Rebel Motivations and Repression

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Abstract

How do different types of motivations influence the politics of collective action? We study a model of endogenous rebellion and repression to understand how different types of individual motivation affect participation, state repression, and the mechanisms by which state violence affects political contention. Unlike psychological rewards, material rewards are divided-up among successful rebels. Hence, in material rewards settings, repression that decreases mobilization and chances of success also increases participants' share of the rewards, reducing repression's impact. Consequently, materially- rather than psychologically-motivated groups are less affected by repression and face less repression, but are also less able to turn early failures into future successes. Moreover, because repression is more effective and used more when rebels are psychologically motivated, rebel motivations are a confounder in estimates of the relationship between repression and mobilization. This can lead to over-estimation of repression's impact and to more statistically-significant results exactly when repression is more effective.

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In some conflicts, participants are motivated by material considerations—the spoils of war, future political power, and so on. In others, the motivation is ideological or psychological. How do different types of motivation influence the success or failure of collective action? How does the nature of the good being sought in the process of popular dissent affect how both rebellion and repression work? Does a state's repression policy vary depending on the primary motivations of the rebels? We develop a model of endogenous collective action and endogenous repression to study how different types of individual motivation affect participation, states' repressive policies, and the mechanisms by which state violence affects political contention.[1]

We adopt the standard conception of state repression as any action by the state that "raises the contenders' cost of collective action" (Tilly 1978, 100; also see, Davenport 2007; Earl 2011). Thus, in our model, higher levels of repression are represented by the state imposing higher costs of mobilizing for rebellion.

We compare two broad types of rebel motivations: psychological and material. The psychological motivations we consider have to do with concerns like emotion, identity, and the quest for justice, which have been much discussed in the literature on why people rebel (Opp and Ruehl 1990; Wood 2003; Blattman and Miguel 2010; Balcells 2012; Pearlman 2013, 2018; Toft and Zhukov 2015; Lawrence 2017; Zhukov and Talibova 2018; Aytaç and Stokes 2019). For instance, Wood (2003) finds that rebels in El Salvador were motivated by psychological rewards, ranging from vengeance to the opportunity to be "part of the making of history" (18–19). The material motivations we consider have to do with the rents associated with political and territorial control, which are also widely discussed (Hirshleifer 1991; Ellis 1999; Weinstein 2007; Humphreys and Weinstein 2008; Dal Bó and Dal Bó 2011; Dube and Vargas 2013). For example, Weinstein (2007) and Humphreys and Weinstein (2008) find that many rebel fighters in Sierra Leone were motivated by opportunities for looting, drug sales, and other material gains.

The difference between material and psychological motivations, in our approach, hinges on whether or not the rewards from successful rebellion are rivalrous. Material goods are rivalrous in our model because materially motivated rebels must share the spoils of victory. In contrast, psychologically motivated rebels need not divide the fruits of victory, since one person's feelings of having achieved justice or having been part of history need not detract from another's feelings of the same.

[1]Ritter (2014) emphasizes the importance of endogenizing both mobilization and repression for understanding the efficacy of repression.

Our model provides insights that advance our understanding of both the mechanisms by which state violence affects political contention and why certain types of policy responses to public demands may or may not be successful. In particular, the model establishes four key results. We show that, all else being equal:

(1) Strategic governments repress psychologically motivated groups more than materially motivated groups.

(2) Psychologically motivated groups are less effective at achieving their goals than are materially motivated groups.

(3) Repression has a larger marginal effect on the efficacy of psychologically motivated groups than of materially motivated groups—materially motivated rebels are harder to discourage.

(4) At the endogenous repression level chosen by governments, psychologically motivated groups are less effective at achieving their goals than are materially motivated groups.

Thus, the model yields predictions about the amount of repression against different types of rebel groups, the efficacy of that repression, and the likelihood of success of differentially motivated movements.

In addition to providing new insight into rebellion and repression, our model's implications point to three complications for empirical studies of the efficacy of repression. These complications may help shed light on why the empirical literature on repression finds such highly variable results (see Davenport (2007) and Earl (2011) for reviews). The first complication involves causal inference. If governments repress psychologically motivated groups more than materially motivated groups (result 1) and psychologically motivated groups are less effective than materially motivated groups all else equal (result 2), then rebel motivations are a confounder in attempts to estimate the efficacy of repression. The second complication involves heterogeneous treatment effects. Our model implies that the effect of repression depends on rebel motivations (result 3). Hence, estimates of the efficacy of repression are sensitive to the sample of conflicts being studied. And, moreover, if repression is more frequently used against psychologically motivated groups (result 1), the set of cases where we observe repression and can estimate its efficacy will over-represent cases where it is particularly efficacious. The third complication is methodological. If repression is relatively rare, then with finite data, all else equal, the effect of repression will be more precisely estimated in conflicts with a relatively high level of repression (so that the treated group is closer in size to the untreated group). This will affect the set of conflicts for which we can find statistically significant evidence of the efficacy of repression and is important to take into consideration when considering how to interpret the results of a meta-analysis (whether formal or implicit in a reading of the literature) that weights estimates by the inverse of their precision. We provide a detailed discussion and numerical illustrations in Section 4.

While our focus is on how motivations affect rebellion and repression, it is worth noting that our model has some broader implications as well.

First, our results on which types of groups are most affected by repression also apply to the effects of exogenous economic shocks or other non-repressive changes that influence participation costs—just as endogenous repression decisions by the state affect those costs. Non-repressive changes in the opportunity costs of mobilization have the same effect in the model as repression. For instance, better economic opportunities increase the opportunity costs of participation and, thus, have similar heterogeneous effects as repression. Counterintuitively, then, the model implies that positive economic shocks will decrease rebel efficacy and that the impact of such shocks is greater on psychologically motivated groups than on materially motivated groups. Indeed, the literature features conflicting empirical results on the effect of economic conditions on mobilization (see, e.g., the discussion in Bazzi and Blattman 2014). The literature suggests different potential explanations—e.g., based on the distribution of opportunity cost shocks in the population (Dube and Vargas 2013) or informational mechanisms (Shadmehr and Boleslavsky 2022)—but does not take rebel motivations into account.

Second, we provide an extension that considers the resiliency of rebel groups to early setbacks. In a dynamic setting, we show that movements whose members are psychologically rather than materially motivated are better able to turn early failures, resulting from repression, into future successes. This is because the committed core that is often left behind by repression (Wood 2003; Lawrence 2017; Bursztyn et al. 2021; Pearlman 2021) is better able to spark future mobilization when motivations are psychological—see also Diani and McAdam (2003). This result provides an important caveat to the implication of our earlier analysis suggesting that, all else equal, psychologically motivated rebels are less effective and more easily repressed than materially motivated rebels. The extension shows that, while groups whose members are psychologically rather than materially motivated are better deterred by repression, they are also better able to turn early failures into future successes.

Third, the need to coordinate for collective action is not unique to rebellion. Many of the same issues arise in analyzing mobilization for non-violent protest and even for government-sponsored war. As such, our analysis may apply to such behavior as well.

The Nature of Material and Psychological Motivations In our conceptualization, material and psychological motivations share an important feature and also differ in an important respect. The common feature is that both are contingent on the success of the movement.[2] Rewards being contingent on success is important because it implies a force pushing for strategic complementarities—if an agent believes other agents are more likely to participate, and therefore the rebellion is more likely to succeed, that agent believes they are more likely to enjoy benefits from having participated. The point of divergence is that material rewards are rival goods, while psychological rewards are non-rival. When rewards are material, as the movement becomes larger, success is more likely, but the rewards to each individual conditional on success are smaller. When rewards are psychological, as the movement becomes larger, success is more likely and rewards don't change. Why these similarities and distinctions?

Our focus on success-contingent motivation is consistent with Rasler's (1996) "value expectancy" model, and her empirical evidence supports the associated implications (148). As Rasler (1996) argues: "Value-expectancy models assert that people will rebel if they become convinced that dissent will achieve the collective good (Klandermans 1984; Muller and Opp 1986; Finkel, Muller, and Opp 1989). If the value of the collective good (e.g., overthrow of the Shah's government) is combined with a high expectation of success, people are likely to participate in mass actions" (134).

Material benefits take various forms, including direct payments, protection, opportunities for looting, and promises of future economic spoils. Consider a few examples from the literature. Popkin (1979) describes offering peasants material rewards for mobilizing as a crucial recruitment strategy for Vietnamese insurgents. Ross (2006) summarizes the extensive literature showing that the presence of lootable diamonds helps to motivate and sustain rebellion. Several studies shows evidence that rebel violence in conflicts ranging from Colombia to Chad to the Republic of Congo is motivated by the desire to capture control over valuable oil re-

[2]We focus on success contingent rewards, which have been the focus of the substantive literature and allows for a clean analysis. The logic, however, is more general. One could contemplate generalizing the results—e.g., by extending the framework in Shadmehr (2019a), in which the expected rewards are a more general function of the fraction of revolters/rebels.

sources (Englebert and Ron 2004; Humphreys 2005; Dube and Vargas 2013). Shapiro (2013) presents documentary evidence of disputes within al Qaeda around various members' material compensation. And Goodwin and Skocpol (1989, 494) argue that quite broadly "it is the on-going provision of such collective and selective goods, not ideological conversion in the abstract, that has played the principal role in solidifying social support for guerrilla armies."

Of course, some material resources, such as the looting while fighting or monthly salaries, may be enjoyed by participants even during the course of a failing campaign. A conflict in which such rewards were unlimited (and, hence, non-rival) and unrelated to success would not be well described by our model. But in the typical case material resources are scarce and a losing movement will eventually be unable to keep providing such material resources. Moreover, many economics benefits of rebellion, such as the rents from oil production discussed above are only available if the rebels can successfully hold oil producing territory. And, of course, economic spoils are finite. They must be divided among the participants in the victorious movement; hence the disputes documented by Shapiro (2013). As such, it is natural to think that they are rival—the larger the movement, the less each individual participant expects to receive. This assumption is consistent with a large literature arguing that there is often conflict among rebels when the rebellion is materially motivated—see Fjelde and Nilsson (2012) for a discussion and evidence.

The nature of psychological benefits has been the subject of long debate. Early work emphasized purely expressive motives (Davies 1962; Geschwender 1967; Gurr 1970). But later studies showed that even psychologically motivated individuals account for the likelihood of success and the costs of participation when deciding whether to mobilize (Tilly 1978, 2008; McAdam 1999; Tarrow 2011).[3] In particular, movements with no prospect of success are unlikely to be sustainable because the costs of participation exceed the psychological benefits. Later studies confirmed this insight and developed a success-contingent conception of psychological and ideological rewards. Wood's (2003) notion of pleasure-in-agency captures psychological rewards associated with participating in a successful movement. Wood defines pleasure-in-agency as "the positive effect associated with self-determination, autonomy, self-esteem, efficacy, and pride that come from the successful assertion of intention" (235). Based on extensive fieldwork and building on the historical and sociological literature, Wood found that agents motivated by psychological rewards both account for the likelihood of success and they act strategically:

[3] As Washington wrote to the Continental Congress in the 1770s, "The honor of making a brave defense does not seem to be a sufficient stimulus, when the success is very doubtful and the falling into the Enemy's hands probable" (Middlekauff 2005, 342).

pleasure-in-agency is "a frequency-based motivation: it depends on the likelihood of success, which in turn increases with the number participating (Schelling 1978; Hardin 1982)" (235–6). Such findings suggest that whether psychological rewards derive from ideology, the satisfaction of "being part of the making of history," justice, honor, or vengeance, the net benefit is positive only if the movement succeeds (Petersen 2001; Wood 2003; Morris and Shadmehr 2017; Pearlman 2018; Aytaç and Stokes 2019). By contrast with the material setting, the satisfaction from implementing an ideological vision, achieving justice, or being part of history is not diminished for being shared. As such, it is natural to think of psychological rewards as non-rival—as more people join the movement, the likelihood of success increases, with no diminution in individual rewards conditional on success.

Capturing these ideas—especially the rivalrous nature of material rewards—requires an analysis with multiple people considering whether or not to mobilize. This gives rise to coordination considerations: whether one individual wishes to participate depends on her beliefs about how many others will participate. The dual presence of coordination concerns and congestion externalities (due to rivalrous material rewards) significantly complicates the strategic environment, precluding the application of standard models. Almost all models of protest and revolution feature pure coordination considerations with no congestion externalities (Boix and Svolik 2013; Edmond 2013; Casper and Tyson 2014; Loeper et al. 2014; Chen et al. 2016; Rundlett and Svolik 2016; Tyson and Smith 2018; Nandong 2020; Correa 2021).[4] The complexity arises because there is a force for strategic complementarity (when more people mobilize, the chances of success are higher) and a force for strategic substitutes (when more people mobilize, the rewards of victory are smaller). Consequently, for example, as a citizen becomes more optimistic about the likelihood of regime change, her incentives to participate may, paradoxically, fall. The analysis of these competing forces and their interactions with repression requires a formal model that incorporates both forces in a tractable manner. We provide such a model and analysis.

Model of Rebellion

We start with a model of rebellion with fixed repressive capacity. Within that model we characterize equilibrium and analyze the efficacy of repression as comparative statics. We then add an earlier stage in which the government chooses repressive capacity and characterize perfect

[4] An exception is Shadmehr (2019b), which studies the interactions between political stability and the economy. We make use of the results in that paper for our technical characterization of equilibrium.

Bayesian equilibria of this augmented game.

In the model of rebellion, there is a continuum of citizens of size $a > 0$, indexed by $i \in [0, a]$. Citizens simultaneously decide whether to participate in a rebel movement. The rebellion succeeds if and only if the fraction of rebels in the population exceeds the state of the world, θ, which captures the strength of the status quo regime.[5] Letting $m \in [0, a]$ be the size of the rebels, the fraction of rebels in the population is $\frac{m}{a}$.

The payoff of a citizen who does not rebel is normalized to 0. A citizen who rebels pays a cost $c \in (0, 1)$. If the rebellion succeeds, a citizen who participated receives a payoff u^j, $j = p, m$, where u^p is the reward in the setting with *psychological* rewards, and u^m is the reward in the setting with *material* rewards. Psychological rewards are normalized to 1, and material rewards are normalized to $\frac{a}{m}$, so that if the rebellion succeeds, the total available rewards in both settings is a. Figure 1 represents the payoffs.

psychological

	outcome of rebellion: win ($^m/_a > \theta$)	outcome of rebellion: lose ($^m/_a \leq \theta$)
rebel	$1 - c$	$-c$
don't rebel	0	0

material

	outcome of rebellion: win ($^m/_a > \theta$)	outcome of rebellion: lose ($^m/_a \leq \theta$)
rebel	$\frac{a}{m} - c$	$-c$
not rebel	0	0

Figure 1: **Psychological versus Material Rewards.** The size of the population is a, the size of rebel movement is $m \leq a$, the cost of participation is c, and the regime's strength is θ. The left panel captures movements with psychological rewards: net rewards from participation do not depend on how many participate. The right panel captures movements with material rewards: net rewards from participation fall with more participation because participants must share the spoils.

The state of world is uncertain, and citizens share a common prior that θ is distributed on $\mathbb{R}$ according to an improper uniform distribution. Each citizen i receives a noisy private signal $x_i = \theta + \sigma\epsilon_i$, where θ and ϵ_is are distributed independently, with $\epsilon_i \sim F$ and the corresponding pdf f. We assume f is log-concave with full support on $\mathbb{R}$.

[5]This captures the idea that, even a state prepared to engage in considerable repression, will face real pressure if that repression fails to curtail popular unrest. As Erich Mielke, the head of East German Stasi, told Erich Honecker, the president of East Germany, in 1989: "we can't beat up hundreds of thousands of people" (Przeworski 1991, 64). We will sometimes refer to this threshold as *regime strength*, although it captures only one aspect of regime strength. For instance, we will treat the regime's exercise of strength through repression separately.

Complete Information Benchmark

We begin with the complete information benchmark in which the regime's strength θ is known. (All proofs are in the appendix.)

Proposition 1 *The setting with psychological rewards and the setting with material rewards both have the same pure strategy equilibria:*

- *If $\theta \geq 1$, there is a unique equilibrium in which no one rebels, the regime survives, and each citizen receives* 0*.*
- *If $\theta < 0$, there is a unique equilibrium in which everyone rebels, the regime collapses, and everyone receives* 1*.*
- *In between, both equilibria co-exist.*

Proposition 1 implies that the settings with psychological and material rewards generate the same outcomes. However, this complete information setting is misleading. Of course, it abstracts from information frictions that exist in the real world. Moreover, it has two problematic properties: (1) there are multiple equilibria, which makes empirical prediction difficult; and (2) equilibrium outcomes are insensitive to parameters of the model like the costs of rebellion. The introduction of incomplete information addresses both issues.

Equilibrium

We now analyze our incomplete information model of rebellion. The left panel in Figure 1 is the quintessential regime change game (Morris and Shin 1998, 2003; Angeletos et al. 2007).[6] In it, equilibrium is characterized by two thresholds (x^p, θ^p), so that a citizen i with signal $x_i < x^p$ rebels, and the regime collapses if and only if $\theta < \theta^p$. These thresholds are determined by the indifference (optimality) and belief consistency conditions:

$$\Pr(x_i < x^p | \theta^p) = \theta^p \text{ (belief consistency)} \quad \text{and} \quad \Pr(\theta < \theta^p | x_i = x^p) = c \text{ (indifference)}. \qquad (1)$$

Because each citizen rebels whenever her signal of the regime's strength is below a threshold, for any given regime strength θ, the aggregate size of the rebellion as a fraction of the population is

[6] Papers featuring variations of this game include Boix and Svolik (2013), Edmond (2013), Casper and Tyson (2014), Loeper et al. (2014), Chen et al. (2016), Rundlett and Svolik (2016), Tyson and Smith (2018), and Shadmehr (2019b).

$\Pr(x_i < x^p|\theta)$. Naturally, the size of the rebellion is decreasing in the regime's strength, implying that the regime collapses below a threshold of regime strength and survives above it. Thus, that critical threshold (which we call θ^p) is exactly the size of the rebellion at that critical threshold.

How do we find this critical rebellion size? Because a citizen rebels whenever her belief about the likelihood of success is larger than the cost of rebelling, to find the size of the rebellion at the critical threshold we need to know the distribution of these beliefs at that critical threshold. As Shadmehr (2019a) discusses in detail, when there is no prior knowledge about θ,[7] the distribution of these beliefs about the likelihood of success at the critical threshold is uniformly distributed on $[0, 1]$ among citizens. Thus, the size of the rebellion as a fraction of the population is the probability that a random citizen's belief is above the rebellion cost, i.e., $1 - c$. That is,

$$\theta^p = 1 - c. \tag{2}$$

The nature of strategic interactions is a pure coordination problem. The game is a standard global game of regime change, where the actions of citizens are always strategic complements: when one citizen believes that others are more likely to rebel, her incentives to join the rebellion increase because the rewards remain the same, but the likelihood of success increases.

In contrast, the game in the right panel of Figure 1 is not a pure coordination game. In this game, when a citizen believes that others are more likely to rebel, her incentives to protest may fall because, although success is more likely, the limited rewards from that success will be shared among a larger group, so that each participant will expect to receive less rewards conditional on success. That is, the game does not feature global strategic complements due to congestion externalities. In particular, for a given level of regime strength, θ, the net payoff from revolting versus not revolting is:

$$\mathbf{1}_{\{\theta < m/a\}} \cdot \frac{a}{m} - c.$$

This net payoff is non-monotone in the size of the rebellion m. It jumps up from 0 to $\frac{a}{m} - c$ at $\frac{m}{a} = \theta$ (the threshold at which regime change succeeds), but then falls smoothly to $1 - c$ as more people join the movement. Therefore, the best response to a monotone strategy is not monotone in general, and monotone equilibria may not exist. The source of this complication, relative to the psychological rewards setting, is that the expected rewards do not boil down to the likelihood of success, because higher chances of success also imply a larger rebellion size,

[7] For example, when citizens share a prior that θ is distributed according to an improper uniform distribution on $\mathbb{R}$, or when the noise in private signals is vanishingly small.

which in turn, implies a smaller reward for each participant. That is, when a citizen receives a lower signal, she updates that the regime is weaker and the size of the rebellion larger. This updating increases her assessment of the chances of success, but reduces her assessment of the reward conditional on that success (the citizen updates $\mathbf{1}_{\{\theta<m/a\}}$ upward, but $\frac{a}{m}$ downward). Despite this non-monotonicity, Proposition 2 shows that our assumptions are enough to deliver the existence and uniqueness of symmetric monotone equilibria.[8]

Proposition 2 *The setting with psychological rewards has a unique equilibrium in which the rebellion succeeds if and only if the strength of the regime is below a threshold $\theta^p = 1 - c$. The setting with material rewards has a unique equilibrium in which the rebellion succeeds if and only if the strength of the regime is below a threshold $\theta^m = e^{-c}$.*

Proposition 2 implies that $\theta^m > \theta^p$. Because total rewards in the material setting are divided among rebel participants, and some citizens always choose not to rebel in equilibrium due to information frictions, the equilibrium incentives are stronger in the material rewards setting ($1 < \frac{a}{m}$ for $m \in (0, a)$).

With these equilibrium characterizations in hand, we can turn to our main topic of interest: the differential efficacy of repression against materially versus psychologically motivated rebel groups and its empirical implications. But, before doing so, it is worth commenting on some features of our model.

Comments on the Model

Several natural questions arise from our basic set-up. The first is what happens if people are motivated by some mix of psychological and material motivations. We analyze this question in Online Appendix A, showing that the results in the mixed case lie in between the results for the pure material and pure psychological cases we consider in the main text.

The second is about the robustness of results to the assumption of an improper uniform prior. We make that assumption, which is standard in the global games literature (Morris and Shadmehr 2017), to introduce strategic uncertainty while maintaining tractability that allows us to focus on the question of interest—the interactions of different motivation types and state repression. We are not focused on the effects of information per se. That said, in

[8]See Morris and Shin (2003, 68-70) and Shadmehr (2019b) for technical discussions.

Online Appendix B, we show that the results are robust to other informational assumptions. In particular, we show that the same results obtain for any smooth prior in the limit when the noise becomes vanishingly small. We then provide numerical examples for a standard normal prior for both the case of a uniform distribution of noise and a standard normal distribution of noise. Finally, we provide additional numerical examples for the effect of a public signal about the regime strength (θ) in both settings with psychological and material rewards.

The third is about whether our results are sensitive to the normalization that total material and psychological rewards are equal at full participation and that, therefore, individual psychological rewards are less than individual material rewards for less than full participation. To address this concern, in Online Appendix C we show the robustness of our results to a variant of the model where individual material rewards are given by $k\frac{a}{m}$, for $k > 0$ and $\frac{c}{k} \in (0, 1)$.

Finally, it is worth commenting on a few other features of payoffs in our model.

We have assumed that rewards are contingent on participating. This is distinct from rewards that are gained by every citizen if the regime falls—in the language of Olson (1965) and Tullock (1971), our rewards are selective/private benefits. As we argued extensively in the Introduction, we think the idea of participation-contingent rewards are substantively appropriate in both our material and psychological rewards settings. But it is also worth noting that our results are robust to adding rewards that are not participation-contingent. In particular, since our model has a continuum of individuals, each individual regards their personal contribution to the probability of success as negligible. This implies that any reward (or cost) that does not depend on whether a person participates cannot affect that person's participation decisions. Hence, introducing additional rewards that are not contingent on participation would not alter our results.

It is also worth noting that we do not directly include costs that a citizen might suffer should she fail to participate in a rebellion that ultimately succeeds. Such costs are, of course, quite substantively plausible. But, notice, success-contingent costs associated with not participating are mathematically equivalent (with opposite sign) to success-contingent benefits associated with participating. So our model captures the substantive effects of such costs, without adding an additional parameter to directly represent them.

Efficacy of Repression

In this section, we ask how the efficacy of repression differs when deployed against groups with material versus psychological motivations. For this analysis, we continue to treat repression as a parameter, examining its efficacy through a comparative static analysis. In the next section we leverage these results to characterize the level of repression chosen by a strategic government.

We represent the idea of an increase in repression with an increase in the cost of rebellion, c. This corresponds to the standard conception of state repression as any action by the state "which raises the contender's cost of collective action" (Tilly 1978, 100; Davenport 2007; Earl 2011). Of course, repression may raise both a citizen's direct costs of rebelling and a citizen's direct benefit from rebelling due to a sense of injustice or a desire for vengeance (Wood 2003; Davenport 2007; Earl 2011; Siegel 2011; Lawrence 2017; Pearlman 2018; Aytaç and Stokes 2019; Shadmehr and Boleslavsky 2022). In our model, the cost c is, in fact, the ratio of the costs to benefits of rebellion. Representing increased repression with an increase in c means that even though both the numerator and the denominator may rise, we assume the direct cost-benefit ratio is increasing. This is consistent with the standard view of higher repression as reducing political opportunities (Tilly 1978, 2006; McAdam 1999; Davenport 2007; Earl 2011; Tarrow 2011).

Proposition 3 *The equilibrium regime change threshold is less responsive to repression in the material rewards setting than in the psychological rewards setting:* $\frac{\partial \theta^p}{\partial c} < \frac{\partial \theta^m}{\partial c} < 0$.

Proposition 3 shows how the likelihood of success in differently motivated groups responds to variations in repression levels. The direct effect of higher rebellion costs is to reduce incentives to protest in both settings. But there is also a strategic effect: a citizen recognizes that higher costs of mobilization mean that others have less incentives to rebel, and adjusts her behavior accordingly. In the psychological rewards setting, this further reduces the incentives to rebel because the likelihood of success is lower. This strategic effect in weaker in the material rewards setting and may off-set parts of the direct effect (if actions are strategic substitutes at equilibrium). The reason is that even though the likelihood of success is lower, the size of the rebellion is also smaller, so that if the rebellion succeeds each participant receives a larger reward. Due to this strategic effect, the likelihood of success in the material rewards setting is less sensitive to increases in the direct costs of rebellion. Thus, repression is less effective against groups whose members are materially motivated.

It is also worth noting that, since we model repression as increasing the costs of mobilization, our results apply to any change in the world that affects these costs, whether due to repression or otherwise. For instance, the model predicts that a positive economic change that increases wages and, thus, the opportunity costs of mobilization has the same effects as repression—reducing mobilization. Moreover, just like repression, the effects of economic shocks will be heterogeneous so that, perhaps counterintuitively, economic shocks have a bigger effect on mobilization among psychologically motivated rebels than among materially motivated rebels.

The Government's Repression Decision

In this section, we consider a government choosing how much to invest in repression. As Balcells and Stanton (2021) highlight, not all instances of government repression and violence are intentional (as opposed to collateral damage) or even a matter of policy (as opposed to practice (Wood 2018)). However, intentional government policies of repression constitute an important category of repression and violence (Davenport 1995, 2007; Earl 2011; Balcells and Stanton 2021), and our analysis focuses on this type of state repression.

To study the government's decision, we add an earlier stage to our base model, in which the government chooses a level of repressive capacity, c, prior to information being revealed about regime strength.[9] The government cares about two things: it wants to reduce the risk of a successful rebellion and it bears direct costs for engaging in repression. In particular, the government's objective is to minimize a combination of the regime change threshold and the costs of investment in repressive capacity:

$$\min_{c\geq 0} \theta^j(c) + C(c),\ \ j = p, m,$$

where $C(0) = C'(0) = 0$, and $0 < C'(c), C''(c)$ for all $c > 0$, captures the costs of a repression level c for the government.[10]

[9] The government's decision captures the resources that it puts into security forces at some earlier time, say t, in anticipation of future protests. Although the government surely has some information about its strength at that point, we assume there are sufficient idiosyncratic shocks to the regime's strength that when the protest happens at a later date, the information content of the regime's repression decision about its strength is negligible. This allows us to abstract from the interactions between signaling and coordination, which has been studied elsewhere (Angeletos et al. 2006), as well as the well-known "signaling resolve" models in IR (Weiss 2013) and the protest literature (Ginkel and Smith 1999).

[10] To see the logic, consider a regime that is maximizing its expected payoff: $\max_{c\geq 0}(1 - G(\theta^j(c)))B - \widehat{C}(c)$, where $B > 0$ is the payoff of defeating the rebellion and θ is distributed according to a cdf G with the pdf g. This is equivalent to $\min_{c\geq 0} G(\theta^j(c)) + \widehat{C}(c)/B$. The first order condition is: $d\theta^j(c)/dc = -\widehat{C}'(c)/(Bg(\theta^j))$.

Let c^j, $j = p, m$, be the regime's choice of repression when the rebels are psychologically and materially motivated, respectively.

Proposition 4 *The government chooses a higher repression level against psychologically motivated groups than against materially motivated groups: $c^p > c^m$. Moreover, in equilibrium with the endogenous choice of government repression, the equilibrium regime change threshold is higher in the material rewards setting than in the psychological rewards setting: $\theta^p(c^p) < \theta^m(c^m)$.*

Proposition 4 says two things. First, all else equal, a strategic government engages in more repression against a psychologically motivated rebel group than against a materially motivated rebel group. Second, even with endogenous repression, psychologically motivated groups are less likely to succeed than materially motivated groups.

The intuition builds on the earlier the analysis. We showed that higher repression has a larger marginal impact on reducing the probability of successful rebellion when motivations are psychological rather than material (Proposition 3). This implies that the government obtains a larger marginal benefit from applying repression against psychologically motivated groups than against materially motivated groups. As a result, the government represses psychologically motivated groups more ($c^p > c^m$).

Moreover, for a given (exogenous) level of repression, the equilibrium regime change threshold is higher in the material rewards setting than in the psychological rewards settings (Proposition 2). That is, all else equal, psychologically motivated groups are less likely to succeed in overturning the status quo than materially motivated groups. Accounting for the government's strategic choice of repression reinforces this result because, as we just discussed, states use more repression against psychologically motivated groups.

Discussion and Empirical Implications

We have established four key results:

1. Strategic governments repress psychologically motivated groups more than materially motivated groups (Proposition 4).

When θ is distributed uniformly, $g(x)$ is a positive constant $\hat{g} > 0$ and can be absorbed into $\widehat{C}'(c)/B$, so that $d\theta^j(c)/dc = -C'(c)$, where $C'(c) = \widehat{C}'(c)/(B\hat{g})$. As we show in Online Appendix B, the same equilibrium regime change threshold is obtained with a general G if the noise in private signals is vanishingly small. But as the appendix shows, such generalizations does not change the insights of the model.

2. All else equal (e.g., repression held constant), psychologically motivated groups are less effective at achieving their goals that materially motivated groups (Proposition 2).

3. Repression has a larger marginal effect on the the efficacy of psychologically motivated groups than of materially motivated groups. (Proposition 3).

4. At the equilibrium level of repression chosen by governments, psychologically motivated groups are less effective at achieving their goals than are materially motivated groups (Proposition 4).

Each of these is an empirical implication in its own right. Thus, the model yields testable hypotheses about both the amount of repression we should expect to see used against different types of rebel groups (implication 1), the efficacy of that repression (implication 3), and the likelihood of success of differentially motivated rebel movements (implications 2 and 4). Moreover, as discussed earlier, the model also has implications about the (heterogeneous) effects of economic or other non-repressive changes that affect the costs of mobilization. Non-repressive changes in the opportunity costs of mobilizing (e.g., increases in economic opportunity) have the same effect in the model as repression—thus, the model also implies that positive economic shocks will decrease rebel efficacy and that the impact of such shocks is greater on psychologically motivated groups than on materially motivated groups.

In addition to these positive implications, the model also highlights some complications for empirically estimating the effect of repression, which may shed light on why the empirical literature finds conflicting and varied results—what Davenport (2007) refers to as the *punishment puzzle*. Here we consider three such complications.

The first complication has to do with the way rebel motivations complicate causal inference. Consider, for instance, a regression of either mobilization or rebel success on repression. Points 1 and 2, together, show that motivations are a confounder in such a regression. Holding repression fixed, materially motivated groups have higher levels of mobilization and are more likely to succeed than psychologically motivated groups. But they also face less repression than psychologically motivated groups. Hence, those regressions will return correlations that are over-estimates of the efficacy of repression—some of the negative correlation between the measure of repression and that of protest success is due to systematic baseline differences in mobilization or likelihood of success among rebel groups that face more or less repression, not due to the effect of the repression itself.

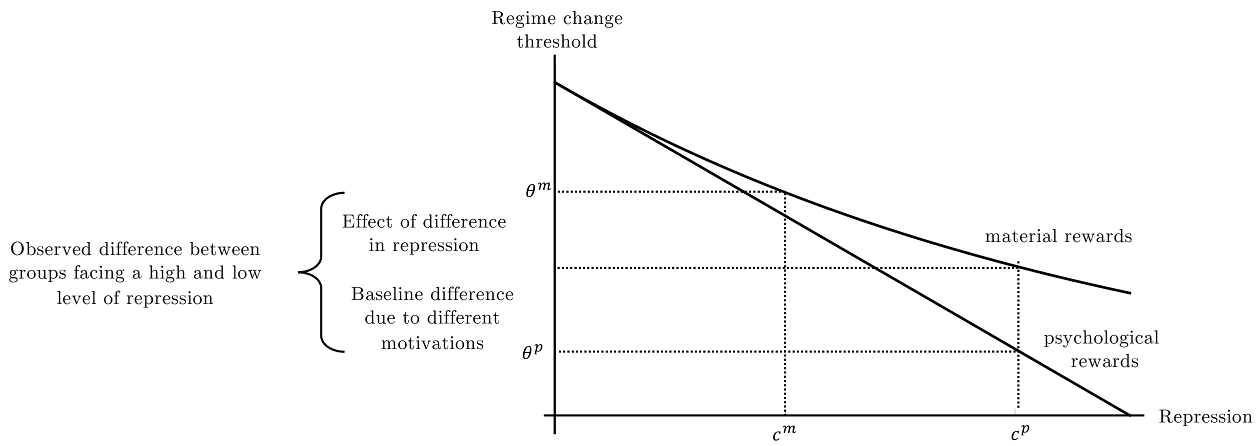

Figure 2: Some of the observed correlation between rebel success and repression is the result of baseline differences coming from the correlation between motivations and repression, rather than the causal effect of repression.

A theoretical version of this observation is illustrated in Figure 2. The figure shows the equilibrium regime change threshold on the vertical axis and the equilibrium level of repression on the horizontal axis. The higher the regime change threshold, the more likely the rebel group is to succeed. In the figure, all psychologically motivated groups face repression c^p and all materially motivated groups face repression c^m. But, for any given level of repression, psychologically motivated groups also face a lower regime change threshold (i.e., are less likely to succeed). Thus, motivation is correlated with both repression and likelihood of success and, so, is a confounder if we want to interpret the correlation between repression and success as an estimate of the causal effect of repression.

Of course, in real data, other parameter values will vary, so not all conflicts with the same motivations will experience the same level of repression or the same regime change threshold. Figure 3 illustrates what such data might look like. The data in the figure are generated as follows. For each type of motivation, the level of repression in any given observation is the equilibrium level plus mean-zero noise. And the regime change threshold is the equilibrium regime change threshold from the model, given that level of repression and the type of motivations, plus (independent) mean-zero noise.

The problem of confounding is evident in the figure. Both the outcome (regime change threshold) and treatment (level of repression) are correlated with motivations (represented by the different colored data points). In conflicts with psychologically motivated rebels (black

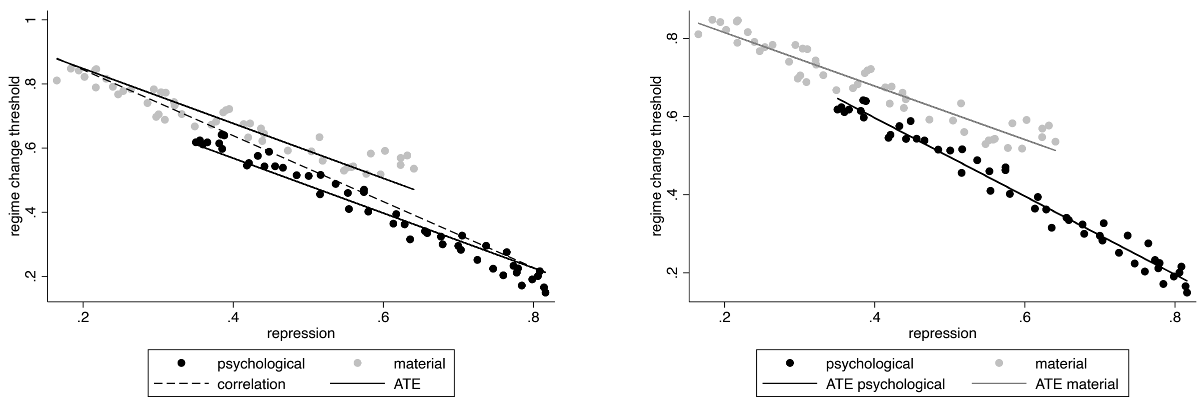

Figure 3: Data simulated from the model shows that motivation is a confounder in the regression of the regime change threshold on repression and that repression has heterogeneous treatment effects.

dots), repression tends to be high and the regime change threshold tends to be low. In conflicts with materially motivated rebels (gray dots), repression tends to be low and the regime change threshold tends to be high. The resulting bias can be seen directly in the left-hand panel of the figure. The dashed line represents the simple regression of regime change threshold on repression—its slope estimates the correlation. The solid lines represents the regression of regime change threshold on repression and a dummy variable for the two possible types of rebel motivation. Since this regression controls for motivation and there are no other confounders, the slope of these lines (which are parallel by construction) estimates the average treatment effect of repression.[11] The solid lines are shallower than the dashed line. This means that the correlation over-estimates (in magnitude) the average treatment effect.

A second complication concerns heterogeneous treatment effects. Suppose an empirical study credibly estimates the effect of repression for some set of cases. Result (3) says that repression has heterogeneous treatment effects on rebellion, depending on rebel motivations. In particular, repression has a bigger effect when rebels are psychologically motivated than when they are materially motivated. This is evident in the right-hand panel of Figure 3. In that figure, the lines represent the regression of regime change threshold on repression for each type of conflict separately. Since there are no other confounders in our simulations, the slopes of

[11] The regression equation is Regime Change Threshold $= \beta_0 + \beta_1 \cdot$ Repression $+ \beta_2 \cdot$ Motivation. The parameter β_1 gives the slope of the linear relationship between regime change threshold and repression controlling for motivations, which estimates the average treatment effect of repression. The parameter β_2 gives the vertical distance between the lines, which is the relationship between motivations and repression controlling for repression—i.e., the average treatment effect of motivations.

these regression lines estimate the average treatment effect of repression in each type of conflict. The regression line for psychologically-motivated conflicts is steeper than the regression line for materially-motivated conflicts, reflecting the heterogeneous treatment effects. Hence, estimates of the efficacy of repression will be sensitive to the sample of conflicts being studied. That is, a study that happens to focus on a region of the world or type of conflict where, for instance, most groups are psychologically motivated is expected to get a different estimate of the effects of repression than a study that happens to focus on a region of the world or type of conflict where most groups are materially motivated.

The third complication is more methodological. Many of the most convincing empirical studies of the efficacy of repression employ a difference-in-differences design—e.g., comparing changes in rebel activity in locations within a country that did and did not experience repression in a given time period (e.g., Lyall 2009; Kocher, Pepinsky, and Kalyvas 2011; Condra and Shapiro 2012; Benmelech, Berrebi, and Klor 2015; Dell and Querubin 2018; Rozenas and Zhukov 2019). In such studies, repression is typically relatively rare; that is, there is not repression in most regions in most periods. That implies that, in a within-country design, most units are "untreated" in most periods. But our result (1) suggests this will be less true for conflicts involving psychologically motivated groups—in those conflicts, the untreated and treated groups will be more evenly balanced since repression is used more often. In a finite sample, this means that (all else being equal), estimates of the efficacy of repression will be more precise in settings with psychologically motivated groups than in settings with materially motivated groups. Hence, we are more likely to find statistically significant evidence of the efficacy of repression in psychologically motivated conflicts not only because it is in fact more effective in such conflicts, but also because it is more precisely estimated. And, moreover, a meta-analysis (whether formal or implicit from a reading of the literature) that weights estimates by the inverse of their precision will overestimate the average efficacy of repression because it will put excess weight on estimates from conflicts with psychologically motivated groups which, according to result (3), are the settings where repression is most effective.

Extension: Resilience to Repression and the Committed Core

Our paper focuses on the strategic interactions between motivations in collective action and the choice of repression by the state. However, to show broader applications and the flexibility of our framework, we now extend the base model to consider the resiliency of rebel groups to early set-backs. In particular, we now turn to a dynamic question: which type of movement is more resilient to repression in the long-run, given that even successful repression often leaves behind a committed core that will attempt to resurrect the movement in the future?

Many movements do not succeed or fail in a single episode. A movement that initially appears to have been defeated may resurface later when another political opportunity arises (McAdam, Tarrow, Tilly 2001; Tarrow 2011). Moreover, in such instances, the experience of earlier repression often creates a core of deeply committed participants. For instance, Rasler (1996) highlights how, in the short-run, government repression appears to have succeeded in putting down the protests that preceded the Iranian revolution, but that in the longer-run the movement inspired by these protests rose back up on the foundation built by the committed core. Wood (2003) and Lawrence (2017) emphasize how the desire for justice or vengeance can create such a committed core, focusing on the cases of El Salvador and Morocco, respectively. Bursztyn et al. (2021) and Pearlman (2021) highlight the ways in which social ties can contribute to the creation of a committed core, with a focus on the cases of Hong Kong and Syria, respectively. (See also Diani and McAdam (2003)).

To study how early failure that leaves in place a committed core affects the ultimate likelihood of success, we extend the model to two periods, and normalize the population size to 1. To study these dynamics, we abstract away from endogenous repression, though it is straightforward to add it along the lines of the analysis above. The stage game in the first period is identical to the previous setting. If the rebellion succeeds, the game ends. However, if the rebellion fails in the first period, in the second period citizens again play a similar regime change game. However, now there is a committed core: a fraction $1-a \in (0,1)$ of citizens who will surely participate in the second period rebellion. Thus, there are two differences between periods 1 and 2: in the second period, a fraction $1-a$ of citizens are committed to the rebellion and citizens have the additional, common knowledge that the regime survived the first period. To ease exposition, we focus on Normal distributions of noise so that $F = N(0,1)$.

In period 2, each citizen has three pieces of information: her signal from the first period, her signal from the second period, and the fact that the regime has survived. Because conditional expectations of normally distributed variables are linear, a citizen's private information in period 2 is effectively the average of her private signals in periods 1 and 2. Let x_2 be that average. We refer to this average signal as a citizen's private signal in period 2.

As before, we focus on symmetric monotone equilibria. In period 1, a citizen rebels if and only if her private signal is below a threshold x_1^*. In period 2, a fraction $1-a$ of citizens will be committed and rebel, and a citizen from the remaining group rebels if and only if her private signal x_2 is below a threshold x_2^*. As in the static setting, there is no equilibrium in which a citizen always revolts: $x_t^* < \infty$. If the regime survives the first period, this implies $\theta > 0$. Thus, there could be an equilibrium in which $x_2^* = -\infty$, and only the fraction $1-a$ of (committed) citizens rebel. We focus on the interesting case of finite cutoff equilibria, so that $x_2^* \in \mathbb{R}$.

Because a single citizen's action does not change the outcome (each individual is too small to make a non-negligible difference), in the first period the equilibrium behavior of citizens is the same as in the static game. Let θ_t^j, $j \in \{p, m\}$, $t = 1, 2$, be the period t equilibrium regime change threshold in the settings with psychological ($j = p$) and material ($j = m$) rewards, respectively. Let x_t^p and x_t^m be the corresponding equilibrium citizen cutoffs. From our earlier analysis, $\theta_1^p = 1 - c$ and $\theta_1^m = e^{-c}$. In the second period, in the setting with material rewards, any pair of cutoffs (θ_2^m, x_2^m) that satisfy the following belief consistency and indifference conditions constitute an equilibrium:

$$\theta_2^m = (1-a) + a \Pr(x_i < x_2^m | \theta_2^m) \tag{3}$$

$$c = E\left[\frac{\mathbf{1}_{\{\theta < \theta_2^m\}}}{(1-a) + a \Pr(x_j < x_2^m)} \middle| x_i = x_2^m, \theta \geq \theta_1^m \right]. \tag{4}$$

In the second period, in the setting with psychological rewards, any (θ_2^p, x_2^p) that satisfy the following conditions constitute an equilibrium:

$$\theta_2^p = (1-a) + a \Pr(x_i < x_2^p | \theta_2^p) \tag{5}$$

$$c = \Pr(\theta < \theta_2^p | x_i = x_2^p, \theta \geq \theta_1^p). \tag{6}$$

These equilibrium conditions reflect the two differences between period 2 and period 1. The information content of the regime's survival is reflected in conditioning on $\theta > \theta_1^j$, $j \in \{p, m\}$, in the indifference conditions. The emergence of a committed rebel core is represented by the term $1 - a$ in the belief consistency conditions.

It is bad news for the rebels that the regime survived the first period: they've learned that $\Pr(\theta < \theta_1^j) = 0$, $j \in \{p, m\}$. This may prevent rebellion in period 2 altogether (finite-cutoff equilibria may not exist). But if citizens' private information is sufficiently precise, they effectively discard the relatively imprecise information that $\theta \geq \theta_1^j$, $j \in \{p, m\}$: compared to their precise private information, this public information receives little weight in their Bayesian updating. Cross-period informational linkages have been studied elsewhere in the literature (Angeletos et al. 2007). To focus on the new insight that the effect of a committed core depends on motivations, in our theoretical results, we abstract away from the informational linkage across periods—letting the noise in the second period's private signals become vanishingly small. We then provide numerical examples with information linkages (i.e., learning) between periods and discuss the effect of informational linkage on the dynamic.[12]

Proposition 5 *Suppose the noise in the second period's private signals becomes vanishingly small, and we focus on the largest equilibrium. Conditional on failure in the first period, the chances of success is higher in the psychological rewards setting than in the material rewards setting.*

The logic is as follows. A failure in the first attempt creates a committed core. This group of committed participants increases the likelihood of success in both settings, but the effect is weaker in the material rewards setting because, conditional on success, the group that will share the rewards is surely larger than the size of the committed members. Combining Propositions 2 and 5 implies that movements with psychological rewards are less likely to succeed in the first period, but conditional on a failure in the first period, they are more likely to succeed than movements with material rewards. This result resonates with the finding in Shadmehr and Bernhardt (2019) that it is more difficult for a movement to begin organically (without a revolutionary vanguard); but movements that begin organically are more likely to succeed.

In this analysis, because citizens have very precise private information in the second period, they do not need to rely on the informational content of the failure in the first period.

[12]More generally, the formal literature has focused on various aspects of the dynamics of protest, while abstracting from others. For example, some papers focus on different aspects of signaling and coordination (Lohmann 1994; Bueno de Mesquita 2010; Loeper et al. 2014; Shadmehr and Bernhardt 2019; Barbera and Jackson 2020; Chen and Suen 2021), while others focus on the interactions between repression and dissent (Gibilisco 2021; Shadmehr and Boleslavsky 2022).

Consequently, similar results hold if the regime's strength is independent across periods, an assumption that fits settings in which sufficient time has passed since the first revolt. But suppose there are genuine informational linkages across periods, can our findings continue to hold?

To see the forces at work once information linkages are reintroduced, recall that regime change is more likely in the material rewards setting in the first period ($\theta_1^m > \theta_1^p$). Therefore, upon observing that the regime has survived the rebellion, citizens in the material rewards settings infer that the regime is stronger than citizens in the psychological rewards settings do. That is, the direct informational effect of early failures makes citizens more pessimistic about the likelihood of success in the material rewards settings than in the psychological rewards setting, reinforcing the effect of committed core. Hence, there is reason for optimism that the overall finding that rebellions characterized by psychological motivations will be more resilient following early failures is robust. Below we show computational results consistent with that intuition.

Lemma 1 in the proof of Proposition 5 shows how equilibrium regime change thresholds can be calculated away from the limit of vanishingly small noise. Suppose $a = 0.8$ and $c = 0.2$, so that $\theta_1^p = 1-c = 0.8$ and $\theta_1^m = e^{-c} \approx 0.82$. Moreover, suppose the noise is normally distributed with the standard deviation of the average signal being σ. When $\sigma = 0.01$, we have: $\theta_2^p \approx 0.84$ and $\theta_2^m \approx 0.85$. Thus, consistent with Proposition 5, $\theta_2^p - \theta_1^p \approx 0.04 > \theta_2^m - \theta_1^m \approx 0.03$—the presence of a committed core has a larger impact in the setting with psychological rewards. Conditional on failure in the first period, the chances of success is higher in the psychological rewards setting than in the material rewards setting.

Now, suppose we increases the noise to $\sigma = 0.02$, further moving away from the limiting case of vanishingly small noise. We still have $\theta_1^p = 1 - c = 0.8$ and $\theta_1^m = e^{-c} \approx 0.82$. In second period of the psychological rewards setting, we have $\theta_2^p \approx 0.838 > \theta_1^p$ and the revolution might succeed in the second period after failing in the first period. By contrast, in the second period of the material rewards setting, the likelihood of success is 0. This case is a stark example of our finding that conditional on failure in the first period, the chances of success is higher in the psychological rewards setting than in the material rewards setting.

Our findings also do not depend critically on the assumption of a uniform prior. To see this, consider an example with a normal prior about θ.[13] Suppose that $a = 0.6$, $c = 0.7$, $\theta \sim N(0, 2)$,

[13]Generally, the information that the regime has survived is like a public signal about the regime's strength. This public signal changes the common prior between periods. Given this new common prior, the analysis of the second period is closely related to that of the static game, but with a general prior. In Online Appendix B, we provide an analysis of the static game with a general prior.

and that noise is distributed iid across citizens and periods according to $N(0, 0.25)$. Now, $\theta_1^p \approx 0.305$ and $\theta_1^m \approx 0.505$. As in our previous example, there is still a finite threshold in the psychological motivations setting, $\theta_2^p \approx 0.511$, and a positive probability of the revolution succeeding in the second period. But in the material motivations case, the revolution will surely fail in the second period, again providing a stark illustration of our result. Thus, in all these examples, allowing for an information linkage across periods strengthens the result that conditional on failure in the first period, the chances of success is higher in the psychological rewards setting than in the material rewards setting.

It is worth relating this dynamic extension of our model to two strains of the literature.

First, we distinguish our approach to modeling the dynamics of rebellion and repression from that of Tsebelis and Sprague (1989) and Francisco (2009). Those analyses adopt phenomenological models of predator-prey from mathematical biology. Tsebelis and Sprague (1989) posit that revolutionary activity R and state repression C follow two linear differential equations $dR/dt = -a_1R + b_1C + d_1,\ dC/dt = a_2R - b_2C + d_2$, where $a_i, b_i, d_i,\ i = 1, 2$, are constants. Francisco (2009) considers the non-linear Lotka-Volterra equations, with interaction terms $R \times C$ instead of C. Methodologically, they focus on phenomenological modeling, in which aggregate behavior is assumed to follow a form of differential equations. In contrast, in our approach, actors make intentional decisions to achieve their goals given their constraints. As Tsebelis and Sprague (1989) argue, their approach "alienates strategic choices by historical actors from the process in which they participate in favor of some impersonal logic of revolutionary processes" (pp. 555–6). Thus, while we focus on strategic interactions, "agency is immaterial to the formalism" (Tsebelis and Sprague 1989, p. 555) that they use. Substantively, our models share the feature that, all else equal, earlier mobilization facilitates later mobilization—in the above formulation, higher R_t begets higher R_{t+1}. The size of this effect as well as the impact of repression are captured by the constants of their equations. Thus, while variations in motivation, strategic interactions, and endogenous choices of mobilization and repression are collapsed in those constants in their models, we aimed to study these features.

Second, we compare the role played by the committed core in our model to that played by revolutionary vanguards in models of rebellion. Our model of the committed core is most similar to models of vanguards as "early-risers"—anti-government activists who come to the streets early to inspire regime change (Kuran 1991; Lohmann 1994; Tarrow 2011; Shadmehr and Bernhardt 2019). Indeed, this is precisely the effect of our committed core in the version of our model with psychological motivations. However, as the analysis above shows, the effects of the committed core are different with material incentives. In particular, the presence of congestion externalities creates off-setting effects—a committed core makes victory more likely, but reduces the expected rewards of such a victory. These competing effects have not previously been discussed in the literature on vanguards.

Conclusion

We explored the interaction between rebel motivations, rebel mobilization, and government repression. We showed that, movements with material rewards are less affected by repression and face less repression, while movements with psychological rewards are more resilient to repressive efforts that result in early failures but leave behind a committed core. A key ingredient of the underlying logic is the rivalry of material rewards versus the non-rivalry of psychological rewards—the other key ingredient is strategic uncertainty as Propositions 1 and 2 reveal. The effects of these motivations is complicated by the presence of coordination concerns among citizens. We show that, because material rewards must be shared upon success, repression has less influence on movements with material motives: such changes decrease the likelihood of success, but by decreasing participation they also increase the rewards of success in movements with material motives. The model yielded both positive empiric predictions, as well as results about confounding and heterogeneous treatment effects that may help understand why empirical studies find inconsistent results.

In addition to these empirical implications, these insights have policy implications. Policy makers should be more concerned about the existence of a committed core or vanguard when confronting movements with psychological and ideological motives rather than material motives. And, for this reason, they should be more cautious about the long-run efficacy of early victories when facing a group whose members are psychologically or ideologically motivated, as they are more resilient to such early failures than are movements using primarily material motives. By contrast, policy makers should recognize that movements motivated by material reward are more resilient to repression. Combining these observations suggests the optimal policy that aims to reduce the chances of success are qualitatively different across movements whose members are differentially motivated. When dealing with movements whose members are motivated by psychological or ideological rewards, the focus should be on the raising the costs of participation. In contrast, in dealing with movements whose members are materially motivated, it might be more effective to focus on reducing the material rewards that participants hope to gain should the movement succeed.

Our analysis also suggests avenues for future research. First, we introduced incomplete information into our model as a form of equilibrium selection, which allowed us to focus on how the efficacy of different types of repression depends on motivations. But we largely abstracted away from the substantive effects of information itself. Future work might explore how different sources of uncertainty interact with motivations and repression. Second, our results suggest hypotheses about the heterogeneous treatment effects of both repression and economic shocks that have not been investigated but which we hope will motivate future empirical work.

Appendix: Proofs

Proof of Proposition 1: When $\theta < 1$, the regime collapses if almost all citizens rebel, so that $m = a$. Thus, when $\theta < 1$, a citizen rebels if she believes that almost all others will rebel, because her payoff from rebelling will be $1 - c > 0$. When $\theta \geq 0$, the regime survives if almost no citizen rebels, so that $m = 0$. Thus, when $\theta \geq 0$, a citizen does not rebel if she believes that almost no other citizen will rebel, because her payoff from rebelling will be $-c < 0$. $\square$

Proof of Proposition 2: We look for symmetric monotone equilibria in which a citizen rebels if and only if her signal is below a finite threshold $x_i < x^m$. A monotone strategy implies that the regime collapses if and only if $\theta < \theta^m$, where

$$\Pr(x_i < x^m|\theta^m) = \theta^m \quad \text{(belief consistency).} \tag{7}$$

A citizen with signal x_i rebels if and only if her expected payoff from rebellion exceeds its costs:

$$E\left[\mathbf{1}_{\{\theta<\theta^m\}} \cdot \frac{a}{m}\middle| x_i\right] = E\left[\mathbf{1}_{\{\theta<\theta^m\}} \cdot \frac{a}{a\Pr(x_j < x^m)}\middle| x_i\right] = \int_{\theta=-\infty}^{\theta^m} \frac{\text{pdf}(\theta|x_i)}{\Pr(x_j < x^m|\theta)} d\theta > c. \tag{8}$$

If a symmetric finite threshold equilibrium exists, the marginal citizen who receives the threshold signal $x_i = x^m$ must be indifferent between rebelling or not. Moreover, as Shadmehr (2019b, Lemma 3) shows, when there is no prior information about θ, the marginal citizen believes that the size of the rebellion is uniformly distributed. Thus, the marginal citizen's expected payoff from rebellion and the indifference condition become

$$\int_{\Pr(x_j<x^m|\theta^m)}^{1} \frac{du}{u} = -\log(\Pr(x_j < x^m|\theta^m)) = c.$$

Combining this with (7) yields $-\log(\theta^m) = c$, so that the unique equilibrium regime change threshold is

$$\theta^m = e^{-c}. \tag{9}$$

Alternatively, let $z(\hat{\theta}) = \Pr(\theta < \hat{\theta}|x_i = x^m)$, with $z^m = \Pr(\theta < \theta^m|x_i = x^m)$. Because there is no prior information about θ: $\Pr(\theta < \theta^m|x_i = x^m) = 1 - \Pr(x_i < x^m|\theta = \theta^m)$. Thus, $1 - z^m = \theta^m$. Moreover, the left hand side of the inequality (8) can be re-written in terms of z, so that the indifference condition becomes:

$$\int_{\theta=-\infty}^{\theta^m} \frac{\text{pdf}(\theta|x_i = x^m)}{\Pr(x_j < x^m|\theta)} d\theta = \int_{z=0}^{z^m} \frac{dz}{1-z} = -log(1-z)\Big|_{z=0}^{z^m} = -log(1-z^m) = c. \tag{10}$$

Because $1 - z^m = \theta^m$, this shows $\theta^m = e^{-c}$.

It remains to show that the best response to a monotone strategy is also monotone. Let $\pi(\theta) = \mathbf{1}_{\{\theta<\theta^m\}} \cdot \frac{1}{\Pr(x_j<x^m|\theta)} - c$. If $c \in (0, 1)$, then $\pi(\theta)$ has a single-crossing property. Because (x, θ) satisfy monotone likelihood ration property, by Karlin's theorem (Shadmehr 2019b, Online Appendix), single-crossing property holds under the integral transformation in (8), and the best response to a monotone strategy is also monotone. This means that the marginal citizen with signal $x_i = x^m$ must be indifferent between rebelling or not. □

Proof of Proposition 3: From Proposition 2,

$$\frac{\partial\theta^p}{\partial c} = -1 < -e^{-c} = \frac{\partial\theta^m}{\partial c},$$

where the inequality follows from $e^c > 1$ for $c > 0$. □

Proof of Proposition 4: From Proposition 2, the government's marginal benefit of raising repression level c is (weakly) decreasing in both settings, with $\frac{\partial\theta^p}{\partial c} < \frac{\partial\theta^m}{\partial c} < 0$. Thus, the government's optimal repression level is interior, and $c^p > c^m$. Moreover, from Proposition 2, $\theta^p(c) < \theta^m(c)$. Thus, $\theta^p(c^p) < \theta^p(c^m) < \theta^m(c^m)$. □

Proof of Proposition 5: First, we prove a lemma that characterizes finite cutoff equilibria.

Lemma 1 $\theta_2^m > \max\{\theta_1^m, 1-a\}$ *is an equilibrium regime change threshold of the material rewards setting if and only if is satisfies*

$$\theta_2^m = \left(1 - a + aF\left(\frac{\theta_2^m - \theta_1^m}{\sigma} + F^{-1}\left(\frac{\theta_2^m - (1-a)}{a}\right)\right)\right) e^{-ac\ F\left(\frac{\theta_2^m - \theta_1^m}{\sigma} + F^{-1}\left(\frac{\theta_2^m - (1-a)}{a}\right)\right)} \tag{11}$$

and $\theta_2^p > \max\{\theta_1^p, 1-a\}$ *is an equilibrium regime change threshold of the psychological rewards setting if and only if is satisfies*

$$\theta_2^p = 1 - a + a(1-c)F\left(\frac{\theta_2^p - \theta_1^p}{\sigma} + F^{-1}\left(\frac{\theta_2^p - (1-a)}{a}\right)\right). \tag{12}$$

Proof of Lemma 1: We first consider the material rewards setting. From equation (4), the marginal citizen's net expected payoff from rebellion is:

$$E\left[\frac{\mathbf{1}_{\{\theta<\theta_2^m\}}}{1-a+a\Pr(x_j<x_2^m)}\middle| x_i=x_2^m,\theta\geq\theta_1^m\right]$$

$$= \int_{\theta_1^m}^{\theta_2^m}\frac{1}{1-a+a\Pr(x<x_2^m|\theta)}\frac{\text{pdf}(\theta|x_2^m)}{\Pr(\theta>\theta_1^m|x_2^m)}d\theta$$

$$= \int_{\theta_1^m}^{\theta_2^m}\frac{1}{1-a+aF\left(\frac{x_2^m-\theta}{\sigma}\right)}\frac{f\left(\frac{x_2^m-\theta}{\sigma}\right)g(\theta)}{\int_{\theta_1^m}^{\infty}f\left(\frac{x_m-\theta}{\sigma}\right)g(\theta)d\theta}\,d\theta \quad (\text{let } g(\theta) \text{ be the prior pdf of } \theta)$$

$$= \frac{\int_{\theta_1^m}^{\theta_2^m}\frac{f\left(\frac{x_2^m-\theta}{\sigma}\right)}{1-a+aF\left(\frac{x_2^m-\theta}{\sigma}\right)}d\theta}{\int_{\theta_1^m}^{\infty}f\left(\frac{x_2^m-\theta}{\sigma}\right)d\theta} \quad (g(\theta)=1 \text{ for uniform}).$$

Thus,

$$E\left[\frac{\mathbf{1}_{\{\theta<\theta_2^m\}}}{1-a+a\Pr(x_j<x_2^m)}\middle| x_i=x_2^m,\theta\geq\theta_1^m\right] = \frac{\frac{1}{a}\log\left(\frac{1-a+aF\left(\frac{x_2^m-\theta_1^m}{\sigma}\right)}{1-a+aF\left(\frac{x_2^m-\theta_2^m}{\sigma}\right)}\right)}{F\left(\frac{x_2^m-\theta_1^m}{\sigma}\right)}$$

$$= \frac{1}{a}\frac{\log\left(\frac{1-a+aF\left(\frac{x_2^m-\theta_1^m}{\sigma}\right)}{\theta_2^m}\right)}{F\left(\frac{x_2^m-\theta_1^m}{\sigma}\right)}, \tag{13}$$

where the last equality follow from equation (3). Substituting from (13) into (4) yields:

$$\log\left(1-a+aF\left(\frac{x_2^m-\theta_1^m}{\sigma}\right)\right)-\log(\theta_2^m)=acF\left(\frac{x_2^m-\theta_1^m}{\sigma}\right). \tag{14}$$

Substituting x_2^m from (3) into (14) yields:

$$\theta_2^m=\left(1-a+aF\left(\frac{\theta_2^m-\theta_1^m}{\sigma}+F^{-1}\left(\frac{\theta_2^m-(1-a)}{a}\right)\right)\right)\; e^{-ac\;F\left(\frac{\theta_2^m-\theta_1^m}{\sigma}+F^{-1}\left(\frac{\theta_2^m-(1-a)}{a}\right)\right)}. \tag{15}$$

Similarly for the psychological rewards setting, from equation (6), the marginal citizen's net expected payoff from rebellion is:

$$E\left[\mathbf{1}_{\{\theta<\theta_2^p\}}\middle| x_i=x_2^p,\theta\geq\theta_1^p\right]=\frac{F\left(\frac{x_2^p-\theta_1^p}{\sigma}\right)-F\left(\frac{x_2^p-\theta_2^p}{\sigma}\right)}{F\left(\frac{x_2^p-\theta_1^p}{\sigma}\right)}. \tag{16}$$

Thus, any (θ_2^p, x_2^p) that satisfied the following equations constitute an equilibrium.

$$1 - a + aF\left(\frac{x_2^p - \theta_2^p}{\sigma}\right) = \theta_2^p \quad \text{and} \quad \frac{F\left(\frac{x_2^p - \theta_1^p}{\sigma}\right) - F\left(\frac{x_2^p - \theta_2^p}{\sigma}\right)}{F\left(\frac{x_2^p - \theta_1^p}{\sigma}\right)} = c. \tag{17}$$

Substituting x_2^p from the belief consistency condition into the indifference condition yields:

$$\theta_2^p = 1 - a + a(1-c)F\left(\frac{\theta_2^p - \theta_1^p}{\sigma} + F^{-1}\left(\frac{\theta_2^p - (1-a)}{a}\right)\right) \tag{18}$$

□

Lemma 2

$$\lim_{\sigma \to 0} \max\{\theta_2^p(\sigma)\} = 1 - a + a(1-c) \quad \textit{and} \quad \lim_{\sigma \to 0} \max\{\theta_2^m(\sigma)\} = e^{-ac}.$$

Proof of Lemma 2: When $\theta_2^m > \max\{\theta_1^m, 1-a\}$, we have:

$$\lim_{\sigma \to 0} F\left(\frac{\theta_2^m - \theta_1^m}{\sigma} + F^{-1}\left(\frac{\theta_2^m - (1-a)}{a}\right)\right) = 1. \tag{19}$$

Thus, the right hand side of (11) approaches e^{-ac}, so that the largest crossing of the 45 degree line approaches e^{-ac}:

$$\lim_{\sigma \to 0} \max\{\theta_2^m(\sigma)\} = e^{-ac}.$$

Similarly,

$$\lim_{\sigma \to 0} \max\{\theta_2^p(\sigma)\} = 1 - a + a(1-c).$$

□

Lemma 2 reflects that when noise in private signals is small, citizens discard their public information. Thus, the informational channel is shut down in the limit. From Lemma 2 and Proposition 2,

$$\Delta^m = \lim_{\sigma \to 0} \max\{\theta_2^m(\sigma)\} - \theta_1^m = e^{-ac} - e^{-c} \quad \text{and} \quad \Delta^p = \lim_{\sigma \to 0} \max\{\theta_2^p(\sigma)\} - \theta_1^p = (1-a)c. \tag{20}$$

$\Delta^m < \Delta^p$ if and only if $\frac{e^{-c} - e^{-ac}}{c - ac} > -1$, which is true because e^{-x} is strictly decreasing and convex with $\left.\frac{de^{-x}}{dx}\right|_{x=0} = -1$.

To calculate conditional probabilities, suppose $\theta \sim G$, while we recognize that $G = U[-l, u]$ is a uniform distribution, where $l, u > 0$ are large. We want to show

$$\frac{G(e^{-ac}) - G(e^{-c})}{1 - G(e^{-c})} < \frac{G(1 - a + a(1-c)) - G(1-c)}{1 - G(1-c)}.$$

Because G is uniform

$$\frac{e^{-ac} - e^{-c}}{u - e^{-c}} < \frac{(1-a)c}{u - (1-c)}, \text{ i.e., } \frac{e^{-ac} - e^{-c}}{(1-a)c} < \frac{u - e^{-c}}{u - (1-c)}.$$

Because the right hand side is increasing in u, it suffices to show that the inequality holds for $u = 1$, i.e.,

$$\frac{e^{-ac} - e^{-c}}{(1-a)c} < \frac{1 - e^{-c}}{1 - (1-c)}, \text{ i.e., } a < \frac{1 - e^{-ac}}{1 - e^{-c}},$$

which holds for all $a, c \in (0, 1)$. □

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Online Appendices

Mixed Motivations

We have compared the two extreme kinds of rewards, purely material or purely psychological. But as Kennedy (1999) aptly puts in his study of "the rumbles of discontent" during the Great Depression, people "can subsist on solely spiritual nourishment little longer than they can live on bread alone" (218).[14] We now analyze movements in which incentives to rebel are a combination of material and psychological rewards. We generalize our payoffs in Figure 1 by adding a parameter $\bar{m} \in [0,1]$ that generates our purely material rewards setting in one extreme ($\overline{m} = 0$) and our purely psychological rewards setting in the other extreme ($\overline{m} = 1$). Figure 4 shows the payoffs—we normalize the population size to 1.

	outcome: $m \geq \theta$	outcome: $m < \theta$
rebel	$\frac{1}{\overline{m}}(\mathbf{1}_{\{m\leq\overline{m}\}} + \mathbf{1}_{\{m\geq\overline{m}\}} \cdot \frac{\overline{m}}{m}) - c$	$-c$
not rebel	0	0

Figure 4: Payoffs combining material and psychological motivations.

Proposition 6 characterizes the unique equilibrium. Figure 5 illustrates the result.

Proposition 6 *Let θ^* be the equilibrium regime change threshold in the setting with mixed motivations. Then,*

$$\theta^* = \begin{cases} e^{-c} & ; \overline{m} \leq e^{-c} \\ \overline{m}\ (1 - c - \log(\overline{m})) & ; \overline{m} \geq e^{-c}. \end{cases}$$

Moreover, $\theta^m > \theta^*(\overline{m}) > \theta^p$ for $\overline{m} \in (0,1)$, with $\lim_{\overline{m}\to 0} \theta^* = \theta^m$ and $\lim_{\overline{m}\to 1} \theta^* = \theta^p$.

Proof of Proposition 6: The net payoff from rebelling versus not is:

$$\frac{1}{\overline{m}} \left(\mathbf{1}_{\{\theta<m, m\leq\overline{m}\}} + \mathbf{1}_{\{\theta<m, m\geq\overline{m}\}} \cdot \frac{\overline{m}}{m} \right) - c \tag{21}$$

[14] Kennedy, David M. 1999. *Freedom from Fear: The American People in Depression and War, 1929-1945.* New York: Oxford University Press.

As in the pure material rewards setting, this net payoff is non-monotone in the fraction of rebels m. It jumps up at $m = \theta$ (the threshold at which regime change succeeds), but then falls, weakly is some range and strictly in others, as more citizens join the movement.

As before, given a value of θ, the fraction of rebels is $m(\theta) = \Pr(x < x^*|\theta)$, and $\Pr(x_i < x^*|\theta^*) = \theta^*$. Moreover, $m(\theta) < \overline{m}$ if and only if $\theta > \bar{\theta}$, where $\Pr(x_i < x^*|\bar{\theta}) = \overline{m}$. Then, the net expected payoff from rebellion versus not is:

$$\int_{\theta=-\infty}^{\infty} \frac{1}{\overline{m}} \left(\mathbf{1}_{\{\theta<\theta^*,\theta\geq\bar{\theta}\}} + \mathbf{1}_{\{\theta<\theta^*,\theta\leq\bar{\theta}\}} \cdot \frac{\overline{m}}{\Pr(x_i < x^*|\theta)} \right) \text{pdf}(\theta|x_i) - c. \tag{22}$$

As before, if $c < \min\{1, 1/\overline{m}\} = 1$, we can invoke the Karlin's Theorem to conclude to that the best response to a monotone strategy is also monotone. The indifference condition is:

$$\int_{\theta=-\infty}^{\infty} \left(\mathbf{1}_{\{\theta<\theta^*,\theta\geq\bar{\theta}\}} + \mathbf{1}_{\{\theta<\theta^*,\theta\leq\bar{\theta}\}} \cdot \frac{\overline{m}}{\Pr(x_i < x^*|\theta)} \right) \text{pdf}(\theta|x_i = x^*) = \overline{m}\ c. \tag{23}$$

First, suppose $\bar{\theta} > \theta^*$. Then,

$$\int_{\theta=-\infty}^{\infty} \mathbf{1}_{\{\theta<\theta^*\}} \cdot \frac{\overline{m}}{\Pr(x_i < x^*|\theta)}\ \text{pdf}(\theta|x_i = x^*) = \overline{m}\ c. \tag{24}$$

Thus,

$$\theta^* < \bar{\theta}\ \Rightarrow\ \theta^* = e^{-c}, \tag{25}$$

where we recognize that $\bar{\theta}$ is endogenous and depends on x^*. However, recall that $\Pr(x < x^*|\bar{\theta}) = \overline{m}$ and $\Pr(x < x^*|\theta^*) = \theta^*$. Thus, $\theta^* < \bar{\theta}$ is equivalent to $\theta^* > \overline{m}$. Given (25), $\theta^* > \overline{m}$ is equivalent to: $-c > \log(\overline{m})$.

Next, suppose $\bar{\theta} < \theta^*$, i.e., $\theta^* < \overline{m}$. Then,

$$\begin{aligned} \overline{m}\ c &= \int_{\theta=-\infty}^{\bar{\theta}} \frac{\overline{m}}{\Pr(x_i < x^*|\theta)}\ \text{pdf}(\theta|x_i = x^*)d\theta + \int_{\bar{\theta}}^{\theta^*} \text{pdf}(\theta|x_i = x^*)d\theta \\ &= -\overline{m}\ \log(1 - \Pr(\theta < \bar{\theta}|x_i = x^*)) + \Pr(\theta < \theta^*|x_i = x^*) - \Pr(\theta < \bar{\theta}|x_i = x^*). \end{aligned} \tag{26}$$

Substituting for $\Pr(x_i < x^*|\bar{\theta}) = \overline{m} = 1 - \Pr(\theta < \bar{\theta}|x_i = x^*)$ and $\Pr(\theta < \theta^*|x_i = x^*) = 1 - \theta^*$ yields $-\overline{m}\ \log(\overline{m}) + \overline{m} - \theta^* = \overline{m}\ c$, i.e.,

$$\theta^* = \overline{m}\ (1 - \log(\overline{m})) - \overline{m}\ c. \tag{27}$$

Thus, $\theta^* < \overline{m}$ if and only if $-c < \log(\overline{m})$.

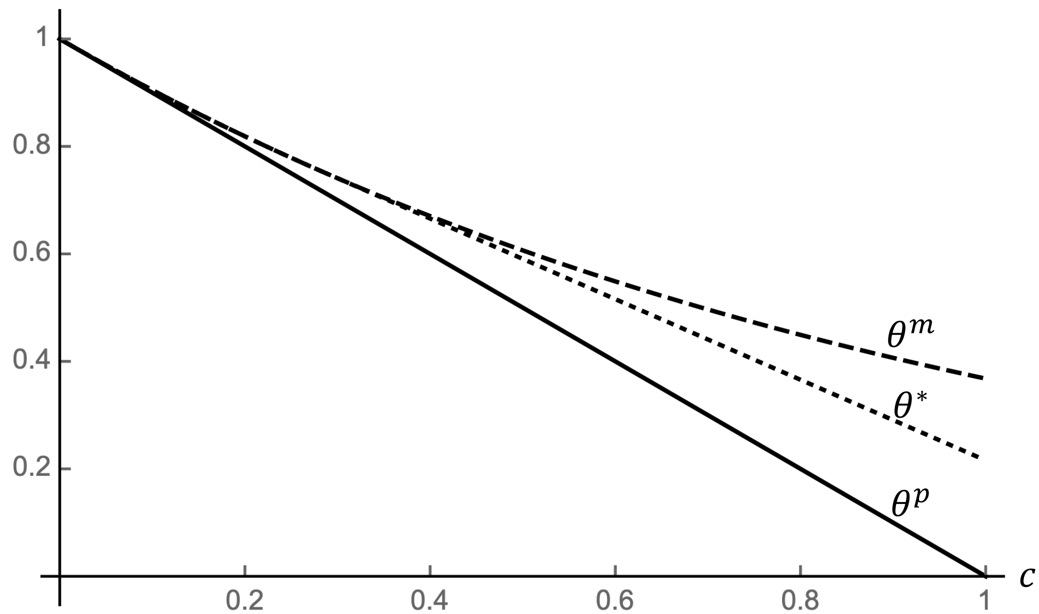

Figure 5: The equilibrium regime change threshold for the settings with pure psychological rewards (solid line, θ^p), pure material rewards (dashed curve, θ^m), and a mix of psychological and material rewards (dotted curve, θ^*). Parameters: $\overline{m} = 0.75$.

Combining this results yield:

$$\theta^* = \begin{cases} e^{-c} & ; c \leq -\log(\overline{m}) \\ \\ \overline{m}\,(1 - c - \log(\overline{m})) & ; c \geq -\log(\overline{m}) \end{cases} \tag{28}$$

We observe that

$$\left.\frac{\theta^*(c)}{dc}\right|_{c=-\log(\overline{m})} = -\overline{m}.$$

$\square$

Proposition 6 and Figure 5 show that when motivations are a mix of psychological and material, the effects of repression and early failure lie in between those effects in the settings with material and psychological rewards analyzed earlier. The key intuition comes from thinking about the extent to which rewards are rival. In the pure material rewards setting, rewards are entirely rival. In the pure psychological rewards setting, rewards are entirely non-rival. In this mixed setting, we can think of some portion of the rewards as being rival and another portion being non-rival.

Interestingly, this points to a different interpretation of this version of the model, where we interpret the rewards as material, but imperfectly divisible, such as promises to hold future government office. Suppose there are a total of $\overline{m}$ offices available. If the rebellion is small, $m < \overline{m}$, and succeeds, each participant in the rebellion gets an office. But there are too many offices for the rebels to fill all of them. So some offices must be left in the hands of their previous holders. (Think of a small rebel group not fully purging the bureaucracy after taking control of the state.) However, if the rebellion is large, $m > \overline{m}$, there are not enough offices to go around and the congestion externality returns. So, if the number of participants is smaller than the number of offices, an increase in participation in the rebellion does not diminish the rewards an individual enjoys should they success. For example, if 1000 offices are available, whether 600 or 800 citizens rebel, there are enough offices for each to get one. This feature shares the non-rival aspect of the psychological rewards setting. However, if the number of participants exceed 1000, further increases in the number of participants reduces the chances that each rebel receives an office upon success because there will not be enough government offices to go around. This feature shares the rival aspect of the material rewards setting.

The real world, of course, is not so clear cut. More offices can be created and responsibilities may be shared. However, the insight that government offices tend to be more discrete than, for example, cash, diamonds, or land remains true. As such, in settings where such offices are the main reward of victory, the effect of repression on the rebel movement falls between the effects in settings with pure (continuous) material rewards and settings with psychological rewards.

Relaxing Informational Assumptions

In the text, we focused on the case in which players share a prior that θ is distributed uniformly on $\mathbb{R}$ (improper prior). With a smooth (proper) prior, the same results obtain in the limit when the information content of the prior becomes vanishingly small, e.g., $\theta \sim N(\mu, \sigma_0)$ when σ_0 becomes unboundedly large. Here, we show that the same results also obtain for any smooth prior in the limit when the noise becomes vanishingly small ($\sigma \to 0$). We then provide numerical examples for a standard normal prior for both the case of a uniform distribution of noise and a standard normal distribution of noise. Finally, we provide additional numerical examples for the effect of a public signal about the strength of the regime (θ) in both settings with psychological and material rewards.

Consider the setting in the text, but suppose $\theta \sim G$, where $G(\cdot)$ is smooth and $G(\theta) \in (0,1)$ for all $\theta \in \mathbb{R}$. Let $g(\cdot)$ be the corresponding pdf. We begin by proving that $\theta^m > \theta^p$. From the belief consistency condition, $x^j = \theta^j + \sigma F^{-1}(\theta^j/a)$, $j \in \{p, m\}$. Because the right hand side is increasing in θ^j, it is invertible. Define $\Omega(\cdot)$, so that $\theta^j = \Omega(x^j)$. Thus, the indifference conditions can be written as:

$$c = \int_{-\infty}^{\Omega(x^m)} \frac{\text{pdf}(\theta|x^m)}{F\left(\frac{x^m-\theta}{\sigma}\right)} d\theta = \int_{-\infty}^{\Omega(x^p)} \text{pdf}(\theta|x^p) d\theta. \tag{29}$$

Because $F(\cdot)$ in the denominator is less that 1, we have:

$$c < \int_{-\infty}^{\Omega(x^p)} \frac{\text{pdf}(\theta|x^p)}{F\left(\frac{x^p-\theta}{\sigma}\right)} d\theta.$$

Thus, $x^m = x^p$ (and hence $\theta^m = \theta^p$) cannot be part of the equilibrium in the material rewards setting. x^m (and hence θ^m) must adjust to restore the equilibrium. In the stable equilibrium, they must increase, so that higher costs c imply higher likelihoods of regime change. Thus, we have:

Proposition 7 *In a stable equilibrium of the material rewards setting, $\theta^m > \theta^p$.*

To further characterize the equilibrium regime change thresholds, we provide analytical results when the noise is very small ($\sigma \to 0$) and numeral results when noise is larger.

Analytical Results for Vanishingly Small Noise

Lemma 3 *θ^j, $j \in \{p, m\}$, is an equilibrium regime change threshold if it satisfies the following equation:*

$$c = \Gamma_j(\theta^j;\sigma) \equiv \frac{\int_{F^{-1}(\theta^j/a)}^{\infty} f(z)\ g(\theta^j + \sigma(F^{-1}(\theta^j/a) - z))\ \frac{1}{\mathbf{1}_{\{j=m\}}F(z)+\mathbf{1}_{\{j=p\}}}dz}{\int_{-\infty}^{\infty} f(z)\ g(\theta^j + \sigma(F^{-1}(\theta^j/a) - z))\ dz},$$

where $\mathbf{1}_{\{\cdot\}}$ is the indicator function.

Proof of Lemma 3: The belief consistency condition is:

$$\frac{\theta^j}{a} = F\left(\frac{x^j - \theta^j}{\sigma}\right). \tag{30}$$

The indifference condition is:

$$\begin{aligned}
c &= \int_{\theta=-\infty}^{\theta^j} \text{pdf}(\theta|x^j)\ \frac{1}{\mathbf{1}_{\{j=m\}}F\left(\frac{x^m-\theta}{\sigma}\right) + \mathbf{1}_{\{j=p\}}}\ d\theta \\
&= \int_{\theta=-\infty}^{\theta^j} \frac{f\left(\frac{x^j-\theta}{\sigma}\right) g(\theta)}{\int_{\theta=-\infty}^{\infty} f\left(\frac{x^j-\theta}{\sigma}\right) g(\theta) d\theta}\ \frac{1}{\mathbf{1}_{\{j=m\}}F\left(\frac{x^m-\theta}{\sigma}\right) + \mathbf{1}_{\{j=p\}}}\ d\theta \\
&= \int_{z=z^j}^{\infty} \frac{f(z)\, g(x^j - \sigma z)}{\int_{z=-\infty}^{\infty} f(z)\, g(x^j - \sigma z) dz}\ \frac{1}{\mathbf{1}_{\{j=m\}}F(z) + \mathbf{1}_{\{j=p\}}}\ dz \\
&= \int_{z=F^{-1}(\theta^j/a)}^{\infty} \frac{f(z)\, g(\theta^j + \sigma(F^{-1}(\theta^j/a) - z))}{\int_{z=-\infty}^{\infty} f(z)\, g(\theta^j + \sigma(F^{-1}(\theta^j/a) - z)) dz}\ \frac{1}{\mathbf{1}_{\{j=m\}}F(z) + \mathbf{1}_{\{j=p\}}}\ dz \quad \text{(from (30))},
\end{aligned}$$

where, in the third equality, we did a change of variables from θ to $z = \frac{x^j-\theta}{\sigma}$, with $z^j = \frac{x^j-\theta^j}{\sigma}$. □

In the limit when $\sigma \to 0$, the terms involving $g(\cdot)$ in Lemma 3 will cancel, and θ^j simplifies to those in Proposition 2 in the text with improper uniform prior.

Proposition 8 *In the limit when the noise become vanishingly small ($\sigma \to 0$) we have:*

$$\lim_{\sigma\to 0} \Gamma_j(\theta^j;\sigma) = \begin{cases} 1 - \theta^p/a & ; j = p \\ -\log(\theta^m/a) & ; j = m, \end{cases}$$

so that $\theta^p = a(1-c)$ and $\theta^m = ae^{-c}$.

Proof of Proposition 8: From Lemma 3,

$$\lim_{\sigma\to 0} \Gamma_j(\theta^j;\sigma) = \int_{F^{-1}(\theta^j/a)}^{\infty} f(z)\ \frac{1}{\mathbf{1}_{\{j=m\}}F(z) + \mathbf{1}_{\{j=p\}}} dz = \begin{cases} 1 - F(F^{-1}(\theta^p/a)) & ; j = p \\ \log(1) - \log(F(F^{-1}(\theta^m/a))) & ; j = m. \end{cases}$$

□

An Example: Uniform Noise

We next provide a simple example to demonstrate a special case of this general result. Suppose $F = U[-1, 1]$. Then,

$$\text{pdf}(\theta|x_i) = \frac{\text{pdf}(x_i|\theta)g(\theta)}{\int_{-\infty}^{\infty} \text{pdf}(x_i|\theta)g(\theta)d\theta} = \begin{cases} \frac{\frac{1}{2\sigma}g(\theta)}{\int_{x_i-\sigma}^{x_i+\sigma} \frac{1}{2\sigma}g(\theta)d\theta} = \frac{g(\theta)}{G(x_i+\sigma)-G(x_i-\sigma)} & ; \theta - \sigma \leq x_i \leq \theta + \sigma \\ 0 & ; otherwise. \end{cases} \tag{31}$$

Thus, for a given $\hat{\theta}$ and $\hat{x}$,

$$\Pr(\theta < \hat{\theta}|x_i = \hat{x}) = \begin{cases} 0 & ; \hat{\theta} \leq \hat{x} - \sigma \\ \frac{G(\hat{\theta})-G(\hat{x}-\sigma)}{G(\hat{x}+\sigma)-G(\hat{x}-\sigma)} & ; \hat{x} - \sigma \leq \hat{\theta} \leq \hat{x} + \sigma \\ 1 & ; \hat{x} + \sigma \leq \hat{\theta}. \end{cases} \tag{32}$$

Similarly,

$$\Pr(x_i < \hat{x}|\theta = \hat{\theta}) = \begin{cases} 1 & ; \hat{\theta} \leq \hat{x} - \sigma \\ \frac{\hat{x}-(\hat{\theta}-\sigma)}{2\sigma} & ; \hat{x} - \sigma \leq \hat{\theta} \leq \hat{x} + \sigma \\ 0 & ; \hat{x} + \sigma \leq \hat{\theta}. \end{cases} \tag{33}$$

Lemma 4 *For any $\hat{x}$ and $\hat{\theta}$, we have:*

$$\lim_{\sigma \to 0} \Pr(\theta < \hat{\theta}|x_i = \hat{x}) = 1 - \lim_{\sigma \to 0} \Pr(x_i < \hat{x}|\theta = \hat{\theta}).$$

Proof of Lemma 4: From equations (32) and (33), the result is immediate for the cases of $\hat{\theta} \leq \hat{x} - \sigma$ and $\hat{x} + \sigma \leq \hat{\theta}$. For completeness, consider $\hat{x} - \sigma \leq \hat{\theta} \leq \hat{x} + \sigma$ and equation (32). Using a Taylor's expansion, in the limit $\sigma \to 0$, we have:

$$\begin{aligned} G(\hat{\theta}) - G(\hat{x} - \sigma) &= G(\hat{x} + (\hat{\theta} - \hat{x})) - G(\hat{x} - \sigma) = G(\hat{x}) + g(\hat{x})(\hat{\theta} - \hat{x}) - (G(\hat{x}) - g(\hat{x})\sigma) \\ &= g(\hat{x})(\hat{\theta} - \hat{x} + \sigma). \end{aligned} \tag{34}$$

Similarly,

$$G(\hat{x} + \sigma) - G(\hat{x} - \sigma) = G(\hat{x}) + g(\hat{x})\sigma - (G(\hat{x}) - g(\hat{x})\sigma) = g(\hat{x})2\sigma. \tag{35}$$

Combining equations (34) and (35), for $\hat{x} - \sigma \leq \hat{\theta} \leq \hat{x} + \sigma$, we have:

$$\lim_{\sigma \to 0} \frac{G(\hat{\theta}) - G(\hat{x} - \sigma)}{G(\hat{x} + \sigma) - G(\hat{x} - \sigma)} = \frac{g(\hat{x})(\hat{\theta} - \hat{x} + \sigma)}{g(\hat{x})2\sigma} = 1 - \frac{\hat{x} - (\hat{\theta} - \sigma)}{2\sigma} = 1 - \Pr(x_i < \hat{x}|\theta = \hat{\theta}).$$

□

As shown in Shadmehr (2019a,b), Lemma 4 is the statistical property that delivers the uniform beliefs property, which, in turn, delivers the result in Proposition 2 in the text.

Numerical Simulations for Larger Noise

We have established the results analytically in the asymptotic cases of vanishingly small noise and no prior information (about θ). The results also hold when the noise is sufficiently small, or there is sufficiently little common knowledge, e.g., the prior is $N(\mu, \sigma_0)$ and σ_0 is sufficiently large. We now provide numerical simulations to show that our results are not limited to the cases of very small noise or very little common knowledge, leaving to future research a fuller characterization of the interactions between information and motivation in contentious settings.

First, we continue the example above by providing a numerical example for the case of standard normal prior distribution and uniform noise distribution: $G = N(0,1)$, $F = U[-1,1]$, and $\sigma = 1$. From equation (33), the belief consistency condition can be written as:

$$\frac{\theta^j}{a} = \min\{1, \max\{0, \frac{1}{2} + \frac{x^j - \theta^j}{2\sigma}\}\},\ j \in \{p, m\}.$$

Because $\theta^j/a \in (0,1)$, we have:

$$\theta^j = \frac{x^j + \sigma}{\frac{2\sigma}{a} + 1},\ j \in \{p, m\}. \tag{36}$$

From equation (31), the indifference condition can be written as:

$$\begin{aligned} c &= \int_{-\infty}^{\theta^j} \frac{g(\theta) \cdot \mathbf{1}_{\{x^j - \sigma \le \theta \le x^j + \sigma\}}}{G(x^j + \sigma) - G(x^j - \sigma)} \frac{1}{\mathbf{1}_{\{j=m\}} \Pr(x_i \le x^j | \theta) + \mathbf{1}_{\{j=p\}}} d\theta \\ &= \int_{x^j - \sigma}^{\theta^j} \frac{g(\theta)}{G(x^j + \sigma) - G(x^j - \sigma)} \frac{1}{\mathbf{1}_{\{j=m\}} \left(\frac{1}{2} + \frac{x^m - \theta}{2\sigma}\right) + \mathbf{1}_{\{j=p\}}} d\theta,\ j \in \{p, m\}. \end{aligned} \tag{37}$$

Substituting from (36) into (37) yields:

$$c = R^j(x^j) \equiv \int_{x^j - \sigma}^{\frac{x^j + \sigma}{\frac{2\sigma}{a} + 1}} \frac{g(\theta)}{G(x^j + \sigma) - G(x^j - \sigma)} \frac{1}{\mathbf{1}_{\{j=m\}} \left(\frac{1}{2} + \frac{x^m - \theta}{2\sigma}\right) + \mathbf{1}_{\{j=p\}}} d\theta,\ j \in \{p, m\}. \tag{38}$$

To demonstrate, suppose $G = N(0,1)$, and $\sigma = a = 1$, so that $\theta^j = \frac{x^j + 1}{3}$. Figure 6 shows $R^j(x^j)$, $j \in \{p, m\}$. Both $R^m(x)$ and $R^p(x)$ are decreasing, so that raising the costs (c) reduces the equilibrium threshold. Moreover, when c approaches 0, both x^m and x^p approach 2, implying that θ^m and θ^p approach 1. When, instead, c approaches 1, x^p approaches -1, so that

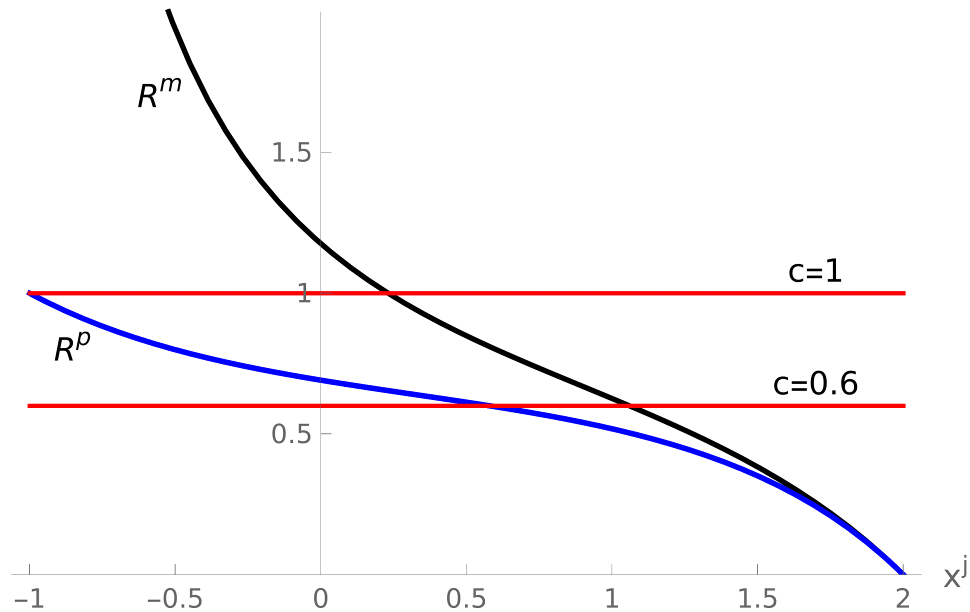

Figure 6: An example with $G = N(0, 1)$, $F = U[-1, 1]$, and $\sigma = a = 1$. From equation (38), the equilibrium threshold satisfies $R^j(x^j) = c$, $j \in \{p, m\}$. Note that an increase in c causes a sharper reduction in x^p than in x^m.

θ^p approaches 0. In contrast, x^m and hence θ^m both remain positive as in our model with no prior information about θ. Critically, $R^m(x)$ changes faster with x, so that as increase in costs c causes a smaller reduction in x^m than in x^p. Equation (38) shows the additional term $\frac{1}{2} + \frac{x^m - \theta}{2\sigma}$ in the denominator for the material rewards settings. When c increases, in any stable equilibrium, the equilibrium threshold x^j must fall so restore the indifference condition—citizens become less likely to revolt. In our example, the presence of $\frac{1}{2} + \frac{x^m - \theta}{2\sigma}$ in the denominator causes x^m to fall by less. That is, the same reduction in x^j has a larger effect in restoring the indifference condition and the equilibrium in the material rewards setting.

Next, we provide a numerical example when both the prior and the noise have the standard normal distribution: $G = N(0, \sigma_0)$, $F = N(0, 1)$, and $\sigma_0 = \sigma = a = 1$. The belief consistency condition is:

$$\theta^j = \Phi\left(\frac{x^j - \theta^j}{\sigma}\right), \text{ so that } x^j = \theta^j + \sigma\Phi^{-1}(\theta^j). \tag{39}$$

The indifference conditions are:

$$c = \Phi\left(\frac{\theta^p - bx^p}{\sqrt{b\sigma^2}}\right) = \int_{-\infty}^{\theta^m} \frac{\frac{1}{\sqrt{b\sigma^2}}\phi\left(\frac{\theta - bx^m}{\sqrt{b\sigma^2}}\right)}{\Phi\left(\frac{x^m - \theta}{\sigma}\right)}\, d\theta, \text{ where } b = \frac{\sigma_0^2}{\sigma^2 + \sigma_0^2}. \tag{40}$$

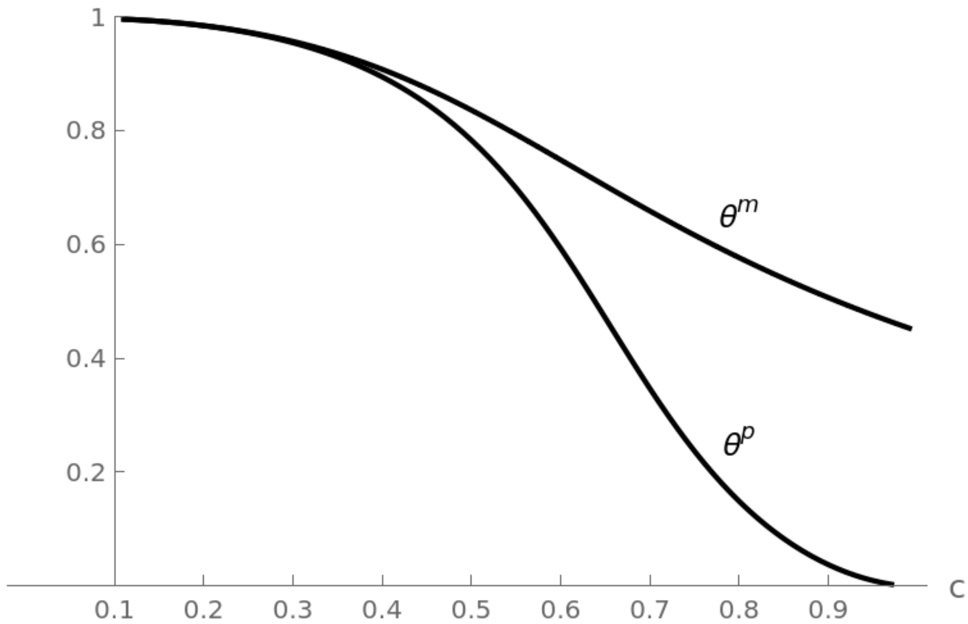

Figure 7: The equilibrium regime change threshold for the psychological rewards setting (θ^p), and material rewards setting (θ^m) when $\theta \sim N(0,1)$, $\epsilon_i \sim iidN(0,1)$, and $\sigma = a = 1$.

Substituting from (39) into (40) yields:

$$c = \Phi\left(\frac{(1-b)\theta^p - b\sigma\Phi^{-1}(\theta^p)}{\sqrt{b\sigma^2}}\right) = \int_{-\infty}^{\theta^m} \frac{\frac{1}{\sqrt{b\sigma^2}}\phi\left(\frac{\theta - b\theta^m - b\sigma\Phi^{-1}(\theta^m)}{\sqrt{b\sigma^2}}\right)}{\Phi\left(\frac{\theta^m + \sigma\Phi^{-1}(\theta^m) - \theta}{\sigma}\right)}\, d\theta. \tag{41}$$

Based on (41), Figure 7 demonstrates the equilibrium regime change thresholds θ^p and θ^m as functions of costs c when $\sigma_0 = \sigma = a = 1$.

Public Signal

To further highlight the logic behind our results, we also compare the effect of public signals about the regime's strength on the equilibrium regime change threshold in the psychological and material rewards settings. There is a link between this analysis and our discussion of a general prior. Suppose players share an improper uniform prior about θ as in the paper, but receive a noisy public signal p about θ in the form of $p = \theta + \sigma_p \nu$, where $\nu \sim H$. This setting is equivalent to players having a (proper) prior with mean p. For example, if $\nu \sim N(0,1)$ and $p = 1$, players will share a prior that $\theta \sim N(1, \sigma_p)$. In particular, beginning from no prior information about θ, the public signal will generates some common knowledge about θ. We now investigate the effect of a higher public signal in both settings. A higher public signal generates

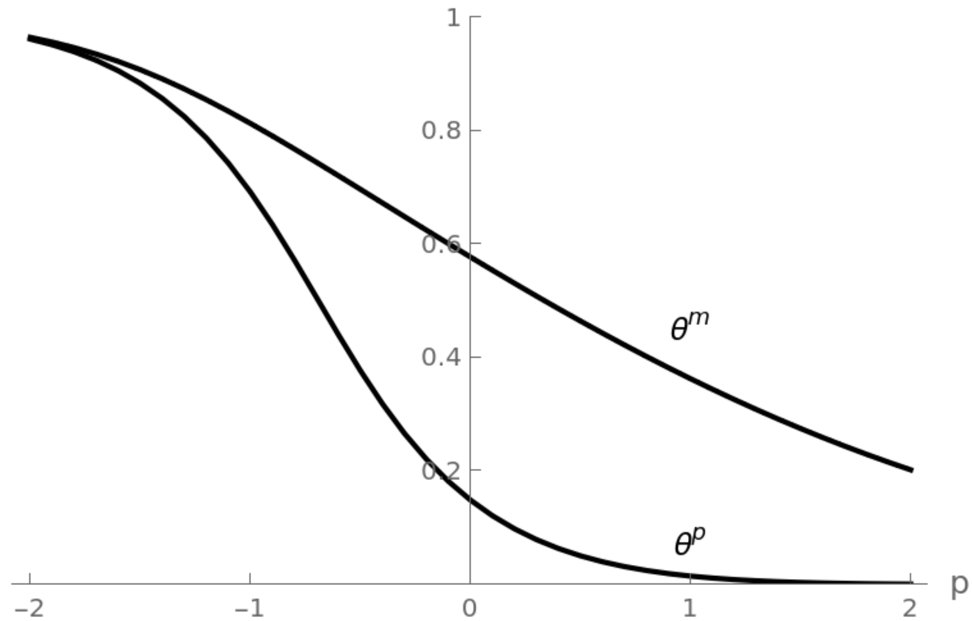

Figure 8: The equilibrium regime change threshold for the psychological rewards setting (θ^p), and material rewards setting (θ^m) as a function of a public signal $p = \theta + \nu$. Parameters: $G = N(0,1)$, $\nu \sim N(0,1)$, $F = N(0,1)$, $\sigma = a = 1$.

common knowledge that the regime is stronger, and hence less likely to collapse. As a result, both θ^p and θ^m and the likelihood of regime change fall. Figure 8 illustrates the equilibrium regime change thresholds for different values of p for the came of Normal noise: $\nu \sim N(0,1)$, $F = N(0,1)$, $\sigma = a = 1$. As expected $\theta^m > \theta^p$. Moreover, as long as θ^p/θ^m is not too small, the marginal effect of a higher p is lower in the material rewards settings. The logic is the same as before: all else equal, a higher p reduces the citizens' incentives to revolt, and hence the likelihood of regime change. But, in the material rewards setting, a smaller number of revolutionaries makes the rewards of a successful regime change larger, thereby partially canceling the first effect. All else equal is important. An p increases, the probably of regime change in the psychological rewards setting falls to almost 0. Beginning from such a low probability, the marginal effect of a higher p then becomes very small. Thus, for the right comparison, one must compare the slopes of θ^p and θ^m when the levels are about the same ($\theta^p \approx \theta^m$). Now, it is clear that the marginal effect of a higher p is much smaller at in the material rewards setting.

Normalization of Material Rewards

In the text, we normalized material rewards to $\frac{a}{m}$, so that if the rebellion succeeds, the total available reward in both settings is a. We now explore the robustness of our results by using more general payoffs. In particular, we assume that material rewards are $\frac{k\times a}{m}$, for some $k > 0$. Our analysis in the text corresponds to $k = 1$. Given the payoff structure represented in Figure 1, this change is equivalent to normalizing the costs in the material rewards setting from $c \in (0,1)$ to $c/k \in (0,1)$. Then, the equilibrium regime change thresholds in Proposition 2 become: $\theta^p = 1 - c$ (as before) and $\theta^m = e^{-c/k}$ (new). Thus, $\frac{d\theta^p}{dc} = -1$ and $\frac{d\theta^m}{dc} = -\frac{1}{k}e^{-c/k}$, so that $\frac{d\theta^p}{dc} < \frac{d\theta^m}{dc}$ if and only if $e^{-c/k} < k$, i.e., $-k\log(k) < c$. When $k \geq 1$, the left hand side is non-positive, and the inequality holds for all $c > 0$. When $k < 1$, this inequality holds at the upper bound of $c = k < 1$ if and only if $-k\log(k) < k$, i.e., $k > 1/e \approx 0.37$. Then, there will be a threshold $\hat{c} \in (0,k)$ such that $-k\log(k) < c$ if and only if $c > \hat{c}(k)$. To summarize:

Proposition 9 $\frac{d\theta^p}{dc} < \frac{d\theta^m}{dc}$ *if and only if either* $k \geq 1$*, or* $k > 1/e$ *and* $c > \hat{c}(k)$*, where* $\hat{c} \in (0,k)$*.*

Proposition 5 has a similar analogue. In the proof of Proposition 5, observe that changing c to c/k in the material rewards setting will change (20) to:

$$\Delta^m = \lim_{\sigma\to 0}\max\{\theta_2^m(\sigma)\} - \theta_1^m = e^{-ac/k} - e^{-c/k} \quad \text{and} \quad \Delta^p = \lim_{\sigma\to 0}\max\{\theta_2^p(\sigma)\} - \theta_1^p = (1-a)c.$$

Thus, $\Delta^m < \Delta^p$ if and only if $\frac{e^{-c/k}-e^{-ac/k}}{c-ac} > -1$, i.e., $\frac{e^{-c/k}-e^{-ac/k}}{c/k-ac/k} > -k$. Now, let $d = c/k \in (0,1)$ and observe that d can change independently of k. Thus, $\Delta^m < \Delta^p$ if and only if $\frac{e^{-d}-e^{-ad}}{d-ad} > -k$, for $d \in (0,1)$. Because e^{-x} is strictly decreasing and convex with $\frac{de^{-x}}{dx}\big|_{x=0} = -1$, this inequality holds for all $k \geq 1$. When $k < 1$, as long as $k > 1/e$, there exists $a, c/k \in (0,1)$ such that $\Delta^m < \Delta^p$. To see this, observe that $\frac{de^{-x}}{dx}\big|_{x=1} = -1/e$. Thus, we have:

Proposition 10 *Suppose the noise in the second period's private signals becomes vanishingly small, and we focus on the largest equilibrium. Conditional on failure in the first period, the chances of success is higher in the psychological rewards setting than in the material rewards setting if (i)* $k \geq 1$*, or (ii)* $k > 1/e$ *and* a *and* c *are sufficiently large.*