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Is There Really a Dictator's Dilemma? Information and Repression in Autocracy

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Abstract

In his seminal work on the political economy of dictatorship, Ronald Wintrobe (1998) posited the existence of a "dictator's dilemma," in which repression leaves an autocrat less secure by reducing information about discontent. We explore the nature and resolution of this dilemma with a formalization that builds on recent work in the political economy of nondemocracy. When the regime is sufficiently repressive, and the dictator's popularity correspondingly unclear to opposition as well as autocrat, the ruler faces two unattractive options: he can mobilize the repressive apparatus, even though there may be no threat to his rule, or he can refrain from mobilizing, even though the threat may be real. Semicompetitive elections can ease the dilemma through the controlled revelation of discontent. Depending on the ease of building a repressive apparatus, autocrats who manage information in this way may prefer more or less repression than Wintrobe's dilemma alone implies.

Keywords: dictator's dilemma, information, repression, autocracy, elections

Romanian Communist leader Nicolae Ceauşescu could be forgiven for expecting support from the assembled crowd as he walked out on a balcony in central Bucharest in late 1989 to condemn the ongoing unrest in Timişoara. After all, Ceauşescu had spoken to crowds in Palace Square before—most notably, on August 21, 1968, when he denounced the Warsaw Pact invasion of Czechoslovakia to tens of thousands of cheering Romanians. This time, however, he was met with jeers and shouts from the multitude that Party officials had hastily convened. Video of the event—required viewing for any student of autocracy—records Ceauşescu's shock. A member of the Communist Party from his early teens, a man who presided over a repressive autocracy, Ceauşescu was apparently oblivious of his unpopularity. Within four days, he and his wife Elena would be dead.

In his failure to comprehend public opinion until it was too late, Nicolae Ceauşescu was a victim of what Ronald Wintrobe famously called the "dictator's dilemma." In his seminal work on the political economy of dictatorship, Wintrobe (1998, p. 22) wrote:

> The more threatened they are by the ruler, the more the subjects will be afraid to speak ill of or to do anything which might conceivably displease him or her.

One might also cite Kuran (1997) on this point, as well as Wedeen (2015) and—as does Wintrobe—Xenophon (see esp. Strauss, 1948). But Wintrobe famously continues:

> Therefore, it would seem, the less the dictator knows what they are really thinking, and the more reason for him or her to be insecure!. . . The greater the dictator's power, the more reason he or she has to be afraid.

In other words, if one assumes that the existence of a repressive apparatus reduces information about discontent, it follows that a more repressive dictator is less secure. The assumption seems reasonable; many contemporary scholars of autocracy would treat it as axiomatic. But the conclusion is not obvious. The presence of a repressive state affects the ruler's survival in two ways. Through a first, *direct effect*, a ruler can use security forces and secret police to head off unrest before it spirals out of control. Yet through a second, *Wintrobe effect*, the ubiquity of those same security forces and secret police encourages conforming displays of popular support, creating uncertainty about when the repressive apparatus of the state should actually be deployed. These two effects work in opposite directions—one increasing the ruler's hold on power, the other decreasing it.

Are authoritarian rulers invariably less secure by virtue of having built a repressive state? What precisely is the "dictator's dilemma," anyway—and how do autocrats resolve it? We examine these questions with a simple model that builds on recent work on the political economy of nondemocracy. Our formalization adopts a standard setup in which an opposition decides whether to challenge a ruler, where a challenge is successful if and only if the ruler is "unpopular" and fails to mobilize against a potential challenge. We introduce Wintrobe's assumption that the availability of information about the ruler's popularity, as expressed in a public signal, is a decreasing function of the regime's repressiveness, initially taken as exogenous. We also assume, however, that mobilization against a potential challenge is less costly, the more repressive is the regime. These two competing forces determine the behavior of ruler and opposition.

Our analysis of this model clarifies the nature of the dictator's dilemma. Confronted with uncertainty about his popularity—uncertainty that a potential opposition may share—the dictator faces a choice between two unattractive options. He can mobilize the repressive apparatus, even though doing so is costly and there may be no real threat to his rule. Or he can refrain from mobilizing, risking removal from a threat that he failed to take anticipate. The first alternative risks an error of commission; the second, an error of omission.

The presence and resolution of this dilemma depend on the repressiveness of the regime. When the regime is very repressive, ruler and opposition alike are disinclined to believe signals of popular support, and the cost of mobilization is minimal, so the ruler mobilizes to ward off a potential challenge that may or may not exist. At moderate levels of repressiveness—a region that exists if the ruler is a priori less likely to be popular—the ruler gambles that professions of support are genuine, whereas the opposition gambles that they are not. As with Ceauşescu, sometimes the ruler's gamble is lost: misled by what people say and do in public, he fails to mobilize when, with the advantage of hindsight, he should have. Finally, when the regime is minimally repressive, signals of popular support are likely to be genuine. Understanding this, the opposition chooses not to challenge after observing such support, and the ruler survives without mobilization: there is no dilemma.

The dictator's dilemma, then, is substantially a problem of the *opposition*'s beliefs, not just the dictator's. In an extension, we demonstrate that the ruler can ease the dilemma with semicompetitive elections and related tools of information manipulation. As emphasized in the literature that we survey below, autocratic elections are a mechanism by which authoritarian rulers can signal their popular support. When such elections are properly managed (from the autocrat's perspective), and when the ruler wins, the opposition does not challenge, even though some of the time that victory is due to electoral fraud. The ruler of a "moderately" repressive regime therefore survives not only when he is popular, as in the baseline model, but also when he is lucky—with the requisite luck determined by optimal electoral manipulation. This tilts the scales toward the second resolution of the dictator's dilemma, in which the ruler does not mobilize.

With elections or without, the dictator faces no dilemma when the regime is least repressive. This does not, of course, guarantee that the dictator would fare better in a less repressive regime, as discontent is more likely to be expressed in such an environment, and the dictator is especially ill prepared to mobilize against it. In a second extension, we consider an augmented model in which the ruler chooses the regime's repressiveness at the beginning of the game, before observing the public signal of his popularity. In this version of the model, the optimal level of repressiveness depends critically on whether the ruler has semicompetitive elections or similar instruments in his toolkit (as discussed below, Ceauşescu arguably did not). In particular, the ruler is inclined toward greater repressiveness with elections than without—information manipulation and repression are complements—when building a repressive apparatus is neither too easy nor too hard. In contrast, when the autocrat is comparatively unconstrained in his choice of repression, then information manipulation and repression are substitutes.

1 Information and repression in the literature

As the discussion above illustrates, the role of information has long been at the center of research on authoritarian politics. Broadly speaking, existing theoretical work on information design in autocracies examines one of three tools of autocratic survival: electoral manipulation (e.g., Gehlbach and Simpser, 2015; Little, 2017*a*; Luo and Rozenas, 2018*b*; Egorov and Sonin, 2021), propaganda (e.g., Besley and Prat, 2006; Gehlbach and Sonin, 2014; Little, 2017*b*; Horz, 2021), or censorship (e.g., Egorov, Guriev and Sonin, 2009; Lorentzen, 2014; Shadmehr and Bernhardt, 2015). Many of the same principles govern the effectiveness of these superficially dissimilar tools, such as the need to mix enough fact with fiction for messages to be believable. Relatedly, many of the models in this literature model information manipulation as Bayesian persuasion (Kamenica and Gentzkow, 2011), in which a sender commits to a state-contingent probability distribution over signals. We adopt a similar formalization when considering the use of semicompetitive elections and related tools to weaken the dictator's dilemma. In the particular context of elections, the assumption that the autocrat can commit to more or less informative signals can be interpreted as a choice to invite election monitors (Fearon, 2011; Little, 2012; Little, Tucker and LaGatta, 2015; Luo and Rozenas, 2018*a*), empower electoral commissions (Chernykh and Svolik, 2015), and allow some opposition candidates to appear on the ballot (Ma, 2020).

Theoretical work on repression tends to build on the insight that autocrats face two threats to their hold on power: revolution from below and seizure of power from within (Svolik, 2012; Bueno de Mesquita et al., 2003). Accordingly, existing models focus on repression targeted at mass publics (e.g., Shadmehr, 2014; Paine, 2022; Sun, 2023) or elites (e.g., Montagnes and Wolton, 2019). In either case, a goal of repression is to discourage coordination by potential regime opponents (e.g., through demographic targeting: see Gregory, Schröder and Sonin, 2011; Shadmehr and Haschke, 2016; Rozenas, 2020)—an explicit emphasis of some of the models discussed below. A particular challenge for the ruler is that investments in capacity to prevent coordination cannot be made quickly, such that a ruler may find himself locked in by earlier decisions to build a more or less repressive state. As in Bueno de Mesquita and Shadmehr (2023), we formalize this stickiness by first analyzing an environment with fixed repressive capacity, following which we consider an augmented game with a prior move in which the ruler chooses such capacity (see also Di Lonardo, Sun and Tyson, 2020).

Preventing revolution and seizures of power requires that agents of the state be compensated for carrying out repression (e.g., Bove, Platteau and Sekeris, 2017; Dragu and Lupu, 2018; Tyson, 2018). The "punisher's dilemma" is that greater threats require greater compensation, thus potentially rendering threats of repression noncredible (Bueno de Mesquita et al., 2023). Given this cost, a dictator naturally would not want to mobilize the repressive apparatus unless he had too.[1] The "dictator's dilemma" is that uncertainty about public opinion—itself a consequence of investment in repressive capacity—presents a choice between mobilizing when that may be unnecessary and not mobilizing when it may be. As in Tyson and Smith (2018), we assume that any public signal of the ruler's popularity is observed by regime adherents (here, ruler) and opponents alike, though we subsequently allow for the endogenous provision of additional information to the opposition.

There is comparatively little work that jointly examines information and repression in authoritarian regimes. A notable exception is Guriev and Treisman (2020, 2022), who examine the conditions under which autocrats choose to establish "spin dictatorships" rather than "fear dictatorships." As this formulation suggests, it is natural to think of information

[1]Dilemmas abound in the literature on autocracy. Shadmehr and Bernhardt (2011) examine two "punishment dilemmas" related to the relationship between the harshness of repression and incidence of protest, respectively, and the incidence of repression.

manipulation and repression as substitutes—that is, as alternative means toward the same end, albeit of typically different cost and effectiveness. Egorov and Sonin (2022, Example 4.3) and Gitmez and Sonin (2023), in contrast, show that propaganda and repression can be complements, as repressing the most skeptical citizens increases scope for persuading the least.[2] In our setting, neither relationship holds universally. Rather, information manipulation (articulated as authoritarian elections, though generalizable beyond that particular instrument) and repression may be either substitutes or complements, depending on the ease of building a repressive apparatus.

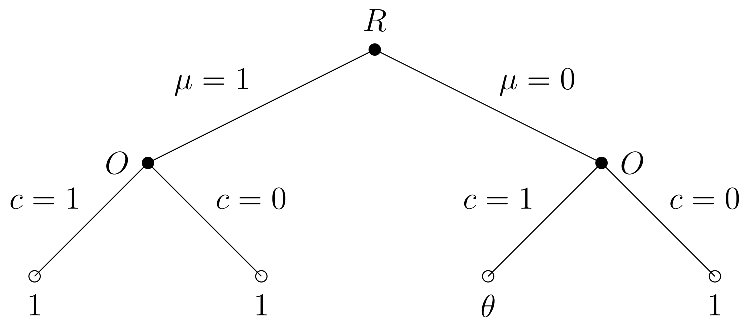
2 Baseline model

Our baseline model adopts a standard setup in which an opposition (it) chooses whether to challenge an authoritarian ruler (he), who if challenged loses power if and only if he a) is "unpopular" among an unmodeled citizenry, and b) has not preemptively mobilized against the opposition. Relative to other models, the key innovation is that the repressiveness of the regime—taken initially as exogenous—reduces both information about the ruler's popularity and the cost of mobilizing against a potential challenge. We assume for now that information is symmetric between ruler and opposition: in a repressive environment, they equally mistrust opinion polls and even private conversations with longtime acquaintances, who may choose to self-censor.[3] In the next section we extend the model to allow for the endogenous provision of additional information to the opposition.

[2]In Shadmehr and Boleslavsky (2022), repression itself conveys information—about the motivations of the regime and of opposition activists.

[3]Lohmann (1994), for example, argues that the repressive environment in East Germany created an environment in which widespread discontent was commonly understood only after the public actually turned out to protest.

Figure 1: The actions of the ruler (R) and opposition (O) and their consequences for the ruler's probability of survival.



2.1 Setup

The players are a ruler (R) and an opposition (O) competing for power. Winning power provides either with a payoff normalized to 1. The contest for power may depend on the ruler's popularity, $\theta \in \{0, 1\}$, where $\theta = 1$ indicates that the ruler is *popular* (among unmodeled citizens) and $\theta = 0$ indicates that he is unpopular. The popularity of the ruler is observed directly by neither ruler nor opposition, who share the prior belief $\Pr(\theta = 1) = p \in (0, 1)$.

The game begins with a public signal $s \in \{0, 1\}$ of the ruler's popularity, of which more below. Following this, the ruler chooses whether to *mobilize* the security apparatus, $\mu \in \{0, 1\}$, against a potential challenge. Having observed the public signal s and the ruler's mobilization choice μ, the opposition decides whether to *challenge* the ruler, $c \in \{0, 1\}$, at opportunity cost $k \in (0, 1)$. The ruler survives with probability

$$\mu + (1 - \mu)(1 - c + c\theta).$$

In other words, the opposition replaces the ruler if and only if the ruler chooses not to mobilize ($\mu = 0$), the opposition chooses to challenge ($c = 1$), and the ruler is unpopular ($\theta = 0$). Figure 1 summarizes the actions of the two players and their consequences for the ruler's probability of survival.

The regime has a given level of *repressiveness* $\omega \in \mathbb{R}_+$, which affects the ruler's survival in two ways. First, mobilization costs the ruler $1 - \pi(\omega)$, with $\pi(\omega)$ continuous and strictly increasing in ω, $\pi(0) = 0$, and $\lim_{\omega \to \infty} \pi(\omega) = 1$. A more repressive regime is therefore able to more efficiently mobilize to preemptively eliminate potential threats—security forces are already on the payroll and need not be organized on short notice, a conscription army with unclear loyalties need not be deployed instead, and so forth. This is the *direct effect* of repressiveness.

Second, the public signal $s \in \{0, 1\}$ of the ruler's popularity is generated according to

$$\Pr(s = 1 \mid \theta) = \theta + (1 - \theta) q(\omega),$$

with $q(\omega)$ continuous and strictly increasing in ω, $q(0) = 0$, and $\lim_{\omega \to \infty} q(\omega) = 1$. The signal s is thus imperfectly informative of the ruler's popularity. When the ruler is popular ($\theta = 1$), the public signal always indicates support ($s = 1$). In contrast, if the ruler is unpopular, the public signal is more likely to indicate support, the more repressive is the regime. Intuitively, we can think of unmodeled citizens as more likely to "falsify" their preferences in a repressive environment.[4] This is the *Wintrobe effect* of repressiveness, which in contrast to the direct effect enters payoffs only indirectly, through the information and thus behavior that repressiveness implies.

The preceding discussion implies that the ruler has preferences over terminal histories represented by the utility function

$$u_R(\mu, c; \theta, \omega) = \mu \pi(\omega) + (1 - \mu)(1 - c + c\theta)$$

whereas the opposition has preferences represented by

$$u_O(\mu, c; \theta) = c\left[(1 - \mu)(1 - \theta) - k\right].$$

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[4]The language is Kuran's (1997). A natural interpretation of this assumption is that citizens bear a psychic cost $\epsilon \in \mathbb{R}_+$ of preference falsification, drawn from a continuous and strictly increasing distribution F, whereas they suffer a (material, physical, etc.) cost equal to the regime's repressiveness ω when expressing opposition to the ruler. Then when the ruler is unpopular, the probability that they nonetheless express support for the ruler is $q(\omega) = F(\omega)$, which is continuous and strictly increasing in ω.

Our solution concept is perfect Bayesian equilibrium ("equilibrium"). To rule out trivial cases, we assume $p < 1 - k$, which implies that the opposition would challenge the ruler absent additional information if the ruler chooses not to mobilize.

2.2 Analysis

We solve the game by backward induction. By mobilizing the security apparatus, the ruler survives regardless of the opposition's choice. As a result, the opposition never challenges ($c = 0$) if the ruler mobilizes ($\mu = 1$). In contrast, if the ruler chooses not to mobilize ($\mu = 0$), then the opposition prefers not to challenge if and only if its posterior belief that the ruler is unpopular, given the public signal s, does not justify the cost of challenging:

$$1 - \Pr(\theta = 1 \mid s) \leq k. \tag{1}$$

Consider first the case in which the public signal $s = 0$. In this case, both the ruler and the opposition infer that the ruler is unpopular,

$$\Pr(\theta = 1 \mid s = 0) = 0.$$

As a consequence, the opposition challenges and deposes the ruler if the ruler does not mobilize. Anticipating this, the ruler mobilizes ($\mu = 1$) despite the cost, which then deters the opposition from challenging ($c = 0$). For the ruler, there is no dilemma: his unpopularity is common knowledge, leaving only one reasonable course of action.

Now consider the more interesting case in which the public signal is consistent with the ruler's being popular ($s = 1$). The ruler and opposition share the posterior belief

$$\Pr(\theta = 1 \mid s = 1) = \frac{p}{p + (1-p)\,q(\omega)} \equiv \tilde{p}(\omega, p). \tag{2}$$

Due to the Wintrobe effect, as captured by the assumption that the function $q(\omega)$ is continuous and strictly increasing in ω, the posterior belief $\tilde{p}(\omega, p)$ is continuous and strictly decreasing in repressiveness ω. There is consequently a unique ω such that Condition 1 holds with equality,

$$\underline{\omega}(p) \equiv q^{-1}\left(\frac{k}{1-k} \cdot \frac{p}{1-p}\right),$$

and if $\omega \leq \underline{\omega}(p)$ the opposition does not challenge regardless of the ruler's mobilization decision. It immediately follows that, if $s = 1$ and $\omega \leq \underline{\omega}(p)$, the ruler prefers not to mobilize and enjoys perfect security.

In contrast, if $s = 1$ and $\omega > \underline{\omega}(p)$, the ruler faces an unattractive choice—the dictator's dilemma. By mobilizing, the ruler ensures survival but pays the cost of mobilization, which is unnecessary if he is in fact popular; this provides a net payoff of $\pi(\omega)$. By not mobilizing, the ruler saves the cost of mobilization, but the opposition challenges (because $\omega > \underline{\omega}(p)$) and the ruler survives only if he is truly popular—when unpopular, he would have been better off mobilizing. In the latter case, the ruler's expected payoff is precisely the posterior probability that he is popular, $\tilde{p}(\omega, p)$, given $s = 1$.

The ruler resolves the dilemma in favor of no mobilization if and only if

$$\tilde{p}(\omega, p) \geq \pi(\omega).$$

Lemma 1. *There exists a unique $\overline{\omega}(p) > 0$ such that $\tilde{p}(\omega, p) \geq \pi(\omega)$ holds if and only if $\omega \leq \overline{\omega}(p)$. Moreover, $\overline{\omega}(p) > \underline{\omega}(p)$ if and only if*

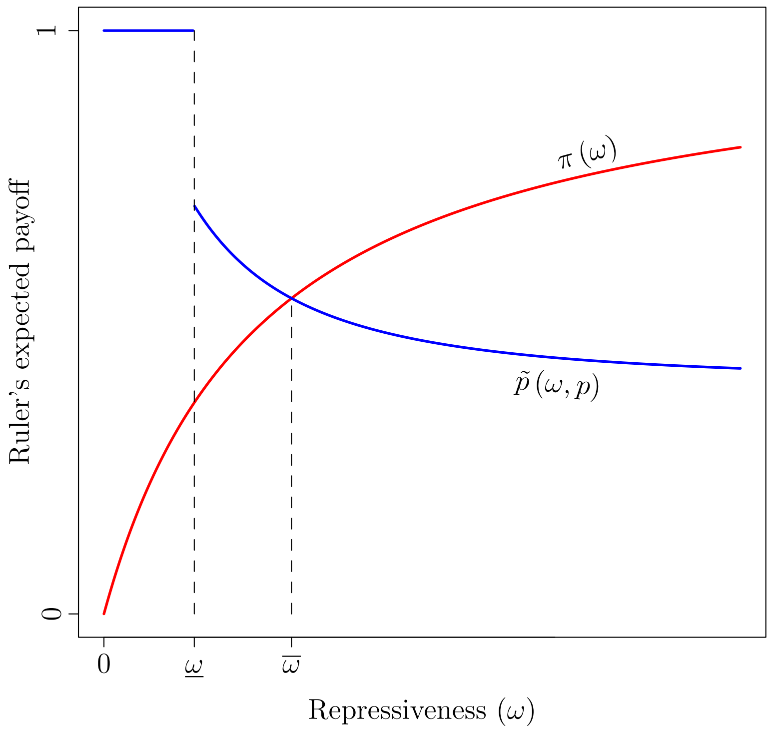
$$p < \overline{p} \equiv \overline{\omega}^{-1}\left(\pi^{-1}(1-k)\right),$$

where $\overline{p} \in (0, 1-k)$.

Proof. See appendix. □

Figure 2 illustrates this lemma and the preceding discussion for the case in which $\underline{\omega}(p) < \overline{\omega}(p)$, which holds if the prior probability that the ruler is popular is sufficiently low. (Where doing so does not create confusion, including in this figure, we omit the argument p to economize on notation.) The red curve represents the ruler's net payoff from mobilization, which is increasing in ω, given the direct effect of repressiveness. The blue locus of points, in turn, represents the ruler's probability of survival when he does not mobilize and the public signal $s = 1$. If $\omega \leq \underline{\omega}$, the opposition is sufficiently confident that the ruler is popular after observing $s = 1$ that it does not challenge, in which case the ruler survives with certainty. In

Figure 2: Ruler's expected payoff from mobilization (red curve) and no mobilization (blue locus of points) when the public signal $s = 1$.



contrast, if $\omega > \underline{\omega}$, the opposition suspects that the ruler is unpopular, notwithstanding the public signal $s = 1$. In this case, the opposition challenges the ruler and the ruler survives if in fact he is popular—this is true with probability strictly decreasing in ω, given the Wintrobe effect of repressiveness. As the regime becomes more repressive, the ruler is thus more inclined to rely on his security apparatus rather than gamble on public expressions of support, with the two curves crossing at $\overline{\omega}$.

Proposition 1. *If the public signal $s = 0$, the ruler mobilizes ($\mu = 1$) and the opposition does not challenge ($c = 0$). If $s = 1$:*

1. *If $\omega \leq \underline{\omega}(p)$, the ruler does not mobilize ($\mu = 0$) and the opposition does not challenge ($c = 0$).*
2. *If $\omega > \max\{\underline{\omega}(p), \overline{\omega}(p)\}$, the ruler mobilizes ($\mu = 1$) and the opposition does not challenge ($c = 0$).*

3. *If* $p < \overline{p}$ *and* $\underline{\omega}(p) < \omega \leq \overline{\omega}(p)$*, the ruler does not mobilize (*$\mu = 0$*) and the opposition challenges (*$c = 1$*).*

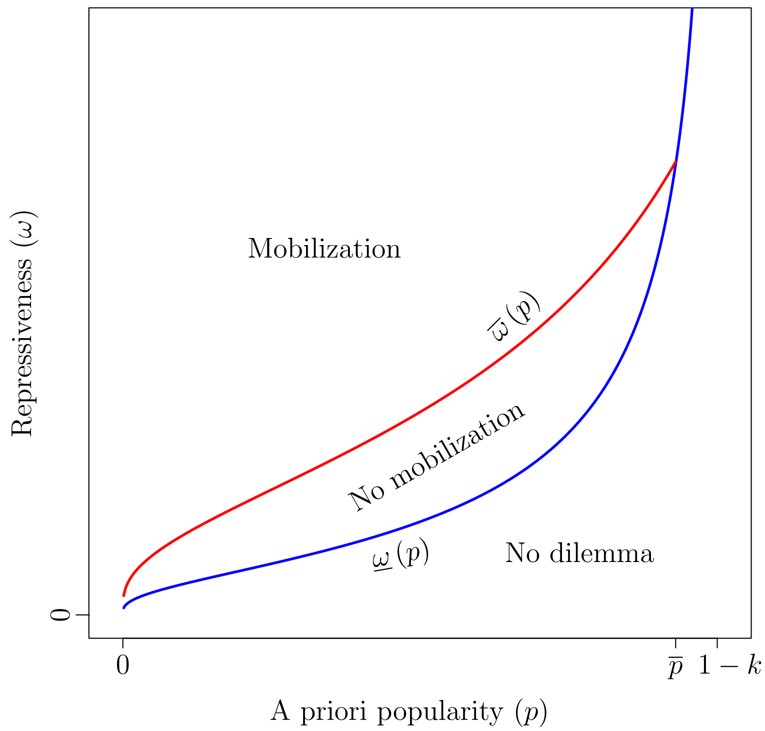
Proof. See above. □

Proposition 1, as illustrated in Figure 3 for the case in which the public signal $s = 1$, clarifies Wintrobe's dilemma. When the regime is minimally repressive, expressions of popular support for the ruler are likely to be genuine, and the ruler need not mobilize to discourage challenges to his hold on power; there is no dilemma. For higher levels of repressiveness, the ruler faces a choice between two unattractive options: mobilization when that may be unnecessary, no mobilization when it may be necessary. The first alternative is preferable when the regime is very repressive, as then neither ruler nor opposition is inclined to believe expressions of support. In contrast, for moderate levels of repressiveness—a region that exists if the ruler is a priori less likely to be popular—the ruler gambles that he is popular when he receives good news and does not mobilize, even as the opposition wagers that the ruler is unpopular and challenges. In such environments, the ruler knowingly puts himself at risk of losing power rather than bearing the cost of mobilization. Some of the time, it is a decision that he comes to regret.

3 Authoritarian elections

The analysis of our baseline model demonstrates that the dictator's dilemma is substantially a problem of the opposition's beliefs, not just the dictator's. From the ruler's perspective, the problem is that public expressions of support may be insufficiently credible to dissuade the opposition from challenging, even as they provide sufficient optimism to the ruler to discourage him from mobilizing. What the ruler needs is a mechanism that can more credibly convey to the opposition that he is popular, when that is the case, without always revealing that he is unpopular when that is true. Elections or plebiscites, not fully free and fair but allowing some gauge of the popular mood, provide such a mechanism.

Figure 3: Wintrobe's dilemma. If the public signal $s = 1$ (the case depicted), and the regime is sufficiently repressive, $\omega > \underline{\omega}(p)$, the ruler risks either mobilizing when there is no threat to his rule (an error of commission) or not mobilizing when the threat may be real (an error of omission). The ruler resolves the dilemma in favor of not mobilizing when he is a priori less likely to be popular and the regime is of intermediate repressiveness.



3.1 Setup

We follow Gehlbach and Simpser (2015), Rozenas (2016), and Luo and Rozenas (2018*b*) in modeling authoritarian elections as a form of Bayesian persuasion. In particular, we extend the baseline model as follows. Following observation of the public signal s, the ruler decides whether to mobilize, $\mu \in \{0, 1\}$, and selects an *election design* $\tau = (\tau_0, \tau_1)$, which probabilistically generates an outcome (vote) $v \in \{0, 1\}$ conditional on θ:

$$\Pr(v = 1 \mid \theta) = \tau_\theta.$$

Without loss of generality, we require $\tau_0 \leq \tau_1$, so that $v = 1$ is a positive message about the ruler's popularity and $v = 0$ is a negative message. Having observed the public signal s, the ruler's choices μ and τ, and the election outcome v, the opposition then decides whether to challenge the ruler, $c \in \{0, 1\}$.

A few comments about this setup are in order. First, in the context of election design, the assumption that the ruler can commit to a signal structure τ can be interpreted as the selection of opposition candidates allowed to run, the choice of cities in which election observers are allowed to operate, and other institutional decisions that determine how preferences are translated into votes (Gehlbach, 2021, ch. 8). Second, the assumption that mobilization and the election design are chosen simultaneously captures the idea that it is difficult for a ruler to retain power after losing a possibly rigged election. Prominent examples of dictators who lost support of key coalition members and were forced to step down following election or plebiscite losses include Wojciech Jaruzelski in Poland and Augusto Pinochet in Chile. Third, the restriction to binary elections is without loss of generality: as Luo and Rozenas (2018*b*, Lemma 1) demonstrate, for any mapping from $\{0, 1\}$ to a probability distribution on a generic set of election outcomes, there exists a binary election that provides the ruler with an expected payoff at least as large. Fourth, consider two special cases. The election design $\tau = (0, 1)$ corresponds to a perfectly informative election, and incentives for the ruler and opposition are identical to those had we assumed a priori that the opposition observed the ruler's popularity. In contrast, any election design such that $\tau_0 = \tau_1$ is completely uninformative and functionally equivalent to not holding an election.

3.2 Optimal election design

When the ruler mobilizes ($\mu = 1$), election design is irrelevant, as the opposition would not challenge regardless of s, τ, or v. Election design is also irrelevant when the public signal is negative ($s = 0$), in which case the opposition is certain that the ruler is unpopular. Thus, the only event in which election design could matter is when the public signal is positive and the ruler chooses not to mobilize, $s = 1$ and $\mu = 0$. We characterize the ruler's optimal election design for this case.

When $s = 1$, the ruler and the opposition share the belief that the ruler is popular with probability $\tilde{p}(\omega, p)$. Suppose repressiveness $\omega \leq \underline{\omega}(p)$. In this case, $\tilde{p}(\omega, p) \geq 1 - k$ (by definition of $\underline{\omega}$: see Equation 2), so the positive signal is sufficient to persuade the opposition not to challenge. It is therefore optimal for the ruler to choose an election design that discloses no additional information about his popularity, that is, any τ such that $\tau_0 = \tau_1$, which is equivalent to no election at all.

Now suppose $\omega > \underline{\omega}(p)$, which implies $\tilde{p}(\omega, p) < 1 - k$. Due to the Wintrobe effect, the positive signal alone is insufficiently strong evidence of the ruler's popularity to dissuade the opposition from challenging the ruler. Without mobilizing his security apparatus, the ruler can avoid being challenged only by providing new information. A positive election outcome provides such information if the posterior belief of the ruler's popularity, given the election design τ, satisfies

$$\Pr(\theta = 1 \mid s = 1, v = 1) = \frac{\tilde{p}(\omega, p) \cdot \tau_1}{(1 - \tilde{p}(\omega, p)) \cdot \tau_0 + \tilde{p}(\omega, p) \cdot \tau_1} \geq 1 - k,$$

or, equivalently,

$$\tau_0 \leq \frac{k}{1-k} \cdot \frac{p}{1-p} \cdot \frac{1}{q(\omega)} \cdot \tau_1. \tag{3}$$

Even manipulated elections can be lost, however, and a negative election outcome guarantees that the ruler will see a challenge:

$$\Pr(\theta = 1 | s = 1, v = 0) = \frac{\tilde{p}(\omega, p) \cdot (1 - \tau_1)}{(1 - \tilde{p}(\omega, p)) \cdot (1 - \tau_0) + \tilde{p}(\omega, p) \cdot (1 - \tau_1)} \leq \tilde{p}(\omega, p) < 1 - k.$$

The optimal election design $\hat{\tau}$ thus maximizes the probability of a positive outcome ($v = 1$), subject to Condition (3), which ensures that the opposition "obeys" the election result. Formally, $\hat{\tau}$ solves

$$\begin{aligned} \max_{\tau} \quad & (1 - \tilde{p}(\omega, p)) \cdot \tau_0 + \tilde{p}(\omega, p) \cdot \tau_1 \\ s.t. \quad & \tau_0 \leq \frac{k}{1-k} \cdot \frac{p}{1-p} \cdot \frac{1}{q(\omega)} \cdot \tau_1, \end{aligned}$$

where the probability weights in the maximand follow from the fact that the ruler has observed $s = 1$. This problem admits a unique solution $\hat{\tau}$ such that

$$\begin{aligned} \hat{\tau}_0 &= \frac{k}{1-k} \cdot \frac{p}{1-p} \cdot \frac{1}{q(\omega)} \\ \hat{\tau}_1 &= 1. \end{aligned} \tag{4}$$

The optimal election design always produces a positive election outcome when the ruler is popular, while "falsifying" the outcome when the ruler is unpopular with probability just small enough for a positive outcome to be persuasive. In particular, the more repressive is the regime, the more truthful must be the election design to compensate for the noise in the public signal. With this design, the opposition does not challenge if the election outcome $v = 1$, whereas the opposition challenges and the ruler is deposed with certainty if $v = 0$, which occurs only if the ruler is unpopular.

3.3 Mobilization or election

We now examine the ruler's decision to mobilize. Recall that when the public signal is negative ($s = 0$), it is common knowledge that the ruler is unpopular, so that the ruler mobilizes ($\mu = 1$) and the opposition does not challenge ($c = 0$). Moreover, when the public signal is positive ($s = 1$) and the regime is not too repressive, $\omega \leq \underline{\omega}(p)$, the ruler can ensure survival by choosing an uninformative election design, $\tau_0 = \tau_1$, so that he does not mobilize and the opposition does not challenge.

Now suppose the public signal indicates support ($s = 1$) and the regime is sufficiently repressive, $\omega > \underline{\omega}(p)$. If the ruler chooses to mobilize, he ensures his survival and pays the cost of mobilization, receiving the net payoff $\pi(\omega)$. If the ruler instead forgoes mobilization, the best he can do is employ the optimal election design $\hat{\tau}$. In this case, the challenger does not challenge, and the ruler correspondingly survives, if and only if the election outcome is positive ($v = 1$). Thus, by not mobilizing, the ruler receives the expected payoff

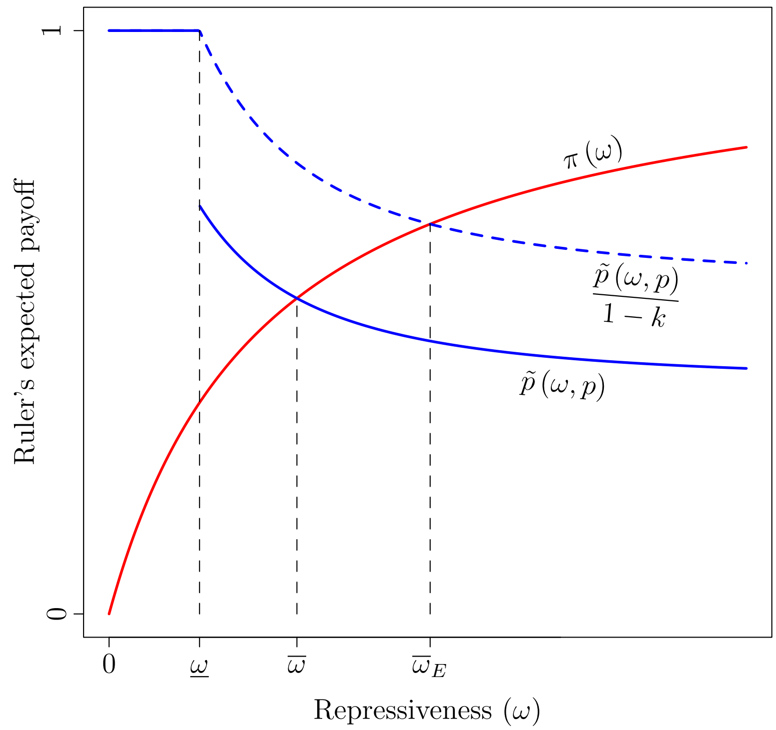
$$(1 - \tilde{p}(\omega, p)) \cdot \hat{\tau}_0 + \tilde{p}(\omega, p) \cdot \hat{\tau}_1 = \frac{\tilde{p}(\omega, p)}{1 - k},$$

which is the probability (given $s = 1$) of a positive election outcome. The ruler therefore prefers not to mobilize and gambles on a positive election outcome if and only if

$$\frac{\tilde{p}(\omega, p)}{1 - k} \geq \pi(\omega).$$

Lemma 2. *There exists a unique* $\overline{\omega}_E(p) > \max\{\underline{\omega}(p), \overline{\omega}(p)\}$ *such that* $\frac{\tilde{p}(\omega,p)}{1-k} \geq \pi(\omega)$ *holds if and only if* $\omega \leq \overline{\omega}_E(p)$.

Figure 4: Ruler's expected payoff from mobilization (red curve), election (dashed blue locus of points), and no mobilization or election (solid blue locus of points) when the public signal $s = 1$.



Proof. See appendix. □

Figure 4 illustrates Lemma 2 and the preceding discussion for the case in which $\underline{\omega}(p) < \overline{\omega}(p)$. As in Figure 2, the red curve represents the ruler's net payoff from mobilization, and the solid blue locus of points represents his probability of survival when he neither mobilizes nor uses elections (i.e., $\tau_1 = \tau_0$) and the public signal $s = 1$. The dashed blue locus of points, in contrast, is the ruler's probability of survival under no mobilization and the optimal election design, given that $\omega > \underline{\omega}(p)$. As the regime becomes more repressive, the ruler must tolerate a higher probability of a negative election outcome when he is truly unpopular to maintain the persuasiveness of a positive election outcome (see Condition 3). As a consequence, semicompetitive elections are less attractive at high than at low levels of repressiveness. The apparent infrequency of such barometers of the public mood in highly repressive autocracies is consistent with this result.

A further implication of Lemma 2 is that the ruler is more reluctant to mobilize when elections are in his toolkit than when they are not. As illustrated in Figure 4, when $s = 1$ and $\omega > \underline{\omega}(p)$, the ruler's probability of survival is larger by a factor of $\frac{1}{1-k}$ under the optimal election design than without elections. In essence, elections improve upon the lottery implied by not mobilizing. Not only does the ruler survive when he is in fact popular, but also—with probability $\hat{\tau}_0$—when he is unpopular. The level of repressiveness below which mobilization is suboptimal is correspondingly higher.

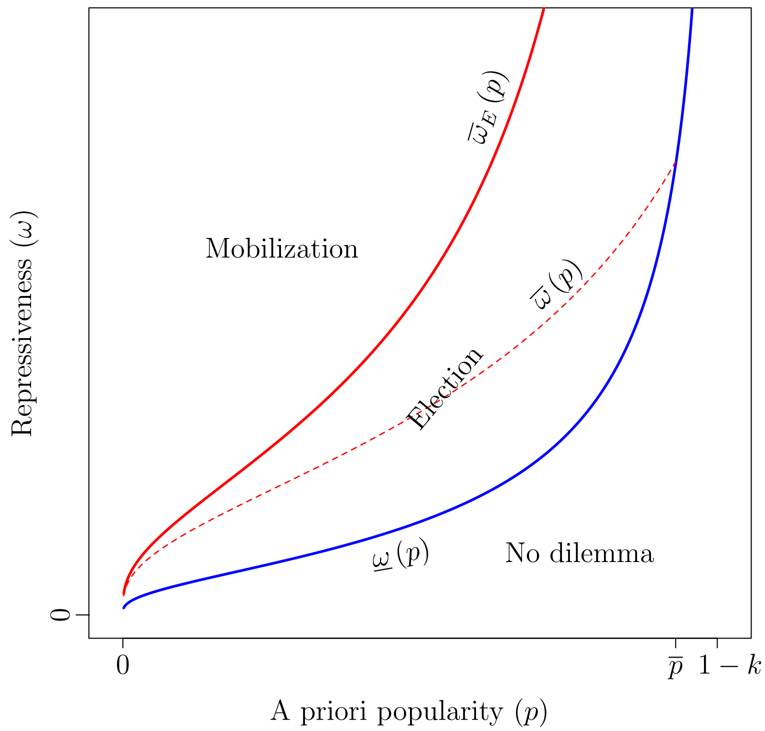
Proposition 2. *Suppose the ruler is able to manipulate information through elections. If the public signal $s = 0$, the ruler mobilizes ($\mu = 1$) and the opposition does not challenge ($c = 0$); the election design is irrelevant. If $s = 1$:*

1. *If $\omega \leq \underline{\omega}(p)$, the ruler does not mobilize ($\mu = 0$), the ruler chooses an uninformative election design, and the opposition does not challenge ($c = 0$).*
2. *If $\omega > \overline{\omega}_E(p)$, the ruler mobilizes ($\mu = 1$) and the opposition does not challenge ($c = 0$); the election design is irrelevant.*
3. *If $\underline{\omega}(p) < \omega \leq \overline{\omega}_E(p)$, the ruler does not mobilize ($\mu = 0$), the ruler chooses the optimal election design $\hat{\tau}$, and the opposition challenges ($c = 1$) if and only if the election outcome is negative ($v = 0$).*

Proof. See above. □

Figure 5 illustrates Proposition 2 for the case in which the public signal $s = 1$. The availability of elections as a tool of autocratic survival extends the set of environments in which the ruler puts himself at risk of losing power rather than bearing the cost of mobilization. For any (p, ω) in the interior region, the autocrat risks a negative election outcome and the belated realization that he should have mobilized when he had the chance. Yet the ruler is better, not worse, off with elections than without: the optimal election design dominates any "non-election" in which $\tau_0 = \tau_1$. Elections give the ruler of a "moderately" repressive regime the chance to survive without paying the cost of mobilization not only

Figure 5: Authoritarian elections. If the public signal $s = 1$ (the case depicted), and if the regime is of intermediate repressiveness, the ruler uses elections to more credibly convey that he is popular, when that is the case, without always revealing that he is unpopular when that is true. Relative to the case with no elections, mobilization is optimal for a smaller region of the parameter space.



when he is popular, but also when he is lucky. In essence, a repressive environment presents less of a dilemma when the dictator can stage a managed election in his defense.

4 Optimal repressiveness

In our baseline model and the extension to authoritarian elections, we explore the presence, strength, and resolution of the dictator's dilemma for a fixed level of repressiveness. In this section, we ask what level of repressiveness is optimal for the ruler—and how that is affected by his ability to shape beliefs through semicompetitive elections.

Suppose that, before the public signal s is generated, the ruler chooses a level of repressiveness $\omega \in [0, \omega^{\max}]$. The parameter $\omega^{\max} > 0$, which is maximum possible repressiveness, measures the extent to which the ruler is constrained for reasons external to our model:

communication technology, geopolitical considerations, state capacity, and so forth.[5] As we have little to say about the direct costs of imposing a more or less repressive regime, we simply assume a lexicographic preference such that the ruler prefers the minimum level of repressiveness among all those that provide maximum expected utility, given the payoffs defined in the baseline model.

Let $U(\omega)$ denote the ruler's ex ante expected payoff in the baseline model without elections, and let $U_E(\omega)$ be the analogue when the ruler is able to hold and manipulate elections. To ease notation, we suppress dependence on p, but all results hold for any $p < 1 - k$. Then,

$$U(\omega) = \begin{cases} p + (1-p)q(\omega) + (1-p)\left(1-q(\omega)\right)\pi(\omega), & \omega \leq \underline{\omega} \\ p + (1-p)\left(1-q(\omega)\right)\pi(\omega), & \underline{\omega} < \omega \leq \overline{\omega} \\ \pi(\omega), & \omega > \overline{\omega} \end{cases}$$

and

$$U_E(\omega) = \begin{cases} p + (1-p)q(\omega) + (1-p)\left(1-q(\omega)\right)\pi(\omega), & \omega \leq \underline{\omega} \\ \frac{p}{1-k} + (1-p)\left(1-q(\omega)\right)\pi(\omega), & \underline{\omega} < \omega \leq \overline{\omega}_E \\ \pi(\omega), & \omega > \overline{\omega}_E \end{cases},$$

which differ only for $\underline{\omega} < \omega \leq \overline{\omega}_E$.

Our goal is to characterize and compare

$$\omega^* := \min \arg \max_{\omega \in [0, \omega^{\max}]} U(\omega)$$

and

$$\omega_E^* := \min \arg \max_{\omega \in [0, \omega^{\max}]} U_E(\omega),$$

that is, the minimum repressiveness that maximizes the ruler's expected utility under no elections and elections, respectively. Recall that $\underline{\omega}$ is the maximum ω such that the opposition

[5] Much could be cited here. Levitsky and Way (2022), for example, discuss the coercive power of revolutionary regimes that survive counterrevolutionary wars. For our purposes, it is sufficient that there is some limit to the repressive environment the regime can create.

prefers not to challenge if $s = 1$ and the ruler does not mobilize. As a preliminary step, the following lemma establishes that, for $\omega > \underline{\omega}$, the ruler's expected utility exceeds that from $\underline{\omega}$ for a level of repressiveness weakly lower with elections than without.

Lemma 3. *Define*

$$\hat{\omega} := \inf \left\{ \omega > \underline{\omega} : \; U(\omega) > U(\underline{\omega}) \right\} \tag{5}$$

$$\hat{\omega}_E := \inf \left\{ \omega > \underline{\omega} : \; U_E(\omega) > U(\underline{\omega}) \right\}. \tag{6}$$

Then, $\underline{\omega} \leq \hat{\omega}_E \leq \hat{\omega} < \infty$.

Proof. See appendix. □

Figure 6, to which we refer repeatedly in this section, illustrates Lemma 3. (As in the preceding figures, we illustrate the case for which $p < \bar{p}$, which implies $\underline{\omega} < \overline{\omega}$, but neither this lemma nor the subsequent propositions depend on this assumption.) Without elections, the ruler's ex ante expected payoff suffers a discontinuous drop at $\underline{\omega}$—the point beyond which the dictator's dilemma exists. With elections, in contrast, there is no discontinuity, as the ruler provides just enough information to dissuade the opposition from challenging. With less ground to make up, the ruler's expected utility exceeds that at $\underline{\omega}$ for a lower level of repressiveness with elections than without.

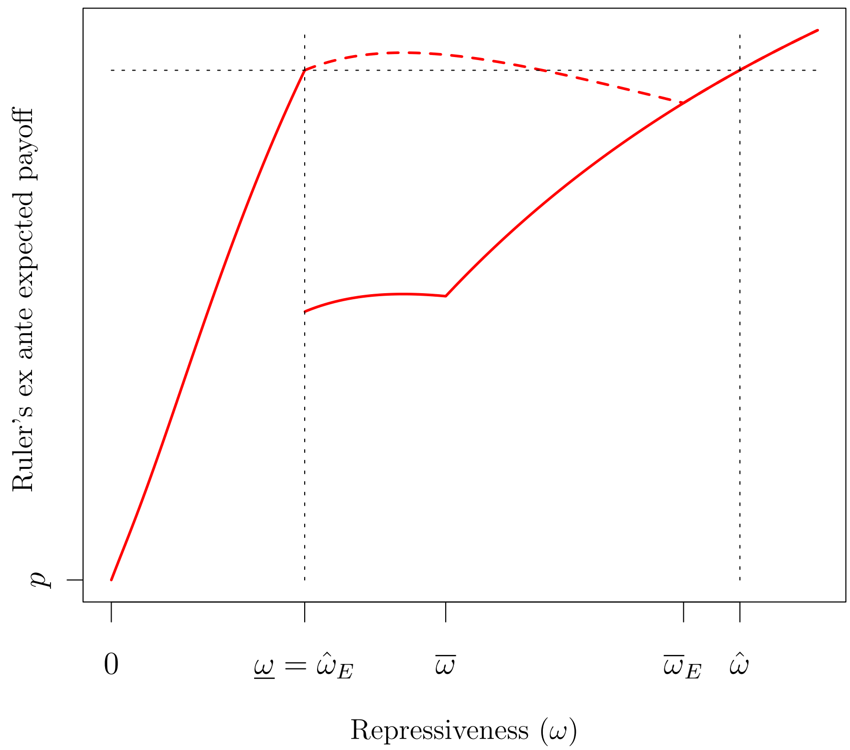
We are now in a position to derive the optimal level of repressiveness with elections and without. In the following propositions, we consider two cases: that in which the maximum level of repressiveness is lower than $\hat{\omega}$, as defined in Equation 5, and that in which it is higher.

Proposition 3. *If* $\omega^{\max} \leq \hat{\omega}$, *then* $\omega^* \leq \omega_E^*$. *Moreover, given* $\omega^{\max} \leq \hat{\omega}$, *then* $\omega^* < \omega_E^*$ *holds if and only if* $\omega^{\max} > \hat{\omega}_E$.

Proof. See appendix. □

Proposition 3 says that when the ruler finds it comparatively difficult to create a repressive regime, the optimal level of repressiveness is weakly greater with elections than without.

Figure 6: Ruler's ex ante expected payoff with and without elections, respectively. Where these diverge, the expected payoff with elections is given by the dashed line.



Moreover, the inequality is strict when $\omega^{\max} > \hat{\omega}_E$. Together, these two statements yield a surprising conclusion: When building a repressive apparatus is neither too easy nor too hard, information manipulation (semicompetitive elections in our primary but not exclusive interpretation) and repression are *complements*. Figure 6 shows why. When $\omega^{\max} \leq \hat{\omega}$, the optimal level of repressiveness without elections is $\underline{\omega}$—just shy of where the opposition would challenge when the public signal $s = 1$. At the same time, given that $\omega^{\max} > \hat{\omega}_E$, a ruler able to shape beliefs through semicompetitive elections optimally chooses a higher level of repressiveness, anticipating that the opposition will refrain from challenging when $s = 1$ so long as the ruler subsequently wins the election. The easing of the dictator's dilemma with autocratic elections encourages greater repression.

Proposition 4. *If* $\omega^{\max} > \hat{\omega}$ *and if* $(1 - q(\omega))\,\pi(\omega)$ *is single-peaked in* $\omega \in [\underline{\omega}, \overline{\omega}_E]$, *then* $\omega^* \geq \omega_E^*$.

Proof. See appendix. □

Proposition 4 shows that information manipulation and repression can instead be *substitutes* when building a repressive state is comparatively easy ($\omega^{\max} \geq \omega_E^*$). The additional assumption of single-peakedness implies that $\omega^* = \omega_E^*$ if $\omega^* \in (\hat{\omega}, \omega^{\max})$. This condition is guaranteed when π is concave and q is differentiable with log-concave derivative q'. The former assumption is natural, given that $1 - \pi$ is the cost of mobilization. As to the latter, as previously discussed, $q(\omega)$ can be interpreted as $F(\omega)$, where $F(.)$ is the distribution of (unmodeled) citizens' cost of "preference falsification." Under this interpretation, assuming that q has a log-concave derivative is equivalent to assuming F has a log-concave density, which is satisfied for many common distributions.

To see why the availability of semicompetitive elections or other forms of information manipulation can reduce the optimal level of repressiveness, consider again Figure 6. If $\omega^{\max}$ is slightly to the right of $\hat{\omega}$, the ruler is better off choosing the level of repressiveness that corresponds to the peak of the dashed curve. The logic is similar to that for Proposition 3. The easing of the dictator's dilemma with autocratic elections creates scope to choose a "moderate" level of repressiveness, whereby the ruler relies substantially on elections to retain power without bearing the cost of mobilization.

5 Conclusion

The ruler of a repressive autocracy faces a dilemma that follows from uncertainty about public opinion. Suspecting that professions of support for the regime are insincere, the dictator can choose to mobilize the repressive apparatus of the state—but this is costly and may be unnecessary. Alternatively, he can hope that he truly is popular, risking a failure to mobilize when, with the advantage of hindsight, he should have. Which of these unattractive options the dictator chooses depends on the repressiveness of the regime. The ruler of a truly repressive state finds it less costly to mobilize security forces, even as he is particularly unconvinced that statements of popular support are genuine. He chooses to mobilize. In contrast, the ruler of a moderately repressive regime gambles that he truly is popular, even as the opposition gambles that he is not. When the regime is minimally repressive, there is no dilemma.

The baseline model from which these arguments follow is honest to the environment Wintrobe described. In an extension, we allow the ruler to also employ a more "modern" instrument: the manipulation of beliefs through semicompetitive elections or related tools. By allowing for the controlled revelation of discontent, use of this instrument softens the dilemma. When autocratic elections are properly managed—say, through the selective elimination of candidates or calibrated use of electoral commissions and outside monitors—election victories for the ruler are uncontested, even though some of the time they fail to reflect public opinion. This encourages the ruler of somewhat more repressive regimes not to mobilize the repressive apparatus. Backing up, and thinking about the optimal choice of regime, it can even encourage more repressiveness, though whether that or the opposite is true depends on the ease of building a repressive state.

The easing of the dictator's dilemma under semicompetitive elections suggests the following question: Why have not more autocratic rulers chosen to employ such technologies? One answer is that earlier rulers were constrained for ideological or geopolitical reasons not to allow true competition. Such was the case in Ceauşescu's Romania, for example, where, as in other East European socialist states, non-competitive elections were held with only "national front" candidates on the ballot. A second response begs rather than answers the question. Is electoral autocracy—the strategic manipulation of beliefs more generally—really such an unusual and recent phenomenon? One need look no further than Napoleon III to find a 19th-century autocrat who governed like a 21st-century one. Elections under the 1852 French constitution allowed for limited electoral competition, such that the Bonapartist victory in the 1863 parliamentary elections looks much like that for Vladimir Putin in today's Russia: a strong but not unanimous vote for the ruling regime. Further exploration of the ways in which past and present autocrats have managed the dictator's dilemma is a fruitful topic for future research.

Appendix

Proof of Lemma 1

First, because $q(\omega)$ and $\pi(\omega)$ are continuous and strictly increasing in ω, the expression

$$\tilde{p}(\omega, p) - \pi(\omega)$$

must be continuous and strictly decreasing in ω. Second, because $q(0) = \pi(0) = 0$ and $\lim_{\omega\to\infty} q(\omega) = \lim_{\omega\to\infty} \pi(\omega) = 1$,

$$\tilde{p}(0, p) - \pi(0) = 1 > 0$$

and

$$\lim_{\omega\to\infty} [\tilde{p}(1, p) - \pi(1)] = p - 1 < 0.$$

The intermediate value theorem therefore implies that the equation $\tilde{p}(\omega, p) = \pi(\omega)$ admits a unique solution $\overline{\omega}(p) > 0$. Third, because $\tilde{p}(\omega, p) - \pi(\omega)$ is strictly decreasing in ω, the definition of $\overline{\omega}(p)$ implies that $\tilde{p}(\omega, p) > \pi(\omega)$ if and only if $\omega < \overline{\omega}(p)$. This establishes the first part of the lemma.

Now, because $\tilde{p}(\omega, p) - \pi(\omega)$ is continuous in p, $\overline{\omega}(p)$ must also be continuous in p. We further show that $\overline{\omega}(p)$ is strictly increasing in p. To see this, note that for any $p, p' \in (0, 1)$ such that $p < p'$, $\tilde{p}(\omega, p) < \tilde{p}(\omega, p')$ holds for all $\omega > 0$, so that

$$\tilde{p}(\overline{\omega}(p'), p') - \pi(\overline{\omega}(p')) = 0 = \tilde{p}(\overline{\omega}(p), p) - \pi(\overline{\omega}(p)) < \tilde{p}(\overline{\omega}(p), p') - \pi(\overline{\omega}(p)).$$

As $\tilde{p}(\omega, p) - \pi(\omega)$ is strictly decreasing in ω, the above inequality implies that $\overline{\omega}(p') > \overline{\omega}(p)$. Next, by definition of $\underline{\omega}$ and $\overline{\omega}$, the condition $\overline{\omega}(p) > \underline{\omega}(p)$ holds if and only if

$$\pi(\overline{\omega}(p)) < 1 - k,$$

which is equivalent to

$$p < \overline{p} \equiv \overline{\omega}^{-1}\left(\pi^{-1}(1 - k)\right). \tag{7}$$

Finally, by definition of $\overline{\omega}(p)$ in the first part of the lemma,

$$\pi\left(\overline{\omega}\left(1-k\right)\right)=\frac{1-k}{1-k+kq\left(\overline{\omega}\left(1-k\right)\right)}>1-k,$$

that is,

$$1-k>\overline{\omega}^{-1}\left(\pi^{-1}\left(1-k\right)\right),$$

which together with the definition of $\overline{p}$ in Equation 7 implies $\overline{p}<1-k$. This establishes the second part of the lemma. □

Proof of Lemma 2

First, because $q(\omega)$ and $\pi(\omega)$ are continuous and strictly increasing in ω, the expression

$$\frac{\tilde{p}\left(\omega,p\right)}{1-k}-\pi\left(\omega\right)$$

is continuous and strictly decreasing in ω. Second, because $\lim_{\omega\to\infty} q(\omega)=\lim_{\omega\to\infty}\pi(\omega)=1$ and $p<1-k$,

$$\lim_{\omega\to\infty}\left(\frac{\tilde{p}\left(\omega,p\right)}{1-k}-\pi\left(\omega\right)\right)=\frac{p}{1-k}-1<0.$$

Third, by the definition of $\underline{\omega}(p)$ and $\overline{\omega}(p)$,

$$\begin{aligned}\frac{\tilde{p}\left(\underline{\omega}\left(p\right),p\right)}{1-k}-\pi\left(\underline{\omega}\left(p\right)\right)&=1-\pi\left(\underline{\omega}\left(p\right)\right)>0\\ \frac{\tilde{p}\left(\overline{\omega}\left(p\right),p\right)}{1-k}-\pi\left(\overline{\omega}\left(p\right)\right)&=\left(\frac{1}{1-k}-1\right)\pi\left(\overline{\omega}\left(p\right)\right)>0.\end{aligned}$$

The intermediate value theorem therefore implies that the equation $\frac{\tilde{p}(\omega,p)}{1-k}=\pi(\omega)$ admits a unique solution $\overline{\omega}_E(p)>\max\{\underline{\omega}(p),\overline{\omega}(p)\}$. Finally, because $\frac{\tilde{p}(\omega,p)}{1-k}-\pi(\omega)$ is strictly decreasing in ω, the definition of $\overline{\omega}_E(p)$ implies that $\frac{\tilde{p}(\omega,p)}{1-k}\geq\pi(\omega)$ if and only if $\omega\leq\overline{\omega}_E(p)$.

□

Proof of Lemma 3

Because

$$\lim_{\omega\downarrow\underline{\omega}}U(\omega)=p+(1-p)\left(1-q(\underline{\omega})\right)\pi(\underline{\omega})<\frac{p}{1-k}+(1-p)\left(1-q(\underline{\omega})\right)\pi(\underline{\omega})=U(\underline{\omega})$$

and

$$\lim_{\omega \uparrow \infty} U(\omega) = \lim_{\omega \uparrow \infty} \pi(\omega) = 1 > U(\underline{\omega}),$$

it must be true that $\hat{\omega} \in (\underline{\omega}, \infty)$. Similarly, $\hat{\omega}_E \in [\underline{\omega}, \infty)$. Moreover, because $U_E(\omega) \geq U(\omega)$ holds for all $\omega \in \mathbb{R}_+$,

$$\{\omega > \underline{\omega} : \; U(\omega) > U(\underline{\omega})\} \subseteq \{\omega > \underline{\omega} : \; U_E(\omega) > U(\underline{\omega})\},$$

which implies $\hat{\omega}_E \leq \hat{\omega}$.

□

Proof of Proposition 3

Because $U(\omega) = U_E(\omega)$ is strictly increasing in $\omega \leq \underline{\omega}$, $\omega^* = \omega_E^* = \omega^{\max}$ if $\omega^{\max} \leq \underline{\omega}$; and if $\omega^{\max} > \underline{\omega}$, it must be true that $\omega^* \geq \underline{\omega}$ and $\omega_E^* \geq \underline{\omega}$. As the proposition holds trivially when $\omega^{\max} \leq \underline{\omega}$, in what follows, we consider the case when $\omega^{\max} > \underline{\omega}$.

First, suppose $\omega^{\max} \leq \hat{\omega}_E \leq \hat{\omega}$. By definition of $\hat{\omega}$ and continuity of $U(\omega)$ in $\omega > \underline{\omega}$, $U(\omega) \leq U(\underline{\omega})$ holds for all $\omega \leq \omega^{\max} \leq \hat{\omega}$, which implies that $\omega^* = \underline{\omega}$. Similarly, the definition of $\hat{\omega}_E$ and continuity of $U_E(\omega)$ in $\omega \in \mathbb{R}_+$ together imply that $U_E(\omega) \leq U(\underline{\omega}) = U_E(\underline{\omega})$ for all $\omega \leq \omega^{\max} \leq \hat{\omega}$, which in turn implies that $\omega_E^* = \underline{\omega} = \omega^*$.

Second, suppose $\hat{\omega}_E < \omega^{\max} \leq \hat{\omega}$. Because $\hat{\omega}_E \geq \underline{\omega}$, $\omega^{\max} > \underline{\omega}$, so that $\omega^* = \underline{\omega}$, as shown above. Because $U_E(\omega)$ is continuous in $\omega \in \mathbb{R}_+$, the definition of $\hat{\omega}_E$ implies that $U_E(\hat{\omega}_E + \epsilon) > U(\underline{\omega}) = U_E(\underline{\omega})$ for sufficiently small $\epsilon > 0$, such that $\hat{\omega}_E + \epsilon \leq \omega^{\max}$. Then it must be true that $\omega_E^* > \underline{\omega} = \omega^*$.

□

Proof of Proposition 4

Because $\omega^{\max} > \hat{\omega} > \underline{\omega}$, as shown in the proof of Proposition 3, it must be true that $\omega^* \geq \underline{\omega}$ and $\omega_E^* \geq \underline{\omega}$. Moreover, because $U(\omega)$ is continuous in $\omega > \underline{\omega}$, the definition of $\hat{\omega}$ implies $U(\hat{\omega} + \epsilon) > U(\underline{\omega})$ for sufficiently small $\epsilon > 0$ such that $\hat{\omega} + \epsilon \leq \omega^{\max}$. It follows that $\omega^* > \underline{\omega}$.

If $\omega^* = \omega^{\max}$, then obviously $\omega_E^* \leq \omega^{\max} = \omega^*$. In what follows we therefore focus on the case when $\omega^* < \omega^{\max}$.

First, we show that $\omega^* < \omega^{\max}$ implies that $\omega^* < \overline{\omega}$. Assume otherwise, $\omega^* \geq \overline{\omega}$. Then, $\omega^{\max} > \omega^* \geq \overline{\omega}$, so that

$$U(\omega^*) = \pi(\omega^*) < \pi(\omega^{\max}) = U(\omega^{\max}),$$

which contradicts the definition of ω^*. Hence, it must be true that $\omega^* < \overline{\omega}$. Observe that because $\omega^* \geq \underline{\omega}$, this case is possible only if $\underline{\omega} < \overline{\omega}$ which, in turn, requires $p < \overline{p}$, as defined in Lemma 1.

Second, we show that ω^* uniquely maximizes $U_E(\omega)$ on $[\underline{\omega}, \overline{\omega}_E]$. By definition, ω^* maximizes

$$U(\omega) = p + (1-p)\,(1-q(\omega))\,\pi(\omega)$$

on $\omega \in (\underline{\omega}, \min\{\omega^{\max}, \overline{\omega}\}]$. The single-peakedness of $(1-q(\omega))\,\pi(\omega)$ implies that ω^* must uniquely maximize $(1-q(\omega))\,\pi(\omega)$ on $\omega \in (\underline{\omega}, \min\{\omega^{\max}, \overline{\omega}\}]$. Then, because $\overline{\omega}_E > \overline{\omega} \geq \min\{\omega^{\max}, \overline{\omega}\}$ and because $\omega^* < \min\{\omega^{\max}, \overline{\omega}\}$, the single-peakedness of $(1-q(\omega))\,\pi(\omega)$ implies that ω^* uniquely maximizes $(1-q(\omega))\,\pi(\omega)$ on $[\underline{\omega}, \overline{\omega}_E]$. Thus, because

$$U_E(\omega) = \frac{p}{1-k} + (1-p)\,(1-q(\omega))\,\pi(\omega)$$

for all $\omega \in [\underline{\omega}, \overline{\omega}_E]$, ω^* uniquely maximizes $U_E(\omega)$ on $[\underline{\omega}, \overline{\omega}_E]$.

Finally, we show that $U_E(\omega^*) \geq U_E(\omega)$ for all $\omega \in (\overline{\omega}_E, \omega^{\max}]$, given that $\omega^{\max} > \overline{\omega}_E$. Now suppose $\omega^{\max} > \overline{\omega}_E$. It follows that $\omega^{\max} > \overline{\omega}_E > \overline{\omega}$. As a result,

$$U_E(\omega) = U(\omega) = \pi(\omega)$$

holds for all $\omega \in (\overline{\omega}_E, \omega^{\max}]$. But because $\omega^* < \overline{\omega} < \overline{\omega}_E$ and because of the definition of ω^*,

$$\begin{aligned} U_E(\omega^*) &= \frac{p}{1-k} + (1-p)\,(1-q(\omega^*))\,\pi(\omega^*) \\ &> p + (1-p)\,(1-q(\omega^*))\,\pi(\omega^*) \\ &= U(\omega^*) \geq U(\omega) = U_E(\omega) \end{aligned}$$

must hold for all $\omega \in (\overline{\omega}_E, \omega^{\max}]$. This and the previous step together imply that $\omega_E^* = \omega^*$, which completes the proof.

□

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