$ is exchangeable so that $\mathbb{P}_1^\theta = \mathbb{P}_2^\theta =: \mathbb{P}^\theta$ for all $\theta \in \Theta$.

Let $\mu(s) := \mathcal{P}(\{\boldsymbol{\theta} = 1\} | \{\mathbf{S}_g = s\})$ denote the posterior probability that any agent in group g assigns to the state being 1 given a realized signal s. We assume that $\mu : \mathcal{S} \to [0, 1]$ is injective. Given group g, we let $\mathbf{S}_{-g}$ be the random variable denoting the signal of the other group. Let $\mathcal{P}_s^\theta \in \Delta(\mathcal{S})$ denote the conditional distribution of $\mathbf{S}_{-g}$ given state $\boldsymbol{\theta} = \theta$ and $\mathbf{S}_g = s$. Since $\mathbb{P}^\theta$ is exchangeable, $\mathcal{P}_s^\theta(\cdot)$ is the same for every group.

B. *Strategies and Aggregate Participation*

Strategies: A (pure) strategy of agent i from group g is a mapping,

$$\sigma_g : \mathcal{S} \to \{0, 1\}.$$

That is, we assume symmetric strategies within a group. We restrict attention to pure strategies throughout the paper. Given a strategy profile $\sigma = (\sigma_1, \sigma_2)$, we define the *participation set of* σ_g *for group* g, denoted by $P(\sigma_g)$, to be the set of signals such that $\sigma_g(s) = 1$. Analogously, we define the *nonparticipation set of* σ, denoted by $NP(\sigma_g) := \mathcal{S} \backslash P(\sigma_g)$. When the dependence on σ_g is obvious, we denote $P(\sigma_g)$ and $NP(\sigma_g)$ by P_g and NP_g, respectively.

Aggregate participation: Let $\mathbf{A}$ denote the random variable corresponding to the total number of participating agents, given a strategy profile.

$$\mathbf{A} := \sum_{g=1}^{2} N \sigma_g(\mathbf{S}_g)$$

We call $\mathbf{A}$ the aggregate participation. $\mathbf{A}$ is $\mathbf{S}$-measurable and depends on σ, and when this is obvious, we suppress σ. All agents in group g receive the same signal and have the same belief. Let $\mathbf{A}_{-g}(s_g, s_{-g}; \sigma)$ be the aggregate participation according to an agent in group g, excluding herself. Then we have

$$\begin{aligned} \mathbf{A}_{-g}(s_g, s_{-g}; \sigma) &:= N\sigma_{-g}(s_{-g}) + (N-1)\sigma_g(s_g) \\ &= N\mathbb{1}_{s_{-g} \in P_{-g}} + (N-1)\mathbb{1}_{s_g \in P_g}. \end{aligned}$$

Expected aggregate participation in $\boldsymbol{\theta} = 1$:

For any σ, define

$$\mathscr{V}(\sigma) := \mathbb{E}[\mathbf{A}(\mathbf{S};\sigma)|\boldsymbol{\theta} = 1] \tag{2}$$

to be the expected aggregate participation in state 1, which is the state in which it is beneficial to change the regime. For a fixed σ, $\mathscr{V}(\sigma)$ depends only on the marginal distribution of the signals and not on the joint distribution. So information similarity affects $\mathscr{V}$ only by affecting the equilibrium σ. We state this in the following lemma. The proof is in the appendix. With some abuse of notation, let $\mathbb{P}^1(S)$ denote $\mathcal{P}(\mathbf{S}_g \in S|\boldsymbol{\theta} = 1)$.

LEMMA 1: *For any σ, with associated participation sets P_g for $g \in \{1, 2\}$*

$$\mathscr{V}(\sigma) = N \sum_{g=1}^{G} \mathbb{P}^1(P_g).$$

Therefore, $\mathscr{V}(\sigma) = N[\mathbb{P}^1(P_1 \bigcup P_2) + \mathbb{P}^1(P_1 \bigcap P_2)]$.

Solution concept: We consider Bayes Nash equilibria in pure strategies. We do not impose any additional structure on the equilibrium, such as monotone or symmetric strategies. Multiple equilibria may exist, including one in which no one participates regardless of the signal.

In a collective action problem, best responses are not monotonic in aggregate participation, unlike in other regime-change games with only strategic complementarities (Morris and Shin, 2002, for example). Therefore, it is not clear whether equilibria can be ordered in any natural way. This means we cannot use existing tools—such as those used in supermodular games—directly. Let $\mathcal{E}(\mathcal{P})$ be the set of strategy profiles that constitute an equilibrium under information structure $\mathcal{P}$. Given multiple equilibria, we focus on how increased similarity affects the maximal possible participation in any equilibrium. Accordingly, we define the following.

DEFINITION 1: ***Maximal Participation Equilibrium and Maximal Equilibrium Aggregate Participation:*** *We say that an equilibrium σ^* is a maximal participation equilibrium if $\mathscr{V}(\sigma^*) \geqslant \mathscr{V}(\sigma)$ for all $\sigma \in \mathcal{E}(\mathcal{P})$.*[8] *Let $\mathscr{V}^*(\mathcal{P})$ denote the expected aggregate participation (in state 1) in the maximal participation equilibrium given information structure $\mathcal{P}$, and call it the maximal equilibrium aggregate participation.*

Both the expected aggregate participation given a strategy $\mathscr{V}(\sigma)$ and the maximal equilibrium aggregate participation for an information structure $\mathscr{V}^*(\mathcal{P})$ are defined *conditional on* $\boldsymbol{\theta} = 1$; that is, when change is beneficial. For brevity,

[8] Since the set of signals is finite and we look at pure strategies, the existence of a maximal aggregate participation equilibrium is guaranteed.

henceforth, we do not mention this explicitly. $\mathscr{V}(\cdot), \mathscr{V}^*(\cdot)$ also depend on other parameters, such as $\bar{\boldsymbol{n}}$. We typically suppress this dependence and only make the dependence on the information structure explicit.[9]

Arguably, instead of studying maximal aggregate participation, we could have focused on maximal welfare. One reason to focus on participation is its empirical relevance. Recent work in political science on collective action measures aggregate participation in mass protests.[10] In Section IV, we also discuss the impact of similarity of information on welfare.

C. A Measure of Information Similarity

Given our research question, we need a notion of informational similarity. Agents make participation decisions based on their beliefs about the state of the world and the expected aggregate participation. So they must reason about the *conditional* probability of others' information given their own. We use the following similarity order for two-dimensional random variables using such conditional beliefs.

DEFINITION 2 (**Concentration Along Diagonal (CAD)**): *Let $\mathcal{Y} \subset \mathbb{R}$ be a finite set. Let Y and $\widehat{Y}$ be two $\mathcal{Y}^2$-valued exchangeable random variables whose distributions are given by $\mathscr{D}$ and $\widehat{\mathscr{D}}$, respectively. We say Y is more similar than $\widehat{Y}$ in the CAD order, denoted by $Y \succcurlyeq_{CAD} \widehat{Y}$ or $\mathscr{D} \succcurlyeq_{CAD} \widehat{\mathscr{D}}$, if the following two conditions hold.*

1) *Y_i and $\widehat{Y}_i$ are identically distributed for all $i \in \{1, 2\}$.*
2) *For $y \in \mathcal{Y}$ and $T \subseteq \mathcal{Y}$,*
   a) *$\mathscr{D}(Y_2 \in T | Y_1 = y) \geqslant \widehat{\mathscr{D}}(\widehat{Y_2} \in T | \widehat{Y_1} = y)$ if $y \in T$.*
   b) *$\mathscr{D}(Y_2 \in T | Y_1 = y) \leqslant \widehat{\mathscr{D}}(\widehat{Y}_2 \in T | \widehat{Y}_1 = y)$ if $y \notin T$.*

By exchangeability of the distributions, we can interchange Y_1 and Y_2 in the definition. We use the CAD order to compare $\mathcal{P}_s^{\theta}(\cdot)$, the beliefs of players conditional on a state, and a realized signal, keeping the marginal beliefs conditional on $\boldsymbol{\theta} = \theta$ by $\mathbb{P}^{\theta}$ unchanged.[11]

The CAD order captures the idea that when information becomes more similar, any agent believes that it is now more likely that others received the same signal as they did. Agents face two types of uncertainty: fundamental uncertainty about

[9] Most of our results about the expected aggregate participation remain unchanged if we used the ex-ante expected aggregate participation rather than expected aggregate participation when $\boldsymbol{\theta} = 1$.

[10] For instance, several empirical studies (Enikolopov, Makarin and Petrova, 2020, e.g.), as well as popular press articles (e.g., `https://www.nytimes.com/2023/11/22/opinion/does-protest-work-bevins.html`) and even datasets that document protests over time (Clark and Regan, 2016, e.g.) record turnout.

[11] We analyze the effect of increasing similarity of $\mathcal{P}_s^1(\cdot)$. This is because, given the definitions of states and payoffs in our game, changing $\mathcal{P}_s^0(\cdot)$ is not payoff relevant if marginals $\mathbb{P}^{\theta}$ are unaltered. See Section VIII for a more detailed discussion.

$\boldsymbol{\theta}$, and strategic uncertainty about the other group's information. Part 1 in the definition means that an increase in CAD keeps the fundamental uncertainty unchanged, and potentially varies only the strategic uncertainty.

The large literature that studies the value of *public* information in coordination games (for example, Morris and Shin, 2002) alters both fundamental and strategic uncertainty at the same time since public information changes both the joint and the marginal distribution. By keeping the fundamental uncertainty unchanged, our formulation isolates the effect of strategic uncertainty. In Section VIII, we discuss how our results are robust to allowing the marginal distributions to change.

To gain more intuition about the notion of CAD, it is useful to consider a simple numerical example of two information structures that are CAD-ordered. Suppose $(\widehat{Y}_1, \widehat{Y}_2)$ is an information structure with $\widehat{Y}_i$'s being conditionally independent. Now consider a new information structure Y, with the same marginal distribution as $\widehat{Y}$. But now the Y_i's are conditionally independent with probability $1-\varepsilon$ for some $\varepsilon > 0$ and perfectly correlated with probability ε. Y is more similar than $\widehat{Y}$ in the CAD order. To see how such a CAD increase in information similarity can arise in practice, consider how people have converged on where they get information from. For instance, with a dominant platform like YouTube and algorithms steering content to users, it has become more likely (higher ε) that people view exactly the same content, compared to several years ago. This corresponds to a CAD increase.

The CAD order above is equivalent to a notion proposed by Meyer (1990). Definition 2 can be equivalently stated as $Y \succcurlyeq_{CAD} \widehat{Y}$ if the probability of events in which $\widehat{Y}_1, \widehat{Y}_2$ are *exactly equal* must (weakly) increase under Y, and the probability of events in which $\widehat{Y}_1, \widehat{Y}_2$ are unequal must (weakly) decrease under Y. The CAD order can also be defined for more than two-dimensional random variables. In this case, we need to reformulate the order in terms of the distribution of the number of other agents with the same signal realization. It is worth highlighting that with more than two dimensions, CAD is distinct from various orders in Meyer (1990), and is also not nested in some standard orders like the supermodular order. The interested reader may refer to our companion paper Basak, Deb and Kuvalekar (2025), in which we provide results about the comparison between CAD orders and other well-known orders like the supermodular order.[12]

The requirement that the agents see exactly the same signal with a higher probability may be too strong in some contexts, making the CAD order quite incomplete. Indeed, two information structures Y and $\widehat{Y}$ are not comparable in the CAD order if the probability of events in which $\widehat{Y}_1, \widehat{Y}_2$ are *very close in value* increased under Y and the probability of events in which $\widehat{Y}_1, \widehat{Y}_2$ are *significantly different*

[12]In Basak, Deb and Kuvalekar (2025) we develop a class of orders—all based on the idea of greater concentration along a diagonal—and argue why these are the right orders of information similarity for Bayesian games of pure coordination.

decreased. We discuss the implications of using alternative, more complete orders after presenting our main results.

Finally, notice that we construct posterior beliefs explicitly using the signals, rather than model signals as posteriors themselves, as is now standard, following Kamenica and Gentzkow (2011). Our assumption that $\mu(\cdot)$ is injective implies that signals and posteriors are interchangeable. We could have chosen signals as posteriors and started with a *feasible* joint distribution over posterior beliefs instead. With more than one agent, characterizing the feasible joint distributions over posteriors is not trivial. Recently, Arieli et al. (2021) characterize the set of feasible two-dimensional joint distributions. By working with signals directly and performing the CAD operations, we have feasible joint distributions by construction.

III. Information Similarity and Participation

In this section, we present our main results that characterize how increased similarity of information affects participation in equilibrium. All proofs are in the appendix.

A. Preliminaries

In an equilibrium of our regime-change game, an agent is willing to incur the cost of participation if and only if she believes that it is sufficiently likely that a change is beneficial and that her participation will make a difference. Consider an agent in group $g \in \{1, 2\}$. If both groups participate, then her participation makes a difference only if the required threshold of participation for regime change $\bar{\boldsymbol{n}} + 1 = 2N$. Similarly, if only her own group participates, then her participation makes a difference only if $\bar{\boldsymbol{n}} + 1 = N$. Finally, if only the other group participates, then she makes a difference if $\bar{\boldsymbol{n}} + 1 = N + 1$. Below, we define expressions Λ_{b}, Λ_{o}, and $\Lambda_{-\mathrm{o}}$, which denote, respectively, the probabilities of an agent being pivotal when both groups participate, only her own group participates, and only the other group participates.

$$\Lambda_{\mathrm{b}} := \psi(2N - 1),\ \Lambda_{\mathrm{o}} := \psi(N - 1),\ \Lambda_{-\mathrm{o}} := \psi(N). \tag{3}$$

We assume that a single agent cannot cause regime change. This means an agent can never be pivotal if no other agent participates, i.e., $\psi(0) = 0$. While models with pivotality considerations are ubiquitous in the voting literature, one common critique is that voters in large electorates are unlikely both to condition on being pivotal, and to ever be pivotal. But in our setting with uncertainty about the required threshold, it is natural to assume that agents do think about whether their participation can make a difference. Moreover, Λ_{b}, Λ_{o}, and $\Lambda_{-\mathrm{o}}$ are smooth functions of pivotal probabilities. They serve as a way of modeling the incentive to avoid costly participation when there is strategic uncertainty.

We assume throughout the paper that from any agent's perspective, the probability of being pivotal when only the other group participates is weakly smaller than the probability of being pivotal when only her own group participates or when both groups participate.

ASSUMPTION 1: $\max\{\Lambda_o, \Lambda_b\} \geqslant \Lambda_{-o}$

We first write down the conditions for a strategy profile to be an equilibrium.

PROPOSITION 1: *A strategy profile σ is an equilibrium if and only if for all $g \in \{1,2\}$ and for all $s \in \mathcal{S}$,*

$$\text{(IC:P)} \qquad \mathcal{P}_s^1(P_{-g})\Lambda_b + (1 - \mathcal{P}_s^1(P_{-g}))\Lambda_o \geqslant \frac{c}{\mu(s)} \text{ if } s \in P_g$$

$$\text{(IC:NP)} \qquad \mathcal{P}_s^1(P_{-g})\Lambda_{-o} \leqslant \frac{c}{\mu(s)} \text{ if } s \in NP_g.$$

The intuition is straightforward. Consider an agent in group g with signal $s \in P_g$. If the other group also receives a signal in its participation set, which occurs with probability $\mathcal{P}_s^1(P_{-g})$, then this agent can make a difference with probability Λ_{b}. If the other group does not receive a signal in P_{-g}, then the agent can make a difference with probability Λ_{o}. (IC:P) simply says that the agent has an incentive to incur the cost of participating if she believes she can make a difference with a sufficiently high probability. The logic behind (IC:NP) is similar.

To capture how the incentives change with similarity of information, it is convenient to partition the model primitives into two environments.[13]

DEFINITION 3: *[Encouragement/Discouragement]*

- *We say we are in an* ***encouragement environment*** *if*

  $$\text{(E)} \qquad \Lambda_b > \Lambda_o.$$

  In this case, an agent is more likely to make a difference when both groups participate than if only her own group participates; that is, higher aggregate participation encourages participation.

- *We say we are in a* ***discouragement environment*** *if*

  $$\text{(D)} \qquad \Lambda_o > \Lambda_b.$$

  In this case, an agent is more likely to make a difference when only her group participates than if both groups participate; that is, higher participation by others discourages individual participation.

[13]In the knife-edge case $\Lambda_b = \Lambda_o$, changing information similarity has no impact.

The reader may wonder if there is a connection between the encouragement and discouragement environments and strategic complementarities and substitutabilities.[14] In our two-player example in the introduction, the condition for the encouragement environment boils down to $(1-q) > q$ or $q < \frac{1}{2}$, and the discouragement condition is $q > \frac{1}{2}$. When $q < \frac{1}{2}$ an agent's incentive to participate is increasing in the probability that the other agent participates: In other words, the encouragement environment is exactly an environment of strategic complementarity. Conversely, when $q > \frac{1}{2}$ an agent's incentive to participate is decreasing in the probability that the other agent participates making the discouragement environment one of strategic substitutability.

However, for two groups with $N > 1$ agents, the equivalence between the discouragement environment and strategic substitutability does not hold. What is different with $N > 1$ agents, is that an agent's incentive to participate depends also on what other agents in her own group do. (IC:P) is the agent's incentive constraint to participate after her group receives a signal in the participation set, and (IC:NP) is the incentive constraint to not participate after her group receives a signal in the non-participation set. In the encouragement environment, an agent's incentive to participate increases as the other group participates more (i.e., if P_{-g} expands), regardless of her signal. Therefore, the encouragement environment is equivalent to one of strategic complementarity. However, in the discouragement environment, the incentive to participate decreases as the other group participates more, only for agents with signals in the participation set. In contrast, for agents with a signal in the non-participation set, their incentive to participate depends on,

$$\mathcal{P}_s^1(P_{-g})\Lambda_{-\mathrm{o}}.$$

Clearly, if P_{-g} increases (in the set order), the incentive to participate increases. Therefore, the discouragement environment is not equivalent to an environment with strategic substitutability.

Theorems 1 and 2 establish that if we compare information similarity in the sense of CAD, then the above simple condition about primitives (whether $\Lambda_{\mathrm{b}} > \Lambda_{\mathrm{o}}$ or $\Lambda_{\mathrm{o}} > \Lambda_{\mathrm{b}}$) yields a complete characterization of when increased information similarity facilitates or hinders participation.

B. *Encouragement Environment*

THEOREM 1: *In encouragement environments, the maximal equilibrium aggregate participation increases when information becomes more similar. That is,*

[14] Typically, we say that a game exhibits strategic complementarities (substitutabilities) if each agent's best response action increases if the expected action of the other agents increases (decreases) (see Morris and Shin, 2003).

$$\mathcal{P}^\theta \succcurlyeq_{CAD} \widehat{\mathcal{P}}^\theta \textit{ for all } \theta \implies \mathscr{V}^*(\mathcal{P}) \geqslant \mathscr{V}^*(\widehat{\mathcal{P}}) \textit{ in } \text{(E)}.$$

This is true regardless of how $\mathcal{P}^0$ changes, as long as the marginals $\mathbb{P}^\theta$ are unaltered.

The proof is in the appendix and proceeds in two steps. First, we show that in encouragement environments, the maximal participation equilibrium must be in symmetric strategies. Then we show that any maximal participation equilibrium remains an equilibrium when information similarity increases. Suppose that in the maximal equilibrium, in each group, an agent participates if and only if $s \in P$. If information similarity increases, an agent with $s \in P$ now assigns a higher probability that the other group also sees a signal $s \in P$ that induces them to participate. That is, $\mathcal{P}^1_s(P)$ increases for $s \in P$. Since $\Lambda_\text{b} > \Lambda_\text{o}$, we can see from (IC:P) that such an agent has an even stronger incentive to participate. Analogously, if information similarity increases, a nonparticipating agent with $s \in NP$ now assigns a lower probability that the other group sees $s \in P$. That is, $\mathcal{P}^1_s(P)$ decreases for $s \in NP$. We can see from (IC:NP) that a nonparticipating agent has an even weaker incentive to participate.

C. *Discouragement Environment*

Next, we analyze discouragement environments, in which $\Lambda_\text{o} > \Lambda_\text{b}$. Let us first restrict attention to symmetric equilibrium. A symmetric equilibrium under $\widehat{\mathcal{P}}$ might no longer be an equilibrium under $\mathcal{P}$ when $\mathcal{P} \succcurlyeq_{CAD} \widehat{\mathcal{P}}$. This alone does not imply a smaller maximal equilibrium participation under $\mathcal{P}$, because new equilibria may arise under $\mathcal{P}$ that were not sustainable under $\widehat{\mathcal{P}}$. Given any information structure $\mathcal{P}$ and a maximal equilibrium σ^*, we define a condition that describes why σ^* is maximal under $\mathcal{P}$. Under symmetric equilibrium, this condition simply says that the equilibrium is maximal because, for any other strategy with greater participation, some participating agent wants to free-ride. Formally, for any such strategy with participation set P,

$$\left\{\mathcal{P}^1_s(P)\Lambda_\text{b} + (1 - \mathcal{P}^1_s(P))\Lambda_\text{o}\right\} < \frac{c}{\mu(s)}$$

for some $s \in P$. We call this *maximality due to free-riding*. Under this above condition, no new equilibrium with greater participation can emerge under more CAD-similar information because some agents who were supposed to participate would want to free-ride.

Recall that the above condition was derived by restricting attention to symmetric equilibrium. However, in general, the maximal equilibrium might no longer be symmetric in the discouragement environment. Therefore, the sufficient condition we need for maximality of equilibrium (defined below) is more involved.

DEFINITION 4 (Condition M): *Let σ^* be a maximal equilibrium for $\mathcal{P}$ with par-*

ticipation sets (P_1^*, P_2^*). We say that $\mathcal{P}$ satisfies condition M if, for any strategy profile $\widehat{\sigma}$ with participation sets $(\widehat{P}_1, \widehat{P}_2)$ such that $\mathscr{V}(\widehat{\sigma}) > \mathscr{V}(\sigma^*)$,

at least one of the following holds.

(M1) $\exists s \in \widehat{P}_1 \bigcap \widehat{P}_2$ *such that*

$$\min_{i\in\{1,2\}} \left\{\mathcal{P}_s^1(\widehat{P}_i)\Lambda_b + (1-\mathcal{P}_s^1(\widehat{P}_i))\Lambda_o\right\} < \frac{c}{\mu(s)}.$$

Or

(M2) $\exists s \in (\widehat{P}_1 \bigcup \widehat{P}_2) \backslash (\widehat{P}_1 \bigcap \widehat{P}_2)$ *such that*

$$\mathbb{1}_{s\in\widehat{P}_1}\mathcal{P}_s^1\left(\widehat{P}_1\right) + \mathbb{1}_{s\in\widehat{P}_2}\mathcal{P}_s^1\left(\widehat{P}_2\right) > \frac{c}{\Lambda_{-o}\mu(s)}.$$

Condition M says there are two reasons why any strategy profile $\widehat{\sigma}$ with a larger expected participation than the maximal equilibrium σ^* fails to be an equilibrium. Either (IC:P) is violated for some signal that prescribes both groups to participate under $\widehat{\sigma}$, or (IC:NP) is violated at a signal at which exactly one group is prescribed to participate under $\widehat{\sigma}$. Below we establish that in discouragement environments, if the information structure satisfies condition M, increasing information similarity leads to lower maximal equilibrium aggregate participation.

Condition M is not a condition on the primitives of the model. However, a straightforward sufficient condition that guarantees condition M is as follows. Let $\mathcal{S}$ be ordered according to the posterior beliefs, $\mu(s)$. Define $\widehat{s} := \inf\{s : \mu(s)\Lambda_o \geqslant c\}$. If $\widehat{\sigma} := \mathbb{1}_{\mathbf{S}\geqslant\widehat{s}}$ is an equilibrium for some $\mathcal{P}$, then $\mathcal{P}$ satisfies condition M. The reason is that regardless of the information structure, (IC:P) can never be satisfied for $s < \widehat{s}$. Therefore, no equilibrium can have a larger expected participation than $\widehat{\sigma}$. And therefore condition M is satisfied. One easily verifies with a binary-signal example that this sufficient condition is not vacuous. Equipped with this condition, we now present our second main result, which establishes how increased information similarity can reduce maximal aggregate participation.

THEOREM 2: *In a discouragement environment that satisfies condition M, the maximal equilibrium participation decreases when information becomes more similar. That is,*

$$\mathcal{P}^\theta \geqslant_{CAD} \widehat{\mathcal{P}}^\theta, \text{ for all } \theta \implies \mathscr{V}^*(\mathcal{P}) \leqslant \mathscr{V}^*(\widehat{\mathcal{P}}) \text{ in (D) if } \widehat{\mathcal{P}} \text{ satisfies condition M.}$$

Moreover, the inequality can be strict. The result is true regardless of how $\mathcal{P}^0$ changes, as long as the marginals $\mathbb{P}^\theta$ are unaltered.

The proof is in the appendix. The argument involves two steps. First, we argue that the maximal equilibrium might no longer be an equilibrium when information becomes more similar. Let σ^* with participation sets (P_1^*, P_2^*) be the maximal equilibrium under $\widehat{\mathcal{P}}$. Consider a participating agent with a signal $s \in P_1^* \bigcap P_2^*$. If information becomes more similar, this agent assigns a higher probability to the event that the other group also receives a signal in their respective participation set. However, unlike in encouragement environments, this reduces her incentive to participate since $\Lambda_o > \Lambda_b$. As a result, this agent's (IC:P) may be violated. Indeed, a nonparticipant's (IC:NP) may also fail. Consider a signal $s \in P_1^* \backslash P_2^*$. An agent in group 2 who receives such a signal is prescribed to not participate. However, with increased similarity of information, this agent assigns a higher probability that group 1 will participate. This, in turn, makes her more likely to participate, which may violate (IC:NP). So the maximal equilibrium σ^* under $\widehat{\mathcal{P}}$ may no longer be an equilibrium under $\mathcal{P}$.

In the second step, we establish that no new equilibrium with larger expected participation arises under $\mathcal{P}$. Suppose, for a contradiction, there is an equilibrium σ' with $\mathscr{V}(\sigma') > \mathscr{V}(\sigma^*)$. By the maximality of σ^*, we know that σ' is not an equilibrium under $\widehat{\mathcal{P}}$. By condition M, two cases arise. In case (i), σ' is not an equilibrium under $\widehat{\mathcal{P}}$ because an agent's incentive to participate (IC:P) is violated at some signal $s \in P_1' \bigcap P_2'$, where both groups are prescribed to participate. With more similar information, (IC:P) would continue to be violated. To see why, note that (IC:P) is a convex combination of Λ_b and Λ_o, and with more similar information, she assigns a higher weight to Λ_b. Now if (IC:P) was violated under $\widehat{\mathcal{P}}$, then it will also be violated under $\mathcal{P}$ because in discouragement environments, $\Lambda_b \leqslant \Lambda_o$. In case (ii), σ' is not an equilibrium under $\widehat{\mathcal{P}}$ because (IC:NP) is violated for some agent—say, from group 2—with a signal in $(P_1' \backslash P_2')$. Such an agent wishes to participate under $\widehat{\mathcal{P}}$ because she assigns a high probability to the event that group 1 participates. Under $\mathcal{P}$, when information is more similar, she has an even stronger incentive to participate (since she believes that the other group is more likely to participate and her own group is not going to participate). So, in both cases, if σ' is not an equilibrium under $\widehat{\mathcal{P}}$, then it cannot be an equilibrium under $\mathcal{P}$ either.

Discussion of Theorems 1 and 2: A few observations are worth highlighting. First notice that we partitioned the model primitives into encouragement and discouragement environments. The partition was independent of any particular information structure. Theorems 1 and 2 make clear the economic significance of this partition: The encouragement (discouragement) setting captures when coordination (free-riding) is the primary hurdle to collective action. Measuring information similarity using CAD yields the intuitive economic insight that increasing information similarity helps collective action exactly when coordination is the main challenge, and can hinder it when free-riding is the main challenge.

Second, we assume a fixed finite signal space without any additional restrictions on the signal structure. Consequently, there is little hope of characterizing all equilibria. However, using an indirect approach, we can characterize the effects of changing similarity of information on the set of equilibria and the maximal ones. We restrict attention to pure strategies. In encouragement environments, this is without loss: maximal equilibria are in symmetric pure strategies. In discouragement environments, this need not be true. However, while not proved formally in the paper, the qualitative insight that increased information similarity can lead to lower participation in discouragement environments remains valid even if the maximal equilibrium is in mixed strategies.

Finally, the extant literature often restricts attention to cutoff strategies for the sake of tractability. In games of pure complementarities, this is a reasonable assumption especially if one wishes to study the best (or the worst) equilibria (see Morris and Shin (2002) for instance). However, in our setting with both complementarities and substitutabilities, maximal equilibria, in general, need not be monotone or symmetric. Moreover, especially in the discouragement environment, cutoff equilibria with positive participation may not even exist, even though natural non-monotone equilibria with participation exist.[15]

However, if we focus on monotonic (cutoff) strategies, we can still obtain results similar to Theorems 1 and 2, using an order that is weaker than CAD. Given information structures Y and $\widehat{Y}$ with the same marginals, we say $Y \succeq_{CCAD} \widehat{Y}$ if

$$Prob(Y_2 \in A | Y_1 = s) \geqslant Prob(\widehat{Y}_2 \in A | \widehat{Y}_1 = s)$$

for all s and all *interval sets* A containing s.[16] Intuitively, increased similarity no longer means that there is a higher chance of getting *exactly the same* signal. Rather, $Y \succeq_{CCAD} \widehat{Y}$ if Y_1, Y_2 are *close to each other in value* with a higher probability relative to $\widehat{Y}_1, \widehat{Y}_2$. It is obvious to see that $Y \succcurlyeq_{CAD} \widehat{Y} \implies Y \succeq_{CCAD} \widehat{Y}$, but not vice-versa. Corollary 1 below (whose proof we omit) is the analog of Theorems 1 and 2 when restricting attention to cutoff strategies.

COROLLARY 1: *Suppose that we restrict attention to cutoff strategies and let $\bar{\mathscr{V}}(\cdot)$ denote the maximal equilibrium participation restricting attention to cutoff strategies. Then, the following hold:*

1) *If $\Lambda_b > \Lambda_o$ and $\mathcal{P}^\theta \succeq_{CCAD} \widehat{\mathcal{P}}^\theta$ for all θ, then $\bar{\mathscr{V}}(\mathcal{P}) \geqslant \bar{\mathscr{V}}(\widehat{\mathcal{P}})$.*
2) *If $\Lambda_o > \Lambda_b$ and $\mathcal{P}^\theta \succeq_{CCAD} \widehat{\mathcal{P}}^\theta$ for all θ, then $\bar{\mathscr{V}}(\mathcal{P}) \leqslant \bar{\mathscr{V}}(\widehat{\mathcal{P}})$ if $\widehat{\mathcal{P}}$ satisfies condition M restricted to cutoff strategies.*

IV. Information Similarity and Welfare

In this regime-change game, participation is costly for an agent but generates no benefit when $\boldsymbol{\theta} = 0$, or when $\boldsymbol{\theta} = 1$ and the agent is not pivotal. In these events,

[15]Shadmehr (2021) considers a game similar to ours, and highlights the absence of cutoff equilibria when the noise in the signals is small.
[16]This assumes that the set of signals, $\mathcal{S}$, is an ordered set.

participation is, in fact, inefficient. An important question is whether or not the increase in participation due to more similar information also generates higher social welfare. We show that if the distribution of the threshold participation required for regime change ψ is single-peaked, then maximal welfare unambiguously increases in the encouragement environment.

Given a strategy profile with participation sets of the two groups (P_1, P_2), we define the welfare as follows.

$$\begin{aligned} W(P_1, P_2; \mathcal{P}) := & \ 2N\mu_0\Psi(2N-1)\mathcal{P}^1(P_1, P_2) \\ & + \ 2N\mu_0\Psi(N-1)\left(\mathcal{P}^1(P_1, NP_2) + \mathcal{P}^1(NP_1, P_2)\right) \\ & - \ cN\mathbb{P}(P_1) - cN\mathbb{P}(P_2), \end{aligned}$$

where NP_i denotes the complement of set P_i, and $\mathbb{P}(S) := \mu_0\mathbb{P}^1(S) + (1-\mu_0)\mathbb{P}^0(S)$. The first term is the total benefit to society if both groups participate to cause regime change. To see how we derive this term, note that $2N$ is the total number of agents, μ_0 is the probability that $\boldsymbol{\theta} = 1$, $\mathcal{P}^1(P_1, P_2)$ is the probability that both groups participate in $\boldsymbol{\theta} = 1$, and in this case, the regime changes only if $\bar{\boldsymbol{n}} + 1 \leqslant 2N$. The second term is the total benefit to society if only one group participates to cause regime change. Analogously, in this term, $2N$ is the number of agents, μ_0 is the probability that $\boldsymbol{\theta} = 1$, $\mathcal{P}^1(P_i, NP_j)$ is the probability that group i participates and group j does not when $\boldsymbol{\theta} = 1$, and in this case the regime changes only if $\bar{\boldsymbol{n}} + 1 \leqslant N$. The two negative terms are the costs of participating agents. We divide through by N, and define the normalized maximal welfare as

$$W^*(\mathcal{P}) := \max_{\sigma \in \mathcal{E}(\mathcal{P})} \frac{1}{N} W(P_1(\sigma), P_2(\sigma); \mathcal{P}).$$

THEOREM 3: *If the distribution of* $\bar{\boldsymbol{n}}$, $\psi(\cdot)$, *is single-peaked, then*

$$\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1, \ \mathcal{P}^0 = \widehat{\mathcal{P}}^0, \quad \textit{and } \Lambda_b > \Lambda_o \Longrightarrow W^*(\mathcal{P}) \geqslant W^*(\widehat{\mathcal{P}}).$$

The above theorem implies that if ψ is single peaked, then, much like maximal participation, maximal welfare also increases in the encouragement environment. Moreover, as in Theorem 2, in the discouragement environment where increased information similarity can reduce participation, it can also reduce welfare.

The proof of Theorem 3 is quite different from that of Theorem 1. We proceed in two key steps. First, we show that in the encouragement environment, the welfare maximizing equilibrium is symmetric. Recall that we showed also in the proof of Theorem 1 that the maximal participation equilibrium is symmetric in the encouragement environment. This does not immediately imply the same is true for the welfare-maximal equilibrium, because higher participation does not necessarily increase welfare. Nevertheless we show that, given any asymmetric equilibrium with participation sets (P_1, P_2), welfare is higher if both groups participate when they see signals in $P_1 \bigcup P_2$. But for the strategy with participation set $P_1 \bigcup P_2$, while (IC:P) is satisfied, (IC:NP) may be violated. We complete the argument by establishing that there always exists a symmetric equilibrium with participation sets (T, T) with $P_1 \bigcup P_2 \subseteq T$ which results in even higher welfare.

Second, aggregate participation only depends on the marginal distribution of signals, but this is not true for welfare. Even if agents play the same symmetric equilibrium strategy under more similar information, it is more likely that both groups will participate or no group will participate. The first effect positively impacts welfare whereas the second effect does the opposite. Therefore, the overall effect on welfare could be ambiguous. We show that for any symmetric strategy profile σ, the welfare difference between $\mathcal{P}$ and $\widehat{\mathcal{P}}$ is proportional to

$$Prob(\bar{\boldsymbol{n}} \in \{N, \dots, 2N-1\}) - Prob(\bar{\boldsymbol{n}} \in \{0, N-1\}).$$

This difference is always non-negative in the encouragement environment when $\psi(\cdot)$ is single-peaked. This proves the theorem.

Finally, while not stated explicitly in Theorem 3, it is easy to see how increased information similarity can reduce maximal welfare in the discouragement environment. To this end, notice that when $\psi(\cdot)$ is single-peaked, the above probability difference can be negative in the discouragement environment. In such situations, even if σ is an equilibrium under both, $\mathcal{P}$ and $\widehat{\mathcal{P}}$, welfare can be strictly lower under $\mathcal{P}$ as compared to $\widehat{\mathcal{P}}$. It is straightforward to construct such examples.

V. Application 1: Protests and Regime Resilience

We can apply our framework directly to study mass protests, and ask when we see encouragement or discouragement environments in practice. We consider regimes with resilience $\bar{\boldsymbol{n}}$ and assume $\bar{\boldsymbol{n}} - 1$ is drawn from a Poisson distribution.[17] We show that sufficiently resilient regimes are encouragement environments.

PROPOSITION 2: *If $\bar{\boldsymbol{n}} - 1$ is drawn from a Poisson distribution with mean n, then there exists a threshold resilience n^* such that*

1) *if the average resilience $n > n^*$, we are in an encouragement environment;*
2) *if the average resilience $n < n^*$, we are in a discouragement environment.*

The proof of the proposition follows directly from the fact that if $\bar{\boldsymbol{n}} - 1$ follows a Poisson distribution, then the probability of an agent being pivotal given that $k \in \{1, 2\}$ groups participate is, $\frac{\exp(-n)(n)^{kN-2}}{(kN-2)!}$.[18]

[17]The assumption that $\bar{\boldsymbol{n}} - 1$ is distributed Poisson ensures that at least two participating agents are necessary for regime change.

[18]Shadmehr (2021) establishes a similar result in a slightly different setup with N agents, a fixed threshold, and heterogeneous costs. He addresses the empirical puzzle posed by Cantoni et al. (2019)

This proposition and Theorems 1 and 2 together immediately imply that the effect of changing information similarity is qualitatively different based on the resilience of regimes: Increased similarity of information facilitates greater participation in a mass protest when the regimes are hard to change (high expected resilience), but can hurt participation in protests against weaker regimes.

In fact we can go further: Below we show that this is true not only about the the extent of participation but also about the likelihood of a successful protest: Increased information similarity increases (can decrease) maximal equilibrium probability of successful regime change against sufficiently (insufficiently) resilient regimes. Formally, we define, for a given information structure $\mathcal{P}$ and equilibrium strategy profile σ

$$\Pi(\sigma;\mathcal{P}) := \mathcal{P}(\mathbf{A} \geqslant \bar{n}+1|\boldsymbol{\theta}=1)$$

as the probability that the regime changes. We assume that the regime anticipates that agents will play the equilibrium with the maximal probability of regime change. For simplicity, we restrict attention to symmetric equilibrium.[19] We define

$$\Pi^*(\mathcal{P}) := \max_{\sigma\in\mathcal{E}(\mathcal{P})} \Pi(\sigma).$$

We define a condition analogous to Condition M.

DEFINITION 5 (Condition M'): *Fix an information structure $\mathcal{P}$. Let $\overline{\sigma}$ be an equilibrium with maximum probability of success, i.e., $\Pi^*(\mathcal{P}) = \Pi(\overline{\sigma};\mathcal{P})$. We say that $\mathcal{P}$ satisfies condition M' if, for any strategy profile $\widehat{\sigma}$ with $\Pi(\widehat{\sigma};\mathcal{P}) > \Pi^*(\mathcal{P})$, ther exists $s \in \widehat{P} := P(\widehat{\sigma})$, such that*

$$\mathcal{P}^1_s(\widehat{P})\Lambda_b + (1-\mathcal{P}^1_s(\widehat{P}))\Lambda_o < \frac{c}{\mu(s)}.$$

PROPOSITION 3: *If $\bar{\boldsymbol{n}}-1$ is distributed according to the Poisson distribution with mean n, then there exists $n^{**} < n^*$, such that*

1) *For $n > n^*$, if $\mathcal{P}^1 \geqslant_{CAD} \widehat{\mathcal{P}}^1$, then $\Pi^*(\mathcal{P}) \geqslant \Pi^*(\widehat{\mathcal{P}})$*
2) *For $n < n^{**}$, if $\mathcal{P}^1 \geqslant_{CAD} \widehat{\mathcal{P}}^1$, agents play a symmetric equilibrium, and $\widehat{\mathcal{P}}$ satisfies Condition M', then $\Pi^*(\mathcal{P}) \leqslant \Pi^*(\widehat{\mathcal{P}})$*

The proof of the result for the likelihood of successful regime change is similar to the proof of Theorem 3. We show that for any symmetric equilibrium σ,

by showing how a canonical regime change game exhibits strategic complementarities (substitutabilities) when the threshold for a successful regime change is high (low).

[19]As in Theorem 3, it is without loss of generality to restrict attention to symmetric equilibrium in the encouragement environment.

$\Pi(\sigma;\mathcal{P}) - \Pi(\sigma;\widehat{\mathcal{P}})$ is proportional to

$$Prob(\bar{\boldsymbol{n}} \in \{N,\ldots,2N-1\}) - Prob(\bar{\boldsymbol{n}} \in \{0,N-1\}).$$

Since the Poisson distribution is single peaked, this difference is always positive in the encouragement environment ($n > n^*$). This means for sufficiently resilient regimes, higher CAD-similarity increases the aggregate protest size and the probability of regime change. However, this difference is not necessarily negative in the discouragement environment ($n < n^*$). This means even if higher CAD-similarity reduces the size of protest, the probability of regime change may still increase. However, there exists $n^{**} < n^*$ such that if the average resilience $n < n^{**}$, then the above difference is negative,[20] implying that higher CAD-similarity reduces probability of regime change.[21]

These results speak to the discourse on the role of media in mass protests. For instance, Enikolopov, Makarin and Petrova (2020) provide empirical support for increased protest turnout due to social media penetration in Russia. Manacorda and Tesei (2020) show that increased mobile phone usage facilitated protests in Africa. Our results highlight that while these studies show how a more connected world enabled large protests against regimes previously thought to be impregnable, they do not consider how this same increased information similarity could have hindered collective action in other movements with ex ante easier goals.

Little (2016) and Shadmehr and Bernhardt (2017) are two papers that show that greater communication *can reduce* the likelihood of a successful protest. In Shadmehr and Bernhardt (2017), if the regime is sufficiently bad, information sharing may persuade individuals who would otherwise protest to stay home. In Little (2016) communication makes it easier for citizens to air grievances, and raises the threshold of bad news required for agents to protest. We offer a qualitatively different explanation: Increased information similarity can hinder protests by exacerbating free-riding, which is pervasive in any collective action setting.

Our theory also has implications for press freedom under authoritarian governments. A common tool used by such regimes is curbing press freedom, that is, reducing the similarity of information across individuals. Our results suggest that it is precisely the resilient authoritarian governments that benefit more from curbing press freedom. Less powerful regimes may face larger protests and a higher likelihood of being overthrown when they restrict press freedom.

[20]It is easy to see that the probability difference is negative for $n = 1$, and the result follows from continuity.

[21]In the appendix (Proposition 6), we show that given a strategy profile that is an equilibrium under both $\mathcal{P}$ and $\widehat{\mathcal{P}}$, conditional on there being a protest, increased similarity increases the probability of a successful regime change.

VI. Application 2: Costly Voting in Committees

Next, we apply our framework to voting in committees (à la Palfrey and Rosenthal, 1985). Consider members of a monetary policy committee who must vote on whether to raise interest rates. An interest rate increase is implemented if and only if a threshold number of members vote in favor of it. Voting in favor of an interest rate increase entails an individual cost. This is because votes are public and the median public opinion wants the status quo to be maintained. So, members who vote in favor incur a reputation cost, or a cost of facing public hostility ex-post. The committee members want to increase interest rates only if such an increase is warranted. They choose how to vote based on their private information about how a rate increase affects the economy. Members' private information exhibit different levels of similarity depending on the diversity of their backgrounds—for example, different academic expertise may lead members to focus on different aspects of the available evidence. What effect do changes in diversity of the committee have on voting outcomes? We apply our tools to characterize when increased information similarity (less diversity among committee members) strengthens or weakens the incentive to vote in favor of a rate increase based on evidence, and how it affects the choice of the optimal voting threshold.

Suppose the committee comprises $G > 2$ members. The economy is in one of two possible states: a rate increase is either unnecessary ($\boldsymbol{\theta} = 0$) or warranted ($\boldsymbol{\theta} = 1$). Each member i privately receives a noisy binary signal $\mathbf{S}_i \in \mathcal{S} = \{0, 1\}$ about the state $\boldsymbol{\theta}$. Conditional on state $\boldsymbol{\theta}$, the signals are drawn from a joint distribution $\mathcal{P}^{\theta}$. These signals can be interpreted as each committee member's understanding of the available data given their background or expertise. Information among committee members is more similar if their backgrounds are more similar. The committee uses a qualified majority threshold rule to overturn the status quo, i.e., a rate increase is implemented if and only if more than $\bar{n} + 1$ members cast votes in favor. Unlike in our baseline setup, the threshold is fixed. If a rate increase is implemented, the members get a payoff of θ. Voting in favor of a rate increase costs c. For simplicity, we assume $\frac{c}{\mu(0)} > 1$ to guarantee that in any equilibrium, a member who receives $\mathbf{S}_i = 0$ never votes in favor of a rate increase. We restrict attention to symmetric strategies.

With $G > 2$ agents, we need to extend our notion of CAD to compare information similarity of random variables with more than two dimensions. Let $I = \sum_{j \in G} \mathbb{1}_{\mathbf{S}_j = 1}$ denote the number of committee members who receive signal $\mathbf{S}_j = 1$, and let $I_{-i} = \sum_{j \in G \setminus \{i\}} \mathbb{1}_{\mathbf{S}_j = 1}$ denote the number of members other than i who receive signal $\mathbf{S}_j = 1$. Let γ be the probability distribution function of I_{-i} conditional on $\boldsymbol{\theta} = 1$ and $\mathbf{S}_i = 1$

DEFINITION 6: *We say $\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$ if there exists $k^* \in \{0, 1, \ldots, G-2\}$ such that*

$$\gamma(k) \leqslant \widehat{\gamma}(k) \text{ for all } k \leqslant k^*$$

and $\gamma(k) \geqslant \widehat{\gamma}(k)$ *for all* $k > k^*$.

We call k^* *the index of sign change between* $\mathcal{P}^1$ *and* $\widehat{\mathcal{P}}^1$.

Suppose a member receives a signal 1. This definition means that when information similarity increases, then conditional on the rate increase being warranted ($\boldsymbol{\theta} = 1$), each member assigns a higher probability to more than k^* others having also observed signal 1 and a lower probability to fewer than k^* others having observed the opposite signal 0.[22]

Consider a strategy profile, denoted by σ^1, in which members vote in favor of a rate increase whenever they receive $\mathbf{S}_i = 1$. For σ^1 to be an equilibrium, it must be that an agent i who receives a signal $\mathbf{S}_i = 1$ believes that he is sufficiently likely to be pivotal, and he is pivotal when $I_{-i} + 1 = \bar{n} + 1$. Formally, σ^1 is an equilibrium if

$$\text{(IC-voting)} \qquad \gamma(\bar{n}) \geqslant \frac{c}{\mu(1)}.$$

Proposition 4 below characterizes how increased similarity of information affects the maximal number of votes in equilibrium in favor of a rate hike (conditional on it being warranted).

PROPOSITION 4: *Fix* $\bar{n}$, *the threshold number of votes required to implement a rate increase. Suppose* $\mathcal{P}^1 \geqslant_{CAD} \widehat{\mathcal{P}}^1$, *and let* k^* *be the associated index of sign change between* $\mathcal{P}^1$ *and* $\widehat{\mathcal{P}}^1$. *Suppose* $\sigma^1 \in \mathcal{E}(\widehat{\mathcal{P}})$.

1) *If* $k^* < \bar{n}$, *then* $\sigma^1 \in \mathcal{E}(\mathcal{P})$.
2) *If* $k^* \geqslant \bar{n}$, *then it is possible that* $\sigma^1 \notin \mathcal{E}(\mathcal{P})$.

The only candidate equilibrium with any votes in favor of a rate hike is σ^1. Studying maximal equilibria reduces to starting out with σ^1 that constitutes an equilibrium and checking if it remains an equilibrium when information similarity increases. To see the intuition behind the result, let us examine the incentives of a committee member i who believes that a rate increase is warranted based on her signal $\mathbf{S}_i = 1$, for two extreme voting rules. First, suppose that a unanimous vote is required to increase rates ($\bar{n} + 1 = G$). Then member i's vote is relevant only when all the others also vote for a hike. This requires that all others have received the same signal. With increased information similarity, $\gamma(G-1)$ increases, which makes it more likely that her vote is relevant. This increases her incentive to vote in favor of a rate increase conditional on the signal $\mathbf{S}_i = 1$, regardless of k^*. Next, suppose that one vote in favor is enough to implement the rate increase

[22] We do not restrict the conditional beliefs after $\mathbf{S}_i = 0$. This is because, given $c > \mu(0)$, an agent never votes in favor of a rate increase after observing $\mathbf{S}_i = 0$. For more general environments, we would need restrictions on the conditional beliefs after any signal realization. In a companion paper, we present extensions of the CAD order for more than two dimensions and study their implications for equilibrium behavior in a class of binary-action games.

($\bar{n}+1=1$). Then member i's vote is relevant only if all the others vote against the interest rate hike. Increased information similarity means $\gamma(0)$ decreases. The incentive to vote for a hike in this case is diminished, regardless of k^*. In general, how increased information similarity affects a member's incentive to vote will depend on k^*. Intuitively, conditional on the rate increase being warranted, less similar information (a more diverse committee) strengthens the incentive to vote correctly and increases the maximal equilibrium number of votes in favor of a rate increase if the qualified majority threshold is low. Conversely, less similar information weakens the incentive to vote correctly, if the threshold is high. This leads to an interesting normative question about the design of optimal voting rules in committees: how do changes in the diversity of a committee affect the choice of the optimal voting threshold rule?[23] We address this question in Appendix A.A8.

VII. Application 3: Public Good with Private Costs

As a final application, we consider a public good provision problem. There are two groups consisting of N agents each. Each agent simultaneously decides whether or not to contribute to a public good. The public good is provided if at least $\bar{\boldsymbol{n}}+1$ agents contribute. It is commonly known that the public good is beneficial for society, and gives each agent a positive payoff of 1. An agent in group $g \in \{1,2\}$ has a cost $\mathbf{S}_g$ of contributing to the public good. We assume $\mathbf{S} := (\mathbf{S}_1, \mathbf{S}_2)$ is drawn from a joint distribution $\widehat{\mathcal{P}}$ (with finite support). Costs are private, in that agents observe only the realized cost of their own group. We can interpret participation in our baseline model as contribution, and the private signal as the private cost. The payoff matrix is as follows.

	$A \geqslant \bar{\boldsymbol{n}}+1$	$A \leqslant \bar{\boldsymbol{n}}$
$a=1$	$1-s_i$	$-s_i$
$a=0$	1	0

Table 3—: Payoffs for agent with private cost s_i

Unlike in our baseline setup, there is no uncertainty about a common state. Rather, agents face only strategic uncertainty, because of private costs. Dziuda, Gitmez and Shadmehr (2021) study such a public good contribution game. In this environment, we can ask the same question: do more similar costs across groups generate more contribution? We can define CAD-similarity of private costs, and establish that the same result applies.

DEFINITION 7: *Let $\mathcal{P}$ and $\widehat{\mathcal{P}}$ be two joint distribution of private costs. $\mathcal{P}$ is*

[23]In a recent paper, Kattwinkel and Winter (2023) study the optimal decision mechanism for juries, allowing for general mechanisms but keeping the information structure fixed with independent signals across jurors. Our framework considers a special class of decision mechanisms, namely those in which a minimum threshold number of votes is required for a decision, and asks how the optimal rule changes with a changing information structure.

said to be more CAD-similar than $\widehat{\mathcal{P}}$ if

1) *The marginal distributions are the same, and*
2) $\mathcal{P}(\mathbf{S}_j \in T|\mathbf{S}_i = s) \geqslant \widehat{\mathcal{P}}(\mathbf{S}_j \in T|\mathbf{S}_i = s)$ *if* $s \in T$ *and* $\mathcal{P}(\mathbf{S}_j \in T|\mathbf{S}_i = s) \leqslant \widehat{\mathcal{P}}(\mathbf{S}_j \in T|\mathbf{S}_i = s)$ *if* $s \notin T$.

For simplicity, restrict attention to symmetric (pure strategy) equilibria. Given any strategy profile σ, we let $P(\sigma)$ denote the realized costs for which each group contributes. As before, we let $\mathscr{V}(\sigma)$ denote the expected contribution for a fixed σ, and let $\mathscr{V}^*(\widehat{\mathcal{P}})$ denote the expected contribution in the equilibrium with maximal contribution, given information structure $\widehat{\mathcal{P}}$. We can also define, in this environment, the probabilities of an agent being pivotal when both groups contribute Λ_{b}, only her own group contributes Λ_{o}, and only the other group contributes $\Lambda_{-\mathrm{o}}$.

PROPOSITION 5: *Consider the public good provision game with private costs.*

1) *In an encouragement environment, the maximal equilibrium aggregate contribution increases when information becomes more similar.*

$$\mathcal{P} \geqslant_{CAD} \widehat{\mathcal{P}} \implies \mathscr{V}^*(\mathcal{P}) \geqslant \mathscr{V}^*(\widehat{\mathcal{P}}) \text{ in (E)}.$$

2) *In a discouragement environment that satisfies condition M, the maximal equilibrium contribution decreases when information becomes more similar.*

$$\mathcal{P} \geqslant_{CAD} \widehat{\mathcal{P}} \implies \mathscr{V}^*(\mathcal{P}) \leqslant \mathscr{V}^*(\widehat{\mathcal{P}}) \text{ in (D) if } \widehat{\mathcal{P}} \text{ satisfies condition M}.$$

We omit the proof since it is the same as that of Theorems 1 and 2. The outline of the argument is as follows. Consider an agent with cost $s \in P$. Under any given joint distribution of costs $\mathcal{P}$, his incentive to contribute is

$$\Delta(s, \mathcal{P}) = \Lambda_{\mathrm{b}}\mathcal{P}_s(P) + \Lambda_{\mathrm{o}}(1 - \mathcal{P}_s(P)) - s.$$

Comparing this expression under $\widehat{\mathcal{P}}$ and more CAD-similar $\mathcal{P}$ we have

$$\Delta(s, \mathcal{P}) - \Delta(s, \widehat{\mathcal{P}}) = (\Lambda_{\mathrm{b}} - \Lambda_{\mathrm{o}})[\mathcal{P}_s(P) - \widehat{\mathcal{P}}_s(P)].$$

This expression is non-negative under the encouragement environment ($\Lambda_{\mathrm{b}} > \Lambda_{\mathrm{o}}$) and non-positive under the discouragement environment ($\Lambda_{\mathrm{o}} > \Lambda_{\mathrm{b}}$). Therefore, under more CAD-similar costs, the contributor has a higher (lower) incentive to contribute in the encouragement (discouragement) environment. Moreover, for a non-contributor $s \notin P$, we have

$$\Delta(s, \mathcal{P}) - \Delta(s, \widehat{\mathcal{P}}) = \Lambda_{-\mathrm{o}}[\mathcal{P}_s(P) - \widehat{\mathcal{P}}_s(P)] \leqslant 0.$$

This implies that in the encouragement environment, a strategy profile that is an equilibrium under $\widehat{\mathcal{P}}$ remains an equilibrium under $\mathcal{P}$, this (weakly) increasing maximal equilibrium contribution under more CAD-similar costs. This is not true in the discouragement environment, and condition M ensures no new equilibrium emerges with higher contribution.

VIII. Discussion

Finally, we discuss some extensions. Formal results are in the online appendix.

Population Uncertainty:

In large populations, it may be reasonable to assume that there is also uncertainty about the number of agents, as in Myerson (1998). Our results extend to this setting. Suppose that the number of agents in any group g, denoted by $\mathbf{N}_g$, is a $\mathbb{Z}_+$-valued random variable with probability mass function $\eta(\cdot)$ and mean N, and agents do not observe the size of their own group or other groups. Then, an agent in group $g \in \{1,2\}$ believes that the size of the other group is $\mathbf{N}_{-g} \sim \eta(.)$. Her own belonging to group g makes her potentially update her belief also about the size of her own group, so that $\mathbf{N}_g - 1 \sim \eta^A(\cdot)$. Let $\eta_2^A(\cdot)$ denote her belief about $\mathbf{N}_g - 1 + \mathbf{N}_{-g}$.[24] As in our benchmark setup, the agent's participation incentive depends on whether she expects her own participation to make a difference to the outcome. The only difference is that now probabilities of being pivotal also depend on the population size.

$$\Lambda_{\mathrm{b}} := \sum_{k=0}^{\infty} \psi(k)\eta_2^A(k),\ \Lambda_{\mathrm{o}} := \sum_{k=0}^{\infty} \psi(k)\eta^A(k),\ \Lambda_{-\mathrm{o}} := \sum_{k=0}^{\infty} \psi(k)\eta(k).$$

We use these to define the encouragement and discouragement environments, as $\Lambda_{\mathrm{b}} > \Lambda_{\mathrm{o}}$ and $\Lambda_{\mathrm{o}} > \Lambda_{\mathrm{b}}$ respectively. Theorems 1 and 2 readily extend.

Uncertainty about attainability of regime change:

We assumed that agents share common uncertainty about $\boldsymbol{\theta}$ which reflects the desirability of regime change. Suppose instead that it was commonly known that regime change is desirable (yielding a payoff of 1 to everyone regardless of their participation decision), but there was uncertainty about the attainability of regime change. Suppose the state $\boldsymbol{\theta}$ signified whether the resilience of the regime $\bar{\boldsymbol{n}}$ was drawn from $\psi_1(\cdot)$ or $\psi_0(\cdot)$ where $\psi_1 \succcurlyeq_{st} \psi_0$, i.e., the distribution of $\bar{\boldsymbol{n}}$ in state 1 first-order stochastically dominates the distribution in 0. In other words, a regime change is more difficult in state 1 than in state 0. As in the baseline model, suppose that players were uncertain about the state and received private information about it before making participation decisions. Identical arguments as in Theorems 1 and 2 imply that information similarity facilitates greater participation in collective action in the encouragement environment but can hinder

[24]Since $\mathbf{N}_1$ and $\mathbf{N}_2$ are i.i.d., this distribution does not need to be indexed by group g.

it in the discouragement environment.

More general payoffs:

To understand the limits of our main results, it is useful to write the payoffs more generally. We rewrite the payoffs from Table 2 in Table 4 below, with $|u(\theta)| \geqslant |v(\theta)|$. Our model has $u(\theta) = v(\theta) = \theta$ and $h(\cdot) = -c$.

	$A \geqslant \bar{n}+1$	$A \leqslant \bar{n}$
$a=1$	$u(\theta)+h(s)$	$h(s)$
$a=0$	$v(\theta)$	0

Table 4—: More general payoffs

The specification in our baseline model has two economically substantive implications. First, $v(0) = 0$ means that a regime change has no social cost beyond the participation costs. Suppose this were not true. Say, $u(0) = v(0) = -1$, while $h(\cdot) = -c$ as before, so that a regime change in state $\boldsymbol{\theta} = 0$ was socially costly. We analyze this environment in Section B1 of the Online Appendix. Proposition 7 shows how having $u(0) = v(0) = -1$ would yield qualitatively different results. An increase in CAD-similarity in the state when change is desirable ($\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$) increases (can decrease) maximal participation in the encouragement (discouragement) environment. However, if information becomes more CAD-similar in a state where change is not desirable ($\mathcal{P}^0 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^0$), then the opposite is true: Expected participation may decrease in encouragement environments and increase in discouragement environments.

Second, $u(\theta) = v(\theta)$ for all θ means that the reward to an agent from regime change does not depend on her participation decision. Suppose instead $u(\theta) - v(\theta) > 0$. This would mean that agents get an extra *warm glow* utility from having participated in a successful regime change. Intuitively, this reduces an agent's incentive to free-ride. Consider the extreme case of $v(\theta) = 0$ for all θ, so that an agent can get a positive benefit of regime change only if she participated. In this case, the only obstacle to successful regime change is coordination,[25] and an increase in CAD-similarity in a state where a change is desirable only increases participation. But this extreme case is, strictly speaking, not a collective action problem at all because agents have no motive to free-ride.

Moving away from the extreme benchmark, we show that if $u(\theta) - v(\theta)$ is sufficiently small, then Theorems 1 and 2 are still valid. In other words, increased information similarity can hinder participation in collective action settings only when agents face enough of an incentive to free-ride on others.

[25]See Edmond (2013); Shadmehr and Bernhardt (2011) for examples of such settings.

It may be instructive to consider different parametric cases of the general payoffs given in Table 4 above. Table 5 provides a snapshot of the results for several cases, and maps each case to canonical models in existing literature. The formal results are in the online appendix (Proposition 8 in Section B2).

Class	**Specification**	**References**	**Effect of increased information similarity**
Common value Free-riding present	$u(\theta) = \theta$ $v(\theta) = \theta$ $h(s) = -c$	Our paper	Encouragement: Positive Discouragement: Can be negative
Common value No free-riding	$u(\theta) = \theta$ $v(\theta) = 0$ $h(s) = -c$	Morris and Shin (1998)	Always positive
Common value No free-riding	$u(\theta) = \theta + c$ $v(\theta) = 0$ $h(s) = -c$	Shadmehr and Bernhardt (2011)	Always positive
Common value Partial free-riding	$u(\theta) = \theta$ $v(\theta) = (1 - \lambda)\theta$ $\lambda \in (0, 1)$ $h(s) = -c$	De Mesquita (2010)	Encouragement: Positive Discouragement: Can be negative
Private values Free-riding present	$u(\theta) = 1$ $v(\theta) = 1$ $h(s) = -s$	Dziuda, Gitmez and Shadmehr (2021) Our Application 3	Encouragement: Positive Discouragement: Can be negative

Table 5—: Classification of games and the effect of information similarity.

Informativeness of turnout:

Individuals often use protests and petitions to convey dispersed private information to policymakers, and in turn, policymakers use observed participation in protests or petitions to *infer* the state of the world and then decide whether to change policy. Our model abstracts from this, since regime change occurs whenever turnout exceeds an exogenous threshold. We consider a version of our model in which a strategic policymaker observes the realized turnout, updates her belief about the state of the world, and then decides whether to change the regime. Recent work by Battaglini (2017) and Ekmekci and Lauermann (2022) use a similar setup and study the informational role of turnout. In the online appendix (Section B3), we apply our framework to ask: Does increased similarity of information affect the informational content of participation and improve information aggregation? We show, in Proposition 10 that informativeness of equilibria can decrease with more similar information.[26] The intuition is that when information becomes more similar, holding the strategies fixed, the policymaker wants to lower the threshold, and this has two opposing effects. On the one hand, a lower threshold encourages more participation because individuals are more likely to make a difference. On the other hand, a lower threshold exacerbates free-riding. We also show (Proposition 9) that when the threshold belief at which the policymaker changes the regime is not extreme (in an intermediate range), increasing information similarity can enable information aggregation that would have been impossible under conditionally independent signals.

INFORMATION DESIGN:

A natural question is how a designer might choose the optimal level of similarity of information, given a certain objective. We assume that that the designer anticipates that the agents will play the maximal participation equilibrium. In the online appendix (Section B4), we derive the information structure that maximizes expected participation when regime change is beneficial (in $\boldsymbol{\theta} = 1$). In Proposition 11, we show that in encouragement environments, the optimal information structure is full correlation: both groups receive identical signals. In discouragement environments, interior levels of similarity—neither conditionally independent signals nor full correlation—can be optimal if the conditionally independent signals do not satisfy condition M. Our analysis restricts attention to information structures that are (weakly) more similar than conditionally independent signals. More generally, in discouragement environments, some negative interdependence may be desirable. Conversely, if the designer wants to minimize maximal participation, then in the encouragement environment, she should make the information conditionally independent, and in the discouragement environment, fully correlated signal could be optimal if it satisfies condition M.

CHANGING MARGINAL DISTRIBUTIONS:

We consider changes in the joint distribution while keeping the marginal distributions unchanged. This ensures that our results are driven by changes not in the fundamental uncertainty about $\boldsymbol{\theta}$, but in the strategic uncertainty. In practice, increases in information similarity can simultaneously endow agents with more information about the fundamentals. It is straightforward to provide examples when more similar information can lead to lower participation in the discouragement environment (as in Theorem 2) even when the marginal distributions change.

[26] This is consistent with current public discourse. For instance, in a piece about technology and protests in *The Atlantic*, Zeynep Tufekci writes, “Protests are signals: ‘We are unhappy, and we won’t put up with things the way they are.’ But for that to work, the ‘We won’t put up with it’ part has to be credible. Nowadays, large protests sometimes lack such credibility, especially because digital technologies have made them so much easier to organize.”

In the online appendix (Section B5), we define an order of similarity that does not require marginals to be unchanged. Using that, Proposition 12 delivers a result similar to Theorem 1 if we further require that the groups' marginal distributions over posteriors are ranked in the "more spread-out order" when $\boldsymbol{\theta} = 1$.[27]

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[27]Without this condition, in encouragement environments, information that is both more similar and more Blackwell-informative informative about $\boldsymbol{\theta}$ can lead to a lower expected participation. Examples are available with the authors.

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Mathematical Appendix

A1. Proof of Lemma 1

PROOF:

Let $\vec{s} = (s_1, s_2)$ be a profile of signal realizations. By definition,

$$\begin{aligned}\mathscr{V}(\sigma) &= \sum_{\vec{s}\in\mathcal{S}^2} \mathcal{P}^1(\vec{s}) \left[\sum_{g=1}^{2} N\mathbb{1}_{s_g\in P_g}\right] \\ &= \sum_{\vec{s}\in\mathcal{S}^2} \sum_{g=1}^{2} \mathcal{P}^1(\vec{s}) N\mathbb{1}_{s_g\in P_g} \\ &= \sum_{g=1}^{2} \sum_{s_g\in\mathcal{S}} \mathbb{P}^1_g(s_g) N\mathbb{1}_{s_g\in P_g} \\ &= N\sum_{g=1}^{2} \mathbb{P}^1(P_g).\end{aligned}$$

where the last equality is due to the exchangeability of the distribution.

A2. Proof of Proposition 1

PROOF:

Consider the payoff difference for any agent between participating and not. Let $u_g(a, s; \sigma)$ be the expected payoff of an agent from group g by playing action a given that $\mathbf{S}_g = s$, and the players are following σ. We define the net expected payoff from participation as

$$\Delta_g(s; \sigma) := u_g(1, s; \sigma) - u_g(0, s; \sigma)$$

Consider an agent in group g. Suppose that $\mathbf{S}_g = s$. If she participates, she incurs a cost c and gets a positive payoff only if the regime change is beneficial ($\boldsymbol{\theta} = 1$) and at least $\bar{\boldsymbol{n}}$ other agents participate. If she does not participate, then she gets a positive payoff only if $\boldsymbol{\theta} = 1$ and the turnout is at least $\bar{\boldsymbol{n}} + 1$ without her participation. So, assuming that players play according to σ, we have

$$\begin{aligned}&\Delta_g(s;\sigma) \\ &= \mathcal{P}\left(\{\boldsymbol{\theta} = 1\}\bigcap\{\mathbf{A}_{-g} \geqslant \bar{\boldsymbol{n}}\}\middle|\mathbf{S}_g = s\right) - c - \mathcal{P}\left(\{\boldsymbol{\theta} = 1\}\bigcap\{\mathbf{A}_{-g} \geqslant \bar{\boldsymbol{n}} + 1\}\middle|\mathbf{S}_g = s\right) \\ &= \mathcal{P}(\boldsymbol{\theta} = 1|\mathbf{S}_g = s)\Big[\mathcal{P}(\mathbf{A}_{-g} \geqslant \bar{\boldsymbol{n}}|\mathbf{S}_g = s, \boldsymbol{\theta} = 1) - \mathcal{P}(\mathbf{A}_{-g} \geqslant \bar{\boldsymbol{n}}+1|\mathbf{S}_g = s, \boldsymbol{\theta} = 1)\Big] - c \\ &= \mu(s)\mathcal{P}(\mathbf{A}_{-g} = \bar{\boldsymbol{n}}|\boldsymbol{\theta} = 1, \mathbf{S}_g = s) - c\end{aligned}$$

To simplify the above expression further, consider two cases. (i) Suppose $s \in P_g$. If the realized signal for the other group $s_{-g} \in P_{-g}$, then $\mathbf{A}_{-g} = 2N-1$, and if $s_{-g} \notin P_{-g}$, then $\mathbf{A}_{-g} = N-1$. (ii) Suppose $s \notin P_g$. Then, $s_{-g} \in P_{-g} \implies \mathbf{A}_{-g} = N$, and $s_{-g} \notin P_{-g} \implies \mathbf{A}_{-g} = 0$. Therefore,

$$\Delta_g(s;\sigma) = \begin{cases} \mu(s)\Big[\mathcal{P}^1_s(P_{-g})Prob\,(\bar{\boldsymbol{n}} = 2N-1 \mid \boldsymbol{\theta}=1, \mathbf{S}_g = s) \\ \quad +\mathcal{P}^1_s(NP_{-g})Prob(\bar{\boldsymbol{n}} = N-1 \mid \boldsymbol{\theta}=1, \mathbf{S}_g = s)\Big] & \text{if } s \in P_g \\ \mu(s)\mathcal{P}^1_s(P_{-g})Prob(\bar{\boldsymbol{n}} = N \mid \boldsymbol{\theta}=1, \mathbf{S}_g = s) & \text{if } s \notin P_g \end{cases}$$

Finally, σ is an equilibrium if, for all $s \in \mathcal{S}$ and for all $g \in \{1,2\}$,

1) $\sigma_g(s) = 1 \implies \Delta_g(s;\sigma) \geqslant 0$.
2) $\sigma_g(s) = 0 \implies \Delta_g(s;\sigma) \leqslant 0$.

A3. Proof of Theorem 1

PROOF:

We prove this result using two steps. In Step 1, we establish that the maximal equilibrium is symmetric. In step 2, we show that the symmetric equilibrium under $\widehat{\mathcal{P}}^1$ remains an equilibrium under $\mathcal{P}^1$.

STEP 1:

With some abuse of notation, we say that $(P_1, P_2) \in \mathcal{E}(\mathcal{P})$ to mean that $\sigma := (\mathbb{1}_{\mathbf{S}_1 \in P_1}, \mathbb{1}_{\mathbf{S}_2 \in P_2}) \in \mathcal{E}(\mathcal{P})$.

LEMMA 2: *There is a unique maximal equilibrium in encouragement environments, and it is symmetric.*

PROOF:

Suppose that σ is some asymmetric equilibrium with participation sets P_1 and P_2 for groups 1 and 2 respectively. We show that $\exists$ a symmetric equilibrium $\widehat{\sigma}$ with a participation set $P \supseteq P_1 \bigcup P_2$.

For any set S, define

$$\mathcal{T}(S) := S \bigcup \left\{ s \in \mathcal{S} : \mathcal{P}^1_s(S)\Lambda_{-\mathrm{o}} \geqslant \frac{c}{\mu(s)} \right\}. \tag{A1}$$

In words, $\mathcal{T}(S)$ adds those signals to S (if there are any) at which an agent wants to participate if he believes that his group will not participate but the other group will participate if they receive a signal in S.

CLAIM 1: *Let* $\sigma = (\mathbb{1}_{P_1}, \mathbb{1}_{P_2})$ *be a strategy profile such that* (IC:P) *is satisfied for all* $s \in P_1 \bigcup P_2$ *given that players follow* σ*. Then, for all* $s \in \mathcal{T}(P_1 \bigcup P_2)$*,*

$$\mathcal{P}_s^1(\mathcal{T}(P_1 \bigcup P_2))\Lambda_b + (1 - \mathcal{P}_s^1(\mathcal{T}(P_1 \bigcup P_2)))\Lambda_o \geqslant \frac{c}{\mu(s)}$$

PROOF:

Since $(P_1, P_2) \in \mathcal{E}(\mathcal{P})$, (IC:P) implies,

$$\mathcal{P}_s^1(P_2)\Lambda_{\mathrm{b}} + (1 - \mathcal{P}_s^1(P_2))\Lambda_{\mathrm{o}} \geqslant \frac{c}{\mu(s)} \qquad \text{if } s \in P_1$$
$$\mathcal{P}_s^1(P_1)\Lambda_{\mathrm{b}} + (1 - \mathcal{P}_s^1(P_2))\Lambda_{\mathrm{o}} \geqslant \frac{c}{\mu(s)} \qquad \text{if } s \in P_2$$

Since $\Lambda_{\mathrm{b}} > \Lambda_{\mathrm{o}}$ and $\mathcal{P}_s^1(\cdot)$ is monotonic (in the set inclusion order),

$$\mathcal{P}_s^1(P_1 \bigcup P_2)\Lambda_{\mathrm{b}} + (1 - \mathcal{P}_s^1(P_1 \bigcup P_2))\Lambda_{\mathrm{o}} \geqslant \frac{c}{\mu(s)} \quad \forall s \in P_1 \bigcup P_2$$

If $\mathcal{T}(P_1 \bigcup P_2) \neq P_1 \bigcup P_2$, then, for all $s \in \mathcal{T}(P_1 \bigcup P_2) \backslash (P_1 \bigcup P_2)$, we have,

$$\mathcal{P}_s^1(P_1 \bigcup P_2)\Lambda_{-\mathrm{o}} \geqslant \frac{c}{\mu(s)}$$
$$\implies \mathcal{P}_s^1(P_1 \bigcup P_2)\Lambda_{\mathrm{b}} + (1 - \mathcal{P}_s^1(P_1 \bigcup P_2))\Lambda_{\mathrm{o}} \geqslant \frac{c}{\mu(s)}$$

where the inequality is due to $\Lambda_{\mathrm{b}} > \Lambda_{\mathrm{o}} > 0$ and $\max\{\Lambda_{\mathrm{b}}, \Lambda_{\mathrm{o}}\} \geqslant \Lambda_{-\mathrm{o}}$ (see assumption 1).

Define, $\mathcal{T}^*(P_1 \bigcup P_2) := \mathcal{T}^{|\mathcal{S}|}(P_1, P_2)$. First, notice that $\mathcal{T}(\cdot)$ is an increasing (in the set-inclusion order) map. Therefore, either $\mathcal{T}^*(S) = \mathcal{S}$ (due to the finiteness of $\mathcal{S}$), or $S \subseteq \mathcal{T}^*(S) \subset \mathcal{S}$ for any S. If $\mathcal{T}^*(P_1 \bigcup P_2) \neq \mathcal{S}$, then, by definition, (IC:NP) is satisfied for all $s \notin \mathcal{T}^*(P_1 \bigcup P_2)$ when players play $(\mathbb{1}_{\mathbf{S}_1 \in \mathcal{T}^*(P_1 \bigcup P_2)}, \mathbb{1}_{\mathbf{S}_2 \in \mathcal{T}^*(P_1 \bigcup P_2)})$. Moreover, (IC:P) is satisfied when both the groups play $a = 1$ on $\mathcal{T}^*(P_1 \bigcup P_2)$ by Claim 1. Therefore, given any equilibrium (P_1, P_2), $\mathcal{T}^*(P_1 \bigcup P_2)$ is a larger symmetric equilibrium.

Finally, let (P, P) and (P', P') be two maximal symmetric equilibria with $P \neq P'$. First, Claim 1 establishes that (IC:P) is satisfied for all signals in $\mathcal{T}(P \bigcup P')$, and hence for all the signals in $\mathcal{T}^*(P \bigcup P')$. By construction, (IC:NP) is satisfied for all the signals outside of $\mathcal{T}^*(P \bigcup P')$. Therefore, $\mathcal{T}^*(P \bigcup P')$ is an equilibrium, and $P, P' \subseteq \mathcal{T}^*(P \bigcup P')$, contradicting the maximality of P, P'. Therefore, $P = P'$, i.e., there is a unique maximal equilibrium.

Step 2:

By definition, $\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$ implies the following:

1) $\mathcal{P}^1_s(P(\sigma)) \geqslant \widehat{\mathcal{P}}^1_s(P(\sigma))$ for all $s \in P(\sigma)$.
2) $\mathcal{P}^1_s(P(\sigma)) \leqslant \widehat{\mathcal{P}}^1_s(P(\sigma))$ for all $s \in NP(\sigma)$.

Consider (IC:P), the incentive constraint for an agent who participates. The left hand side is a convex combination of Λ_b and Λ_o. In encouragement environments, a higher weight on Λ_b increases the LHS of (IC:P), making the constraint easier to satisfy. Therefore,

$$\begin{aligned}\mathcal{P}^1_s(P(\sigma))\Lambda_\mathrm{b} + (1-\mathcal{P}^1_s(P(\sigma)))\Lambda_\mathrm{o} &\geqslant \widehat{\mathcal{P}}^1_s(P(\sigma))\Lambda_\mathrm{b} + (1-\widehat{\mathcal{P}}^1_s(P(\sigma)))\Lambda_\mathrm{o}\\ &\geqslant \frac{c}{\mu(s)} \text{ since } \sigma \in \mathcal{E}(\widehat{\mathcal{P}}).\end{aligned}$$

Therefore, (IC:P) is satisfied for all $s \in P(\sigma)$ under $\mathcal{P}$. Similarly, for all $s \in NP(\sigma)$, $\mathcal{P}^1_s(P(\sigma)) \leqslant \widehat{\mathcal{P}}^1_s(P(\sigma))$. Therefore, (IC:NP) is satisfied for all $s \in NP(\sigma)$ under signal $\mathcal{P}$. Therefore, $\sigma \in \mathcal{E}(\mathcal{P})$.

Finally, since $\mathscr{V}(\cdot)$ depends only the marginal distributions (by Lemma 1)—which are the same in $\mathcal{P}$ and $\widehat{\mathcal{P}}$—it follows that $\mathscr{V}^*(\mathcal{P}) \geqslant \mathscr{V}^*(\widehat{\mathcal{P}})$.

A4. Proof of Theorem 2

PROOF:

We prove this result using two steps. In step 1, we show that the maximal equilibrium under $\widehat{\mathcal{P}}^1$ may no longer be an equilibrium under $\mathcal{P}^1$. In step 2, we show that no larger equilibrium can emerge when information becomes more similar.

Step 1:

Let σ^* be a maximal equilibrium with the associated participation sets (P^*_1, P^*_2).

Case 1. $P^*_1 = P^*_2$

Let $P := P^*_1 = P^*_2$. By definition, $\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$ implies the following:

a) $\mathcal{P}^1_s(P) \geqslant \widehat{\mathcal{P}}^1_s(P)$ for all $s \in P$.
b) $\mathcal{P}^1_s(P) \leqslant \widehat{\mathcal{P}}^1_s(P)$ for all $s \in NP$.

Consider (IC:P), the incentive constraint for an agent who participates. The left hand side is a convex combination of Λ_b and Λ_o. In discouragement environments, a higher weight on Λ_b decreases the LHS of (IC:P).

Therefore, for all $s \in P$,

$$\mathcal{P}_s^1(P)\Lambda_{\text{b}} + (1 - \mathcal{P}_s^1(P))\Lambda_{\text{o}} \leqslant \widehat{\mathcal{P}}_s^1(P)\Lambda_{\text{b}} + (1 - \widehat{\mathcal{P}}_s^1(P))\Lambda_{\text{o}}$$

Therefore, (IC:P) may fail for some $s \in P$ under $\mathcal{P}$, in which case σ may no longer be in $\mathcal{E}(\mathcal{P})$.

Case 2. $P_1^* \neq P_2^*$

Then, $\mathcal{P}_s^1(P_i^*) \geqslant \widehat{\mathcal{P}}_s^1(P_i^*)$ for all $i \in \{1,2\}$ and $s \in P_i^*$. Notice that at least one of $P_1^* \backslash P_2^*$ and $P_2^* \backslash P_1^*$ is not $\varnothing$. Let $P_1^* \backslash P_2^* \neq \varnothing$ wlog. Consider some $s \in P_1^* \backslash P_2^*$. Agents in group 2 must find it incentive compatible to not participate when they receive a signal in P_1^*. Therefore, we must have,

$$\mathcal{P}_s^1(P_1^*)\Lambda_{-\text{o}} \leqslant \frac{c}{\mu(s)}$$

for all $s \in P_1^*$. However, since $\mathcal{P}_s^1(P_1^*) \geqslant \widehat{\mathcal{P}}_s^1(P_1^*)$ for all $s \in P_1^*$, (IC:NP) is harder to satisfy for any $s \in P_1^* \backslash P_2^*$, and for any $s \in P_2^* \backslash P_1^*$. Hence, σ^* may no longer be in $\mathcal{E}(\mathcal{P})$.

STEP 2:

Next, consider any $(\widehat{P}_1, \widehat{P}_2) \geqslant (P_1^*, P_2^*)$. For $(\widehat{P}_1, \widehat{P}_2)$ to be an equilibrium, one necessary condition is (IC:NP) for signals in $\widehat{P}_1$ and $\widehat{P}_2$ for groups 2 and 1 respectively. That is, we need that, at least one of the following holds:

$$\mathcal{P}_s^1(\widehat{P}_1)\Lambda_{-\text{o}} \leqslant \frac{c}{\mu(s)} \text{ if } s \in \widehat{P}_1$$
$$\mathcal{P}_s^1(\widehat{P}_2)\Lambda_{-\text{o}} \leqslant \frac{c}{\mu(s)} \text{ if } s \in \widehat{P}_2$$

Suppose that $\widehat{P}_1 \bigcap \widehat{P}_2 = \varnothing$. Since $\widehat{\mathcal{P}}$ satisfies condition M (Definition 4), part $(M2)$ implies that, for some $s \in \widehat{P}_1 \bigcup \widehat{P}_2$,

$$\widehat{\mathcal{P}}_s^1(\widehat{P}_1)\Lambda_{-\text{o}} > \frac{c}{\mu(s)} \text{ if } s \in \widehat{P}_1$$
$$\widehat{\mathcal{P}}_s^1(\widehat{P}_2)\Lambda_{-\text{o}} > \frac{c}{\mu(s)} \text{ if } s \in \widehat{P}_2$$

By CAD, $\mathcal{P}_s^1(\widehat{P}_1) \geqslant \widehat{\mathcal{P}}_s^1(\widehat{P}_1)$ if $s \in \widehat{P}_1$ (and analogously for $\widehat{P}_2$). Therefore, $(\widehat{P}_1, \widehat{P}_2)$ cannot be an equilibrium in $\mathcal{P}$ if $\widehat{P}_1 \bigcap \widehat{P}_2 = \varnothing$.

Suppose that $\widehat{P}_1 \bigcap \widehat{P}_2 \neq \varnothing$. Since $\widehat{\mathcal{P}}$ satisfies Condition M, if $(M1)$ holds for some

$s \in \widehat{P}_1 \bigcap \widehat{P}_2$, then,

$$\min_{i\in\{1,2\}} \left\{ \widehat{\mathcal{P}}^1_s(\widehat{P}_i)\Lambda_{\rm b} + (1 - \widehat{\mathcal{P}}^1_s(\widehat{P}_i))\Lambda_{\rm o} \right\} < \frac{c}{\mu(s)}$$

By CAD, $\mathcal{P}^1_s(\widehat{P}_i) \geqslant \widehat{\mathcal{P}}^1_s(\widehat{P}_i)$ for $i \in \{1,2\}$. Since $\Lambda_{\rm o} > \Lambda_{\rm b}$, this implies that,

$$\min_{i\in\{1,2\}} \left\{ \mathcal{P}^1_s(\widehat{P}_i)\Lambda_{\rm b} + (1 - \mathcal{P}^1_s(\widehat{P}_i))\Lambda_{\rm o} \right\} < \frac{c}{\mu(s)}$$

Therefore, (IC:P) fails for such an s.

Finally, if (IC:P) is satisfied for all $s \in \widehat{P}_1 \bigcap \widehat{P}_2$, then, by Condition M (*ii*), the exact same argument as in the case when $\widehat{P}_1 \bigcap \widehat{P}_2 = \varnothing$ implies that $(\widehat{P}_1, \widehat{P}_2)$ cannot be an equilibrium under $\mathcal{P}$. Therefore, no larger equilibrium can exist under $\widehat{\mathcal{P}}$, i.e., $\mathscr{V}^*(\widehat{\mathcal{P}}) \leqslant \mathscr{V}(\mathcal{P})$.

A5. Proof of Theorem 3

PROOF:

We prove this theorem using a series of lemmas. The first three lemmas establish that, in the encouragement environment, the welfare maximizing equilibrium must be in symmetric strategies. The next two lemmas then establish that when the distribution of the threshold $\bar{\boldsymbol{n}}$, ψ, is single peaked, under symmetric strategies, welfare improves when similarity increases.

Recall that the per person expected welfare of an asymmetric strategy profile (S_1, S_2), where S_1 and S_2 are the participation sets of groups 1 and 2 respectively, is defined as follows:

$$\begin{aligned} \frac{1}{N} W(S_1, S_2) := {} & 2\Psi_2 \mathcal{P}^1(S_1, S_2) \\ & + 2\Psi_1 \mathcal{P}^1(S_1, NS_2) + 2\Psi_1 \mathcal{P}^1(NS_1, S_2) \\ & - c\mathbb{P}(S_1) - c\mathbb{P}(S_2) \end{aligned}$$

where $\Psi_k := Prob(\bar{\boldsymbol{n}} + 1 \leqslant kN)$ is the probability of a successful protest given that k groups participate. Moreover, NS_1, NS_2 are the complements of sets S_1 and S_2 respectively.

LEMMA 3: *If* $(S_1, S_2) \in \mathcal{E}(\mathcal{P})$ *and* $\Lambda_b > \Lambda_o$*, then* $W(S, S) \geqslant W(S_1, S_2)$ *where* $S := S_1 \bigcup S_2$.

PROOF:

Define,

$$\begin{aligned}
\Delta :=& \frac{1}{N}\left[W(S,S) - W(S_1,S_2)\right] \\
=& \left[\mu_0(2\Psi_2\mathcal{P}^1(S,S) + 4\Psi_1\mathcal{P}^1(S,NS)) - 2c\mathbb{P}(S)\right] \\
&- \left[\mu_0(2\Psi_2\mathcal{P}^1(S_1,S_2) + 2\Psi_1(\mathcal{P}^1(S_1,NS_2) + \mathcal{P}^1(NS_1,S_2)) - c\mathbb{P}(S_1) - c\mathbb{P}(S_2)\right].
\end{aligned}$$

Here, $\mathbb{P}(.) = \mu_0\mathcal{P}^1(.) + (1-\mu_0)\mathcal{P}^0(.)$. Rearranging, we get

$$\begin{aligned}
\Delta = \mu_0 \Big\{ & 2(\Psi_2 - \Psi_1)\left[\mathcal{P}^1(S_1, S_1\backslash S_2) + \mathcal{P}^1(S_2\backslash S_1, S_2)\right] \\
&+ 2\Psi_2\left[\mathcal{P}^1(S_2\backslash S_1, S_1\backslash S_2)\right] \\
&+ 2\Psi_1\left[\mathcal{P}^1(S_2\backslash S_1, NS) + \mathcal{P}^1(NS, S_1\backslash S_2)\right] \Big\} \\
&- c\left[\mathbb{P}(S_2\backslash S_1) + \mathbb{P}(S_1\backslash S_2)\right].
\end{aligned}$$

The first term captures the events where both groups join now but only one group used to join; the second term captures the events where both groups join now but no group used to join; the third term captures the events where one group joins now but no group used to join. On the other hand, the agents bear the additional cost in those events where they now join but they did not join before. Since $\mathcal{P}^1(S,.) = \mathcal{P}^1(S_1,.) + \mathcal{P}^1(S_2\backslash S_1,.)$ and $\mathcal{P}^1(.,S) = \mathcal{P}^1(.,S_2) + \mathcal{P}^1(.,S_1\backslash S_2)$,

$$\begin{aligned}
\Delta = \mu_0 \Big\{ & (\Psi_2 - \Psi_1)\left[\mathcal{P}^1(S, S_1\backslash S_2) + \mathcal{P}^1(S_2\backslash S_1, S)\right] - 2(\Psi_2 - \Psi_1)\left[\mathcal{P}^1(S_2\backslash S_1, S_1\backslash S_2)\right] \\
&+ (\Psi_2 - \Psi_1)\left[\mathcal{P}^1(S_1, S_1\backslash S_2) + \mathcal{P}^1(S_2\backslash S_1, S_2)\right] \\
&+ 2\Psi_2\left[\mathcal{P}^1(S_2\backslash S_1, S_1\backslash S_2)\right] \\
&+ \Psi_1\left[\mathcal{P}^1(S_2\backslash S_1, NS) + \mathcal{P}^1(NS, S_1\backslash S_2)\right] \\
&+ \Psi_1\left[\mathcal{P}^1(S_2\backslash S_1, NS) + \mathcal{P}^1(NS, S_1\backslash S_2)\right] \Big\} \\
&- c\left[\mathbb{P}(S_2\backslash S_1) + \mathbb{P}(S_1\backslash S_2)\right].
\end{aligned}$$

Simplifying this, we get

$$\begin{aligned}\Delta = \mu_0 \Bigg\{ & (\Psi_2 - \Psi_1) \left[\mathcal{P}^1(S, S_1 \backslash S_2) + \mathcal{P}^1(S, S_2 \backslash S_1)\right] \\ & + \Psi_1 \left[\mathcal{P}^1(NS, S_2 \backslash S_1) + \mathcal{P}^1(NS, S_1 \backslash S_2)\right] \Bigg\} \\ & - c \left[\mathbb{P}(S_2 \backslash S_1) + \mathbb{P}(S_1 \backslash S_2)\right] \\ & + \mu_0 \Bigg\{ (\Psi_2 - \Psi_1) \left[\mathcal{P}^1(S_1, S_1 \backslash S_2) + \mathcal{P}^1(S_2 \backslash S_1, S_2)\right] \\ & + \Psi_1 \left[2Pr(S_1 \backslash S_2, S_2 \backslash S_2) + \mathcal{P}^1(S_2 \backslash S_1, NS) + \mathcal{P}^1(NS, S_1 \backslash S_2)\right] \Bigg\}.\end{aligned}$$

Since $\Psi_2 - \Psi_1 \geqslant \Lambda_{\mathrm{b}} \geqslant 0$ and $\Psi_1 \geqslant \Lambda_{\mathrm{o}} \geqslant 0$, the last two terms are non-negative. Therefore, a sufficient condition to have $\Delta \geqslant 0$ is if

$$\begin{aligned}\Delta' := \mu_0 \Bigg\{ & (\Psi_2 - \Psi_1) \left[\mathcal{P}^1(S, S_1 \backslash S_2) + \mathcal{P}^1(S, S_2 \backslash S_1)\right] \\ & + \Psi_1 \left[\mathcal{P}^1(NS, S_2 \backslash S_1) + \mathcal{P}^1(NS, S_1 \backslash S_2)\right] \Bigg\} \\ & - c \left[\mathbb{P}(S_2 \backslash S_1) + \mathbb{P}(S_1 \backslash S_2)\right]\end{aligned}$$

is non-negative. Rearranging,

$$\begin{aligned}
\Delta' =& \sum_{s\in S_1\setminus S_2} \left\{\mu_0\left[(\Psi_2-\Psi_1)\mathcal{P}^1(S,s)+\Psi_1\mathcal{P}^1(NS,s)\right]-c\mathbb{P}(s)\right\}\\
&+\sum_{s\in S_2\setminus S_1} \left\{\mu_0\left[(\Psi_2-\Psi_1)\mathcal{P}^1(S,s)+\Psi_1\mathcal{P}^1(NS,s)\right]-c\mathbb{P}(s)\right\}\\
\implies \Delta' =& \sum_{s\in S_1\setminus S_2} \mathbb{P}(s)\left\{\frac{\mu_0\mathcal{P}^1(s)}{\mathbb{P}(s)}\left[(\Psi_2-\Psi_1)\mathcal{P}^1(S|s)+\Psi_1\mathcal{P}^1(NS|s)\right]-c\right\}\\
&+\sum_{s\in S_2\setminus S_1} \mathbb{P}(s)\left\{\frac{\mu_0\mathcal{P}^1(s)}{\mathbb{P}(s)}\left[(\Psi_2-\Psi_1)\mathcal{P}^1(S|s)+\Psi_1\mathcal{P}^1(NS|s)\right]-c\right\}\\
\implies \Delta' \geqslant& \sum_{s\in S_1\setminus S_2} \mathbb{P}(s)\left\{\mu(s)\left[\Lambda_{\mathrm{b}}\mathcal{P}^1_s(S)+\Lambda_{\mathrm{o}}\mathcal{P}^1_s(NS)\right]-c\right\}\\
&+\sum_{s\in S_2\setminus S_1} \mathbb{P}(s)\left\{\mu(s)\left[\Lambda_{\mathrm{b}}\mathcal{P}^1_s(S)+\Lambda_{\mathrm{o}}\mathcal{P}^1_s(NS)\right]-c\right\}\\
\geqslant& 0.
\end{aligned}$$

The last inequality is due to (IC:P) for all $s \in S_1\setminus S_2$ and $S_2\setminus S_1$ for the strategy profile (S,S), and $\Psi_2-\Psi_1 \geqslant \Lambda_{\mathrm{b}}$ and $\Psi_1 \geqslant \Lambda_{\mathrm{o}}$.

Lemma 3 proves that if (S_1,S_2) is an equilibrium, then (S,S) yields a higher welfare than (S_1,S_2), where $S := S_1\bigcup S_2$. As Theorem 1 showed, (IC:P) is satisfied at (S,S) but (S,S) may not be an equilibrium. The reason is that, given the strategy profile (S,S), (IC:NP) may be violated for some $s \in NS$. That is, for some $s \notin S$, we might have,

$$\mu(s)\mathcal{P}^1_s(S)\Lambda_{-\mathrm{o}} \geqslant c.$$

We use this observation to present the next lemma.

LEMMA 4: *Suppose that* $(S_1,S_2) \in \mathcal{E}(\mathcal{P})$ *and* $\Lambda_b > \Lambda_o$. *Let* $T \supseteq S := S_1\bigcup S_2$ *be such that* (IC:NP) *is violated for all* $s \in T\setminus S$ *given the strategy profile* (S,S). *Then,* $W(T,T) \geqslant W(S,S)$.

PROOF:

Let T be the largest set containing S such that for all $s \in T\setminus S$, (IC:NP) is violated for the strategy profile (S,S). That is, for all $s \in T\setminus S$,

$$\mu(s)\mathcal{P}^1_s(S)\Lambda_{-\mathrm{o}} - c \geqslant 0.$$

By Assumption 1 and since $\Lambda_{\mathrm{b}} \geqslant \Lambda_{\mathrm{o}}$, for all $s \in T \backslash S$,

$$\mu(s)[\Lambda_{\mathrm{b}}\mathcal{P}_s^1(S) + \Lambda_{\mathrm{o}}\mathcal{P}_s^1(NS)] - c \geqslant \mu(s)\Lambda_{-\mathrm{o}}\mathcal{P}_s^1(S) - c \geqslant 0. \tag{A2}$$

for all $s \in T \backslash S$. If $T = S$, then $W(T,T) \geqslant W(S,S)$ tautologically. Suppose $T \supset S, T \neq S$. Define

$$\begin{aligned}
\Delta :=& \frac{1}{N}[W(T,T) - W(S,S)] \\
=&\mu_0\left\{2(\Psi_2 - \Psi_1)[2\mathcal{P}^1(T\backslash S, S)] + 2\Psi_2\mathcal{P}^1(T\backslash S, T\backslash S) + 2\Psi_1(2\mathcal{P}^1(T\backslash S, NT))\right\} \\
&- 2c\mathbb{P}(T\backslash S) \\
=&\mu_0\left\{(\Psi_2 - \Psi_1)[2\mathcal{P}^1(T\backslash S, S)] + \Psi_1(2\mathcal{P}^1(T\backslash S, NS)) - \Psi_1(2\mathcal{P}^1(T\backslash S, T\backslash S))\right\} \\
&- 2c\mathbb{P}(T\backslash S) \\
&+\mu_0\left\{(\Psi_2 - \Psi_1)[2\mathcal{P}^1(T\backslash S, S)] + 2\Psi_2\mathcal{P}^1(T\backslash S, T\backslash S) + \Psi_1(2\mathcal{P}^1(T\backslash S, NT))\right\} \\
=&\mu_0\left\{(\Psi_2 - \Psi_1)[2\mathcal{P}^1(T\backslash S, S)] + \Psi_1(2\mathcal{P}^1(T\backslash S, NS))\right\} - 2c\mathbb{P}(T\backslash S) \\
&+\mu_0\left\{(\Psi_2 - \Psi_1)[2\mathcal{P}^1(T\backslash S, S) + 2\mathcal{P}^1(T\backslash S, T\backslash S)] + \Psi_1(2\mathcal{P}^1(T\backslash S, NT))\right\}
\end{aligned}$$

Notice that,

$$(\Psi_2 - \Psi_1)[2\mathcal{P}^1(T\backslash S, S) + 2\mathcal{P}^1(T\backslash S, T\backslash S)] + \Psi_1(2\mathcal{P}^1(T\backslash S, NT)) \geqslant 0.$$

Therefore, as in Lemma 3, establishing that

$$\Delta' := \mu_0\left[(\Psi_2 - \Psi_1)\mathcal{P}^1(S, T\backslash S) + \Psi_1\mathcal{P}^1(NS, T\backslash S)\right] - c\mathbb{P}(T\backslash S) \geqslant 0$$

would suffice to prove that $\Delta \geqslant 0$. To this end,

$$\begin{aligned}
\Delta' =& \sum_{s\in T\backslash S}\mathbb{P}(s)\left\{\frac{\mu_0\mathcal{P}^1(s)}{\mathbb{P}(s)}\left[(\Psi_2 - \Psi_1)\mathcal{P}^1(S|s) + \Psi_1\mathcal{P}^1(NS|s)\right] - c\right\} \\
\geqslant& \sum_{s\in T\backslash S}\mathbb{P}(s)\left\{\mu(s)\left[\Lambda_{\mathrm{b}}\mathcal{P}_s^1(S) + \Lambda_{\mathrm{o}}\mathcal{P}_s^1(NS)\right] - c\right\} \\
\geqslant&0.
\end{aligned}$$

where the last inequality is the same as (A2).

LEMMA 5: *Suppose that* $(S_1, S_2) \in \mathcal{E}(\mathcal{P})$. *Then,* $\exists T \supseteq S_1 \bigcup S_2$ *such that* $(T,T) \in \mathcal{E}(\mathcal{P})$ *and* $W(T,T) \geqslant W(S_1, S_2)$.

PROOF:

Consider any equilibrium (S_1, S_2). By Lemma 3, $W(S,S) \geqslant W(S_1, S_2)$ when $S = S_1 \bigcup S_2$. We know, from the proof of Theorem 1 (Claim 1) that (IC:P) is satisfied for all $s \in S$ for the strategy profile (S,S). Therefore, if $(S,S) \notin \mathcal{E}(\mathcal{P})$, it must be because (IC:NP) is violated for some $s \notin S$. Let T' be the set of all such $s \notin S$ where the (IC:NP) is violated for the strategy profile (S,S). Define $T := T' \bigcup S$. By Lemma 4, $W(T,T) \geqslant W(S,S)$. If $(T,T) \notin \mathcal{E}(\mathcal{P})$, we can iteratively construct a sequence $(T_k)_{k \in \mathbb{N}}$ such that $T_k \subset T_{k+1}$ as in the proof of Theorem 1. By the finiteness of $\mathcal{S}$, $\exists T^*$ such that $T_k = T^*$ for all k sufficiently large, and $T^* \in \mathcal{E}(\mathcal{P})$. Moreover, for each k, by Lemma 4, $W(T_k, T_k) \geqslant W(S,S) \geqslant W(S_1, S_2)$. Therefore, $W(T^*, T^*) \geqslant W(S_1, S_2)$ with $(T^*, T^*) \in \mathcal{E}(\mathcal{P})$ completing the proof.

The above lemma shows that in the encouragement environment, it is without loss of generality to restrict attention to symmetric strategies. The following lemma establish an useful property of CAD order for symmetric strategies.

LEMMA 6: *If* $\mathscr{D} \geqslant_{CAD} \widehat{\mathscr{D}}$, *then, for every* $T \subseteq \mathcal{Y}$, $\exists\ \alpha_T \geqslant 0$ *such that* $\mathscr{D}(T,T) = \widehat{\mathscr{D}}(T,T) + \alpha_T$, *and* $\mathscr{D}(T, \mathcal{Y} \backslash T) = \widehat{\mathscr{D}}(T, \mathcal{Y} \backslash T) - \alpha_T$.

PROOF:

Suppose $\mathcal{Y} \subset \mathbb{R}$ is finite, and Y and $\widehat{Y}$ are two $\mathcal{Y}^2$-valued random variables with joint distributions $\mathscr{D}$ and $\widehat{\mathscr{D}}$ respectively, and identical marginals. Consider any two distinct points in the support of Y, say y_j, y_k. Define an "elementary transformation along identical intervals" (ETI) as an operation in which, for some $\alpha > 0$, we increase the probability mass on points (y_j, y_j) and (y_k, y_k) each by α, and reduce the probability mass on (y_j, y_k) and (y_k, y_j) each by α. An alternative characterization of our CAD order in two dimensions is that $\mathscr{D} \geqslant_{CAD} \widehat{\mathscr{D}}$ if and only if $\mathscr{D}$ can be derived from $\widehat{\mathscr{D}}$ by a finite sequence of ETIs. This follows from Meyer (1990) (Proposition 1). We use this characterization to establish Lemma 6.

Let $(y_{i,k}, y_{j,k})_k$, $k = 1, \ldots n$, be a finite set of points in $\mathcal{Y}^2$ describing a sequence of ETIs, each with a mass α_k, to obtain $\mathscr{D}$ from $\widehat{\mathscr{D}}$. Let the resulting distribution after the k-th ETI be $\widehat{\mathscr{D}}_k$. So, $\widehat{\mathscr{D}}_1 = \widehat{\mathscr{D}}$ and $\widehat{\mathscr{D}}_n = \mathscr{D}$. If $(y_{i,k}, y_{j,k}) \in T \times T$ or $(\mathcal{Y} \backslash T) \times (\mathcal{Y} \backslash T)$, then $\widehat{\mathscr{D}}_k(T,T) = \widehat{\mathscr{D}}_{k-1}(T,T)$. On the other hand, if exactly one of $\{y_{i,k}, y_{j,k}\}$ is in T for some k, then $\widehat{\mathscr{D}}_k(T,T) = \widehat{\mathscr{D}}_{k-1}(T,T) + \alpha_k$. Therefore, $\mathscr{D}(T,T) = \widehat{\mathscr{D}}(T,T) + \sum_{k=1}^n \alpha_k$. Since an ETI leaves the marginal distribution unchanged, therefore $\mathscr{D}(T, \mathcal{Y} \backslash T) = \widehat{\mathscr{D}}(T, \mathcal{Y} \backslash T) - \sum_{k=1}^n \alpha_k$. The lemma follows.

LEMMA 7: *If $\psi(\cdot)$ is single-peaked, and $\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$, $\mathcal{P}^0 = \widehat{\mathcal{P}}^0$ and $\Lambda_b > \Lambda_o$, then for symmetric equilibrium $\sigma \in \mathcal{E}(\widehat{\mathcal{P}})$, $W(\sigma;\mathcal{P}) \geqslant W(\sigma;\widehat{\mathcal{P}})$.*

PROOF:

Suppose $\Lambda_\text{b} > \Lambda_\text{o}$ and $\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$. First, by the argument in Theorem 1, $\mathcal{E}(\widehat{\mathcal{P}}) \subseteq \mathcal{E}(\mathcal{P})$. By Lemma 5, it is without loss of generality to restrict attention to symmetric equilibria to study the welfare-maximizing equilibria in this environment. Consider any symmetric equilibrium $\sigma \in \mathcal{E}(\widehat{\mathcal{P}})$, and let the associated participation and nonparticipation sets be P and NP respectively. By Lemma 6, $\mathcal{P}^1(P,P) = \widehat{\mathcal{P}}^1(P,P) + \alpha$ and $\mathcal{P}^1(P,NP) = \widehat{\mathcal{P}}^1(P,NP) - \alpha$ for some $\alpha \geqslant 0$. Therefore,

$$\begin{aligned} W(\sigma;\mathcal{P}) - W(\sigma;\widehat{\mathcal{P}}) =& 2\alpha\left(\Psi_2 - 2\Psi_1\right) \\ =& 2\alpha\left(\sum_{k=N+1}^{2N} Prob(\bar{\boldsymbol{n}} = k-1) - \sum_{k=1}^{N} Prob(\bar{\boldsymbol{n}} = k-1)\right) \\ =& 2\alpha\sum_{k=1}^{N}\left(\psi(k+N-1) - \psi(k-1)\right) \end{aligned}$$

We now establish that this condition holds in the encouragement environment if $\psi(\cdot)$ is single-peaked. To this end, in the encouragement environment, $\psi(2N-1) > \psi(N-1)$. When $\psi(\cdot)$ is single-peaked, it implies that $\psi(k) > \psi(N-1)$ for all $k \in \{N, 2N-1\}$. Moreover, $\psi(N-1) > \psi(k)$ for all $k < N-1$. Therefore, $\Pi(\sigma;\mathcal{P}) - \Pi(\sigma;\widehat{\mathcal{P}}) > 0$, as desired.

Therefore, when ψ is single peaked, the maximal welfare W^* increases in the encouragement environment when information becomes more CAD similar.

A6. Proof of Proposition 3

PROOF:

Towards establishing (1), suppose $\Lambda_\text{b} > \Lambda_\text{o}$ and $\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$. First, by the argument in Theorem 1, $\mathcal{E}(\widehat{\mathcal{P}}) \subseteq \mathcal{E}(\mathcal{P})$. Second, by argument in Theorem 3, we can restrict attention to symmetric equilibrium. Consider any symmetric equilibrium $\sigma \in \mathcal{E}(\widehat{\mathcal{P}})$, and let the associated participation and nonparticipation sets be P and NP respectively. By Lemma 6,

$$\begin{aligned}\Pi(\sigma;\mathcal{P})-\Pi(\sigma;\widehat{\mathcal{P}}) =&\alpha\left(\Psi_2-1\Psi_1\right)\\ =&\alpha\left(\sum_{k=N+1}^{2N}Prob(\bar{\boldsymbol{n}}=k-1)-\sum_{k=1}^{N}Prob(\bar{\boldsymbol{n}}=k-1)\right)\\ =&\alpha\sum_{k=1}^{N}\left(\psi(k+N-1)-\psi(k-1)\right)\end{aligned}$$

Since $\bar{\boldsymbol{n}}-1$ is a Poisson distribution, $\psi(.)$ is single-peaked. Therefore, as in Lemma 7, the above difference is positive in the encouragement environment ($\Lambda_{\mathrm{b}} > \Lambda_{\mathrm{o}}$), and we know from Proposition 2 that for $n > n^*$, we are in the encouragement environment. Therefore, the result follows.

However, note that the above probability difference is not necessarily negative in the discouragement environment. If the average resilience $n = 1$, then ψ is decreasing, which makes the above probability difference negative. By continuity, there exists $n^{**} < n^*$ such that $\Pi(\sigma;\mathcal{P}) - \Pi(\sigma;\widehat{\mathcal{P}})$ is negative for all $n < n^{**}$.

Towards establishing (2), suppose for contradiction that $\Pi^*(\mathcal{P}) > \Pi^*(\widehat{\mathcal{P}})$, $\mathcal{P}^1 \succcurlyeq_{CAD} \widehat{\mathcal{P}}^1$, agents play symmetric equilibrium, $\widehat{\mathcal{P}}^1$ satisfies Condition M', and $n < n^{**}$. Let σ^* and $\widehat{\sigma}^*$ be the equilibria with maximum probabilities of success under $\mathcal{P}$ and $\widehat{\mathcal{P}}$ respectively.

First, we argue that $\Pi(\sigma^*;\widehat{\mathcal{P}}) > \Pi(\widehat{\sigma}^*;\widehat{\mathcal{P}})$. Suppose not, that is, $\Pi(\sigma^*;\widehat{\mathcal{P}}) \leqslant \Pi(\widehat{\sigma}^*;\widehat{\mathcal{P}})$. Since $n < n^{**}$, for the same equilibrium σ^*, the probability of success decrease when information becomes more CAD-similar, that is, $\Pi(\sigma^*;\mathcal{P}) \leqslant \Pi(\sigma^*;\widehat{\mathcal{P}})$. Recall that $\Pi(\sigma^*;\mathcal{P}) = \Pi^*(\mathcal{P})$ and $\Pi(\widehat{\sigma}^*;\widehat{\mathcal{P}}) = \Pi^*(\widehat{\mathcal{P}})$ and we have assumed that the maximal probability of success has strictly increased under more CAD-similar information, that is, $\Pi(\widehat{\sigma}^*;\widehat{\mathcal{P}}) < \Pi(\sigma^*;\mathcal{P})$. Therefore,

$$\Pi(\widehat{\sigma}^*;\widehat{\mathcal{P}}) < \Pi(\sigma^*;\mathcal{P}) \leqslant \Pi(\sigma^*;\widehat{\mathcal{P}}) \leqslant \Pi(\widehat{\sigma}^*;\widehat{\mathcal{P}});$$

a contradiction.

But, if $\Pi(\sigma^*;\widehat{\mathcal{P}}) > \Pi(\widehat{\sigma}^*;\widehat{\mathcal{P}})$, then, by Condition-M', $\sigma^* \notin \mathcal{E}(\mathcal{P})$. Therefore, it cannot be an equilibrium with maximum probability under $\mathcal{P}$.

Turnout conditional on protests

In the main text, we focus on how information similarity affects the equilibrium participation. However, even when we fix an equilibrium, information similarity makes the participation more coordinated. Accordingly, conditional on there being a protest, we may see that the protests are more likely to bring about social changes. The following proposition formalizes this intuition.

PROPOSITION 6: *Suppose* $\mathcal{P}^1 \geqslant_{CAD} \widehat{\mathcal{P}}^1$, *and* $\sigma \in \mathcal{E}(\mathcal{P}) \bigcap \mathcal{E}(\widehat{\mathcal{P}})$ *and* σ *is symmetric. Then,*

$$\mathcal{P}^1 \left[\mathbf{A}(\sigma) > \bar{\boldsymbol{n}} \middle| \mathbf{A}(\sigma) > 0\right] \geqslant \widehat{\mathcal{P}}^1 \left[\mathbf{A}(\sigma) > \bar{\boldsymbol{n}} \middle| \mathbf{A}(\sigma) > 0\right].$$

PROOF:

Suppose that $\sigma \in \mathcal{E}(\mathcal{P}) \bigcap \mathcal{E}(\widehat{\mathcal{P}})$ and $\mathcal{P}^1 \geqslant_{CAD} \widehat{\mathcal{P}}^1$. Under $\widehat{\mathcal{P}}$, the probability of there being a protest at all when $\boldsymbol{\theta} = 1$ is $\mathcal{P}^1(\{\mathbf{A} > 0\}) = 1 - \widehat{\mathcal{P}}^1(NP, NP)$. Here $\mathcal{P}^1(NP, NP)$ means $\mathcal{P}^1(\{\mathbf{S}_1 \in NP(\sigma), \mathbf{S}_2 \in NP(\sigma)\})$. Therefore,

$$\mathcal{P}^1 \left(\{\mathbf{A}(\sigma) > \bar{\boldsymbol{n}})\} \middle| \{\mathbf{A}(\sigma) > 0\}\right) = \frac{\left[\Psi_2 \mathcal{P}^1(P,P) + 2\Psi_1 \mathcal{P}^1(P, NP)\right]}{1 - \mathcal{P}^1(NP, NP)}.$$

Then, by Lemma 6, there exists $\alpha > 0$ such that

$$\begin{aligned}
&\mathcal{P}^1 \left(\{\mathbf{A}(\sigma) > \bar{n})\} \middle| \{\mathbf{A}(\sigma) > 0\}\right) \\
&= \frac{\left[\Psi_2(\widehat{\mathcal{P}}^1(P,P) + \alpha) + 2\Psi_1(\bar{n}))(\widehat{\mathcal{P}}^1(P,NP) - \alpha)\right]}{1 - \widehat{\mathcal{P}}^1(NP,NP) - \alpha} \\
&= \underbrace{\frac{\widehat{\mathcal{P}}^1(P,P) + \alpha}{1 - \widehat{\mathcal{P}}^1(NP,NP) - \alpha}}_{\text{Increasing in } \alpha} \Psi_2 + \underbrace{\left(1 - \frac{\widehat{\mathcal{P}}^1(P,P) + \alpha}{1 - \widehat{\mathcal{P}}^1(NP,NP) - \alpha}\right)}_{\text{Decreasing in } \alpha} \Psi_1
\end{aligned}$$

The equality follows from noting that $(\widehat{\mathcal{P}}^1(P,P) + \alpha) + 2(\widehat{\mathcal{P}}^1(P,NP) - \alpha) = 1 - \widehat{\mathcal{P}}^1(NP,NP) - \alpha$. Notice that $\Psi_2 \geqslant \Psi_1$. Therefore, the LHS assigns a larger weight on the larger term for any $\alpha \geqslant 0$, which implies

$$\begin{aligned}
&\mathcal{P}^1 \left(\{\mathbf{A}(\sigma) > \bar{n})\} \middle| \{\mathbf{A}(\sigma) > 0\}\right) \\
&> \frac{\widehat{\mathcal{P}}^1(P,P)}{1 - \widehat{\mathcal{P}}^1(NP,NP)} \Psi_2 + \left(1 - \frac{\widehat{\mathcal{P}}^1(P,P)}{1 - \widehat{\mathcal{P}}^1(NP,NP)}\right) \Psi_1 \\
&= \widehat{\mathcal{P}}^1 \left(\{\mathbf{A}(\sigma) > \bar{n})\} \middle| \{\mathbf{A}(\sigma) > 0\}\right).
\end{aligned}$$

A7. Proof of Proposition 4

PROOF:

Suppose that $k^* < \bar{n}$. Then, $\sigma^1 \in \mathcal{E}(\widehat{\mathcal{P}})$ implies that $\widehat{\gamma}_1^1(\bar{n}) \geqslant \frac{c}{\mu(1)}$. By CAD, $\gamma_1^1(\bar{n}) \geqslant \widehat{\gamma}_1^1(\bar{n})$. Therefore, (IC-voting) continues to be satisfied under $\mathcal{P}$, and hence $\sigma^1 \in \mathcal{E}(\mathcal{P})$.

On the other hand, if $k^* \geqslant \bar{n}$, then $\gamma_1^1(\bar{n}) \leqslant \hat{\gamma}_1^1(\bar{n})$. Therefore, it is possible that $\sigma^1 \in \mathcal{E}(\widehat{\mathcal{P}})$ but $\sigma^1 \notin \mathcal{E}(\mathcal{P})$. Hence, part (2) of the proposition follows.

A8. *Optimal voting rule from Section VI*

Since there are multiple equilibria, we assume the maximal equilibrium is played, and the optimal vote threshold is one that maximizes the probability that a rate increase is implemented conditional on it being warranted; that is, the optimal threshold $\bar{n}^*(\mathcal{P})$ is given by

$$\bar{n}^*(\mathcal{P}) := \text{argmax}_{\bar{n}}\, \mathcal{P}^1(I \geqslant \bar{n} + 1 | \boldsymbol{\theta} = 1),$$

subject to the (IC-voting) constraint.[28] In the absence of the incentive constraint, the lowest possible $\bar{n}$ would be optimal. However, a low $\bar{n}$ reduces an individual member's incentive to vote in favor of a rate increase (conditional on private information and the increase being warranted). So the optimal rule is the lowest vote threshold that satisfies the incentive constraint. We can ask how this optimal threshold varies with committee diversity.

PROOF:

Consider $k^* < \bar{n}^*(\widehat{\mathcal{P}})$. Then, by definition,

$$\gamma(\bar{n}^*(\widehat{\mathcal{P}})) \geqslant \hat{\gamma}(\bar{n}^*(\widehat{\mathcal{P}})) \geqslant \frac{c}{\mu(1)}.$$

This means under the same policy threshold $\bar{n}^*(\widehat{\mathcal{P}})$, the incentive constraint is satisfied even under more similar experiences ($\mathcal{P}$). Since the designer's objective $\mathcal{P}^1(I \geqslant \bar{n} + 1)$ is decreasing in $\bar{n}$, we have $\bar{n}^*(\mathcal{P}) \leqslant \bar{n}^*(\widehat{\mathcal{P}})$.

Next, consider $k^* \geqslant \bar{n}^*(\widehat{\mathcal{P}})$. Recall that $\bar{n}^*(\widehat{\mathcal{P}})$ is the lowest $\bar{n}$ that satisfies the incentive constraint under $\widehat{\mathcal{P}}$. Therefore, for any $\bar{n} < \bar{n}^*(\widehat{\mathcal{P}})$,

$$\hat{\gamma}(\bar{n}) < \frac{c}{\mu(1)}.$$

Since $k^* \geqslant \bar{n}^*(\widehat{\mathcal{P}}) > \bar{n}$, by definition,

$$\gamma(\bar{n}) \leqslant \hat{\gamma}(\bar{n}) < \frac{c}{\mu(1)}.$$

This means for any policy $\bar{n} < \bar{n}^*(\widehat{\mathcal{P}})$, under more similar experiences ($\mathcal{P}$), the incentive constraint does not hold. Moreover, since $\gamma(\bar{n}^*(\widehat{\mathcal{P}})) \leqslant \hat{\gamma}(\bar{n}^*(\widehat{\mathcal{P}}))$, even

[28]The qualitative argument is unchanged if we assume a small negative payoff from raising rates when not necessary to do so. Essentially, this formulation assumes that the cost of inflation due to failure to raise rates when required far outweighs a contemporaneous loss in output.

under policy $\bar{n}^*(\widehat{\mathcal{P}})$, the incentive constraint may no longer be satisfied under more similar experiences $(\mathcal{P})$. Therefore, $\bar{n}^*(\mathcal{P}) \geqslant \bar{n}^*(\widehat{\mathcal{P}})$.