

Persistent Protests

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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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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.¹ 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

¹There 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.² 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. Higher income levels, related to larger opportunity costs of participation in protests, are connected to later entry times and earlier exit times. The

²To 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.

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.

Using variations in the incidence of COVID-19, I capture the idea of opportunity costs through two components. First, I exploit variation in the extent of reopening by county, and measures of job flexibility by county. As for the latter, I use [Dingel & Neiman \(2020\)](#)'s recent notion of *teleworkability* to obtain the share of workers in *flexible* jobs.³ The idea of teleworkability measures how easy it is to do a job from home. I find that more flexibility is consistent with earlier entry times for those counties which had already reopened when the protests started nationwide. In a second approach, I use Google's Community Mobility Reports to capture people's time flexibility. To address the possibility of omitted variable bias, I follow an instrumental variables strategy, using data on weather and the incidence of COVID-19 as instruments. I obtain that people spending more time at their residences is consistent with earlier entry, and later exit.

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

I contribute to the literature on persistent participation in public protests as a collective action problem. The literature most closed to this work is the one 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 \(2018\)](#).

The main contribution of this paper to the literature is to provide a full characterization of the dynamics of participation in equilibrium. The dynamics I obtain are intuitive, but novel at the same time. A paper related to mine is the recent study by [Chenoweth & Belgioioso \(2019\)](#). As my paper, their work focuses on dynamics of participation instead of a static one-shot measure of the size of a protest. The authors propose to approximate 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.

³As I explain in more detail later, I closely follow the methodology proposed by [Glaeser et al. \(2020\)](#). They study how effective restrictions on mobility are in limiting the spread of COVID-19, and use [Dingel & Neiman \(2020\)](#)'s teleworkability shares to construct an instrument for the level of mobility.

They show empirical evidence of similar dynamics to the build-up stage in my framework. Moreover, their idea of momentum is based in the principle that social movements can compensate for low popular support by concentrating their activities in time. As I show in Section 4.2, in this dynamic model there is a similar trade-off, but it occurs between delay in the time at which the government starts conceding, and participation.⁴

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.

This work is also related to the literature on the social psychology of public protests. In this literature, intrinsic motives for participation have been studied as a result of ideology or group identity (see [Cohen \(1985\)](#) and [Jasper \(1998\)](#)). Our assumption of a *veteran prize* constitutes a new explanation for persistent participation in protests that combines both an *intrinsic* motivation, i.e. the veteran reward, with an *instrumental* motivation: agents obtain this value only if the movement is successful, so that they take into account their expectations about the government conceding.⁵ Intrinsic motives to protest coming from emotions have also been studied by [Passarelli & Tabellini \(2017\)](#), who study a game in which agents react to anger (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 inequality, and the main idea is that inequality affects both grievances and opportunity costs (see [Dal Bó & Dal Bó \(2011\)](#) and [Dube & Vargas \(2013\)](#)). Although protests can be seen as 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).

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 large player and a continuum of citizens. The seminal work of

⁴In particular, I show that among the set of equilibria, there is an inverse relation between the peak in participation, and the time at which the government makes the first probabilistic concession.

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

[Hendricks et al. \(1988\)](#) solves 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 dropouts 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 firms competing for a set of prizes. More recently, [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 with the setup analyzed here.

Finally, this work also contributes to the recent literature studying the effects of COVID-19. I provide preliminary evidence for the effect of workers flexibility during the pandemic, over citizens decisions on the timing of protests. I follow the approach proposed by [Glaeser et al. \(2020\)](#), and use [Dingel & Neiman \(2020\)](#)'s notion of teleworkability of an occupation, to obtain a measure of job flexibility. I then explore how this flexibility affects the timing of protests at the county level.

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 θ . I assume 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 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, staring 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 in both 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 π_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 π , 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 τ , 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, citizens can enjoy it even if they were not involved in the protest. If the government concedes at a time τ , 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 is only made available if the citizen is still in the protest by the time the government concedes. We 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 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 the government concedes at some time τ , possibly random. Consider a citizen with opportunity cost θ 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 τ . In words, the citizen will pay the cost of the protest for as long as she remains being 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 to protest or not, they only observe participation until *an instant before* they join. To help grasping better 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 to concede or not. Thus, when citizens choose their actions, they only observe 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 π_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 θ 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 (σ, γ) , where $\sigma = \{\sigma^\theta\}_{\theta \in [\underline{\theta}, \bar{\theta}]}$.

For any strategy profile (σ, γ) , let $\pi^{\sigma t}$ be the trajectory up to time t , conditional on no concession, generated by the strategy σ . 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 government's strategies along the equilibrium path. This is equivalent to focusing government strategies that are *open-loop*, in the sense that it is as if it commits to a sequence of actions at the beginning of the game. The idea of these strategies, is that players do not have to consider how their opponents would react to deviations from the equilibrium path.⁶

We allow the government to randomize over concession times. As we focus on the trajectory of participation the government expects in equilibrium, we can characterize its strategy as a mixed strategy: a distribution of concessions $G(t)$.⁷ This distribution of government's concession 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:

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

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 to 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 σ , such that given the outcome path $\{\pi_t^\sigma\}_{t \geq 0}$,

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

⁶[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.

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

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 can be enjoyed by all citizens, irrespective of their participation or merits 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 [Wood & Jean \(2003\)](#) and [Pearlman \(2018\)](#). I follow the second line.

In the context of protests, several studies recognized the relevance of group-based emotions and intrinsic psychological motivations for citizens to participate.⁸ The literature on 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; and (iv) *Ideology*, related to individual values and the perception of an illegitimate state of affairs. The latter three motives (namely, Identity, Emotions, and Ideology) operate through generating an inner obligation to contribute that prevents free riding.⁹ However, as it is shown by [Simon et al. \(1998\)](#), 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 merits in an eventual victory against the government, but they only obtain this rewarding feeling if they attain the goal. The necessity of goal attainment to obtain the reward captures the instrumental component, whereas the necessity of merits captures the intrinsic component. As the protest in this case needs persistence to be successful, merits are 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 only get their veteran prize if they are actively participating at the time the government concedes. It might be natural, however, for citizens who make a relevant contribution to build-up the protest, to obtain some rewards 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

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

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

prize even if they retire before concession, provided that a part of the prize is only obtained by staying until government concession. If this wasn'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 to concede.

3.2.3. Cumulative Nature of the Veteran Prize. I formulated the model in 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 that contributes by protesting every weekend does not need to feel less veteran than a citizen that condense the same participation in 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 that differentiate the weekend-protester from the one that protest seven days a week that are not included in this model. For instance, some cyclical or non monotonic variation of the opportunity costs might make the weekdays being more costly than weekends, but that possibility is not considered here.¹⁰

4. The Dynamics of Protests

4.1. Equilibrium Characterization. In this section, I fully characterize the set of equilibria in which a protest occurs. We 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 $\pi_t^\sigma = 0$ 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 multiplicity of equilibria in this game. But what makes the results remarkable is that every equilibrium with protest has the same qualitative features. As I show in Theorem 1, 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 then the government does not make any concession. 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

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

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

- (i) *There is always delay in government concession, i.e. $\tau_0 > 0$.*
- (ii) *π_t^σ 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 τ_0 .*
- (iv) *If $G(\tau_0) < 1$, then $G(t)$ is strictly increasing and continuous, and $\tau_1 = \infty$.*
- (v) *In equilibrium, the government concedes with probability 1, i.e. $\lim_{t \rightarrow \infty} G(t) = 1$.*

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 interval of time and resumes concession later on, citizens who are already in the protest would 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, then it must be that along the support, the following indifference condition holds:¹¹

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

This indifference condition imposes a constraint to the number of people protesting 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, we also conclude that it must be that the interval must go all the way to infinity, i.e. $\tau_1 = \infty$. This result follows from government's incentives to

¹¹See Lemma 3 in Section A.

randomize: it must be that at any time, the government is indifferent between conceding and waiting another instant. If the interval was finite, then there is a time at which the government is no indifferent anymore, and the equilibrium would unravel.

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

Consider the problem of a citizen with opportunity cost θ , who enters at t_0 and exits at t_1 . Since the government makes the first probabilistic concession at time τ_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 θ . However, the gains are given by the marginal increase in the veteran prize the agent might obtain during the time she remains in the protest. Then, an agent with opportunity cost θ 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 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 to leave. In equilibrium, both thresholds coincide at τ_0 , generating a continuous trajectory of participation which 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:

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

This 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 at 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 we have shown that any equilibrium with protests can be parametrized by a time τ_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 τ_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 is conceding 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, θ . 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.¹² Given that entry is monotone in θ , 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 increase, the payoff from entering at 0 decrease as well. 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 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 bound 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 we obtain the following existence result.

Theorem 2. *For every $\tau_0 \in [\underline{\tau}, \bar{\tau}]$, there exists a unique equilibrium $(G, (\pi_t^\sigma)_{t \geq 0})$ where the government concedes for the first time at τ_0 .*

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

To prove this result, we 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 latter follows from a fixed point argument that I explain below.

I define a modified problem, in which the peak time τ_0 is chosen by a fictitious player, and is given to both the citizens and the government. Suppose time τ_0 is given. Recall that in

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

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 θ exits at the time t at which $F(\theta) = \tilde{\pi}_t$. Then, their best reply is a sequence of entry times given the government distribution of concessions, and given their exit times.

The government in turn, given these entry times, for any $t \geq \tau_0$ 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). To close things up, we introduce the fictitious player whose only role is to adjust τ_0 for equation 12 to be satisfied with equality, given the government's best reply. This also allows us to get rid of discontinuities of the government strategy at τ_0 , and then we 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.

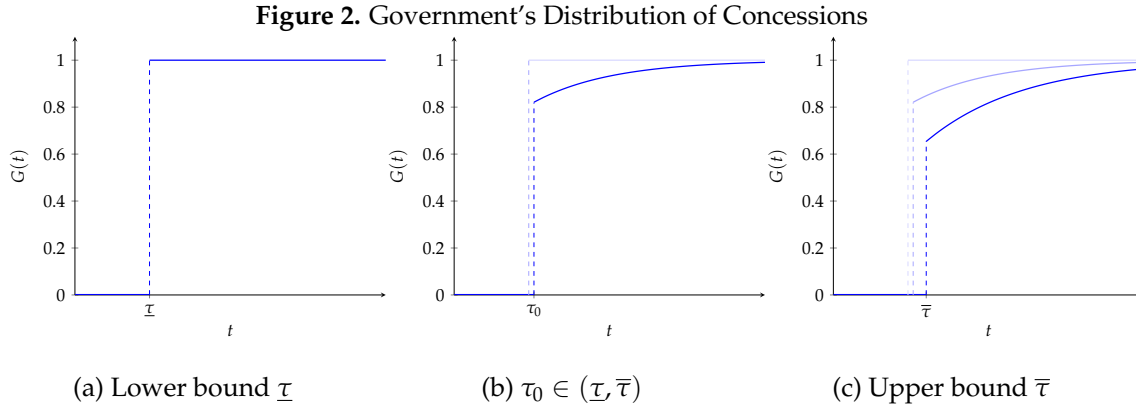
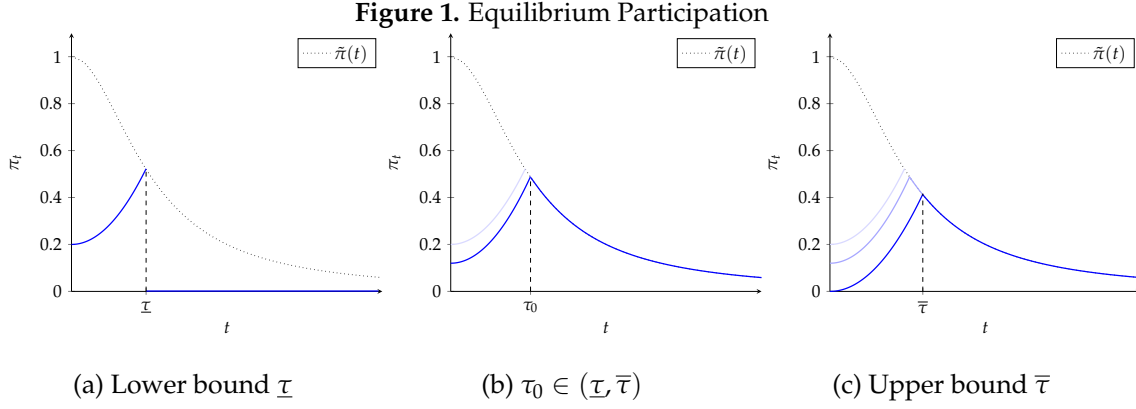
Figures 1 and 2 illustrate the continuum of equilibria. In both figures, Panel (a) shows the equilibrium with the shortest delay, $\underline{\tau}$; Panel (b) shows an equilibrium with an intermediate delay, $\tau_0 \in (\underline{\tau}, \bar{\tau})$; and Panel (c) shows an equilibrium with the maximum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

The three panels in Figure 1 illustrate the trajectory of participation for the three delays. The decreasing dotted line, $\tilde{\pi}_t$, corresponds to the indifference participation level. For any participation level π_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 τ_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. As in this stage participation 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.

Now let's move to panel (b), with $\tau_0 \in (\underline{\tau}, \bar{\tau})$. 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 we increase delay (moving to panels (b) and (c)) participation decreases for every t on 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. The existence of multiple equilibria is a natural feature of this model. As it has been recognized in the literature, the spontaneous nature of mass uprisings gives them the features of a coordination problem which 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 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 for why a society focal point centers on one particular equilibrium, such as social norm, 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 we observe 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, we 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 smaller 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, π_{τ_0} , is inversely related with the delay in reaching the peak, τ_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 it requires a very high participation peak. But it could also have a slow trend upwards, in which case the participation peak is 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 derive into an over-estimation of the critical mass required for a protest to be successful.¹³

There is also a second observation that can be highlighted respect to the set of equilibria. In the same way as 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, τ_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 it is the first event of a social movement respect to

¹³This is in line with the intuition developed recently by [Chenoweth & Belgioioso \(2019\)](#), who propose that protests 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).

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 be also enough to characterize the expected duration until government concession.

5.2. Expected Duration across Equilibria. We would like to know in this setting how do different equilibria relate to each other in terms of welfare. In order to assess this, we 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 τ_0 . Putting this together with Corollary 2, we obtain the following.

Corollary 3. *The expected duration of protests increases with τ_0 , and decreases with π_0 .*

This property follows from the fact that the distributions of government concessions do not cross. Then, the probability of survival of a protests is monotone in τ_0 for any $t > \tau_0$. The same holds if we parametrize equilibria by initial participation. This result is intuitive, as 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 highest initial participation. Moreover, from agents optimality condition, we learn that when the protest starts, on 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 non trivial 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, on the other side, 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 so that the protest is less costly than concession. As in this stage government is strictly better off with the protest than with concession, 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 equilibrium set. An increase in citizens' opportunity costs has two effects. On one side, it has a direct effect over agents' entry decision, as a citizen with higher opportunity cost will want to wait for the marginal value of entry to increase. On the other side, it has an indirect effect over the government's best reply. In particular, as the opportunity cost of a citizen increases, the hazard rate that is required to make her drop out also increases. This is as if citizens with higher opportunity costs were 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 we 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. We 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 results above follows 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 amount 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 $\theta \in [\underline{\theta}, \bar{\theta}]$, and the following result holds.

Proposition 2. *Suppose that citizens opportunity costs increase by the same proportion α , 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 then they alleviate the cost burden of the protest. As an example, suppose protesters' demand is a stimulus package to provide economic assistance. Instead of providing the entire package, the government might decide to offer it but in a smaller amount to what protesters demand. This concession might be enough for some agents, who then choose to leave the protest, whereas others continue protesting to exert pressure for 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 the government can concede a fraction of the public good. Conceding a fraction α of the public good has a cost αq , where q is the cost of the entire public good. Every time the government concedes a fraction α of the public good, agents receive a flow utility $\alpha v(t - t_0)$, corresponding to their veteran payoff. Other than this, citizens' and 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, we 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 public good that the government provides at time t . We also denote by $H(t)$ the share of 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 θ 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, we obtain analogous characterization results as 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) π_t^σ 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 τ_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 for citizens to obtain rewards from their merits in the protest even if they do not remain protesting until the government concedes.

Suppose that if an agent leaves before the government concedes, instead of throwing away the time invested in the protest, 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 τ for the government, the expected payoff of a citizen with opportunity cost θ 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 τ . 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 θ . The right hand side is the expected benefit, which is now a convex combination of the

payoff the agent gets by purely staying in the protest, and the payoff the agent gets once the government concedes. The payoff from purely being in the protest decreases over time, as the marginal returns from merits is decreasing.

As for the entry condition, the citizen with opportunity cost θ 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 entry, the citizen not only takes into account the marginal increase in future payoffs in which she will be there once 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 was higher than in the baseline model. Now not only the toughest veterans enjoy the victory, but even small contributions to the revolution are rewarded if the protest succeeds.

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

6.3. Unsuccessful Protests. In our 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 with protests that end before the government concedes, we need to be very precise in the definition of the *ending* of a protest. This is crucial to understand how to associate our main equilibrium results with empirical observations about protests failure. However, identifying the ending 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 sufficiently large, so that the movement becomes small, but still some fraction of the population remains participating. My model can perfectly accommodate these situations. To see this, note that our “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 eventually concedes. Then, many persistent protests that we interpret as failures, might be part of an equilibrium on a late decay stage, in which still the probability of future government’s concession is, although small, positive.

Another possibility, is to understand the end of a protest as 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 keep going, and then eventually concession will occur.

[Klandermans & van Stekelenburg \(2013\)](#) study people disengagement from social movements as the result of two possible effects, i.e. *insufficient gratification* and *declining commitment*, that 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 this 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 precipitate agents exit.

Suppose 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 was smaller than in the baseline case. The exit decision for an agent with opportunity cost θ is now given by the following expression:

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

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

We 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 we have characterized agents opportunity cost of the time spent in the protest by a parameter θ . This parameter captures the utility that agents give up by spending time in the protest instead of spending that time on other activities. In general, those other activities are often related to productive activities, and then the opportunity cost can be associated to labor income.

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

Suppose now agents have heterogeneous income, ω . Let ϵ be the fraction of time an agent spends in the protest (i.e. if the agent works 8 hours each day, and the demonstration lasts one hour, then $\epsilon = 1/8$). In addition, suppose 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 then she can only afford to join a protest 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 be 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 σ . If $\sigma < 1$, then the marginal utility of income is increasing, which implies that for citizens with higher income the hour spent in the demonstration is more costly than for citizens with lower income. In the extreme case with $\sigma = 0$, utility is linear and then $\theta = \epsilon\omega$. 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 incentives to delay their entry compared to those with lower income.¹⁴

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 with education and the type of industries under

¹⁴In Section 7 I explore these predictions for the case of *Black Lives Matter* protests.

analysis. Moreover, income might affect other components in the propensity of an agent to protest that might not be related with opportunity costs. Education, for instance, is key in how knowledgeable about the political environment citizens are. This implies that when comparing citizens with different income levels we need to also take into account the effect of their income over education levels.

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 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 citizens only value the veteran prize 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 (τ_0, ∞) .

Any citizen with opportunity cost θ solves the exact 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 re-scaling of the original problem, and is given by $\pi_t = p \cdot F(\tilde{\theta}_0(t))$. Then, both Theorem 1 and Theorem 2 hold in this framework.

I highlight some of the main features that differentiate this case with respect to 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 has to 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.¹⁵ The upper bound it

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

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 $G(\tau_0) < G_p(\tau_0)$.

The main idea of these differences, is that now the universe of citizens is smaller, as not all of them are willing to enter the protest. However, conditional on reaching some participation level, it has to be that the ones 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.

Reputation concerns in this model arise when there is some information about agents that is private. The attrition nature of the game makes behavioral types a la [Abreu & Gul \(2000\)](#) a natural candidate for refinement. Introducing a probability of the government being a behavioral type who never concedes, and a probability of citizens being some type who will protest forever, will pin down a unique equilibrium. The only issue with this refinement is that, depending on the parametrization, in our framework 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 in general is about the strength of the regime (although it might as well 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 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 a share of the population high enough joins the protest at the beginning. If all citizens are better off with this outcome, we would expect no coalitions blocking that equilibrium, and then 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 make 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 our model, a leader could 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. Preliminary Empirical Evidence

The equilibrium characterization developed in this paper provides us with some testable empirical predictions. First, participation is hump-shaped. We should always observe, at least, 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 over time. Second, government concessions occur after the peak, they are more likely to happen at the peak, and after it, the likelihood of concession decreases over time. And third, citizens entry and exit decisions are monotonic in opportunity cost: citizens with higher opportunity costs enter later and stay a shorter time in the protest.

The *Black Lives Matter* protests occur as a reaction to a long history of discrimination and mistreatment of black and African-American citizens. The complexity of this problem is, of

course, impossible to capture with a theoretical model. The multiple dimensions in which racial discrimination has affected black and African-Americans imply that people's demands and the policies required to make a change are far from uni-dimensional. However, this analysis does not aim to explain the motives for people's outrage nor the grievances behind their decisions to demonstrate. Far from that, I will focus on some specific features of these protests, and provide preliminary evidence that map the empirical predictions of the model.

There are many reasons why I focus on this movement. First, note that this movement gathers the support of a broad sector of the population. Although we have seen events of violence occurring more recently, most protests were pacific 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.

7.1. Data. To measure participation, 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.¹⁶ The unit of analysis is a specific demonstration, and captures the time, location, and participants, as well as other information.

To analyze entry times, I use events occurring between May 26, and June 30 2020. There is a record of 7,707 events across the US in favor of the civil rights movement on the period of analysis.¹⁷

For one of the main measures of opportunity costs, I use [Dingel & Neiman \(2020\)](#)'s teleworkability shares by 2-digit NAICS. In order to construct the measure, I combine their estimation of the feasibility of doing telework for each occupation, with county-level employment data from the Quarterly Census of Employment and Wages, from the Bureau of Labor Statistics.

For a second measure of opportunity cost, I 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

¹⁶The CCC data can be found here: [CCC Website](#). This data also includes data from the CountLove.org initiative, which can be found here: [CountLove Website](#) which gathers events and participation records from media sources.

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

National Oceanic and Atmospheric Administration.¹⁸ For Covid-19, I use data on new cases by county from USAFacts.org. Finally, I include 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 contrast, in the model 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.

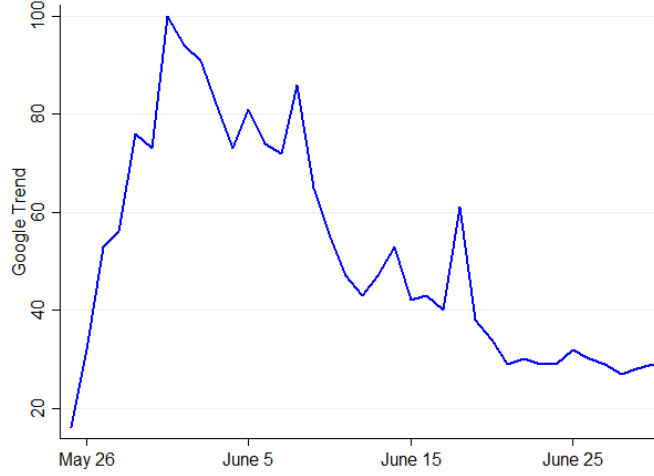
7.2.1. Government and Concessions. I focus on people’s demands related to police system reforms. There are many levels in which these demands can be fulfilled, from reforms to police conduct, to a complete police defunding. In the model with partial concessions, a policy targeted to *Defund the Police* 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 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. To map individual decisions to aggregate data, I first map each event to a county to obtain an aggregate measure of daily participation at the county level. With this, I can map participation to citizens’ characteristics.

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 μ_j to be the mass of citizens living at 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 the sum of an aggregate

¹⁸Global Historical Climate Network includes daily land surface observations for the US. The station dataset includes max 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.

component θ_j , which is common to all citizens living at county j , and an idiosyncratic component that we do not observe, ϵ_i . I assume this unobserved component is *iid* across the population.

Given that citizens' entry decisions are monotone in opportunity cost, for any time t there exists an entry threshold $\tilde{\theta}_0(t)$ such that a citizen protests if $\theta_i \leq \tilde{\theta}_0(t)$, and waits otherwise. Thus, participation at county j is given by:

$$\pi_{j,t} = P(\theta_j + \epsilon_i < \tilde{\theta}_0(t)) \cdot \mu_j \quad (23)$$

This is, the size of the county times the probability of participation.

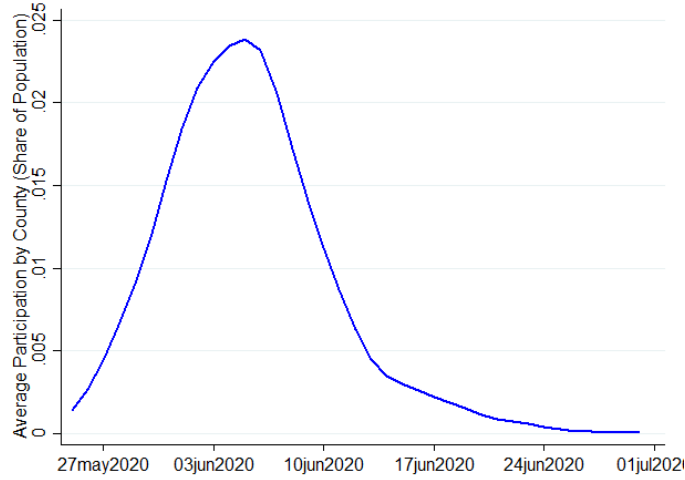
Let $\bar{\pi}_{j,t} = \frac{\pi_{j,t}}{\mu_j}$ be the adjusted participation level at time t in county j . This participation level corresponds to the percentage of the county population that is protesting at time t . As is natural, this is a small number. To illustrate this, in Figure 5 I plot the average daily participation across all US counties. At the peak, participation reaches an average of around 0.025%. To have an idea, this corresponds to around 5,400 protesters in Saratoga County, NY, and 34,000 protesters in the Bronx, NY.

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 , adjusted participation $\bar{\pi}_{j,t}$ is decreasing in θ_j .*

To take this observation to an *entry time*, define for any $p \in [0, 1]$, the time $t_0^j(p)$ as the first time at which the adjusted participation crosses the level p . Analogously, define the *exit*

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



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:

$$d^j(p) = t_1^j(p) - t_0^j(p) + 1. \quad (25)$$

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 θ_j .

Prediction 2. For any $p \in [0, 1]$, both the exit time $t_1^j(p)$ and the duration $d^j(p)$ are decreasing in θ_j .

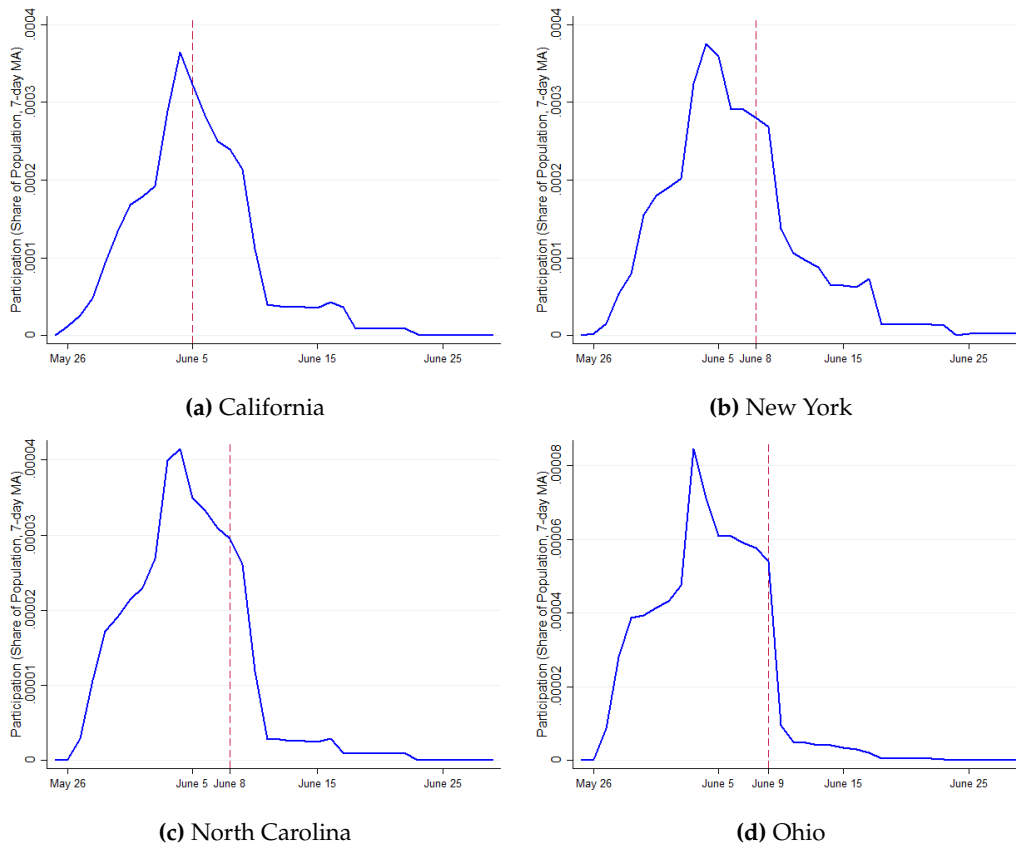
Given that the distribution of entry and exit times is skewed, I use the logarithm of these times as the dependent variables.

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 after the peak, and the probability of occurrence is decreasing over time. Thus, it is more likely to observe concessions closer to the peak than in far future periods. In this section we show some descriptive evidence suggesting these dynamics.

The four panels in Figure 6 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 only dissuade some 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. Entry, Exit, and Opportunity Costs. In this section, I focus on the predictions regarding the timing of protests and the opportunity cost. These predictions are informative of regularities in agents' behavior that, to the best of my knowledge, have not been documented. The relevance of these regularities lies in the fact that monotonic agents' behavior allows us to understand the dynamics of protesters' characteristics. If people with higher

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.

opportunity costs enter later, that implies that as participation increases, agents who are protesting are paying a higher price for being there. In my model, those are also the agents that the government has to encourage to leave the protest, and then the higher the opportunity cost, the costlier it is to make them go home.

7.4.1. Income and Education. It is not an easy task to come up with a measure of opportunity cost that captures its essence in this context. 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. To set ideas, I begin by studying the relation between the timing of entry, and two factors affecting opportunity costs: income and education. Both are imperfect measures of opportunity costs, and in the next section, I make efforts to capture this more precisely.

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 activities during workdays, such as protesting.¹⁹ We would then expect that people with lower education levels have a higher opportunity cost, and then they enter later.

¹⁹According 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](#).

In Table 2 I explore the relationship between income and education with the time of entry and the duration in the protest. In the first three regressions, the dependent variable is the (logarithm of the) time at which the respective entry threshold is crossed. As we can see, both the share of the population with less than a college degree, and the median household income are positively correlated to entry times for every threshold level p . In columns (4)-(6), the dependent variable is the permanence of the county in the protest, in logarithm. The signs of the coefficients are 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 a shorter duration.

Table 2. Entry and Duration (OLS)

Threshold p	Entry $\log(t_0^j(p))$			Duration $\log(d^j(p))$		
	(1) 0.005%	(2) 0.01%	(3) 0.02%	(4) 0.005%	(5) 0.01%	(6) 0.02%
UNDER COLLEGE	0.0150*** (0.00341)	0.0142*** (0.00359)	0.0133*** (0.00366)	-0.0187*** (0.00225)	-0.0168*** (0.00274)	-0.0130*** (0.00289)
INCOME (10K)	0.137*** (0.0259)	0.107*** (0.0264)	0.112*** (0.0257)	-0.0961*** (0.0163)	-0.0775*** (0.0168)	-0.0573*** (0.0195)
Other Controls	X	X	X	X	X	X
State FE	X	X	X	X	X	X
Observations	1083	1024	891	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 *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.

In the following sections, I explore different ways to capture the level of opportunity costs of protesting.

7.4.2. Job Flexibility. Following the intuition developed above, I conjecture that a higher share of workers in flexible occupations is consistent with a lower opportunity cost. To measure flexibility, I first use [Dingel & Neiman \(2020\)](#)'s *teleworkability* shares. In their recent study, the authors determine, for each occupation, the feasibility of working from home. To do this, they take into account different features of the work, as the use of physical activities, the level of risk, and the machinery required. I follow the same

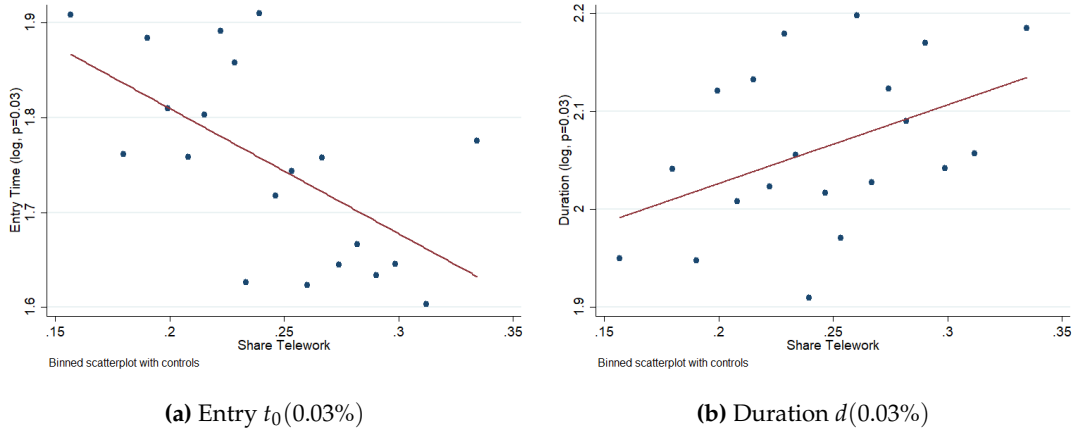
ideas than Glaeser et al. (2020), and combine Dingel & Neiman (2020)'s probabilities of each occupation being done remotely (i.e. the teleworkability shares) with county-level employment data at the 2-digit NAICS. As a result, I obtain the variable TELEWORK, that corresponds to the percentage of workers in occupations that can be done from home. Figure 8 shows the distribution of the variable for all counties.

Figure 8. Histogram of Telework



Figure 9 show the relation between TELEWORK, and the dependent variables for entry and duration for the threshold $p = 0.03\%$. The scatterplots include demographic controls (see Table 7 for a full list of controls). A higher share of workers in more flexible occupations—more *teleworkable*—, is consistent with agents with a lower opportunity cost. Panel (a) shows that lower opportunity cost (higher share of telework) is consistent with entering earlier (lower threshold on the vertical axis). The opposite holds for the duration, as agents with more flexible occupations seem to spend more time in the protest (see Panel (b)).

As these demonstrations started in the middle of a pandemic, counties economies were affected by lockdowns and economic restrictions. I exploit the variation in counties reopening status, to capture the differential effect of job flexibility for open and closed counties. I consider two different specifications for reopening. First, the variable OPEN is a dummy that takes value 1 if the county had reopened by May 25. We expect having more flexible positions makes entry happen earlier if the county is open. The intuition is that if the county is closed, the difference in job flexibility is less relevant as most activities are constrained. Second, the variable DAYS OPEN is a continuous variable corresponding to the number of days passed between the county's reopening date and May 25 (which takes

Figure 9. Entry, Duration, and Share of Teleworkability Jobs with Controls

Controls: INCOME, UNDER COLLEGE, CLINTON, LABOR FORCE, UNDER 29, POPULATION, DENSITY, RURAL, BLACK.

value 0 for those counties that were still closed). The intuition for using this continuous measure of reopening is that we expect economic activity to take time to go back to normal after reopening. Then, as a county has been reopened for a longer time, we expect workers flexibility to be lower.

We estimate the following regression for entry:

$$\log(t_0(p\%)) = \beta_0 + \beta_1 \text{OPEN} + \beta_2 \text{TELEWORK} + \beta_3 \text{OPEN} \times \text{TELEWORK} + \beta_4 X_j + \beta_5 \text{STATE} + \epsilon_j. \quad (26)$$

Then I estimate the same regression using the continuous variable DAYS OPEN.

The results of the first regression can be found in Table 3 (see Table 7 for a description of the controls). As the table shows, a higher share of workers in teleworkable occupations implies earlier entry for counties that were open by May 25. This result suggests that having more flexibility makes a difference only if the county is open. Intuitively, a county being closed makes workers' conditions more similar, as workers see themselves in the same condition regardless of their type of occupation. Moreover, overall open counties enter later, which is consistent with the cost of time being higher when citizens have to go to work.

It is worth mentioning the relationship between the findings shown in Table 3 and Table 2. Citizens with higher income tend to have works that rely less on physical activities and working with other people. However, the effect of having a higher share of workers on teleworkable occupations goes in the opposite direction. The intuition is that they capture different components of the opportunity cost: the value of time, and the flexibility of it.

Table 3. Entry: Telework and Reopening

Dependent Variable: $\log(t_0^j(p))$				
Threshold p :	(1) 0.01%	(2) 0.02%	(3) 0.03%	(4) 0.04%
OPEN \times TELEWORK	-2.616*** (1.008)	-2.271*** (0.824)	-2.365** (0.944)	-2.212** (1.039)
OPEN	0.849*** (0.311)	0.686** (0.269)	0.816** (0.322)	0.893** (0.350)
TELEWORK	1.435 (0.995)	0.669 (0.816)	0.682 (0.966)	0.952 (1.047)
County Controls	X	X	X	X
State FE	X	X	X	X
Observations	1024	891	769	645

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
 Controls: INCOME, UNDER COLLEGE, POPULATION, BLACK,
 UNDER 29, CLINTON, LABOR FORCE, DENSITY, RURAL.

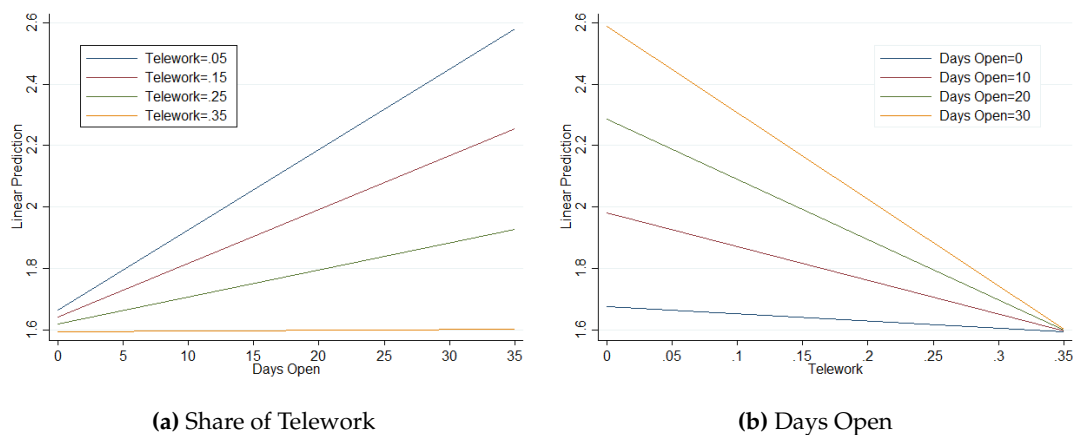
Table 4 shows the results of the same regression but interacting TELEWORK with DAYS OPEN. Although the interpretation of coefficients for the interaction of two continuous variables is more subtle, I plot the marginal effects of each variable in Figure 11. The left-hand side panel shows that the more days have passed since the county reopened, the later it joins the protest, for every level of TELEWORK. In the right-hand side panel, we see that a higher teleworkability share is consistent with earlier entry, for all levels of reopening.

Table 4. Entry: Telework and Reopening

Dependent Variable: $\log(t_0^j(p))$				
Threshold p :	(1) 0.01%	(2) 0.02%	(3) 0.03%	(4) 0.04%
DAYS OPEN \times TELEWORK	-0.0517 (0.0317)	-0.0766** (0.0310)	-0.0864** (0.0342)	-0.0905** (0.0373)
DAYS OPEN	0.0297*** (0.0110)	0.0258** (0.0117)	0.0305** (0.0126)	0.0363*** (0.0134)
TELEWORK	-0.157 (0.625)	-0.284 (0.603)	-0.230 (0.671)	0.230 (0.704)
County Controls	X	X	X	X
State FE	X	X	X	X
Observations	1024	891	769	645

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
 Controls: INCOME, UNDER COLLEGE, POPULATION, BLACK,
 UNDER 29, CLINTON, LABOR FORCE, DENSITY, RURAL.

To take care of the possibility of omitted variable bias, I add a set of county controls. As Dingel & Neiman (2020) report, the extent to which an activity can be done from home

Figure 11. Marginal Effect, DAYS OPEN and TELEWORK. Dependent Variable $\log(t_0(0.03\%))$.

Controls: INCOME (10K), UNDER COLLEGE, CLINTON, LABOR FORCE, UNDER 29, POPULATION (LOG), DENSITY (LOG), RURAL, BLACK.

is related to demographics, such as age, income, and education. Activities who are not possible done from home are those that involve physical efforts and higher risks, which tend to be the ones with lower wages. This will also affect how workers react to reopening policies. In Table 8 in the Appendix, I evaluate the sensitivity of the coefficient and R^2 to the addition of controls. This procedure has been done in the context of conflicts by Bellows & Miguel (2009) (see also Gonzalez & Miguel (2015) and Oster (2016)). I do this specifically for the case of $p = 0.03\%$.

7.4.3. Time Flexibility and Mobility. The third approach I consider to capture people's time flexibility is to use directly information about their mobility. Google's *Community Mobility 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 a baseline period.²⁰ 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, we would expect that a higher residential index would be consistent with people entering earlier, and staying longer in the protest.

The benefit of using the mobility index, is that it corresponds to a direct measure of people's behavior. However, many factors that could be explaining these changes in mobility, and unfortunately, some of them could relate to the decision to protest. For instance, people's aversion to taking risks might affect their changes in behavior in front

²⁰In particular, the Mobility Index reported by Google corresponds to the change in mobility with respect to the five weeks between January 3 and February 6, 2020.

of a pandemic, and at the same time might correlate with the propensity to participate in a protest. To address this issue, first, in the same way as in the previous section I control for a full set of county demographics, including age composition, race, income and education. In addition to this, I follow an instrumental variables strategy that uses as instruments, information on weather the weeks prior to the start of the protests, and the incidence of COVID-19. The relevance restriction requires that both weather and the incidence of COVID-19 are correlated with the change in mobility at a given county. The exclusion restriction requires that these variables do not impact the timing of protests, besides the effect through a change in people's mobility.

More specifically, for weather I use minimum, temperature, maximum temperature and average precipitation during the second week of May.²¹ For COVID-19, I use the average daily new cases during April.

Table 5 shows the results for entry and duration of the protest, for four thresholds. Columns (1)-(4) show the regressions for entry. The coefficient of RESIDENTIAL INDEX is negative and significant for every threshold, which is consistent with what we predicted. Moreover, the signs reverse for the duration of the protest, and the coefficients are significant for thresholds below 0.03%. As the threshold increases, the sample size decreases as there are fewer counties that reach this threshold.

Table 5. Entry and Residential Mobility Index (IV)

Threshold p :	Dependent Variable: $\log(t_0^j(p))$				Dependent Variable: $\log(d^j(p))$			
	(1) 0.01%	(2) 0.02%	(3) 0.03%	(4) 0.04%	(5) 0.01%	(6) 0.02%	(7) 0.03%	(8) 0.04%
RESIDENTIAL INDEX	-0.108** (0.0530)	-0.138** (0.0674)	-0.163** (0.0791)	-0.299** (0.129)	0.0540* (0.0327)	0.0798** (0.0369)	0.0858* (0.0485)	0.145 (0.106)
County Controls	X	X	X	X	X	X	X	X
State FE	X	X	X	X	X	X	X	X
Observations	1024	891	769	645	766	662	563	457

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

Controls: INCOME, UNDER COLLEGE, POPULATION, BLACK, UNDER 29, CLINTON, LABOR FORCE, DENSITY, RURAL.

In Table 6, I show the statistics of the first stage regression. The F statistic is high for all thresholds (which change the sample size), which suggests the instruments are not weak.

7.5. Discussion. In this section I provide some preliminary evidence about the main empirical predictions of the model. Of course, this analysis has some caveats. First, it is worth mentioning that this is not a test of the validity of the model. There could be other forces

²¹To obtain these variables, I computed the average of each measure across all stations on a given county.

Table 6. First Stage Statistics

	Entry Regression: $\log(t_0^j(p))$				Duration Regression: $\log(d^j(p))$			
Threshold p :	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	0.01%	0.02%	0.03%	0.04%	0.01%	0.02%	0.03%	0.04%
R^2	0.87	0.879	0.8851	0.8891	0.879	0.8797	0.9954	0.8895
F	113.61	104.75	91.47	110.91	114.14	105.56	91.91	110.32
$Prob > F$	0	0	0	0	0	0	0	0
Observations	1024	891	769	645	766	662	563	457
Instruments: MIN TEMP, MAX TEMP, PRECIPITATIONS, COVID.								

and incentives generating these dynamics that are not considered here. Second, the data I use for participation is just an approximation, and as such, it might be biased. 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 cell-phone data or other individual-level records. I plan to replicate in the future this study using these types of data.

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 value 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, the model predicts: (a) participation is hump-shaped, (b) concessions happen after the peak, and they are more likely to occur close to the peak, and (c) citizens participation decisions are monotone in opportunity costs: people with higher opportunity costs enter later and exit earlier.

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 re-normalization, the questions that can be addressed by differentiating the cost from the value are empirically relevant. In particular, it would allow understanding how does the relationship between people's participation costs and the value for the public good affects 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 since 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. We begin by proving some properties of the government's equilibrium strategy, and then we use these to fully characterize the set of equilibria. In the first lemma, we show that if there is an interval after τ_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 θ 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

$$\int_0^\delta e^{-rs} c(\pi_{t_0+s}^\sigma, t_0 + s) ds + e^{-r\delta} \frac{q}{r} \quad (27)$$

Then, we have:

$$\int_0^\delta e^{-rs} c(\pi_{t_0+s}^\sigma, t_0 + s) ds + e^{-r\delta} \frac{q}{r} \geq \frac{q}{r} \quad \forall \delta > 0 \quad (28)$$

or, equivalently

$$\int_0^\delta e^{-rs} (c(\pi_{t_0+s}^\sigma, t_0 + s) - q) ds \geq 0 \quad \forall \delta > 0. \quad (29)$$

Define $\bar{t} = \frac{t_0 + t_1}{2}$. Note that as 29 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 $\pi_{t+s}^\sigma \geq \pi_{t_0+s}^\sigma$ for all $s \in (0, \bar{\delta}]$. As, $\pi_{t_0} > 0$, then the cost is strictly increasing in time, and we have:

$$c(\pi_{t_0+s}^\sigma, t_0 + s) < c(\pi_{\bar{t}+s}^\sigma, \bar{t} + s) \quad \forall s \in (0, \bar{\delta}] \quad (30)$$

Then, we can compute:

$$\begin{aligned} \int_{t_0}^{t_1} e^{-r(s-t_0)} (c(\pi_s^\sigma, s) - q) ds &= \int_{t_0}^{\bar{t}} e^{-r(s-t_0)} (c(\pi_s^\sigma, s) - q) ds \\ &+ e^{-r(\bar{t}-t_0)} \int_{\bar{t}}^{t_1} e^{-r(s-\bar{t})} (c(\pi_s^\sigma, s) - q) ds \end{aligned} \quad (31)$$

The first term on the right hand side is weakly greater than 0. By 30 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:

$$\int_0^\tau e^{-rs} c(\pi_s^\sigma, s) + e^{-r\tau} \frac{q}{r} = a \quad \forall \tau \in [\tau_0, \tau_1] \quad (32)$$

for some constant a . Taking first order conditions with respect to τ , 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 we allow the government to randomize. For citizens the problem is a little different. Given that we 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, we 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 we 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 θ who does enter, the optimal entry and exit times, $t_0(\theta), t_1(\theta)$ are a solution to the following sufficient conditions:*

$$\theta = \lambda_{t_1} v(t_1 - t_0) \quad (33)$$

$$\theta = \frac{1}{1 - G(t_0)} \int_{t_0}^{t_1} e^{-r(s-t_0)} v'(s - t_0) dG(s) \quad (34)$$

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

Proof. Consider a citizen with opportunity cost θ 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 τ for the government, the citizen solves the following problem:

$$\max_{(t_0, t_1) \in [0, \infty]^2} E \left[-\theta \int_{t_0}^{t_1 \wedge \tau} e^{-rs} ds + e^{-r\tau} \mathbb{1}_{\tau < t_1} v(t - t_0) \right] \quad (35)$$

where the expectation is taken over τ , 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:

$$U(t_0, t_1; \theta) = \int_{t_0}^{t_1} \left[-\frac{\theta}{r}(e^{-rt_0} - e^{-rs}) + e^{-rs}v(s - t_0) \right] dG(s) - (1 - G(t_1))\frac{\theta}{r}(e^{-rt_0} - e^{-rt_1}) \quad (36)$$

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:

$$\frac{\partial U}{\partial t_0} = -(1 - G(t_0))\theta + g(t_0)v(0) + \int_{t_0}^{t_1} e^{-r(s-t_0)}v'(s - t_0)dG(s) \quad (37)$$

$$\frac{\partial U}{\partial t_1} = -\theta e^{-rt_1}(1 - G(t_1)) + g(t_1)e^{-rt_1}v(t_1 - t_0) \quad (38)$$

Reorganizing, we obtain equations 33 and 34 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 θ , i.e.

$$\frac{\partial^2 U}{\partial t_0 \partial \theta} = e^{-rt_0}(1 - G(t_0)) \geq 0 \quad \frac{\partial^2 U}{\partial t_1 \partial \theta} = -e^{-rt_1}(1 - G(t_1)) \leq 0 \quad (39)$$

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 35, 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 33 we see that an agent will exit when the marginal cost of staying another instant, i.e. θ , 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 34 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 34 holds with equality). Any citizen with opportunity cost $\theta < \tilde{\theta}_0(t)$ is strictly better off by being in the protest. Analogously define $\tilde{\theta}_1(t) = t_1^{-1}(\theta)$, 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 π_t^σ 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 τ_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 33 in Lemma 4, for citizens' decision to be optimal the exit threshold must satisfy:

$$\tilde{\theta}_1(t) = \lambda_t v(t - t_0(\tilde{\theta}_1(t))) \quad (40)$$

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 40 is decreasing, while the prize function increases over time, so it has to be that λ_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 τ 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 τ , 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 λ_t is decreasing in t . So, $\tau_1 = \infty$.

Step 5: If a citizen with opportunity cost θ 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 θ entering at $t_0 > \tau_0$. From lemma 4, the marginal benefit of entering is given by:

$$\lambda_{t_0} v(0) + \frac{1}{1 - G(t_0)} \int_{t_0}^{t_1} e^{-r(s-t_0)} v'(s - t_0) dG(s) \quad (41)$$

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 $t < \tau_0$, π_t^σ is increasing. From the previous claim, $\pi_t^\sigma = F(\tilde{\theta}_0(t))$, which is increasing.

Step 7: π_t^σ is continuous at every $t \in [0, \infty]$. We know that π_t^σ 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 τ_0 . In particular, we rule out cases in which there is a positive mass of people entering at a given time t (see figure 13). 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:

$$\tilde{\theta}_1(t_1) = \int_{\bar{t}_0}^{t_1} e^{-r(s-\bar{t}_0)} v'(s-\bar{t}_0) dG(s) < \int_{\bar{t}_0}^{t'_1} e^{-r(s-\bar{t}_0)} v'(s-\bar{t}_0) dG(s) = \tilde{\theta}_1(t'_1) \quad (42)$$

a contradiction.

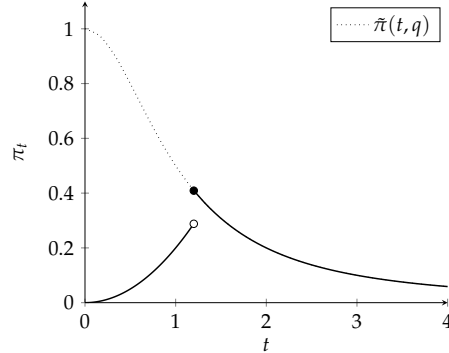


Figure 13. Continuity of π_t .

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 τ_0 , i.e. $G(\tau_0) = 1$. Note that the payoff from entering at τ_0 is zero, so at τ_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 τ_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.

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:

$$\lim_{t \rightarrow \infty} G(t) = 1 - \lim_{t \rightarrow \infty} \left[(1 - G(\tau_0)) \exp \left(- \int_0^t \lambda_s ds \right) \right] = 1 \quad (43)$$

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

Lemma 5. *Government initial concession $G(\tau_0)$ is decreasing in τ_0 .*

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

$$\tilde{\theta}_0(t) = \begin{cases} \int_t^{t_1} e^{-r(s-t)} v'(s-t) dG(s) & t \in [0, \tau_0) \\ \tilde{\theta}_1(t) & t = \tau_0 \end{cases} \quad (44)$$

Using continuity of π_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 τ_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 τ_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*

$$\underline{\theta} = \int_{\bar{\tau}}^\infty e^{-rs} v'(s) dG(s) \quad (45)$$

Proof. In order to prove existence of this equilibrium with the longest delay, I show that there exists a fixed point satisfying condition 45.

As I describe in Section 4.2, in equilibrium citizens' exit times are determined by the government indifference condition.²² 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 τ_0 , in such a way that, given $G(t)$, condition 45 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 τ_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:

$$\Psi = (\Gamma(t_0, \tau_0), \Phi(G, \tau_0), \Theta(G, t_0)) \quad (46)$$

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,²³ 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 time that solves the following equation:

$$\tilde{\theta}_1(t) = \int_{t_0}^t e^{-r(s-t_0)} v'(s-t_0) dGs \quad (47)$$

where $\tilde{\theta}_1(t) = F^{-1}(\tilde{\pi}(t))$. Figure 14 illustrates citizens' best reply function.

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 τ_0 , the government chooses a distribution

²²More 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 $t \in \mathcal{T}$.

²³Space of functions that are increasing, right-continuous, and such that $\lim_{t \rightarrow -\infty} G(t) = 0$ and $\lim_{t \rightarrow \infty} G(t) = 1$.

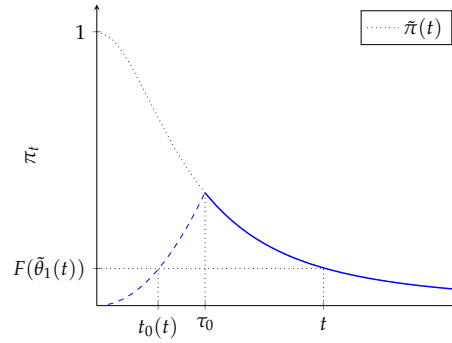


Figure 14. Citizens' exit is determined by $\tilde{\pi}_t = F(\tilde{\theta}_1(t)) \forall t \in [\tau_0, \infty)$. A citizen with opportunity cost $\theta = \tilde{\theta}_1(t)$ exits at t , and given this exit time, equation 47 defines the entry time $t_0(t)$.

of concessions over $[\tau_0, \infty)$, i.e. $G : [\tau_0, \infty) \rightarrow [0, 1]$ such that:

$$G(t) = 1 - (1 - G(\tau_0)) \exp \left(- \int_{\tau_0}^t \lambda_s ds \right) \quad (48)$$

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

$$\underline{\theta} = \int_{\tau_0}^{\infty} e^{-rs} v'(s) dG(s) \quad (49)$$

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 λ_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:

$$\tilde{\theta}_1(t) = \int_{t_0}^t e^{-r(s-t_0)} v'(s - t_0) dGs \quad (50)$$

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

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

Step 5: Ψ 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. Γ 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:

$$\bar{\lambda}(t) = \frac{F^{-1}(\tilde{\pi}(t))\epsilon}{v(t - \bar{t}_0(t))} \quad (51)$$

which proves the graph is closed.

Claim 2. Φ 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:

$$H(t_0; G, \tau_0) = \frac{1}{r} \left[\ln F^{-1}(\tilde{\pi}(t)) - \ln \left(\int_{t_0}^t e^{-rs} v'(s - t_0(t)) dG(s) \right) \right] \quad (52)$$

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

$$\|\bar{t}_0 - H(\bar{t}_0; \bar{G}, \bar{\tau})\| \leq \|\bar{t}_0 - t_0^n\| + \|t_0^n - H(t_0^n)\| + \|H(t_0^n; G^n, \tau^n) - H(\bar{t}_0; \bar{G}, \bar{\tau})\| \quad (53)$$

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. Θ 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 $(\bar{\tau}_0) \in \Theta(\bar{t}_0, \bar{G})$. Note that G^n converges to \bar{G} in distribution, and then applying Continuous Mapping Theorem we obtain

$$\int_{\tau_0^n}^{\infty} e^{-rs} v'(s) dG^n(s) \rightarrow \int_{\bar{\tau}_0}^{\infty} e^{-rs} v'(s) d\bar{G}(s) \quad (54)$$

Then, using claims 1, 2 and 3, we have that Ψ 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 τ_0^1, τ_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

$$\frac{\partial \tilde{\theta}_0(t)}{\partial \tau_0} = -e^{-r(\tau_0-t)} v'(\tau_0-t) g(\tau) + \int_t^{\tau_1(t)} e^{-r(s-t)} v'(\tau_0-t) g'(\tau_0) ds < 0 \quad (55)$$

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

$$\underline{\theta} < \int_{\bar{\tau}}^{\infty} e^{-rs} v'(s) dG(s) \quad (56)$$

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 τ^* . Using the same arguments, a fixed point exists. As τ^* 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

$$\tilde{\pi}_{\underline{\tau}_j} = F_j(v'(0)) \quad (57)$$

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.

A.5. Proof of Proposition 2. The effect of the proportional increase in opportunity costs follows directly from part (i) in Proposition 1.

Now we show $\bar{\tau}_\alpha < \bar{\tau}$. Denote the initial government strategy by G , which is given by:

$$G(t) = 1 - (1 - G(\tau_0)) \exp\left(-\int_0^t \lambda_s ds\right) \quad (58)$$

with $\lambda_s = \frac{\tilde{\theta}(t)}{v(t-t_0(\tilde{\theta}(t)))}$. Keeping government concession constant, an increase in agents' opportunity costs delays agents' optimal entry times.

Note that as all citizens' opportunity costs increase in the same proportion, then it must be that the new exit threshold is proportional to the initial one, $\tilde{\theta}'_1(t) = \tilde{\theta}_1(t)$. Consider first a hypothetical compensated movement in the government's distribution of concessions such that citizens' best reply (their entry times) with the new opportunity costs, is equal to the original one. Then the new hazard rate is given by $\lambda'_t = \frac{\tilde{\theta}'(t)}{v(t-t_0(\tilde{\theta}(t)))} = \lambda_t(1 + \alpha)$.

Given that agents entry times remain the same, $\bar{\tau}$ remains the same, and the initial probability of government concession must increase to $G'(\bar{\tau}) = \frac{\tilde{\theta}(\bar{\tau})}{v'(0)} = \frac{\tilde{\theta}(\bar{\tau})(1+\alpha)}{v'(0)} = (1 + \alpha)G(\bar{\tau})$.

Fix an exit time t , so that a citizen with opportunity cost $\tilde{\theta}(t)$ exits at t and enters at some time t_0 . Note that we're constructing an equilibrium in which this same citizen, now with opportunity cost $\tilde{\theta}'(t) = (1 + \alpha)\tilde{\theta}(t)$ enters and exit at the same times. The following conditions must hold:

$$\tilde{\theta}(t) = \int_0^t e^{-r(s-t_0)} v'(s-t_0) dG(s) \quad (59)$$

$$\tilde{\theta}'(t) = \int_0^t e^{-r(s-t_0)} v'(s-t_0) dG'(s) \quad (60)$$

Putting both of them together, we have the following:

$$\tilde{\theta}'(t) = \int_0^t e^{-r(s-t_0)} v'(s-t_0) \lambda'_s (1 - G'(\bar{\tau})) \exp(-\Lambda'(s)) ds \quad (61)$$

$$\tilde{\theta}(t)(1 + \alpha) = \int_0^t e^{-r(s-t_0)} v'(s-t_0) \lambda_s (1 + \alpha) (1 - G'(\bar{\tau})) \exp(-\Lambda(s)(1 + \alpha)) ds \quad (62)$$

$$\tilde{\theta}(t) = (1 - G'(\bar{\tau})) \int_0^t e^{-r(s-t_0)} v'(s-t_0) \lambda_s \exp(-\Lambda(s)(1 + \alpha)) ds \quad (63)$$

where $\Lambda(t) = \int_0^t \lambda_s ds$, and $\Lambda'(t) = \int_0^t \lambda'_s ds$. But note that the left-hand side of equation 63 is equal to

$$\tilde{\theta}(t) = (1 - G(\bar{\tau})) \int_0^t e^{-r(s-t_0)} v'(s-t_0) \lambda_s \exp(-\Lambda(s)) ds \quad (64)$$

which is strictly greater than the right hand side of 63. Then keeping the same entry times is not an equilibrium. Citizens have incentives to delay their entry, which will increase the government hazard rate. But as every citizen has incentives to delay entry in order to increase returns. As we picked an arbitrary agent, this is also the case for the citizen with the lowest opportunity cost. Then it must be that $\bar{\tau}' < \bar{\tau}$. \square

B. Empirical Appendix

Table 7. Description of Main Variables

Variable	Description
TELEWORK	Share of workers on teleworkable occupations.
OPEN	Dummy to indicate if the county was open by May 25.
RESIDENTIAL	Average Google Mobility Index, week prior to May 25.
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
UNDER COLLEGE	Population with less than college degree

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Table 8. Sensitivity Analysis II: Telework and Reopening

	Dependent Variable: $\log(t_0(0.01\%))$	
	(1)	(2)
DAYS OPEN \times TELEWORK	-0.0809** (0.0352)	-0.0864** (0.0342)
DAYS OPEN	0.0311** (0.0127)	0.0305** (0.0126)
TELEWORK	-1.126* (0.576)	-0.230 (0.671)
CLINTON		-0.534* (0.312)
POPULATION (LOG)		0.000453 (0.0385)
DENSITY (LOG)		-0.00625 (0.0359)
BLACK		0.000740 (0.00357)
BELOW COLLEGE		0.0133*** (0.00414)
UNDER 29		-0.00766 (0.00478)
LABOR SHARE		-0.725 (0.501)
RURAL		-0.000309 (0.00144)
INCOME (10K)		0.0995*** (0.0286)
CONSTANT	1.646*** (0.325)	0.950 (0.747)
State FE	X	X
Observations	769	769
R ²	0.136	0.212

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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