The Political Economy of Public Debt: A Laboratory Study*

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Abstract

This paper reports the results from a laboratory experiment designed to study the role of political distortions in the accumulation of public debt. In a legislature, representatives of each of n districts bargain over the current period's endowment for investment in a public good and transfers to each district. The legislature can issue or purchase risk-free bonds, and the level of public debt creates a dynamic linkage across policymaking periods. We analyze the equilibrium policies under different voting q-rules, where q is the number of votes required for passage. We conduct a laboratory experiment with five-person committees that compares three alternative voting rules: oligarchy ($q = 2$), simple majority ($q = 3$), and super majority ($q = 4$). In line with the theoretical predictions, we find that the efficiency of public policies is increasing in q, with higher investment in the public good and lower levels of debt. Finally, we present results for a second treatment, where we keep political institutions fixed and we manipulate the economic conditions, namely, the risk of a shock to society.

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1 Introduction

Predicting the evolution of public debt and understanding how over-indebtedness can be successfully avoided have been significant research enterprises for practitioners and academic scholars for decades. A large theoretical literature, rich in empirical predictions, has been developed. The macroeconomic literature has focused on the development of normative models in sophisticated dynamic environments in which a benevolent planner optimally chooses public debt to maximize social welfare (see, among others, Barro 1979, Stokey and Lucas 1983, Ayiagari et al. 2002). This literature has highlighted the role of public debt for consumption smoothing and characterized its implications for intertemporal allocation of resources. The political economy literature, instead, has focused on the development of positive models which stressed the inefficiencies induced by the political process (Buchanan and Tullock 1962, Buchanan 2000). This literature has shed light on how political distortions can induce rational agents to over-accumulate debt and limit the scope of consumption smoothing (Persson and Svensson 1989, Alesina and Tabellini 1990, Battaglini and Coate 2008).

Testing the predictions of these theories has proven challenging. Testing for consumption smoothing, for example, is difficult when it is hard to measure accurately the shocks hitting the economy, or the agents' expectations and preferences. Even more difficult is testing for the effect of institutions on public debt, since both institutions and fiscal policy are endogenous variables that depend on many other factors that are hard to control for. This leaves us with many important unanswered questions about these theories and their underlying assumptions. To what extent do these models accurately predict behavior in empirical settings? Is indebtedness driven by strategic and forward-looking decision makers, as assumed in these models, or is it more simply due to myopic political agents? How do inefficiencies depend on the institutions that govern collective decision making?

In this work, we address these questions by examining the theoretical implications of a simple political economy model of public debt by means of a controlled laboratory experiment. In our model policy choices are made by a legislature that can borrow or save in the capital market in the form of risk-free one-period bonds. Public revenues are used to finance the provision of a public good that benefits all citizens, and to provide targeted district-specific transfers, which are interpreted as pork-barrel spending, or local public goods without spillovers across districts. The value of the public good to citizens is stochastic, reflecting shocks, such as, economic crises, wars, or natural disasters. The legislature makes policy decisions by voting and legislative policy making in each period is modeled using a dynamic legislative bargaining as in Battaglini and Coate (2008). The level of public debt acts as a state variable, creating a dynamic linkage across policy making periods. This model has been explicitly designed to capture most of the key issues emerging from the public debt literature, while at the same time keeping it simple enough to investigate its predictions in the laboratory.

The model generates predictions about how the legislature uses the debt instrument to smooth consumption over time and how the political process affects this activity. Fixing the distribution of the shocks, the model predicts that the legislature issues too much debt and uses the proceedings to fund transfers targeted to a minimal winning coalition of legislators. The amount of debt is decreasing in the size of the required majority and converges to the efficient level (a negative level, corresponding to positive savings) as the decision becomes unanimous. Fixing the voting rule, the level of debt is a decreasing function of the probability of the future state in which the public good has high value.

In the experiments, we find evidence that confirms the comparative statics implications of the model, but the data also provide some surprising findings that suggest new insights about the effect of voting rules on behavior in legislative bargaining games. A clear results emerging from the analysis is that players are forward-looking and political institutions have a crucial role. Aggregate outcomes are consistent with the predicted treatment effects: we observe higher public good provision and lower borrowing with a higher majority requirement; and we observe lower borrowing with a higher risk of a shock to society. Political institutions, however, have a larger effect on outcomes than economic conditions or the perceived degree or risk; indeed the main driving force behind public debt accumulation is the voting rule governing collective decision making. An encouraging finding in the experiment is that public policies are less inefficient than predicted under all voting rules, with approximate efficiency under super-majority (without the need of a unanimity requirement).

Two other results appear surprising and worth highlighting. First, we find that balancing the budget in each period appears to be a focal point for the players: this phenomenon limits the size of the distortions below the levels that we would have expected form the theory alone. Second, we find that higher majority requirements induce difficulties to reach an agreement, with such bargaining delays creating a potentially transaction cost, akin to political gridlock, about which the model is silent. The problem of bargaining delay may partly explain why we do not observe unanimous rules used more frequently in real world institutions. These deviations have important empirical implications for the optimal design of political institutions and suggest the need of a deeper empirical study of the advantages and disadvantages of introducing legislative supermajorities or veto powers in fiscal policy legislation.

Our paper is not the first to study experimentally how agents allocate resources over time. Two approaches have been attempted by the previous literature. The first was to embrace a representative agent model, abstracting from how public decisions are collectively taken (Hey and Dardanoni 1988, Carbone and Hey 2004, and Noussair and Matheny 2000).[1] This literature was mainly interested in exploring the extent to which single agents can solve discrete-time optimization problems in isolation and is mute on the question of how public debt is determined in a legislature operating under agenda procedures and voting rules. The second approach was to study collective decision making by a legislature whose current decision influences the future bargaining environment, but without allowing the possibility of issuing debt (see, for example, Agranov, Frechette, Palfrey, and Vespa 2015, Battaglini and Palfrey 2012, Battaglini, Nunnari and Palfrey 2012, and Nunnari 2014).[2] To our knowledge, our paper is the first to study the political determination of public debt accumulation with a laboratory experiment.

The rest of the paper is organized as follows. In Section 2, we outline the model and characterize the first best allocation as a benchmark. In Section 3, we characterize the political equilibrium and its testable implications. Section 4 details the experimental design. Section 5 presents the experimental results. We conclude in Section 6.

2 Model

We study a model in which a committee of n players collectively chooses how to allocate resources over two periods. There are two goods: a public good, g, and a consumption good, s. The public good can be produced from the consumption good with a technology that transforms a unit of consumption into a unit of public good. An allocation in period t is a vector $\{g_t, s_t^1, ..., s_t^n\}$ where g_t is the public good at t, and s_t^i is the level of private consumption of agent i at t.

Each citizen's per period utility function (for s units of consumption and a public good g) is $s + Au(g)$, where $u(g)$ is a strictly increasing, strictly concave and continuously differentiable function, with $\lim_{g\to 0^+} u'(g) = \infty$ and $\lim_{g\to +\infty} u'(g) = 0$. The parameter A measures the relative importance of the public good to the citizens. The value of the public good varies across periods in a random way, reflecting shocks to society, such as wars, natural disasters, or economic crisis. Specifically, in period 1 the value of the public good is A; in

[1] Cadsby and Frank (1991) and Lei and Noussair (2002) study a community of multiple agents but consider decentralized decision making.

[2] A somewhat intermediate approach is found in Battaglini, Nunnari and Palfrey (2015), who study a dynamic free rider problems in which players actions are independent but are linked by externalities.

period 2 the value is $A_H > A$ with probability p, and $A_L < A$ with probability $1 - p$. The value of the public good in period 2 is the state of the world, $\theta = \{L, H\}$. Citizens discount future per period utilities at rate δ.

In every period, the committee receives public revenues equal to W. At $t = 1$, the committee can also borrow or lend money at a constant interest rate r. If the committee borrows an amount x in period 1, it must repay $x(1 + r)$ in period 2. Public revenues and debt are used to finance the provision of the public good and the monetary transfers. Since the legislature can either borrow or lend, x can be positive or negative. We assume that the initial level of debt is zero. In period 1, the allocation must satisfy the following budget constraint:

$$W + x - \sum s_1^i - g_1 \geq 0 \tag{1}$$

In period 2, the allocation in state $\theta = \{L, H\}$ must satisfy the following budget constraint:

$$W - (1 + r)x - \sum s_{2\theta}^i - g_{2\theta} \geq 0 \tag{2}$$

The committee makes public decisions following a standard bargaining protocol à la Baron and Ferejohn (1989). In period 1, one of the legislators is randomly selected to make the first policy proposal, with each member having an equal chance of being recognized. A proposal is described by an $n+2$-tuple $\{g_1, x, s_1^1, ..., s_1^n\}$, where g_1 is the proposed amount of public good provided at $t = 1$; x is the proposed level of public debt; and s_1^i is the proposed transfer to district i's residents at $t = 1$. This proposal must satisfy the budget constraint (1) and the non negativity constraints: $g_1 \geq 0$, $s_1^i \geq 0$, $i = 1, ..., n$. If the proposer's plan is accepted by q legislators, then it is implemented and the legislature adjourns until the beginning of the next period. If, on the other hand, the first proposal is not accepted, then another legislator is chosen randomly (with replacement) to make a proposal. This process repeats itself a proposal is accepted by q legislators: at that point the proposal is implemented and the legislature adjourns until the beginning of the next period.

In period 2, the committee inherits the level of debt x chosen at $t = 1$, and observe the realized state of nature, $A_\theta = \{A_L, A_H\}$. As in period 1, one of the legislators is randomly selected to make the first policy proposal, with each member having an equal chance of being recognized. In this case a proposal is described by an $n + 1$-tuple $\{g_{2\theta}, s_{2\theta}^1, ..., s_{2\theta}^n\}$, where $g_{2\theta}$ is the amount of the public good provided and $s_{2\theta}^i$ is the proposed transfer to district i's residents in state θ. This proposal must satisfy the budget constraint (2), given x, and the non negativity constraints: $g_{2\theta} \geq 0$, $s_{2\theta}^i \geq 0$, $i = 1, ..., n$. If the proposer's plan is accepted by q legislators, then it is implemented and the game ends. If the proposal is not accepted, then another legislator is chosen, and the procedure continues until a proposal is accepted by q legislators: at this point the proposal is implemented and the game ends. In both periods, we assume that the rounds of bargaining within the same period are fast and so there is no discounting following a rejected proposal.

There is a limit on the amount the government can borrow: $x \leq \overline{x}$, where $\overline{x}$ is the maximum amount that the government can borrow. The limit on borrowing is determined by the unwillingness of borrowers to hold government bonds that they know will not be repaid. If the government borrowed an amount x such that the interest payments exceeded the maximum possible tax revenues—i.e., $x > W/(1+r)$—then, it would be unable to repay the debt even if it provided no public good or transfers. Thus, the maximum level of debt is certainly does not exceed this level, so we assume $\overline{x} = W/(1+r)$.

In a competitive equilibrium, we must have $\delta(1+r) = 1$. Otherwise, no agent would be willing to lend (if $\delta(1+r) < 1$) or to borrow (if $\delta(1+r) > 1$) and the debt market would not be in equilibrium. This condition pins down the equilibrium interest rate as a simple function of the discount factor. In the following analysis and in the experiment, we assume the competitive equilibrium interest rate, that is, $r = 1/\delta - 1$.

To limit the number of possible cases, we make two assumptions on the parameters of the model. As will be shown in the next section, the efficient levels of public good are:

$$g_1^O = [u']^{-1}\left(\frac{1}{An}\right),\ g_{2\theta}^O = [u']^{-1}\left(\frac{1}{A_\theta n}\right)$$

First, we assume that, without the debt market, in the second period the legislature does not have enough resources to cover the efficient level of g if there is a high shock:

$$W < g_{2H}^O \tag{3}$$

If this assumption was not satisfied, then there would be no economic reason for precautionary savings. Second, we assume that, with a debt market to shift budgets across periods, there are enough resources available to society to make sure that an optimal solution is feasible even when there is a high shock in the second period:

$$W + \frac{W}{1+r} \geq g_1^O + \frac{g_{2H}^O}{1+r} \tag{4}$$

Given these assumptions, a benevolent planner can achieve the efficient allocation, but it can do it only by saving in the first period. In the next section we characterize exactly the amount of savings required for the efficient solution.

2.1 Optimal Public Policy

As a benchmark with which to compare the equilibrium allocations by a legislature, this section characterizes the public policy that maximizes the sum of utilities of the districts. This is the *optimal public policy.* The optimization problem is as follows:

$$\max_{s_1,g_1,s_{2\theta},g_{2\theta},x} \left\{ \begin{array}{c} ns_1 + Anu(g_1) + \left\{ \begin{array}{c} (1-p)\left[ns_{2L} + A_L nu(g_{2L})\right] \\ +p\left[ns_{2H} + A_H nu(g_{2H})\right] \end{array} \right\} \\ s.t.\ W + x - ns_1 - g_1 \geq 0, \\ W - (1+r)x - ns_{2L} - g_{2L} \geq 0, \\ W - (1+r)x - ns_{2H} - g_{2H} \geq 0, \\ s_1 \geq 0, s_{2\theta} \geq 0, g_1 \geq 0, g_{2\theta} \geq 0 \end{array} \right\} \tag{5}$$

In (5) we assume that all citizens receive the same transfer: s_1 in period 1 and $s_{2\theta}$ in period 2 in state θ. This is without loss of generality since with quasilinear utilities the policy-maker is indifferent with respect to the distribution of transfers. The optimal levels of public good, in particular, are independent from the distribution of transfers. The first three constraints are the budget constraints for, respectively, the first period, the second period in the low state, and the second period in the high state. The other constraints are the non-negativity constraints for transfers and public good levels.

The following result, proven in Appendix A, characterizes the uniquely defined optimal provision of public goods and the feasible range of public debt.[3]

Proposition 1. *The optimal public policy is given by:*

$$\begin{aligned} x^O &\in \left[g_1^O - W, \frac{W - g_{2H}^O}{1+r}\right] \\ g_1^O &= [u']^{-1}\left(\frac{1}{nA}\right) \\ g_{2L}^O &= [u']^{-1}\left(\frac{1}{nA_L}\right) \\ g_{2H}^O &= [u']^{-1}\left(\frac{1}{nA_H}\right) \end{aligned} \tag{6}$$

Proposition 1 has the following implication.

[3] In the Appendix, we also specify an optimal allocation for the transfers. Note that the total amount of transfers is uniquely determined by the equilibrium public good and debt presented in Proposition 1. The distribution of these transfers however is indeterminate since a utilitarian policy-maker is indifferent with respect to redistribution.

Corollary 1. *The optimal level of debt is negative.*

The planner provides the efficient level of public good, that is the level that maximizes the joint utility of n districts, in both periods and in both states of the world. This implies that the social planner has an incentive to self-insure against shocks to society which make the public good more valuable to its citizens—for example, a war, a natural disaster or an economic crisis. The planner hence saves in the first period, in order to be able to provide the efficient level of public good in the second period, in case of a positive shock to the marginal benefit from public spending.

The following result clarifies how the planner chooses public debt:

Corollary 2. *At the optimum, the expected marginal utility of the public good is equal in both periods:*

$$Au'(g_1^O) = E\left[A_\theta u'(g_{2\theta}^O)\right] \tag{7}$$

Equation (7) is the so called Euler equation for problem (5). It says that, at the optimal solution, the marginal utility of the public good at $t = 1$ (the left hand side of (7)) must be equal to the expected marginal utility of the public good at $t = 2$ (the right hand side).

3 Political Equilibrium

We now consider a legislature, composed by representatives of the n districts, that allocates the resources through the bargaining process described in Section 2. We solve the model by backward induction.

3.1 Behavior in Period 2

In the second period, legislators take the level of debt incurred in the first period, x, as given and know the realized state of the world, $\theta = \{H, L\}$. The equilibrium policy is chosen by the proposer, as described in Section 2. The proposer chooses the policy that maximizes his own utility under the feasibility constraints and under the a constraint requiring that a minimal winning coalition of other players is willing to support his proposal. In a stationary symmetric equilibrium, the proposer randomly selects $q-1$ other players out of the remaining $n-1$, each with probability $(q-1)/(n-1)$, to be part of his minimal winning coalition, and treats all the members of his minimal winning coalition in the same way.

The proposer's problem can be formally written as:

$$\max_{s,g}\left\{\begin{array}{c} W-(1+r)x-(q-1)s-g+A_\theta u(g) \\ s.t.\ W-(1+r)x-(q-1)s-g\geq 0,\ s\geq 0, g\geq 0 \\ s+A_\theta u(g)\geq v_2(x,\theta) \end{array}\right\}$$

where g is the level of public good and s is the transfer that the proposer chooses to give to the $q-1$ coalition members. The proposer benefits from the resources he can extract net of interest payments, the payments to the other coalition members and the cost of the public good (i.e. $W-(1+r)x-(q-1)s-g$), and from the public good ($A_\theta u(g)$). The first constraint is the budget constraint (given the level of debt inherited from the first period); the second and third constraints are the non-negativity constraint on public good and districts' transfers. The fourth constraint is the incentive compatibility constraint: voters support the proposal if and only if the utility they derive from it (i.e. $s+A_\theta u(g)$) is at least as large as their continuation value in a further round of bargaining, $v_2(x,\theta)$. If the proposer does not receive q votes, a new proposer is chosen at random, so the continuation value $v_2(x,\theta)$ is the expected utility at $t=2$ when the state is (x,θ) and before the identity of the proposer is known.

In Appendix A, we characterize the unique solution to this problem and we compute the value function $v_2(x,\theta)$ associated with any level of debt incurred in the first period. We show that $v_2(x,\theta)$ is a concave and almost everywhere differentiable function of debt x characterized by a state-dependent critical value of debt, $\widehat{x}_\theta$. When $x\leq\widehat{x}_\theta$, the citizens have sufficient resources in the second period for transfers, and the proposer makes positive transfers to himself and the other members of his coalition. When $x>\widehat{x}_\theta$, instead, debt is so high that transfers are zero at $t=2$ in state A_θ. The value function fails to be differentiable at the point $\widehat{x}_\theta$, where the non negativity constraints for transfers becomes binding.

Taking expectations with respect to θ, we obtain the expected continuation utility $V_2(x)=Ev_2(x,\theta')$. Naturally, $V_2(x)$ is also concave and almost everywhere differentiable in x. Now we have two points of non-differentiability: at $\widehat{x}_L$, where the non-negativity constraint for transfers is binding in state L; and at $\widehat{x}_H$, where the non-negativity constraint for transfers is binding in state H. Figure 1 illustrates it in two examples.

The threshold $\widehat{x}_H$ is strictly lower than $\widehat{x}_L$: when the state is high, it is optimal to choose a higher level of public good; so, if transfers are unfeasible in state A_L, then they are unfeasible in state A_H too. When $x\leq\widehat{x}_H$, the non negativity constraint for transfers is not binding in either state, and we have transfers in both states; when $x\geq\widehat{x}_L$, the constraint is binding in both states, so transfers are zero in both states; when $x\in(\widehat{x}_H,\widehat{x}_L)$, then the non

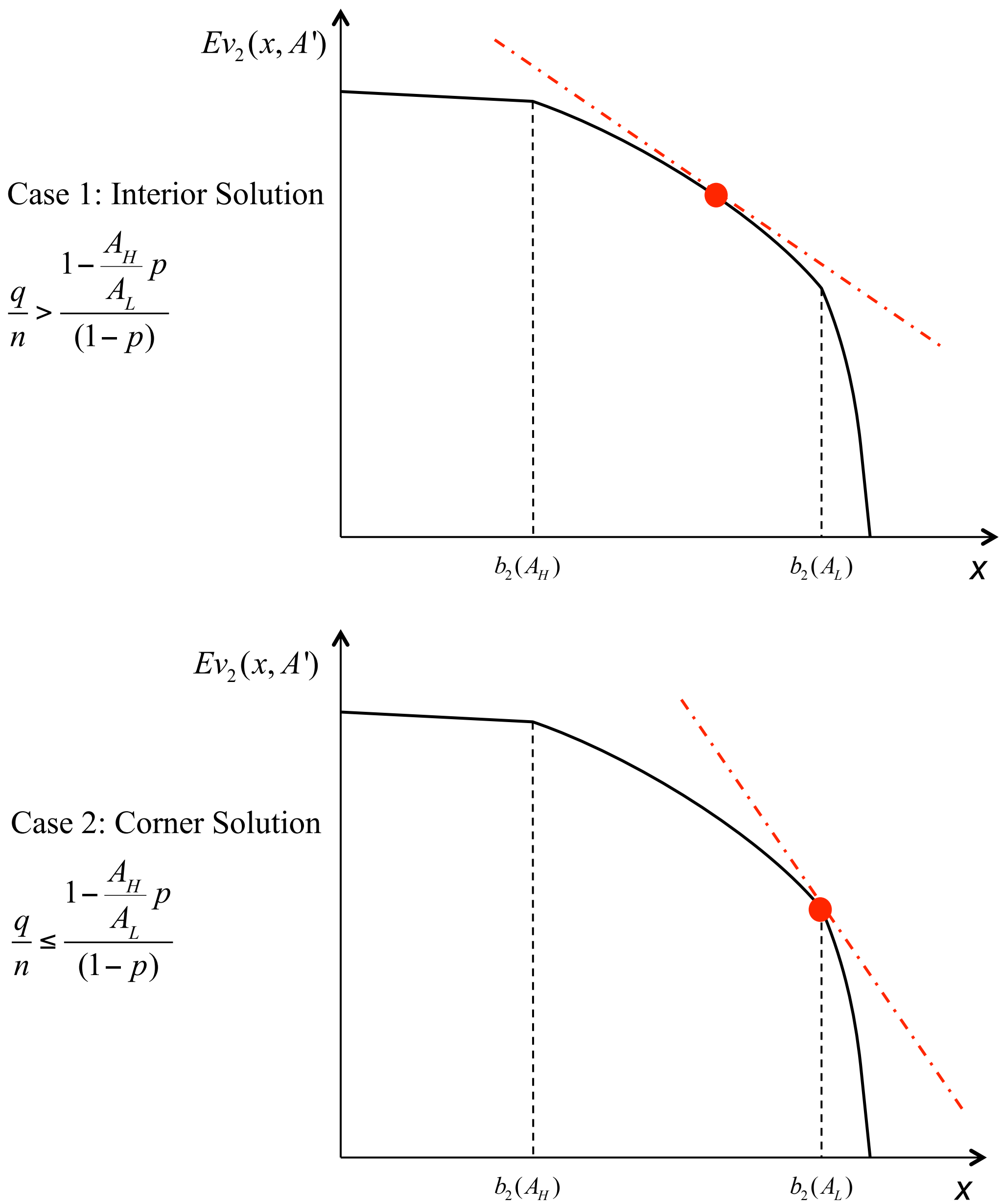


Figure 1: Value Function in Political Equilibrium.

negativity constraint is biding in state A_H, and not binding in state A_L, implying that we have transfers only in state A_L.

3.2 Behavior in Period 1

Given the characterization of the continuation value function $v_2(x, \theta)$, we can now solve for the political equilibrium in the first period, in which forward-looking proposers and voters take into account how their current decision to save or borrow will affect their future bargaining power and the future outcomes.

In the first period, the proposer's problem can be written as:

$$\max_{s,g,x} \left\{ \begin{array}{c} W + x - (q-1)s - g + Au(g) + \delta V_2(x) \\ s.t.\ W + x - (q-1)s - g \geq 0,\ s \geq 0, g \geq 0 \\ s + Au(g) + \delta V_2(x) \geq v_1 \end{array} \right\} \tag{8}$$

Again the proposer maximizes his own expected utility, now comprised of the transfer he can assign to himself (i.e. $W + x - (q-1)s - g$), the value of public good in period one ($Au(g)$), and the discounted expected continuation value as a function of debt x ($\delta V_2(x)$). The first constraint is the budget constraint; the second and third constraints are the non-negativity constraint on public good and districts' transfers; and the fourth constraint is the incentive compatibility constraint for coalition members, where v_1 is the expected period 1 utility before the proposer has been selected.[4]

To solve this problem, we first note that:

$$W + x - (q-1)s - g \geq 0 \text{ and } s \geq 0 \tag{9}$$

implying $W + x - g \geq 0$ So the following problem is a relaxed version of (8):

$$\max_{s,g,x} \left\{ \begin{array}{c} W + x - (q-1)s - g + Au(g) + \delta V_2(x) \\ s.t.\ s + Au(g) + \delta V_2(x) \geq v_1, \\ W + x - g \geq 0 \end{array} \right\} \tag{10}$$

If we find a solution of this problem that satisfies (9), then we have a solution of (8). In (10), moreover, we can assume without loss of generality that the first constraint is satisfied as equality; so after eliminating irrelevant constants, we have the following:

$$\max_{s,g,x} \left\{ \begin{array}{c} x + Aqu(g) - g + \delta q V_2(x) \\ s.t.\ \ W + x - g \geq 0 \end{array} \right\} \tag{11}$$

To solve (11), the key consideration is the determination of debt, since this determines the resources available at $t = 1$ and at $t = 2$. As in the planner case, the proposer will try to equalize the marginal utility of a dollar at time $t = 1$ to the expected marginal utility at $t = 2$. Because the expected value function is not differentiable in x, however, the analysis

[4] There are two additional constraints: $x \in [-W, W/(1+r)]$. These constraints are never binding because of the Inada conditions on $u(g)$, in particular because $\lim_{g \to 0^+} u'(g) = \infty$, so we drop them.

is less straightforward than in Section 3. In Appendix A, we show that only two cases are possible. When $q/n > \left(1 - \frac{A_H}{A_L}p\right)/(1-p)$, the optimal value is $x^\star \in (\widehat{x}_H, \widehat{x}_L)$. In this case the marginal value of a unit of debt at time t is exactly equal to the marginal expected cost at $t = 2$. See Case 1 of Figure 1. When, instead, $q/n \leq \left(1 - \frac{A_H}{A_L}p\right)/(1-p)$, debt is at a corner solution at $\widehat{x}_L$, where the value function is not differentiable (Case 2 of Figure 1). Interestingly, this is not just a theoretical possibility that occurs for non generic parameter sets: it occurs for any $q/n \leq \left(1 - \frac{A_H}{A_L}p\right)/(1-p)$.

Notice that in both cases, $x^\star > \widehat{x}_H$. This implies that there are never transfer in equilibrium in the high value state. All the remaining budget is allocated to the public good if $\theta = H$. This discussion leads to the following characterization of the political equilibrium of the two stage game. A formal proof of the proposition is given in Appendix A.

Proposition 2. *In a political equilibrium, policies are given by:*

$$x^\star = \begin{cases} \frac{W-[u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right)}{1+r} & \text{if } \frac{q}{n} > \frac{1-\frac{A_H}{A_L}p}{(1-p)} \\ \frac{W-[u']^{-1}\left(\frac{1}{A_L q}\right)}{1+r} & \text{if } \frac{q}{n} \leq \frac{1-\frac{A_H}{A_L}p}{(1-p)} \end{cases} \tag{12a}$$

$$g_1^\star = [u']^{-1}\left(\frac{1}{qA}\right) \tag{12b}$$

$$g_{2L}^\star = [u']^{-1}\left(\frac{1}{qA_L}\right) \tag{12c}$$

$$g_{2H}^\star = W - (1+r)x^\star = [u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right) \tag{12d}$$

$$s_1^\star = \frac{W + x^\star - g_1^\star}{n} \tag{12e}$$

$$s_{2\theta}^\star = \frac{W - (1+r)x^\star - g_{2\theta}^\star}{n}\ ,\ \theta = \{H, L\} \tag{12f}$$

$$\pi_1^\star = \left(1 - \frac{q-1}{n}\right)(W + x^\star - g_1^\star) \tag{12g}$$

$$\pi_{2\theta}^\star = \left(1 - \frac{q-1}{n}\right)(W - (1+r)x^\star - g_{2\theta}^\star)\ ,\ \theta = \{H, L\} \tag{12h}$$

where π is the transfer to the proposer.

Political decision making distorts policy choices. The proposition identifies two sources of these distortions. First, the proposer must attract support for his proposal from q-1 coalition partners. Accordingly, given that utility is transferable, he is effectively constructing a proposal that maximizes the utility of q legislators. The fact that q is less than n means that the decisive coalition does not fully internalize the costs of reducing public good spending. Hence, the right hand side of equations (12b) and (12c) have q in the denominator instead of n. If the legislature operated by unanimity rule (i.e., $q = n$), then legislative decision making would reproduce the optimal solution. This follows immediately from Proposition 2 once it is noted that, with $q = n$, the public good levels are just the optimal levels and the debt level, $x^{\star}$, equals the upper bound of x^{O}. More generally, moving from majority to super-majority rule will improve welfare, since raising q reduces debt and raises public good.

Second, the uncertainty about proposal power in the legislature at $t = 2$ creates uncertainty about the identity of the minimum winning coalition. This uncertainty means that the proposer is tempted to issue more debt. Issuing an additional dollar of debt would gain $1/q$ units for each legislator in the minimum winning coalition and would lead to a one-unit reduction in pork in the next period, when the marginal utility from the public good is low. This has an expected cost of only $(1-p)/n$ because members of the current minimum winning coalition are not sure they will be included in the next period, and because there is uncertainty over the future state of the world.

Comparing (6) and (12a) we have:

Corollary 3. *In any political equilibrium, if $q < n$ then debt is higher than efficient and g is lower than efficient in all periods and all states. If $q = n$, then both debt and public good provision are efficient.*

The fact that political decision making introduces dynamic distortions is highlighted by a failure of the Euler equation (7).

Corollary 4. *In any political equilibrium, if $q < n$, we have $Au'(g_1^{\star}) < E\left[A_{\theta} u'\left(g_{2\theta}^{\star}\right)\right]$.*

The failure of the Euler equation highlighted in Corollary 4 is at the core of the inefficiency problem associated with legislative choice of public debt. If the same minimal winning coalition of q legislators chose the policy in both periods, the outcome would internalize only the utilities of q agents and so would differ from the utilitarian optimum of Proposition 1. Still, that solution would coincide with the Pareto efficient solution corresponding to welfare weights that are positive only for the coalition members: and therefore it would satisfy the Euler equation. The equilibrium of Proposition 2, on the contrary, does not correspond to the Pareto optimum for *any* choice of welfare weights. The reason for this is that the minimal winning coalition at $t = 2$ is uncertain and typically different from the coalition at $t = 1$. Hence the coalition members at $t = 1$ tend to underestimate the marginal benefit of resources at $t = 2$: this leads to a failure of the Euler equation. Therefore the equilibrium of Proposition 2 is Pareto inefficient.

3.3 Summary of Theoretical Predictions

The model offers a number of testable predictions, which we will bring to the data.

On First Period Behavior:

- *If $q < n$, then public debt is larger than efficient.*
- *Public debt is decreasing in q/n.*
- *Public debt is weakly decreasing in p, the probability society incurs a crisis.*
- *If $q < n$, then public good provision is inefficient.*
- *Public good provision is increasing in q/n.*
- *Public good provision does not depend on p.*
- *Pork to the proposer is decreasing in q/n.*
- *Pork to the proposer is weakly decreasing in p.*

On Second Period Behavior:

- *For any level of debt: if $q < n$, then public good provision is inefficient.*
- *For any level of debt: public good provision is weakly increasing in q/n.*
- *For any level of debt: pork to the proposer is weakly decreasing in q/n.*
- *For the equilibrium level of debt: no pork is provided if $\theta = H$.*

On Dynamic Distortions:

- *If $q < n$, then $Au'(g_1^\star) < E\left[A_\theta u'\left(g_{2\theta}^\star\right)\right]$; the wedge is increasing in q/n.*

4 Experimental Design

The experiments were conducted at the Social Science Experimental Laboratory (SSEL) using students from the California Institute of Technology, and at the Columbia Experimental Laboratory for the Social Sciences (CELSS) using students from Columbia University. Subjects were recruited from a database of volunteer subjects. Twelve sessions were run, using a total of 185 subjects. No subject participated in more than one session. In all sessions, the committees were composed of five members ($n = 5$), the exogenous amount of resources in each period was $W = 150$, and the payoff from the public good was proportional to the square root of the amount invested in the public good in that period, $u(g_t) = A_t\sqrt{g_t}$. The multiplier of this public good utility, A, was always 3 in the first period but it was either $A_L = 1$ or $A_H = 5$ in the second period.

Our experimental treatments are the majority requirement for passage of a proposal (that is, the political institution, q) and the probability distribution of the public good marginal benefit in the second period (that is, the chance of an economic crisis, p). Six sessions were run using a simple majority requirement to pass a proposal ($q = 3$, M), three sessions using a super majority requirement ($q = 5$, S), and three sessions under an oligarchic rule ($q = 2$, O). In three sessions with simple majority and in all sessions with super majority and oligarchy, there was the same chance of a high shock ($A_2 = 5$) or a low shock ($A_2 = 1$) to the marginal benefit from the public good in the second period ($p = 0.5$). In three sessions with simple majority, there was a low chance of a high shock to the public good marginal benefit in the second period (that is, the probability of $A_2 = 5$ was $p = 1/12$).

Sessions were conducted with 10, 15 or 20 subjects, divided into committees of 5 members each. Committees stayed the same throughout the two periods of a given match, and subjects were randomly rematched into committees between matches. Each session lasted 2 hours: subjects played 20 repetitions of the two-periods game in all sessions with $q = 2$, in all sessions with $q = 3$ and $p = 1/2$, and in one session with $q = 3$ and $p = 1/12$; they played 10 matches in all sessions with $q = 4$; and they played 15 matches in two sessions with $q = 3$ and $p = 1/12$. Table 1 summarizes the design.

Majority Rule	**Risk**	**n**	**q**	**p[θ = H]**	**Sessions**	**Committees**	**Subjects**
Oligarchy (O)	High	5	2	1/2	3	160	40
Simple Majority (M)	High	5	3	1/2	3	180	45
Super Majority (S)	High	5	4	1/2	3	100	50
Simple Majority (M)	Low	5	3	1/12	3	165	50

Table 1: Experimental Design

Before the first match, instructions were read aloud, followed by a practice match and a comprehension quiz to verify that subjects understood the details of the environment including how to compute payoffs. The experiments were conducted via computers.[5] The current

[5]The computer program used was an extension to the open source Multistage game software. See

Panel A: Period 1

	High Risk			Low Risk	Optimum
	Oligarchy	**Simple Maj**	**Super Maj**	**Simple Maj**	
Public Debt	140.2	121.3	80.6	147.8	[-6.3, -93.8]
Public Good	9.0	20.3	36.0	20.3	56.3
Pork to Proposer	225.0	150.6	77.8	166.5	-
Pork to Partner	56.2	50.2	38.9	55.5	-
Pork to MWC	281.2	251.0	194.5	277.5	-
Total Pork	281.2	251.0	194.5	277.5	[0, 87.5]

Panel B: Period 2, Given Equilibrium Level of Public Debt

	High Risk			Low Risk	Optimum
	Oligarchy	**Simple Maj**	**Super Maj**	**Simple Maj**	
$\theta = L$					
Public Good	1.0	2.3	4.0	2.3	6.3
Pork to Proposer	7.0	15.6	26.2	0.0	-
Pork to Partner	1.8	5.3	13.1	0.0	-
Pork to MWC	8.8	26.5	65.4	0.0	-
Total Pork	8.8	26.5	65.4	0.0	[150, 237.5]
$\theta = H$					
Public Good	9.8	28.7	69.4	2.3	156.3
Pork to Proposer	0.0	0.0	0.0	0.0	-
Pork to Partner	0.0	0.0	0.0	0.0	-
Pork to MWC	0.0	0.0	0.0	0.0	-
Total Pork	0.0	0.0	0.0	0.0	[0, 87.5]

Table 2: Theoretical Predictions for Experimental Parameters

period's payoffs from the public good investment (called *project size* in the experiment) was displayed graphically, with the size of public good on the horizontal axis and the corresponding payoff on the vertical axis. Subjects could click anywhere on the curve and the payoff for that level of public good appeared on the screen.

Each period had two separate stages, the proposal stage and the voting stage. At the

http://multistage.ssel.caltech.edu. A sample copy of the instructions from one of the sessions is in Appendix C.

beginning of each match, each member of a committee was randomly assigned a committee member number which stayed the same for both periods of the match. In the proposal stage, each member of the committee submitted a *provisional budget* for how to divide the budget between the public good, called *public project*, and private allocations to each member. After everyone had submitted a proposal, one was randomly selected and became the *proposed budget*. Members were also informed of the committee member number of the proposer, but not informed about the unselected provisional budgets. Each member then cast a vote for or against the proposed budget. The proposed budget passed if and only if it received at least q votes. Payoffs for that period were added to each subject's earnings. At the end of the last match each subject was paid privately in cash the sum of his or her earnings over all matches plus a show-up fee of $5. Average earnings, including show-up fee, were $24.

Table 2 summarizes the theoretical properties of the political equilibrium for the four treatments, as well as the optimal policies. It is useful to emphasize that, as proven in Appendix A, given these parameters the public debt and public good levels are uniquely defined for all treatments.

5 Experimental Results

Because we are interested in the accumulation of public debt and in the role of intertemporal incentives, most of this Section focuses on outcomes and behavior in the first period. The second period is simply a bargaining game over the allocation of a fixed amount of resources among a public good and private transfers to committee members. Moreover, since the resources available to second period committees depends on first period debt choice, different committees typically have different budgets at the beginning of the second period. This makes aggregating outcomes across committees less meaningful. We discuss outcomes and behavior in the second period at the end of this Section.

5.1 First Period Outcomes

We start the analysis of the experimental results by looking at outcomes by treatment. Table 3, Figure 2, and Figure 3 compare the observed levels of public debt and public good by treatment. To aggregate across committees, we use the average level of public debt and public good from all first period committees.[6] We compare these outcomes to the policies

[6] Appendix B shows the observed outcomes for experienced first period committees, that is, for first period committees in matches six and beyond. The behavior of experienced committees does not differ significantly

	High Risk						Low Risk	
	Oligarchy		Simple Maj		Super Maj		Simple Maj	
	Obs: 160		Obs: 180		Obs: 100		Obs: 165	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Public Debt	98.8	5.3	12.5	3.3	-2.9	3.8	57.9	5.7
Public Good	25.9	4.0	36.8	2.2	54.1	3.0	39.8	3.7
Pork to Proposer	108.6	4.7	39.2	1.7	19.7	0.8	49.6	2.8
Pork to MWC	202.0	8.4	112.1	4.8	78.5	3.1	142.2	7.8
Total Pork	222.8	7.1	125.7	4.1	93.0	3.3	168.2	7.1

Table 3: Outcomes in Approved Allocations, Period 1, All Treatments, All Matches

	O vs. M	O vs. S	M vs. S	High vs. Low Risk
Public Debt	0.00	0.00	0.06	0.00
Public Good	0.00	0.00	0.00	0.48
Pork to Proposer	0.00	0.00	0.00	0.08
Pork to MWC	0.00	0.00	0.00	0.05
Total Pork	0.00	0.00	0.00	0.00

Table 4: P-values of Wilcoxon-Mann-Whitney Tests, Period 1 Outcomes

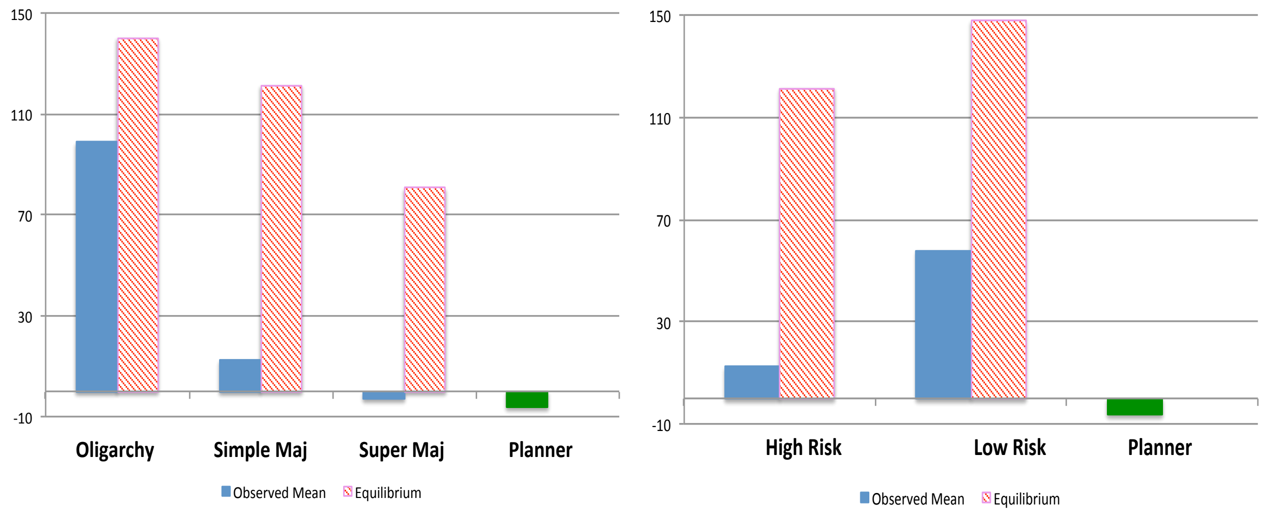
predicted by the political equilibrium and to the optimum.

FINDING 1. Higher q leads to lower public debt and higher public good provision. The average level of public debt is positive in Oligarchy and Simple Majority, and negative in Super Majority. According to Wilcoxon-Mann-Whitney tests[7], the level of debt in Oligarchy is lower than the level of debt in each of the other two voting rules (Simple Majority and Super Majority; and the level of debt in Simple Majority is lower than the level of debt in Super Majority (see Table 4).[8] In Oligarchy, 52% (83/160) of committees spend its whole inter-temporal budget in the first period—that is, these committees incur a

from the behavior of all committees.

[7]Unless otherwise noted, our significance tests are based on Wilcoxon-Mann-Whitney tests. The null hypothesis of a Wilcoxon-Mann-Whitney test is that the underlying distributions of the two samples are the same. We are treating as unit of observation a single group. The results are unchanged if we use t-tests for differences in means (see Tables 13 and 15 in Appendix B).

[8]The differences between Oligarchy and Simple Majority and between Oligarchy and Super Majority are significant at the 1% level. The difference between Simple Majority and Super Majority is significant at the 10% level (p-value 0.0557). The difference between each pair of voting rules is significant at the 1% level according to the results of t-tests (see Table 12 in Appendix B).



(a) Comparison of Majority Rules ($p = 1/2$) (b) Comparison of Economic Risk ($q = 3$)

Figure 2: Average Public Debt in Approved Allocations

debt of 300 and have no resources to allocate in the second period. This fraction goes down to 8% in Simple Majority (14/180) and 1% (1/100) in Super Majority.

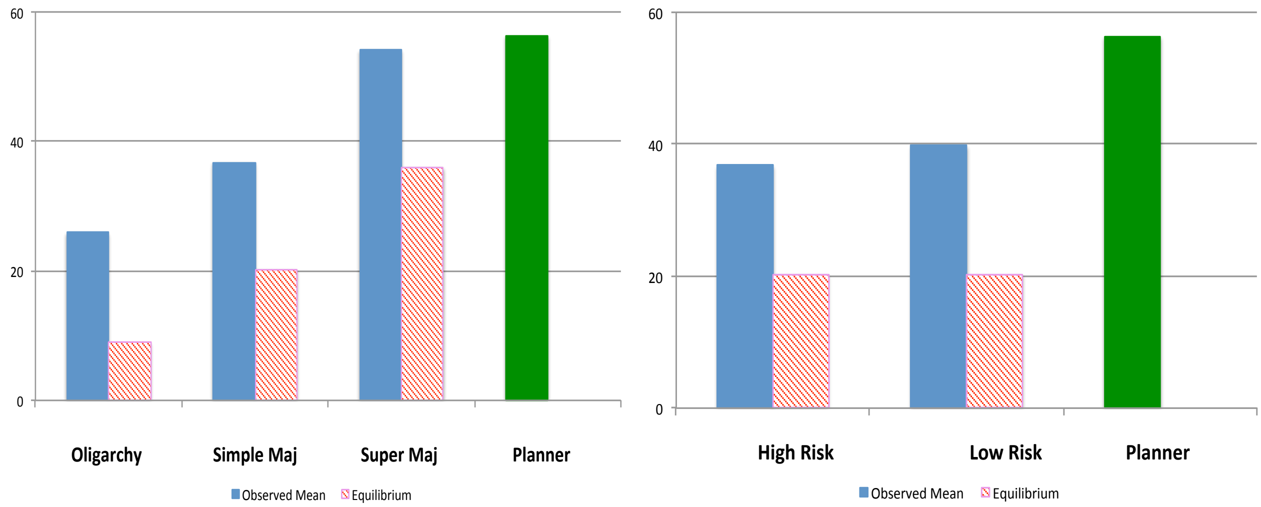
Regarding the provision of public goods, the average level is 25.9 in Oligarchy, 36.8 in Simple Majority, and 54.1 in Super Majority. These differences are statistically significant at the 1% level (see Table 4).[9]

FINDING 2. Oligarchy and Simple Majority lead to inefficient debt and inefficient public good levels; Super Majority leads to almost optimal savings and almost optimal public good provision. In the optimal policy, there is a period one budget surplus (negative debt) in order to guarantee the efficient provision of public good in both states of the world in the second period. The minimum amount of budget surplus that guarantees efficient public good provision when the future marginal value of the public good is high is 6.25 (that is, a negative debt of -6.25). The average debt in Oligarchy and Simple Majority is significantly greater than zero (12.5 in Simple Majority and 98.8 in Oligarchy). On the other hand, the average debt in Super Majority is slightly negative (-2.9) and we cannot reject the hypothesis that the amount saved in committees which decide by Super Majority is equal to the amount of savings in the optimal policy.[10]

We draw similar conclusions regarding public good provision. According to t-tests, the average public good level is significantly lower than the efficient level of 56.25 at the 1% level

[9] According to t-tests, the difference between O and M is significant at the 5% level (p-value 0.0145), the differences between O and S and between M and S are significant at the 1% level.

[10] The p-value associated with a t-test is equal to 0.3799.



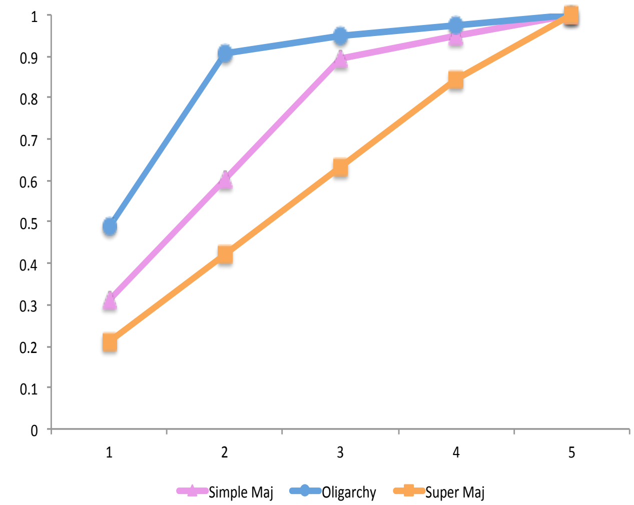
(a) Comparison of Majority Rules ($p = 1/2$) (b) Comparison of Economic Risk ($q = 3$)

Figure 3: Average Public Good in Approved Allocations, Period 1

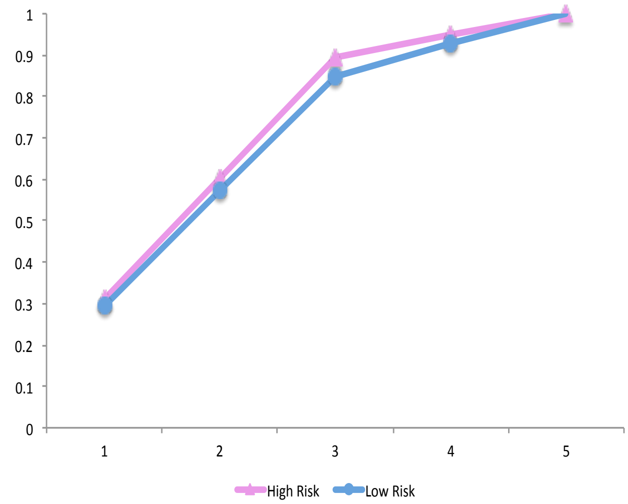
for Oligarchy and Simple Majority. On the other hand, we cannot reject the hypothesis that the average public good level in Super Majority (54.1) is different from the optimum.

FINDING 3. Higher p leads to higher public debt but does not affect public good provision. In addition to manipulating voting rules, we test the effect on public policies of another important dimension: how decreasing the risk of a shock to society affects the accumulation of debt in the first period. According to the theory, in a political equilibrium, public debt is sensitive to the probability of a shock: the current proposer has a larger incentive to provide private transfers when it is less likely that a shock will occur and public good will be valuable. In the experiments, the average level of public debt approved in committees that decide by Simple Majority when $p = 1/2$ is 12.5; the average level of public debt approved in committees that decide by Simple Majority when $p = 1/12$ is 57.9. The difference is statistically significant at the 1% level (see Table 4). The average public good level in committees that decide by Simple Majority and face either a high or low risk of a shock to society is indistinguishable (36.8 for committees with high risk and 39.8 for committees with low risk). This lack of an equilibrium treatment effect of p on g is implied by the theory.

Since private transfers are common, it is interesting to check whether transfers are egalitarian or whether they are mainly concentrated on a minimal winning coalition of voters. Figure 4 shows the distribution of transfers in accepted proposals when committee members are indexed in decreasing order of their allocation.



(a) Comparison of Majority Rules ($p = 1/2$)



(b) Comparison of Economic Risk ($q = 3$)

Figure 4: Cumulative Distribution of Transfers

FINDING 4. In Oligarchy and Simple Majority, a minimum winning coalition of agents receives a more than proportional share of transfers; in Super Majority transfers tend to be more egalitarian. In the Oligarchy treatment, 91% of the private transfers goes to the proposer and one other minimum winning coalition partner. In the Simple Majority treatments (pooling together committees with different risk), 87% goes to the proposer and two other minimum winning coalition partners. In Super Majority, proposed allocations of the private good tend to be more equitable; the proposer is allocated 21% and the member allocated the least receives 16% on average. These observations are in line with findings reported in other experiments on legislative bargaining (Frechette, Kagel, and Lehrer 2003; Frechette, Kagel, and Morelli 2012).

5.2 First Period Proposing Behavior

We now turn to a descriptive analysis of the proposed allocations, as a function of q and p. For this analysis we focus on the amount of debt proposed. Table 5 shows the breakdown of proposals for the four treatments. In each treatment, the first column lists the proportion of proposals of each type that were proposed at the provisional stage (i.e., before a proposal was randomly selected to be voted on). The second column gives the proportion of proposals of each type that passed when they were voted on.

In Simple Majority with High Risk and Super Majority, most first period proposals balance the budget; in Oligarchy and Simple Majority with Low Risk, most first period

Proposal Type	High Risk Oligarchy		High Risk Simple Maj		High Risk Super Maj		Low Risk Simple Maj	
	% Pr	% Ac	% Pr	% Ac	% Pr	% Ac	% Pr	% Ac
Positive Debt	0.70	0.88	0.17	0.62	0.20	0.42	0.59	0.78
- Debt $\in (0, 150)$	0.17	1.00	0.09	0.56	0.16	0.50	0.28	0.75
- Spend Everything	0.53	0.83	0.08	0.67	0.05	0.14	0.31	0.81
Balanced Budget	0.21	0.96	0.68	0.86	0.53	0.70	0.29	0.87
Negative Debt (Savings)	0.10	0.94	0.15	0.39	0.27	0.36	0.13	0.41
- Debt $\in (0, -150)$	0.09	0.94	0.13	0.41	0.20	0.40	0.11	0.42
- Save Everything	0.01	-	0.02	0.25	0.07	0.20	0.01	0.00
All Proposals	1.00	0.89	1.00	0.75	1.00	0.56	1.00	0.74

Table 5: Proposal Types and Acceptance Rates by Treatment, Period 1

proposals accumulate debt. In Simple Majority with High Risk, 68% of all first period budget proposals use exactly W, the per-period flow of societal resources (that is, they balance the budget); in Oligarchy, Simple Majority with Low Risk, and Super Majority, these balanced budget proposals account for, respectively, for 21%, 29% and 53%. Proposals that spend less than W (that is, saved for the second period) were uncommon in Oligarchy (9%) and Simple Majority (15% with High Risk, 13% with Low Risk), but much more common in Super Majority, where they account for 27% of all provisional proposals. In contrast to the data, the political equilibrium proposals should have displayed positive debt in all three voting rules.

5.3 First Period Voting Behavior

Proposal Acceptance Rates. The theory predicts that all proposals should pass. Is this consistent with the data? Table 5 displays the probability that proposals of different type will pass for each treatment.

FINDING 5. In Oligarchy and Simple Majority, the vast majority of proposals pass. In Super Majority, only half of proposals pass. Overall acceptance rates are 89% in Oligarchy, 75% in Simple Majority, and 56% in Super Majority. Even if our legislative

	Oligarchy	High Risk Simple Maj	Super Maj	Low Risk Simple Maj
EU(Accept)-EU(Reject)	0.05***	0.13***	0.08***	0.07***
	(0.007)	(0.004)	(0.025)	(0.013)
Proposer's Relative Greed	-0.07	-0.57***	-0.09***	-0.01
	(0.005)	(0.019)	(0.025)	(0.014)
Herfindahl Index	-4.02***	-1.13	2.14	-0.24
	(1.112)	(1.868)	(1.596)	(1.321)
Constant	1.60***	2.48***	1.82**	0.49*
	(0.389)	(0.695)	(0.755)	(0.274)
Pseudo-R^2	0.5630	0.4939	0.1390	0.2622
Observations	716	960	716	892

Notes: Dependent Variable: Prob {vote 'yes'}. Observations do not include second-period committees with a budget of zero. SE clustered by subjects in parentheses. * significant at 10% level; ** significant at 5 significant at 5% level; *** significant at 1% level.

Table 6: Logit Estimates of Voting Behavior, All Treatments

game is different from the standard Baron-Ferejohn setting, it is interesting to note that the numbers for O and M are nearly as high as the acceptance rates for first-period proposals in experiments testing that bargaining protocol with simple majority: In Frechette, Kagel, and Morelli (2003) 96.4% of first period proposals are accepted. One surprise in the data is the relatively low acceptance rates for proposals with Super Majority. Acceptance rates differ by type of proposal. Some kinds of proposals are rejected somewhat frequently. This is particularly true for proposals which do not balance the budget. In Simple Majority committees and High Risk, only 62% of proposals with debt and 39% of proposals with savings pass. In Super Majority committees, only 42% of proposals with debt and 36% of proposals with savings pass. This has a natural interpretation as a laboratory example of "political gridlock" that can result from using a supermajority rule.

Factors Affecting Voting. Table 6 displays the results from Logit regressions where the dependent variable is the probability of voting in favor of a proposal. An observation is a single committee member's vote decision on a single proposal.[11] The proposer's vote is

[11] We cluster standard errors by subject to take into account possible correlations among decisions taken by the same individuals.

excluded.[12] The data are broken down according to the treatment. The first independent variable is the difference between EU(Accept), the expected value to the voter of a "yes" outcome, and EU(Reject), the expected value to the voter of a "no" outcome (including the discounted theoretical continuation value). Theoretically, a voter should vote yes if and only if the expected utility of the proposal passing is greater than or equal to the expected utility of rejecting it and going to a further round of bargaining within the same period. This would imply a positive coefficient on EU(Accept)-EU(Reject).

Voting behavior could be affected by factors other than just the continuation value and the expected utility from the current policy proposal—for instance, by other-regarding preferences. In order to account for this, we include two additional regressors: a Herfindahl index, that captures how unequal the proposed allocation of private good is across committee members; and the difference between the private allocation to the proposer and the private allocation offered to the voter (what we call "relative greed"). In the case of other-regarding preferences, the sign on the Herfindahl Index and Proposer's Relative Greed should be negative (in the sense that greedier or less egalitarian proposals are punished with more negative votes).

The coefficient on EU(Accept)-EU(Reject) has the correct sign and is highly significant in all treatments: the difference between the (theoretical) expected utility of the proposal and the (theoretical) expected utility of another round of bargaining is an important factor behind voting behavior. Some of the behavioral factors we introduced are statistically significant. For the Oligarchy treatment, proposals that share transfers more evenly across committee members are more likely to receive a positive vote; in the Simple Majority treatment with High Risk and in the Super Majority treatment, proposals that are less greedy. receive greater support.

5.4 Intertemporal Inefficiencies

Section 3.2 showed that political decision making introduces static distortions in the provision of public goods. These static distortions are due to the fact that a minimal winning coalition of size $q < n$ does not fully internalize the benefit of public good provision for the whole community. In addition to this, the model suggests that inefficiencies will arise also because of dynamic distortions: the uncertainty over political power in the second period leads the first period coalition to undervalue the marginal benefit of future resources. This means that the political equilibrium does not coincide with the Pareto efficient solution for any choice of welfare weights (for example, weights that are positive only for the first period coalition

[12] Proposers vote for their own proposals 97% of the time.

	High Risk			Low Risk
	Oligarchy	**Simple Maj**	**Super Maj**	**Simple Maj**
$Au'(g_1)$	18.31	7.35	1.64	10.55
$E[A_\theta u'(g_{2\theta})]$	29.46	8.68	5.21	13.10
Difference	-11.16	-1.33	-3.57	-2.54
P-value	0.0000	0.0182	0.0003	0.0142

Table 7: Test of Intertemporal Inefficiencies

members) and leads to the failure of the Euler equation in Corollary 4. We next test this implication of the theoretical model with data from the laboratory committees.

FINDING 6. The provision of public goods by committees displays dynamic distortions. For each treatment, Table 7 shows the average marginal utility of the public good level provided in each period.[13] In all treatments, the expected marginal utility is larger in the second period and the difference between the two periods is statistically significant at conventional levels according to Mann-Whitney-Wilcoxon tests (see Table 7).[14]

5.5 Second Period Outcomes and Behavior

This section examines outcomes and behavior in the second and last period of the game. At this point, committees do not make any decision regarding public debt and their budget is determined by their first period debt decision. Since different committees take on different amounts of debt in the first period, the budget available to second period committees is heterogeneous and this poses a challenge to analyze this data. First, some committees borrow W in the first period and do not have any available budget for the second period. This happens in 52% of Oligarchy committees, 20% of Simple Majority committees, and 1% of Super Majority committees. Since these committees are not making any decision in the second period, they have to be excluded from the analysis. Second, since the state of the world is realized and publicly announced at the beginning of the period, we pool together the data from the two treatments using a Simple Majority rule, with a high or low probability

[13] Some committees provide no public good. Since marginal utility in this case is equal to infinity, we use the marginal utility of the public good level plus a small constant. Table 7 shows results using as constant 0.001. The results of the Mann-Whitney-Wilcoxon tests shown in Table 7 are unchanged if we use a different constant between 0 and 0.1.

[14] Using t-tests on the differences of averages, rather than Mann-Whitney-Wilcoxon tests on the differences of distributions, the difference is statistically significant for the $q = 2$ and $q = 4$ voting rules, but not the $q = 3$ voting rule.

$\theta = L$	**Oligarchy** Obs: 42		**Simple Maj** Obs: 188		**Super Maj** Obs: 59	
	Mean	SE	Mean	SE	Mean	SE
Public Good (% Budget)	0.04	0.01	0.03	0.01	0.03	0.01
Pork to Prop (% Budget)	0.39	0.02	0.28	0.01	0.21	0.01
Pork to MWC (% Budget)	0.73	0.04	0.81	0.01	0.85	0.01
Total Pork (% Budget)	0.96	0.01	0.97	0.01	0.97	0.01
Efficiency (Given Budget)	0.83	0.33	0.69	0.11	0.66	0.17
$\theta = H$	**Oligarchy** Obs: 35		**Simple Maj** Obs: 89		**Super Maj** Obs: 41	
	Mean	SE	Mean	SE	Mean	SE
Public Good (% Budget)	0.71	0.06	0.77	0.03	0.92	0.03
Pork to Prop (% Budget)	0.11	0.03	0.08	0.01	0.02	0.01
Pork to MWC (% Budget)	0.23	0.06	0.23	0.03	0.08	0.93
Total Pork (% Budget)	0.29	0.06	0.23	0.03	0.08	0.03
Efficiency (Given Budget)	0.72	0.06	0.77	0.03	0.94	0.03

Notes: '% Budget' refers to percentage of the available budget; the budget available to second-period committees is $150 - x$, where x is the public debt accrued in the first period by the same committee; statistics for outcomes as a percentage of available budget are computed excluding committees which have zero budget; second period committees with zero budget are 40/82 in Oligarchy and $\theta = L$; 43/78 in Oligarchy and $\theta = H$; 56/244 in Simple Majority and $\theta = L$; 12/101 in Simple Majority and $\theta = H$; 1/59 in Super Majority and $\theta = L$; 0/41 in Super Majority and $\theta = H$.

Table 8: Outcomes in Approved Allocations, Period 2, All Treatments, All Matches

of a shock. Table 8 shows the average fraction of the available budget devoted to public good provision, private transfer to the proposer, private transfers to a minimal winning coalition, and total private transfers as a function of q and θ. It also reports the average ratio between the public good provided by the committee and the efficient level, given the available resources.

We highlight two results from Table 9, which are in line with the theoretical predictions:

FINDING 7. When the public good is valuable, higher q leads to higher public good provision. When the public good is not valuable ($\theta = L$), committee members devote only a negligible fraction of their budgets to public goods and play a divide-the-dollar game among themselves. On the other hand, when the public good is valuable ($\theta = H$), most

$\theta = L$	**O vs. M**	**O vs. S**	**M vs. S**
Public Good (% Budget)	0.32	0.01	0.01
Pork to Prop (% Budget)	0.00	0.00	0.00
Pork to MWC (% Budget)	0.21	0.15	0.57
Total Pork (% Budget)	0.32	0.01	0.01
$\theta = H$	**O vs. M**	**O vs. S**	**M vs. S**
Public Good (% Budget)	0.15	0.00	0.00
Pork to Prop (% Budget)	0.10	0.00	0.00
Pork to MWC (% Budget)	0.63	0.00	0.00
Total Pork (% Budget)	0.15	0.00	0.00

Table 9: P-values of Wilcoxon-Mann-Whitney Tests, Period 2 Outcomes

resources are devoted to public good provision. This pattern is predicted by our model. In the latter case, both the relative expenditure in the public good and the level of efficiency (as a function the budget) are increasing in the majority rule adopted. While the difference between Oligarchy and Simple Majority is not significant, the difference between Super Majority and the other two rules is significant at the 1% level. Super Majority committees spend 92% of the budget on public goods, for an average level of efficiency of 94%.

FINDING 8. Higher q reduces proposer power. As we increase q, the proposer captures a lower share of the available resources for his own consumption. In the low state, the average fraction to the proposer is 39% in Oligarchy, 28% in Simple Majority, and 21% in Super Majority. These differences are statistically significant. In the high state, the average fraction to the proposer is 11% in Oligarchy, 8% in Simple Majority, and only 2% in Super Majority. While the difference between Oligarchy and Simple Majority is not statistically significant, the other differences are significant at the 1% level.

Finally, we look at the proposed allocations, as a function of q. We focus on whether proposals include private transfers. Table 10 shows the breakdown of proposals for the three majority rules. For each treatment, the first column lists the proportion of proposals of each type that were proposed at the provisional stage (i.e., before a proposal was randomly selected to be voted on); the second column gives the proportion of proposals of each type that passed when they were voted on. In line with the theoretical predictions, in all voting rules, most second period proposals offer no private transfers when the value of the public good is high; most proposals offer private transfers when the value of the public good is low. As in the first period, acceptance rates are lower as we increase the majority requirements.

Panel A: Period 2, Low Value of Public Good ($\theta = L$)

Proposal Type	**Oligarchy**		**Simple Maj**		**Super Maj**	
	% Pr	% Ac	% Pr	% Ac	% Pr	% Ac
Some Pork	0.99	0.84	0.99	0.77	0.95	0.50
No Pork	0.01	0.67	0.01	0.75	0.05	0.37
All Proposals	1.00	0.84	1.00	0.77	1.00	0.50

Panel B: Period 2, High Value of Public Good ($\theta = H$)

Proposal Type	**Oligarchy**		**Simple Maj**		**Super Maj**	
	% Pr	% Ac	% Pr	% Ac	% Pr	% Ac
Some Pork	0.54	0.90	0.57	0.80	0.62	0.64
No Pork	0.46	0.94	0.43	0.89	0.38	0.77
All Proposals	1.00	0.92	1.00	0.84	1.00	0.72

Table 10: Proposal Types and Acceptance Rates by Treatment and Period

Notes: Observations do not include second-period committees with a budget of zero.

Proposals with positive investment in the public good when the public good is not valuable and proposals with private transfers when the public good is valuable are more likely to be turned down.

6 Conclusions

This article investigated, theoretically and experimentally, the accumulation of public debt by a legislature, operating with procedures that entail bargaining and voting. We ask two main questions: do legislatures accumulate inefficient levels of debt? To what extent does this inefficiency depend on the voting rule adopted by the floor?

The experimental analysis of three alternative voting rules (oligarchy, simple majority, and super majority) supports the main qualitative implications of the theoretical model: a higher majority requirement leads unambiguously to significantly higher public good production and lower public debt accumulation. This result confirms, from an experimental point of view, the importance of institutions for public policies and the fact that incentives matter in a way predicted by complex theoretical models. Our model, with supporting evidence from a laboratory experiment, identifies an important force by which super majority voting systems may increase efficiency in the inter-temporal allocation of resources. But the experiments also identify some forces outside the model that may work in the opposite direction: super majority requirements can lead to political gridlock that creates significant bargaining delays in the decision-making process.

There are many possible directions for future research. On the theoretical side, a model that allows for imperfect best response (e.g., Quantal Response Equilibrium) could explain the lower acceptance rates observed with a larger majority requirement. This richer model might have implications for how delay depends on the voting rule, and thus provide a clearer theoretical picture of the trade-off between optimal allocations and bagaining delays in the different institutions.

Our experimental design was intentionally very simple and used a limited set of treatments. We have limited the analysis to legislatures that differ on the q-rule adopted and use a specific procedure. It would be interesting to consider the impact of different proposal and voting procedures. Moreover, our political process does not have elections and parties, and there is no executive branch to oversee the general interest common to all districts. Elections, parties, and non-legislative branches are all important components of democratic political systems, and incorporating such institutions into our framework would be a useful and challenging direction to pursue. Finally, it would be interesting to allow for a richer set of preferences and feasible allocations, such as allowing for diversity of preferences or multiple public goods, more than two periods, and to study the incentives for intergenerational shift of the financial burden in an overlapping generation model.

Appendix A: Proofs

Proof of Proposition 1

Consider the optimization problem (5). First note that the budget constraints must be binding. Moreover, the public good can be assumed to be non negative without loss of generality. If we ignore the non negativity constraints for the transfers, we have the following relaxed problem:

$$\max_{g_1, g_{2\theta}, x} \left\{ \begin{array}{c} W + x - g_1 + Anu(g_1) \\ + \left\{ \begin{array}{c} (1-p)\left[W - (1+r)x - g_{2L} + A_L nu(g_{2L})\right] \\ +p\left[W - (1+r)x - g_{2H} + A_H nu(g_{2H})\right] \end{array} \right\} \\ s.t.\ x \in [-W, \overline{x}] \end{array} \right\} \tag{13}$$

We have the following FOCs with respect to the public good:

$$\begin{aligned} Anu'(g_1) &= 1 \\ A_\theta nu'(g_{2\theta}) &= 1 \;\forall\theta = \{L, H\} \end{aligned} \tag{14}$$

It is also easy to see that any $x \in [-W, \overline{x}]$ is optimal in (13). Rewriting (14), we have:

$$g_1^* = [u']^{-1}\left(\frac{1}{An}\right),\; g_{2\theta}^* = [u']^{-1}\left(\frac{1}{A_\theta n}\right) \tag{15}$$

Assuming the planner treats districts symmetrically, the associated transfers are:

$$\begin{aligned} s_1^* &= \frac{W + x - g_1}{n}, \\ s_{2\theta}^* &= \frac{W - (1+r)x - g_{2\theta}}{n}, \;\forall\theta = \{L, H\} \end{aligned} \tag{16}$$

To verify that this is a solution, we need to check that there is an optimal x such that the transfers are all non negative. For (15)-(16) to be a solution we need:

$$\begin{aligned} W + x - g_1 &\geq 0 \\ W - (1+r)x - g_{2L} &\geq 0 \\ W - (1+r)x - g_{2H} &\geq 0 \end{aligned}$$

These inequalities can be satisfied if:

$$x^* \in \left[g_1 - W, \frac{W - g_{2H}}{1+r}\right]$$

where the interval is non empty thanks to (4). We conclude that g_1^*, $g_{2\theta}^*$, s_1^*, $s_{2\theta}^*$ for $\theta = L, H$ and x^* are optimal policies.■

Proof of Proposition 2

We solve the model by backward induction.

Second Period

At $t = 2$, the proposer's problem can be written as:

$$\max_{s,g} \left\{ \begin{array}{c} W - (1+r)x - (q-1)s - g + A_\theta u(g) \\ s.t.\ W - (1+r)x - (q-1)s - g \geq 0,\ s \geq 0, \\ s + A_\theta u(g) \geq v_2(x,\theta) \end{array} \right\} \tag{17}$$

where $v_2(x,\theta)$ is the utility at $t = 2$ when the state is (x,θ) and before the identity of the proposer is known. Notice that the constraints

$$W - (1+r)x - (q-1)s - g \geq 0 \text{ and } s \geq 0 \tag{18}$$

imply

$$W - (1+r)x - g \geq 0$$

It follows that

$$\max_{s,g} \left\{ \begin{array}{c} W - (1+r)x - (q-1)s - g + A_\theta u(g) \\ s.t.\ s + A_\theta u(g) \geq v_2(x,\theta), \\ W - (1+r)x - g \geq 0 \end{array} \right\} \tag{19}$$

is a relaxed version of (17). If we solve this problem and satisfy (18), then we have a solution. In (19), we must have $s = v_2(x,\theta) - A_\theta u(g)$, that is, the proposer does not waste resources and makes voters exactly indifferent between accepting and rejecting his proposal. The problem of the proposer becomes:

$$\max_{g} \left\{ \begin{array}{c} A_\theta q u(g) - g + [W - (1+r)x - q v_2(x,\theta)] \\ s.t.\ W - (1+r)x - g \geq 0 \end{array} \right\} \tag{20}$$

To solve (20), let us first ignore the constraint $W - (1+r)x - g \geq 0$. Eliminating irrelevant constants, we have:

$$\max_{g} \{A_\theta q u(g) - g\}$$

implying:

$$\begin{aligned} g^\star_{2\theta}(x) &= [u']^{-1}\left(\frac{1}{A_\theta q}\right) \\ s^\star_{2\theta}(x) &= v_2(x,\theta) - A_\theta u\left(g^\star_{2\theta}(x)\right) \end{aligned}$$

In any symmetric equilibrium, we must have:

$$v_2(x,\theta) = \max\left\{\frac{W-(1+r)x-g^{\star}_{2\theta}(x)}{n}, 0\right\} + A_\theta u\left(g^{\star}_{2\theta}(x)\right). \tag{21}$$

So in this case, since $W-(1+r)x-g \geq 0$ by assumption, we have:

$$\begin{aligned} g^{\star}_{2\theta}(x) &= [u']^{-1}\left(\frac{1}{A_\theta q}\right) \\ s^{\star}_{2\theta}(x) &= \frac{W-(1+r)x-g^{\star}_{2\theta}(x)}{n} \end{aligned} \tag{22}$$

It is immediate to see that (22) satisfies $W-(1+r)x-g^{\star}_{2\theta}(x) \geq 0$ if and only if:

$$W-(1+r)x-[u']^{-1}\left(\frac{1}{A_\theta q}\right) \geq 0$$

That is:

$$x \leq \frac{W-[u']^{-1}\left(\frac{1}{A_\theta q}\right)}{1+r} = \widehat{x_\theta} \tag{23}$$

If (23) is not satisfied, then the solution of (19) is

$$\begin{aligned} g^{\star}_{2\theta}(x) &= W-(1+r)x \\ s^{\star}_{2\theta}(x) &= 0 \end{aligned} \tag{24}$$

It is immediate that this solution satisfies (18), so it is a solution of (17) as well. Moreover it is also easy to see that with proposal strategies (22)-(24), the expected value function at $t=2$ is (21). We conclude that the equilibrium strategy in the second period is:

$$g^{\star}_{2\theta}(x) = \begin{cases} [u']^{-1}\left(\frac{1}{A_\theta q}\right) & x \leq \widehat{x_\theta} \\ W-(1+r)x & else \end{cases}, \; s_2(x,\theta) = \begin{cases} \frac{W-(1+r)x-g^{\star}_{2\theta}(x)}{n} & x \leq \widehat{x_\theta} \\ 0 & else \end{cases} \tag{25}$$

Given this equilibrium strategy, the value function in state (x,θ) is:

$$v_2(x,\theta) = \begin{cases} \frac{W-(1+r)x-g^{\star}_{2\theta}(x)}{n} + A_\theta u\left(g^{\star}_{2\theta}(x)\right) & x \leq \widehat{x_\theta} \\ A_\theta u(W-(1+r)x) & else \end{cases} \tag{26}$$

It is easy to verify that $v_2(x,\theta)$ is continuous, differentiable everywhere except at $\widehat{x_\theta}$ with

$$v_2'(x,\theta) = \begin{cases} -\frac{(1+r)}{n} & x \leq \widehat{x_\theta} \\ -A_\theta(1+r)u'(W-(1+r)x) & else \end{cases} \tag{27}$$

and $\lim_{x\to\overline{x}} v_2'(x,\theta) = -\infty$. We also have:

Lemma 1. *The value function at t=2 is concave in x for all θ with $v_2'(x^1,\theta) \leq v_2'(x^2,\theta)$ for $x^1 \geq x^2$ and $-v_2'(x,\theta) \geq (1+r)/q$ for $x > \widehat{x_\theta}$.*

Proof. To see that $v_2(x,\theta)$ is concave, note that the left derivative at $\widehat{x_\theta}$ is $-\frac{(1+r)}{n}$, the right derivative is:

$$\begin{aligned} -A_\theta(1+r)u'(W-(1+r)\widehat{x_\theta}) &= -(1+r)A_\theta u'\left([u']^{-1}\left(\frac{1}{A_\theta q}\right)\right) \\ &= -\frac{(1+r)}{q} < -\frac{(1+r)}{n} \end{aligned}$$

The result follows from the fact that $v_2(x,\theta)$ is linear on the left of $\widehat{x_\theta}$, strictly concave on the right of $\widehat{x_\theta}$, and continuous. The first inequality in the statement immediately follows from (27). For the second inequality in Lemma 1, we have:

$$-v_2'(x,\theta) = A_\theta(1+r)u'(W-(1+r)x) \geq (1+r)/q \text{ for } x > \widehat{x_\theta}$$

The second inequality above follows from the fact that if $u'(W-(1+r)x) < 1/A_\theta q$ then it would be optimal to have $g_2(x,\theta) < W-(1+r)x$. This implies $x \leq \widehat{x_\theta}$, a contradiction. ■

First Period

At $t=1$, the proposer's problem can be written as:

$$\max_{s,g,x}\left\{\begin{array}{c} W+x-(q-1)s-g+Au(g)+\delta E v_2(x,\theta) \\ s.t.\ W+x-(q-1)s-g \geq 0,\ s \geq 0 \\ s+Au(g)+\delta E v_2(x,\theta) \geq v_1 \end{array}\right\} \tag{28}$$

where v_1 is the expected utility at $t=1$ before the proposer has been identified, and $\delta E v_2(x,\theta)$ is the expected utility at $t=2$.

Proceeding as before, we note that the first two constraints in (28) imply $W+x-g \geq 0$. This means that the following problem is a relaxed version of (28):

$$\max_{s,g,x}\left\{\begin{array}{c} W+x-(q-1)s-g+Au(g)+\delta E v_2(x,\theta) \\ s.t.\ s+Au(g)+\delta E v_2(x,\theta) \geq v_1, \\ W+x-g \geq 0 \end{array}\right\} \tag{29}$$

If we find a solution of this problem that satisfies $W + x - (q-1)s - g \geq 0$ and $s \geq 0$, we have a solution of (28).

In (29) we can assume, without loss of generality, that the first constraint is satisfied as equality. After eliminating irrelevant constants, we can write the problem as:

$$\max_{s,g,x} \left\{ \begin{array}{c} x + Aqu(g) - g + q\delta E v_2(x,\theta) \\ s.t.\ \ W + x - g \geq 0 \end{array} \right\}$$

We analyze (29) by assuming that the constraint $W+x-g \geq 0$ is satisfied, and then verifying that this conjecture is correct. From the first order condition with respect to g and x we have:

$$1/q = Au'(g) \tag{30}$$

$$1/q \in -\delta E \nabla v_2(x,\theta) \tag{31}$$

where $-E\nabla v_2(x,\theta)$ is the subdifferential of $Ev_2(x,\theta)$. We need to have this more general approach because the value function is not differentiable at $t=2$. However, since the value function is concave, it has a well defined differential. If we denote $Ev_2^-(x,\theta)$, $Ev_2^+(x,\theta)$ as the left and right derivative of $Ev_2(x,\theta)$ at x, then

$$-\nabla E v_2(x,\theta) = -\left[Ev_2^-(x,\theta), Ev_2^+(x,\theta)\right].$$

Note that we cannot have $x \leq \widehat{x_\theta}$ for $\theta = \{H, L\}$, otherwise we would have $-v_2^+(x,L) = 1/n$ and $-v_2^+(x,H) \leq 1/q$, so $1/q < \delta E v_2'(x,\theta)$ and (30)-(31) would not be true. We conclude that we must have $x > \min\{\widehat{x_L}, \widehat{x_H})\} = \widehat{x_H}$. This implies that $v_2(x,H)$ is differentiable at x and that:

$$\delta v_2'(x,H) = -\delta A_H(1+r)u'(W-(1+r)x) < -\frac{\delta(1+r)}{q} = -\frac{1}{q}$$

where, in the first line, the first inequality follows from Lemma 1 and the second equality from the fact that r is the equilibrium interest rate.

We have two cases: $x \leq \widehat{x_L}$ and $x > \widehat{x_L}$. Assume first that $x > \widehat{x_L}$. In this case $v_2'(x,L)$ is also differentiable at x and:

$$-\delta v_2'(x,L) = \delta A_L(1+r)u'(W-(1+r)x) > 1/q$$

Then (31) implies $1/q = -\delta E v_2'(x,\theta) > 1/q$, a contradiction.

We conclude that in equilibrium we must have $x \leq \widehat{x_L}$ and:

$$\begin{aligned} \delta v_2'(x,H) &= -A_H u'(W-(1+r)x) > 1/q && (32) \\ \delta v_2^-(x,L) &= \delta v_2^+(x,L) = -1/n \text{ if } x < \widehat{x_L} && (33) \\ \delta \nabla v_2(x,L) &= [-1/q, -1/n] \text{ if } x = \widehat{x_L} && (34) \end{aligned}$$

Let's first assume $x < \widehat{x_L}$. In this case, the FOC of (29) with respect to x is

$$1/q = -(1-p)\delta v_2'(x,L) - p\delta v_2'(x,H)$$

Then (32) and (33) imply:

$$1/q = \frac{(1-p)}{n} + pA_H u'(W-(1+r)x)$$

After some algebra, we obtain:

$$x = \frac{W - [u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right)}{1+r} \tag{35}$$

This conjecture is correct if

$$\frac{W - [u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right)}{1+r} = x < \widehat{x_L} = \frac{W - [u']^{-1}\left(\frac{1}{A_L q}\right)}{1+r}$$

That is if:

$$[u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right) > [u']^{-1}\left(\frac{1}{A_L q}\right)$$

Or if:

$$\frac{q}{n} > \frac{1-\frac{A_H}{A_L}p}{(1-p)}$$

If $\frac{q}{n} \leq \frac{1-\frac{A_H}{A_L}p}{(1-p)}$, instead, we have that $x = \widehat{x_L}$. So we can conclude:

$$x^\star = \begin{cases} \frac{W-[u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right)}{1+r} & \text{if } \frac{q}{n} > \frac{1-\frac{A_H}{A_L}p}{(1-p)} \\ \frac{W-[u']^{-1}\left(\frac{1}{A_L q}\right)}{1+r} & \text{if } \frac{q}{n} \leq \frac{1-\frac{A_H}{A_L}p}{(1-p)} \end{cases} \tag{36}$$

Since $x^\star \in [\widehat{x_H}, \widehat{x_L}]$, we have:

$$g^\star_{2H}(x) = W - (1+r)x = [u']^{-1}\left(\frac{1/q - (1-p)/n}{pA_H}\right) \tag{37}$$
$$g^\star_{2L}(x) = [u']^{-1}\left(\frac{1}{qA_L}\right)$$

and:

$$g^\star_1 = [u']^{-1}\left(\frac{1}{qA}\right) \tag{38}$$

For this to be an equilibrium, we must now verify that the initial conjecture is correct. This means that we need $W + x^\star - g^\star_1 \geq 0$ to be verified. Note that from (36) we know that:

$$x^\star \geq \frac{W - [u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right)}{1+r}$$

This implies that a sufficient condition is the second inequality of the following expression:

$$W + x^\star - g^\star_1 \geq \; W + \frac{W - [u']^{-1}\left(\frac{1/q-(1-p)/n}{pA_H}\right)}{1+r} - [u']^{-1}(qA_L) \geq 0$$

To prove that this sufficient condition is verified, we first prove the following Lemma:

Lemma 2. *If $q/n > \left[1 - \frac{A_H}{A_L}p\right]/(1-p)$, then the equilibrium level of debt is inefficiently large, that is, $x^\star \geq \frac{W - g^O_{2H}}{1+r} \geq x^O$.*

Proof. Note that:

$$\frac{1}{q} = \frac{(1-p)}{n} + pA_H u'\left(W - (1+r)x^\star\right)$$

While:

$$\frac{1}{n} = \frac{(1-p)}{n} + pA_H u'\left(g^O_{2H}\right)$$

Subtracting the two equations, we have:

$$u'\left(W - (1+r)x^\star\right) - u'\left(g^O_{2H}\right) = \frac{1}{pA_H}\left(1/q - 1/n\right) > 0$$

So $g^O_{2H} > W - (1+r)x^\star$, that is $x^\star \geq \frac{W - g^O_{2H}}{1+r}$. ■

Given Lemma 2, we have:

$$W + x^\star - [u']^{-1}(qA_L) \geq W + \frac{W}{1+r} - g^O_{2H} - [u']^{-1}(nA_L) > 0$$

where the last inequality follows from (4). ■

6.1 Proof of Corollary 3

It can be seen immediately from (6), (12b), and (12c) that g is inefficiently small in period 1 and state L. In state H we have

$$\begin{aligned} g^\star_{2H}(x^\star) &= W-(1+r)x^\star \\ &< W-(1+r)\frac{W-g^O_{2H}}{1+r} \leq g^O_1 \end{aligned}$$

where the first inequality follows from Lemma 2 and the last from Proposition 1.

6.2 Proof of Corollary 4

We have:

$$\begin{aligned} Au'(g^\star_1) &= 1/q \leq \frac{(1-p)}{n} + pA_H u'\left(g^\star_{2H}(x^\star)\right) \\ &= E\left[A_\theta u'(g^\star_{2\theta}(x^\star))\right] + (1-p)\left(1/n - A_L u'(g^\star_{2L}(x^\star)\right) \\ &= E\left[A_\theta u'(g^\star_{2\theta}(x^\star))\right]) + (1-p)\left(1/n - 1/q\right) \\ &< E\left[A_\theta u'(g^\star_{2\theta}(x^\star))\right] \end{aligned}$$

where the first equality and the first inequality follow from the first order necessary conditions; the second equality is just a rewriting; the third equality follows from (12c). ■

Appendix B: Additional Tables

	O vs. M	**O vs. S**	**M vs. S**	**High vs. Low Risk**
Public Debt	0.00	0.00	0.00	0.00
Public Good	0.01	0.00	0.00	0.48
Pork to Proposer	0.00	0.00	0.00	0.00
Pork to MWC	0.00	0.00	0.00	0.00
Total Pork	0.00	0.00	0.00	0.00

Table 11: P-values of T-Tests, Period 1 Outcomes

Panel A: All Committees

	High Risk						Low Risk	
	Oligarchy		**Simple Maj**		**Super Maj**		**Simple Maj**	
	Obs: 160		Obs: 180		Obs: 100		Obs: 165	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Public Debt	98.8	66.9	12.5	43.6	-2.9	37.8	57.9	72.6
Public Good	25.9	50.5	36.8	29.4	54.1	29.8	39.8	47.2
Pork to Proposer	108.6	59.2	39.2	23.3	19.7	7.7	49.6	36.2
Pork to MWC	202.0	106.0	112.1	63.9	78.5	30.7	142.2	100.7
Total Pork	222.8	89.2	125.7	55.0	93.0	33.4	168.2	91.3

Panel B: Experienced Committees (Matches 6+)

	High Risk						Low Risk	
	Oligarchy		**Simple Maj**		**Super Maj**		**Simple Maj**	
	Obs: 120		Obs: 135		Obs: 50		Obs: 115	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Public Debt	113.7	58.8	13.5	42.9	-6.9	38.9	67.3	75.7
Public Good	24.9	53.2	36.3	28.9	50.8	22.5	31.5	27.7
Pork to Proposer	119.0	56.6	39.9	23.1	19.5	7.8	56.2	38.0
Pork to MWC	219.1	99.5	113.6	62.5	78.0	31.2	160.5	104.8
Total Pork	238.8	82.3	127.2	53.1	92.2	34.2	185.7	91.0

Table 12: Outcomes in Approved Allocations, Period 1, All Treatments

$\theta = L$	**O vs. M**	**O vs. S**	**M vs. S**
Public Good (% Budget)	0.47	0.04	0.00
Pork to Prop (% Budget)	0.00	0.00	0.00
Pork to MWC (% Budget)	0.03	0.09	0.81
Total Pork (% Budget)	0.47	0.04	0.00
$\theta = H$	**O vs. M**	**O vs. S**	**M vs. S**
Public Good (% Budget)	0.02	0.00	0.00
Pork to Prop (% Budget)	0.00	0.00	0.00
Pork to MWC (% Budget)	0.28	0.00	0.00
Total Pork (% Budget)	0.02	0.00	0.00

Table 13: P-values of T-Tests, Period 2 Outcomes

Appendix C: Experimental Instructions

Thank you for agreeing to participate in this experiment. During the experiment we require your complete, undistracted attention, and ask that you follow instructions carefully. Please do not open other applications on your computer, chat with other students, or engage in other distracting activities, such as using your phone, reading books, etc. It is important that you do not talk or in any way try to communicate with other participants during the experiments.

You will be paid for your participation in cash, at the end of the experiment. Different participants may earn different amounts. What you earn depends partly on your decisions, partly on the decisions of others, and partly on chance. Everyone will be paid in private and you are under no obligation to tell others how much you earned. Your earnings during the experiment are denominated in POINTS. For this experiment the conversion rate is 100 POINTS equal $1.50.

This is an experiment in committee decision making. The experiment will take place over a sequence of 20 matches. We begin the match by randomly dividing you into committees of five members each and randomly assigning each of you a committee member number, either 1, 2, 3, 4, or 5. The identity of your committee members will never be revealed to you and your committee members will never know your identity. Each match consists of two rounds.[15] Your committee will have a budget of 150 in each of the two rounds, and in each round you must decide on how to divide the budget between Private Allocations to each of

[15] In the experiment, the two periods were referred to as "rounds".

the committee members and a Public Project. Proposals will be voted up or down (accepted or rejected) by majority rule; that is, for a proposal to pass it must get at least 3 yes votes.

Each match starts with Round 1. In round 1 your committee is not required to exactly spend your budget of 150. Your committee may spend less than 150 in round 1 and carry over part of it to spend in round 2. Your committee may also spend more than 150 in round 1 and the extra amount will be subtracted from your round 2 budget. Thus, for example, if your committee spends 140 in round 1, then the round 2 budget will be equal to 160. If your committee spends 180 in round 1, then the round 2 budget will be equal to 120. Your committee is not allowed to spend more than it can pay back. Therefore, in round 1, your committee is free to spend any total amount between 0 and 300.

Your five-member committee will decide how to divide the round 1 budget by majority rule voting. To do this each member of the committee will submit a provisional allocation proposal that specifies six numbers: a Private Allocation to committee member 1, a Private Allocation to committee member 2, a Private Allocation to committee member 3, a Private Allocation to committee member 4, a Private Allocation to committee member 5, and a Public Project allocation that generates earnings to all five committee members. The sum of these six numbers must add up to a number between 0 and 300.

After everyone in your committee has submitted a provisional allocation proposal, one of them will be selected at random for a vote as the proposed allocation. All provisional allocation proposals have equal probability of being selected as the proposed allocation. The proposed allocation will be posted on your computer screens and you will have to decide whether to vote yes or no. If the proposed allocation passes (at least 3 yes), it is enacted and you move on to Round 2. If the proposed allocation fails (0, 1, or 2 yes), there will be a call for new proposals. This process repeats itself until a proposed allocation passes.

In Round 2, the committee will again divide the budget between the private allocations to each of the five committee members and a public project. Remember, the budget in round 2 may be higher or lower than 150, depending on whether your committee spent less than or more than 150 in round 1. The proposal and voting process is the same: each committee member starts by submitting a provisional allocation proposal.

Your earnings in Round 1 depend on the Round 1 allocation that passed in the following way [SHOW SLIDE]:

$$\text{Your Private Allocation in Round 1} + \text{Public Project Earnings in Round 1}$$

The public project earnings are the same for all members of the committee and are computed according to the formula:

$$\text{Round 1 Public Project Earnings} = 3\,(\text{Amount allocated to Public Project in Round 1})^{0.5}$$

Your earnings in Round 2 depend on the Round 2 allocation that passed in the following way [SHOW SLIDE]:

$$\text{Your Private Allocation in Round 2} + \text{Public Project Earnings in Round 2}$$

With probability 1/2, the Round 2 Public Project earnings are computed according to a HIGH formula:

$$\text{Round 2 Public Project Earnings} = 5\,(\text{Amount allocated to Public Project in Round 1})^{0.5}$$

With probability 1/2, the Round 2 Public Project earnings are computed according to a LOW formula:

$$\text{Round 2 Public Project Earnings} = 1\,(\text{Amount allocated to Public Project in Round 1})^{0.5}$$

Independently for each match, at the beginning of round 2, the computer will randomly assign whether the HIGH or LOW formula for public project earnings applies to your committee, and it will be revealed to you and the other members of your committee on your computer screens BEFORE provisional allocation proposal are submitted. The assignment of your committeeÕs formula is completely random and independent, and does not depend in any way on any participantÕs previous allocation decisions, proposals, or votes.

We will now explain the computer interface. [SHOW SLIDE] At the beginning of the first round of match 1, you will see a screen like this. On the right are boxes where you enter your provisional allocation proposal. On the left is a graphical calculator. If you move the cursor inside the graph it will display the values corresponding to different allocations to the public project (labeled project size). At the bottom of your screen is the history panel. Next you enter your provisional allocation proposal and click submit, at which point your screen will look like the following. [SHOW SLIDE] Of course, the exact numbers will be whatever you entered; the numbers on the screens are just for illustration. After everyone in your committee has submitted their provisional allocation proposals, one of the five provisional proposals is selected at random by the computer as the proposed allocation for the committee to vote on. It requires at least 3 yes votes in order to pass. At this point, your screen will look like this. [SHOW SLIDE] Notice that the screen also shows the committee number of whose provisional proposal was selected by the computer to be the proposed allocation. After everyone has clicked yes or no, the vote outcome screen appears. [SHOW SLIDE] In this example, everyone but one member voted no, so we go back and start round 1 again, and each committee member is again prompted to enter a provisional allocation proposal. Notice that this screen tells you exactly how each committee member voted. After you submit your new provisional allocation proposal the screen looks like. [SHOW SLIDE] The computer randomly selects one committee memberÕs provisional proposal to be the proposed allocation. [SHOW SLIDE]. Everyone in your committee votes, and in this example the proposal passes. The screen calculates how much you earned this round and displays that calculation and graphs the project size and its value on the left. The information is also recorded in the history screen at the bottom. Specific information for each committee member is ordered by committee number, with your own information highlighted in red. We then go to the second round of match 1, and your screen looks like this. [SHOW SLIDE] The total amount that your provisional allocation proposal must add up to is displayed. This is equal to 150 plus or minus whatever you underspent or overspent in round 1. In this example, in round 1 the committee spent 17+27+22+19+41+39=165 for a budget carryover of 150-165=-15. The budget available in the second round is thus 150-15=135. Each member now submits a provisional allocation proposal for round 2 that must add up exactly to this amount, since it is the last round of the match. Round 2 proceeds exactly like round 1: after everyone submits a provisional proposal, the computer randomly selects one of them to be the proposed allocation; you then vote yes or no and a proposal passes with at least 3 yes votes. Once a proposal passes, match 1 ends. You are then randomly re-matched into a new committee and randomly re-assigned a new committee member number and match 2 begins. Match 2 proceeds just like match 1.

We will now proceed to the practice match to familiarize you with the interface. You are not paid for your decisions during the practice match. Please click on the icon marked Multistage Client on your desktop. Then enter your assigned Computer Name, click enter, and then wait. Please complete the practice match on your own. Feel free to raise your hand if you have a question during the practice match.

The practice match is now over. Remember, you are not paid the earnings from this practice match. If you have any questions from now on, raise your hand, and an experimenter will come and assist you. We will now begin the 20 paid matches.

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