

# Persistent Protests

Sofia Correa<sup>‡</sup>

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**Abstract.** A continuum of citizens with heterogeneous opportunity costs participate in a public protest, with well-defined demands. The government can concede at any time. As long as it does not, it shoulders a cost that is increasing in time and in participation rates. Apart from their collective demands, citizens enjoy a “merit reward” if the government concedes while they are actively participating. A protest equilibrium of the ensuing dynamic game must display: (a) a *build-up stage* during which citizens continuously join the protest, but the government ignores them, followed by (b) a *peak* at which the government concedes with some positive probability, failing which there is (c) a protracted *decay stage*, in which the government concedes with some density, and citizens continuously drop out. Citizens with higher opportunity costs enter later and exit earlier. While there are multiple equilibria, *every* equilibrium with protest has the above properties, and the set of all equilibria is fully described by a single pseudo-parameter, the protest peak time, which can vary within bounds that I characterize. Preliminary evidence from the *Black Lives Matter* movement support the features that I extract from this model.

## 1. Introduction

Public protests and social movements vary in size and duration. Static theories capture the essential multiplicity of “protest equilibria,” giving us some idea of how people overcome coordination barriers. However, such theories do not capture the dynamics of protest: the entry and exit of citizens into the movement, the resulting path of the participant stock, and the pattern of government concessions over time. The objective of my paper is to study the dynamics of participation in public protest in a context in which agents have heterogeneous opportunity costs of participating. I study how heterogeneity influences social behavior and shapes the overall contours of a persistent protest.

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<sup>‡</sup>Department of Economics, New York University, scorrea@nyu.edu.

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I understand a protest event as the gathering of people to demonstrate against some authority about a given policy. The word *persistence* in this context refers to the duration of political unrest, in each of its potentially distinct phases. A protest may take time to build. It may take time to die out. The government may take more or less time to concede. Perhaps the most prominent example of a persistent protest is the Arab Spring, which began in Tunisia in the early 2010s, spreading to other countries. More recent examples of protests include Chile and Iran in 2019, where again there was persistence of the protest in its different phases. The *Black Lives Matter* movement in the US is the most recent case of public protests characterized by persistent participation in all states, with different dynamics of participation and concessions.

In this paper, I build a model of protests to capture these dynamics, including buildups, sudden or slow concessions, and decays. The following assumed features are central to my theory. First, protests are costly to both parties. For citizens, the act of protest uses time and resources. For the government, facing down a protest is costly, both in terms of economic loss and political reputation. Second, the act of participation by an individual citizen is largely voluntary.<sup>1</sup> And finally, even if the goal of the protest is some non-excludable public good, citizens do have a separate individual incentive to participate, driven by a psychological or socially-conferred “merit reward” of being an active member of the movement.

Formally, I posit a continuum of small players — the citizens — and a single large player, the government. Time is continuous, and at any instant citizens face a binary choice: whether to participate in a protest or not. The cost of participating is the opportunity cost of the time spent in the protest, which is heterogeneous across citizens. The government decides at any instant whether to concede or not, but as long as it does not concede, it faces a cost that is increasing both in the number of people protesting and in the duration of the protest. At the same time, concession is also costly to the government, because in that event it has to pay the cost of some public good: a new policy perhaps, or a regime change, or an expansion of rights. Everyone can enjoy this public good, whether or not they participated in the protest.

As already mentioned, citizens additionally enjoy a reward for being actively involved in the protest if and when the government concedes. To emphasize that the duration of involvement matters, we refer to this one-time victory payoff as a *veteran prize*. This formulation aims to combine an instrumental motive, i.e. obtaining the public good, with an intrinsic motive, i.e. personally contributing to the victory. The veteran reward increases with the time spent in the protest, but is only made available once the government

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<sup>1</sup>There could be other settings in which an institutional affiliation enforces participation, but we do not study them here.

concedes. The model works with the same qualitative features whether or not the reward is fully contingent on being there at the moment of victory, but for concreteness we focus on this particular case.

In this dynamic game, one side is populated by a continuum of agents. As it is natural in standard policy analysis, I assume that the government can only observe citizens' aggregate behavior. Then, every aggregate strategy that is the same barring a measure zero of agents will be taken to generate the same observed history from the point of view of the government. (Matters would be different if there were a leader or a distinguished, non-anonymous agent, leading to the possibility of folk-theorem-like arguments. We do not consider that model here.)

That said, anonymity does not eliminate multiplicity, for multiplicity is a natural (and non-technical) consequence of any game with strategic complementarities. But it dramatically sharpens the set of equilibria. There is always an equilibrium with no protest and no government concession, but more remarkably, *every* equilibrium in which a protest occurs has exactly the same qualitative features. It is characterized by three stages: a build-up stage, a peak, and possibly a decay stage. The *build-up stage* corresponds to an initial period during which the protest grows as people continuously enter. It involves no concession at all on the part of the government. The second stage lasts but an instant, and is distinguished by the possibility of a government concession with positive probability — the protest is costly enough that the government can no longer ignore it. We call this stage the *peak*. If a concession does not occur, the third and final *decay phase* starts up. It is described by continuous dropout by the citizens, with the aggregate mass of protestors shrinking with time. All along, the government concedes with a continuous but changing hazard rate that we fully characterize.

The decay stage will be familiar to any economic theorist: it unfolds as a war of attrition, but the twist I add is that one side we have a *continuum* of players; namely, the citizens. Their cost heterogeneity allows me to purify their aggregate behavior, leading to ongoing dropouts in the decay phase. On the other side we have the government, which must randomize according to a continuous distribution over concession times. In particular, it must be indifferent at any time between conceding and waiting another instant. For this indifference condition to hold in equilibrium, the government will concede at some time-varying hazard rate that generates exactly the path of participation rates that guarantees this indifference. As far as citizens are concerned, they take as given the hazard path, and drop out as their expected gains from continuation become too low relative to their cost. Individual exits are deterministic, and aggregate to a smooth path of decay.

The peak stage is special because it involves a non-trivial probability of concession. Mathematically, that "initializes" the starting conditions of the war of attrition to follow,

but it is also conceptually important because it suggests a sudden change in government attitudes that occurs precisely at the height of the protest.

In addition to these features, the build-up phase I describe is, to my knowledge, completely novel. It is not a part of any war of attrition, and stems from the assumption of varying opportunity costs of participation, along with the structure of the veteran reward. Individuals enter the protest in a spread-out way, leading to a swelling in unrest. During this entire period, I show that there cannot be a positive response from the government, because it must strictly prefer not to concede in this phase. Taken together, the three phases generate a rich but uniform prediction for the path of protests.

A central feature of equilibrium is that individual entry and exit decisions are monotone in their opportunity costs. I show that citizens enter at most once and exit at most once. The time at which an individual enters the protest increases with her opportunity cost, and the time at which she exits decreases in her cost. The resulting dynamics of entry and exit are therefore of the first-in-last-out form. The agent with the lowest opportunity cost is the first to enter, and will hold against the government forever. The last agent who joins the protest enters right before the peak, and exits just after it.

While build-up times, peak concession probabilities, decay rates and concession rates vary across equilibria, *all* equilibria share these qualitative features. Moreover, indiscriminate variation is not possible. I show that the set of all equilibria is fully described by a single “pseudo-parameter,” the protest peak time, which can only vary within a range that I fully characterize.<sup>2</sup> This range is a bounded interval with a strictly positive lower bound. The veteran reward is responsible for the positive lower bound, as agents need time to build it, which means that every equilibrium with protests will involve a minimum delay before concessions are made. On the other hand, the peak is also bounded above, so that citizens with the lowest opportunity cost have incentives to begin the protest.

These predictions highlight the relevance of analyzing the dynamic shape of protests, not just theoretically but empirically. Specifically, my model provides a clear empirical prediction about the timing of participation: citizens with higher opportunity cost join protests later, and exit earlier. I explore this idea using county-level data from the recent *Black Lives Matter* protests. While individual participation is not directly observed, we can use county-level thresholds of participation, expressed as a share of the population, to map the notion of *individual* entry and exit to *aggregate* participation at the county level. Then, using these thresholds as our dependent variable, I study their relationship to different measures of opportunity costs.

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<sup>2</sup>To be precise, there is also a second “pseudo-parameter” that could index equilibria, which is the start time of the protest, but without any loss of generality I normalize this to zero.

As the protests started in the middle of the COVID-19 pandemic, people's daily lives were affected in several ways. Probably one of the more direct and observable effects was the change in the amount of time people were spending at their residences. Social distancing policies, school closures, and several economic restrictions forced people to change their lifestyles to adjust to the new environment. I conjecture that spending more time at home affects time flexibility and the opportunity cost of time. Then, I exploit variation in the number of people staying at home to measure the effect of opportunity costs over participation decisions. To address the possibility of omitted variable bias, I follow an instrumental variables strategy, using data on the weather at the beginning of the pandemic as instruments. The main channel exploited is that the weather at the initial stages of the pandemic creates an exogenous variation that has permanent effects over the virus's spread, and therefore, over staying at home behavior before the protests.<sup>3</sup> I obtain that people spending more time at their residences is consistent with earlier entry and later exit.

To complement this analysis, I explore the relation between income and education, and the timing of entry and exit. Higher income levels, related to higher opportunity costs of participation in protests, are connected to later entry times and earlier exit times. The same holds (controlling for income) for counties with a larger share of individuals with less than a college degree. Controlling for income, individuals with lower education levels will tend to work on less flexible jobs, so that their opportunity cost is expected to be higher.

This paper is organized as follows. In the next subsection we briefly review the related literature and our main contribution. In Section 3, I develop the baseline model and provide some discussion of its main features. In Section 4, I characterize the dynamics of protests in equilibrium, and in Section 5 I show some additional properties of the equilibrium set. I develop some extensions in Section 6, and the empirical analysis can be found in Section 7. All proofs can be found in Appendix A.

## 2. Related Literature

This paper contributes to the literature on the dynamics of participation in public protests as a collective action problem. The literature most closely related to my paper is that studying the coordination problem among citizens. Static models of coordination in protests have been studied by [Shadmehr & Bernhardt \(2011\)](#), [Boix & Svolik \(2013\)](#) and [Morris & Shadmehr \(2018\)](#).

This paper's main contribution to the literature is to provide a full characterization of the dynamics of participation and government concession in equilibrium. The dynamics I

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<sup>3</sup>See [Kapoor et al. \(2020\)](#) and [Qiu et al. \(2020\)](#).

obtain are intuitive and novel at the same time. A recent paper related to mine is by [Chenoweth & Belgioioso \(2019\)](#), who propose approximating the effect of social movements by the law of *momentum*: mass times velocity. The mass of a protest is the number of people participating, and the velocity is the frequency of events. They show empirical evidence of dynamics that are similar to the build-up stage in my framework. Moreover, their idea of momentum is based on the principle that social movements can compensate for low popular support by concentrating their activities over time. As I show in Section 4.2, there is a similar trade-off in this dynamic model. However, it occurs between the time at which the government starts to concede and the participation peak.<sup>4</sup>

The dynamics I focus on in this work also differ from those analyzed by [Acemoglu & Wolitzky \(2014\)](#). By developing an overlapping generations model, they study how incomplete information affects the dynamics of conflicts, understood as conflict spirals that generate more unrest in some periods than in others. In this paper, I do not focus on how a current protest affects the probability of occurrence of future events. On the contrary, I focus on one protest and study the participation dynamics for that specific movement. Each equilibrium represents a unique protest with different stages of participation, concessional peaks, and decay.

Another strand of the literature studies participation in collective action and the effects of social interactions. [González \(2020\)](#) studies the impact of Chilean students' networks on their involvement in protests and shows that their network's behavior influences their own. [Bursztyn et al. \(2020\)](#) study how participation in protests increases subsequent attendance at protests and show evidence suggesting that social interactions generate persistent engagement. My paper differs in that I focus on the coordination game's equilibrium between citizens and the government. In my model, even though participation is not directly affected by other protesters' decisions, participation affects citizens' decisions through the probability of government concession.

From a methodological point of view, this work is related to the literature on wars of attrition. The decay stage of equilibria unfolds as a war of attrition with complete information between a single large player and a continuum of citizens. The seminal work of [Hendricks et al. \(1988\)](#) addresses the war of attrition in a context with complete information for the case of two players. In my model, one of the sides is replaced by a continuum of anonymous citizens. When aggregated, their continuous dropout resembles the behavior of a single opponent in the classic war of attrition.

There are, however, other works studying wars of attrition with more than two players. For instance, [Bulow & Klemperer \(1999\)](#) analyze a war of attrition with a finite number of

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<sup>4</sup>In particular, I show that among the set of equilibria, there is an inverse relationship between the rise in participation and the time at which the government makes the first probabilistic concession.

firms competing for a set of prizes. In a more recent paper, [Kambe \(2019\)](#) studies a war of attrition with several agents, in which the exit of a single player is enough to end the game. The lack of anonymity in these cases changes the strategic problem in ways that are unrelated to the setup analyzed here.

This work is also related to the literature on the social psychology of public protests. That literature studies intrinsic motives for participation as a result of ideology or group identity (see [Cohen \(1985\)](#) and [Jasper \(1998\)](#)). The *veteran prize* constitutes a new explanation for persistent participation in a protest, which combines both an *intrinsic* motivation—i.e., the veteran reward—with an *instrumental* motivation—agents obtain this value only if the movement is successful.<sup>5</sup> Studying a game in which agents react to anger, [Passarelli & Tabellini \(2017\)](#) examine intrinsic motivations to protest based on emotions (see also [Wood & Jean \(2003\)](#) and [Pearlman \(2018\)](#) for the case of intrinsic motives and voting).

This work is also related to the literature on conflict (see [Ray & Esteban \(2017\)](#) for a detailed review). There is an extensive literature analyzing the relationship between conflict intensity and income, the main idea being that income affects both the size of the prize that can be obtained from conflict and the opportunity costs (see [Chassang & Padró i Miquel \(2009\)](#), [Dal Bó & Dal Bó \(2011\)](#), and [Mitra & Ray \(2014\)](#)). Although protests can be a particular case of a conflict, the main forces driving the dynamics are different when the “fight” is between a single large player facing an increasing participation cost (the government), and a continuum of small, negligible players (the citizens).

Finally, this work also contributes to the empirical literature on the effects of opportunity costs on conflict and public protests by providing evidence of the effect of opportunity costs on the dynamics of participation over time. [Dube & Vargas \(2013\)](#) and [Bazzi & Blattman \(2014\)](#) exploit exogenous income shocks to disentangle the effect of an income increase on opportunity costs from the effect on the gains from the conflict. [Bazzi & Blattman \(2014\)](#) find that economic shocks do not significantly trigger new wars but affect the persistence of the existing ones. In the context of the *Tea Party* movement, [Madestam et al. \(2013\)](#) have used weather as an exogenous shock to measure opportunity costs, and [Miguel et al. \(2004\)](#) have used weather in the context of conflict in African countries. My approach is closer to the latter, as I do not use weather as a direct shock to attendance at protests, but as an indirect shock affecting the opportunity cost of time.

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<sup>5</sup>See [Feather & Newton \(1982\)](#) and [Klandermans \(1984\)](#) for an analysis of instrumental motivations in protests.



### 3. A Dynamic Model of Protest

In Section 3.1, I describe the baseline model, along with its main assumptions and the equilibrium concept. In Section 3.2, I comment on the assumptions and more generally on the model setup.

**3.1. The Model.** There is a single large player, the *government*, and a continuum of small players, the *citizens* or the *people*. Citizens are indexed by  $i \in [0, 1]$ . Time is continuous, and at any instant  $t \in [0, \infty]$ , citizens decide whether to participate in a protest to ask the government for a public good. The choice for the government is also binary. At any moment in time, the government can either concede or keep waiting. The game ends when one of the two sides fully concedes: either the government provides the public good, or all citizens drop out.

Protests are costly to everyone. For citizens, participating in the protest requires an investment of time and resources, which is captured by an opportunity cost parameter  $\theta$ . I assume that the opportunity cost is heterogeneous and drawn from a distribution  $F$ . In practice, this heterogeneity in opportunity costs may capture different levels of income, types of jobs, or even different residence locations that make protesting more costly for some agents than for others. I assume that  $F$  is continuously differentiable, with full support  $[\underline{\theta}, \bar{\theta}]$ , for some  $\underline{\theta} > 0$ . The maximum cost  $\bar{\theta}$  might be unbounded.

For the government, starting down a protest is also costly. This cost might represent losses due to direct disruption caused by demonstrations, a loss in nationwide economic productivity, or a hit to the government's political reputation. I model this by presuming that the government pays a flow cost that is increasing both in the number of people participating in the protest at a given time and in the duration of the protest. Concession is also costly, as once the government concedes, it pays the equivalent of a flow cost of  $q$  forever.

Let  $\pi_t$  be the mass of citizens protesting at  $t$ , and let  $t = 0$  be the time at which the protest begins. I make some natural assumptions regarding the cost function. First, if there is no one protesting, there is no cost to the government. Second, if the entire population is protesting, the flow cost of bearing the protest is higher than the flow cost of the public good. I summarize this and the above discussion in the following assumption.

**Assumption 1.** *The cost function  $c : [0, 1] \times [0, \infty) \rightarrow \mathbb{R}_+$  is continuously differentiable on both arguments and satisfies:*

(i)  $c(0, t) = 0$  for all  $t$ , and  $c(1, 0) > q$ ;

(ii)  $c(\pi, t)$  is strictly increasing in  $\pi$ , and is strictly increasing in  $t$  if  $\pi > 0$ .



Let  $(\pi_t)_{t \geq 0}$  be a trajectory of participation. If the government concedes at some time  $\tau$ , then its overall costs are given by:

$$\int_0^\tau e^{-rs} c(\pi_s, s) ds + e^{-r\tau} \frac{q}{r}, \quad (1)$$

where  $r > 0$  is the discount rate, which is the same as the citizens' discount rate.

Because the public good is non-excludable, even citizens who did not protest can enjoy it. If the government concedes at a time  $\tau$ , then from that time onward, every citizen receives an extra flow payoff from enjoying the public good. Notice that the value of the public good does not affect citizens' decision to protest, and it is without loss to assume that all of them obtain a value from the public good equal to 1.

In addition to the payoff from the public good, citizens get a reward for being active participants in the protest. This payoff increases with the time spent in the protest, and it is made available only if the citizen is still protesting by the time the government concedes. I call this prize the *veteran reward*. Formally, if the government concedes at time  $t$ , an agent who has been in the protest since time  $t_0$ , and is still in the protest when the government concedes, gets a one-time reward of  $v(t - t_0)$ . I assume that the veteran reward increases with the time spent in the protest, but at a decreasing rate. The following assumption formalizes this idea.

**Assumption 2.** *The veteran reward  $v : [0, \infty) \rightarrow \mathbb{R}_+$  is continuously differentiable, and*

(i)  $0 < v'(\Delta) < \infty$  and  $v''(\Delta) \leq 0$  for all  $\Delta \geq 0$ ;

(ii)  $v(0) = 0$ .

Part (i) ensures that  $v$  is increasing and concave. Part (ii) rules out opportunistic behavior, as it precludes the possibility of agents entering the protest at the exact moment the government is conceding.

Suppose that the government concedes at some time  $\tau$ , possibly random. Consider a citizen with opportunity cost  $\theta$  who starts protesting at some time  $t_0$  and is planning to exit at time  $t_1$ . Her expected payoff is given by the following expression:

$$E \left[ -\theta \int_{t_0}^{t_1 \wedge \tau} e^{-rs} ds + e^{-r\tau} \left( \mathbb{1}_{\tau < t_1} v(\tau - t_0) + \frac{1}{r} \right) \right], \quad (2)$$

where the expectation is taken over  $\tau$ . In words, the citizen will pay the cost of the protest for as long as she remains an active participant. If, by the time the citizen drops out, the government has not conceded, then the citizen simply goes home and receives nothing at that time. Eventually, she will get to enjoy the public good if and when the government

decides to provide it. If, on the contrary, the government concedes before the citizen drops out, then, in addition to the public good, she gets a one-time veteran reward of  $v(\tau - t_0)$ .

It remains to specify how the game is played at each instant. I assume that when the government decides whether to concede, it is already observing how many people are protesting. However, when citizens decide whether or not to protest, they observe participation only until *an instant before* they join. To help better explain the interpretation for continuous time, we can build some intuition with a discrete-time case. Imagine a game played repeatedly at times  $\{0, 1, 2, \dots\}$ . At any time  $t$ , the stage game is such that, first, citizens make a protest decision, and then the government decides whether or not to concede. Thus, when citizens choose their actions, they observe only a history of participation up to  $t - 1$ —i.e.  $\{\pi_0, \pi_1, \dots, \pi_{t-1}\}$ . Once they take an action, the government gets to observe  $\pi_t$  before deciding whether to concede. Hence, the relevant history for the government is given by  $\{\pi_0, \pi_1, \dots, \pi_t\}$ .

Following this intuition, for any time  $t$ , define the histories  $\pi^t = \{\pi_s : 0 \leq s < t\}$  and  $\bar{\pi}^t = \{\pi_s : 0 \leq s \leq t\}$ . Let  $\Pi^t = \{\pi^t\}_{t \geq 0}$  be the set of all possible open histories at time  $t$ , and  $\bar{\Pi}^t = \{\bar{\pi}^t\}_{t \geq 0}$  the set of all possible closed histories at time  $t$ . Also, define  $\pi^0 = \emptyset$ . A strategy for the government is a process  $\gamma = \{\gamma_t\}_{t \geq 0}$ , with  $\gamma_t : \bar{\Pi}^t \rightarrow \{0, 1\}$ , where  $\gamma_t = 1$  stands for *concede* and  $\gamma_t = 0$  for *not concede*. A strategy for a citizen with opportunity cost  $\theta$  is a process  $\sigma^\theta = \{\sigma_t^\theta\}_{t \geq 0}$  with  $\sigma_t^\theta : \Pi^t \rightarrow \{0, 1\}$ , where 1 stands for *participate* and 0 for *not participate*. While the government decision is irreversible, citizens can reenter the protest after leaving. We denote a strategy profile by  $(\sigma, \gamma)$ , where  $\sigma = \{\sigma^\theta\}_{\theta \in [\underline{\theta}, \bar{\theta}]}$ .

For any strategy profile  $(\sigma, \gamma)$ , let  $\pi^{\sigma t}$  be the trajectory up to time  $t$ , conditional on no concession, generated by the strategy  $\sigma$ . This can be defined recursively as follows:

$$\pi_t^\sigma = \int \sigma_t^\theta(\pi^{\sigma t}) dF(\theta) \quad \forall t \geq 0. \quad (3)$$

I focus on the set of Nash Equilibria of the game. Given that the only observable that matters in equilibrium is the aggregate behavior of protesters and not their individual decisions, citizens are anonymous (see [Schmeidler \(1973\)](#) and [Mas-Colell \(1984\)](#)). Then, it is enough to describe the government's strategies along the equilibrium path. This is equivalent to focusing on government strategies that are *open-loop*, in the sense that it is as if the government commits to a sequence of actions at the beginning of the game. The idea behind these strategies is that players do not have to consider how their opponents would react to deviations from the equilibrium path.<sup>6</sup>

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<sup>6</sup>[Fudenberg & Levine \(1988\)](#) compare the notions of *open-loop* and *closed-loop* equilibria for the case of games with non-atomic players. In particular, they show that if there is a unique Nash equilibrium in every subgame, then both equilibria coincide.

We allow the government to randomize over concession times. As we focus on the trajectory of participation that the government expects in equilibrium, we can characterize its strategy as a mixed strategy: a distribution of concessions  $G(t)$ .<sup>7</sup> This distribution of government concessions corresponds to the probability of the government conceding in  $[0, t]$ , given a trajectory of participation up to time  $t$ ,  $\pi^{\sigma t}$ . This function is weakly increasing and right continuous in  $t$ , and its support is defined as:

$$\mathcal{T} = \{t \geq 0 \mid G(t) - G(t - \epsilon) > 0 \ \forall \epsilon > 0\}. \quad (4)$$

Define  $\tau_0 = \inf \mathcal{T}$ —i.e., the first time at which the government makes some concession—and  $\tau_1 = \sup \mathcal{T}$ . On the citizens' side, their anonymous nature comes into play again, as it implies that we can obviate mixed strategies and focus on pure strategies only.

I focus on the set of Nash Equilibria. An *equilibrium* is given by a distribution of government concessions  $G(t)$  and a profile of citizens' strategies  $\sigma$ , such that given the outcome path  $\{\pi_t^\sigma\}_{t \geq 0}$ ,

- (i) the strategy for the government maximizes its expected total payoff; and
- (ii) citizens' strategies maximize their expected total utility given the government's distribution of concession  $G$ .

Before moving to the equilibrium characterization, I discuss some features of the model.

### 3.2. Key Features of the Model.

**3.2.1. The Psychology of the Veteran Prize.** The problem of coordination in collective action problems lies in the fact that if collective action succeeds, it generates gains that all citizens can enjoy, irrespective of their participation or merit in the victory (see [Olson \(2012\)](#)). Scholars have explained participation in these collective action problems either by introducing incomplete information—such as in [Lohmann \(1993\)](#), [Battaglini \(2017\)](#) and [Barbera & Jackson \(2019\)](#)—or by introducing some intrinsic payoffs—such as in [Wood & Jean \(2003\)](#) and [Pearlman \(2018\)](#). I follow the second line.

In the context of protests, several studies have recognized the relevance of group-based emotions and intrinsic psychological motivations for citizens to participate.<sup>8</sup> The literature on the social psychology of public protests has identified four motives for protesting: (i) *Instrumental*: related to the expectation of reaching a goal; (ii) *Identity*: related to the identification with a group; (iii) *Emotions*: related to grievances and group-based anger;

<sup>7</sup>Without anonymity, a behavioral strategy in this context would specify for each possible history  $\bar{\pi}^t$ , a probability of concession.

<sup>8</sup>For group-based emotions as motives, see [Klandermans \(1984\)](#) and [Van Stekelenburg & Klandermans \(2013\)](#).

and (iv) *Ideology*: related to individual values and the perception of an illegitimate state of affairs. The latter three motives (Identity, Emotions, and Ideology) operate through generating an inner obligation to contribute that prevents free riding.<sup>9</sup> However, as [Simon et al. \(1998\)](#) show, in practice, these three motives complement the instrumental one.

The veteran prize then aims to capture this complementarity between instrumental and intrinsic motives. People want to have merit in an eventual victory against the government, but they obtain this rewarding feeling only if they attain the goal. The necessity of goal attainment to obtain the reward captures the instrumental component, whereas the necessity of merit captures the intrinsic component. As the protest in this case needs persistence to be successful, merit is increasing in the time the agent participates, and so it is the veteran reward.

**3.2.2. Conditional Nature of the Veteran Prize.** As the model is currently described, citizens get their veteran prize only if they are actively participating at the time the government concedes. It might be natural, however, for citizens who make a relevant contribution to building up the protest to obtain some reward, even if they drop out before the government concedes. It is direct to extend the model to allow for citizens to obtain part of the veteran prize even if they retire before concession, provided that they obtain it only when the government concedes. If this weren't the case, citizens' strategies would be completely independent of government behavior. This is consistent with the idea just described about protesters' motives. Intrinsic motives, such as identity, emotions and ideology, incentivize participation in ways that complement the instrumental motive of having the government concede.

**3.2.3. Cumulative Nature of the Veteran Prize.** I formulated the model in such a way that the veteran prize is a function of how long the citizen has been in the protest before government concession. This might seem restrictive in practice. For instance, a citizen who contributes by protesting every weekend does not need to feel less veteran than a citizen who participates the same number of hours distributed throughout a week. This assumption can be easily modified without changing the behavior of agents in this game. As citizens discount the future and the opportunity cost is constant, they will always prefer to push all their participation forward. In practice, there may be factors, not included in this model, that differentiate the weekend protester from the one who protests seven days a week. For instance, some cyclical or non-monotonic variation in the opportunity costs might make weekdays more costly than weekends, but that possibility is not considered here.<sup>10</sup>

<sup>9</sup>In a similar vein, in their book *Why Bother?*, [Aytaç & Stokes \(2019\)](#) develop the idea of a psychological *abstention cost*—i.e., a cost for not being in the protest, which encourages people's participation in protests.

<sup>10</sup>However, if opportunity costs change monotonically, all the results of our model would still hold.

**3.2.4. Heterogeneity in Opportunity Costs .** In my model, agents' heterogeneity comes from differences in their opportunity costs of participating in the protests. Naturally, there might be other sources of heterogeneity that are relevant in the context of public protests. It is natural to believe that agents have heterogeneous preferences and then heterogeneous stakes in the conflict. As I pointed out above, in the model's current specification, differences in the value from the public good do not affect citizens' decisions, and then assuming homogeneity is without loss of generality. However, if these heterogeneous values affect the veteran prize's magnitude, the heterogeneity becomes relevant. For instance, one could assume that the value of the public good,  $x$ , multiplies the veteran reward, i.e.,  $x \cdot v(\cdot)$ , so that citizens that care more about the public good feel more rewarded when they win against the government. If that is the case, our opportunity cost parameter will capture the relative effect of costs and valuations. I explore more the possibility of heterogeneous values from the protest in the empirical analysis in Section 7.

## 4. The Dynamics of Protests

**4.1. Equilibrium Characterization.** In this section, I fully characterize the set of equilibria in which a protest occurs. I refer to an equilibrium as an *equilibrium with protests* if there is some (possibly probabilistic) concession by the government—i.e.,  $\mathcal{T} \neq \emptyset$ . In addition to the set of equilibria with protests characterized below, there is always an equilibrium in pure strategies in which the government never concedes and nobody protests—i.e.,  $G(t) = 0$  and  $\pi_t^g = 0$  for every  $t$ . This equilibrium arises naturally in coordination games with complete information, and in protest games, it represents many situations in which protests simply do not occur.

Naturally, there is a multiplicity of equilibria in this game. But what makes the results remarkable is that every equilibrium with protest has the same qualitative features. As Theorem 1 shows, any equilibrium with protests is characterized by three stages: a build-up stage, a peak, and, possibly, a decay stage. The *build-up* stage corresponds to the initial period in which the protest grows as people continuously enter. However, in this initial stage, the protest is still not costly enough to the government, and, thus, the government does not concede. The *peak* is the first time at which there is a possibility of concession by the government with positive probability. It coincides with the time at which participation reaches its maximum level, and the protest becomes costly enough that the government can no longer ignore it. If concession occurs at the peak, the protest ends. If it does not occur, then the *decay* stage starts. In the decay stage, citizens continuously drop out, and participation decreases. The government continues conceding with a decreasing hazard rate.

This result is formalized in the following theorem.

**Theorem 1.** *Let  $G : [0, \infty] \rightarrow [0, 1]$ ,  $(\pi_t^g)_{t \geq 0}$  be an equilibrium with protests. Then, the following features obtain:*

- (i) *There is always delay in government concession—i.e.,  $\tau_0 > 0$ .*
- (ii)  *$\pi_t^g$  is continuous, increasing for  $t \leq \tau_0$ , and if  $G(\tau_0) < 1$ , decreasing for all  $t \geq \tau_0$ .*
- (iii) *The distribution of concessions has, at most, one discrete jump at  $\tau_0$ .*
- (iv) *If  $G(\tau_0) < 1$ , then  $G(t)$  is strictly increasing and continuous, and  $\tau_1 = \infty$ .*

Although I prove the result in Appendix A, I provide the main intuition here.

First, note that in any equilibrium with protests, the government's strategy is restricted to either a singleton support  $\{\tau_0\}$ , or an interval  $[\tau_0, \tau_1]$  (see Lemma 2 in Appendix A). To see this, note that if the government stops conceding during some time interval and resumes concession later, citizens who are already in the protest will wait until the government starts conceding again. As the cost of the protest increases with time, this strategy cannot be optimal.

For the government to play a mixed strategy, it must be that along the support, the following indifference condition holds:<sup>11</sup>

$$c(\pi_t, t) = q \text{ for all } t \in [\tau_0, \tau_1]. \quad (5)$$

This indifference condition imposes a constraint on the number of protesters that the government is willing to tolerate. Define the *indifference participation level*  $\tilde{\pi}_t$  as the trajectory of participation that satisfies equation 5 for any time  $t \in [0, \tau_1]$ . By Assumption 1, this indifference participation path is continuous and strictly decreasing in  $t$ . In equilibrium, the trajectory of participation on the support of  $G(t)$  must coincide with the function  $\tilde{\pi}_t$ , and then it is decreasing.

From the indifference condition, I also conclude that it must be that the interval goes all the way to infinity—i.e.,  $\tau_1 = \infty$ . This result follows from the government's incentives to randomize: it must be that at any time, the government is indifferent between conceding and waiting another instant. If the interval is finite, then there is a time at which the government is no longer indifferent, and the equilibrium will unravel.

Citizens, on the other hand, take the distribution of concession  $G(t)$  as given and decide when to protest. Even when they are allowed to exit and re-enter many times, I show that in equilibrium, they enter and exit, at most, once. Moreover, they enter only before the government starts conceding, and they exit only afterwards.

<sup>11</sup>See Lemma 3 in Appendix A.

Consider the problem of a citizen with opportunity cost  $\theta$ , who enters at  $t_0$  and exits at  $t_1$ . Since the government makes the first probabilistic concession at time  $\tau_0$ , the entry and exit times must be such that  $t_0 < \tau_0 \leq t_1$ . Let  $\lambda_t = \frac{g(t)}{1-G(t)}$  to be the government's hazard rate of concession—i.e., the instantaneous probability of conceding at time  $t$ , given that it has not conceded yet. Once in the protest, this citizen keeps protesting as long as the benefit of staying another instant weakly exceeds the cost. In particular, she exits the protest if:

$$\theta \geq \lambda_{t_1} v(t_1 - t_0). \quad (6)$$

The left-hand side corresponds to the opportunity cost of staying another instant. The right-hand side corresponds to the expected gains: the veteran reward she can obtain, times the hazard rate at which the government is conceding.

Consider, now, the entry decision of the citizen who expects to exit at  $t_1$ . At any time  $t < \tau_0$ , she compares the expected payoff from entering at  $t$  against the payoff from waiting an instant to enter. By entering at  $t$  instead of an instant later, the agent has to pay the flow opportunity cost  $\theta$ . However, the gains are given by the marginal increase in the veteran prize that the agent might obtain during the time she remains in the protest. Then, an agent with opportunity cost  $\theta$  enters the protest at  $t_0$  if:

$$\theta \leq E \left[ e^{-r(\tau-t_0)} \mathbb{1}_{\tau < t_1} v'(\tau - t_0) \right]. \quad (7)$$

As I show in Lemma 4 in Appendix A, citizens' utilities satisfy a single-crossing property with respect to opportunity cost, and then these optimality conditions are both necessary and sufficient. Moreover, their strategies are monotone in the opportunity cost.

This monotonicity allows us to characterize their strategies by a pair of entry and exit thresholds that we denote by  $\tilde{\theta}_0(t)$  and  $\tilde{\theta}_1(t)$ , respectively. At any time  $t < \tau_0$ , a citizen enters if  $\theta \leq \tilde{\theta}_0(t)$ . At any time  $t \geq \tau_0$ , she exits if  $\theta \geq \tilde{\theta}_1(t)$ . Then, equilibrium participation is given by:

$$\pi_t^\sigma = \begin{cases} F(\tilde{\theta}_0(t)) & t \leq \tau_0 \\ F(\tilde{\theta}_1(t)) & t > \tau_0. \end{cases} \quad (8)$$

The expected benefits from entry and exit depend on the government's strategy  $G(t)$ , and this, in turn, determines the entry and exit thresholds,  $\tilde{\theta}_0(t)$  and  $\tilde{\theta}_1(t)$ . The entry threshold is increasing in time, which makes citizens to continuously join over time, and the exit threshold is decreasing, which makes citizens leave. In equilibrium, both thresholds coincide at  $\tau_0$ , generating a continuous trajectory of participation that reaches its peak at that time.

If the government concedes with probability one on its first concession—i.e.,  $\mathcal{T} = \{\tau_0\}$ —then there is no relevant exit decision. In this case, there is no decay stage, as the protest ends at the peak. If, on the contrary, the support  $\mathcal{T}$  is an interval, then the trajectory of



participation in the decay stage must coincide with the indifference participation level  $\tilde{\pi}_t$ . Then, the following equilibrium condition must hold:

$$\pi_t^\sigma = F(\tilde{\theta}_1(t)) = \tilde{\pi}_t. \quad (9)$$

That is, the participation level generated by citizens' best responses must coincide with the indifference participation level.

The equilibrium condition allows us to pin down a precise trajectory for the hazard rate of government concession. At any time  $t \geq \tau_0$ , there is a citizen who is on the margin between staying another instant or dropping out. From the condition in equation 9, this citizen's opportunity cost must be such that  $\tilde{\theta}_1(t) = F^{-1}(\tilde{\pi}_t)$ . Then, citizens' exit times are determined in equilibrium by the trajectory of  $\tilde{\pi}_t$ . Given this exit time, citizens choose an entry time  $t_0(t)$  according to the entry condition 7. Then, the government hazard rate at time  $t$  is given by:

$$\lambda_t = \frac{\tilde{\theta}_1(t)}{v(t - t_0(t))}, \quad (10)$$

which defines a unique distribution of concessions  $G(t)$ .

**4.2. Equilibrium Multiplicity.** So far, I have shown that any equilibrium with protests can be parametrized by a time  $\tau_0$  at which the level of participation reaches its peak and at which the government makes the first concession. In this section, I show that the set of possible times  $\tau_0$  is bounded.

The bounds happen to be very intuitive. The lower bound, is given by the equilibrium in which the government concedes with probability 1 at the time that participation reaches its peak. Let's call this lower bound  $\underline{\tau}$ . If the government concedes with probability 1 at  $\underline{\tau}$ , the marginal benefit of the last agent entering is given by  $v'(0)$ , while the marginal cost is its opportunity cost,  $\theta$ . As all the agents with lower opportunity cost have already entered, participation at the time of concession is given by  $F(v'(0))$ . Then,  $\underline{\tau}$  solves:

$$c(F(v'(0)), \underline{\tau}) = q. \quad (11)$$

The upper bound is a bit more subtle. Recall that I normalize the time so that  $t = 0$  is the time at which the first citizen enters the protest.<sup>12</sup> Given that entry is monotone in  $\theta$ , the first citizen entering is the citizen with the lowest opportunity cost  $\underline{\theta}$ . Note that as the delay in the start of government concession increases, the payoff from entering at 0 also decreases. But in order to have an equilibrium with protests, at least the agent with the lowest opportunity cost must be willing to enter. Then, the upper bound  $\bar{\tau}$  must be such

<sup>12</sup>To be more precise, this normalization is an equilibrium selection. However, given that protests can happen at any time, and the objective of this work is to characterize their dynamics, if we did not set the starting time to 0, the predictions obtained with this normalization could be reproduced on any possible starting point.

that:

$$\underline{\theta} = E [e^{-r\tau} v'(\tau)] . \quad (12)$$

The left-hand side is the lowest opportunity cost, and the right-hand side is the expected marginal benefit of entering at 0 and staying in the protest forever, given the government's strategy  $G(t)$ . This condition can be rewritten as:

$$\underline{\theta} = \int_{\bar{\tau}}^{\infty} e^{-rs} v'(s) dG(s), \quad (13)$$

where I have modified the right-hand side to show the direct dependence on  $\bar{\tau}$ . In an equilibrium in which the first discrete probabilistic concession occurs at time  $\bar{\tau}$ , the benefit obtained by a citizen who stays in the game forever must coincide with the lowest possible opportunity cost.

I impose the following assumption, which ensures that the lower and upper bounds are distinct and well defined.

**Assumption 3.** *Let  $\underline{\tau}$  be such that  $c(F(v'(0)), \underline{\tau}) = q$ . Then,  $\underline{\theta} < e^{-r\underline{\tau}} v'(\underline{\tau})$ .*

Using these bounds, I obtain the following existence result.

**Theorem 2.** *For every  $\tau_0 \in [\underline{\tau}, \bar{\tau}]$ , there exists a unique equilibrium  $(G, (\pi_t^\sigma)_{t \geq 0})$  in which the government concedes for the first time at  $\tau_0$ .*

This result provides a strong characterization of the set of equilibria. Not only are the possible delays bounded, but, also, given any possible delay in government concession within these bounds, the equilibrium is unique.

To prove this result, I first show existence for the lower and upper bounds,  $\tau_0 = \underline{\tau}$  and  $\tau_0 = \bar{\tau}$ . The lower bound is straightforward, and the upper bound follows from a fixed-point argument that I explain below.

I define a modified problem in which the peak time  $\tau_0$  is chosen by a fictitious player and is given to both the citizens and the government. Suppose that time  $\tau_0$  is given. Recall that in the decay stage, the trajectory of participation is fixed at  $\tilde{\pi}_t$ . Thus, in equilibrium, citizens' exit times are given: a citizen with opportunity cost  $\theta$  exits at time  $t$ , at which  $F(\theta) = \tilde{\pi}_t$ . Then, citizens' best reply is a sequence of entry times, given the government distribution of concessions and given their exit times.

Given these entry times, for any  $t \geq \tau_0$ , the government, in turn, must choose a hazard rate that makes the marginal agent indifferent between conceding and waiting another instant (in order to keep participation at the indifference level in the concession stage). The final step is to introduce the fictitious player whose only role is to adjust  $\tau_0$  for equation (12) to

be satisfied with equality, given the government's best reply. This also allows me to get rid of discontinuities in the government's strategy at  $\tau_0$ , and then I can apply standard fixed-point theorems. It is then straightforward to use the same fixed-point argument to show that for any  $\tau_0 \in [\underline{\tau}, \bar{\tau}]$ , an equilibrium exists.

Figures 1 and 2 illustrate the continuum of equilibria. In both figures, panel (a) shows the equilibrium with the shortest delay,  $\underline{\tau}$ ; panel (b) shows an equilibrium with an intermediate delay,  $\tau_0 \in (\underline{\tau}, \bar{\tau})$ ; and panel (c) shows an equilibrium with the maximum delay possible,  $\bar{\tau}$ .

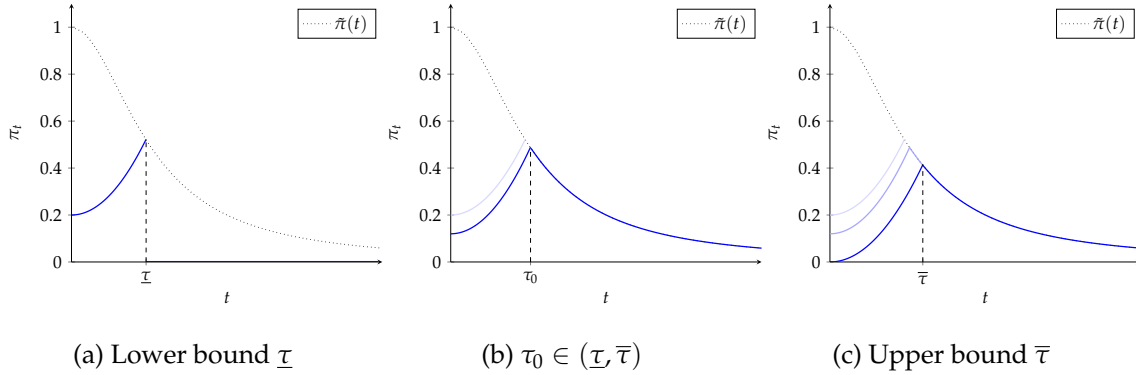
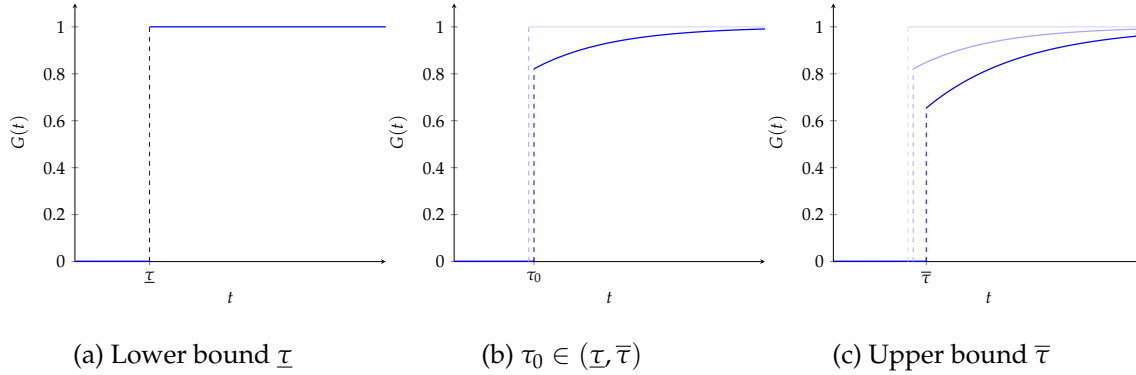
The three panels in Figure 1 illustrate the trajectory of participation for the three delays. The downward-sloping dotted line,  $\tilde{\pi}_t$ , corresponds to the indifference participation level. For any participation level  $\pi_t$  below this dotted line, the cost of the protest is still too low relative to the cost of the public good, and then the government is better off by ignoring protesters. Analogously, any participation level above this line is too costly, and then the government would rather concede. The three panels in Figure 2 show the distributions of government concession corresponding to each delay  $\tau_0$ .

Note, first, that for any delay  $\tau_0 \in [\underline{\tau}, \bar{\tau}]$ , participation is increasing on  $[0, \tau_0]$ . This corresponds to the build-up stage. Since participation in this stage is everywhere below the line  $\tilde{\pi}_t$ , the government is better off by waiting. Then, in the three panels in Figure 2,  $G(t) = 0$  on  $[0, \tau_0]$ . Once participation hits the dotted line, then the protest becomes too costly and the government has to make some concession. The very precise moment at which this happens corresponds to the *peak*. The equilibrium with the shortest delay,  $\underline{\tau}$  in panel (a), corresponds to the equilibrium in which the government concedes with probability 1 at the peak. Then, the distribution of government concessions jumps up to 1, and everyone drops out.

In panel (b),  $\tau_0 \in (\underline{\tau}, \bar{\tau})$ . Note that the government still makes a discrete concession, but with probability less than 1. Immediately after this concession, the government continues randomizing over time, and people continuously drop out. Participation then coincides with the dotted line in equilibrium.

Note that as delay increases (moving to panels (b) and (c)), participation decreases for every  $t$  in the build-up stage. In Section 5.1, I show that this is, in fact, a general feature of the equilibrium set.

Before finishing this discussion, a brief comment on multiplicity is warranted. The existence of multiple equilibria is a natural feature of this model. As has been recognized in the literature, the spontaneous nature of mass uprisings gives them the features of a coordination problem that might, or might not, be successful (see Schelling (1960), Hardin (1997), and more recently, De Mesquita (2014)). In the case of static models of collective

**Figure 1. Equilibrium Participation****Figure 2. Government's Distribution of Concessions**

action, this implies that, in general, there are two equilibria in pure strategies: one in which a protest occurs and one in which it does not occur. In my model, not only we observe equilibrium with and without protests, but there is a continuum of equilibria in which a protest occurs. We can think of many reasons that a society's focal point centers on one particular equilibrium, such as social norms, culture, or coordination technologies. Despite their relevance, this model does not aim to explain these factors.

It is worth mentioning that the type of multiplicity observed here is insightful, in the sense that it provides key ideas about both the dynamics that are common to all equilibria and the trade-offs between persistence and participation across them. In the next section, I study how different equilibria within the equilibrium set compare to each other in terms of duration and participation.

## 5. Equilibrium Set and Comparative Statics

**5.1. Trade-off between Persistence and Participation.** From Figure 1 in the previous section, it is possible to see that there is an inverse relation between the peak in participation and delay in the first probabilistic concession: longer delay is consistent with a lower participation at the peak. We formalize the result in the following corollary.

**Corollary 1.** *Let  $[\underline{\tau}, \bar{\tau}]$  be the set of equilibrium delays. The size of the protest at the peak,  $\pi_{\tau_0}$ , is inversely related to the delay in reaching the peak,  $\tau_0$ .*

This suggests the existence of a trade-off between the mass of people that needs to get involved and the persistence required to make the government concede in equilibrium. In particular, participation could grow and hit the constraint very quickly, and, in that case, a very high participation peak would be required. But there could also be a slow trend upwards, in which case the participation peak would be smaller, as the protest can take advantage of the cost of time the government has to bear.

This trade-off provides novel empirical insights. In a dynamic setting, the characterization of a successful protest should combine a *critical mass*, with a *critical persistence*. Ignoring this trade-off might result into an over-estimation of the critical mass required for a protest to be successful.<sup>13</sup>

A second observation can be highlighted with respect to the set of equilibria. In the same way that we can obtain an inverse relation between participation peak and the time of the peak, we can obtain an inverse relation between participation at  $t = 0$  and the time of the peak,  $\tau_0$ . In particular, participation at time 0 reaches its maximum when delay is at the lower bound  $\tau_0 = \underline{\tau}$ , and its minimum when delay is at the upper bound  $\tau_0 = \bar{\tau}$ . Let  $\underline{\pi}_0$  and  $\bar{\pi}_0$  be the minimum and maximum levels of initial participation. The following corollary formalizes the result.

**Corollary 2.** *Fix an initial participation level  $\pi_0 \in [\underline{\pi}_0, \bar{\pi}_0]$ . There exists a unique equilibrium trajectory of participation  $(\pi_t^\sigma)_{t \geq 0}$  with initial level  $\pi_0^\sigma = \pi_0$ .*

In other words, conditional on the first event, the trajectory of participation is unique. This result gives an idea of how informative the first event of a social movement is with respect to the future trajectory of participation. Fixing the fundamentals, the initial participation is enough to describe the full trajectory of participation. As we see in the next section, this will also be enough to characterize the expected duration until government concession.

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<sup>13</sup>This is in line with the intuition developed recently by [Chenoweth & Belgioioso \(2019\)](#), who propose that a protest can be described by its *momentum*, which is defined as a function of mass (i.e., participation), and velocity (i.e., the frequency of events).

**5.2. Expected Duration across Equilibria.** In this setting, how do different equilibria relate to each other in terms of welfare? In order to assess this, I first need to characterize equilibrium expected duration.

From the characterization of the equilibrium set in Theorem 2, it follows that the expected duration of a protest is increasing in  $\tau_0$ . Putting this together with Corollary 2, I obtain the following.

**Corollary 3.** *The expected duration of protests increases with  $\tau_0$  and decreases with  $\pi_0$ .*

This property follows from the fact that the distributions of government concessions do not cross. Thus, the probability of a protest's survival is monotone in  $\tau_0$  for any  $t > \tau_0$ . The same holds if I parametrize equilibria by initial participation. This result is intuitive because when there are more people on the streets, the government concedes earlier.

Even when duration varies monotonically along the equilibrium set, welfare analysis is more subtle. As the utility obtained from the veteran reward is either psychologically or socially conferred, it is hard to think about a way to measure it. Consider, first, a situation in which we ignore the existence of the veteran prize. As citizens care about the public good, and protesting is costly for them, on aggregate, they will be better off with the equilibria with the shortest duration and the highest initial participation. Moreover, from agents' optimality condition, we learn that when the protest starts, in any equilibria but the upper bound  $\bar{\tau}$ , there is a positive mass of agents who are strictly better off by entering the protest. That mass increases as the peak is reached sooner.

Including the veteran prize has a nontrivial effect. Activism is valuable to citizens, even when protesting is costly. It might very well be that in some cases, after taking the value of activism into account, citizens are better off in an equilibrium with later concession because, then, they get to maximize their contribution to the social movement.

The government, however, is always better off with the equilibrium with the longest delay. To see this, note that during the decay stage, the government is indifferent between conceding and staring down the protest. However, during the build-up stage, participation is still low enough that the protest is less costly than concession. Since the government is strictly better off with the protest than with concession in this stage, it would rather delay concession as much as possible to minimize overall costs.

**5.3. Changes in the Distribution of Opportunity Costs.** In this section, I analyze how changes in the distribution of opportunity costs affect the equilibrium set. An increase in citizens' opportunity costs has two effects. On the one hand, it has a direct effect over agents' entry decision, as a citizen with a higher opportunity cost will want to wait for the marginal

value of entry to increase. On the other hand, it has an indirect effect on the government's best response. In particular, as the opportunity cost of a citizen increases, the hazard rate that is required to make her drop out also increases. In other words, citizens with higher opportunity costs are stronger in front of the government, as they force it to concede faster. The second effect is not observed in the equilibrium with the shortest delay, but it affects the upper bound.

Consider, first, a general increase in agents' opportunity cost. When citizens' opportunity costs increase, it takes longer to reach the level of participation required to make the government concede with probability 1. This moves the lower bound of the equilibrium set to the right.

If, instead of a general increase, I apply a mean preserving spread to the distribution of opportunity costs, then the effect is ambiguous. The result now depends on what happens with the agent who is at the margin when the government is going to concede for sure. I formalize these ideas in the following result.

**Proposition 1.** *Let  $F_1$  and  $F_2$  be two symmetric and unimodal distributions, with corresponding equilibrium sets  $[\underline{\tau}_1, \bar{\tau}_1]$  and  $[\underline{\tau}_2, \bar{\tau}_2]$ .*

- (i) *If  $F_1$  first-order stochastically dominates  $F_2$ , then  $\underline{\tau}_1 \geq \underline{\tau}_2$ .*
- (ii) *If  $F_2$  is a mean preserving spread of  $F_1$ , and  $v'(0) < \int \theta dF_1(\theta)$ , then  $\underline{\tau}_1 > \underline{\tau}_2$ .*
- (ii) *If  $F_2$  is a mean preserving spread of  $F_1$ , and  $v'(0) > \int \theta dF_1(\theta)$ , then  $\underline{\tau}_1 < \underline{\tau}_2$ .*

The above results follow from the fact that the lower bound of the equilibrium set for a distribution  $F$ , depends uniquely on  $F(v'(0))$ . In any equilibrium at which the government concedes for sure, the number of people who are willing to enter are those with opportunity cost  $\theta \leq v'(0)$ . Then, any change to the distribution of opportunity costs that increases the number of citizens that are willing to enter forces the government to concede faster.

The effect of a change in opportunity costs over the upper bound is more subtle, as now the indirect effect through the government's hazard rate plays a role. Consider, first, a general increase in citizens' opportunity costs, so that protesting becomes more costly for every agent. Let  $F_1$  be the initial distribution of opportunity costs and  $F_2$  be the distribution after the increase. Then,  $F_1(\theta) > F_2(\theta)$  for all  $\theta \in [\theta, \bar{\theta}]$ , and the following result holds.

**Proposition 2.** *Suppose that citizens' opportunity costs increase by the same proportion  $\alpha$ , and let  $[\underline{\tau}_\alpha, \bar{\tau}_\alpha]$  to be the new equilibrium set. Then, it must be that  $\underline{\tau} < \underline{\tau}_\alpha < \bar{\tau}_\alpha < \bar{\tau}$ .*

To see the intuition for the change in the upper bound, consider first a hypothetical situation in which the government's strategy remains constant after the change in the



distribution of opportunity costs. In that case, agents delay their entry as protesting becomes more costly. But then, in order to give agents incentives to exit according to the indifference participation level, the government has to increase the hazard rate. This new situation cannot be an equilibrium, as the entry time for the lowest opportunity cost citizen would be such that  $t_0(\underline{\theta}) > 0$ .

## 6. Extensions

**6.1. Government Partial Concessions.** In many situations, the decision to provide a public good is not discrete. Authorities might make some concessions that do not entirely fulfill protesters' demands, but that dissuade some of them and, thus, alleviate the cost burden of the protest. As an example, suppose that the protesters' demand is a stimulus package to provide economic assistance. Instead of providing the entire package, the government might decide to offer a smaller amount than demanded. This concession might be enough for some agents, who then choose to leave the protest, whereas others continue protesting to exert pressure on the government to provide the full package. In this section, I illustrate how the baseline model can be modified to allow for such concessions.

Suppose that the government can concede a fraction of the public good. Conceding a fraction  $\alpha$  of the public good has a cost  $\alpha q$ , where  $q$  is the cost of the entire public good. Every time the government concedes a fraction  $\alpha$  of the public good, agents receive a flow utility  $\alpha v(t - t_0)$  corresponding to their veteran payoff. Other than that, citizens' and the government's payoffs remain the same as in the baseline case. The protest ends when either all citizens have dropped out, or the government has fully provided the public good.

Following the same reasoning as in the baseline case, I can define the government's strategy as a function  $h : [0, \infty) \rightarrow [0, 1]$  that determines, for any time  $t$ , the additional share of the public good that the government provides at time  $t$ . I also denote by  $H(t)$  the share of the public good that has been provided at time  $t$ .

A citizen's payoff from entering at a time  $t_0$  and exiting at  $t_1$  is given by:

$$U(t_0, t_1; \theta) = -\theta \left[ \frac{e^{-rt_0} - e^{-rt_1}}{r} \right] + \int_{t_0}^{t_1} e^{-rs} v(s - t_0) dH(s). \quad (14)$$

As in the main model, citizens' utility functions satisfy a single-crossing property, and then their strategies are monotone in opportunity cost. In particular, entry and exit conditions for a citizen with opportunity cost  $\theta$  are given by:

$$\theta = \int_0^{t_1} e^{-rs} v'(s - t_0) dH(s) \quad (15)$$

$$\theta = v(t_1 - t_0) h(t_1). \quad (16)$$

Then, I obtain characterization results analogous to those in the baseline model. For any equilibrium  $H : [0, \infty) \rightarrow [0, 1]$ ,  $(\pi_t^\sigma)_{t \geq 0}$  with  $\tau_0 = \inf\{t \in [0, \infty] : h(t) > 0\}$ , the following conditions hold:

- (i) There is always delay in government concession—i.e.,  $\tau_0 > 0$ .
- (ii)  $\pi_t^\sigma$  is continuous, increasing for  $t \leq \tau_0$ , and if  $H(\tau_0) < 1$ , decreasing for all  $t \geq \tau_0$ .
- (iii) The government makes, at most, one discrete concession at  $\tau_0$ .
- (iv) If  $H(\tau_0) < 1$ , then  $H(t)$  is strictly increasing, concave, and for  $t > \tau_0$   $H(t) < 1$ .

In the empirical analysis in Section 7, I use the partial concessions framework to study police reforms in the context of the *Black Lives Matter* protests.

**6.2. Unconditional Veteran Prize.** In this section, I briefly develop an extension of the model to allow citizens to obtain rewards based on their merit in the protest, even if they do not continue to protest until the government concedes.

Suppose that if an agent leaves before the government concedes, instead of the time she invested in the protest being wasted, she still might get some rewards. In particular, suppose that if a citizen retires before the protest succeeds, she obtains a share  $\alpha \in (0, 1)$  of the veteran prize that will be delivered retroactively once the government concedes. Still, staying until the government concedes is preferable because, in that case, agents receive the full veteran prize  $v(\tau - t_0)$ .

Now, given a random concession time  $\tau$  for the government, the expected payoff of a citizen with opportunity cost  $\theta$  is given by:

$$E \left[ -\theta \int_{t_0}^{t_1 \wedge \tau} e^{-rs} ds + e^{-r\tau} [v(\tau - t_0) \mathbb{1}_{\tau < t_1} + \alpha v(t_1 - t_0) \cdot \mathbb{1}_{\tau \geq t_1}] \right], \quad (17)$$

where the expectation is taken over  $\tau$ . Then, the citizen exits at time  $t_1$  if the following condition holds:

$$\theta \geq (1 - \alpha) \lambda_t v(t_1 - t_0) + \alpha \cdot v'(t_1 - t_0) \cdot \frac{1}{1 - G(t_1)} \int_{t_1}^{\infty} e^{-r(s-t_1)} dG(s). \quad (18)$$

The left-hand side is the cost of staying another instant, given by the opportunity cost  $\theta$ . The right-hand side is the expected benefit, which is now a convex combination of the payoff the agent gets simply by staying in the protest and the payoff he gets once the government concedes. The payoff from simply being in the protest decreases over time, as the marginal returns from merit is decreasing.

As for the entry condition, the citizen with opportunity cost  $\theta$  enters the protest at time  $t_0$  if the following condition holds:

$$\theta \leq \frac{1}{1 - G(t_0)} \left[ \int_{t_0}^{t_1} v'(s - t_0) dG(s) + \alpha v'(t_1 - t_0) \int_{t_1}^{\infty} e^{-r(s-t_1)} dG(s) \right]. \quad (19)$$

The new component in this setup is the second term inside the brackets. When choosing a time to enter, the citizen takes into account not only the marginal increase in the veteran prize for the periods she will be protesting when the government concedes, but also the probability that the government might concede afterwards.

When citizens can enjoy the veteran prize even if they leave before government concession, it is as if the value of protesting is higher than in the baseline model. Now, not only do the toughest veterans enjoy the victory, but even small contributions to the revolution are rewarded if the protest succeeds.

Note that the merit reward still is obtained only if the government concedes, and, thus, agents do not have incentives to protest if they know the government will never concede.

**6.3. Unsuccessful Protests.** In the baseline model, every protest that occurs in equilibrium will eventually succeed. In reality, however, we see many protests that end before they succeed in reaching their ultimate goal.

In order to study situations in which protests end before the government concedes, I need to be very precise in the definition of the *end* of a protest. This is crucial to understanding how to associate our main equilibrium results with empirical observations about protests' failure. However, identifying the end of a social movement is not an easy task.

One possibility is to define the *end* of a persistent protest as a decay in participation that is sufficiently large that the movement becomes small, but some fraction of the protesters continue to participate. My model can perfectly accommodate these situations. To see this, note that my "always concession" result does not state that the protest will be successful in a precise finite time. On the contrary, it states that in the limit, the government continues randomizing until it eventually concedes. Therefore, many persistent protests that we interpret as failures might be part of an equilibrium in a late decay stage, in which the probability of government's future concession is positive, though small.

Another way to understand the end of a protest is a situation in which all protesters give up with no government concession. Unfortunately, with the current specification, this type of behavior cannot be observed as an equilibrium of this model. Citizens know that once the government is randomizing it is just a matter of keeping going, and eventually concession will occur.

Klandermans & van Stekelenburg (2013) study people's disengagement from social movements as the result of two possible effects—*insufficient gratification* and *declining commitment*—which, together with a *precipitating event*, make the agent leave. In general, these precipitating events are some exogenous shocks that precipitate the exit of agents who already have the intention to leave. I borrow the intuition of these precipitating events and introduce the possibility of an exogenous shift in agents' preferences. The shift is captured by a shock that makes the value of winning to the government become vanishingly small, so that agents no longer have incentives to remain active in the protest. This shock can represent, for instance, news events that shift citizens' attention away from the goals of the social movement, or any possible small event (as in Klandermans & van Stekelenburg (2013)) that just precipitates agents' exit.

Suppose that with a small constant hazard rate  $\delta > 0$ , citizens receive a shock that brings the veteran prize to zero. In practice, agents take into account the possibility that they might not enjoy the victory if the shock is realized, and then it is as if the effective veteran prize is smaller than in the baseline case. The exit decision for an agent with opportunity cost  $\theta$  is now given by the following expression:

$$\theta \geq \lambda_t(1 - \delta)v(t - t_0(t)), \quad (20)$$

which is just a renormalization of the original exit condition. Then, citizens' behavior is the same as without the shock. The same will happen with entry.

I can show that the equilibrium will have the same features as the baseline model. However, with some small probability, the shock realizes, and as soon as this happens, citizens give up and the protest ends immediately. Even when, in expectation, the behavior is the same, empirically, we might observe some scenarios in which people give up with no government concession.

**6.4. Income and Opportunity Cost.** So far, I have characterized agents' opportunity cost of the time spent in the protest by a parameter  $\theta$ . This parameter captures the utility that agents give up by spending time on the protest instead of on other activities. In general, those other activities are often related to productive activities, and, thus, the opportunity cost can be associated with labor income.

In order to set ideas, consider the following situation. As in the baseline framework, there is a protest, and citizens have to decide whether and when to join. Every day, a citizen who joins the protest attends a demonstration that lasts one hour (every day is discrete, but consider this just an illustration). There is no physical cost of protesting, and the only cost to the citizen is the possible alternative use of that hour, which is equivalent to one hour-wage.

Suppose, now, that agents have heterogeneous income,  $\omega$ . Let  $\epsilon$  be the fraction of time an agent spends in the protest (i.e., if the agent works eight hours each day, and the demonstration lasts one hour, then  $\epsilon = 1/8$ ). In addition, there is a minimum level of consumption that citizens must satisfy, which corresponds to a subsistence level. We can think of this consumption as basic needs that the agent must fulfill, and she can afford to join a protest only once these basic needs are covered. I represent the subsistence level by a minimum income  $\underline{\omega}$ , such that any agent with income  $\omega < \underline{\omega}$  cannot afford to become an activist.

The cost of attending the protest for a citizen with  $\omega \geq \underline{\omega}$  is equivalent to:

$$\theta = u(\omega) - u(\omega(1 - \epsilon)), \quad (21)$$

where  $u(\cdot)$  is the agent's utility of income (consumption). Then, the relation between citizens' income and opportunity costs depends on the shape of the utility function.

Consider, for instance, the following CRRA utility function:

$$u(\omega) = \frac{\omega^{1-\sigma}}{1-\sigma} \quad (22)$$

for some  $\sigma \geq 0, \sigma \neq 1$ . In this case, the relation between income and opportunity cost depends on the curvature of the utility function, captured by  $\sigma$ . If  $\sigma < 1$ , then the marginal utility of income is increasing, which implies that for citizens with higher income, the hour spent demonstrating is more costly than for citizens with lower income. In the extreme case with  $\sigma = 0$ , utility is linear, and, thus,  $\theta = \epsilon\omega$ . In this case, there is a one-to-one relation between the distribution of opportunity costs and the distribution of income. In general, when the marginal utility of income is increasing, high-income citizens have greater incentives than those with lower incomes to delay their entry.<sup>14</sup>

If the opposite holds—i.e.  $\sigma > 1$ —then the marginal utility of income is decreasing. In this case, high-income citizens are able to enter earlier, as the forgone utility for them is lower.

There are other factors that might affect the relation between income and opportunity cost. For instance, job flexibility might affect how workers can make use of their own time. This, in general, is also related to education and the type of industries under analysis. Moreover, income might affect other factors in an agent's propensity to protest that might not be related to opportunity costs. Education, for instance, is key in how knowledgeable citizens are about the political environment. This implies that when comparing citizens with different income levels, we need to also take into account the effect of their income on their education levels.

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<sup>14</sup>In Section 7, I explore these predictions for the case of *Black Lives Matter* protests.

**6.5. Support for the Public Good.** In the baseline model, the entire mass of citizens is willing to consider participation in the protest, as the only constraint is the heterogeneity in opportunity costs. In this section, I illustrate the case in which only a subset of agents is willing to consider participating in the protest. Suppose that the value of the public good  $x$  is now a random variable that can take two values, 0 or 1, and let  $p$  be the probability of  $x = 1$ . Each citizen's value for the public good is independent of her opportunity cost.

Moreover, assume that citizens value the veteran prize only if they value the public good. Thus, I modify the veteran prize function to be  $x \cdot v(t - t_0)$ . With this new framework, agents who don't value the public good do not have incentives to participate in the protest. It is clear to see that the baseline case is equivalent to setting  $p = 1$ , and then as  $p$  decreases, the mass of citizens willing to enter the protest also decreases.

What is interesting about this perturbation is that all the dynamics of the model remain the same, but the set of equilibria is reduced. For the government, the properties shown for the baseline case still hold: (i) the government concedes according to a distribution  $G(t)$  with support  $\mathcal{T}$ , with  $\tau_0 = \inf \mathcal{T}$ ; (ii) the support might be either a singleton or an interval  $[\tau_0, \infty)$ ; (iii) if  $G(\tau_0) < 1$ , then  $\mathcal{T} = [\tau_0, \infty)$ , and  $G(t)$  is continuous, strictly increasing, and differentiable in  $(\tau_0, \infty)$ .

Any citizen with opportunity cost  $\theta$  solves the same problem as in the baseline model. Citizens' strategies can be characterized by thresholds  $\tilde{\theta}_0(t), \tilde{\theta}_1(t)$  such that a citizen enters if  $\theta \leq \tilde{\theta}_0(t)$  and exits if  $\theta > \tilde{\theta}_1(t)$ . For any possible entry threshold  $\tilde{\theta}_0(t)$ , participation is just a rescaling of the original problem and is given by  $\pi_t = p \cdot F(\tilde{\theta}_0(t))$ . Thus, both Theorem 1 and Theorem 2 hold in this framework.

I highlight some of the main features that differentiate this case from the baseline case. Let  $[\underline{\tau}, \bar{\tau}]$  be the equilibrium set in the baseline case, and denote by  $[\underline{\tau}_p, \bar{\tau}_p]$  the equilibrium set with  $p < 1$ . First, note that it must be that  $\underline{\tau} < \underline{\tau}_p$  and  $\bar{\tau}_p \leq \bar{\tau}$ . The intuition is analogous to the comparative statics in Proposition 1. To see why the lower bound is delayed with  $p < 1$  (i.e.,  $\underline{\tau} < \underline{\tau}_p$ ), recall that this corresponds to the equilibrium in which the government concedes with probability 1. When not all agents are willing to participate, it takes more time to make the government concede.<sup>15</sup> The upper bound does not necessarily decrease, as it depends on the citizen with the lowest opportunity cost.

Consider, now, an intermediate equilibrium with delay  $\tau_0 \in (\underline{\tau}_p, \bar{\tau}_p)$ . Let  $G(t)$  be the government distribution of concessions with  $p = 1$ , and  $G_p(t)$  for  $p < 1$ . Note that both  $G_p(t)$  and  $G(t)$  have support  $[\tau_0, \infty)$ . Moreover, in both equilibria, participation must coincide on  $[\tau_0, \infty)$ . Then, the initial government concession is such that  $G(\tau_0) < G_p(\tau_0)$ .

<sup>15</sup>Formally, concession occurs when  $\tilde{\pi}_{\underline{\tau}} = F(v'(0))$ . When not all agents are willing to participate,  $\tilde{\pi}_{\underline{\tau}_p} = p \cdot F(v'(0)) < \tilde{\pi}_{\underline{\tau}}$ .

The main idea of these differences is that the universe of citizens is smaller now, as not all of them are willing to enter the protest. However, conditional on reaching some participation level, those who are protesting have (weakly) higher opportunity costs than in the baseline case, and that makes them stronger in front of the government.

*6.6. Refinements and Equilibrium Selection.* For some problems, it might be relevant to refine the set of equilibria. In order to do this, it is key to modify the model to include some sort of incomplete information. The three main approaches that might be applied as refinements are: (i) reputation; (ii) global games; and (iii) coalition-proofness.

Reputational concerns in this model arise when there is some information about agents that is private. The attritional nature of the game makes behavioral types a la [Abreu & Gul \(2000\)](#) natural candidates for refinement. Introducing a probability of the government being a behavioral type that never concedes, and a probability of citizens being a type that will protest forever will pin down a unique equilibrium. The only issue with this refinement is that, depending on the parametrization, in this framework, it might not be very informative of the equilibrium selected.

Global games are a theoretical framework commonly used to study uprisings and regime change models. Since the seminal work of [Morris & Shin \(1998\)](#), their framework has been used to study public protests and revolutions in different institutional settings (see [Edmond \(2013\)](#), [Egorov et al. \(2009\)](#), [Boix & Svolik \(2013\)](#) and [Morris & Shadmehr \(2018\)](#)). The key component in these models is a coordination game with incomplete information, in which uncertainty is generally about the strength of the regime (although it might also be uncertainty about preferences or other features of the game). Agents receive some private information, and, in equilibrium, they use threshold strategies: a player participates if her belief about the revolt being successful is high enough with respect to some threshold. This, in general, pins down a unique equilibrium. In dynamic setups, it is not direct to refine the set of equilibria in this way. For instance, [Angeletos et al. \(2007\)](#) study the role of learning in a framework in which agents can take actions many times and learn about the fundamentals. They show that the dynamic nature of the game introduces multiplicity even under conditions that guarantee uniqueness in static games.

Lastly, the possibility of coalition formation by citizens provides another rationale for equilibrium refinement. Naturally, political activism requires some organization that can be done before a protest begins. This could be done in a decentralized way (via social media, for instance) or through a political leader who is interested in fostering a particular equilibrium. If citizens could make pre-arrangements to decide their participation in the protest, it would be possible to coordinate in an equilibrium with short delay by ensuring that a high enough share of the population would join the protest at the beginning. If all



citizens were better off with this outcome, we would expect no coalitions to block that equilibrium, and, thus, it would be coalition-proof in the sense of [Bernheim et al. \(1987\)](#) (see, also, [Moreno & Wooders \(1996\)](#) and [Ray & Vohra \(2001\)](#)).

Although in coalition-proofness, agreements among agents are non-binding, sometimes leaders take some irreversible actions in order to obtain a specific outcome. For instance, [Morris & Shadmehr \(2018\)](#) construct a model in which citizens choose the level of effort to contribute to a regime change, and a leader designs reward schemes that assign psychological rewards to citizens' actions. In my model, a leader can target some sectors in the society in order to implement a particular equilibrium. For instance, when citizens in the protest have a higher opportunity cost, in equilibrium, the government concedes at a higher hazard rate. Then, the leader might want to design a veteran reward scheme to incentivize participation of people with higher opportunity costs. In practice, leaders make use of their charisma and targeted rhetoric to encourage specific groups of the population to get involved in a revolution. Another alternative is the existence of some organization that implements transfers among citizens, in order to subsidize the protest behavior of specific groups. For instance, in some countries, protest organizers support protesters with food and supplies, which can be seen as a way to reduce participation costs to those citizens who attend demonstrations.

## 7. Black Lives Matter: An Exploration

The equilibrium characterization I develop in this paper provides some testable empirical predictions. First, participation is single-peaked. There is an initial stage with increasing participation. If the protest does not end when participation reaches its peak, then the number of people protesting should decay monotonically thereafter. Second, government concessions occur either at the peak or after it, they are more likely to happen at the peak, and their likelihood decreases over time after that. Third, citizens' entry and exit decisions are monotonic in opportunity cost, and participation dynamics are such that citizens with higher opportunity costs enter later and stay a shorter time in the protest. Notice that testing these predictions is relevant, as they are not obvious. Single peakedness, for instance, rules out the presence of waves of participation and backlashes within a protest. The dynamics of entry and exit are not trivial, either, as they generate a *last-in-first-out* type of participation dynamics, which imposes a bound on how much a citizen with a high opportunity cost might want to delay her entry. In this section, I explore some of these predictions in the context of the *Black Lives Matter* protests.

The *Black Lives Matter* protests are a reaction to a long history of discrimination and mistreatment of African-American and other minority citizens. The full complexity of this problem is, of course, impossible to capture with a theoretical model. The multiple

dimensions along which racial discrimination has affected minority groups imply that the resulting demands and the policies required to make a change are far from uni-dimensional. However, my analysis does not aim to explain the motives for people's outrage nor the grievances behind their decisions to demonstrate. Far more modestly, I will focus on some specific features of these protests, and provide preliminary evidence that map the empirical predictions of the model to available data.

There are many reasons why I focus on *Black Lives Matter*. First, this movement garnered the support of a broad sector of the population. Although we have seen events of violence, most protests were peaceful for the period analyzed. Also, the demonstrations were detonated by an event whose date of occurrence is exogenous, in contrast with other movements that start as a response of changes in government policies and political reforms, which might be more immediately endogenous.

I mainly focus on the monotonicity of citizens' strategies with respect to the opportunity cost. Because I do not observe individual decisions, I study county-level heterogeneity in participation and opportunity costs. To proxy for opportunity costs, I exploit cross-county variation in time flexibility induced by COVID-19 through stay-at-home behavior. As the protests started in the middle of the pandemic, people's behavior and daily lives affected in several ways, and in particular, they saw themselves spending longer time at home. One would expect that when people spend more time at their residences, they have more time flexibility and hence a lower opportunity cost. I provide evidence suggesting that counties with more intensive stay-at-home behavior display earlier entry into protest, and later exit.

As I mentioned above, this modelling of heterogeneity is a simplification of a possibly more intricate problem. It could very well be that citizens also have heterogeneous stakes in the protest, and this might affect their veteran rewards. Although in the theoretical model this distinction is not relevant, for the empirical analysis it is. I take this into account in Section 7.4.2.

**7.1. Data.** To measure participation in Black Lives Matter protests, I use data from the *Crowd Counting Consortium*. This consortium collects publicly available data on political crowds reported in the United States, including marches, protests, strikes, demonstrations, riots, and other actions.<sup>16</sup> The unit of analysis in the data is a specific demonstration, and captures the time, location, and participants, as well as other information. I use events

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<sup>16</sup>The CCC data can be found here: [CCC Website](#).

occurring between May 26 and June 30, 2020. There is a record of 7,707 events across the US during this period which are identifiable with this movement.<sup>17</sup>

To capture the number of people staying at home, I use mobility statistics provided by the *Bureau of Transportation Statistics*<sup>18</sup> The travel statistics are produced from an anonymized national panel of mobile device data from multiple sources. As an alternative measure, I also use Google’s Community Mobility Reports.

To construct instrumental variables, I use data on daily precipitation, minimum and maximum temperatures at the Station-level obtained from the Daily Summaries from the *National Oceanic and Atmospheric Administration*.<sup>19</sup> Finally, I use county-level demographics from the *MIT Election Data and Science Lab*.

**7.2. Mapping the Model to the Data.** In this section, I describe how to map the main features of the model to the specific context of the Black Lives Matter protests. In the model, there is a government and a continuum of citizens. Citizens have heterogeneous opportunity costs, and they individually decide whether to participate in the protest. In the baseline model, the government concedes only once, and it fully provides the public good. In the extension with partial concessions I develop in Section 6.1, the government decides a share of the public good to provide at any time. In both scenarios, concessions (either full or partial) are irreversible.

**7.2.1. Government and Concessions.** I focus on people’s demands related to police system reforms. There are many levels in which these demands can be fulfilled, from reforms to police conduct, to a complete police defunding. In the model with partial concessions, a policy targeted to *Defund the Police* would correspond to a full concession, whereas any other police reform would be considered a partial concession. In Figure 3 I plot the evolution of Google searches for the term “Police” in the US. As the figure shows, the interest increases during the first days of demonstrations and reaches a peak on May 31, which is close to the peak of the movement.

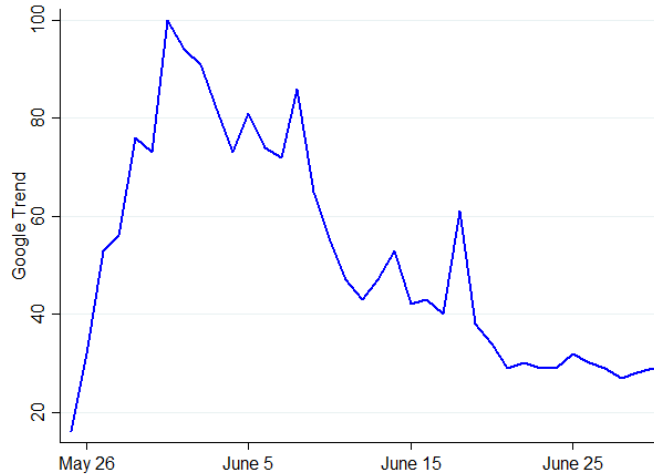
Because of the political and administrative division of the US, there are different levels at which these reforms can be addressed. In this paper, I focus on the State level. Then, the

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<sup>17</sup>Although the data entry for the Crowd Counting Consortium keeps going, in this draft I use data downloaded on October 1st 2020, as I plan to keep updating. The partial entries might generate lower estimates of participation than what we would get using the finalized data.

<sup>18</sup>This data is estimated by the Maryland Transportation Institute and Center for Advanced Transportation Technology Laboratory at the University of Maryland. Website: [BTS](#).

<sup>19</sup>Global Historical Climate Network includes daily land surface observations for the US. The station data set includes maximum and minimum temperatures, total precipitation, snowfall, and depth of snow on ground. Website: [Climate Data Online](#).

**Figure 3.** Google Search Trend: “Police” (US)

Note: The trend represents search interest with respect to the maximum value for the US, between May 25 and June 30, 2020. A value of 100 corresponds to the maximum interest.

unit mass of citizens that characterize a population in the model corresponds to the State’s population, and the authority corresponds to the State’s Governor.

**7.2.2. Citizens’ Participation Decisions.** The data available corresponds to event data, in which the unit of analysis is a protest event with a specific date, location and number of participants. Since I do not have individual participation records, I use county-level heterogeneity within a state. To do this, I first map each event to a county to obtain an aggregate measure of daily participation at the county level, and then use this participation to construct a proxy for a county’s *entry* and *exit*.

More precisely, let’s normalize the population of a state to a unit mass of citizens, and suppose it is distributed over a set of  $J$  counties. Let  $\mu_j$  be the mass of citizens living in county  $j$ . As in the baseline model, each citizen is characterized by an opportunity cost of protesting. The opportunity cost of citizen  $i$  at county  $j$  is taken to be the sum of an aggregate component  $\theta_j$ , which is common to all citizens living in county  $j$ , and an idiosyncratic component that we do not observe,  $\epsilon_i$ . I assume this unobserved component is drawn iid across the population.

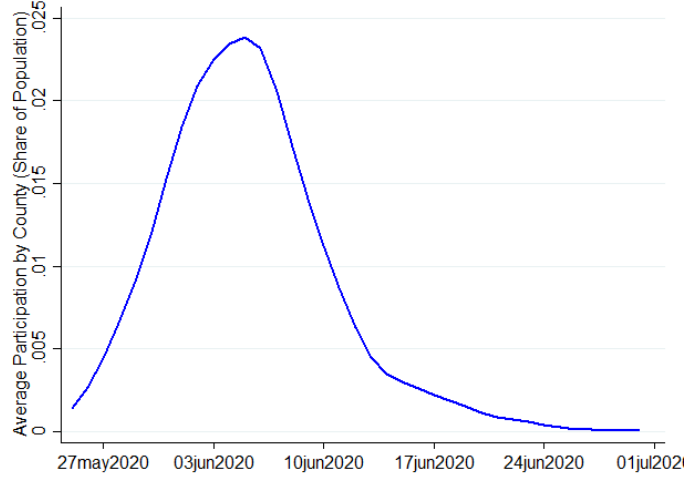
Given that citizens’ entry decisions are monotone in opportunity cost, for any time  $t$  there exists an entry threshold  $\tilde{\theta}(t)$  such that a citizen protests if  $\theta_i \leq \tilde{\theta}(t)$ , and does not protest otherwise. Thus, total participation at county  $j$  is given by:

$$\pi_{j,t} = P(\theta_j + \epsilon_i < \tilde{\theta}(t)) \cdot \mu_j, \quad (23)$$

which is the size of the county times the probability of participation. Notice that from the model, the threshold  $\tilde{\theta}(t)$  is given by the minimum between an increasing entry threshold  $\tilde{\theta}_0(t)$ , and a decreasing exit threshold  $\tilde{\theta}_1(t)$ .

Let  $\bar{\pi}_{j,t} = \frac{\pi_{j,t}}{\mu_j}$  be the adjusted participation rate at time  $t$  in county  $j$ , which is just the fraction of the county population that is protesting at time  $t$ . In Figure 5, I plot the average daily participation across all US counties. At the peak, participation reaches an average of around 0.025%. To provide an idea of the numbers, this corresponds to around 5,400 protesters in Saratoga County, NY, and 34,000 protesters in the Bronx, NY.

**Figure 5.** Average Daily Participation as a Share of County Population (All US Counties)



Using this adjusted participation, from equation (23) I obtain the following observation.

**Claim 1.** *If citizens' decisions are monotone in opportunity cost, for every time  $t$ , the participation rate  $\bar{\pi}_{j,t}$  is decreasing in the aggregate component  $\theta_j$ .*

But note that my predictions go even further. As the entry threshold is increasing, and the exit threshold is decreasing, we obtain the following observations.

**Claim 2.** *If  $\tilde{\theta}(t)$  is single-peaked, the time it takes the participation rate  $\bar{\pi}_{j,t}$  to reach a given participation level  $p$  for the first time is increasing in the aggregate component  $\theta_j$ .*

**Claim 3.** *If  $\tilde{\theta}(t)$  is single-peaked, the time it takes the participation rate  $\bar{\pi}_{j,t}$  to fall below a given participation level  $p$  is decreasing in the aggregate component  $\theta_j$ .*

To map these observations to entry and exit times define, for any  $p \in [0, 1]$ , the *entry time*,  $t_0^j(p)$ , as the first time at which the adjusted participation reaches a level  $p$ . Analogously,

define the *exit time*,  $t_1^j(p)$ , as the last time at which the adjusted participation crosses the level  $p$ . Formally,

$$t_0^j(p) = \min\{t : \pi_{jt} \geq p\}; \quad t_1^j(p) = \max\{t : \pi_{jt} \geq p\}. \quad (24)$$

Moreover, I define the *duration* of a county in the protest as:

$$d^j(p) = t_1^j(p) - t_0^j(p). \quad (25)$$

To illustrate this, we can go back to Figure 5. Fixing a threshold  $p$  corresponds to fixing a level of participation in the vertical axis. Suppose we set  $p = 0.005$ . The entry time of a county measures the time it takes for the county to reach a participation level of 0.005% of the population. In the graph, the average across counties reaches this level very quickly, around May 28. The exit, corresponds to the last time at which the participation level is above this threshold. In the graph, this happens around June 13th. Finally, the duration captures the time span for which the county records a participation level above the given threshold 0.005%.

We can then state our empirical predictions as follows.

**Prediction 1.** For any  $p \in [0, 1]$ , the entry time  $t_0^j(p)$  is increasing in  $\theta_j$ .

**Prediction 2.** For any  $p \in [0, 1]$ , the exit time  $t_1^j(p)$  is decreasing in  $\theta_j$ .

Predictions 1 and 2 together imply the following weaker prediction:

**Prediction 3.** For any  $p \in [0, 1]$ , the duration time  $d^j(p)$  is decreasing in  $\theta_j$ .

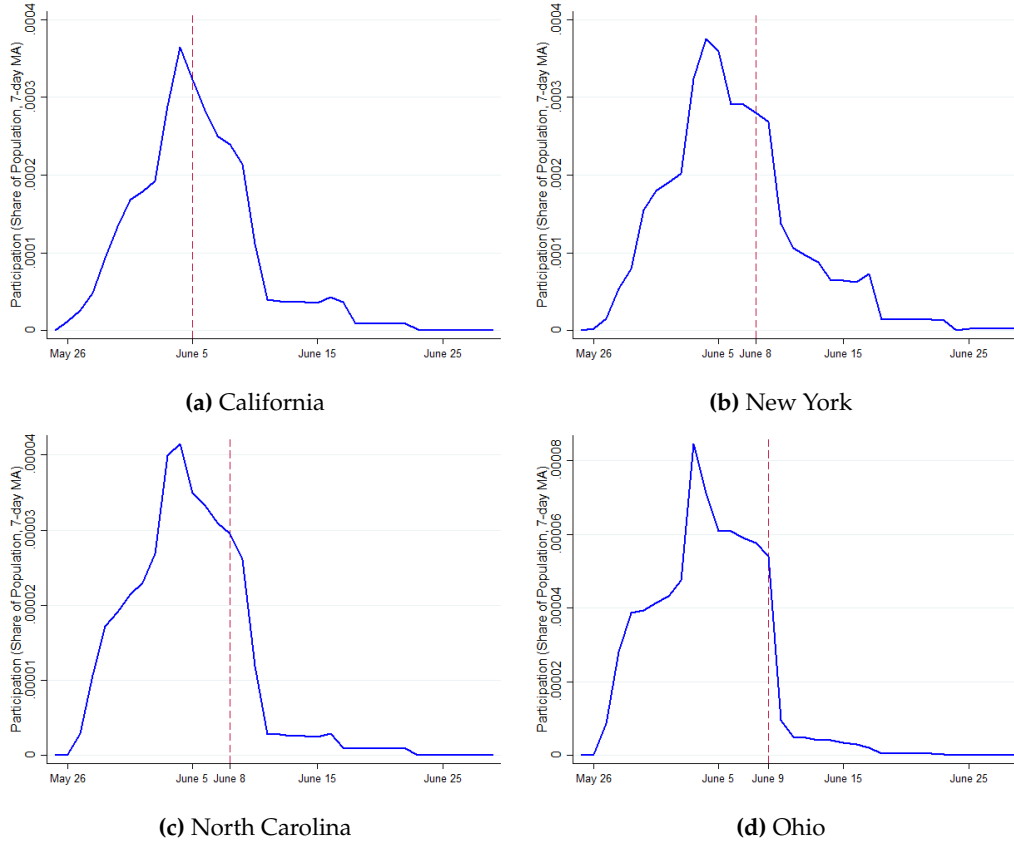
I use the logarithm of these times as the dependent variables, measured since the day before the protests started. For any threshold  $p$ , denote these variables by:  $\text{ENTRY}_j(p) = \log(t_0^j(p))$ ,  $\text{EXIT}_j(p) = \log(t_1^j(p))$ , and  $\text{DURATION}_j(p) = \log(d^j(p))$ .

**7.3. Participation and Concessions.** In the characterization of equilibria, we saw that participation is hump-shaped, and can be described by three stages: a build-up, a peak and a decay stage. Moreover, concessions by the government only occur on or after the peak, and the probability of occurrence is decreasing over time. Thus, one is more likely to observe concessions closer to the peak than before or after it.

Figure 6 shows some descriptive evidence suggesting these dynamics. The four panels show the trajectory of participation for four states: California, New York, North Carolina and Ohio. The blue lines show the 7-day moving average of daily participation at the State level, as a share of the population. The vertical red lines correspond to the time at which a first concession by each State's Governor is recorded (details in Table 1). Two things are worth highlighting from these figures. First, in the four states shown participation follows

a path that resembles the three stages described in equilibrium. In all of them participation increases initially and reaches a peak around June 3 - June 4. Then, participation decreases over time. And second, in all of them there is some concession soon after the peak. These concessions are partial, as in general they consist in some specific police reforms, and as such, it is expected that they would only have dissuaded a fraction of the protesters.

**Figure 6.** Participation by State and First Concession



Note: Vertical red line corresponds to the time of the first concession by State Governor's, obtained from news reports (see Appendix for details). Participation corresponds to the 7-day moving average of the total number of people protesting at the state, divided by the population of the state.

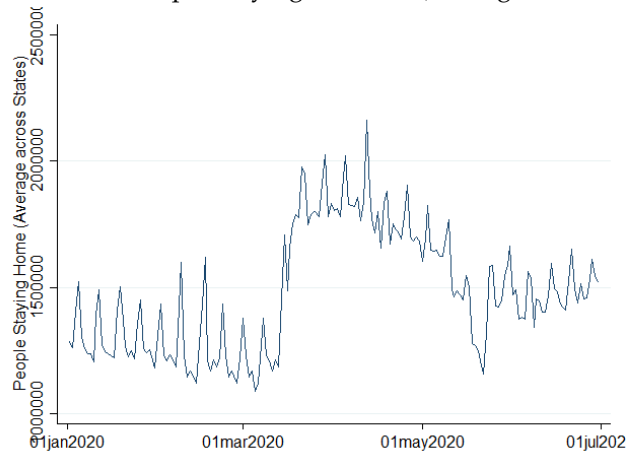
**7.4. The Timing of Entry and Exit.** Now, let us focus on the main predictions, regarding the timing of participation in protests and opportunity costs. I explore different proxies for opportunity costs. In section 7.4.1 I study variations in idleness induced by COVID-19. To account for heterogeneous stakes in the protest, in Section 7.4.2 I consider the racial composition of the population in a county. In Section 7.4.3 I focus on income and education, and study the correlation between them and the timing of participation in protests.



**Table 1.** Governors' Actions

State	Date	Action
California	June 5	Launching of police reform task force.
New York	June 8	Announcement of 10 bill-package, officially signed on June 12.
North Carolina	June 8	Direction to law enforcement agencies to review the use of force, de-escalation techniques, arrest procedures, cultural sensitivity training and the investigative process
Ohio	June 9	State task force to develop minimum standards of police force.

**7.4.1. Opportunity Cost: Time Spent at Home.** As the Black Lives Matter protests started in the middle of the pandemic, citizens' daily lives had been affected by social-distancing restrictions and economic lock-downs. People were spending more time at home, either teleworking, home-schooling, or prevented from going to work because of business closures (see Figure 8). One would expect that when people are spending more time at home, they have more time flexibility and a lower opportunity cost. Following this intuition, I use county-level variation in stay-at-home behavior as a proxy for the opportunity cost of time.

**Figure 8.** Number of People Staying at Home (Average across States, US)

Source: Bureau of Transportation Statistics.

To measure stay-at-home behavior, I use daily mobility statistics from the Bureau of Transportation Statistics. These reports use mobile device data and other sources to capture people's behavior at the county level. The main variable, which I call  $\Delta HOME$ , is defined as the percentage variation in the number of people staying at home the month before the protests started, with respect to the equivalent month the previous year. More

precisely, let  $\text{HOME}_{20}$  be the average number of people staying at home the month before the protests started, between April 24 and May 24, 2020. Analogously, let  $\text{HOME}_{19}$  be the average number of people staying at home in the equivalent month in 2019 (between April 26 and May 26, 2019). The variable  $\text{HOME}$  is defined as:

$$\Delta\text{HOME} = \frac{\text{HOME}_{20} - \text{HOME}_{19}}{\text{HOME}_{19}}. \quad (26)$$

There is, however, a second channel through which the incidence of COVID-19 might affect stay-at-home behavior, which is through the risk of contagion. If people are spending more time at home because they want to avoid having contact with others, one would expect that it is more costly to attend a demonstration for those people. Naturally, this effect goes in the opposite direction than the effect of time flexibility. Thus, to measure both effects correctly, one should consider both stay-at-home behavior and the incidence of COVID-19 as explanatory variables in our structural equations.

Suppose that we estimate the following equations:

$$\text{ENTRY}_{j,s}(p) = \alpha_0 + \alpha_1 \Delta\text{HOME}_{j,s} + \alpha_2 \text{COVID}_{j,s} + \gamma_s + \epsilon_j \quad (27)$$

$$\text{EXIT}_{j,s}(p) = \beta_0 + \beta_1 \Delta\text{HOME}_{j,s} + \beta_2 \text{COVID}_{j,s} + \gamma_s + \epsilon_j \quad (28)$$

$$\text{DURATION}_{j,s}(p) = \delta_0 + \delta_1 \Delta\text{HOME}_{j,s} + \delta_2 \text{COVID}_{j,s} + \gamma_s + \epsilon_j \quad (29)$$

where the subscript  $j, s$  denotes county  $j$  in state  $s$ , and  $\gamma_s$  is a state fixed effect. The variable  $\text{COVID}_{j,s}$  is the average daily new cases at county  $j$  in state  $s$ , the month prior to the protests (as a fraction of the population). One would expect  $\alpha_1$  to be negative, as it captures the effect of time flexibility, and  $\alpha_2$  to be positive, as it should capture the effect of the risk of the contagion. Analogously, the coefficients in the exit and duration equations should have opposite sign than those in the entry equation. In particular, one would expect both  $\beta_1$  and  $\delta_1$  to be positive, as time flexibility allows counties to exit later, and then, to stay longer in the protest. For  $\text{COVID}_{j,s}$ , one would expect  $\beta_2$  and  $\delta_2$  to be negative, as more risk of contagion acts as a cost to protesters, who might then want to leave sooner.

Table 2 shows the results from estimating equations (27) and (28). Columns (1)-(4) show the results for the entry equation for four different values of the threshold  $p$ , and columns (5)-(8) show the results for the exit equation for the same thresholds. The coefficients of  $\Delta\text{HOME}$  are significant and have the expected sign, for all thresholds, and for both entry and exit. However, the variable  $\text{COVID}$  is not significant, and the coefficient is near zero for every regression.

There might be multiple reasons for the insignificant effect of  $\text{COVID}$ . One of the main reasons, is that the population participating in the protest tend to be young people, who

are not part of the risk population. According to a survey by the Pew Research Center,<sup>20</sup> protesters were younger than the American population. Around 41% of those who say they attended a protest were between 18 and 29 years, whereas 19% of the U.S. population is within this age range.

**Table 2.** Entry and Exit (OLS)

Dependent Variable:	ENTRY( $p$ )				EXIT( $p$ )			
Threshold $p$ :	(1) 0.001%	(2) 0.005%	(3) 0.01%	(4) 0.02%	(5) 0.001%	(6) 0.005%	(7) 0.01%	(8) 0.02%
$\Delta\text{HOME}$	-2.426*** (0.365)	-1.901*** (0.353)	-1.468*** (0.359)	-1.131*** (0.366)	2.704*** (0.242)	2.133*** (0.235)	1.697*** (0.250)	1.167*** (0.267)
COVID	-0.004 (0.002)	-0.003 (0.002)	-0.002 (0.002)	-0.000 (0.002)	0.002 (0.002)	0.002 (0.002)	0.001 (0.001)	0.001 (0.001)
State FE	X	X	X	X	X	X	X	X
Observations	1084	1052	992	864	1084	1052	992	864

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Then, for the analysis that follows, I will only consider the effect of COVID-19 through stay-at-home behavior. The structural equations then are as follows,

$$\text{ENTRY}_j(p) = \alpha_0 + \alpha_1 \Delta\text{HOME}_j + \gamma_s + \epsilon_j \quad (30)$$

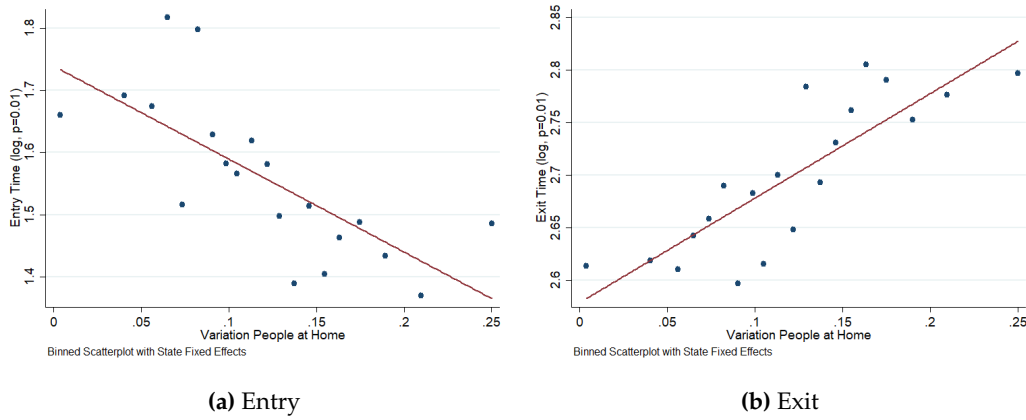
$$\text{EXIT}_j(p) = \beta_0 + \beta_1 \Delta\text{HOME}_j + \gamma_s + \epsilon_j \quad (31)$$

$$\text{DURATION}_j(p) = \delta_0 + \delta_1 \Delta\text{HOME}_j + \gamma_s + \epsilon_j, \quad (32)$$

where  $\gamma_s$  is a state fixed effect. Given that as  $\Delta\text{HOME}_j$  increases we expect the opportunity cost to decrease, its effects goes in the opposite direction as well. In particular, we expect  $\alpha_1$  to be negative, as a lower opportunity cost (higher  $\Delta\text{HOME}_j$ ) makes entry to occur earlier. Analogously,  $\beta_1$  and  $\delta_1$  are expected to be positive. Figure 10 shows, as a starting point, the relation between the variation in the number of people staying at home, and the entry and exit times. The figure plots the residuals after removing state fixed effects. This suggests that those counties in which people are spending more time at home enter the protest earlier (panel (a)) and exit later (panel(b)).

The variable  $\Delta\text{HOME}$  corresponds to a direct measure of people's behavior. The drawback of this, is that some factors affecting people's mobility might correlate with the propensity to participate in protests. For instance, people's occupation is crucial for the feasibility of stay-at-home behavior, and at the same time might correlate with the propensity to participate in a protest. As this might generate biased estimators due to ommitted variables, I follow an instrumental variables strategy.

<sup>20</sup>2020 Pew Research Center's American Trends Panel, Wave 68 June 2020.

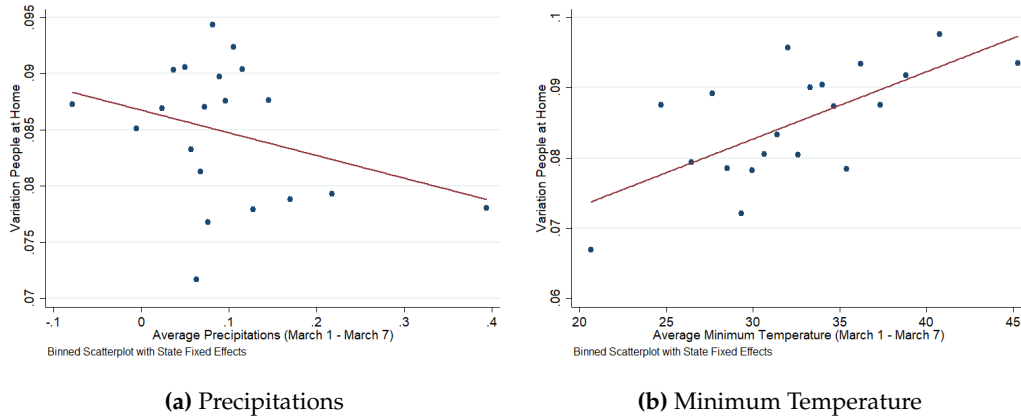
**Figure 10.** Entry, Exit and People Staying Home ( $p = 0.01$ )

Note: Binned Scatterplot. Residuals after controlling for State Fixed Effects.

The main variation in people's environment during the time of analysis is the differential incidence of COVID-19. Given this, I instrument for weather conditions at the beginning of the pandemic. Evidence suggests that weather at initial stages of the pandemic has permanent effects over the spread of the virus. For instance, [Kapoor et al. \(2020\)](#) find evidence that rainfall before the imposition of social-distancing and lock-down measures, generated a natural variation in social-distancing that had permanent effects in the incidence of the virus. Based on these ideas, I use two measures of weather during the first week of March: average minimum temperature and average precipitations. The channel then is that the effect of these measures affect the incidence of COVID-19 through inducing social-distancing (as in [Kapoor et al. \(2020\)](#)), and this has an effect over the time people spend at home during the month prior to the protests. For instance, higher rainfall at the beginning of March would contribute to decrease the incidence of the virus, and then we would expect people spending less time at home.<sup>21</sup> In Figure 12 I plot the relation between  $\Delta\text{HOME}$  and the instruments after controlling for state fixed effects.

The relevance restriction requires the instrument to correlate with our endogenous variable. This condition follows from the intuition developed above and is confirmed in Figure 12. The exclusion restriction requires that the instrument only affects the propensity to protest through  $\Delta\text{HOME}$ . First, note that I carefully chose the timing of events so that there is no endogeneity. Weather conditions—measured the first week of March—affect the incidence of COVID-19 in the upcoming weeks, which, in turn, affects stay-at-home behavior the month before the protests. Second, even though weather conditions correlate with occupation choice, the variable  $\Delta\text{HOME}$  is the variation with respect to 2019. One

<sup>21</sup>There is a second channel, that goes directly from weather to the incidence of the virus. However, this would go in the same direction as the expected effect proposed here.

**Figure 12.** People Staying at Home and Instruments

Note: Binned Scatterplot. Residuals after controlling for State Fixed Effects.

expects the choice of occupation to be a relatively stable variable that is not affected by the weather in the immediate. And a third concern, is that the effect of temperature and precipitations on the incidence of COVID-19 might exacerbate the alternative channel through which COVID-19 affects protests: through the risk of contagion. From the discussion above and Table 2, we expect this channel to not be relevant.

Table 3 shows the results for entry and exit times, for four different thresholds. Panel (a) shows the OLS estimation of equations (30) and (31), and panel (b) reports the IV estimation using the weather measures as instruments. The first four columns show the effect of people spending more time at home on the time of entry. As expected, an increase in the variable HOME is consistent with earlier entry at the county-level. Columns (5)-(6) report the coefficients for exit. The effect goes in the opposite direction: more people staying at home, is consistent with a later exit from the protest for all the coefficients studied.

In addition to this, in Table 4 I report the results of the regression for *duration*, corresponding to equation (32) above. The results show that the number of people at home has a positive effect on the time spent in the protest.

The tables also report the F statistic from the first stage. As it can be seen, it has a value greater than 10 for every threshold, which suggests that the instruments are not weak. Despite this, I evaluate the possibility of weak instruments by analyzing the robustness of the results. I show the results for entry and exit in Table 10 in the Appendix. Panel (a) reproduces the results of the 2SLS regression shown in table 3. Panel (b) shows the results estimating the equation by LIML, as this estimator is less biased than 2SLS when the instruments are weak. In addition, Panel (c) shows the IV regression using only one

**Table 3.** Entry, Exit and People Staying Home

Dependent Variable:	ENTRY( $p$ )				EXIT( $p$ )			
Threshold $p$ :	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	0.001%	0.005%	0.01%	0.02%	0.001%	0.005%	0.01%	0.02%
Panel (a) OLS								
$\Delta HOME$	-2.468*** (0.363)	-1.933*** (0.352)	-1.493*** (0.357)	-1.142*** (0.361)	1.647*** (0.172)	1.208*** (0.171)	0.992*** (0.170)	0.646*** (0.185)
Panel (b) IV								
$\Delta HOME$	-6.940*** (2.344)	-4.569** (2.205)	-3.197 (2.174)	-3.651 (2.362)	3.446*** (1.178)	3.632*** (1.192)	3.230*** (1.157)	2.191* (1.207)
State FE	X	X	X	X	X	X	X	X
Observations	1029	999	943	823	1029	999	943	823
First-Stage F	14.01	13.35	12.98	12.38	14.01	13.35	12.98	12.38

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows OLS regression for different thresholds, and Panel (b) shows the IV regression using weather instruments (MIN TEMP, RAINFALL).

**Table 4.** Duration and People Staying Home

Dependent Variable:	DURATION( $p$ )			
Threshold $p$ :	(1)	(2)	(3)	(4)
	0.001%	0.005%	0.01%	0.02%
Panel (a) OLS				
$\Delta HOME$	2.726*** (0.241)	2.151*** (0.235)	1.704*** (0.250)	1.185*** (0.266)
Panel (b) IV				
$\Delta HOME$	5.875*** (1.630)	5.379*** (1.567)	5.361*** (1.589)	3.500* (1.794)
State FE	X	X	X	X
Observations	1084	1052	992	864
First-Stage F	14.01	13.35	12.98	12.38

SE in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows OLS regression for different thresholds, and Panel (b) shows the IV regression using weather instruments (MIN TEMP, RAINFALL).

instrument. The comparison between the three panels suggests that the results are not driven by weak instruments bias.

In Table 11 in the Appendix, I evaluate the robustness of the IV estimation to the addition to some demographics. I show the results are stable to the inclusion of the share of black population, the fraction of young people, and the fraction of people older than 65. As expected, higher fraction of black people in the county's population is consistent with earlier entry and later exit. The same for people younger than 29 years old. To evaluate

the robustness of the results even further, in the Appendix I replicate the results using Google's Mobility Reports as an alternative measure of time flexibility.

**7.4.2. Preference Heterogeneity: Black Population.** The analysis I develop in the previous section focuses on opportunity cost in its more literal definition: the cost of the alternative use of time. However, heterogeneity across citizens might conceal more than that. It might very well be that people have different stakes in the conflict, and different values for the public good. In the model, stakes affect people's decisions only to the extent they affect the veteran prize (see discussion in 3.2.4). This is natural, as people who value more an issue might want to contribute more, and one would expect them to enjoy even more an eventual victory against the government. Thus, stakes should go in the opposite direction to opportunity costs: people with higher stakes in the protest, should enter earlier and stay longer in the protest.

In the context of the *Black Lives Matter* protests, there is no doubt that African-American citizens are the ones with more stakes in the conflict. In this section, I replicate the analysis above considering the percentage of black people in the county's population. Tables 5 and 6 show the results of the OLS and IV regressions from the previous section, but including the percentage of black people. As one would expect, the coefficients for the entry regression are negative, i.e., the higher the fraction of the African-American population in a county, the faster participation reaches a given participation level. The opposite holds for exit and duration: a higher fraction of African-Americans is consistent with later exit and longer duration.

**7.4.3. Income and Education.** To complement the analysis in Section 7.4.1, I explore other variables that are associated with opportunity costs. The alternative use of the time spent in a demonstration might depend on many factors such as the organization of a city over the space, different lifestyles and types of occupations. More flexible occupations give workers the chance to manage their time more freely, whereas tight schedules tend to make it harder to fit other activities daily. In this section, I explore two factors affecting opportunity costs: income and education.

The effect of income over opportunity costs depends, as I show in Section 6.4, on the shape of the utility function. If the marginal utility of income is increasing, we expect higher income to be consistent with a higher opportunity cost. Thus, we would expect higher income counties to enter later, and exit earlier.

The effect of education is more subtle. It is often the case that people with lower education levels have jobs that rely more on physical activities and that tend to be less flexible in terms of time management. Also, the lower formality of the job makes it harder to realize

**Table 5.** Entry, Exit and Black Population

Dependent Variable:	ENTRY( $p$ )				EXIT( $p$ )			
Threshold $p$ :	(1) 0.001%	(2) 0.005%	(3) 0.01%	(4) 0.02%	(5) 0.001%	(6) 0.005%	(7) 0.01%	(8) 0.02%
Panel (a) OLS								
$\Delta$ HOME	-2.465*** (0.356)	-1.908*** (0.344)	-1.467*** (0.352)	-1.097*** (0.358)	1.644*** (0.168)	1.200*** (0.169)	0.987*** (0.169)	0.643*** (0.185)
BLACK	-0.016*** (0.003)	-0.015*** (0.003)	-0.012*** (0.003)	-0.010*** (0.003)	0.007*** (0.001)	0.004*** (0.001)	0.002* (0.001)	0.001 (0.001)
Panel (b) IV								
$\Delta$ HOME	-6.452*** (2.277)	-4.160* (2.158)	-2.800 (2.147)	-3.294 (2.351)	3.254*** (1.152)	3.535*** (1.182)	3.174*** (1.157)	2.214* (1.221)
BLACK	-0.016*** (0.00270)	-0.015*** (0.00258)	-0.013*** (0.00263)	-0.009*** (0.00275)	0.008*** (0.00136)	0.005*** (0.00142)	0.002* (0.00143)	0.001 (0.00144)
State FE	X	X	X	X	X	X	X	X
Observations	1029	999	943	823	1029	999	943	823
First-Stage F	13.71	13.08	12.71	12.14	13.71	13.08	12.71	12.14

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows OLS regression for different thresholds, and Panel (b) shows the IV regression using weather instruments (MIN TEMP, RAINFALL).

**Table 6.** Duration and Black Population

Dependent Variable:	DURATION( $p$ )			
Threshold $p$ :	(1) 0.001%	(2) 0.005%	(3) 0.01%	(4) 0.02%
Panel (a) OLS				
$\Delta$ HOME	2.724*** (0.231)	2.133*** (0.226)	1.687*** (0.245)	1.165*** (0.263)
BLACK	0.014*** (0.002)	0.011*** (0.002)	0.008*** (0.002)	0.004** (0.002)
Panel (b) IV				
$\Delta$ HOME	5.460*** (1.563)	5.108*** (1.524)	5.124*** (1.561)	3.422* (1.803)
BLACK	0.014*** (0.002)	0.011*** (0.002)	0.008*** (0.002)	0.004* (0.002)
State FE	X	X	X	X
Observations	1084	1052	992	864
First-Stage F	13.71	13.08	12.71	12.14

SE in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows OLS regression for different thresholds, and Panel (b) shows the IV regression using weather instruments (MIN TEMP, RAINFALL).



activities during workdays, such as protesting.<sup>22</sup> We would then expect that people with lower education levels have a higher opportunity cost, and then they enter later.

To explore these ideas, I estimate the following equations:

$$\text{ENTRY}_j(p) = \alpha_0 + \alpha_1 \text{INCOME}_j + \alpha_2 \text{LOW EDUC}_j + \alpha_3 X_j + \alpha_4 \text{STATE}_j + \epsilon_j \quad (33)$$

$$\text{EXIT}_j(p) = \beta_0 + \beta_1 \text{HOME}_j + \beta_2 \text{LOW EDUC}_j + \alpha_3 X_j + \beta_4 \text{STATE}_j + \epsilon_j \quad (34)$$

$$\text{DURATION}_j(p) = \delta_0 + \delta_1 \text{HOME}_j + \delta_2 \text{LOW EDUC}_j + \alpha_3 X_j + \delta_4 \text{STATE}_j + \epsilon_j \quad (35)$$

where  $\text{INCOME}_j$  is the median income in county  $j$ ,  $\text{LOW EDUC}_j$  is the percentage of the population with less than a college degree, and  $X_j$  is a vector of county demographics. The dependent variables are the usual ones: entry, exit, and duration in the protest.

In Table 7 show the results of the OLS regressions for the time of entry and exit. Columns (1)-(4) show the effect of income and education over the time of entry for different values of  $p$ . As we can see, both the share of the population with less than a college degree, and the median household income are positively correlated with entry times for every threshold level  $p$ . Columns (4)-(6) results are also consistent with the model predictions: both the share of the population with less than a college degree, and the median household income, are consistent with earlier exit.

**Table 7.** Entry, Exit and Opportunity Cost

Dependent Variable:	ENTRY( $p$ )				EXIT( $p$ )			
Threshold $p$ :	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	0.001%	0.005%	0.01%	0.02%	0.001%	0.005%	0.01%	0.02%
INCOME	0.139*** (0.025)	0.143*** (0.026)	0.110*** (0.027)	0.115*** (0.026)	-0.043*** (0.014)	-0.033** (0.014)	-0.025* (0.014)	-0.017 (0.015)
LOW EDUCATION	0.013*** (0.003)	0.016*** (0.003)	0.015*** (0.004)	0.013*** (0.004)	-0.011*** (0.002)	-0.011*** (0.002)	-0.009*** (0.002)	-0.006*** (0.002)
Controls	X	X	X	X	X	X	X	X
State FE	X	X	X	X	X	X	X	X
Observations	1129	1093	1030	895	1129	1093	1030	895

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Controls: CLINTON, LABOR, UNDER 29, POPULATION (LOG), DENSITY (LOG), RURAL, BLACK.

A natural concern is that these estimates might be biased due to omitted variables. There are many other variables related to a county's income and educational level that are also related to a propensity to protest. But note that we are not estimating the effect of income and education over *the level of participation* in protests, our dependent variables are the

<sup>22</sup>For instance, according to a News Economic Release from the Bureau of Labor Statistics, 47 percent of workers with a bachelor's degree or higher reported to work from home occasionally. In contrast, only 9 percent of workers with only a high school diploma reported to do so. Source: Job Flexibility and Work Schedules News Release 2017-2018. Webpage: [BLS Economic News Release](#).

**Table 8.** Duration and Opportunity Cost

Dependent Variable:	DURATION( $p$ )			
Threshold $p$ :	(1) 0.001%	(2) 0.005%	(3) 0.01%	(4) 0.02%
INCOME	-0.101*** (0.0156)	-0.096*** (0.016)	-0.078*** (0.017)	-0.057*** (0.020)
LOW EDUCATION	-0.018*** (0.002)	-0.019*** (0.002)	-0.017*** (0.003)	-0.013*** (0.003)
Controls	X	X	X	X
State FE	X	X	X	X
Observations	1129	1093	1030	895

SE in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$   
 Controls: CLINTON, LABOR, UNDER 29, POPULATION (LOG),  
 DENSITY (LOG), RURAL, BLACK.

*timing* of entry and exit. Even when income might correlate with other intrinsic qualities that determine a propensity to protest, these other factors would also have to correlate to agents delaying entry and exiting earlier.

**7.5. Discussion.** In this section I provide some preliminary evidence about the main empirical predictions of the model. This analysis has some caveats. First, it is worth mentioning that there could be other forces and incentives generating these dynamics that are not considered here. Second, the data I use for participation is just an approximation. The Crowd Counting Consortium is an event data in which participation is obtained directly from media sources, participants or organizers. These records might be biased either because of the own media outlets' bias, organizers' bias, or just incorrect measurement. As recent studies show (see [Sobolev et al. \(2020\)](#) and [Van Dijcke & Wright \(2020\)](#)), a more accurate measure of participation would be one coming directly from mobile device data or other individual-level records. I plan to replicate in the future this study using these types of data.

Despite this, the evidence suggests that the regularities obtained from the model are consistent with the dynamics of participation observed. Studying participation over time provides novel insights that complement existing studies that focus on an aggregate measure of engagement in a social movement.

## 8. Concluding Remarks

This paper presents a theory of the dynamics of participation in public protests. I develop a model in which a continuum of citizens protests to ask the government for a policy change or the provision of a public good. Citizens' participation is motivated by a psychological

prize that they get when they win against the government. I show that any equilibrium in this dynamic game displays: (a) a *build-up* stage, during which citizens continuously join the protest and the government waits; followed by (b) a *peak*, at which participation reaches its maximum, and the government makes the first probabilistic concession; and, possibly, (c) a *decay* stage, in which people continuously drop out as the government concedes with some density. Also, when parametrized by the time at which the peak occurs, the set of possible values is bounded, and for each of them, the equilibrium is unique.

I provide preliminary evidence from the recent *Black Lives Matter* to support the main empirical predictions of the model. In particular, evidence suggests that a higher opportunity cost is consistent with later entry and earlier exit.

There are many directions in which these ideas might be developed. Probably the first and most important extension is to allow for heterogeneity in the value for the public good. Even when, in the model, this is just a renormalization, the questions that can be addressed by differentiating the cost from the value are empirically relevant. In particular, it would allow an understanding of how the relationship between people's participation costs and the value for the public good affect the duration of protests. Then, under the proper parametrization, we could understand whether issues that are more relevant to high-income people tend to be solved earlier than those of general interest.

People's heterogeneity in the value obtained from policies opens the door to other extensions, as well. For instance, if the government did not know the value of the policy and should learn it from the protest, this would give rise to novel equilibrium dynamics. When the government seeks to extract information from protesters, dynamic concessions are a double-edged sword, as now, conceding decreases the cost of the protest by persuading people to go home, but also decreases the information that the government can extract from it.

## A. Appendix: Proofs

*A.1. Proof of Theorem 1: Equilibrium Characterization.* This section is devoted to prove the equilibrium characterization described in Section 2. I begin by proving some properties of the government's equilibrium strategy, which then I use to fully characterize the set of equilibria. In the first lemma, I show that if there is an interval after  $\tau_0$  in which the government does not concede (i.e. the distribution  $G$  is constant in that interval), then no agent who is in the protest drops out during that interval. More precisely, we say that an agent with opportunity cost  $\theta$  is participating at a time  $t$  if  $\sigma_t^\theta = 1$ .

**Lemma 1.** *Assume  $\tau_0 < \tau_1$  and take  $t_1, t_2$  such that  $\tau_0 \leq t_1 < t_2 \leq \tau_1$ . If  $G$  is constant in  $(t_1, t_2)$ , then no agent participating at  $t_1$  drops out in  $(t_1, t_2]$ .*

*Proof.* For any citizen that is participating at  $t_1$ , she is strictly better off quitting at  $t_1$ , than at any  $t \in (t_1, t_2]$ .  $\square$

**Lemma 2.** *The support of  $G$  is either a singleton, or a connected interval  $\mathcal{T} = [\tau_0, \tau_1]$ .*

*Proof.* By contradiction, suppose there exists  $t \in [\tau_0, \tau_1]$  such that  $t \notin \mathcal{T}$ . Then,  $t > \tau_0$ , and there exists  $\epsilon \in (0, t - \tau_0]$  such that  $G(t) - G(t - \epsilon) = 0$ . But then  $[t - \epsilon/2, t] \cap \mathcal{T} = \emptyset$ , so if there is  $t \notin \mathcal{T}$ , there is an interval which does not belong to  $\mathcal{T}$ . Then take  $t_0, t_1$ , with  $\tau_0 \leq t_0 < t_1 \leq \tau_1$  such that  $G(s) = G(t_0) \forall s \in [t_0, t_1]$ .

Assume  $[t_0, t_1]$  is maximal, i.e. there is no interval  $[t'_0, t'_1]$  such that  $[t_0, t_1] \subsetneq [t'_0, t'_1]$  and  $G(s) = G(t'_0)$  for every  $s \in [t'_0, t'_1]$ . Maximality of the interval implies that  $t_0 \in \mathcal{T}$ . If not, there exists  $\epsilon_1 > 0$  such that  $G(t_0) - G(t_0 - \epsilon_1) = 0$ , but then  $G(s) = G(t_0 - \epsilon)$   $\forall s \in [t_0 - \frac{\epsilon}{2}, t_1]$ . By maximality, for every  $\epsilon > 0$   $[t_1, t_1 + \epsilon) \cap \mathcal{T} \neq \emptyset$ . Then, it is optimal for the government to concede at  $t_0$  and at  $t_1$ .

Note that for the government to concede at  $t_0$  the cost of conceding must less than or equal than the cost of waiting. The cost of conceding at  $t_0$  is  $\frac{q}{r}$ , while the cost of waiting to concede at some  $t_0 + \delta$  for  $\delta > 0$  is given by

$$\int_0^\delta e^{-rs} c(\pi_{t_0+s}^\sigma, t_0 + s) ds + e^{-r\delta} \frac{q}{r} \quad (36)$$

Then, we have:

$$\int_0^\delta e^{-rs} c(\pi_{t_0+s}^\sigma, t_0 + s) ds + e^{-r\delta} \frac{q}{r} \geq \frac{q}{r} \quad \forall \delta > 0 \quad (37)$$

or, equivalently

$$\int_0^\delta e^{-rs} (c(\pi_{t_0+s}^\sigma, t_0 + s) - q) ds \geq 0 \quad \forall \delta > 0. \quad (38)$$

Define  $\bar{t} = \frac{t_0 + t_1}{2}$ . Note that as 38 holds for every  $\delta > 0$ , it must also hold for  $\bar{\delta} = \bar{t} - t_0$ .

Since  $t_0 \in \mathcal{T}$ , then it must be that  $\pi_{t_0}^\sigma > 0$ , as otherwise the cost of the protest is zero. Moreover, by lemma 1, no citizen drops out at  $(t_0, t_1]$ , so  $\pi_{\bar{t}+s}^\sigma \geq \pi_{t_0+s}^\sigma$  for all  $s \in (0, \bar{\delta}]$ . As,  $\pi_{t_0} > 0$ , then the cost is strictly increasing in time, and we have:

$$c(\pi_{t_0+s}^\sigma, t_0 + s) < c(\pi_{\bar{t}+s}^\sigma, \bar{t} + s) \quad \forall s \in (0, \bar{\delta}] \quad (39)$$

Then, we can compute:

$$\begin{aligned} \int_{t_0}^{t_1} e^{-r(s-t_0)} (c(\pi_s^\sigma, s) - q) ds &= \int_{t_0}^{\bar{t}} e^{-r(s-t_0)} (c(\pi_s^\sigma, s) - q) ds \\ &+ e^{-r(\bar{t}-t_0)} \int_{\bar{t}}^{t_1} e^{-r(s-\bar{t})} (c(\pi_s^\sigma, s) - q) ds \end{aligned} \quad (40)$$

The first term on the right hand side is weakly greater than 0. By 39 the second term must then be strictly greater than zero, which implies  $\int_{t_0}^{t_1} e^{-rs} (c(\pi_{t+s}^\sigma, t+s) - q) ds > 0$ . But then the government strictly prefers to concede at  $t_0$  than at  $t_1$ , which is a contradiction.  $\square$

**Lemma 3.** *If  $\mathcal{T}$  is not a singleton, then it must be that  $c(\pi_s^\sigma, s) = q$  and  $\pi_s^\sigma = \tilde{\pi}_s$  for every  $s \in [\tau_0, \tau_1]$ .*

*Proof.* For the government to be randomizing over concession times  $\tau \in [\tau_0, \tau_1]$ , it must be that:

$$\int_0^\tau e^{-rs} c(\pi_s^\sigma, s) + e^{-r\tau} \frac{q}{r} = a \quad \forall \tau \in [\tau_0, \tau_1] \quad (41)$$

for some constant  $a$ . Taking first order conditions with respect to  $\tau$ , we obtain  $c(\pi_\tau^\sigma, \tau) - q = 0$ , which proves the result.  $\square$

Lemmas 2 and 3 provide a characterization of the regions over which the government concedes. The problem for the government is a stopping time problem, in which I allow it to randomize. For citizens the problem is a little different. Given that I do not impose restrictions on the actions that citizens can take, they could enter and exit the protest many times. So far there is nothing that prevents a citizen to protest over a time interval, then drop out to spend some time outside the protest, and then protesting again. However, I show that in equilibrium citizens enter and exit at most once. In particular, their optimality conditions satisfy a monotonicity property with respect to opportunity cost, that ensures that citizens' strategies can be characterized by opportunity cost thresholds. In lemma 4 I give some sufficient conditions for these entry and exit times to be optimal. Optimality conditions are stated in terms of the hazard rate of government concession,  $\lambda_t = \frac{g(t)}{1-G(t)}$ , which corresponds to the instantaneous probability of government concession conditional on the it being still in the game.

**Lemma 4.** *In equilibrium, citizens enter and exit at most once. For a person with opportunity cost  $\theta$  who does enter, the optimal entry and exit times,  $t_0(\theta), t_1(\theta)$  are a solution to the following*

sufficient conditions:

$$\theta = \lambda_{t_1} v(t_1 - t_0) \quad (42)$$

$$\theta = \frac{1}{1 - G(t_0)} \int_{t_0}^{t_1} e^{-r(s-t_0)} v'(s - t_0) dG(s) \quad (43)$$

Moreover, optimal entry and exit times satisfy  $t'_0(\theta) > 0$  and  $t'_1(\theta) < 0$ , respectively.

*Proof.* Consider a citizen with opportunity cost  $\theta$  who is planning to enter, on the equilibrium path, at some time  $t_0$  and exit at  $t_1$ , i.e.  $\sigma_t^\theta = 1$  for  $t \in [t_0, t_1]$ . Given a random concession time  $\tau$  for the government, the citizen solves the following problem:

$$\max_{(t_0, t_1) \in [0, \infty]^2} E \left[ -\theta \int_{t_0}^{t_1 \wedge \tau} e^{-rs} ds + e^{-r\tau} \mathbb{1}_{\tau < t_1} v(t - t_0) \right] \quad (44)$$

where the expectation is taken over  $\tau$ , and where we have omitted additive payoffs that are not under the agent's control. Plugging in the distribution of government concessions  $G$  the objective function can be rewritten as:

$$U(t_0, t_1; \theta) = \int_{t_0}^{t_1} \left[ -\frac{\theta}{r} (e^{-rt_0} - e^{-rs}) + e^{-rs} v(s - t_0) \right] dG(s) - (1 - G(t_1)) \frac{\theta}{r} (e^{-rt_0} - e^{-rt_1}) \quad (45)$$

As long as an agent is in the protest she has to pay the cost of the protest. If the government concedes before the time she drops out, the citizen gets the veteran reward. If the government has not conceded by the time the agent drops (which happens with probability  $(1 - G(t_1))$ ), then the agent only pays the cost of the protest and does not get any prize. Taking first order conditions with respect to  $t_0$  and  $t_1$ , we have:

$$\frac{\partial U}{\partial t_0} = -(1 - G(t_0))\theta + g(t_0)v(0) + \int_{t_0}^{t_1} e^{-r(s-t_0)} v'(s - t_0) dG(s) \quad (46)$$

$$\frac{\partial U}{\partial t_1} = -\theta e^{-rt_1} (1 - G(t_1)) + g(t_1) e^{-rt_1} v(t_1 - t_0) \quad (47)$$

Reorganizing, we obtain equations 42 and 43 from the lemma. Note that these equations have a unique solution.

The fact that first order conditions are also sufficient follows from a single-crossing property of agents utility with respect to opportunity cost. In particular, the marginal utilities of agents' strategies are monotone in  $\theta$ , i.e.

$$\frac{\partial^2 U}{\partial t_0 \partial \theta} = e^{-rt_0} (1 - G(t_0)) \geq 0 \quad \frac{\partial^2 U}{\partial t_1 \partial \theta} = -e^{-rt_1} (1 - G(t_1)) \leq 0 \quad (48)$$

Thus, citizens follow monotone strategies satisfying  $t'_0(\theta) > 0$ ,  $t'_1(\theta) < 0$ .

Now, suppose an agent is considering to reenter. Note that once the agent exits, her problem becomes the same from equation 44, as the veteran payoff goes back to zero.

But then by the single crossing property we just proved reentry cannot be optimal. This concludes the proof.  $\square$

From equation 42 we see that an agent will exit when the marginal cost of staying another instant, i.e.  $\theta$ , exceeds the marginal benefit, i.e. the prize times the instantaneous probability of government concession conditional on the government being still in the game. Equation 43 has a similar interpretation: the agent enters if the marginal cost is smaller than the marginal benefit. The marginal benefit now has two components. The first term in the right hand side captures the probability of obtaining the prize immediately, while the second one corresponds to the marginal benefit obtained from increasing the prize for all future periods that the agent plans to protest.

From Lemma 4, at any time agents' decision can be characterized by opportunity cost thresholds. More precisely, define  $\tilde{\theta}_0(t) = t_0^{-1}(t)$ , and note that this corresponds to the agent who is indifferent between entering at time  $t$  or waiting (i.e. equation 43 holds with equality). Any citizen with opportunity cost  $\theta < \tilde{\theta}_0(t)$  is strictly better off by being in the protest. Analogously define  $\tilde{\theta}_1(t) = t_1^{-1}(t)$ , and note that it corresponds to the agent who is indifferent between staying in the protest another instant or exit immediately. Any citizen with  $\theta > \tilde{\theta}_1(t)$  is strictly better off by dropping out.

We now put this ingredients together to prove Proposition 1 using the following steps.

*Step 1: If  $\tau_0 < \tau_1$ , then  $\pi_t^\sigma$  is strictly decreasing in  $t$ , for every  $t \in [\tau_0, \tau_1)$ .* From lemma 3, it must be that  $c(\pi_t^\sigma, t) = q$  at every  $t \in [\tau_0, \tau_1)$ . Then,  $\pi_t = \tilde{\pi}(t)$  for every  $t \in [\tau_0, \tau_1)$ . This function is well-defined, continuous and decreasing by assumption 1.

*Step 2: The distribution has at most one discrete jump at  $\tau_0$ .* Suppose there is  $t > \tau_0$  such that the distribution  $G$  jumps at  $t$ , i.e. there is  $\epsilon > 0$  such that  $G(t) > G(s)$  for all  $s \in [t - \epsilon, t)$ . But then there is an interval over which citizens will not drop, contradicting the previous step.

*Step 3: If  $\tau_0 < \tau_1$ , then at every  $t \in [\tau_0, \tau_1)$  the distribution of concessions  $G$  has decreasing hazard rate.* From equation 42 in Lemma 4, for citizens' decision to be optimal the exit threshold must satisfy:

$$\tilde{\theta}_1(t) = \lambda_t v(t - t_0(\tilde{\theta}_1(t))) \quad (49)$$

From the previous step, we have that the threshold must satisfy  $F(\tilde{\theta}_1(t)) = \tilde{\pi}(t)$ , and then it is decreasing over time. Then the left-hand side of equation 49 is decreasing, while the prize function increases over time, so it has to be that  $\lambda_t$  is decreasing.

*Step 4: If  $\tau_0 < \tau_1$ , then  $\tau_1 = \infty$ .* Suppose  $\tau_1 < \infty$ . First, it must be that  $G(\tau_1) = 1$ . Suppose that this is not the case and the government stops conceding at some  $\tau$  with  $G(\tau) < 1$ .

Using the same arguments as in the proof of lemma 2, it must be  $c(\pi_\tau, \tau) \geq q$ . But then  $\pi_\tau > 0$ , as otherwise  $c(\pi_\tau, \tau) = 0$  by assumption 1. By lemma 1 no citizen drops after  $\tau$ , but then as the cost is increasing in time, eventually the cost of the protest would be higher than the cost of waiting, contradicting the optimality of the government's strategy. Thus, it must be that  $G(\tau_1) = 1$ . If this is the case, it must be that  $\int_0^{\tau_1} \lambda_s ds = \infty$ , which cannot happen in finite time as  $\lambda_t$  is decreasing in  $t$ . So,  $\tau_1 = \infty$ .

*Step 5: If a citizen with opportunity cost  $\theta$  ever enters the protest (i.e.  $\exists t$  such that  $\sigma_t^\theta = 1$ ), then  $t_0(\theta) \leq \tau_0 \leq t_1(\theta)$ .  $t_1(\theta) \geq \tau_0$  follows directly from optimality, as otherwise the expected prize is zero with probability 1. Now consider an agent with opportunity cost  $\theta$  entering at  $t_0 > \tau_0$ . From lemma 4, the marginal benefit of entering is given by:*

$$\lambda_{t_0} v(0) + \frac{1}{1 - G(t_0)} \int_{t_0}^{t_1} e^{-r(s-t_0)} v'(s - t_0) dG(s) \quad (50)$$

By step 3, the expression above is decreasing in  $t_0$  for any  $t_0 \geq \tau_0$ , and the marginal cost is constant. Then, the agent is strictly better off entering earlier.

*Step 6: At any  $t < \tau_0$ ,  $\pi_t^\sigma$  is increasing.* From the previous claim,  $\pi_t^\sigma = F(\tilde{\theta}_0(t))$ , which is increasing.

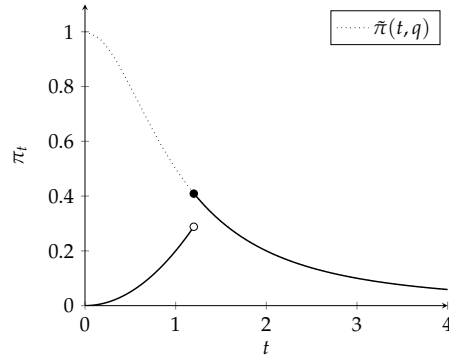
*Step 7:  $\pi_t^\sigma$  is continuous at every  $t \in [0, \infty]$ .* We know that  $\pi_t^\sigma$  is continuous on  $[\tau_0, \infty]$ , and by the entry condition we also know it is continuous in  $[0, \tau_0)$ . It remains to show that it is also continuous at  $\tau_0$ . In particular, we rule out cases in which there is a positive mass of people entering at a given time  $t$  (see figure 14). Take two agents entering at a given time  $\bar{t}_0$ . Note that as  $\tilde{\pi}_t$  is strictly decreasing, these two agents cannot exit at the same time. Suppose they exit at some times  $t_1 < t'_1$ . Thus, from the exit condition their opportunity costs are given by  $\tilde{\theta}_1(t_1) > \tilde{\theta}_1(t'_1)$ . But from the entry condition, we have:

$$\tilde{\theta}_1(t_1) = \int_{\bar{t}_0}^{t_1} e^{-r(s-\bar{t}_0)} v'(s - \bar{t}_0) dG(s) < \int_{\bar{t}_0}^{t'_1} e^{-r(s-\bar{t}_0)} v'(s - \bar{t}_0) dG(s) = \tilde{\theta}_1(t'_1) \quad (51)$$

a contradiction.

*Step 8:  $\tau_0 > 0$ .* We begin by showing that if  $G(\tau_0) = 1$ , then  $\tau_0 > 0$ . Consider first the case in which the government concedes with probability 1 at  $\tau_0$ , i.e.  $G(\tau_0) = 1$ . Note that the payoff from entering at  $\tau_0$  is zero, so at  $\tau_0$  nobody enters anymore. But for  $\tau_0 \in \mathcal{T}$  it must be that  $c(\pi_{\tau_0}, \tau_0) \geq q$  (see the proof of lemma 2). The benefit of the last citizen entering is given by  $G(\tau_0) \cdot v'(0)$ , and then, for this to be an equilibrium, it must be that  $F(v'(0)) = \tilde{\pi}_{\tau_0}$ . This pins down  $\tau_0$  as the time at which  $c(F(v'(0)), \tau_0) = q$ . This time must be strictly positive, as otherwise there is no entry.





**Figure 14.** Continuity of  $\pi_t$ .

Denote by  $\underline{\tau} = \tau_0$  the time at which the government concedes with probability 1. Then, we prove that if  $G(\tau_0) < 1$ , then it must be that  $\tau_0 > \underline{\tau}$ . Note that if  $G(\tau_0) < 1$  then by lemma 3 it must be that  $c(\pi_{\tau_0}, \tau_0) = q$ . The payoff to the last agent entering is given by  $G(\tau_0)v'(0)$ , and then it must be that at  $F(G(\tau_0)v'(0)) = \tilde{\pi}_{\tau_0}$ . But  $\tilde{\pi}_{\tau_0} < \tilde{\pi}_{\underline{\tau}}$ , so by assumption 1 it must be  $\tau_0 < \underline{\tau}$ .

*Step 9: In equilibrium the government concedes in finite time, i.e.  $\lim_{t \rightarrow \infty} G(t) = 1$ .* From step 4,  $\tau_1 = \infty$ . Denote by  $\underline{\lambda}_t = \frac{\theta}{v(t)}$  the hazard rate that makes the lowest opportunity cost citizen indifferent between dropping out and protesting at any time  $t$ . Note that by assumption 2,  $\underline{\lambda}_t > 0$  for all  $t$ . Moreover,  $\lambda_t \geq \underline{\lambda}_t$  for all  $t$ , and then  $\int_0^\infty \lambda_t dt \rightarrow \infty$ . So we have:

$$\lim_{t \rightarrow \infty} G(t) = 1 - \lim_{t \rightarrow \infty} \left[ (1 - G(\tau_0)) \exp \left( - \int_0^t \lambda_s ds \right) \right] = 1 \quad (52)$$

With this, we complete the proof of Theorem 1. □

**Lemma 5.** *Government initial concession  $G(\tau_0)$  is decreasing in  $\tau_0$ .*

*A.2. Proof of Lemma 5.* Using Lemma 5, the entry threshold can be written as:

$$\tilde{\theta}_0(t) = \begin{cases} \int_t^{t_1} e^{-r(s-t)} v'(s-t) dG(s) & t \in [0, \tau_0) \\ \tilde{\theta}_1(t) & t = \tau_0 \end{cases} \quad (53)$$

Using continuity of  $\pi_t$ , it has to be that  $\tilde{\theta}_0(t)$  is also continuous, i.e.  $\lim_{t \rightarrow \tau_0^-} \tilde{\theta}_0(t) = \tilde{\theta}_1(\tau_0)$ .

Thus, at  $\tau_0$  the following condition holds:

$$\tilde{\theta}_0(\tau_0) = v'(0)G(\tau_0) \quad \Rightarrow \quad G(\tau_0) = \frac{\tilde{\theta}_1(\tau_0)}{v'(0)}$$

□

*A.3. Proof of Theorem 2: A Continuum of Equilibria.* It is direct to see that there is an equilibrium with  $\tau_0 = \underline{\tau}$ . I begin by showing that there exists an equilibrium satisfying  $\tau_0 = \bar{\tau}$ . Then, I prove that for any  $\tau_0$  in between this thresholds, an equilibrium exists.

**Lemma 6.** *There exists an equilibrium  $(G, (\pi_t^\sigma)_{t \geq 0})$  with  $\tau_0 = \bar{\tau}$  satisfying*

$$\underline{\theta} = \int_{\bar{\tau}}^{\infty} e^{-rs} v'(s) dG(s) \quad (54)$$

*Proof.* In order to prove existence of this equilibrium with the longest delay, I show that there exists a fixed point satisfying condition 54.

As I describe in Section 4.2, in equilibrium citizens' exit times are determined by the government indifference condition.<sup>23</sup> Then, given their exit times, and the government distribution of concessions  $G(t)$ , their best reply associates each exit time  $t \in [\tau_0, \infty)$ , with an entry time  $t_0(t)$ . The government, given these entry times chooses a distribution of concessions  $G(t)$ .

I consider a modified game, in which there is a fictitious player whose only role is to choose the delay  $\tau_0$ , in such a way that, given  $G(t)$ , condition 54 is satisfied. In this modified game, the government, given citizens' and the fictitious player's best responses, chooses a probability distribution of concessions for  $G(t)$ , for any  $t \in [\tau_0, \infty)$ . Citizens, given the distribution of the government with discrete concession at  $\tau_0$ , choose their entry times.

Define the best reply correspondence:  $\Psi : \mathbf{Z} \rightrightarrows \mathbf{Z}$  with typical element  $\mathbf{z} = (G, t_0, \tau_0)$  as:

$$\Psi = (\Gamma(t_0, \tau_0), \Phi(G, \tau_0), \Theta(G, t_0)) \quad (55)$$

where  $\Gamma(t_0, \tau_0)$  is the government's best reply,  $\Phi(G, \tau_0)$  is citizens' best reply, and  $\Theta(G, t_0)$  is the best reply of the fictitious player.

The space  $\mathbf{Z} = [0, T] \times \mathcal{S} \times \mathcal{C}$  is such that  $\mathcal{S}$  corresponds to the space of probability distributions,<sup>24</sup> and  $\mathcal{C}$  corresponds to the space of continuous functions.  $T$  is the upper bound on the maximum concession time  $\bar{\tau}$ . I use Kakutani-Fan-Glicksberg theorem to prove that an equilibrium exists. This theorem states that if  $\mathbf{Z}$  is a nonempty compact convex subset of a locally convex Hausdorff space, and the correspondence  $\Psi : \mathbf{Z} \rightrightarrows \mathbf{Z}$  has closed graph and nonempty convex values, then the set of fixed points is compact and nonempty (Aliprantis & Border (2013), Corollary 17.55).

*Step 1: Define Citizens' Best Response  $\Phi : [0, T] \times \mathcal{S} \rightarrow \mathcal{C}$ .* In equilibrium, given a distribution  $G \in \mathcal{S}$  with support  $[\tau_0, \infty)$ , for each possible exit time  $t \in [\tau, \infty]$ ,  $t_0(t)$  is the optimal entry

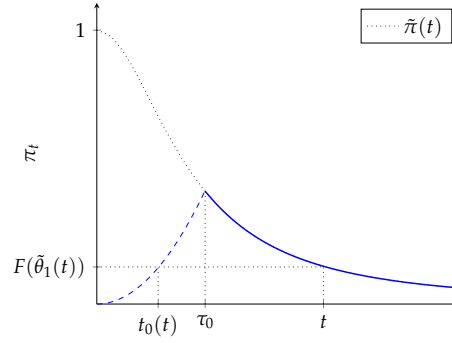
<sup>23</sup>More precisely, on the support  $\mathcal{T}$ , it has to be the case that  $\pi_t = \tilde{\pi}_t$ . Thus, there exist a unique exit threshold  $\tilde{\theta}_1(t)$  such that  $\tilde{\pi}_t = F(\tilde{\theta}_1(t))$  for every  $t \in \mathcal{T}$ .

<sup>24</sup>Space of functions that are increasing, right-continuous, and such that  $\lim_{t \rightarrow -\infty} G(t) = 0$  and  $\lim_{t \rightarrow \infty} G(t) = 1$ .

time that solves the following equation:

$$\tilde{\theta}_1(t) = \int_{t_0}^t e^{-r(s-t_0)} v'(s-t_0) dGs \quad (56)$$

where  $\tilde{\theta}_1(t) = F^{-1}(\tilde{\pi}(t))$ . Figure 15 illustrates citizens' best reply function.



**Figure 15.** Citizens' exit is determined by  $\tilde{\pi}_t = F(\tilde{\theta}_1(t)) \forall t \in [\tau_0, \infty)$ . A citizen with opportunity cost  $\theta = \tilde{\theta}_1(t)$  exits at  $t$ , and given this exit time, equation 56 defines the entry time  $t_0(t)$ .

*Step 2: Define Government's Best Response*  $\Gamma : \mathcal{C} \times [0, T] \rightarrow \mathcal{S}$ . In equilibrium, given citizens' best reply  $t_0 \in \mathcal{C}$  and the delay time  $\tau_0$ , the government chooses a distribution of concessions over  $[\tau_0, \infty)$ , i.e.  $G : [\tau_0, \infty) \rightarrow [0, 1]$  such that:

$$G(t) = 1 - (1 - G(\tau_0)) \exp \left( - \int_{\tau_0}^t \lambda_s ds \right) \quad (57)$$

with  $G(\tau_0) = \frac{\tilde{\theta}_1(\tau_0)}{v'(0)}$ , and  $\lambda_t = \frac{\tilde{\theta}_1(t)}{v(t-t_0(t))}$ .

*Step 3: Fictitious Player Best Response.* The fictitious player best response  $\Theta : \mathcal{C} \times \mathcal{S} \rightarrow [0, T]$  chooses a time  $\tau_0 \in [0, T]$ , that solves

$$\underline{\theta} = \int_{\tau_0}^{\infty} e^{-rs} v'(s) dG(s) \quad (58)$$

*Step 4:  $\mathbf{Z}$  is a non-empty, convex and compact subset of a locally convex Hausdorff space.*

Let  $T$  be the time at which  $\underline{\theta} = e^{-rT} v'(T)$ . This upper bound corresponds to the time that makes the lowest opportunity cost citizen indifferent of entry even if the government concedes for sure, which satisfies  $T > \bar{\tau}$ . Thus,  $[0, T]$  is well defined, and it is compact and convex.

For the space of government's distribution of concession, since both  $G(\tau_0)$  and  $\lambda_t$  are continuous and well defined, it is non-empty. Moreover, note that the function  $G$  constrained to  $[\tau, \infty)$  is continuous and bounded. Moreover, they are monotone by Proposition 1, and have bounded variation. By Helly's selection theorem, it is also compact.

Similarly, note that for citizens  $t_0$  is a monotone continuous function with values in  $[0, \tau_0)$ , and then it has bounded variation. Moreover, it is uniformly bounded, and then we can apply Helly's selection theorem to obtain compactness. To see that it is non-empty, fix  $t$ , and note that  $t_0(t)$  solves the following equation:

$$\tilde{\theta}_1(t) = \int_{t_0}^t e^{-r(s-t_0)} v'(s - t_0) dGs \quad (59)$$

which has always a unique solution for every  $t \in [\tau, \infty]$ .

Finally, by Tychoff Product Theorem (see [Aliprantis & Border \(2013\)](#), Theorem 2.61), the space  $\mathbf{Z}$  is compact in the product topology.

*Step 5:  $\Psi$  has closed graph.* Take a sequence  $(t_0^n, G^n, \tau^n) \in \text{Graph}(\Psi)$  such that  $(t_0^n, G^n, \tau^n) \rightarrow (\bar{t}_0, \bar{G}, \bar{\tau}_0)$ . We want to show  $(\bar{t}_0, \bar{G}, \bar{\tau}_0) \in \text{Graph}(\Psi)$ .

**Claim 1.**  $\Gamma$  has closed graph. We show that for any sequence  $(\tau_0^n, G^n, t_0^n) \rightarrow (\bar{\tau}_0, \bar{G}, \bar{t}_0)$ , with  $(\tau_0^n, G^n) \in \Gamma(t_0^n)$  for all  $n$ , then  $(\bar{\tau}_0, \bar{G}) \in \Gamma(\bar{t}_0)$ .

Note that by continuity of  $\tilde{\theta}_1(t)$ ,  $G^n(\tau_0^n) \rightarrow \bar{G}(\bar{\tau}_0)$ .

Moreover, by continuity of  $v$  and  $F^{-1}$  the hazard rate  $\lambda_n(t)$  converges uniformly to:

$$\bar{\lambda}(t) = \frac{F^{-1}(\tilde{\pi}(t))\epsilon}{v(t - \bar{t}_0(t))} \quad (60)$$

which proves the graph is closed.

**Claim 2.**  $\Phi$  has closed graph. We show that for any sequence  $(\tau_0^n, G^n, t_0^n) \rightarrow (\bar{\tau}_0, \bar{G}, \bar{t}_0)$ , with  $t_0^n \in \Phi(\tau_0^n, G^n)$  for all  $n$ , then  $\bar{t}_0 \in \Phi(\bar{\tau}_0, \bar{G})$ .

Rewrite  $t_0$  as the solution to a fixed point problem to the following equation:

$$H(t_0; G, \tau_0) = \frac{1}{r} \left[ \ln F^{-1}(\tilde{\pi}(t)) - \ln \left( \int_{t_0}^t e^{-rs} v'(s - t_0(t)) dG(s) \right) \right] \quad (61)$$

Thus, it is enough to prove that  $\|\bar{t}_0 - H(\bar{t}_0)\| = 0$ . Note that:

$$\|\bar{t}_0 - H(\bar{t}_0; \bar{G}, \bar{\tau})\| \leq \|\bar{t}_0 - t_0^n\| + \|t_0^n - H(t_0^n)\| + \|H(t_0^n; G^n, \tau^n) - H(\bar{t}_0; \bar{G}, \bar{\tau})\| \quad (62)$$

the first two terms in the right-hand side converge to 0 by hypothesis. The third one also converges pointwise to 0 as  $\int_{t_0^n}^t e^{-rs} v'(t - t_0^n(t)) dG^n(s) \rightarrow \int_{\bar{t}_0}^t e^{-rs} v'(t - \bar{t}_0(t)) d\bar{G}(s)$  for all  $t$ .

Claim 3.  $\Theta$  has closed graph. We show that for any sequence  $(\tau_0^n, G^n, t_0^n) \rightarrow (\bar{\tau}_0, \bar{G}, \bar{t}_0)$ , with  $(\tau_0^n) \in \Theta(t_0^n, G^n)$  for all  $n$ , then  $(\bar{\tau}_0) \in \Gamma(\bar{t}_0, \bar{G})$ . Note that  $G^n$  converges to  $\bar{G}$  in distribution, and then applying Continuous Mapping Theorem we obtain

$$\int_{\tau_0^n}^{\infty} e^{-rs} v'(s) dG^n(s) \rightarrow \int_{\bar{\tau}_0}^{\infty} e^{-rs} v'(s) d\bar{G}(s) \quad (63)$$

Then, using claims 1, 2 and 3, we have that  $\Psi$  has closed-graph, and therefore is upper-hemicontinuous. By Kakutani-Fan-Glicksberg theorem it has a fixed point.  $\square$

**Lemma 7.** Let  $(G^1, (\pi_t^1)_{t \geq 0})$  and  $(G^2, (\pi_t^2)_{t \geq 0})$  be two distinct equilibria with delays  $\tau_0^1, \tau_0^2$ , such that  $\tau_0^1 < \tau_0^2$ . Then, the distributions of concessions  $G^1, G^2$  do not cross at any  $t \in [\tau_1, \infty]$ .

*Proof.* From agents entry condition, we have

$$\frac{\partial \tilde{\theta}_0(t)}{\partial \tau_0} = -e^{-r(\tau_0-t)} v'(\tau_0-t) g(\tau) + \int_t^{\tau_1(t)} e^{-r(s-t)} v'(\tau_0-t) g'(\tau_0) ds < 0 \quad (64)$$

Given that this holds for all  $t \in [0, \tau_0)$ , we have that the functions  $t_0(t)$  do not cross, and this ensures the hazard rates do not cross, and then the distributions of concessions do not cross either.  $\square$

We are now in a place to show that any  $\tau_0 \in [\underline{\tau}, \bar{\tau}]$  generates an equilibrium. Fix an arbitrary  $\tau^* \in (\underline{\tau}, \bar{\tau})$  and let  $(G, (\pi_t)_{t \geq 0})$  be the equilibrium consistent with it. We know from lemma 7 that

$$\underline{\theta} < \int_{\bar{\tau}}^{\infty} e^{-rs} v'(s) dG(s) \quad (65)$$

and  $G(\tau) < 1$ . Then we can solve the same fixed point problem we solved in the previous claim fixing the fictitious player strategy to choosing  $\tau^*$ . Using the same arguments, a fixed point exists. As  $\tau^*$  was arbitrary, this completes the proof of the theorem.  $\square$

**A.4. Proof of Proposition 1.** Recall that for any distribution of opportunity costs  $F_j$ , the lower bound  $\underline{\tau}_j$  is given by the equilibrium in which the government concedes with probability 1, and then it is such that

$$\tilde{\pi}_{\underline{\tau}_j} = F_j(v'(0)) \quad (66)$$

Then, statement (i) follows from the fact that  $F_1$  first order stochastically dominates  $F_2$ , and then  $F_1(v'(0)) < F_2(v'(0))$ .

To prove statements (ii) and (iii), note that as  $F_1$  is symmetric and unimodal and  $F_2$  is obtained from a mean preserving spread, then  $F_2(\theta) < F_1(\theta)$  for every  $\theta < \int \theta dF_1(\theta)$ , and  $F_2(\theta) > F_1(\theta)$  otherwise.

## B. Empirical Appendix

**Table 9.** Description of Main Variables

Variable	Description
$\Delta\text{HOME}$	Variation in the number of people at home, between April 24 - May 24, 2020, and April 26 - May 26, 2019.
RESIDENTIAL	Average Google Mobility Index, week prior to May 25, 2020.
MIN TEMP	Average Minimum Temperature, May 11 - May 17, 2020.
MAX TEMP	Average Minimum Temperature, May 11 - May 17, 2020.
PRECIPITATION	Average Minimum Temperature, May 11 - May 17, 2020.
CLINTON	Share of votes for Clinton, as a total of votes.
LABOR	Labor Force over Total Population
POPULATION (LOG)	Population (Log)
DENSITY (LOG)	Population by Squared Mile (log)
INCOME (10K)	Median Household Income (10k)
RURAL	Share of population living in rural areas
BLACK	Black Population (Share)
UNDER 29	Population under 29 years old
LESS COLLEGE	Population with less than college degree

**Table 10.** Robustness: Entry, Duration and People Staying Home

Dependent Variable:	$\text{ENTRY}_j(p)$				$\text{EXIT}_j(p)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Threshold $p$ :	0.001%	0.005%	0.01%	0.02%	0.001%	0.005%	0.01%	0.02%
Panel (a) 2SLS (Full Set of Instruments)								
$\Delta\text{HOME}$	-8.100*** (2.630)	-5.403** (2.425)	-3.817 (2.333)	-3.985 (2.462)	3.658*** (1.195)	3.600*** (1.182)	3.198*** (1.155)	2.277* (1.256)
Panel (b) LIML (Full Set of Instruments)								
$\Delta\text{HOME}$	-8.606*** (2.867)	-6.553** (2.598)	-4.782** (2.440)	-5.209* (2.670)	5.551*** (1.724)	5.618*** (1.661)	5.220*** (1.623)	4.103** (2.059)
Panel (c) IV (Just-identified)								
$\Delta\text{HOME}$	-10.95*** (3.376)	-7.877*** (2.957)	-5.961** (2.887)	-3.446 (2.825)	6.667*** (2.112)	6.352*** (2.013)	6.138*** (2.072)	1.691 (2.079)
State FE	X	X	X	X	X	X	X	X
Observations	1084	1052	992	864	1084	1052	992	864

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows 2SLS regression for different thresholds using all instruments, Panel (b) shows the LIML estimates with the all instruments, and Panel (c) shows the 2SLS regression using a single instrument MIN TEMP.

### B.1. Robustness.

**Table 11.** Robustness: Entry and Exit with Controls (IV,  $p = 0.001\%$ )

Dependent Variable:	ENTRY <sub>j</sub> ( $p$ )				EXIT <sub>j</sub> ( $p$ )			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta$ HOME	-6.940*** (2.344)	-6.452*** (2.277)	-5.087** (2.172)	-5.636** (2.665)	3.446*** (1.178)	3.254*** (1.152)	3.014*** (1.159)	3.231** (1.390)
BLACK		-0.016*** (0.003)				0.008*** (0.001)		
29 AND YOUNGER			-0.042*** (0.004)				0.010*** (0.002)	
65 AND OLDER				0.035*** (0.013)				-0.006 (0.007)
State FE	X	X	X	X	X	X	X	X
Observations	1029	1029	1029	1029	1029	1029	1029	1029

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: IV regression using MIN TEMP and PRECIP as instruments.

**Table 12.** Robustness: Entry, Duration and People Staying Home

Dependent Variable:	ENTRY <sub>j</sub> ( $p$ )				EXIT <sub>j</sub> ( $p$ )			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Threshold $p$ :	0.001%	0.005%	0.01%	0.02%	0.001%	0.005%	0.01%	0.02%
Panel (a) 2SLS (Full Set of Instruments)								
RESIDENTIAL	-0.082** (0.034)	-0.062* (0.034)	-0.0454 (0.033)	-0.063* (0.033)	0.031* (0.018)	0.041** (0.018)	0.028 (0.017)	0.011 (0.017)
Panel (b) LIML (Full Set of Instruments)								
RESIDENTIAL	-0.088** (0.035)	-0.052 (0.033)	-0.040 (0.033)	-0.055 (0.033)	0.037** (0.018)	0.042** (0.018)	0.033* (0.017)	0.016 (0.018)
Panel (c) IV (Just-identified)								
RESIDENTIAL	-0.132*** (0.048)	-0.089* (0.045)	-0.058 (0.044)	-0.023 (0.042)	0.066* (0.033)	0.073** (0.032)	0.053* (0.032)	-0.009 (0.036)
State FE	X	X	X	X	X	X	X	X
Observations	1084	1052	992	864	1084	1052	992	864

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows 2SLS regression for different thresholds using all instruments, Panel (b) shows the LIML estimates with the all instruments, and Panel (c) shows the 2SLS regression using a single instrument MIN TEMP.

**B.2. Time Flexibility using Google's Mobility Reports.** In this section, I replicate the analysis using Google's *Community Mobility Reports* to measure people's behavior before the start of the protest. These reports document movement of people to different types of locations, such as parks, grocery stores, and residences. I focus on the *Residence Mobility Index*, which reports the percent variation of movements around places of living with respect to the five-week period between January 3 and February 6, 2020. By a similar argument than that of

the previous section, I argue that a higher share of people at their residences, is consistent with them having more time flexibility, and then lower opportunity costs. Then, one would expect that a higher residential index would be consistent with people entering earlier, and staying longer in the protest.

Tables 13 shows the results for entry and exit, and 14 show the results for duration. The variable RESIDENTIAL corresponds to the average of the Residence Mobility Index the week before the start of the protests. The results are consistent with the predictions and those in the previous section. An increase in the residential index is consistent with earlier entry and later exit, although some of the coefficients are statistically insignificant.

In addition, the tables report the F statistics from the first stage. In all of them it is slightly below 10, which could indicate that the instruments are weak. In Table 12 in the Appendix I show robustness results using estimation by LIML, and a just-identified specification (Panels (b) and (c), respectively). Analogous to the case analyze in the previous section, the coefficients seem to remain mostly stable.

**Table 13.** Entry, Exit and Residential Mobility Index

Dependent Variable:	ENTRY( $p$ )				EXIT( $p$ )			
Threshold $p$ :	(1) 0.001%	(2) 0.005%	(3) 0.01%	(4) 0.02%	(5) 0.001%	(6) 0.005%	(7) 0.01%	(8) 0.02%
Panel (a) OLS								
RESIDENTIAL	-0.059*** (0.007)	-0.050*** (0.007)	-0.045*** (0.008)	-0.044*** (0.008)	0.041*** (0.004)	0.030*** (0.004)	0.027*** (0.004)	0.019*** (0.004)
Panel (b) IV								
RESIDENTIAL	-0.087** (0.034)	-0.052 (0.033)	-0.040 (0.032)	-0.055* (0.033)	0.038** (0.018)	0.042** (0.017)	0.033* (0.017)	0.016 (0.017)
State FE	X	X	X	X	X	X	X	X
Observations	921	889	833	718	921	889	833	718
First-Stage F	9.75	9.14	9.03	8.46	9.75	9.14	9.03	8.46

Standard errors in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows OLS regression for different thresholds, and Panel (b) shows the IV regression using weather instruments (MIN TEMP, RAINFALL).



**Table 14.** Duration and Residential Mobility Index

Dependent Variable:	DURATION( $p$ )			
Threshold $p$ :	(1) 0.001%	(2) 0.005%	(3) 0.01%	(4) 0.02%
Panel (a) OLS				
RESIDENTIAL	0.064*** (0.005)	0.053*** (0.005)	0.048*** (0.006)	0.039*** (0.007)
Panel (b) IV				
RESIDENTIAL	0.068*** (0.024)	0.063*** (0.023)	0.053** (0.023)	0.033 (0.027)
State FE	X	X	X	X
Observations	921	889	833	718
First-Stage F	9.75	9.14	9.03	8.46

SE in parentheses; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Note: Panel (a) shows OLS regression for different thresholds, and Panel (b) shows the IV regression using weather instruments (MIN TEMP, RAINFALL).

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