Collective Self-Control

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Abstract

Behavioral economics presents a "paternalistic" rationale for a benevolent government's intervention. We consider an economy where the only "distortion" is agents' time inconsistency. We study the desirability of various forms of collective action, ones pertaining to costly commitment and ones pertaining to the timing of consumption, when government decisions respond to voters' preferences via the political process. If only commitment decisions are centralized, commitment investment is more moderate than if all decisions are centralized. Commitment investment is minimal when only consumption is centralized. First-period welfare is highest under either full centralization or laissez faire, depending on the populations' time-inconsistency distribution.

Keywords: Behavioral Political Economy, Time Inconsistency, Hyperbolic Discounting.

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1 Introduction

Traditional public economics provides efficiency rationales for government intervention that are commonly founded in payoff or information externalities. In particular, none of these rationales justify government policy in areas in which agents make private decisions that do not have impacts on other agents. The behavioral economics literature has introduced a novel justification for government intervention arising from "paternalistic attitudes."[1] This approach is controversial, partly because it drastically departs from standard normative economics.[2] It has, however, proven influential in the policy realm. For instance, in the U.S., some discussion of social security takes an explicitly paternalistic approach by viewing it as a necessary program to correct for many individuals' inability to properly save for retirement.[3] Furthermore, the current U.K. government coalition program states that: "The Government believes that action is needed to protect consumers, particularly the most vulnerable, and to promote greater competition across the economy. We need to promote more responsible corporate and consumer behaviour through greater transparency and by harnessing the insights from behavioural economics and social psychology."

Just as for textbook public policy analysis, it is useful to consider what happens when we abandon the idea of a benevolent planner and instead explicitly model the fact that the political process determines the design of policy. Will politicians seeking election exploit/indulge the voters' behavioral distortions? Are behavioral distortions amenable to aggregation into collective action? What are the implications for the constitutional scope of government activity? The goal of this paper is to develop a tractable model of the potential political economy constraints to the implementation of paternalistic policies in one special, but important, setting.

There are of course many types of behavioral distortions, and each of them may lead to its own collective action environment. We focus here on self-control problems: agents have preferences that display present bias or quasi-hyperbolic discounting a-la Phelps and Polak (1968) and Laibson (1997). These self-control problems can lead to phenomena such as procrastination, insufficient savings for retirement (see O'Donoghue and Rabin 1999 and Laibson, Repetto, and Tobacman 1998), harmful obesity and addictions (Gul and Pesendor-

[1] Camerer, Loewenstein, and Rabin (2004) contains a number of "second generation" contributions to behavioral economics. Frederick, Loewenstein, and O'Donoghue (2002) surveys the experimental evidence on time discounting. Della Vigna (2009) surveys evidence from the field. See also Thaler and Sunstein (2009).

[2] See, for instance, the essays in Caplin and Schotter (2008).

[3] See, e.g., Diamond (1977), Akerlof (1998), Feldstein (1985), and Imrohoroglu, Imrohoroglu, and Joines (2003).

fer 2007, O'Donoghue and Rabin 2000), etc. Furthermore, self-control problems can generate a demand for commitment (rehab clinics, illiquid assets with costly withdrawals, and so on) that cannot arise with exponential discounting. In particular, a benevolent government could, in principle, offer commitment instruments that would help the electorate overcome some of the harmful symptoms of time inconsistency.

Once we depart from a world in which policy is determined by hypothetical benevolent social planners, the set of feasible outcomes is constrained by the political incentives faced by politicians. Time inconsistency offers a simple case study to illustrate how political forces driven by 'behavioral' voters may induce outcomes that differ from those offered by a benevolent social planner. It is easy to construct scenarios in which government intervention leads to worse outcomes than laissez-faire. In order to understand the effects of the political process we contrast the outcomes of several political institutions.

The current paper considers an electorate composed of time inconsistent individuals who make two decisions: how much to invest in commitment instruments, and how to allocate consumption over time. We study the outcomes that emerge from several political processes that impact either or both decisions. Namely, we consider systems in which investment in commitment (say, in the form of 401K accounts that penalize early withdrawals) is mandated collectively or ones in which government intervenes at the time of consumption (say, by using government transfers). While our discussion focuses on electoral settings, our analysis applies immediately to general settings of committee decision making.

Specifically, we study a simple Wicksellian tree-cutting problem, under the standard specification that the tree is growing in value over time. In our baseline setting, agents have the option of cutting a tree at period 2, which generates a value of v_2, or at period 3, which generates a value of v_3, where $v_3 > v_2$. A tension arises since agents exhibit present bias. At any period, *all future periods* are discounted with a factor of $\beta \leq 1$, which is distributed in an arbitrary (but continuous) way in the population. Thus, from the perspective of period 1, all agents prefer to wait until period 3 to cut the tree. But when period 2 arrives, agents compare an immediate value of v_2 with a discounted value of βv_3 and some could potentially prefer to cut the tree early. This problem has been studied by O'Donoghue and Rabin (1999), who show that time inconsistent agents tend to consume (cut the tree) inefficiently early, and that these agents would find it valuable to commit to cutting the tree later (namely, in period 3).[4]

[4] An alternative is to use the preferences studied in Gul and Pesendorfer (2001, 2004, 2007). The main ideas in our paper would apply in such a setting as well.

We modify the O'Donoghue-Rabin model to allow for continuous choices and costly commitment: by investing resources in period 1, agents can make it costly for their future selves to depart from some pre-specified plan of action. The more investment there is early on in commitment, the more costly it is for future selves to cut the tree too early. Indeed, there are many examples in which individuals use costly commitment devices. For instance, as of the writing of this paper, there has been a collective investment of over $14 million in individual contracts through stickk.com. These contracts provide explicit financial punishments for not sticking to pre-specified commitments, which vary among users and include smoking cessation, exercise, work targets, etc.[5] There are also various ways in which governments invest in commitment instruments, most notably ones having to do with retirement savings or drug prohibition.[6]

We first consider a fully decentralized environment, a benchmark case in which government plays no role. We show that preferences for investing in commitment are non monotonic in the strength of present bias. Agents with severe present bias (very low β parameters) require large investments in commitment in order to alter the timing of future consumption: commitment may be too expensive for these individuals. On the other hand, agents who exhibit mild present bias (very high β parameters) are able to postpone consumption even absent commitment instruments: commitment is unnecessary for these individuals. Consequently, when all decisions are decentralized, extreme agents on both sides of the spectrum choose little or no investment in commitment, while moderate agents choose more substantial investments.

We then introduce collective action. We assume collective decisions are determined by the outcome of competition between two office-seeking candidates. We outline three different scenarios that vary in terms of which choices (investment in commitment and/or the timing of consumption) are subject to the political process, and which ones are left to individuals. We believe these scenarios offer a simple taxonomy for an array of plausible environments. They also help highlight the sensitivity of generated welfare levels to the aspects, or timing, of choices in which collective action comes into play.[7]

Suppose, first, that commitment decisions are decentralized, while allocation decisions,

[5] See also Della Vigna and Malmendier (2006), Ayres (2010), and references therein.

[6] For a description of current public sector pension plans, see Beshears et al. (2011) and for a review of alcohol policy in the U.S., see Babor (2003). The introduction of graphic warning labels on cigarette packs has been the topic of recent controversy and is covered in http://www.cnn.com/2013/03/19/health/fda-graphic-tobacco-warnings

[7] We abuse terminology by referring to "welfare" as the utilitarian social surplus measured for the period 1 selves of the voters. We acknowledge that other criteria are relevant and we discuss this more explicitly in Section 6.

regarding when to cut the tree, are taken by a centralized government through a voting mechanism. Concretely, in the second period each of the two candidates offers a platform specifying the fraction of the tree that would be cut collectively and majority vote determines which platform gets implemented. Mandating the timing of consumption can be viewed as a metaphor for, e.g., government transfer payments in the form of welfare, disability insurance, food stamps, or supplemental security income.[8] In this setting, no individual makes any investment in commitment. Indeed, in the second period, it is the effective median agent who is decisive and determines the amount of tree to be cut. Consequently, in period 1, agents know that their individual commitment decisions have no effect on the allocation decision that results from the voting mechanism, and therefore have no incentive to invest in commitment. That is, government intervention completely undermines incentives to invest in commitment because of free riding in commitment investments. Nonetheless, if the median agent is not prone to a strong present-bias, i.e., the decisive agent is virtuous, the political process would lead to delayed consumption and high welfare levels. If, in contrast, the median agent is prone to a strong present bias, consumption would occur early and the process would be particularly inefficient.

Consider next the case in which allocation decisions are taken privately in a decentralized manner, but commitment decisions are centralized. In other words, the two candidates compete in period 1 (via majority rule) over platforms specifying the levels of commitment. This scenario is a natural way to think of many applications that commitment decisions might involve, for instance, setting up fines for consuming savings (say, retirement savings) too early, prohibition legislation, etc. Analysis of this case is more subtle because of the non monotonic amount of commitment desired in the population. In fact, the decisive voter is typically not the agent with the median present-bias parameter. The generated welfare levels in this setting are always dominated by those generated in the fully decentralized setting. Indeed, in the fully decentralized environment nothing prevents agents from privately choosing the level of commitment that emerges in the centralized commitment scenario.

The last system we consider is one that is fully centralized, where both commitment levels and the timing of consumption are decided upon collectively. This setting is reminiscent of the functioning of collective communities such as the Israeli kibbutzes, in which all decisions are effectively taken collectively. While not commonly observed, this setting sheds light on the impact of the timing of collective action on welfare. In this case, the median present-bias voter determines both decisions. When collectively deciding on commitment investments, voters aim at providing commitment for the median voter in the subsequent period. In

[8]See Stephens (2003), Shapiro (2005), Dobkin and Puller (2007), and references therein.

contrast with the decentralized consumption scenarios, where the desired commitment levels are non monotone in β, in the fully centralized environment these desired commitment levels are increasing in β. In equilibrium, positive commitment may take place if the median voter is sufficiently moderate, and the population inherits the virtues or biases of its median voter. As a consequence, when the median voter exhibits a weak but substantial present bias, this system generates the highest welfare levels. Indeed, when commitment decisions are decentralized, the median voter would still opt for early consumption. Thus, in this case full centralization allows the electorate to tailor commitment levels to the median voter, who does not require very costly commitment investments in order to delay consumption.

The comparison of these scenarios that differ in degrees and timing of centralization shows that the welfare consequences of government intervention are fairly nuanced when we take into account the fact that behavioral agents are also political actors, electing the government that is charged with "solving" their behavioral biases. Thus, for instance, outcomes can be worse under centralization than those generated by a laissez faire economy in which all decisions are decentralized. However, particular forms of intervention can be useful. Welfare consequences are sensitive both to the distribution of preferences in the electorate, and to the precise timing in which government intervenes. In particular, when the median voter is not prone to strong present biases, interventions under which the timing of consumption is decided upon collectively are welfare enhancing. They allow the electorate to effectively delegate decisions to a virtuous median voter.

2 Related Literature

Several authors (Benjamin and Laibson 2003, Caplan 2007, Glaeser 2006, Rizzo and Whitman 2009a,b) have informally made the point that when government is not run by a benevolent social planner but by politicians influenced by voting decisions, it is not clear that government intervention is beneficial. In fact, Glaeser and Caplan explicitly make the case that, if voters are boundedly rational, then the case for limited government may be even stronger than in standard models.[9] Krusell, Kurusçu, and Smith (2002, 2010) examine government policy for agents who suffer self-control problems. Krusell, Kurusçu, and Smith (2002) consider a neoclassical growth model with quasi-hyperbolic consumers. They show that, when government is benevolent but cannot commit, decentralized allocations are Pareto

[9]Bendor, Diermeier, Siegel, and Ting (2011) present models of boundedly rational voters that are successful in matching some features of elections that are hard to explain with rational voter models. Diermeier and Li (2013) study the outcomes of dynamic majoritarian elections with 'behavioral' voters who exhibit some persistence in their voting and forgetfulness of past political outcomes.

superior. This is due to a general equilibrium effect of savings that exacerbates an under-saving problem. Benabou and Tirole (2006) discuss how endogenously biased beliefs that are chosen by individuals for self-motivation can generate a belief in a just (unjust) world and ultimately affect redistributive politics.

Time inconsistency and commitment problems have been the focus of a large literature in political economy and macroeconomics, especially in the context of government debt and monetary policy (e.g., Persson and Tabellini 1990, Alesina and Tabellini 1990). In those models, voters are time consistent, but the identity of the decision maker (or decisive voter) changes over time, generating time inconsistent policies. This in turn creates an incentive for early decision makers to manipulate state variables, such as debt, in order to influence subsequent decisions.[10] There is also evidence that time inconsistency may have been at the root of the historical design of pension systems.[11] In this literature time inconsistency of political choices emerges from the interaction among *time consistent* agents who act at different points in time. Our analysis complements this work by studying the consequences of having agents with heterogeneous degrees of time inconsistency participate in the political process. For instance, as mentioned above, a public pension system is sometimes defended as a desirable solution to a potential problem of under-saving due to self-control problems. However, the design of such a system should then take into account the political constraints generated by an electorate composed of voters with these self-control problems. As it turns out, the induced constraints are quite different from those considered in the literature on time inconsistent policy driven by a sequence of time consistent agents. These constraints may affect the choice between a pay-as-you-go system and a funded system, the kind of safeguards that are designed into the system, as well as the timing and evolution of the system.

Bisin, Lizzeri, and Yariv (2013) studies a model of fiscal irresponsibility and public debt in the presence of time-inconsistent voters. The model they consider captures environments where it is either impossible for government to help agents to achieve commitments or it is positively harmful for the government to do so. Their model does not quite fit into any of the scenarios that we discuss in this paper, but does highlight the potential harmful effects government intervention may have in the realm of fiscal policy when voters exhibit time inconsistencies. In fact, the paper offers a new rationale for balanced budget rules in

[10] There is also work (e.g., Lagunoff, 2008) that shows that, if one considers governments that have policy preferences and that know that they may be kicked out of office with positive probability, endogenous present bias may emerge.

[11] Jacobs (2011) provides a comparative history of pension systems, where commitment problems are emphasized as an explanation for why some countries chose, or eventually turned to, a pay-as-you-go system.

constitutions as they restrain governments' responses to voters' desires.[12] Hwang and Mollerstrom (2012) study political reform with time-inconsistent voters and show that gradualism emerges in equilibrium as a consequence of time inconsistency. They also show that election of a patient agenda setter can arise in equilibrium.[13]

3 A Tree Cutting Model

3.1 Preferences and Consumption Possibilities

A continuum of agents decides collectively on the timing of consumption. There are three periods. In period 1 agents make "commitment" decisions (that we specify below). In periods 2 and 3 agents consume fractions of a "tree" of growing value. The tree is worth v_2 in period 2, and v_3 in period 3. We assume that $v_2 < v_3$.[14] In period 2 agents choose a fraction x of the tree to consume in period 2, with $1-x$ remaining to be consumed in period 3. We interpret period 3 as the natural moment of maturity of the tree so that there is an extra cost in cutting part of the tree in period 2. This cost is given by the function $k\left(x,c\right)$, where c is a parameter that is determined in the first period.

Agents have $\beta-\delta$ preferences. That is, for any payoffs u_2 and u_3 in periods 2 and 3, respectively, the assessed utility at time t, denoted by U_t, is given by:

$$\begin{aligned}
U_1 &= \beta\delta u_2 + \beta\delta^2 u_3, \\
U_2 &= u_2 + \beta\delta u_3, \\
U_3 &= u_{3.}
\end{aligned}$$

Individuals are heterogeneous in their present-bias parameter: β is distributed according to a continuous distribution $G[0,1]$ with a median parameter denoted by β_M.

An agent with parameter β has a utility at $t=2$ given by:

$$U_2(x,c,\beta) = v_2 x - k\left(x,c\right) + \beta\delta v_3\left(1-x\right)$$

In period 1 a parameter c is chosen (potentially by a collective action process that we soon specify). This parameter raises the cost of cutting the tree early. We assume that $\frac{\partial k(x,0)}{\partial x}=0$

[12] Gottlieb (2008) studies the optimal design of nonexclusive contracts when firms compete over time-inconsistent consumers. The paper studies the asymmetry between immediate-cost goods and immediate-reward goods that are generated by nonexclusivity. To the extent that firms are akin to political competitors, some of the underlying forces in that paper are relevant for the study of political processes with a time-inconsistent electorate.

[13] Ortoleva and Snowberg (2012) look at the potential effects of over-confidence on electoral outcomes.

[14] Our qualitative results remain in the presence of uncertainty over future tree values.

for all x, so that absent commitment, there is no marginal cost of cutting the tree early. We also assume that $\frac{\partial k(x,c)}{\partial x} \geq 0$, $\frac{\partial^2 k(x,c)}{\partial x^2} > 0$, $\frac{\partial k(x,c)}{\partial c} > 0$, and $\frac{\partial^2 k(x,c)}{\partial x \partial c} > 0$. That is, cutting costs are weakly increasing and convex in the amount of the tree that is cut x and in the extent of commitment in place, as given by the commitment parameter c. The marginal cost of early consumption is also increasing in c. Thus, c serves as a commitment mechanism to delay consumption to period 3. This commitment is costly in period 1: choosing c costs $I(c)$. We assume $I(0) = 0, I'(0) = 0, I'(c) \geq 0$, and $I''(c) > 0$ for all c.[15,16] The regularity restrictions we impose on $k(x,c)$ and $I(c)$ are sufficient for our results and simplify our presentation, but are by no means necessary (in fact, in our running example we will drop the requirement that $\frac{\partial k(x,0)}{\partial x} = 0$).

Utility in period 1 is given by

$$U_1(x, c, \beta) = \beta\delta\left(v_2 x - k\left(x, c\right)\right) + \beta\delta^2 v_3\left(1 - x\right) - I\left(c\right).$$

Agents are assumed to be *sophisticated*, in the sense that they are aware that they are time inconsistent. O'Donoughue and Rabin (1999) analyzed the single person decision problem in this environment, by using the notion of perception perfect equilibrium. When agents are sophisticated, this boils down to preferences that are specified a-la Strotz (1955) who perform backwards induction. We assume sophistication because we want to study how the demand for commitment is mediated by the political system.[17]

For notational simplicity, we assume $\delta = 1$ for the remainder of the analysis. This assumption is effectively without loss of generality (as discounting can be encoded in the v sequence of tree values).

3.2 The Political Process

There are two candidates running for office. Candidates are office motivated, receiving some positive payoffs from each electoral victory. It will be clear that candidates' time preferences play no role in this model.[18] We assume that the electorate has no ideological

[15] The assumption that $I(0) = 0$ is not restrictive. Indeed, assuming $I(0) > 0$ is tantamount to assuming there is a fixed cost to entering our economy.

[16] For the most part we will treat the investment in commitment and the associated increase in $k\left(x, c\right)$ as resource costs that should be counted in welfare calculations. However, for some applications, such as 401K plans, these are taxes whose revenues are not a deadweight loss. Such cases can be accommodated simply by reinterpreting the resource costs as the pure resources involved in administering the tax. Of course, our welfare calculations would then have to be performed differently. Nonetheless, it turns out that our main welfare results are robust to this modification.

[17] In Section 7 we discuss the effects of naivete in our model.

[18] This is not to say that time inconsistencies cannot take place directly at the political level. As mentioned

attachment to the candidates.[19]

We distinguish between three types of environments. These are meant to capture different collective action settings and highlight the effects of the timing of collective decisions on commitment choices.

Centralized Commitment, Centralized Choice. Elections occur in periods $t = 1, 2$. At $t = 1$, each candidate offers a platform consisting of a cost c that determines the cost of consumption in period 2 later on. Majority voting determines which outcome, and corresponding platform, is elected (we assume that ties are broken with a toss of a coin). If the platform c_i is implemented, all agents experience an immediate commitment cost of $I(c_i)$ at $t = 1$. At $t = 2$, the candidates each offer a fraction x_j of the tree to be consumed in period 2 and majority rule (with random breaking of ties) determines which policy is implemented. If an amount x of the tree is consumed at $t = 2$, an agent with taste parameter β receives the value of $v_2 x_j + \beta v_3(1 - x_j)$. All agents experience an immediate cost of $k(x_j, c_i)$.

Dentralized Commitment, Centralized Choice. At $t = 1$, agents choose individually the parameter c that will induce their commitment-breaking costs at time $t = 2$, the cost of which is immediate and given by $I(c)$. At $t = 2$, fraction x of the tree to be consumed in period 2 and majority rule (with random breaking of ties) determines which policy x_i is implemented for the entire population. An individual with taste parameter β who chose a commitment parameter of c at $t = 1$ receives a net value of $v_2 x_i + \beta v_3(1 - x_i)$ and experiences an immediate cost of $k(x_i, c)$.

Centralized Commitment, Decentralized Choice. Elections occur only in period $t = 1$, when each candidate offers a platform consisting of a commitment parameter c_i involving an immediate commitment cost of $I(c_i)$. Majority voting determines which outcome, and corresponding platform is elected (again, ties are broken randomly). At $t = 2$, each of the individual agents decides what fraction x of the tree to consume. An individual with taste parameter β who chooses to consume a fraction x of the tree $t = 2$ receives a net value of $v_2 x + \beta v_3(1 - x)$ and experiences an immediate cost of $k(x, c_i)$.

in the discussion of the related literature, there is a body of work that focuses on time consistency of government policy.

[19] Allowing agents to have idiosyncratic ideological preferences (as in Lindbeck and Weibull 1987) does not change any of the results qualitatively. Details are available from the authors upon request.

In what follows, we analyze the outcomes of a fully decentralized economy in addition to each of the above settings in turn. All proofs are relegated to the Appendix.

3.3 Discussion of the Model

Our model of collective action builds on the individual decision-making problem proposed by O'Donoughue and Rabin (1999), who first considered a version of the type of tree-cutting decision problem analyzed in this paper. We extend this model in two ways and then introduce collective action. First, we allow the agents to *invest* in commitment or self-control. This is reasonable as there are many cases in which the government or individuals can take actions to restrain their future selves (401K plans, rehab programs, weight watchers, internal psychological mechanisms). Notice that if commitment were free, all agents would commit themselves to later consumption and there would effectively be no self-control problem. Consequently, decentralized decisions would lead to first-best outcomes in which all agents would efficiently and fully delay their consumption. The introduction of commitment costs introduces a non-trivial cost-benefit trade-off in decentralized economies, that we soon analyze, which creates room for potentially beneficial government intervention. A second, more technical modification from the model presented by O'Donoughue and Rabin, is that they assume that agents only choose when to cut the tree and cannot cut fractions of it. This is tantamount to a special case of our model in which $k(x, c)$ is linear. We delay the discussion of this special case until Section 7.5 as it introduces some technical complications within the analysis of the Centralized Commitment-Decentralized Choice scenario.

The only dimension of heterogeneity that we explore is the degree of present bias β. We view this as a natural step given the questions we are studying. Some empirical studies of self-control problems suggest non-trivial degrees of heterogeneity (e.g., Fang and Wang 2013 and references therein). Nonetheless, we note that much of our qualitative analysis would remain the same had we assumed a unique $\beta < 1$ in the population and a distribution of commitment technologies (each individual having access to a private commitment cost function I). Similarly, allowing for a non-trivial distribution of both present-bias preferences and commitment technologies would generate qualitatively similar results, though complicate our presentation.

We have chosen to study four scenarios that differ in their degree of centralization of choices. These are natural scenarios and we show below that it is important to distinguish between government action over consumption, such as government transfer payments in the form of welfare, disability insurance, food stamps, or supplemental security income, and government action over commitment, such as 401K pension plans that penalize withdrawals before retirement age, prohibition, cigarette ad campaigns, etc.[20] Furthermore, comparing laissez faire to various degrees of government centralization is an old question in economics and it is useful to understand how centralization affects outcomes in a world with no other reason for government intervention other than 'behavioral' distortions. There are, of course, many other scenarios that can be studied. We discuss some of these in Section 7.

We have modeled collective action as elections of office-motivated candidates. We have done this in part because this is the most standard way to approach political economy models, and is therefore a good starting point to explore collective self-control in this benchmark setting. However, the main forces behind our results are likely to be present in several alternative specifications of the political system. Two particular natural extensions (discussed in Section 7) are the following. First, one could think of collective action generating more targeted policies that affect individuals differentially, say in the form of commitment subsidies or consumption caps. Second, throughout our analysis we take the commitment technology itself (namely, the functions $I(c)$ and $k(x, c)$) as exogenous. While some of the implied costs may be psychological and rather non-malleable, others may derive from institutions and could be an object of political choice as well.[21]

We assume that the commitment technologies faced by individuals and by the government are identical. There is no empirical reason to make this assumption: the relative effectiveness of commitment by the government or by individuals will depend on the specific application. However, assuming identical technologies is a useful benchmark. In Section 7 we consider some aspects of different commitment technologies accessible to the government and the agents.

4 Decentralized Outcomes

Before inspecting the impacts of collective action on commitment decisions, we describe each agent's individual decisions. This analysis corresponds to the case in which all decisions are made in a decentralized fashion.

Given the value of c determined in the first period, in the second period the agent's

[20] The model is not tailored to study addiction. However, the key force of commitment to delay undesirable temptations for immediate gratification is relevant for addiction as well.

[21] We also note that our results carry through almost directly to a citizen-candidate model (under plurality rule) of collective action, for moderate candidacy costs. In that case, in all the scenarios we consider, as in Proposition 1 in Osborne and Slivinski (1996), one citizen would put forward her candidacy and select the policies we characterize.

problem is given by:

$$\max_x U_2(x,c,\beta) \Longleftrightarrow \max_x v_2 x - k\left(x,c\right) + \beta v_3\left(1-x\right).$$

Let $x\left(c,\beta\right)$ denote the solution to this problem.

$$x(c,\beta) = \begin{cases} 1 & \beta < \left(v_2 - \frac{\partial k(1,c)}{\partial x}\right)/v_3 \\ (v_2 - \beta v_3) = \frac{\partial k(x(c,\beta),c)}{\partial x} & \left(v_2 - \frac{\partial k(1,c)}{\partial x}\right)/v_3 \leq \beta < \left(v_2 - \frac{\partial k(0,c)}{\partial x}\right)/v_3 \\ 0 & \beta \geq \left(v_2 - \frac{\partial k(0,c)}{\partial x}\right)/v_3 \end{cases}. \quad (1)$$

Intuitively, whenever the agent either experiences less present bias or higher marginal costs of immediate consumption, delay is more likely. At the extremes, if marginal costs of cutting the whole tree are not too high (namely, $\frac{\partial k(1,c)}{\partial x} < v_2$), very impatient agents will not delay any consumption. Virtuous agents, for whom the marginal costs of very little early consumption outweigh the benefits, will cut the entire tree in period 3. The monotonicity of the consumption function $x(c,\beta)$ is captured by the following lemma, which will be useful for our analysis of the collective-choice settings.

Lemma 1 (Consumption Monotonicity) *The fraction of the tree consumed in period* 2, $x(c,\beta)$, *is decreasing in both* c *and* β.

The first period problem can be written as:

$$\max_c U_1(x,c,\beta) \Longleftrightarrow \max_c \beta v_3 + x\left(c,\beta\right)\left(\beta v_2 - \beta v_3\right) - \beta k\left(x\left(c,\beta\right),c\right) - I\left(c\right)$$

Let $c\left(\beta\right)$ be the solution of this problem. We want to understand the dependence of the commitment parameter $c(\beta)$ on β, which will be an essential input into the collective-action problem.

In order to glean some intuition on the dependence of c on β, consider the case in which $x(c,\beta)$ is interior and differentiable with respect to c. Notice that:

$$\frac{\partial U_1}{\partial c} = \frac{\partial x\left(c,\beta\right)}{\partial c}\beta\left(\left(v_2 - v_3\right) - \frac{\partial k\left(x\left(c,\beta\right),c\right)}{\partial x}\right) - \beta\frac{\partial k\left(x\left(c,\beta\right),c\right)}{\partial c} - I'\left(c\right).$$

In contrast to the standard dynamic optimization problem with geometric discounters, the envelope condition fails and the indirect effect on period 2 consumption does not disappear. Indeed, substituting the second period first-order conditions we obtain:

$$\frac{\partial U_1}{\partial c} = -\beta\left(\frac{\partial x\left(c,\beta\right)}{\partial c}\left(\left(1-\beta\right)v_3\right) + \frac{\partial k\left(x\left(c,\beta\right),c\right)}{\partial c}\right) - I'\left(c\right).$$

The benefit of commitment is captured by the term $-\beta\frac{\partial x(c,\beta)}{\partial c}\left(\left(1-\beta\right)v_3\right)$. This term is increasing in the degree of present bias and captures the fact that the period 1 self and the period 2 self disagree on the value of cutting the tree in period 2.

There are several effects of changes in β on the optimal choice of c. As β increases more weight is put on the future, pushing for more early commitment investment. Furthermore, the fraction of the tree consumed in period 2, $x\left(c,\beta\right)$, is smaller, leading to a smaller marginal cost $\frac{\partial k(x(c,\beta),c)}{\partial c}$ tomorrow. Nonetheless, as β becomes larger, time inconsistency becomes less relevant, so the benefit of $\left(1-\beta\right)v_3$ is smaller. When β is close to zero or close to $\frac{v_2}{v_3}$ period 1 investment will be zero, so investment is not monotone. Intuitively, agents for whom time inconsistency is very severe foresee that reasonably priced commitments will not save them from excessive consumption in period 2 and therefore acquire limited commitment. On the other side of the spectrum, agents who are virtuous (characterized by high β), do not suffer from great temptation in period 2 and therefore do not require extreme commitment to enable them to postpone consumption. In particular, recall that when $\beta \geq v_2/v_3$, agents choose $x\left(c\,,\beta\right)=0$ for all c so their optimal investment in commitment is zero: $c\left(\beta\right)=0$ for all $\beta \geq v_2/v_3$.

In general, $c(\beta)$ may achieve several local maxima between 0 and $\frac{v_2}{v_3}$. The following example illustrates a case in which $c(\beta)$ is concave in this region and only one maximum exists.

Example (Quadratic Commitment Costs) Consider the case of $k\left(x,c\right)=\left(c+v_2\right)\frac{x^2}{2}$ and $I\left(c\right)=\frac{c^2}{2}$. The second period utility is then given by:

$$U_2\left(x,c,\beta\right)=\beta v_3+x\left(v_2-\beta v_3\right)-\left(c+v_2\right)\frac{x^2}{2}$$

and the corresponding first-order condition requires that:

$$x\left(c,\beta\right)=\begin{cases}\frac{\left(v_2-\beta v_3\right)}{\left(c+v_2\right)} & \beta\leq\frac{v_2}{v_3}\\ 0 & \beta>\frac{v_2}{v_3}\end{cases}.$$

Notice that $x(c,\beta)$ is decreasing in β, achieving the maximal value of 1 when $\beta=0$.[22] This generates a second period utility of:

$$U_2(x(c,\beta),c,\beta)=\beta v_3+\frac{\left(v_2-\beta v_3\right)^2}{2\left(c+v_2\right)}.$$

[22] In particular, our specification of the cost function $k(x,c)$ assures that consumption is interior for $\beta\in(0,\frac{v_2}{v_3})$.

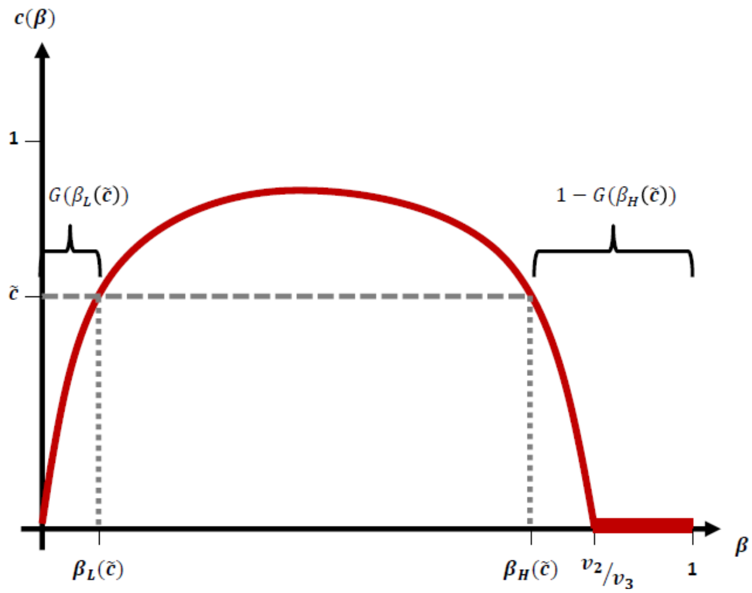

Figure 1: Commitment for the Quadratic Case

Plugging these values into period 1's objective function yields:

$$U_1 = \beta v_3 + \beta \frac{(v_2 - \beta v_3)}{(c + v_2)} (v_2 - v_3) - \beta \frac{(v_2 - \beta v_3)^2}{2(c + v_2)} - \frac{c^2}{2}.$$

The optimum is given by:

$$c(\beta) = \begin{cases} \frac{\alpha_1}{\alpha_2 \sqrt[3]{P_3(\beta) + \sqrt{P_6(\beta)}}} + \sqrt[3]{P_3(\beta) + \sqrt{P_6(\beta)}} - \alpha_3 & 0 < \beta \leq \frac{v_2}{v_3} \\ 0 & \frac{v_2}{v_3} < \beta \leq 1 \end{cases},$$

where $\alpha_1, \alpha_2, \alpha_3$ are positive constants depending on v_2 and v_3, while $P_k(\beta)$ is a polynomial of degree k in β (with coefficients determined by v_2 and v_3).

Figure 1 illustrates the emerging result of $c(\beta)$. As highlighted by the figure, the greatest commitment constraints are chosen by individuals with moderate levels of time inconsistency.

5 Electoral Outcomes

We now turn to inspect the effects of collective action on agents' choices. We start by analyzing the case in which only the choice of commitment levels is done through an electoral process. We then proceed to a case in which both commitment and the timing of consumption are decided upon collectively.

5.1 Collective Commitment with Decentralized Choice

In this setting, the commitment parameter c is determined collectively. From the point of view of an agent of type β, the voting problem is determined as follows. From the analysis of the private decision problem of an agent of type β, if a commitment parameter c is chosen, and subsequent choices are made optimally by the agent, period 1 utility is given by

$$U_1 (x (c, \beta), c, \beta) = \beta v_3 + x (c, \beta) (\beta v_2 - \beta v_3) - \beta k (x (c, \beta), c) - I (c). \tag{2}$$

Thus, the agent votes for candidate 1 offering commitment c_1 over candidate 2, who offers commitment c_2, whenever

$$U_1 (x (c_1, \beta), c_1, \beta) > U_1 (x (c_2, \beta), c_2, \beta).$$

Proposition 1 *Assume that $\frac{\partial k(1,c)}{\partial x} \geq v_2$ for all c. There is a unique pure strategy equilibrium of the collective commitment game in which both candidates offer a platform c^{CD}. Furthermore, when $c(\beta)$ has a unique local maximum in $\left(0, \frac{v_2}{v_3}\right)$, the platform c^{CD} corresponds to the ideal policy for a voter of type β^{CD}, where β^{CD} is higher than the median β, $\beta^{CD} \geq \beta_M$.*

The quadratic case in the example above is useful in illustrating the intuition underlying Proposition 1. Consider Figure 1. If $1 - G(\frac{v_2}{v_3}) \geq 1/2$, there is a majority of agents who prefer no commitment and the equilibrium commitment parameter is naturally $c^{CD} = 0$, which coincides with that preferred by the median. Otherwise, for every $\tilde{c} > 0$, define $\beta_L(\tilde{c})$ and $\beta_H(\tilde{c})$ such that $\tilde{c}$ is their ideal point, i.e. $c(\beta_L(\tilde{c})) = c(\beta_H(\tilde{c})) = \tilde{c}$. All agents with preference parameters below $\beta_L(\tilde{c})$ and above $\beta_H(\tilde{c})$ prefer commitment parameters lower than $\tilde{c}$, while agents with preference parameters between $\beta_L(\tilde{c})$ and $\beta_H(\tilde{c})$ prefer preference parameters above $\tilde{c}$. In particular, the equilibrium commitment parameter c^{CD} is chosen so that these two classes of agents are of equal proportions. That is, $G(\beta_L(c^{CD})) + (1 - G(\beta_H(c^{CD}))) = 1/2$. By construction, $\beta_M \in (\beta_L(c^{CD}), \beta_H(c^{CD}))$ and the result follows. In fact, note that in this case the equilibrium commitment level corresponds to a voter of type β^{CD} that is strictly higher than the median, $\beta^{CD} > \beta_M$. Furthermore, when $c(\beta)$ has a unique local maximum, this construction suggests that equilibrium commitment is lower than that corresponding to the median preferences. That is, $c^{CD} \leq c(\beta_M)$.[23]

This construction of the equilibrium level of commitment can be adapted to environments in which $c(\beta)$ entails several local maxima, it is only the relation to the median agent's

[23] The construction suggests that median preserving spreads of the distribution G would lead to lower equilibrium commitment levels.

preferred level of commitment that hinges on $c(\beta)$ having a unique maximum. However, the construction does rely on all agents having single-peaked preferences with respect to the commitment parameter c. Indeed, in this case, agents with high taste parameter β prefer no investment in commitment, while all others prefer a positive amount of commitment. The condition on $\frac{\partial k(1,c)}{\partial x}$ assure that even individuals with very low parameters β benefit from some level of commitment.[24]

5.2 Collective Commitment with Centralized Choice

We now discuss the case in which the second period choice is also taken via collective action. Two office-motivated candidates, 1 and 2, offer platforms x_1 and x_2 in the second period.

From the analysis of individual choices, recall that (1) provides the second period optimal choice $x(c,\beta)$ for any given commitment parameter c selected in period 1. From Lemma 1, $x(c,\beta)$ is decreasing in β. It is then clear that for any given choice of c in the first period, both candidates will choose to offer the ideal policy of the median voter β_M. Thus, the second period choice will be $x(c,\beta_M)$.

We can now step back and consider a generic voter's first period utility in this scenario.

$$U_1\left(x\left(c,\beta_M\right),c,\beta\right)=\beta v_3+x\left(c,\beta_M\right)\left(\beta v_2-\beta v_3\right)-\beta k\left(x\left(c,\beta_M\right),c\right)-I\left(c\right). \tag{3}$$

Since $x(c,\beta_M)$ is fixed for all β, the choice of commitment in the first period is driven by the desire to commit of an agent of median taste parameter β_M. Denote by $c(\beta,\beta_M)$ the (constrained) optimal commitment parameter for an agent of taste β, foreseeing the second period choice being determined according to the taste of the median parameter β_M. As it turns out, $c(\beta,\beta_M)$ is monotonic in β, with individuals who care more about future consumption preferring greater investment in commitment, as illustrated in the following lemma.

Lemma 2 (Constrained Commitment Monotonicity) *The optimal constrained commitment $c(\beta,\beta_M)$ is increasing in β.*

Note that the monotonicity in β of desired commitment is in contrast with the analysis of both the fully decentralized scenario as well as of the centralized commitment with decentralized choice scenario. The logic for this is the following. The value of investment in commitment is now in reducing incentives for the median agent to cut the tree early. This is particularly valuable for the high-β agents.

[24] We note that it would suffice to assume that $\frac{\partial k(1,c)}{\partial x} \geq v_2$ only for $c>0$, which is satisfied by our running quadratic example.

Lemma 2 implies that it is median preferences that determine first period choices as well. This is captured in the following proposition.

Proposition 2 *When both commitment and consumption are chosen collectively, equilibrium outcomes coincide with those chosen optimally by agents with the median taste parameter β_M.*

It also interesting to highlight how optimal constrained commitment $c(\beta, \beta_M)$ changes as β_M changes. Indeed, the marginal benefit of commitment $(1 - \beta_M)\, v_3$ is higher when β_M is lower and so for the case of interior solutions it follows that:

Remark *Assume that $\frac{\partial k(1,c)}{\partial x} \geq v_2$. Then the optimal constrained commitment $c(\beta, \beta_M)$ is* decreasing in β_M.

The following example illustrates how the optimal constrained commitment and the equilibrium outcome work for the case of quadratic consumption costs.

Example 2 (Quadratic Costs – Fully Centralized Solutions) Consider the setting of Example 1. Assume first $\beta_M < \frac{v_2}{v_3}$. Plug in $x\,(c, \beta_M)$ into U_2 to get

$$U_2(x\,(c, \beta_M)\,, c, \beta) = \beta v_3 + \frac{v_2 - \beta_M v_3}{c + v_2}\,(v_2 - \beta v_3) - \frac{(v_2 - \beta_M v_3)^2}{2\,(c + v_2)}.$$

Moving back to period 1 we obtain:

$$U_1(x\,(c, \beta_M)\,, c, \beta) = \beta v_3 + \frac{v_2 - \beta_M v_3}{c + v_2}\,(\beta v_2 - \beta v_3) - \beta\frac{(v_2 - \beta_M v_3)^2}{2\,(c + v_2)} - \frac{c^2}{2}.$$

The optimal choice of commitment is given by:

$$c(\beta, \beta_M) = \frac{\tilde{\alpha}_1}{\sqrt[3]{P_1(\beta) + \sqrt{P_2(\beta)}}} + \sqrt[3]{P_1(\beta) + \sqrt{P_2(\beta)}} - \tilde{\alpha}_2,$$

where the positive constants $\tilde{\alpha}_1, \tilde{\alpha}_2$, as well as the coefficients of the polynomials $P_1(\beta)$ and $P_2(\beta)$ (of degrees 1 and 2,respectively) are functions of v_1, v_2, and β_M.

Figure 2 depicts $c\,(\beta, \beta_M)$ for different values of $\beta_M \in \left(0, \frac{v_2}{v_3}\right)$.

As Figure 2 illustrates, the optimal desired amount of commitment $c(\beta, \beta_M)$ is increasing in β and decreasing in β_M. Notice, however, that the equilibrium level of commitment is given by $c(\beta_M, \beta_M) \equiv c(\beta_M)$, which is not monotonic.

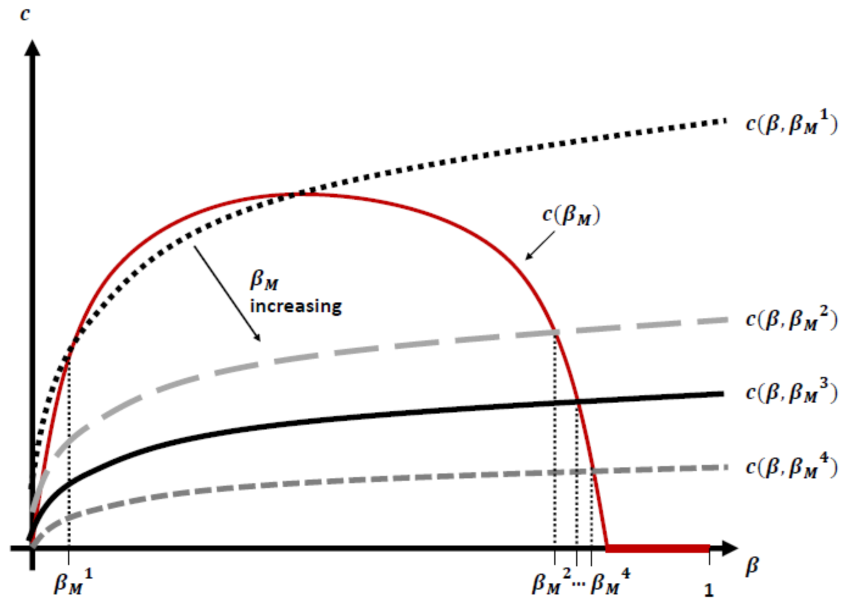

Figure 2: Constrained Commitment for Different Median Preferences

We can now compare the level of commitment in the two collective-action scenarios. When $c(\beta)$ has a unique maximum, Proposition 1 assures that the platform c^{CD} chosen in equilibrium corresponds to the ideal policy for a voter of type β^{CD}, where β^{CD} is higher than the median β, $\beta^{CD} \geq \beta_M$. Furthermore, the construction of the proof of Proposition 1 (extending that appearing for the quadratic case in Example 1) illustrates that $c(\beta^{CD}) \leq c(\beta_M)$ when $c(\beta)$ has a unique local maximum. Therefore, we have the following proposition.

Proposition 3 *Assume that* $\frac{\partial k(1,c)}{\partial x} \geq v_2$ *and suppose that* $c(\beta)$ *has a unique local maximum in* $\left(0, \frac{v_2}{v_3}\right)$. *The equilibrium choice of commitment is higher under full centralization than in the decentralized choice scenario.*

Note that this proposition shows that the optimal amount of commitment is higher in the fully centralized economy although the decisive voter is an agent with a lower β. This is, of course, due to the non monotonicity of $c(\beta)$ and illustrates the fact that delegating the commitment choice to a more virtuous agent may not lead to higher commitment.

When $c(\beta)$ has multiple local maxima, the comparison between the equilibrium commitment levels generated by full centralization and decentralized choice is inconclusive and, in principle, can go either way.

5.3 Decentralized Commitment with Centralized Choice

We now consider the case in which individuals privately invest in commitment, but in period 2 there is an election that determines the time for consumption for all individuals.

Proposition 4 *There is a unique equilibrium of the decentralized commitment, centralized choice case in which all voters choose* $c = 0$*.*

The intuition for this result is that there is free riding in commitment investment. Investment in commitment is only useful if it affects the choice in period 2. But, this choice is made collectively, and the probability that an agent is pivotal in period 2 is vanishingly small when there are many agents so the incentive to invest in commitment also disappears.[25]

This result suggests the following observation. Suppose that in the decentralized setting we observe a median individual making responsible choices in period 2. One may naively conclude that centralizing consumption would be beneficial because it would lead to responsible choices for the entire population, including those who were choosing irresponsibly. However, our result shows that such partial centralization would undermine the incentive to commit that in turn allowed the median person to choose responsibly in period 3. For instance, if $\beta_M < \frac{v_2}{v_3}$, then in this scenario the median choice would be to consume the entire tree in period 2. This discussion suggests that partial centralization may be harmful: centralization of consumption choices should be accompanied by centralization of commitment. We discuss this intuition more formally in the next section.

It is also interesting to note that the zero investment result in this Proposition still holds in the case of a homogeneous population. This is notable since in all of the previous scenarios, outcomes for a homogeneous population would coincide with those generated by a fully decentralized, laissez faire system. Indeed, in our other settings, the key ingredient determining outcomes is the identity of the decisive agent. However, in the setting where only consumption is centralized, the decision-making process itself undermines the incentive to commit. It inherently entails a free rider problem that leads no one to invest in commitment regardless of the distribution of preferences and, in turn, may harm the population as a whole.

[25] This result does rely on the continuum of voters assumption. If the population is finite, more 'efficient' equilibria may exist in which an exact majority invests in the private (decentralized) commitment. In that case, any individual choosing $c = 0$ is best responding since she gains her ideal commitment choice in period $t = 2$. If an investing individual deviates to a lower commitment level, she becomes pivotal at $t = 2$. Therefore, choosing the optimal decentralized level of commitment is optimal for her. In a world with a finite number of voters more care would be needed. However, any amount of noise in turnout would still generate zero investment in commitment in the limit when the voting population becomes large.

5.4 Comparison of Outcomes

We showed that, under some regularity assumptions, commitment investment is larger in the scenario with full centralization relative to the scenario where only commitment is centralized. Because there is no investment in commitment in the case of decentralized commitment and centralized choice, that scenario leads to the lowest aggregate investment in commitment. The comparison between full decentralization and the systems involving centralized commitment choices is instead ambiguous. One obvious case in which the fully decentralized outcome leads to higher investment in commitment is when the median voter is virtuous: $\beta_M \geq \frac{v_2}{v_3}$. In this case all scenarios with some degree of centralization of commitment decisions generate no commitment investment, whereas some investment takes place in the fully decentralized scenario as long as there is a positive mass of individuals who are not virtuous. Finally, in order to construct an example in which centralized commitment leads to higher investment, consider a case where the median voter β_M is such that $c(\beta_M)$ is maximal (i.e., $\beta_M \in \arg\max c(\beta)$). In this case the fully centralized scenario leads to the maximal investment that would be chosen by anybody in the population. All other scenarios lead to lower investment in the aggregate.

6 Welfare Consequences

We now turn to the welfare consequences of each of the political processes analyzed above. In the case of time inconsistent agents, the appropriate welfare criterion is debatable.[26] We start by measuring welfare as the utility of first period agents. We later turn to consider period-zero welfare assessments.

6.1 Period-One Welfare

We denote by $\Pi^{DD}(G), \Pi^{DC}(G), \Pi^{CD}(G)$, and $\Pi^{CC}(G)$ the expected utilitarian welfare corresponding to the fully decentralized, decentralized-centralized, centralized-decentralized, and centralized-centralized systems, respectively, when the underlying preference distribution is given by G. We will at times abuse notation and drop the argument of the welfare function when clarity is not compromised. For presentation simplicity, we assume that $k(x, 0) = 0$ for all x so that no commitment leads agents to experience no costs of early consumption.

The main idea behind our comparison in the welfare generated by the four institutions that we consider is that of delegation. Centralization effectively allows delegation of specific

[26] For a discussion, see Bernheim and Rangel (2009).

decisions to a particular individual. In the setting of our model without any externalities, standard geometric discounters would have no reason to delegate and so laissez faire would dominate all other systems. For individuals with self-control problems, from the perspective of period one welfare, we must distinguish between delegation of consumption choices and delegation of investment in commitment. All individuals benefit from delegating consumption decisions to individuals who are more virtuous than them (higher β) and harmed by delegating decisions to individuals who have worse self-control (lower β). On the other hand, no period-1 self benefits from delegating the commitment decision because there is no self-control problem in period 1.

We start by showing that partial centralization, i.e., mandating only one decision (either commitment *or* consumption) is dominated by either full centralization or laissez-faire.

Proposition 5 *For all preference distributions, either full centralization or full decentralization are welfare maximizing. That is,* $\max\left\{\Pi^{DD}, \Pi^{CC}\right\} \geq \max\left\{\Pi^{CD}, \Pi^{DC}\right\}$.

The proof of this result is quite straightforward. Note first that under laissez faire individuals can always emulate the decisions generated by the centralized-decentralized system: they can choose a commitment level of c^{CD}. Therefore, $\Pi^{DD} \geq \Pi^{CD}$. Let β^* be the threshold preference parameter corresponding to agents who are just indifferent between postponing consumption or consuming immediately in period 2 given zero commitment: $v_2 = \beta^* v_3$. By Proposition 4, in the decentralized-centralized system there is zero investment in commitment. If the median voter is not sufficiently virtuous ($\beta_M < \beta^*$) this leads to $x = 1$: full consumption of the tree in period 2 because early consumption comes at no cost, $k(x, 0) = 0$. In this case, welfare is higher under laissez faire: all agents with preference parameter $\beta < \beta^*$ can do no worse than this, and all virtuous agents with preference parameters $\beta \geq \beta^*$ manage to delay consumption to period 3 even if they do not invest in commitment. It follows that when $\beta_M < \beta^*$, $\Pi^{DD} \geq \Pi^{DC}$. Suppose now that the median voter is virtuous, $\beta_M \geq \beta^*$. In this case, under both the decentralized-centralized and centralized-centralized system, there is no investment in commitment and all consumption is delayed to period 3, so that, in this case, $\Pi^{CC} = \Pi^{DC}$.

The comparison between the fully centralized system and a laissez faire economy depends on the distribution of preferences. Roughly speaking, when the median β is high, centralization is beneficial because a centralized political process allows all agents to delegate choice to a virtuous voter who commits to efficient actions at low costs. On the other hand, when the median voter is prone to a strong present-bias (low β_M), collective decisions lead to bad outcomes: low investment in commitment and high levels of early consumption. In these cases, decentralized decisions do better because at least some of the virtuous voters do well: they are not bound by the self-control problems of a low median β. The following result provides sufficient conditions for ranking the two systems.

Proposition 6 *Suppose* $\frac{\partial k(1,c)}{\partial x} \geq v_2$.

1. *If* $G(\beta^*) > 0$, *and* $\beta_M \geq \beta^*$, *then full centralization is best:* $\Pi^{CC}(G) > \Pi^{DD}(G)$;
2. *Consider a sequence of distributions* $\{G_n\}_{n=1}^{\infty}$ *with corresponding medians* $\{\beta_M^n\}_{n=1}^{\infty}$. *If there exists* $\tilde{\beta} > 0$ *such that* $\left\{G_n(\tilde{\beta})\right\}$ *is uniformly bounded below* 1 *and* $\lim_{n\to\infty} \beta_M^n = 0$, *then there exists* n^* *such that for all* $n > n^*$, *laissez faire is best:* $\Pi^{DD}(G_n) > \Pi^{CC}(G_n)$.

Part 1 of this result says that a sufficient condition for full centralization to be best is that the median voter is sufficiently high that no commitment is required to ensure no early consumption. Of course, this condition is not necessary: for instance, if the median voter is characterized by a preference parameter slightly lower than β^*, a moderate amount of investment in commitment ensures almost no early consumption.

Part 2 is more involved: the condition on the sequence of distributions is ruling out the possibility that there is a sequence such that β_M is converging to zero but there is a vanishing mass of agents whose β is larger than β_M. In such cases centralization would still be best.

Proposition 8 is effectively a delegation result. When the median voter is sufficiently virtuous, the electorate benefits from delegating decisions to the median voter. Recall that the desire to delegate only regards consumption decisions: individuals do not like delegating commitment decisions.

The quadratic costs example is useful in visually illustrating how the different political processes fare in terms of welfare as a function of the underlying preference distribution in the electorate.

Example 3 (Quadratic Costs – Welfare Comparisons) Consider the settings of Examples 1 and 2 above and suppose that G is a triangular distribution with a peak at $d \in (0,1)$. Figure 3 depicts the welfare levels generated by the different processes as a function of the median agent's preferences when $v_2 = 1$ and $v_3 = 3/2$, and $I(c) = 0.0005c^2$.[27] We use the fully decentralized setting as a baseline for comparison.

[27] For a triangular distribution with a peak at d, the corresponding median is given by:

$$\beta_M = \begin{cases} \sqrt{d}/\sqrt{2} & d \geq 1/2 \\ 1 - \sqrt{1-d}/\sqrt{2} & d < 1/2 \end{cases} .$$

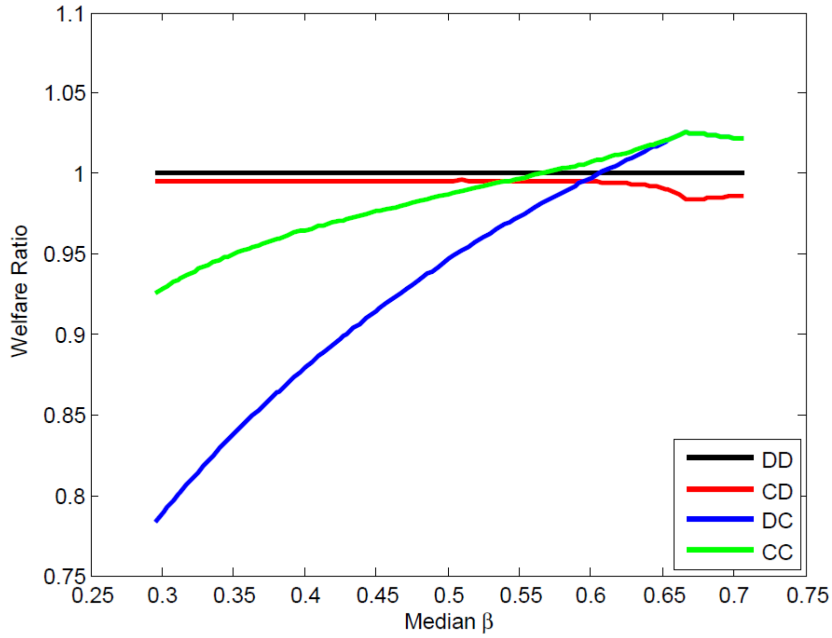

Figure 3: Welfare Comparison for Different Median Preferences

The figure illustrates the way that the four scenarios compare in terms of first-period welfare. Full centralization reaches the highest welfare when the median β is high. Full centralization and decentralized commitment-decentralized choice have the same level of welfare when the median is above $2/3$ because $2/3 = v_2/v_3$ for our parameters and in these cases no commitment is necessary to induce zero tree-cutting in period two. However, the decentralized commitment-centralized choice scenario is a lot worse for lower values of the median β. When the median β is lower full decentralization leads to the best outcome, with centralized commitment-decentralized choice a close second. The reason why the comparison between these scenarios becomes much more favorable to full centralization (especially relative to the setting in which only commitment is centralized) for high values of median β is that when the median β is high there is no commitment in equilibrium, and, under decentralized choice, this harms the individuals with lower β. One interesting aspect of the comparison among welfare levels is that commitment and consumption, are 'complementary': either full centralization or full decentralization generate the greatest levels of welfare, whereas partial centralization yields inferior welfare results.

It is also instructive to compare the welfare resulting from our political processes to that generated by an economy that does not allow for commitment. Denote by Π^S the expected first period utilitarian surplus absent any commitment instruments:

$$\Pi^S = \int_0^{\beta^*} \beta v_2 dG(\beta) + \int_{\beta^*}^1 \beta v_3 dG(\beta). \tag{4}$$

It is easy to construct example where the welfare generated by some centralized political system is worse than Π^S. For instance, if there is a substantial mass of virtuous agents and the median β_M is very low, $\Pi^S > \Pi^{CC}$. In other words, if the constitution makes a bad delegation decision, welfare is even lower than in an economy with no possibility of investing in commitment. However, it is easy to see that $\Pi^S \leq \min\left\{\Pi^{DD}, \Pi^{CC}\right\}$. In fact, $\Pi^S \leq \Pi^{DD}$: under laissez-faire agents can always emulate the no commitment environment by choosing a commitment level of 0. Thus, whenever a positive commitment level is chosen by an individual, the induced first-period utility is higher than that absent commitment.

6.2 Period-Zero Welfare

It is also useful to consider the welfare comparison among the various scenarios from the point of view of period zero, before the commitment choice is made.

Period 0 utility for an agent of type β is given by

$$U_0(x(c,\beta), c, \beta) = \beta\left\{v_3 + x(c,\beta)(v_2 - v_3) - k(x(c,\beta), c) - I(c)\right\}. \tag{5}$$

Comparing expressions (5) and (2) makes it clear that there is an important difference between the period-zero and the period-one perspective: from the point of view of the period-zero self, the commitment choices themselves are now subject to self-control problems. The main consequence of this for our analysis of collective action is that, in contrast to our previous discussion, the period-zero self may now have the incentive to delegate commitment decisions because her period-one self "under-commits."

Despite these differences, an analogous result to Proposition 5 still holds when considering welfare in period zero: If the median voter is sufficiently virtuous, mandating decisions, or delegating them to the virtuous median voter, full centralization is beneficial relative to a laissez faire setting; in contrast, if the median voter has high degree of present bias (low β), then laissez faire is better.

With respect to partial centralization, notice first that full centralization Pareto dominates (for all preference parameters β) the decentralized commitment, centralized consumption system. Indeed, both systems generate a uniform profile of commitment and consumption for all agents. Therefore, all period-zero selves, regardless of their preference parameter

β, rank the two systems alike. However, the agent with median preference parameter β_M is certainly better off in the fully centralized system, which in turn implies that all agents are.

The comparison with the centralized commitment, decentralized consumption system is more intricate. As mentioned, in period zero agents can no longer emulate period-one commitment decisions when considering a laissez faire economy, and for particular settings in which median preferences are not virtuous enough, mandating commitment alone may be superior to both full centralization and full decentralization.

7 Extensions

7.1 Naive Agents

In the literature, when modeling time inconsistent agents, an assumption of naivete is sometimes made in contrast to the assumption of sophistication we have assumed so far.[28] Naive agents have $\beta - \delta$ preferences, but believe that they will have standard geometric preferences in any future period. Sometimes agents are assumed to be partially naive. This is modeled as agents having beliefs about their future selves that are intermediate between full sophistication and full naivete.

Most of our analysis would go through, with some modifications, if agents were partially naive. However, it is useful to comment on the qualitative impact of such agents in the electorate. To simplify our discussion, suppose that some agents in the population are fully naive.

In our model naive agents behave like time consistent (high β) individuals in period 1: they do not have any demand for commitment because they are unaware of their time inconsistency problem. Therefore, the higher the mass of naive agents in the economy, the lower the investment in commitment in equilibrium. However, once period 2 arrives, these agents are tempted by immediate consumption, lowering the effective pivotal β in the centralized consumption scenario. Overall, the presence of these naive agents reduces welfare for the sophisticated agents. However, the naive agents make "worse" individual choices than sophisticated agents so they are more likely to benefit from centralization. If the naive agents constitute a majority and the median β in the second period is such that $\beta < \frac{v_2}{v_3}$, then full decentralization is best: the political outcomes of any centralized decisions would be bad so decentralization would at least deliver good choices for the relatively high β, sophisticated agents.

[28] See, for instance, O'Donoughue and Rabin (1999).

If the naive agents are a minority, then there are opposing forces in favor and against centralization: the presence of the naive agents worsens the choices but the naive agents benefit more from centralization.

7.2 Commitment Subsidies

Instead of considering a centralized commitment scenario where the elected government chooses the amount of commitment in period 1, one could consider a scenario where candidates propose subsidies to commitment. If a voter receives a subsidy s, the choice of commitment in period 1 can be obtained by maximizing

$$U_1\left(x\left(c,\beta\right),c,\beta,s\right)=\beta v_3+x\left(c,\beta\right)\left(\beta v_2-\beta v_3\right)-\beta k\left(x\left(c,\beta\right),c\right)-I\left(c,s\right)$$

where $\frac{\partial I(c,s)}{\partial s}$ is decreasing in s. Thus, the amount of commitment chosen by each individual is increasing in s. However, the voting decision between two candidates who offer different levels of subsidies needs to take into account the budgetary impact of the subsidies and how the corresponding expenses are distributed in the population. The total amount of subsidies depends on the aggregate amount of commitment. Consider then a setting in which subsidies are chosen collectively, and consumption is chosen in a decentralized fashion. If the burden is shared equally across the electorate,[29] it can be shown that the pivotal agent remains that with a preference parameter β^{CD} (the pivotal agent in our baseline centralized commitment-decentralized consumption setting absent subsidies). If this agent invests relatively little in commitment, the value of subsidies for her is lower than her contribution to the collective pool covering overall subsidies in the population. In this case, the outcome of the election would generate zero subsidies. On the other hand, if this agent has a relatively high investment in commitment, so that she is a net beneficiary of the subsidies, she will support fairly high subsidies. In this case, the outcome would lead to higher investment in commitment by all agents relative to that chosen under the fully decentralized scenario. Note, however, that from the perspective of period 1, commitment subsidies generate lower welfare than a laissez-faire economy.

[29] Formally, for any profile of commitment $c(\beta)$, the overall cost of a subsidy level s is given by:

$$\int_0^1 I(c(\beta))dG(\beta)-\int_0^1 I(c(\beta),s)dG(\beta),$$

which is shared equally within the population.

7.3 Consumption Caps

We now consider a scenario in which the government can impose caps on early consumption. Specifically, assume that commitment choices in period 1 are private but, in period 2, the two candidates each propose a cap $\bar{x}_i$ on the fraction of the tree that can be consumed by any individual. Each agent can then choose an amount $x \leq \bar{x}$ of the tree. It can easily be shown that in this setting there is an equilibrium with no caps and the same commitment and consumption choices as in the laissez faire scenario. Namely, at $t = 1$, all agents implement their preferred commitment (as given by $c(\beta)$), expecting there to be no cap ($\bar{x} = 1$). At $t = 2$, both candidates offer $\bar{x} = 1$ and all agents consume as in the fully decentralized setting, $x(c(\beta), \beta)$. All we need to show is that at $t = 2$, offering no cap is an equilibrium for the candidate. Agents for whom $x(c(\beta), \beta) > 0$ would not like to tie their hands so they would vote against any binding cap and are indifferent to any looser cap. Agents for whom $x(c(\beta), \beta) = 0$ do not require a cap (in fact, they are indifferent between all levels of the cap), so they are willing to vote against a cap. Therefore, this profile constitutes an equilibrium.

7.4 Supplementing Commitment

Another natural extension pertains to agents' potential ability to supplement commitment investments that are chosen by the government.

Suppose public and private commitments are governed by the same technology. That is, for any government choice of commitment c_g, each agent experiences a period 1 cost of $I(c_g)$, while additional private commitment of c_p leads the agent to experience an overall period 1 cost of $I(c_g + c_p)$. That is, the cost of supplementing public investment in commitment is incremental. Our equilibrium characterization changes only in the centralized commitment, decentralized consumption setting. Since commitment costs are convex, the government's commitment technology is not inferior to the private technology, and the amount of commitment chosen by the government is given by our Proposition 1. Individuals who seek greater commitment will then supplement the collective commitment privately. From a welfare perspective, this setting still generates lower welfare levels than the fully decentralized one as agents can emulate the generated outcomes privately.

Suppose instead that public and private commitment technologies are independent, so that a choice of government commitment c_g and private commitment c_p generate a period 1 cost of $I_g(c_g) + I_p(c_p)$, where I_g and I_p satisfy our assumptions on the underlying commitment technology that were made in Section 3. In this case, when commitment is subject to collective action agents will typically mix private and public investment. The precise formulation of the equilibrium characterization in the relevant two settings depends more intricately on the functional forms of our model. In such settings, centralizing commitment alone may be beneficial relative to full decentralization as that setting effectively provides individuals access to an aggregate commitment cost technology that is more efficient: individuals can smooth the cost of commitment by splitting their commitment investments between public and private ones.

7.5 Linear Commitment Costs and Single-Peaked Preferences

Throughout the paper, we have often assumed that $\frac{\partial k(1,c)}{\partial x} > v_2$. In that case, individual preferences for commitment are single peaked. When preferences are not single peaked, our analysis needs to be modified, especially for the case of centralized commitment-decentralized consumption.

We will now outline what happens when preferences are not single peaked by considering the special case of linear costs (and dropping the requirement that $\frac{\partial k(x,0)}{\partial x} = 0$). This case is useful since its structure is particularly simple. We first emphasize that the main welfare results still hold in this case. However, the equilibrium construction is more complex.

When consumption costs are linear, we can normalize parameters so that $k(x, c) = cx$. Furthermore, the optimal choice in the second period is generically either $x = 0$ or $x = 1$. In case of indifference, we will assume that an agent breaks the indifference to favor her "commitment self," i.e., she chooses $x = 0$.[30]

Suppose that in period 1 a cost c was chosen, and consider the period 2 choice problem of a voter of type β. She will consume in period 3 if and only if

$$U_2 = v_2 - c \leq \beta v_3. \tag{6}$$

Thus, as before, agents with $\beta > \frac{v_2}{v_3}$ are not willing to pay for commitment: they do not find it necessary.

Commitment is perceived beneficial in period 1 if the delay in consumption due to commitment is worth its costs $I(c)$. That is, whenever there is a commitment parameter c such

[30] This setting can fit a special case of Gul and Pesendorfer (2001, 2004, 2007) type of preferences. Namely, suppose that two functions govern an individual's utility from consumption: $u(x)$ is the direct utility of x, while $v(y)$ is the temptation cost of not having consumed y available at the time of choice. In such a setting, in order to delay consumption in period 2, $u(v_3) - v(v_2) \geq u(v_2)$. Suppose $u(x) = x$ and $v(y) = \alpha y$, where $\alpha > 0$. Then delayed consumption in period 3 occurs when $v_3 \geq v_2(1 + \alpha)$, which is analogous to our linear costs case when taking $\beta = \frac{1}{1+\alpha}$.

that:

$$\beta v_3 - I(c) \geq \beta v_2 \iff \beta(v_3 - v_2) \geq I(c). \tag{7}$$

How do investment incentives now vary with β? It is very difficult (and costly) to make low β agents wait until period 3 to consume. On the other side of the spectrum, high β agents are virtuous and will wait till period 3 even with no commitment instruments. Therefore, investment only pays for intermediate β's.

Thus, as in the case studied previously, incentives to invest are not monotonic in β since both low- and high-β agents dislike investment (for different reasons). However, unlike the previous case, utilities are *not single peaked* with respect to the commitment c: for intermediate β's payoffs are first decreasing in c because we violate condition (6) and so commitment initially affects utility only through its costs, but carries no benefits in terms of the timing of consumption, until we reach a level of commitment c^* such that condition (6) is satisfied, so that $c = 0$ and $c = c^*$ are both local optima.

Consider now the case of collective commitment accompanied by decentralized choice. For all agents of preference parameter $\beta \geq \frac{v_2}{v_3}$, there is no willingness to pay for commitment no matter what the commitment technology is. Recall that $\beta^* = \frac{v_2}{v_3}$. If $1 - G(\beta^*) \geq 1/2$, there is a majority supporting no commitment and, as before, there is a unique equilibrium in which both candidates offer commitment $c^{CD} = 0$. Suppose there is a substantial fraction of the population that is moderate, $1 - G(\beta^*) < 1/2$. Now note that by raising c we obtain an increasing mass of β's for which $\beta v_3 \geq v_2 - c$. Let $\beta(c) \equiv \frac{v_2 - c}{v_3}$. The mass is given by $G(\beta(c))$. Define c_L such that

$$G(\beta^*) - G(\beta(c_L)) = \frac{1}{2}$$

and let $\beta_L \equiv \beta(c_L)$.

Let $\tilde{c}$ be the unique commitment level such that[31]

$$\beta(\tilde{c})(v_3 - v_2) = I(\tilde{c}).$$

The next result characterizes the equilibria in this environment.

Proposition 7 *Assume that $k(x, c) = cx$. When only commitment decisions are centralized,*

1. *If $\beta_L(v_3 - v_2) \leq I(c_L)$, there exists a unique equilibrium with investment of zero in commitment instruments.*

[31] Note that $\beta(\tilde{c})(v_3 - v_2)$ is decreasing in $\tilde{c}$. Since $\beta(0)(v_3 - v_2) > I(0) = 0$ and $0 = \beta(v_2)(v_3 - v_2) < I(v_2)$, the existence of a unique $\tilde{c} \in (0, v_2)$ satisfying the equality is guaranteed.

2. *If* $\beta_L (v_3 - v_2) > I(c_L)$*, there is no pure strategy equilibrium. In this case, there is a continuum of equilibria in mixed strategies. All symmetric profiles having a two-point support* $c_1 < c_2$ *such that there is a mass of 50% of* β*'s between* c_1 *and* c_2*, where* $c_2 \in [c_L, \tilde{c}]$*, constitute part of an equilibrium.*

The intuition for the non existence of positive commitment, pure strategy equilibria is the following. Assume $c > 0$ is part of an equilibrium. A deviation to a slightly lower commitment level attracts votes from two groups of voters: all agents with (low) β's such that c is not sufficient to generate delay and so a lower c is preferable, and all agents with (high) β's such that c is more than enough. Thus, support for the deviating candidate is overwhelming, with the extremes 'squeezing' the middle. Zero commitment is an equilibrium if the commitment technology is not 'too efficient.' If, however, investment is very cheap ($I(c)$ is very low), then zero commitment cannot be an equilibrium because a 'global' deviation to a large commitment would attract a majority of support. The proposition describes the mixed strategy equilibria in this case.

When only consumption choices are mandated (but commitment is chosen individually), the same analysis as in the general case holds and equilibrium is characterized by the entire electorate choosing not to invest in commitment.

Consider, last, the case in which both commitment and choices are mandated. Incentives to vote for investment in the first period may be high for high-β individuals. The optimal commitment parameter c is either 0 or the c^* that is just sufficient to make the median-β individual choose consumption at period 3, i.e., the minimal level of cost that solves

$$v_2 - c^* \geq \beta_M v_3 \text{ or } c^* = \max\{v_2 - \beta_M v_3, 0\}.$$

In period 1, all voters such that $\beta(v_3 - v_2) \geq I(c^*)$ or equivalently such that $\beta \geq \frac{I(c^*)}{(v_3 - v_2)}$ prefer c^* to 0; all agents with lower β's prefer 0. Thus, there can be a broad consensus in favor of investing.

Proposition 8 *Suppose* $k(x, c) = cx$*. When both commitment and consumption decisions are centralized, there exist* $\check{\beta}, \hat{\beta}$ *such that if* $\beta_M \leq \check{\beta}$ *or* $\beta_M \geq \hat{\beta}$*, there is a unique equilibrium with* $c = 0$*, and if* $\beta_M \in \left(\check{\beta}, \hat{\beta}\right)$*, there is an equilibrium with positive commitment.*

Now that we have characterized equilibria in this environment, it can easily be seen that the main forces behind our welfare results from Section 6 are still in place: either full centralization or full decentralization are best, and the comparison between these two institutions depends on how virtuous the median voter is.[32]

8 Conclusions

The paper considers a simple setting in which behavioral agents, who in our case suffer from present bias, are also political actors, electing the government that is charged with "solving" their behavioral biases. While commitment instruments can be beneficial to individuals left to their own devices, we show the sensitivity of collective outcomes to the precise timing in which political processes take place and the underlying distribution of biases in the population. Commitment levels are lowest when only consumption is mandated. Under some regularity assumptions, commitment is highest when only it is subject to collective action. When both commitment and consumption decisions are decided upon collectively, they reflect the preferences of the individual with median present-bias preferences.

From a welfare perspective, there is a complementarity between centralization at the commitment and consumption stages. Indeed, we show that either full centralization or laissez faire economies generate the highest welfare. Full centralization can be beneficial when there is a virtuous median voter. In that case, centralization effectively allows the population to delegate decisions to a virtuous agent.

These results are potentially relevant for many settings. One notable example is the design of pension systems in the U.S. and abroad. Indeed, a public pension system is sometimes defended as an effective solution to under-saving driven by self-control problems. Our results suggest that an analysis of the collective action of self-control is an important aspect of the design of such pension systems. A careful study of the design of a pension system for agents subject to self-control problems requires many specific details that are missing from our model. However, their design needs to take into consideration the political constraints imposed by those same individuals who are prone to self-control problems and comprise the electorate. These constraints may in principle affect the choice between a pay-as-you-go system and a funded system, the safeguards that are embedded in the system, as well as the timing and response of the system to demographic shocks. We view this as an important potential avenue for subsequent research.

Accounts of behavioral biases have generated a rich literature that, by and large, focuses on individual actions. The paper offers some first steps to studies that allow for these same biases when considering policy determination, either ones that attempt at overcoming these

[32] A formal discussion of welfare for the case of linear cost can be found in the supplementary appendix.

biases (such as in the case of retirement savings) or otherwise. In particular, it suggests the potential importance of considering different biases (e.g., overconfidence, belief distortions in general, limited memory, etc.) as well as different types of policies (e.g., debt limits, general upholding of political promises, etc.) when inspecting political processes.[33]

[33] As mentioned, some recent work has started moving in that direction. Ortoleva and Snowberg (2012) study the impacts of over-confidence, while Diermeier and Li (2013) consider impacts on re-election and effort put by politicians who are facing voters with limited memory and an inclination to persist with their past voting behavior.

9 Appendix – Proofs

Proof of Lemma 1. Consider the intermediate region of β parameters:

$$\beta \in \left[\left(v_2 - \frac{\partial k\left(1,c\right)}{\partial x}\right)/v_3, \left(v_2 - \frac{\partial k\left(0,c\right)}{\partial x}\right)/v_3\right).$$

Since $\frac{\partial^2 k(x(c,\beta),c)}{\partial x \partial c} > 0$, increasing c leads to an increase in the right hand side of the first order condition specified in (1). Since $\frac{\partial^2 k(x(c,\beta),c)}{\partial x^2} > 0$ it follows that $x(c,\beta)$ is decreasing in c. Similarly, notice that $\frac{d(v_2-\beta v_3)}{d\beta} < 0$ so that the left hand side of the first order condition is decreasing in β. The assumption that $\frac{\partial^2 k(x(c,\beta),c)}{\partial x^2} > 0$ then assures that $x(c,\beta)$ is decreasing in β. ■

Proof of Proposition 1. The assumption that $\frac{\partial k(1,c)}{\partial x} \geq v_2$ together with our assumptions on k, which assure that $\frac{\partial k(0,0)}{\partial x} = 0$, imply through (1) that for any $\beta < \frac{v_2}{v_3}$, there exists $\bar{c} > 0$, such that $x(c,\beta) \in (0,1)$ for all $c < \bar{c}$. Recall that the first period's utility changes with c in regions where $x(c,\beta) \in (0,1)$ according to:

$$\frac{\partial U_1}{\partial c} = -\beta\left(\frac{\partial x\left(c,\beta\right)}{\partial c}\left(\left(1-\beta\right)v_3\right) + \frac{\partial k\left(x\left(c,\beta\right),c\right)}{\partial c}\right) - I'\left(c\right).$$

Our assumptions guaranty that $x(c,\beta)$ is decreasing in c, while $\frac{\partial k(x,0)}{\partial c} = I'(0) = 0$. Therefore, optimization requires that $c(\beta) > 0$ for all $\beta \in \left(0, \frac{v_2}{v_3}\right)$. Furthermore, since we assume that fundamentals are such that $x(c,\beta)$ is well-behaved, $c(\beta)$ is continuous.

Now, if $1 - G(\frac{v_2}{v_3}) \geq 1/2$, there is a majority of agents who prefer no commitment and the equilibrium commitment parameter is $c^{CD} = 0$, which coincides with that preferred by the median.

Suppose that $1 - G(\frac{v_2}{v_3}) < 1/2$. Let $B(\tilde{c}) = \{\beta \mid c(\beta) \leq \tilde{c}\}$. For any $0 < c_1 < c_2 \leq \max_\beta c(\beta)$, $B(c_1) \subsetneq B(c_2)$. Therefore, there exists a unique c^{CD} such that $G(B(c^{CD})) = 1/2$. For any parameter $c > c^{CD}$, there is a strict majority preferring lower commitment, while for any $c < c^{CD}$, there is a strict majority preferring greater commitment. It follows that c^{CD} defines the unique equilibrium commitment level.

If $c(\beta)$ has a unique maximum, then there exist $\beta_L, \beta_H \in \left(0, \frac{v_2}{v_3}\right)$ such that $B(c^{CD}) = [0, \beta_L] \cup [\beta_H, 1]$. Since G is continuous, by construction $G\left([0,\beta_L]\right), G\left([\beta_H, 1]\right) < 1/2$, implying that $\beta_M \in (\beta_L, \beta_H)$. The result follows. ■

Proof of Lemma 2. Let us first consider the case in which $x\left(c,\beta_M\right)$ is interior.

From the first order condition of the median voter in period 2 we know that whenever $x\left(c,\beta_M\right)>0$,

$$v_2-\beta_M v_3=\frac{\partial k\left(x\left(c,\beta_M\right),c\right)}{\partial x}.$$

Consider the effect of c on an agent of taste parameter β who foresees that period 2 decisions will be made by the median voter.

$$\frac{\partial U_1}{\partial c}=\frac{\partial x\left(c,\beta_M\right)}{\partial c}\left(\beta v_2-\beta v_3\right)-\beta\frac{\partial k\left(x\left(c,\beta_M\right),c\right)}{\partial c}-\beta\frac{\partial k\left(x\left(c,\beta_M\right),c\right)}{\partial x}\frac{\partial x\left(c,\beta_M\right)}{\partial c}-I'\left(c\right).$$

The first order condition for β_M implies that

$$v_2-v_3=-\left(1-\beta_M\right)v_3+\frac{\partial k\left(x\left(c,\beta_M\right),c\right)}{\partial x}$$

and so

$$\frac{\partial U_1}{\partial c}=-\beta\left(\frac{\partial x\left(c,\beta_M\right)}{\partial c}\left(1-\beta_M\right)v_3+\frac{\partial k\left(x\left(c,\beta_M\right),c\right)}{\partial c}\right)-I'\left(c\right).$$

Now, if $\frac{\partial x(c,\beta_M)}{\partial c}\left(1-\beta_M\right)v_3+\frac{\partial k(x(c,\beta_M),c)}{\partial c}\geq 0$, all agents prefer $c=0$ and the claim follows. Otherwise, $\frac{\partial x(c,\beta_M)}{\partial c}\left(1-\beta_M\right)v_3+\frac{\partial k(x(c,\beta_M),c)}{\partial c}<0$ and $\frac{\partial U_1}{\partial c}$ is increasing in β. At a maximum, U_1 is (weakly) concave and the claim follows.

We now consider the cases in which $x(c,\beta_M)$ may be at a corner solution. Note first that when $\beta_M\geq\frac{v_2}{v_3}$, then $x(c,\beta_M)=0$ for all c. In this case, all agents prefer $c=0$ in period 1 and the claim follows. More generally, we have

$$x(c,\beta_M)=\begin{cases}0 & c\geq c_H\left(\beta_M\right)\\ \left(v_2-\beta_M v_3\right)=\frac{\partial k(x(c,\beta_M),c)}{\partial x} & c_L\left(\beta_M\right)<c<c_H\left(\beta_M\right)\\ 1 & c\leq c_L\left(\beta_M\right)\end{cases}.$$

Clearly, there is no value in choosing $c>c_H\left(\beta_M\right)$. thus, $c\geq c_H\left(\beta_M\right)$ and

$$U_1\left(\beta,c_H\left(\beta_M\right)\right)=\beta v_3-I\left(c_H\left(\beta_M\right)\right).$$

Comparing this to interior cases:

$$\begin{aligned}U_1\left(\beta,c_H\left(\beta_M\right)\right)-U_1\left(\beta,c\right)&=\beta v_3-I\left(c_H\left(\beta_M\right)\right)-\beta v_3+x\left(c,\beta_M\right)\left(\beta v_2-\beta v_3\right)-\\&-\beta k\left(x\left(c,\beta_M\right),c\right)-I\left(c\right)=\\&=\beta\left(x\left(c,\beta_M\right)\left(v_3-v_2\right)-k\left(x\left(c,\beta_M\right),c\right)\right)-\left(I\left(c_H\left(\beta_M\right)\right)-I\left(c\right)\right).\end{aligned}$$

If $c_H\left(\beta_M\right)$ is optimal for some $\hat{\beta}$, it has to be the case that

$$\hat{\beta}\left(x\left(c,\beta_M\right)\left(v_3-v_2\right)-k\left(x\left(c,\beta_M\right),c\right)\right)>\left(I\left(c_H\left(\beta_M\right)\right)-I\left(c\right)\right)$$

for all $c < c_H(\beta_M)$. But then, this also holds for all $\beta > \hat{\beta}$.

It is easy to see that it must be the case that when $c \leq c_L(\beta_M)$, then the optimal c is zero: there is no point in investing anything in commitment if it does not help. In this case, the payoff in the first period is $U_1(\beta, 0) = v_2$. Comparing this to interior cases:

$$\begin{aligned} U_1(\beta, c_H(\beta_M)) - U_1(\beta, c) &= \beta v_2 - (\beta v_3 + x(c, \beta_M)(\beta v_2 - \beta v_3) - \beta k(x(c, \beta_M), c) - I(c)) \\ &= -\beta((v_3 - v_2)(1 - x(c, \beta_M)) - k(x(c, \beta_M), c)) + I(c). \end{aligned}$$

If a choice of zero commitment is optimal for some $\hat{\beta}$ it has to be the case that

$$\hat{\beta}((v_3 - v_2)(1 - x(c, \beta_M)) - k(x(c, \beta_M), c)) < I(c)$$

for all $c > c_L(\beta_M)$. But then this also holds for all $\beta < \hat{\beta}$. ■

Proof of Proposition 4. In period 1, all agents but the foreseen pivotal voter of period 2 best respond by choosing $c = 0$, as their choice of commitment parameter affects only the commitment and consumption costs they experience, but not the levels of future consumption. If any agent of taste parameter $\beta \neq \beta_M$ invests in commitment in period 1, the median preferences in period 2 would correspond to those of the median agent with preferences β_M and so investment by the agent of taste parameter β are strictly sub-optimal. Suppose the median agent invests in period 1. In that case, in period 2 her preferences no longer coincide with the median preferences and so her commitment investment does not affect ultimate choice and is thus strictly sub-optimal. The claim then follows. ■

Proof of Proposition 6.

1. Whenever $\beta_M \geq \beta^*$, the fully centralized system generates no commitment, $c(\beta_M) = 0$ and fully delayed consumption, $x(c(\beta_M), \beta_M) = 0$. In particular, since $k(x, 0) = 0$, any agent of preference parameter β experiences a period 1 utility of βv_3. In contrast, in the fully decentralized system, while all agents with $\beta \geq \beta^*$ experience the same period 1 utility as in the fully centralized system, agents with $\beta \in (0, \beta^*)$ choose $c(\beta) > 0$ at a cost of $I(c(\beta)) > 0$ and so receive a utility that is strictly lower than βv_3. Since the distribution G is continuous and $G(\beta^*) > 0$, the result follows.

2. Consider any sequence of distributions $\{G_n\}_{n=1}^{\infty}$ with corresponding medians $\{\beta_M^n\}_{n=1}^{\infty}$. Suppose there exists $\gamma > 0$ such that $G_n(\tilde{\beta}) \geq \gamma$ for some $\tilde{\beta} < \beta^*$ for all n and assume that $\lim_{n\to\infty} \beta_M^n \geq \beta^*$. It follows that:

$$\lim_{n\to\infty} c(\beta_M^n) = 0 \quad \text{and} \quad \lim_{n\to\infty} x(c(\beta_M^n), \beta_M^n) = 0.$$

Therefore, for any $\varepsilon > 0$, there exists $\bar{n}(\varepsilon)$ such that for all $n > \bar{n}(\varepsilon)$, $\Pi^{CC}(G_n) > v_3\mathbb{E}_{G_n}\beta - \varepsilon$. From the proof of Proposition 1, for individuals with preference parameter $\beta \leq \tilde{\beta}$, $c(\beta) > 0$, and so $U_1(x(c(\beta)), c, \beta) < v_3$. Define

$$\tilde{U} \equiv \max_{\beta \leq \tilde{\beta}} U_1(x(c(\beta)), c, \beta) < v_3.$$

Then, for all n,

$$\begin{aligned}
\Pi^{DD}(G_n) &\leq G_n(\tilde{\beta})\tilde{U}\mathbb{E}_{G_n}\left(\beta \mid \beta \leq \tilde{\beta}\right) + (1 - G_n(\tilde{\beta}))v_3\mathbb{E}_{G_n}\left(\beta \mid \beta > \tilde{\beta}\right) = \\
&= v_3\mathbb{E}_{G_n}\beta - (G_n(\tilde{\beta}))\left(v_3 - \tilde{U}\right)\mathbb{E}_{G_n}\left(\beta \mid \beta \leq \tilde{\beta}\right) \leq \\
&\leq v_3\mathbb{E}_{G_n}\beta - \gamma\left(v_3 - \tilde{U}\right)\mathbb{E}_{G_n}\left(\beta \mid \beta \leq \tilde{\beta}\right).
\end{aligned}$$

Furthermore, since we consider continuous distributions, $\mathbb{E}_{G_n}\left(\beta \mid \beta \leq \tilde{\beta}\right) > 0$. Therefore, for $\varepsilon = \gamma\left(v_3 - \tilde{U}\right)\mathbb{E}_{G_n}\left(\beta \mid \beta \leq \tilde{\beta}\right)$, we get that whenever $n > n^*$, where $n^* = \bar{n}\left(\gamma\left(v_3 - \tilde{U}\right)\mathbb{E}_{G_n}\left(\beta \mid \beta \leq \tilde{\beta}\right)\right)$, $\Pi^{DD}(G_n) < \Pi^{CC}(G_n)$, and the claim follows.■

Proof of Proposition 7. We first show that with linear costs there is no pure strategy equilibrium with positive commitment. Assume by way of contradiction that candidate 1 chooses $c > 0$ with probability 1. Then candidate 2 can win with probability 1 by choosing $c - \varepsilon$ for ε sufficiently small. All voters with preference parameter β such that $\beta v_3 \geq v_2 - (c - \varepsilon)$ prefer candidate 2 because they still get to consume in period 3 but the lower investment in commitment is sufficient to do so. Furthermore, all voters with β such $\beta v_3 < v_2 - c$ prefer candidate 2 because they consume in period 2 with both levels of commitment, so prefer the candidate who offers the lower level. The only voters who may prefer c over $c - \varepsilon$ are those whose preference parameter β is such that $\beta v_3 \geq v_2 - c$ and $\beta v_3 < v_2 - (c - \varepsilon)$. However, because the distribution G is continuous, the mass of these voters can be made arbitrarily small by choosing ε small enough.

If $\beta_L(v_3 - v_2) \leq I(c_L)$, then all agents with preference parameter β such that $\beta \leq \beta_L$ prefer $c = 0$ to c_L. Since $I(c)$ is convex, they prefer $c = 0$ to all $c > c_L$. Furthermore, any $0 < c < c_L$ is also worse than $c = 0$ for these agents because $\beta v_3 < v_2 - c$ by the definition of c_L and β_L. Since $(1 - G(\beta^*)) + G(\beta_L) = \frac{1}{2}$, there is a majority in favor of $c = 0$ against all other c's.

If $\beta_L(v_3 - v_2) > I(c_L)$, then all β's between β^* and β_L strictly prefer $c_L + \varepsilon$ to $c = 0$. Furthermore, some β's slightly higher than β_L also prefer $c_L + \varepsilon$ to $c = 0$. Since there half the mass of voters is concentrated between β_L and β^*, $c_L + \varepsilon$ defeats $c = 0$. As shown above, there is no pure strategy equilibrium with positive commitment. This establishes that when $\beta_L(v_3 - v_2) > I(c_L)$, there is no pure strategy equilibrium.

We now show that when $\beta_L(v_3 - v_2) > I(c_L)$ the mixed-strategy profiles in the statement of the proposition constitute equilibria. Note first that c_1 and c_2 as defined in the proposition tie. Consider now a policy $\hat{c} > c_2$. This policy may win against c_1. However, $\hat{c}$ loses against c_2 because all agents of preference parameter $\beta > \beta(c_2) - \delta$ (for some δ) would vote for c_2 over $\hat{c}$. Since $G(\beta(c_1)) - G(\beta(c_2)) = \frac{1}{2}$, there is more than 50% of the voters supporting c_2. Thus, $\hat{c}$ wins with probability 1/2. Consider now a policy $c_1 < \hat{c} < c_2$. Such a policy may win against c_2. However, against c_1, the only potential supporters are agents with preference parameters within $[\beta(\hat{c}), \beta(c_1))$, which by construction entails less than 50% of the population. In particular, c_L is a policy that would lose against c_1. Last, consider a policy $\hat{c} < c_1$. This policy may win against c_1. Against c_2, its only potential supporters are agents with preference parameters $\beta \leq \beta(c_2)$ or $\beta \geq \beta(\hat{c})$, which from the definition of the pair (c_1, c_2) account for less than 50% of the voters. Thus, the candidate equilibrium strategy profile wins with probability at least 1/2 against all possible deviations and no deviation is strictly beneficial. ■

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