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ABSTRACT

We present a theory of endogenous fiscal policy and growth. Fiscal policy — debt, income tax, spending on local public goods and public investment — is determined through legislative bargaining. Economic growth depends directly on public investment, private investment in human capital and, via learning-by-doing, labor supply. The model predicts that the economy converges to a balanced growth path in which consumption, private investment, public investment, public goods provision, public debt and productivity grow at the same constant rate. The transition to the balanced growth path is characterized by what we call the shrinking government effect: public debt grows faster than GDP, provisions of public goods and infrastructure grow slower than GDP and the tax rate declines. We use the model to study the impact of austerity programs which impose a ceiling on the amount of public debt a country can issue.

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1 Introduction

The rapid deterioration of the fiscal position of many western countries in the aftermath of the great recession of 2008 has brought the spotlight on the long-term effect of public debt on the real economy. Federal debt in the U.S. and in many European countries is currently its highest level since the decade following World War II.[1] Concerns over the growth of public debt has led in 2014 to the so-called *Fiscal Compact* in Europe, an intergovernmental treaty that tightens the budget rules previously set in the *Stability and Growth Pact* of 2012;[2] and to the *Budget Control Act* of 2011 in the U.S., which triggers across-the-board automatic cuts in spending in the absence of specified deficit reductions in the following fiscal years.[3] In this context, a few key questions have dominated the public debate: To what extent do high levels of public debt reduce the growth potential of the economy? Are austerity programs, which target debt reduction, effective in increasing growth and welfare? How should they be designed?

To answer these questions we need a theory in which growth and fiscal policy are jointly determined in equilibrium. The literature on growth, however, has traditionally been more focused on the private sector, emphasizing the role of entrepreneurial innovation and technological advancement. With few notable exceptions, fiscal policy has been ignored or assumed as exogenous. Even in the research that has explicitly considered a role for the government, public policy is assumed to balance the budget in every period and public debt is not studied. Yet, fiscal policy has changed in important ways during the last four decades, with potentially significant implications for macroeconomic outcomes.[4]

In this paper we present a political economy theory of endogenous growth in which the government can issue debt to finance expenditures. In our theory the growth rate of the economy depends on public investment, on private investment in human capital and, because of learning-by-doing, private citizens' labor supply. Fiscal policy affects citizens' incentives in two ways: taxation

[1] Public debt is over 100% of GDP in the U.S., over 60% of GDP in more than a half of the 17 Eurozone countries, and over 80% in five of them.

[2] Formally, the *Treaty on Stability, Coordination and Governance in the Economic and Monetary Union*.

[3] The *Bipartisan Budget Act* of 2013 later relaxed the sequestration caps, but it extended their imposition into 2022 and 2023.

[4] In the post WWII era, after bottoming at around 25% of GDP during the seventies, the debt level in the U.S. has been steadily increasing over time, surpassing 60% by the end of 2010. During this period, both the tax revenue and the provision of public goods and infrastructure have declined as shares of GDP, with public investment falling rather dramatically.

distorts labor supply and investment in human capital; deficits distort the consumption/savings decision through their effect on the interest rate. Policy choices are made by a legislature consisting of elected representatives. Political conflict arises because representatives in the legislature have incentives to vote for policies that favor their own constituencies, and citizens benefit only partially from local public goods provided to constituencies to which they do not belong. The level of public debt and the level of productivity in the economy are state variables and create a dynamic linkage across policymaking periods.

We start our analysis by characterizing the conditions under which the economy converges to a balanced growth path in which consumption, private investment, public investment, public goods provision, public debt and productivity grow at the same constant rate. Two forces shape the debt-to-GDP ratio on the balanced growth path: first, the political distortions, pushing politicians to increase debt to finance politically motivated transfers today; second, policy makers' desire to keep the equilibrium interest rate low, leading them to moderate the growth of debt. While both forces have been previously independently studied in the literature, our work is the first to provide a theoretical framework that combines them as building blocks for an equilibrium theory of public debt and growth.

The transition to the balanced growth path is characterized by a novel effect that we call the *shrinking government effect*: starting from a low level, public debt grows faster than GDP, provision of public goods and infrastructure grows slower than GDP and the tax rate declines. Effectively, as the economy converges to its balanced growth path, a decreasing share of output is devoted to providing public services. The shrinking government effect is a consequence of the political distortion and its effect on the interest rate. Political distortions induce the ruling coalition–the coalition in the legislature that controls fiscal policy–to use debt to shift the burden of taxation to the future. In every period the ruling coalition trades off an extra increase in public goods today for their own districts, with a more than proportional reduction in public goods in the following period for all districts. The former option is always more appealing because the ruling coalition can better target current expenditures to their own districts rather than the future expenditure. Consequently, debt increases, forcing legislators to increase the primary surplus to service its cost. The key observation is that legislators find it optimal to do this by reducing expenditures rather than increasing taxes: When expenditures are reduced, disposable income and savings increase, and so the interest rate is held down. To the contrary, when taxes are increased, disposable income and savings decline, so the interest rate goes up.

Next, we employ our model to study the effects of simple but plausible austerity programs on the economy. An austerity program is characterized by two features, a target level for debt and a time horizon: the country is required to bring down debt to a given target level in a given number of years. We find that austerity programs typically increase welfare if they are not excessively ambitious. Interestingly and perhaps counterintuitively the austerity program is not beneficial because it reduces taxes and spending. Conversely, by forcing debt to go down, the austerity program reduces the government incentives to bias the policy in favor of tax cuts and reduction in public goods provision and investment. Effectively, the austerity program reverses the shrinking government effect described above.

Three additional lessons emerge from our analysis. First, there is no "one-size-fits-all" austerity program: The optimal plan depends on the fundamentals and on the initial state of the economy. The higher is the accumulated level of debt, the less aggressive the programs should be, both in terms of the debt target and in terms of its duration. Second, on the transition path of the optimal austerity program, growth is below the pre-austerity level, but welfare is increasing. Finally, an austerity program may work even in the absence of long-term commitment power. However, the lack of commitment can significantly limit the program's effectiveness. Typically, the weaker is the ability to commit, the less ambitious the austerity program should be.

Our paper is related to two strands of literature. First, the literature on endogenous growth. Most of this research is normative and is focused on evaluating the effects of taxation on the capital accumulation process rather than at explicitly modelling policymaking (Rebelo [1990], King and Rebelo [1991], Barro [1991], Stokey and Rebelo [1993], Jaimovich and Rebelo [2013]). Positive theories of growth have been presented in the context of the research studying the political economy of redistribution. The basic idea developed in these papers is that income inequality determines tax policy and therefore growth (Bertola [1993], Perotti [1993], Saint-Paul and Verdier [1993], Alesina and Rodrik [1994], Persson and Tabellini [1994], Krusell and Rios-Rull [1999], Benabou [2000], Saint Paul [2001]). A common trait of these theories (both normative and positive) is that fiscal policy is assumed to balance the budget in every period and so public debt is ruled out by assumption.[5] Our paper contributes to this literature in two ways. First, by introducing debt

[5] An exception is Saint-Paul [1992]. The main result of this paper is that debt is not welfare improving. The paper is normative and does not present a theory of public debt.

we allow for a richer policy space. Second, we offer an explicit dynamic model of political decision making in which rational forward looking policymakers bargain for the policy outcome. To do this, we analyze a symmetric model in which there is no wealth redistribution across citizens. Our focus is on the efficiency of the fiscal policy.

The second strand is the literature on the political economy of public debt (e.g., Persson and Svensson [1989], Alesina and Tabellini [1990], Battaglini and Coate [2008]). These models are specifically aimed at modelling public debt, but they do not allow for growth and make assumptions that simplify the determination of the equilibrium interest rate. These two issues are intimately connected. The key assumption in this literature is that preferences are quasi-linear: in this case the equilibrium interest rate is constant and independent of the chosen policies.[6] Balanced growth, however, is not consistent with these preferences. This is why modelling endogenous growth requires endogenous interest rates. As we show in this paper, the endogeneity of interest rates is crucial to understanding the dynamics of fiscal policy in closed economies. A neoclassical growth model in which the government can expropriate capital in the presence of political economy frictions is presented by Aguiar and Amador [2011, 2012]. Differently from our work, this research focuses on the case of a small open economy for which the interest rate is exogenous: because of this it does not study the interaction between fiscal policy, interest rates and political distortions that is the primary objective of our work. Finally, there is a significant literature studying the political economy of deficit reduction programs both theoretically and empirically.[7] None of the papers explicitly studies the link between debt, fiscal policy and the endogenous growth process.

The organization of the remainder of the paper is as follows. Section 2 outlines the model. Section 3 characterizes the political equilibrium. In Section 4 we study the dynamics of the model using parameters calibrated to the U.S. economy. In Section 5 we use the model to analyze the effect of austerity programs and we study how the optimal austerity program depends on the environment. In Section 6 we discuss the results and some questions open for future research.

[6] In the context of normative models in which policies are chosen by a benevolent planner, the strategic interaction between fiscal policy and interest rates has been first studied by Stokey and Lucas [1983] and then extended to a variety of environments by, among others, Martin [2009] who allows for the presence of money, Rogers [1989], Occhino [2012] and Debortoli and Nunes [2013] who allow for endogenous public spending, and Aiyagari et al [2002] and Shin [2006] who consider stochastic economies.

[7] Among theoretical contributions we have Alesina and Drazen [1991], Grilli and Drazen [1993], Drazen [2001]). More than on studying the effects of deficit reduction, this literature is focused on studying when deficit reduction program are chosen. The effects of a balanced budget rule has been studied by Azzimonti, Battaglini and Coate [2011]. Among empirical contributions in this literature we have Giavazzi and Pagano [1990], McDermott and Wescott [1996], Alesina and Ardagna [1998], Alesina, Perotti and Tavares [1998], Ardagna [2004].

Section 7 concludes.

2 Model

The economy A continuum of infinitely-lived citizens live in n identical districts indexed by $i = 1, ..., n$. The size of the population in each district is normalized to be one. There is a single non-storable consumption good, denoted by C, that is produced using a single factor, labor, denoted by l. There is also a set of n local public goods, denoted by $\gamma = \{\gamma^i\}_{i=1:n}$, which can be produced from the consumption good. The variables at time t will be denoted with a subscript t.

The citizens enjoy the consumption good, invest into their future productivity/human capital, benefit from the local public goods and supply labor. We assume that each citizen's preferences in district i are represented by the following per period utility function:

$$u^i(C_t, l_t, \gamma_t) = \log\left(C_t(1-l_t)^\mu\right) + \omega \log\left[\left(\gamma_t^i\right)^\alpha \left(\sum_{j=1}^n \gamma_t^j\right)^{1-\alpha}\right], \tag{1}$$

where $\mu > 0$, $\omega > 0$ and $\alpha \in [0, 1]$. This utility function describes a situation in which district i enjoys a direct benefit from public good i, but there may also be an externality from (the sum of) public goods provided to all districts. The parameter α measures the size of this externality: the closer α is to one, the smaller are the externalities and the more γ^i benefits only the citizens in district i. Since (1) is a variation of the standard King, Plosser, Rebelo [1988] utility function augmented for public goods, we will refer to it as KPR preferences. Citizens discount future per period utilities at rate δ.

All local public goods are produced from the consumption good according to a linear technology with a unitary marginal rate of transformation. The consumption good at time t is produced with a linear technology $y = z_t\xi_t x$, where the product $z_t\xi_t$ determines the economy's overall labor productivity and x is the labor input. The variable z_t is interpreted as an economy wide productivity factor, which is taken by the citizens as given. In our model it captures two sources of productivity growth: learning-by-doing externalities and public investment, $\mathcal{I}_t$ (such as expenditure on research and development, education, public infrastructure, and other productivity enhancing investment). Specifically, we assume:

$$z_{t+1} = \eta(\bar{l}_t)\phi\left(\frac{\mathcal{I}_t}{z_t\xi_t}\right) z_t, \tag{2}$$

where $\bar{l}_t = \frac{1}{n}\sum_{i=1}^{n} l_t^i$ is the average labor supply; and $\eta(\bar{l}_t) = \eta_0 \cdot (\bar{l}_t)^{\eta_1}$ and $\phi(\frac{\mathcal{I}_t}{z_t\xi_t}) = \phi_0 \cdot (\frac{\mathcal{I}_t}{z_t\xi_t})^{\phi_1}$ are concave increasing functions: η_i, $\phi_i > 0$ for $i = 0, 1$ and η_1, $\phi_1 < 1$. The function η describes the process of learning-by-doing: The more citizens work, the more they learn from each other and more productive they will be in the future. The function ϕ describes the benefits of public investment: The higher is public investment, the higher the next period productivity is. We note that the scaling by $\frac{1}{z_t\xi_t}$ is standard to ensure that public investment as a fraction of output does not shrink to zero over time: In a growing economy, the higher is productivity, the more expensive it should be in absolute terms to improve it.

The variable ξ_t is the level of citizens' labor productivity/human capital. In each period, citizens endogenously determine the next period level of human capital:

$$\xi_{t+1} = \Delta\left(\frac{\mathcal{S}_t}{z_t\xi_t}\right)\xi_t, \tag{3}$$

by choosing private investment level $\mathcal{S}_t$, which translates into human capital growth according to an increasing concave function $\Delta(s) = \Delta_0 s^{\Delta_1}$, where $\Delta_i > 0$ for $i = 0, 1$ and $\Delta_1 < 1$.

There is a competitive labor market. Hence, the wage rate in period t is equal to $z_t\xi_t$. There is also a market in risk-free, one period bonds. Both citizens and the government have access to this market. The assets held by an agent in district i in period t are denoted a_t^i. The gross interest rate is denoted ρ_t: a dollar worth of bonds at time t yields ρ_t at time $t+1$.

For a given sequence of government policies, citizens' maximization problem in period 0 can be written as:

$$\max_{\{C_t, \mathcal{S}_t, l_t\}} \sum_{t=0}^{\infty} \delta^t \left\{ \log\left(C_t(1-l_t)^{\mu}\right) + \omega \log\left[\left(\gamma_t^i\right)^{\alpha} \left(\sum_{j=1}^{n} \gamma_t^j\right)^{1-\alpha} \right] \right\}$$

$$s.t.\ \ \frac{a_{t+1}}{\rho_t} + C_t + \mathcal{S}_t = (1-\tau_t) z_t \xi_t l_t + a_t + \mathcal{T}_t,$$

$$\xi_{t+1} = \Delta\left(\frac{\mathcal{S}_t}{z_t\xi_t}\right)\xi_t \text{ and } z_{t+1} = \eta(\bar{l}_t)\phi\left(\frac{\mathcal{I}_t}{z_t\xi_t}\right) z_t,$$

where τ_t is the tax rate on labor income, and $\mathcal{T}_t$ is the lump-sum transfers from the government.

Public Policies The government provides local public goods, public infrastructure and can make direct lump-sum monetary transfers to the districts. Monetary transfers are uniform across districts and are interpreted as a welfare program symmetrically targeted to all regions.

Revenues are raised by levying a proportional tax on labor income and can be supplemented by borrowing and lending in the bond market. Government policy in period t is described by $\{\tau_t, \beta'_t, \gamma^1_t, ..., \gamma^n_t, \mathcal{I}_t, \mathcal{T}_t\}$, where τ_t is the income tax rate; β'_t is the amount of bonds sold; γ^i_t is the amount of public good provided to district i; $\mathcal{I}_t$ is the level of infrastructure investment; and $\mathcal{T}_t$ is the uniform cash transfer. When β'_t is negative, the government is buying bonds. In each period, the government must also repay the bonds sold in the previous period, which are denoted by β_t. The government's initial debt level in period 0 is β_0; agents initial assets are $a^i_0 = a_0 = \frac{\beta_0}{n}$.

Government policies must satisfy three feasibility constraints. First, tax revenues and net borrowing must be sufficient to cover public expenditures. To see what this implies, consider a period in which the initial level of government debt is β_t and the interest rate is ρ_t. Total expenditure is $\sum_{i=1}^{n} \gamma^i_t + \mathcal{I}_t + \mathcal{T}_t + \beta_t$, tax revenue is $\tau_t z_t \xi_t \sum_{i=1}^{n} l^i_t$, and revenue from bond sales is β'_t/ρ_t. So the government budget constraint is:

$$\beta'_t - \rho_t \left[\beta_t + \sum_{i=1}^{n} \gamma^i_t + \mathcal{I}_t + \mathcal{T}_t - \tau_t z_t \xi_t \sum_{i=1}^{n} l^i_t \right] \geq 0. \quad (4)$$

Second, to keep the policy space compact in the legislator's maximization problem, we assume that local public goods, public investment and transfers as fractions of GDP can not be smaller than some minimal levels: $\gamma^i_t/y_t \geq \underline{g}, \mathcal{I}_t/y_t \geq \underline{I}$, and $\mathcal{T}_t/y_t \geq \underline{T}$ for all i, where $\underline{g} > 0, \underline{I} > 0$, and $\underline{T} \geq 0$. The lower bound $\underline{T}$ is interpreted as commitments on transfers made by previous legislations that are not directly modelled here (as for example Social Security, Medicare and Medicaid). Third, debt, relative to GDP, is bounded: $\beta_t/y_t \in [\underline{b}, \overline{b}]$.[8]

Market equilibrium and political decision making We will study a symmetric equilibrium in which $a^i_t = a_t$ as well as $l^i_t = l_t, C^i_t = C_t$, and $S^i_t = S_t$ for all i's. Since for any given government policy the interest rate must clear the bond market, in such an equilibrium we have $a_t - a_{t+1}/\rho_t = \frac{1}{n}(\beta_t - \beta_{t+1}/\rho_t)$. Using (4) and households' optimality conditions with respect to labor, consumption, and private investment, we can express the citizens' choices as functions of current public policies only. It is useful to express some variables in terms of GDP. Define $g^i_t = \gamma^i_t/y_t,\ I_t = \mathcal{I}_t/y_t, T_t = \mathcal{T}_t/y_t$, and $p_t = \left\{\tau_t, \{g^i_t\}_{i=1:n}, I_t, T_t\right\}$. Labor supply can then be

[8] The upper bound on debt is a standard requirement ruling out Ponzi schemes. As we show later, setting the lower bound on debt to zero is without loss of generality. Since taxes are distortionary, uniform cash transfers are welfare reducing. Hence, the lower bound on the transfers is binding. Of the constraints on the local public goods, $\gamma^i_t/y_t \geq \underline{g}$, only those associated to the districts that are excluded from the coalition in charge of the policy are binding. The identity of these districts changes in every period.

written as:

$$l(p_t) = \frac{1-\tau_t}{\mu_0\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^{n} g_t^i\right)\right]+1-\tau_t}, \tag{5}$$

where $\mu_0 = \frac{\mu}{1+\frac{\delta}{1-\delta}\Delta_1(1+\omega)}$. Consumption can be written as $C(p_t, z_t, \xi_t) = z_t\xi_t c(p_t)$, where

$$c(p_t) = \frac{\mu}{\mu_0}\frac{(1-\tau_t)\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^{n} g_t^i\right)\right]}{\mu_0\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^{n} g_t^i\right)\right]+1-\tau_t}. \tag{6}$$

Private investment can be written as $\mathcal{S}_t(p_t, z_t, \xi_t) = z_t\xi_t s(p_t)$, where

$$s(p_t) = \frac{\delta}{1-\delta}\Delta_1(1+\omega)\frac{\mu}{\mu_0}\frac{(1-\tau_t)\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^{n} g_t^i\right)\right]}{\mu_0\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^{n} g_t^i\right)\right]+1-\tau_t}. \tag{7}$$

These expressions allow us to write citizen i's utility function as a function of only current public policies and the level of overall productivity:

$$u^i(p_t, z_t, \xi_t) = (1+\omega)\log z_t\xi_t + U(p_t) + \omega \log\left[\left(g_t^i\right)^{\alpha}\left(\sum_{j=1}^{n} g_t^j\right)^{1-\alpha}\right], \tag{8}$$

where $U(p_t)$, derived in Lemma A.1 of the Appendix, can be interpreted as the indirect per period utility function, scaled by productivity $z_t\xi_t$. We can also write the resource constraint of the economy as:

$$z_t\xi_t n l(p_t)\left[1-\frac{c(p_t)+s(p_t)}{l(p_t)}-\frac{1}{n}\left(I_t+\sum_{i=1}^{n} g_t^i\right)\right] \geq 0.$$

Note that since the evolution of the economy's overall productivity, $z\xi$, is fully described by the function $Z(p) \equiv \eta(l(p))\phi\left(I \cdot nl(p)\right)\Delta\left(s(p)\right)$, we have that $z_{t+1}\xi_{t+1} = Z(p)z_t\xi_t$. Using this expression, the inter-temporal Euler equation can we written as:

$$\rho_t^{-1} = \delta\frac{u_c(p_{t+1}, z_{t+1}, \xi_{t+1})}{u_c(p_t, z_t, \xi_t)} = \delta\frac{c(p_t)}{Z(p_t)c(p_{t+1})}. \tag{9}$$

From (5)-(7) it is clear that the districts are heterogeneous only with respect to the amount of local public goods $\left\{g_t^i\right\}_{i=1:n}$ they receive. These are the variables over which there is political conflict in the legislature.

Government policy decisions are made by a legislature consisting of representatives from each of the n districts. One citizen from each district is selected to be that district's representative. Since all citizens have the same policy preferences, the identity of the representative is immaterial and, hence, the selection process can be ignored. The legislature meets at the beginning of each period. To describe how legislative decision-making works, suppose the legislature is meeting at the beginning of a period in which the current level of public debt is β_t. The process has two phases: government formation and bargaining in the government.[9] In the first phase, one of the legislators is randomly selected to form a government, with each representative having an equal chance of being recognized. A government is a cabinet of $\mathcal{G}$ representatives and a policy platform $\{\beta_{t+1}, \tau_t, G_t, \mathcal{I}_t, \mathcal{T}_t\}$, where G_t is the aggregate amount of public goods. In the second phase, the cabinet members allocate the local public goods. The initial government formateur proposes a provisional distribution of the local public goods $\left\{\gamma_t^i\right\}_{i=1:n}$. If the first proposal is accepted by $q \leq \mathcal{G}$ cabinet members, then it is implemented and the legislature adjourns until the beginning of the next period. At that time, the legislature meets again with the difference being that the initial level of public debt is β_{t+1} and productivity is given by (2). If, on the other hand, the first proposal is not accepted, another member of the government is chosen to propose an alternative redistribution of $\left\{\gamma_t^i\right\}_{i=1:n}$. The process continues until a proposal is approved by the cabinet. We assume that each proposal round takes a negligible amount of time.[10]

3 The political equilibrium

Before we characterize the political equilibrium in the economy described in the previous section, it is useful to highlight the key determinants of growth in our economy. On a balanced growth path we should expect income, consumption, and private investment, as well as public expenditure and tax revenue, to grow at the same constant rate σ. In an economy with a non trivial public sector we should also expect public expenditure to grow at the same rate as the private economy,

[9] A similar bargaining process in which first a formateur selects the government and then the cabinet members bargain over the allocation of targetable transfers is presented by Baron and Diermeier [2001]. In Baron and Diermeier [2001] the bargaining phase consists in a take it or leave it offer with a status quo policy in case a qualified majority in the government is not reached.

[10] Our bargaining process gives as special cases many bargaining processes used in the political economy literature. When $\mathcal{G} = 1$ the policy is chosen by a randomly selected dictator who maximizes his own utility as in Alesina and Tabellini [1990]. As we will show, when $\mathcal{G} > 1$ and $q = \mathcal{G}$ the policy is chosen to maximize the aggregate utility of a coalition of size $\mathcal{G}$ as in Battaglini and Coate [2014]. When $\mathcal{G} = q = n$, the policy coincide with the utilitarian optimal policy.

and tax revenues to be a constant fraction of income:[11]

$$\frac{\Delta C}{C} = \frac{\Delta S}{S} = \frac{\Delta \gamma}{\gamma} = \frac{\Delta \mathcal{I}}{\mathcal{I}} = \frac{\Delta \mathcal{T}}{\mathcal{T}} = \sigma, \; \Delta \tau = 0. \tag{10}$$

It is easy to see that in our economy the growth rate of all key variables is determined by the growth rate of overall productivity: $\sigma = \frac{\Delta z}{z}\frac{\Delta \xi}{\xi}$. Even before we start studying political decision making, we can see the role of fiscal policy on σ. From (2), on the balanced growth path we have:

$$\sigma = \frac{\Delta z}{z} \cdot \frac{\Delta \xi}{\xi} = Z(p) - 1. \tag{11}$$

The growth rate is a function of the primitives of the economy *and* of public policies. This is not in itself a new observation, since it has been long recognized that in endogenous growth models public policies have a long-term effect on the growth rate (see Rebelo [1991]). The interesting point is that, in our model, explaining fiscal policy is *necessary* to obtain an *endogenous* theory of growth.

Condition (11) leaves two open questions. First, what determines the long-run fiscal policy, and hence the economy's growth rate on the balanced growth path? Second, what are the dynamics of the policy variables? An economy may reach the balanced growth path with an increasing or decreasing growth rate, increasing or decreasing public goods provision, etc... Studying the path of the economy towards the balanced growth path is one way to shed light on the long-run trends of fiscal policy variables. To answer these questions we need an explicit theory of public policymaking. We address these issues in the next two sections. In Section 3.1 we characterize equilibrium behavior. In Section 3.2 we derive the model's implications for the balanced growth path and for the transition path converging to it.

3.1 Equilibrium behavior

To characterize behavior when policies are chosen by a legislature, we look for a symmetric Markov perfect equilibrium (SME) in which players' strategies depend only on the level of public debt scaled by productivity, i.e. $b_t = \beta_t/(z_t\xi_t)$. As we formally show below there is no loss of generality in adopting b_t as the state variable.[12] A symmetric Markov equilibrium can be formally defined

[11] Obviously these conditions need not be satisfied on the path of convergence. The predictions of the model for the convergence path will be discussed in Section 3.2. in greater detail.

[12] Strategies cannot depend on the current level of debt relative to GDP since GDP is itself a function of current policies. The debt-to-GDP ratio at time t is $\beta_t/(z_t\xi_t nl(p_t))$. While $\beta_t/(z_t\xi_t)$ is a state inherited from the past, p_t is a control vector chosen at t.

by a collection of policy functions $p(b) \equiv \{\tau(b), I(b), T(b), b'(b), g(b), g^c(b)\}$. Here $\tau(b)$, $I(b)$ and $T(b)$ are the tax rate and the share of GDP spent on public investment and transfers proposed in state b. The function $b'(b)$ is the new level of debt normalized by the future productivity, i.e. $\beta' / (z'\xi')$. [13] The remaining two functions describe how local public goods are distributed in the economy. In a SME the proposer randomly selects $\mathcal{G} - 1$ legislators to form a cabinet, choosing them from the remaining $n-1$ legislators with equal probability. The proposer provides sufficient local public goods to q cabinet members to guarantee their vote, and as little as possible to the others (in the cabinet or outside). The functions $g(b)$ and $g^c(b)$ are the shares of GDP of the public good proposed for, respectively, the proposer's district and the other districts in the minimal winning coalition. All the other representatives excluded from the minimal winning coalition receive the minimal share of GDP possible, $\underline{g}$.

As standard in the theory of legislative voting, we focus on weakly stage undominated strategies, which implies that legislators vote for a proposal if they prefer it (weakly) to continuing on to the next proposal round. We focus, without loss of generality, on equilibria in which, at each round, proposals are immediately accepted by at least q legislators so that, on the equilibrium path, no meeting lasts more than one proposal round. We say that an equilibrium is smooth if the policy functions are continuously differentiable in b. In the reminder of the paper we focus the analysis on smooth equilibria. This property is satisfied by construction in all equilibria computed in Section 4.

To characterize the equilibrium strategies consider the problem faced by the proposer. The proposer chooses the policies to maximize the utility of his own district under two sets of constraints: First, the budget constraint and the feasibility constraints that we have described in the previous section. Second, an incentive compatibility constraint that guarantees that the proposal is voted by a qualified majority. To be approved, the policies must be such that:

$$U(p) + \omega \log \left[(g^c)^\alpha \left(\sum_{j=1}^{n} g^j \right)^{1-\alpha} \right] + \delta v(b', z', \xi') = v_{\mathcal{G}}(b, z, \xi), \tag{12}$$

where z' and ξ' are the next period productivity factor and human capital level after policy p is implemented, $v(b', z', \xi')$ is the citizens' continuation value, and $v_{\mathcal{G}}(b, z, \xi)$ is the outside option of a cabinet member. The left hand side of this constraint is the expected utility of accepting the

[13] The future level of debt in absolute terms can therefore be expressed in terms of the current policies as $Z(p(b))z\xi \cdot b'(b)$.

proposal for a member of the minimal winning coalition who receives a level $g^c(b)$ of local public good. The outside option of a cabinet member, $v_{\mathcal{G}}(b, z, \xi)$, is the expected utility of voting no and therefore moving to the stage of the bargaining game in which a new government member is randomly selected.[14] The next result shows that (12) imposes a precise relationship between $g(b)$ and $g^c(b)$:

Lemma 1. *In equilibrium, the incentive compatibility constraint (12) is satisfied if and only if* $g^c(b) = g(b)^{Q(\mathcal{G},q)} \cdot \underline{g}^{(1-Q(\mathcal{G},q))}$, *where* $Q(\mathcal{G}, q) = \frac{1}{\mathcal{G}-q+1} \in (0, 1]$.

Lemma 1 shows that the bargaining process forces the proposer to provide a level of local public good to the members of the minimal winning coalition equal to a geometric average of the level he assigns to his own district and the level he assigns to the districts outside the coalition, $\underline{g}$. Total public goods expenditure is a function of $g(b)$ only: $G(b) = g(b) + (q - 1)g(b)^{Q(\mathcal{G},q)}\underline{g}^{(1-Q(\mathcal{G},q))} + (n - q)\underline{g}$. It should be noted that the weight on $g(b)$ is an increasing function of q: The larger is q, the more the proposer is forced to internalize the welfare of the other government members. Indeed, when the voting rule is unanimous and so $q = \mathcal{G}$, we have $g^c = g$.[15]

As shown in Section 2, the citizens' per period indirect utility function is separable in $z\xi$ and p (see expression (8)). The value function has a similar representation. As shown in the Appendix, we can express the value function as $v(b, z, \xi) = \mathcal{A} \log z\xi + \mathcal{V}(b)$, with $\mathcal{V}(b)$ defined recursively as:

$$\mathcal{V}(b) = \mathcal{U}(p(b)) + \alpha\frac{\mathcal{G}}{n}Q(\mathcal{G}, q)\omega \log g(b) + (1 - \alpha)\omega \log G(b) + \delta\mathcal{V}(b'(b)), \tag{13}$$

where $\mathcal{A}$ is a constant and $\mathcal{U}(p)$ is specified in closed form in the Appendix.[16] Using Lemma 1,

[14] Of course, the incentive constraint needs to be satisfied as a weak inequality, requiring the left hand side to be no smaller than the right hand side. In equilibrium, however, the proposer minimizes the cost of obtaining a minimal winning coalition, so (12) is always satisfied as an equality.

[15] When the government deliberates by unanimous rule (i.e. $q = \mathcal{G}$), all the government members are treated in the same way and the policy is chosen to maximize the aggregate utility of government members.

[16] The function $\mathcal{U}(p)$ can be interpreted as the indirect utility function given policy $p(b)$ from consumption and labor, augmented by the (permanent) effect of current policy $p(b)$ on future productivity. We represent the indirect utility function as in (13) to highlight the difference with the objective function of the proposer in (14), as discussed below.

moreover, the proposer's problem can be written as:

$$\max_{b',\tau,g,G,I,T} \left\{ \begin{array}{c} \mathcal{U}\left(p\right)+\alpha\omega\log g+(1-\alpha)\omega\log G+\delta\mathcal{V}(b') \\ s.t.\ Z(b)\frac{b'}{\rho(b,b')}-[b+G(g)+I+T-\tau nl(p)]=0 \\ G=g+(q-1)g^{Q(\mathcal{G},q)}\cdot \underline{g}^{(1-Q(\mathcal{G},q))}+(n-q)\underline{g} \\ b'\leq\overline{b},\ g\geq\underline{g},\ I\geq\underline{I},\ T\geq\underline{T},\tau\in[0,1] \end{array} \right\} \tag{14}$$

The representation in (13)-(14) highlights the role of the political process on how policies are chosen in equilibrium. When $\alpha = 0$ policies have a uniform effect on the citizens' welfare. In this case there is no political conflict and the proposer chooses policies to maximize the welfare of the representative citizen. When $\alpha > 0$, districts value local public goods differently. In this case the proposer overestimates the welfare effect of g. The magnitude of the overestimation depends on $\frac{\mathcal{G}}{n}Q(\mathcal{G},q)$. When $q = \mathcal{G} = n$, we have $Q(\mathcal{G},q) = 1$ and full alignment of interest across districts is re-established. When $\mathcal{G} < n$ or $q < \mathcal{G}$ then $\frac{\mathcal{G}}{n}Q(\mathcal{G},q) < 1$ and we have political conflict.

Using (13)-(14) we have the following characterization of a political equilibrium:

Proposition 1. *Under KPR preferences:*

- *If $p = \{\tau, I, T, b', g, g^c\}$ solves (14) given $\mathcal{V}$, and $\mathcal{V}$ satisfies (13) given p, then p is an equilibrium policy function and $v = \mathcal{A}\log z\xi + \mathcal{V}$ is the associated equilibrium value function.*
- *If $p = \{\tau, I, T, b', g, g^c\}$ is a political equilibrium with value function v, then p is a function only of b and there are a function $\mathcal{V}$ of b only and a constant $\mathcal{A}$ such that the value function can be represented as $v = \mathcal{A}\log z\xi + \mathcal{V}$. Moreover, p solves (14) given $\mathcal{V}$, and $\mathcal{V}$ satisfies (13) given p.*

The first bullet of Proposition 1 shows that to characterize an equilibrium we can simply study (13) and (14), where the state variable is b. Once we have solved for the fixed-point implied by these two conditions, the value function can be immediately found with the formula $v = A\log z\xi + \mathcal{V}$. The second bullet shows that there is no loss of generality in considering the representation (13) and (14), since all equilibria can be expressed in this way.

3.2 Balanced growth and transition dynamics

To study the dynamic properties of a political equilibrium, it is useful to introduce a key concept in public finance, the marginal cost of public funds (MCPF). The marginal cost of public funds is the compensating variation for a marginal increase in tax revenues.[17] It is, therefore, a measure of the distortion introduced by the government into the economy. To see the importance of this concept, consider the marginal cost of public funds associated with policies $\{\tau_t^*, b_t^{*\prime}, I_t^*, T_t^*, g_t^*\}$ that would be chosen by a benevolent planner who can commit to the optimal policy plan. Under standard assumptions, the planner aims at smoothing the cost of taxation over time as much as possible. This implies that polices are chosen so that the marginal cost of public funds is equalized over time: $MCPF_t^* = MCPF_{t+1}^*$ for any $t > 0$.[18] A constant marginal cost of public funds implies that fiscal policy and the growth level of the economy are all constant for any $t > 0$. Is this result still valid in a political equilibrium? If not, what are the implications for the dynamics of the economy?

To answer these questions, let us define the elasticity of the interest rate with respect to b' evaluated at the equilibrium level $b' = b'(b)$ in state b as

$$\varepsilon_\rho(b) = \frac{\partial \rho(b', b)}{\partial b'} \frac{b'}{\rho(b', b)}. \quad (15)$$

This elasticity has a clear interpretation since it measures the relationship between two observable variables, debt and the interest rate. Let us also define $\varepsilon_g(b)$ as the elasticity of the policy function g with respect to debt, $\varepsilon_g(b) = \frac{\partial g(b)}{\partial b} \frac{b}{g(b)}$. We have the following characterization of the evolution of the marginal cost of public funds in a political equilibrium:

Proposition 2. *In equilibrium:*

$$[1 - \varepsilon_\rho(b_t)] \cdot MCPF(b_t) = \left[1 - \alpha\omega \left(\frac{\mathcal{G} \cdot Q(\mathcal{G}, q)}{n} - 1\right) \Phi(b_{t+1})\, \varepsilon_g(b_{t+1})\right] \cdot MCPF(b_{t+1}), \quad (16)$$

where $\Phi(b)$ is a nonnegative function of debt.

As noted above, in the first best, we must have $MCPF(b_t) = MCPF(b_{t+1})$. Proposition 2 shows that in a political equilibrium this equality does not hold: there is generally a wedge

[17] In intuitive terms, the $MCPF$ is the marginal monetary transfer necessary to compensate an agent for a marginal increase in tax revenues.

[18] A formal analysis if the planner's problem is available from the authors upon request. See also Ljungqvist and Sargent [2004] for the analysis of a similar problem in a model with no endogenous growth.

between the marginal cost of public funds at t and at $t+1$. Condition (16) generalizes analogous representations of the evolution of the "cost of resources" in political system that are typically referred to as modified or generalized Euler equations.[19]

The intuition behind (16) is as follows. The left hand side is the marginal benefit of debt: by increasing debt by a unit, tax revenues can be reduced by a unit at time t, inducing a net welfare gain equal to $MCPF(b_t)$. This term is corrected by $(1-\varepsilon_\rho(b_t))$ to account for the fact that the government is not a price taker in the bond market. When, for example $\varepsilon_\rho(b_t)>0$, an increase in debt implies an increase in the interest rate and the corresponding reduction in resources limits the benefit of an increase in b. The right hand side can be interpreted as the marginal cost of debt. An increase in debt generates two effects: it reduces future resources (with a welfare effect measured by the term $MCPF(b_{t+1})$), and changes the future policy mix by affecting policies (this second effect is represented by the term $\left[1-\alpha\omega\left(\frac{\mathcal{G}}{n}Q(\mathcal{G},q)-1\right)\Phi\left(b_{t+1}\right)\varepsilon_g(b_{t+1}))\right]$). When policies are chosen by a utilitarian planner, the second effect is irrelevant: policies are always optimal, so by the Envelope theorem, a marginal change from the optimal level has no welfare effect. Since our model policies are inefficient, however, the change in the policy mix induced by b has a first order impact that cannot be ignored. Naturally, the inefficient policy mix is a result of the political distortion. Not surprisingly, the size of the political distortion depends on α and $\frac{\mathcal{G}}{n}Q(\mathcal{G},q)$: the larger is α, the more severe is political conflict because citizens internalize less the benefit of local public goods provided to districts to which they do not belong. Similarly, the smaller is $\frac{\mathcal{G}}{n}Q(\mathcal{G},q)$, the less the ruling coalition is forced to internalize the welfare of the remaining districts. When $\alpha=0$ or $\frac{\mathcal{G}}{n}Q(\mathcal{G},q)=1$, it is as if policies were chosen by a utilitarian decision maker, so the political distortion is zero.[20]

On a balanced growth path debt grows at the same rate as income, so b_t remains constant at b^*. We say that balanced growth path is *stable* if there is a neighborhood of b^* such that b converges to b^* for any initial state b_0 in that neighborhood. We say that a balanced growth path is *regular* if it stable and two conditions are met: (1) debt is positive on the path, i.e. $b^*>0$; and (2) the interest rate elasticity is positive on the balanced growth path: i.e., $\varepsilon_\rho(b^*)>0$ (or

[19] See Battaglini [2011] for a discussion.

[20] We obtain an interesting interpretation of (16) by dividing both sides by $1-\varepsilon_\rho(b_t)$. The government acts as a standard monopolist: debt is chosen to equalize the marginal benefit to the marginal cost of debt weighted by a standard markup factor that depends on the elasticity of the demand: $1/\left(1-\varepsilon_\rho(b_t)\right)$.

$\partial \rho(b', b)/\partial b' > 0$ at b^*).[21] We say that there is *political conflict* in the economy if $\alpha > 0$ and $q < n$. We have:

Proposition 3. *A stable balanced growth path is regular only if there is political conflict.*

The intuition behind Proposition 3 is illustrated by Figure 1. Consider first Figure 1.A where we present an equilibrium in an environment with no political conflict (so $\frac{\mathcal{G}}{n}Q(\mathcal{G}, q) = 1$ or $\alpha = 0$). The red dotted line represents the left hand side of the previous equation, $(1-\varepsilon_\rho(b))MCPF(b)$; the blue solid line represents the right hand side, $MCPF(b')$.[22] The level of debt corresponding to a balanced growth path is determined by the intersection of these two curves (where $MCPF(b_{t+1}) = MCPF(b_t)$). When there is no political distortion (i.e. $\alpha = 0$ and/or $\frac{\mathcal{G}}{n}Q(\mathcal{G}, q) = 1$), the only point of intersection is $b^* = 0$ (See Figure 1.A). Consider now the situation when there are political distortions. In this case, the solid blue curve corresponding to the right hand side of (16) is shifted downward since $1 - \alpha\omega\left(\frac{\mathcal{G}}{n}Q(\mathcal{G}, q) - 1\right)\Phi\left(b_{t+1}\right)\varepsilon_g(b_{t+1}) < 1$. It follows that the only point of intersection occurs at a $b^* > 0$ (See Figure 1.B), and that is where the economy converges in the long run.

It is interesting to note that the positive *interior* long-run level of debt in the model is the result of two contrasting forces: on the one hand, political economy distortions push debt up; on the other hand, the attempt to manipulate the interest rate pushes debt down. We would not have positive debt on the balanced growth path without the first effect; we would not have an interior level of debt without the second effect: politicians would always have an incentive to shift the financing of expenditure to the future and accumulate more debt. On the balanced growth path the two incentives exactly counterbalance each other.

The next result characterizes the dynamics of the public sector on the convergence path to a regular balanced growth path.

Proposition 4. *Starting from any b_0 in a left neighborhood of a balanced growth path level, both infrastructure and the expected level of local public goods grow at a slower rate than GDP.*

An interesting implication of Proposition 4 is that despite the fact that in this economy the

[21] We find that these properties hold in all of our numerical analysis in the following sections. From an empirical stand point, the requirement of a positive level of debt at the steady state seems natural. For evidence on the interest rate see, for example, Ardagna, Caselli and Lane [2007] and Laubach [2009].

[22] In the Figure, $MCPF(b)$ intersects the origin, but it is not necessary to have $MCPF(0) = 0$. The actual level of $MCPF(0)$ is irrelevant for the analysis.

policymaker has excessive incentives to spend in local public goods, the expected supply of public goods declines over time, and so the public sector becomes smaller and smaller as a fraction of GDP. This phenomenon is a consequence of the political distortion in the presence of endogenous interest rates. Faced with a higher level of debt, the proposer finds it optimal to increase the primary surplus by reducing expenditures rather than by increasing taxes: reducing expenditures rather than raising taxes forces up disposable income and savings, and so it holds interest rates down. To the contrary, an increase in taxes forces down disposable income and savings, and, hence, puts upward pressure on the interest rate. Proposition 4 shows that the legislators always find it optimal to shrink the provision of public services (both in terms of public goods and infrastructure). However, the proposition does not establish that they find it optimal to decrease taxation. This finding will be presented in the next section when we solve numerically a version of the model calibrated to the U.S. economy.

What is the implication of this converging path for productivity? When there is no learning-by-doing or private investment in human capital, this question can be answered analytically.

Proposition 5. *If* $\eta_1 = 0$ and $\Delta_1 = 0$, *then starting from any* b_0 *in a left neighborhood of a regular balanced growth path level, the growth rate in productivity* $\Delta z_t / z_t$ *gradually declines on the convergence path.*

Figure 2 illustrates the last part of Proposition 4 and Proposition 5. As b converges to b^* infrastructure declines: in this case the growth rate of productivity $\phi(I)$ shifts towards the 45 degree line and z grows at a decreasing pace (or potentially may even decline if $\phi(I)$ is lower than one).

Proposition 5 does not necessarily hold in the presence of learning-by-doing or private investment in human capital. The reason is that the tax rate may decline on the transition path. If this decline implies an increase in labor supply, then we have two forces pushing in opposite directions. A decline in the tax rate, however, does not generally imply that labor supply increases. The reason is that, as debt increases, agents hold more financial wealth. The wealth increase implies higher marginal utility of leisure, which may more than counterbalance the effect of the decrease in taxation. In the next section we show that with KPR preferences labor supply typically declines on the transition path, so productivity is decreasing also with learning-by-doing.[23]

[23] Similarly, when there is private investment into productivity, its output share increases along the transition path, potentially offsetting the decline in overall productivity.

Finally, we note that the lower bound on lump-sum transfers always binds. Indeed, transfers are uniform across districts and, hence, are not subject to political conflict over the distribution of resources. Since taxation is distortionary, as long as the government's debt is positive, it is never optimal to tax citizens to simply redistribute the generated revenue back in the form of cash transfers.

4 A calibrated solution of the model

4.1 Positive analysis

In this section we study the model presented above by numerical methods, calibrating it to the U.S. economy. As we detail below, most of the parameter values we use are standard choices in the empirical macroeconomics literature. Those that are key to our approach – the parameters governing the legislative bargaining procedure and the externality parameter α – are chosen to minimize the differences between the balanced growth path values of the fiscal policy variables predicted by the model and the corresponding average values in the U.S. economy in the 2001-2010 period.[24]

We use a log-utility function for consumption as in Jaimovich and Rebelo [2008] and McGrattan and Prescott [2010]. We set μ to 1.37, which yields labor supply elasticity of about 1.5 on the balanced growth path of the model. It is in a mid-range of the parameters used in the literature. We set δ to 0.954 - with 1.2% growth rate this discount factor implies a real interest rate of 6% (Jaimovich and Rebelo, [2008]). The literature provides no guidance on the long-run elasticity of growth via learning-by-doing. We set it to $\eta_1 = 0.245$. That is, we assume that the long-run elasticity of the learning-by-doing with respect to labor is three quarters of its short run elasticity, as estimated by Chang, Gomes and Schorfheide [2002]. The transfer parameter, T, is set to its empirical counterpart, 10% of GDP.

The legislative bargaining parameters are n, $\mathcal{G}$, q, and $\underline{g}$. We normalize the number of districts to 100; we set the government size, $\mathcal{G}$, to 100, the majority required to pass the legislation, q, to 51, and lower bound on local public goods, $\underline{g}$, to .01: 1% of output of a single district. The exact number of districts, the government size, and the size of the minimal winning coalition are not

[24] Implicit is the assumption that fiscal variables have been, on average, at their balanced growth levels during this time period. We note that choosing a different time period to construct empirical values of the fiscal variables, would result in qualitatively identical patterns to those described below. The data description is in the Appendix.

particularly important in absolute terms, what matters is the factor $\frac{\mathcal{G}}{n}Q(\mathcal{G}, q)$. Our choices above imply that it is .02.[25] Recall, however, that the legislative bargaining alone does determine the long-run level of debt. The latter also depends on the externality parameter α. Ceteris paribus, the higher is α, the higher the steady state level of debt is. This relation is exploited in our calibration. In essence, we choose α to match the target value of the debt-to-GDP ratio.[26] More precisely, we choose α, ω, ϕ_1 and Δ_1 together to match the empirically observed (i) debt-to-GDP, (ii) public good-to-GDP, public investment-to-GDP, and private investment-to-GDP ratios. This yields values of 0.53, 0.505, 0.0018 and 0.000525, respectively.

Finally, η_0, ϕ_0, and Δ_0 are scale parameters and can be set to match the desired level of long-run growth. Table 1 shows that the model has no difficulty in achieving the benchmark calibration targets.

Figure 3 describes the dynamics of the model. It shows the transition to the balanced growth path starting with no debt. A number of features of the equilibrium dynamics emerge. First, in the model debt grows faster than GDP. Second, public expenditure, as a fraction of GDP, declines. Both of these patterns conform with our theoretical findings. Third, taxes also decline during the transition. Hence, the shrinking government effect, discussed in Proposition 4, applies also to the revenue side. As debt increases, the government has to increase the primary surplus by either increasing taxes or reducing expenditures. Recall that reduction in expenditures increases citizens' savings and, hence, reduces the equilibrium interest rate. That is, by reducing expenditure the government relaxes the budget constraint both directly and indirectly, by reducing the equilibrium interest rate. The indirect effect of an increase in taxation is different. Higher taxes reduce disposable income and therefore, ceteris paribus, reduce savings and increase the equilibrium interest rate. As the stock of debt increases, the interest rate effect becomes increasingly significant, making tax increases even less attractive.

The fourth feature regards labor supply and provides some insight about the mechanics of the model. Despite the reduction in taxation, labor supply declines over time. This phenomenon is due to the fact that as debt increases, citizens hold more wealth: the wealth effect increases the

[25] Of course, there are alternative combinations of $\mathcal{G}$ and q that are consistent with this value of $\frac{\mathcal{G}}{n}Q(\mathcal{G}, q)$. The behavior of the economy will be very similar under these alternatives.

[26] We note that different values of $\frac{\mathcal{G}}{n}Q(G, q)$ would change the implied value of α, but as long as there is political conflict, an increase in $\frac{\mathcal{G}}{n}Q(G, q)$ will simply translate into an increase in α and vice versa.

marginal utility of leisure, and reduces labor supply.[27]

The fifth feature of the equilibrium shown by Figure 3 regards the growth rate: productivity growth declines as the economy converges to the balanced growth path. This finding also extends the results of the previous section by showing that productivity and output growth decline as the economy approaches the balanced growth path even in the presence of learning-by-doing and private investment. The decline in growth is due to two factors: the decrease in the investment in infrastructure by the government and the decrease in learning-by-doing triggered by the declining labor supply. In addition, the decline in labor supply offsets the rising share of private investment in GDP, countering its positive effect on productivity growth.

Finally, the interest rate declines as the economy converges to the balanced growth path. This decline only partially reflects the falling growth rate of the economy. It is mostly driven by the rise in debt. The higher is debt, the bigger the incentive to reduce spending (as we established in Proposition 4) and to manipulate the interest rate is.

4.2 Robustness

In this section we study the robustness of the model's dynamics with respect to the parameter choices. We change one parameter at a time, keeping others at their benchmark values. In Table 2, for each parameter perturbation we report (i) its benchmark value, (ii) the magnitude and the direction of the change, (iii) the resulting long-run debt-to-GDP, public good-to-GDP, public investment-to-GDP, and private investment-to-GDP ratios. In addition, in the On-line Appendix we provide figures that describe the dynamics of the economy starting from zero debt, just as Figure 3 does it for the benchmark case. In all of these cases, we find qualitatively the same patterns as in the benchmark case: the shrinking government effect, declining labor, declining productivity growth and a declining interest rate.

First (see first two rows), we change the discount factor. Naturally, the closer is the discount factor to one, the more the decision makers take the future into account and, consequently, the lower the long-run debt is.

Second (see third and forth rows), we change the parameter μ, which governs labor supply

[27] If, instead KPR preferences, we use Greenwood, Hercowitz and Huffman [GHH, 1988] preferences, all of our results remain qualitatively unchanged and qualitatively very similar to the reported above with the exception of labor supply. Since GHH preferences do not allow for wealth effects, labor supply increases as the debt-to-GDP ratio converged from below to its balanced growth level. These results are available from authors upon request.

elasticity. The lower μ implies that the labor supply is less responsive to taxes, and hence it is less costly to "distort" future allocations, leading to more debt accumulation.

Third (see fifth row), we increase the growth elasticity with respect to private investment by tenfold. The purpose of such a dramatic increase is to see whether the decline in TFP growth that we saw in the benchmark calibration will also hold if the share of private investment were significantly larger. Naturally, we find that the balanced growth share of private investment increases dramatically, almost tenfold. Labor supply increases relative to the benchmark level. The fiscal policy variables are little affected.

Sixth and seventh rows report what happens if we dramatically decrease the share of public investment and the importance of learning-by-doing externality, respectively. Recall that both public investment and labor supply decline as the economy converges to the balanced growth path from below. Hence both of these forces drive the decline in TFP growth. Shutting them down allows us to assess how general the result about the declining TFP is. In both cases, the balanced growth debt-to-GDP ratio increases significantly. In the first case this follows from the fact that the decision makers are less concerned about providing public investment and can at the margin channel more resources to their own districts. In the second case, as the learning-by-doing externality disappears, it is less costly to tax labor, both contemporaneously and in the future. Consequently, taxation increases dramatically, labor supply falls, more public goods are provided, leading to a higher level of the debt-to-GDP ratio.

Eighth and ninth rows report changes implied by increasing/decreasing the weight of public goods in the citizens' utility. The long-run share of public goods changes with the parameter ω and so do the taxes. The long-run debt-to-GDP ratio moves in the opposite direction, suggesting that the more important pubic goods become, the less misaligned the preferences of legislators are.

The next two exercises concern the parameters governing the degree of political conflict, q and α. As we discussed previously, the larger is q – the majority needed to pass the allocation of public goods – the less is the degree of political conflict. We find that around our benchmark value of 51, the long-run debt-to-GDP ratio does not vary much with q. In fact increasing the majority from 51 to 71, implies only about a percentage point of GDP decrease in debt.[28] We also find that the long-run level of debt is much more responsive to the degree of public good externalities.

[28] Though, of course, when $q = 100$ debt collapses to zero.

As discussed earlier, the higher is α, the more self-interested the legislators become, pushing up the debt-to-GDP ratio. In fact, the highest value of α, at which an interior equilibrium exists is 0.61.[29] In the next section, we discuss in more detail how the long-run behavior of the economy changes with the parameter α.

Finally, we ask how the economy would change in the long run, if the amount of transfers increased or decreased. As the last two rows of Table 2 show, an increase in social transfers is compensated both by an increase in taxes and reduction in public goods provision. Also, there is more debt accumulation, suggesting that the legislators become more inclined to rely on future tax revenue to finance current expenditure.

4.3 Political conflict and long-run outcomes

In this section we study in detail how the long-run predictions of the model change with the degree of the political conflict in the economy, as measured by the externality parameter α. As α rises, the conflict between districts increases because citizens become less sensitive to public goods provided to the constituencies to which they do not belong.

Figure 4 illustrates the effect of changes in α from its benchmark value of 0.53 in our calibration to 0 on the balanced growth path values of the variables of interest.

Three findings are worth noting. First, the figure reiterates that in the model a lower level of political conflict induces a lower long-run level of debt. The level of debt relative to GDP indeed converges to zero as α converges to zero, as discussed in Section 3. Second, as expected, a decrease in political conflict induces a higher level of investment in public infrastructure and local public goods.

The third effect is perhaps more surprising: a decrease in political conflict induces an increase in the tax rate and it has a non-monotonic effect on labor supply and growth. As α decreases, the tax rate increases to finance higher provision of public goods without increasing debt. As α decreases, labor supply initially increases. This phenomenon is due to the wealth effect: the decrease in α induces a decline in public debt and, hence, in privately held wealth, so it induces a decline in the marginal utility of leisure as well. For lower levels of α, however, the higher tax rate tends to counterbalance the wealth effect, and labor supply decreases in response to a decline

[29] Above this value the debt-to-GDP ratio explodes, and the economy converges to its highest sustainable level of debt, public good provision collapses and tax rates increase to the peak of the Laffer curve.

in α. Nonetheless, the effects of taxation and wealth roughly offset each other–the differences in labor supply across different α's do not exceed 0.25 percent.

The non-monotonicity in labor supply explains why the growth rate is non-monotonic in α. It is important to stress, however, that welfare is monotonically increasing in α. Hence, the growth rate is not necessarily a good measure of welfare in this model. As political distortions are reduced, the public goods' share of output increases: public goods increase welfare, but they do not necessarily increase growth. That is, though the economy grows at a slower rate, it has a superior balance between the private and the public sector.

Since debt is monotonically decreasing in α, the non-monotonicity of the growth rate with respect to α may explain why there is evidence suggesting a non-monotonic relation between debt and growth.[30] Figure 4 suggests that we should expect the relationship between growth and debt to be negative for countries with a high α, and positive for countries with low α.

5 Growth and austerity programs

As the analysis of the previous section has highlighted, the political equilibrium is inefficient. It leads to an excessive accumulation of debt relative to GDP and may result in a subpar growth rate. It is, therefore, natural to ask whether and how welfare can be improved by changing the institutional setting. Two sets of variables are of interest: First, the variables determining the "political environment" such as the voting rule and the variables determining legislative bargaining. Second, economic variables such as, for example, self-imposed constitutional constraints on deficit spending, or debt limits.

Regarding the first set of variables, we have already discussed in the previous section the impact of changes in q. We note here that in our model even if within-each-period political conflict is eliminated (by imposing a unanimity rule or, equivalently, imposing a new rule that all districts must receive the same amount of public goods) the economy will not move to its Ramsey allocation. This is because the decision makers today cannot commit to the future policy choices since endogenous interest rates give rise to the standard time inconsistency problem. In fact, starting with a positive level of debt the Ramsey solution implies that the fiscal policy will be constant from next period onward, with some positive level of debt, while the egalitarian

[30] For evidence on the relationship between debt and growth see, for example, Kumar and Wo [2010], Checherita and Rother [2010] and Reinhart and Rogoff [2010].

policymakers, without a commitment device, will slowly drive the debt level to zero. Nevertheless, we find that $q = 100$ is the optimal majority rule even if the economy starts at the level of debt twice the balanced growth level: The higher q first and foremost implies a better distribution of local public goods across districts. The implied expected welfare gains mute the short-term pain associated with higher taxes necessary to pay down the debt. In the long run, there is also a better balance between private and public expenditure.

To better understand the impact of self imposed constraints on deficit spending, we study here a simple class of austerity programs which are characterized by three features: the debt target, the number of periods allowed to reach the target and, finally, whether the target level shall be sustained forever or not (permanent versus temporary debt reduction). Effectively, we are capturing scenarios in which the legislature passes a law that establishes a new, lower, debt ceiling that goes into effect at a certain date in the future. Analyzing these scenarios may help to better understand the likely welfare impact of austerity measures like the Fiscal Compact in Europe or the Budget Control Act of 2011 in the U.S. In what follows, we use our political economy model to assess the effects of these types of programs and the way they should be designed.

We consider two scenarios. In the first scenario the government can permanently commit to the debt ceiling. In the second the government can only commit to bring the debt below a certain level over a certain period of time. The second scenario is, perhaps, a more realistic description of situations in which a country is forced to adopt austerity measures as a pre-condition, .e.g., for international help.

The effects of an austerity plan with commitment. Suppose a country's debt is at its balanced growth path level. Consider the following type of austerity programs: the country is required to run a surplus to permanently reduce its debt by a certain fraction in T years.[31] Figure 5 illustrates the evolution of the equilibrium studied in the previous section when the economy is forced to reduce the level of debt relative to GDP by 50% of its current level in seven years, and keep it there forever. We consider this plan because, as we will show below, it is the optimal austerity plan for the economy with our benchmark parameter values.

[31] In particular we assume that the legislators are forced to reduce b by a constant amount in every period until the new target is reached. Note that here we define debt reduction in terms of b - that is the debt level (scaled by productivity). We do this to ease comparison with the robustness exercises that we report later. For the benchmark case we discuss below it is virtually identical to formulating the austerity program in terms of the reduction in the debt-to-GDP ratio.

After the introduction of the program the tax rate and government expenditure in public goods and infrastructure spike up and down, respectively. There is, however, a key difference in their reaction: the tax rate keeps increasing for the entire period of the program and it settles at a permanently higher level; by contrast, public goods provision dips below the pre-program period level for two years, recovers afterwards and keeps increasing until the new balanced growth level is reached. In the seven years of the program, the tax rate increases by 4 percentage points and total public expenditure as a share of GDP increases by 5 percentage points.[32] During the austerity program, the growth rate of GDP remains below the pre-program level by about 0.5%. Because of the fall in the GDP growth, the debt-to-GDP ratio initially increases, but then it gradually falls until it reaches the target level.

Public investment, except for the initial dip, rises. Private investment shows exactly the opposite pattern. Overall productivity growth is low until the economy reaches its new balanced growth path. This is mostly due to the decline in labor during the transition process. The growth rate, however, is a poor measure of welfare and, hence, a poor way to measure the success of the program. The last panel of Figure 5 illustrates the dynamics of the per period expected indirect utility (augmented with future utility gains stemming from current investment decisions and learning-by-doing). This measure of citizens' welfare initially falls and remains below the pre-austerity level for the first 4 years. After three years, however, the per-period indirect utility starts increasing, and it continues to increase until the end of the program.

An important feature of the transition is that although the program imposes to run a fiscal surplus, the size of the public sector over GDP increases over time. This is the *shrinking government effect* in reverse. As the debt declines, so do the reasons to manipulate the interest rates. This, in turn, reduces the pressure to keep expenditure and taxes low. Consequently, the economy gears to a better policy mix and, through it, a better balance between the private and the public sectors.

The optimal austerity plan with commitment. We now discuss how to chose the optimal austerity plan, and how it changes with the environment. Table 3 compares the welfare effects of alternative austerity programs for the benchmark calibration. The rows of the table list alternative target reductions in the debt. The columns of the table list alternative horizons of

[32] The latter rises more than the former because the government has to pay less interest on debt after the change.

the program. The entry x_{ij} in column i and row j is the equivalence variation associated to the austerity program expressed as a percentage of consumption in each period.[33] Two interesting observations can be drawn from this table. First, except for the cases in which the program is extremely ambitious (both in terms of debt reduction and/or in terms of time horizon), austerity is welfare improving. Second, the effect of a program is neither monotonic in its size nor in its time horizon. If, for example, we fix the time horizon at $T = 7$ periods, austerity implies a gain of 0.83% in per period consumption for the target level of 35% of GDP; as we reduce the target to 20% of GDP, the benefit increases to 2.17%; but for targets below 20%, the benefit declines, reaching a negative value of -2.00% for the complete elimination of debt. Similarly, if we target a debt reduction of 50%, achieving the goal in one period is equivalent to a *permanent* reduction in consumption of -3.09%; achieving it in 7 periods induces a permanent increase in consumption by 2.17%; achieving it in 20 years induces an increase by 1.90%.

The fact that an austerity program forcing fast debt repayment improves welfare may appear surprising at first sight. Although the debt level is inefficiently high at the equilibrium balanced growth path, it may appear that the best way to pay it back is just to evenly spread its cost over time by servicing its cost and keeping the principal constant. To see where the problem with this reasoning is, we should note that although at the balanced growth path the legislators keep policies constant, the policy mix is inefficient. The lack of commitment induces legislators to use fiscal policy to influence the interest rate. Forcing legislators to run a primary surplus is not directly beneficial because it reduces public debt; it is beneficial because it induces them to change the policy mix. This can be seen by comparing the equilibrium balanced growth b^* with the one that would be reached by a benevolent planner with commitment (the first best) and with the balanced growth level reached after the austerity plan, in both cases starting from $b_0 = b^*$.[34] The benevolent planner would increase the tax rate from 21% to 35%, and public goods from 9% to 23%. Imposing the austerity plan at b^* does not induce such a large long-term change in the policy mix, but it brings it closer to this optimal levels, inducing the intermediate levels of 25% and 14%, respectively.

[33] In particular, let c_t, l_t, γ_t and $\widehat{c}_t$, $\widehat{l}_t$, $\widehat{\gamma}_t$ be the path of consumption, labor and public goods provided before and after austerity program ij implemented at t_0. The variable x_{ij} is is chosen so that $\sum_{t=t_0}^{\infty} \delta^t \left[u(c_t(1+x_{ij}), l_t, \gamma_t)\right]$ is equal to $\sum_{t=t_0}^{\infty} \delta^t u(\widehat{c}_t, \widehat{l}_t, \widehat{\gamma}_t)$.

[34] The computation of the steady state when policies are chosen by a benevolent planner with commitment is omitted to save space. The details are available from the authors.

How does the design of the optimal austerity program depend on the level of debt before the plan is implemented? In the benchmark calibration presented above the parameters are chosen so that the balanced growth level of the debt-to-GDP ratio is 40.5%. Table 4 presents optimal austerity for alternative calibrations. For completeness we report what happens for each set of parameters considered in the robustness section. The first five columns are from Table 3. The last two columns describe the associated optimal austerity program in terms of its time horizon and the percent reduction in debt. Table 4 illustrates that there is no "one-size-fits-all" optimal austerity program. For example, as α increases, and therefore debt relative to GDP increases as well, the time horizon of the optimal program becomes longer and the target level less demanding.

Across alternative calibrations one case stands out - the case with dramatically lower learning-by-doing externality. In this case, the economy is so overburdened by debt, that over even 20 years horizon it is not worthwhile to incur the additional pain of raising taxes to move to a permanently lower level of debt.

Austerity with limited commitment. The assumption that the austerity plan can impose a permanent reduction in debt is, perhaps, extreme. Below we assume that austerity can be imposed only for a limited period of time, after which legislators are free to choose policies with no constraints. Figure 6 illustrates the effect of reducing debt by 62% in 5 years; at the end of the 5th year the program is terminated and so legislators return to the political equilibrium.[35]

Naturally, the program induces only a temporary effect on policies. Note, however, that even after the end of the program, the economy converges to the (inefficient) balanced growth path only gradually, so policies remain closer to the first best for a period that is much longer than the length of the program. Table 5 illustrates the welfare effects of alternative austerity programs of this type. It is interesting that even with a limited commitment of 2-5 years, an austerity program that is not too ambitious can improve welfare.

6 A discussion

6.1 On the relationship with Battaglini and Coate [2008] framework

The model presented above finds its inspiration in the political economy model of debt by Battaglini and Coate [2008] (henceforth BC), but it departs from it in many significant ways. Apart from

[35] We assume that the length of the program is rationally anticipated by the legislators, who therefore take into account the temporary nature of the program in choosing the policies.

the fact that BC never considered growth, the main difference is in the way the policy space is modelled. While in BC politicians gain political power by distributing lump-sum transfers, in the model presented above politicians distribute local public goods. It is important to understand why, and the extent to which, this change affects the results.

The first implication of considering local public goods is that they may generate externalities: a bridge constructed in county j will affect neighboring county i, even if the bridge was provided to j as a form of pork. While this expands the scope of the model, it does not change the essence of the political conflict, and, hence, it is not crucial for our analytical results. The presence of the externality is important from a quantitative point of view, as discussed in Section 4.2: a reduction in α implies an increase in the externality and a decrease in the political conflict. Tables 2 and 4 show that differences in α translate into significant differences in political and economic outcomes.[36]

The feature of local public goods that changes the nature of the problem is the fact that they enter in the citizens' utilities in a non-linear way (transfers in BC enter the utility functions linearly). This small change has important implications for the analysis. To see why this is the case note first that as debt increases, the marginal cost of public funds increases. The marginal cost of public funds is a convex function of b and converges to infinity as debt approaches the upper bound $\overline{b}$. When the marginal utility of transfers is linear, this implies that above some (high) level of debt, there are no pork transfers. That is, the economy enters what BC call the *Responsible Policy Making* regime (RPM): the debt level does not rise even when the policy is decided by self-interested politicians.[37] When, as in the model presented here, the marginal utility of transfers (public goods) is non-linear and satisfies the Inada conditions, the economy never reaches the RPM regime because the lower is the level of public goods the higher their marginal benefit is.[38] The only reason why debt does not converge to $\overline{b}$ is that the politicians want to keep interest rates low, a phenomenon that is absent in BC. In the On-line Appendix

[36] We stress that the ultimate determinant of the political conflict is not α, but $\alpha \frac{\mathcal{G}}{n} Q(\mathcal{G}, q)$. To this end, the externality can be disposed off by setting α to 1 and re-calibrating the remaining parameters, including q and $\mathcal{G}$ which are fixed in the benchmark calibration, to match the targeted moments in the data.

[37] In fact, in BC and in the closely related model of Barseghyan, Battaglini and Coate (2013) and Battaglini [2014], debt in RPM regime may decline due to the precautionary savings motive arising from random shocks.

[38] Technically, this statement requires the lower bound on public goods, $\underline{g}$, to be small. However, our upper bound on debt $\overline{b}$ is defined taking into account that at least $\underline{g}$ amount of public goods should be provided to all districts. Hence, the statement is true for all interior b.

we formalize this point by presenting a version of our model in which citizens' utility is linear in consumption, but non-linear in the local public goods. As in BC, this utility implies a constant interest rate, and hence there is no interest rate manipulation channel. As a result, the debt level is ever-growing, converging to its upper bound.

6.2 Closed versus open economies

In the previous analysis, we have focused on a closed economy. In this context, the government has the monopoly on government bonds and so changes in debt have the maximal effect on the interest rate. In an open economy the government competes for funds with other countries: it is reasonable to assume that the elasticity of the interest rate to debt would be lower in these cases. The analysis presented above suggests that in these environments the government has lower incentives to keep debt small. If the elasticity of the interest rate to debt is lower (but still positive), then we should expect a higher level of debt accumulation;[39] in the limit case in which by opening the economy to the world capital markets the elasticity becomes zero, we should expect debt to converge to $\bar{b}$. In the On-line Appendix we formalize this point by presenting a variation of the basic model in which interest rates are completely insensitive to domestic policies. As expected, public debt converges to $\bar{b}$.

We should however stress that for the existence of an interior balanced growth level of debt, Proposition 2 only requires positive elasticity at the steady state, not globally. Even if for low levels of debt the elasticity is zero (as it may be for some countries, at least at a given point in time), it could become positive when public debt grows. There is evidence that seems to confirm that the sensitivity of the interest rate to debt plays an important role in shaping fiscal policy even for an economy fully integrated into the world capital markets and small risk of default such as the U.S.[40]

6.3 Towards an empirical analysis at high and medium frequencies

In this paper we abstracted from shocks, and, hence, our model cannot be immediately used in standard empirical macroeconomic research. However, we view it as a fundamental "ready-to-use"

[39] Azzimonti, de Francisco, and Quadrini [2014] argue that the liberalization of financial markets of the past thirty years has contributed to the rise in public debt across OECD countries as well as the decline in public debt elasticity of the interest rate. They also provide evidence of a positive correlation between public debt and some indices of capital market liberalization.

[40] For evidence on this see the memories of former Treasury Secretary Robert Rubin (Rubin [2003]).

block for applied DSGE models that allows for endogenous fiscal policy – something that, to our knowledge, has been missing from these models. Consider, for example, a standard approach of comparing/fitting impulse response functions generated by the model to those estimated in the data (e.g., Chirstiano, Eichanbaum and Evans [2005]). A crucial step in this literature is to translate a DSGE model into a system of linear difference equations describing the evolution of the variables of interest by linearizing the system of the equations implied by the model around the non-stochastic steady state. Importantly, our solution procedure – constructing global policy functions – automatically determines what the non-stochastic steady state is. Moreover, when exogenous stochastic state variables are i.i.d., the entire impulse response functions, up to a scale parameter, are described by the linearized policy functions, $p(b)$, except of course for the period of the initial shock.

In sum, our model offers an endogenous theory of fiscal policy that can be further enriched to allow for temporary shocks. It can be easily adopted to carry out empirical analysis at high and medium frequencies.

7 Conclusion

This paper develops a political economy theory of growth and fiscal policy. In our theory, the growth rate of the economy depends on public investment, private investment in human capital and, through learning-by-doing, labor supply. Fiscal policy affects citizens' incentives in two ways: taxation distorts labor supply and deficits distort consumption/savings decision through their effect on the interest rate. Policy choices are made by a legislature consisting of elected representatives. Political conflict arises because representatives in the legislature have incentives to vote for policies that favor their own constituencies and citizens benefit only partially from local public goods provided to constituencies to which they do not belong.

The model predicts that the economy converges to a balanced growth path in which consumption, public investment, public goods provision, public debt and productivity grow at the same constant rate. The transition to the balanced growth path is characterized by what we call the *shrinking government effect*: public debt grows faster than GDP, provisions of public goods and infrastructure grow slower than GDP and the tax rate declines.

We use the model as a laboratory to study the impact of austerity programs in which a country is required to bring down its debt-to-GDP ratio. We show that austerity programs may be used to limit political distortions and increase welfare. The analysis also shows that there is no "one-size-fits-all" optimal austerity program: the higher is the accumulated level of debt, the less aggressive the optimal program should be (both in terms of the debt target to reach and timing). The growth rate of the economy is a poor measure welfare and, hence, of the program's success. On the transition path of the optimal austerity program, growth is below the pre-austerity level, but welfare is increasing.

There are many different directions in which the ideas presented here might usefully be developed. To focus on public policies, we have made a number of simplifying assumptions both on the description of the economy and on the political process: there is no private capital, no shocks, we are restricting attention to a symmetric economy with no redistribution, and with a relatively simple political decision making process. Extending the model to relax these assumption would certainly provide a richer framework for analysis and improve the model's predictive ability. We are confident that these assumptions can be relaxed in future research.

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8 Appendix

In this appendix we first detail the statements and propositions presented in Sections 2 and 3. We then describe our data sources used for calibration in Section 4.

8.1 Citizens' Problem

For a given sequence of government policies, citizens' maximization problem in period 0 is:

$$\max_{\{c_t, \mathcal{S}_t, l_t\}} \sum_{t=0}^{\infty} \delta^t \left\{ \log \left(C_t (1-l_t)^{\mu} \right) + \omega \log \left[\left(\gamma_t^i \right)^{\alpha} \left(\sum_{j=1}^{n} \gamma_t^j \right)^{1-\alpha} \right] \right\}$$

$$s.t. \quad \frac{a_{t+1}}{\rho_t} + C_t + \mathcal{S}_t = (1-\tau_t) z_t \xi_t l_t + a_t + \mathcal{T}_t,$$

$$\xi_{t+1} = \Delta_0 \left(\frac{\mathcal{S}_t}{z_t \xi_t} \right)^{\Delta_1} \xi_t.$$

Denote

$$\hat{c}_t = \frac{C_t}{z_t \xi_t}, \hat{s}_t = \frac{\mathcal{S}_t}{z_t \xi_t}, \hat{g}_t = \frac{\gamma_t^i}{z_t \xi_t}.$$

The problem above becomes:[41]

$$\frac{1+\omega}{1-\delta} \log(z_t \xi_t) + \max_{(\hat{s}_t, \hat{c}_t, l_t)_{t=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t \left\{ \begin{array}{c} \log \hat{c}_t + \mu \log(1-l_t) + \omega \log \left[\left(\hat{g}_t^i \right)^{\alpha} \left(\sum_{j=1}^{n} \hat{g}_t^j \right)^{1-\alpha} \right] + \\ + \frac{\delta}{1-\delta} \Delta_1 (1+\omega) \log \hat{s}_t \end{array} \right\},$$

$$\frac{a_{t+1}}{\rho_t} + C_t + \mathcal{S}_t = (1-\tau_t) z_t \xi_t l_t + a_t + \mathcal{T}_t,$$

$$\xi_{t+1} = \Delta_0 \left(s_t \right)^{\Delta_1} \xi_t.$$

Using the citizens' FOC with respect to consumption, investment and labor we have that:

$$\begin{aligned} \mu \frac{\hat{c}_t}{1-l_t} &= 1-\tau_t, \\ \hat{s}_t &= \frac{\delta}{1-\delta} \Delta_1 (1+\omega) \hat{c}_t, \end{aligned}$$

which implies that

$$\hat{c}_t + \hat{s}_t = \left[1 + \frac{\delta}{1-\delta} \Delta_1 (1+\omega) \right] \hat{c}_t.$$

[41] Note that at any period $t' \geq t$ both the citizens' and the policy makers decisions are independent of $z_t \xi_t$ and hence of any investment decisions that are made by the households in the previous periods. That is, it is without loss of generality to assume that households take $g_{t'}^i$'s as invariant to their choice of $\hat{s}_t$, for all $t' \geq t$

Next, we use the resource constraint and the definitions of I_t and g_t^i to get that

$$\hat{c}_t + \hat{s}_t = l_t \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right].$$

Going back to the citizens' intra-temporal Euler equation and substituting consumption out, we have that

$$\frac{\mu}{1 + \frac{\delta}{1-\delta} \Delta_1 (1+\omega)} \frac{l_t \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right]}{1 - l_t} = 1 - \tau_t.$$

It follows that

$$l(p_t) = \frac{1 - \tau_t}{\mu_0 \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right] + 1 - \tau_t},$$

where $\mu_0 \equiv \frac{\mu}{1 + \frac{\delta}{1-\delta} \Delta_1 (1+\omega)}$ as stated in (5). Note that,

$$1 - l(p_t) = \frac{\mu_0 \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right]}{\mu_0 \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right] + 1 - \tau_t},$$

and, hence, consumption and private investment can now be written as in (6) and (7), respectively. Next, we define $u_+^i(c_t, s_t, l_t)$ as the citizens' utility scaled by overall productivity and augmented by the permanent future utility gains from current investment into productivity:

$$u_+^i(\hat{c}_t, \hat{s}_t, l_t) \equiv \log \hat{c}_t + \mu \log(1 - l_t) + \frac{\delta}{1-\delta} \Delta_1 (1+\omega) \log \hat{s}_t.$$

It follows from above that

$$u_+^i(c_t, s_t, l_t) = (1 + s_0) \log \left(\frac{1 - \tau_t}{\mu} \left(\frac{\mu_0 \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right]}{\mu_0 \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right] + 1 - \tau_t} \right)^{1+\mu} \right),$$

where

$$s_0 \equiv \frac{\delta}{1-\delta} \Delta_1 (1+\omega).$$

Finally, note that since $\hat{g}_t^i = n g_t^i l_t$, we have that

$$\omega \log \left[\left(\hat{g}_t^i \right)^{\alpha} \left(\sum_{j=1}^{n} \hat{g}_t^j \right)^{1-\alpha} \right] = \omega \log \frac{n(1 - \tau_t)}{\mu_0 \left[1 - \frac{1}{n} \left(I_t + \sum_{i=1}^{n} g_t^i \right) \right] + 1 - \tau_t} + \omega \log \left[\left(g_t^i \right)^{\alpha} \left(\sum_{j=1}^{n} g_t^j \right)^{1-\alpha} \right].$$

In essence, the utility from public goods can be decomposed into two components: (i) the utility from output, and (ii) the output share of public goods.

Combining the two lines from above and collecting terms we have that

$$\begin{aligned} u^i(p_t, z_t, \xi_t) &= (1+\omega)\log z_t\xi_t + u^i_+(c_t, s_t, l_t) + \\ &\quad +\omega \log \frac{n(1-\tau_t)}{\mu_0\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^n g_t^i\right)\right]+1-\tau_t} + \omega \log\left[\left(g_t^i\right)^\alpha\left(\sum_{j=1}^n g_t^j\right)^{1-\alpha}\right], \end{aligned}$$

or

$$u^i(p_t, z_t, \xi_t) = (1+\omega)\log z_t\xi_t + U(p_t) + \omega\log\left[\left(g_t^i\right)^\alpha\left(\sum_{j=1}^n g_t^j\right)^{1-\alpha}\right],$$

where

$$U(p_t) \equiv u^i_+(c_t, s_t, l_t) + \omega\log\frac{n(1-\tau_t)}{\mu_0\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^n g_t^i\right)\right]+1-\tau_t},$$

is the citizens' indirect per-period utility function scaled by overall productivity and augmented by (i) the permanent future utility from current private investment and (ii) by the "output part" of the utility from public goods. We summarize this as

Lemma A1. *The per-period indirect utility function is given by (8) where*

$$U(p_t) = (1+s_0)\log\left(\begin{array}{c} n^\omega \frac{\mu_0^{1+\mu}}{\mu}\left(1-\tau_t\right)^{1+\omega}\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^n g_t^i\right)\right]^{1+\mu} \cdot \\ \left[\frac{1}{\mu_0\left[1-\frac{1}{n}\left(I_t+\sum_{i=1}^n g_t^i\right)\right]+1-\tau_t}\right]^{1+\mu+\omega} \end{array}\right) \tag{17}$$

We next provide the proof of Lemma 1.

8.2 Proof of Lemma 1

A citizen, whose district is in the government, has the following expected continuation value:

$$v_{\mathcal{G}}(b, z, \xi) = U(p) + \omega E\log\left[\left(g^i\right)^\alpha\left(\sum_{j=1}^n g^j\right)^{1-\alpha}\right] + \delta v(b', z', \xi).$$

Hence, the incentive compatibility constraint holds with equality iff $E\log g^i = \log g^c$. Since

$$E\log g^i|_{i\in\{1:\mathcal{G}\}} = \frac{1}{\mathcal{G}}\left(\log g + (q-1)\log g^c + (\mathcal{G}-q)\log \underline{g}\right).$$

it must be the case that $g^c = g^{\frac{1}{\mathcal{G}-q+1}} \underline{g}^{1-\frac{1}{\mathcal{G}-q+1}}$, as stated. ■

8.3 Proof of Proposition 1

Write $v_t = \sum_{\tau=t}^{\infty} \delta^{\tau-t} u(p_\tau, z_\tau, \xi_\tau)$ as:

$$v_t = \sum_{\tau=t}^{\infty} \delta^{\tau-t} \left\{ (1+\omega) \log z_\tau \xi_\tau + U(p_\tau) + \omega E \log \left[\left(g_\tau^i\right)^\alpha \left(\sum_{j=1}^{n} g_\tau^j \right)^{1-\alpha} \right] \right\}.$$

Since $\log(z_{t+1}\xi_{t+1}) = \log(z_t \xi_t) + \phi_1 \log(I_t \cdot l_t) + \Delta_1 \log s_t + \eta_1 \log l_t + \log \Delta_0 \phi_0 \eta_0 n^{\phi_1}$, we have:

$$\log(z_{t+T}\xi_{t+T}) = \log(z_t\xi_t) + \sum\nolimits_{\tau=t}^{t+T-1} \left[\phi_1 \log(I_\tau) + \Delta_1 \log s_\tau + (\eta_1 + \phi_1) \log l_\tau + \log \Delta_0 \phi_0 \eta_0 n^{\phi_1} \right].$$

Using this formula and (5)-(9), we can express v_t as

$$\begin{aligned} v_t &= \frac{1+\omega}{1-\delta} \log(z_t \xi_t) + \\ & + \sum_{\tau=t}^{\infty} \delta^{\tau-t} \left\{ \begin{array}{c} U(p_\tau) + \frac{(1+\omega)\delta}{1-\delta} \left[\phi_1 \log(I_\tau) + \Delta_1 \log s_\tau + (\eta_1+\phi_1) \log l_\tau + \log \Delta_0 \phi_0 \eta_0 n^{\phi_1} \right] \\ +\omega E \log \left[\left(g_\tau^i\right)^\alpha \left(\sum_{j=1}^{n} g_\tau^j \right)^{1-\alpha} \right] \end{array} \right\}, \end{aligned}$$

which, in turn, using the expression for $E \log g^i$ can be written as

$$v_t = \mathcal{A} \log(z_t \xi_t) + \sum\nolimits_{j=t}^{\infty} \delta^{j-t} \left[\mathcal{U}(p_t) + \omega\alpha \frac{\mathcal{G}}{n} Q(\mathcal{G}, q) \log g_t + \omega(1-\alpha) \log(G_t) \right],$$

where $G_t \equiv \left(\sum_{j=1}^{n} g_t^j \right)^{1-\alpha} = g_t + (q-1) g_t^{Q(\mathcal{G},q)} \underline{g}^{(1-Q(\mathcal{G},q))} + (n-q)\underline{g}$, $\mathcal{A} = \frac{1+\omega}{1-\delta}$ and

$$\mathcal{U}(p_t) = A_0 + U(p_t) + \frac{(1+\omega)\delta}{1-\delta} \left[\phi_1 \log(I_t) + \Delta_1 \log s_t + (\eta_1 + \phi_1) \log l_t \right], \tag{18}$$

with $A_0 = \frac{(1+\omega)\delta}{1-\delta} \log\left(\Delta_0 \phi_0 \eta_0 n^{\phi_1}\right) + \alpha\omega \left(\frac{\mathcal{G}}{n} \frac{\mathcal{G}-q}{\mathcal{G}-q+1} + \frac{n-\mathcal{G}}{n} \right) \log \underline{g}$.

If we define $\mathcal{V}_t = \sum_{\tau=t}^{\infty} \delta^{\tau-t} \left[\mathcal{U}(p_\tau) + \alpha\omega \frac{\mathcal{G}}{n} Q(\mathcal{G}, q) \log g_\tau + \omega(1-\alpha) \log(G_t) \right]$ or, in a recursive form,

$$\mathcal{V}_t = \mathcal{U}(p_t) + \omega\alpha \frac{\mathcal{G}}{n} Q(\mathcal{G}, q) \log g_t + \omega(1-\alpha) \log(G_t) + \delta \mathcal{V}_{t+1}, \tag{19}$$

condition (18) can be written as $v_t = \mathcal{A}\log(z_t\xi_t) + \mathcal{V}_t$. The expected value of a citizen who is the government formateur, v_t^p, can be represented in the same. The only difference is that the proposer receives $\log g_t$ for sure instead of $E\log\left[\left(g_t^i\right)^\alpha \left(\sum_j g_t^j\right)^{1-\alpha}\right]$. We have:

$$v_t^p = \mathcal{A}\log(z_t\xi_t) + \mathcal{U}\left(p_t\right) + \alpha\omega\log g_t + \omega\left(1-\alpha\right)\log\left(G_t\right) + \delta\mathcal{V}_{t+1}. \tag{20}$$

where $\mathcal{V}_{t+1}$ is defined by (19).

The proof of the proposition now follows immediately. Since $\mathcal{A}\log(z\xi)$ is a constant, if $p(b)$ solves (14) given $\mathcal{V}(b)$, then it must be an optimal reaction function given the true value function $\mathcal{A}\log(z\xi)+\mathcal{U}\left(p\right)+\alpha\omega\log g+\omega\left(1-\alpha\right)\log\left(G(g)\right)+\delta\mathcal{V}(b')$; moreover if $\mathcal{V}(b)$ satisfies (13) given $p(b)$, then $v(b,z,\xi) = \mathcal{A}\log z\xi + \mathcal{V}(b)$ is the expected value in the bargaining game. On the contrary, if $p(b)$ is an equilibrium, then we must have $v(b) = \mathcal{A}\log z\xi + \mathcal{V}(b)$ and the proposer must maximize (14). ■

8.4 Proof of Proposition 2

It is first convenient to formally define the marginal cost of public funds. Let

$$B(b,p) = \rho\left(b,p\right)\left[b + G(g) + I + T - \tau nl(p)\right].$$

From the proposer's budget constraint in (14), we have $\beta' = z\xi B(b,p)$. In order to reduce nominal debt β' by one marginal unit the required increase in taxes must be $d\tau = -\left[z\xi B_\tau(b,p)\right]^{-1}$. The net marginal reduction in utility from an increase in taxes is given by $\mathcal{V}_\tau(b,p)$, where $\mathcal{V}$ is the indirect utility function defined in (13).[42] The reduction in utility in absolute value is therefore $\frac{\mathcal{V}_\tau(b,p)}{z\xi B_\tau(b,p)}$. Moreover the marginal utility of consumption is $\frac{1}{z\xi c(p(b))}$. The marginal cost of public funds, then is: $\frac{c(p)\mathcal{V}_\tau(b,p)}{B_\tau(b,p)}$. Note that the Lagrangian multiplier λ from (14) can be written as: $\lambda(b) = \frac{\mathcal{V}_\tau(b,p)}{B_\tau(b,p)}$. We conclude that the marginal cost of public funds when policies are p and the Lagrangian multiplier is λ is $MCPF(b) = \lambda(b)c(p)$.

We now prove (16). Consider the first order condition with respect to b' of (14):

$$\frac{\lambda(b)Z(p)}{\rho(b,p)}\left[1 - \frac{b'}{\rho(b,p)}\frac{\partial\rho(b,p)}{\partial b'}\right] = -\delta\cdot\mathcal{V}'(b').$$

[42] The indirect utility is evaluated at the equilibrium policy $p(b)$, where b is the state. For simplicity we omit the state form the expression of the policy when it does not create confusion.

We have

$$\frac{\lambda(b)Z(p)}{\rho(b,p)}\left(1-\varepsilon_{\rho}\left(b\right)\right)=-\delta\cdot\mathcal{V}'(b'), \tag{21}$$

where $\varepsilon_{\rho}\left(b\right)$ is the elasticity of the interest rate as defined in (15). Let $\mathcal{V}_p(b)$ be the objective function of (14). Adding and subtracting $\alpha\omega\log\left(g(b)\right)$, we can write: $\mathcal{V}(b)=\mathcal{V}_p(b)+\alpha\omega\left(\frac{\mathcal{G}}{n}Q(\mathcal{G},q)-1\right)\log g(b)$. From the Envelope theorem applied to (14), at any point of differentiability we have $\mathcal{V}_p'(b)=-\lambda\left(b\right)$, so we can write:

$$\mathcal{V}'(b)=-\lambda\left(b\right)+\alpha\omega\left(\frac{\mathcal{G}}{n}Q(\mathcal{G},q)-1\right)\frac{\partial g(b)/\partial b}{g(b)}. \tag{22}$$

Using (21) and we have:

$$\left(1-\varepsilon_{\rho}\left(b\right)\right)\frac{\lambda Z(p)}{\delta\rho(p)}=\lambda\left(b'\right)-\alpha\omega\left(\frac{\mathcal{G}}{n}Q(\mathcal{G},q)-1\right)\frac{\partial g(b')/\partial b'}{g(b')}. \tag{23}$$

Observe now that (9) can be written as: $\delta\rho(b,p)=c(p(b'))Z(p)/c(p)$. We can therefore write:

$$\left(1-\varepsilon_{\rho}\left(b\right)\right)c(p)\cdot\lambda\left(b\right)=c(p(b'))\cdot\lambda\left(b'\right)\left[1-\frac{1}{\lambda\left(b'\right)}\alpha\omega\left(\frac{\mathcal{G}}{n}Q(\mathcal{G},q)-1\right)\frac{\partial g(b')/\partial b'}{g(b')}\right]. \tag{24}$$

Define: $\Phi\left(b'\right)=1/\left(b'\cdot\lambda\left(b'\right)\right)$, and let $\varepsilon_g(b')=\frac{\partial g(b')}{\partial b'}\frac{b'}{g(b')}$ be the elasticity of $g(b')$ with respect to b'. Using the fact that $MCPF(b)=\lambda(b)c(p)$, we obtain (16). ■

8.5 Proof of Proposition 3

If $\mathcal{G}=q=n$ and/or $\alpha=0$, we have $\alpha\left(1-\frac{\mathcal{G}}{n}Q(\mathcal{G},q)\right)=0$. In this case, at the balanced growth b^* we must have: $\frac{\partial\rho(b',b^*)}{\partial b'}\frac{b^*}{\rho(b^*,b^*)}=0$, where the derivative is evaluated at b^*. Since $MCPF(b^*)>0$ and $\frac{\partial\rho(b',b)}{\partial b'}>0$ at $b=b^*$, a balanced growth path is possible only if $b^*=0$. ■

8.6 Proof of Proposition 4

In a regular balanced growth b^* we have:

$$\varepsilon_{\rho}(b^*)=-\alpha\omega\left(1-\frac{\mathcal{G}}{n}Q(\mathcal{G},q)\right)\Phi\left(b^*\right)\varepsilon_g(b^*). \tag{25}$$

where $\varepsilon_{\rho}(b^*)>0$ and $\Phi\left(b^*\right)>0$. We conclude that $\varepsilon_g(b^*)<0$ and so $g(b)$ is decreasing in b in a neighborhood of the balanced growth level in any smooth equilibrium. Since the balanced growth path is stable, starting from b_0 in a left neighborhood, $b_{t+1} > b_t$, and so $\gamma_{t+1}/\gamma_t < y_{t+1}/y_t$ for any $t > 0$. By Lemma 1, we must have $\gamma^c_{t+1}/\gamma^c_t < y_{t+1}/y_t$, where $\gamma^c_t = g^c_t y_t$ is the dollar value of public goods allocated to the districts in the minimal winning coalition. From the first order conditions of (14) it is also easy to show that I_t is monotone in g_t, so we have $\mathcal{I}_{t+1}/\mathcal{I}_t < y_{t+1}/y_t$ as well. ■

8.7 Data

Data on output is obtained from BEA's National Income and Product Accounts (NIPA, Tables 7.1).[43] Data on debt is taken from the U.S. Office of Management and Budget (Table 7.1).[44] For public goods we use the U.S. Office of Management and Budget (Table 3.1).[45] Our definition of public investment comes from Federal Outlays, NIPA, Table 9.1. We have looked at two measures: "Research and Development," and "Total Investment Outlays for Major Public Physical Capital, Research and Development, and Education and Training." We conservatively use the former in our benchmark calibration. Using the latter leaves the results qualitatively unchanged. For private investment in productivity we use private sector's "Research and Development" measures from NIPA Table 5.3.

[43] Available at *http://www.bea.gov/iTable/index_nipa.cfm*

[44] Available at *http://www.whitehouse.gov/omb/budget/Historicals).*

[45] We use the following classification of Federal Outlays, as reported by the Office of Management and Budget: Public Goods: (i) National Deference; (ii) Education, Training, Employment and Social Services; (iii) Health, (iv) Energy; (v) National Resources and Environment; (vi) Transportation; (vii) Community and Regional Development; (viii) International Affairs; (ix) General Science, Space and Technology, (x) Agriculture; (xi) Administration of Justice; (xii) General Government; (xiii) Veterans Benefits and Services. Transfers: (i) Medicare; (ii) Income Security; (iii) Social Security; (iv) Commerse and Housing Credit. Other: Net Interest.

	$\frac{\text{Federal Debt}}{\text{GDP}}$	$\frac{\text{Public Goods}}{\text{GDP}}$	$\frac{\text{Public Investment}}{\text{GDP}}$	$\frac{\text{Private Investment}}{\text{GDP}}$
Data	40.4	9.4	0.9	1.5
Model	40.5	9.4	0.9	1.5

Table 1. Calibration.

Parameter	Role	Benchmark Value	Change	S.S. $\frac{\text{debt}}{\text{GDP}}$	S.S. $\frac{\text{public G.}}{\text{GDP}}$	S.S. $\frac{\text{public I.}}{\text{GDP}}$	S.S. $\frac{\text{private I.}}{\text{GDP}}$	S.S. taxes	S.S. labor	change. in growth, % p.
benchmark				40.4	9.4	0.9	1.5	21.3	100	0
δ	discount factor	0.954	$+ .02$	24.9	10.0	1.6	2.6	20.6	101.7	0.5
			$- .02$	60.0	7.6	0.5	1.0	21.6	98.2	-0.6
μ	labor supply	1.37	x 2	38.9	7.9	0.7	1.5	19.7	62.0	-11.1
			: 2	44.53	11.5	1.1	1.4	23.6	143.3	9.3
Δ_1	private inv.	.000525	x 10	44.2	8.7	0.9	13.0	20.7	108.4	
η_1	public inv.	0.0018	: 10	64.9	5.4	0.0	1.5	18.4	99.6	
ϕ_1	LBD extern.	0.245	: 10	77.8	12.6	1.2	1.4	26.2	98.3	
ω	public good provision	0.505	$+ .20$	34.5	12.3	1.0	1.6	23.9	100.0	0.0
			$- .20$	55.2	5.5	0.7	1.3	18	99.7	-0.1
q	majority in government	51	$+ 20$	39.3	9.7	0.9	1.5	21.5	100.0	0.0
			$- 20$	41.0	9.3	0.9	1.5	21.2	100.0	0.0
α	public good externality	0.53	$+ .08$	68.3	5.5	0.5	1.5	18.6	99.4	-0.3
			$- .08$	27.4	12.2	1.2	1.4	23.5	100.2	0.1
T	social sec.	10	$+ 5$	51.8	6.4	0.6	1.5	23.8	96.1	-1.1
	transfers		$- 5$	31.4	13.0	1.2	1.4	19.5	103.9	1.0

Table 2. Robustness.[46]

[46] For the experiments regarding η_1, ϕ_1 and η_1 we do not report the changes in productivity growth, as the changes in these parameters change the nature of the growth process and, hence, do not allow for meaningful comparisons.

Reduction	Target	Duration											
in b,%	$\frac{\text{debt}}{\text{GDP}}$	1	2	3	4	5	6	7	8	9	10	15	20
12.5	35	0.52	0.81	0.84	0.85	0.85	0.84	0.83	0.82	0.80	0.79	0.72	0.66
25	30	0.47	1.34	1.45	1.50	1.51	1.5	1.49	1.47	1.45	1.43	1.31	1.20
37.5	25	-0.45	1.56	1.81	1.91	1.95	1.96	1.95	1.94	1.92	1.89	1.76	1.63
50	20	-3.09	1.38	1.84	2.03	2.11	2.15	2.17	2.17	2.16	2.14	2.03	1.90
62.5	15		0.69	1.45	1.77	1.92	2.01	2.06	2.09	2.10	2.10	2.06	1.97
75	10		-0.70	0.49	0.98	1.24	1.40	1.51	1.58	1.63	1.67	1.76	1.77
87.5	5		-3.12	-1.31	-0.57	-0.16	0.10	0.29	0.44	0.56	0.66	0.98	1.17
100	0		-7.15	-4.45	-3.37	-2.75	-2.32	-2.00	-1.73	-1.50	-1.31	-0.58	-0.08

Table 3. Long-term austerity programs.[47]

[47] No entry implies that the austerity program is not feasible.

Parameter	Role	Benchmark Value	Change	S.S. $\frac{\text{debt}}{\text{GDP}}$	Optimal Austerity Measure. years	reduction in %
benchmark				40.4	7	50
δ	discount factor	0.954	+ .02	24.9	7	62.5
			− .02	60.0	8	50
μ	labor supply	1.37	x 2	38.9	15	25
			: 2	44.53	10	75
Δ_1	private inv.	.000525	x 10	44.2	9	50
η_1	public inv.	0.0018	: 10	64.9	8	37.5
ϕ_1	LBD extern.	0.245	: 10	77.8	NA	NA
ω	public good provision	0.505	+ .20	34.5	8	62.5
			− .20	55.2	10	50
q	majority in government	51	+ 20	39.3	7	50
			− 20	41.0	8	50
α	public good externality	0.53	+ .08	68.3	9	37.5
			− .08	27.4	7	62.5
T	social sec.	10	+ 5	51.8	9	50
	transfers		− 5	31.4	8	62.5

Table 4. Optimal austerity measures for alternative calibrations.

Reduction in b,%	Target $\frac{\text{debt}}{\text{GDP}}$	Duration 1	2	3	4	5
12.5	35	-0.04	0.28	0.34	0.37	0.39
25	30	-0.57	0.38	0.53	0.62	0.67
37.5	25	-1.85	0.28	0.58	0.75	0.84
50	20	-4.73	-0.02	0.49	0.75	0.90
62.5	15		-0.56	0.25	0.84	0.63
75	10		-1.38	-0.16	0.37	0.66
87.5	5		-2.54	-0.76	-0.05	0.34
100	0		-4.17	-1.6	-0.65	-0.16

Table 5. Short term term austerity programs.[48]

[48] No entry implies that the austerity program is not feasible.

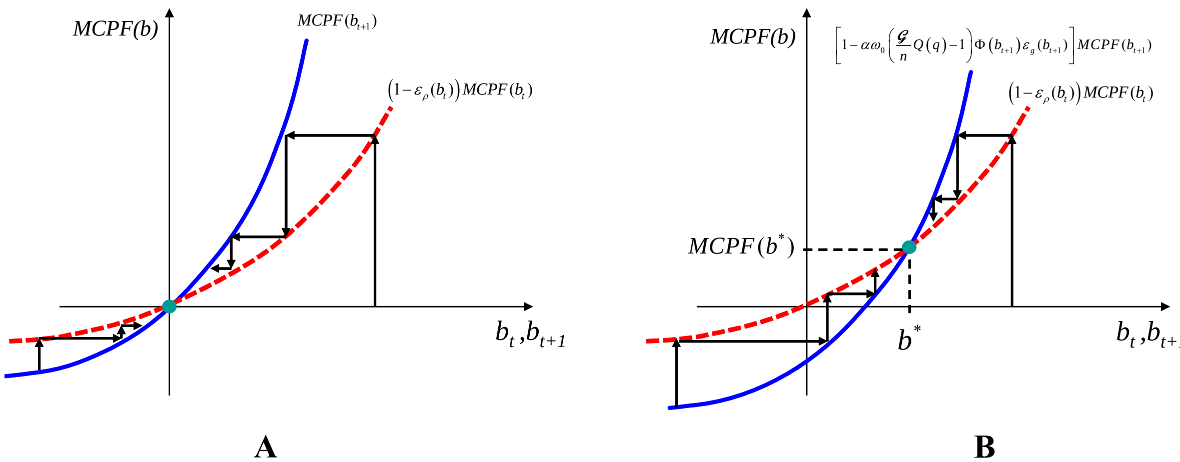

Figure 1: The Euler equation for $\mathcal{G} = q = n$ and $q < n$.

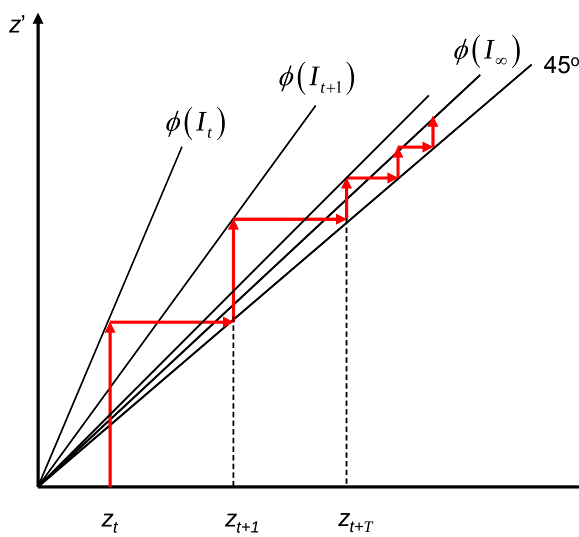

Figure 2: Growth Dynamics.

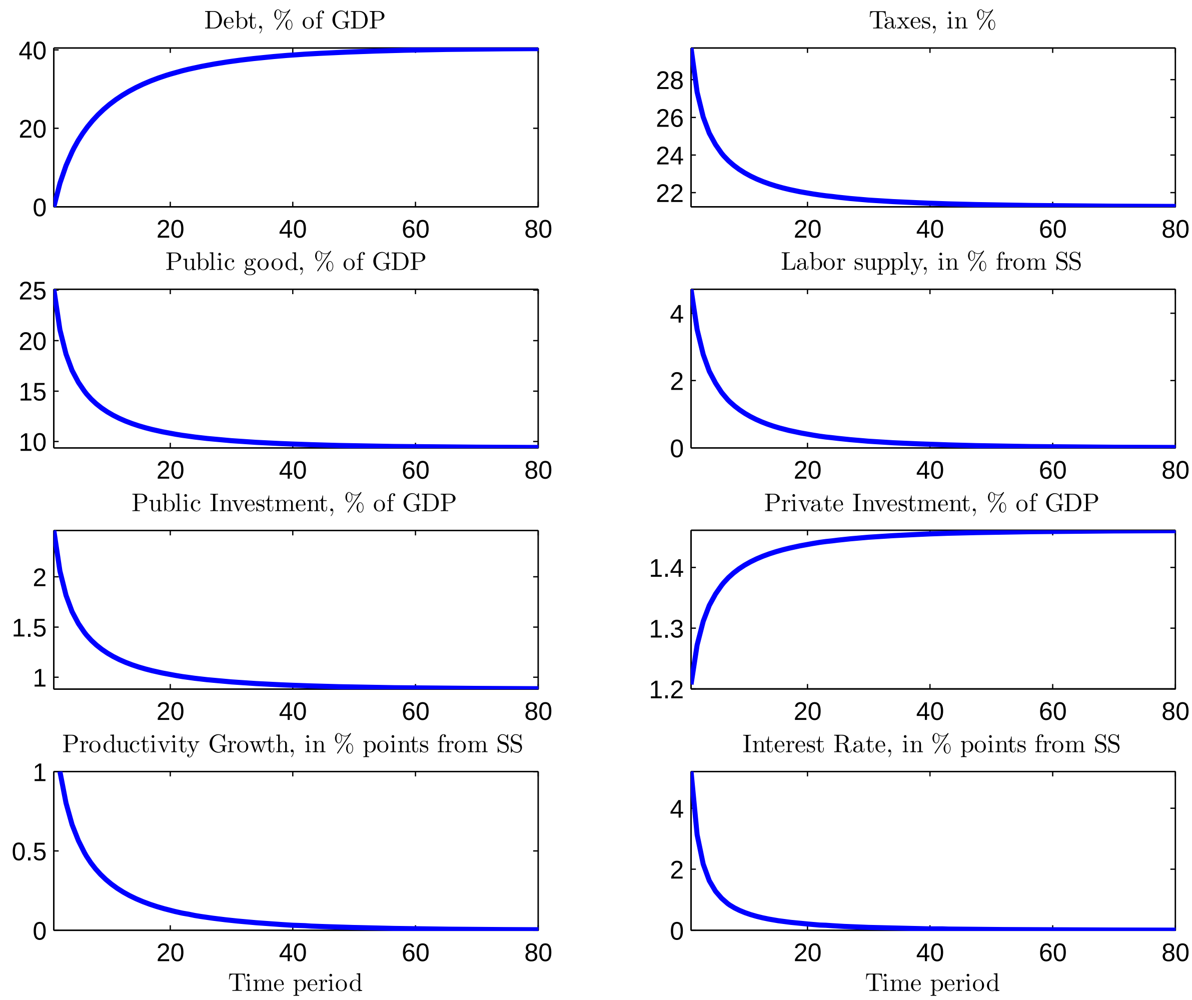

Figure 3: Dynamics starting with zero debt.

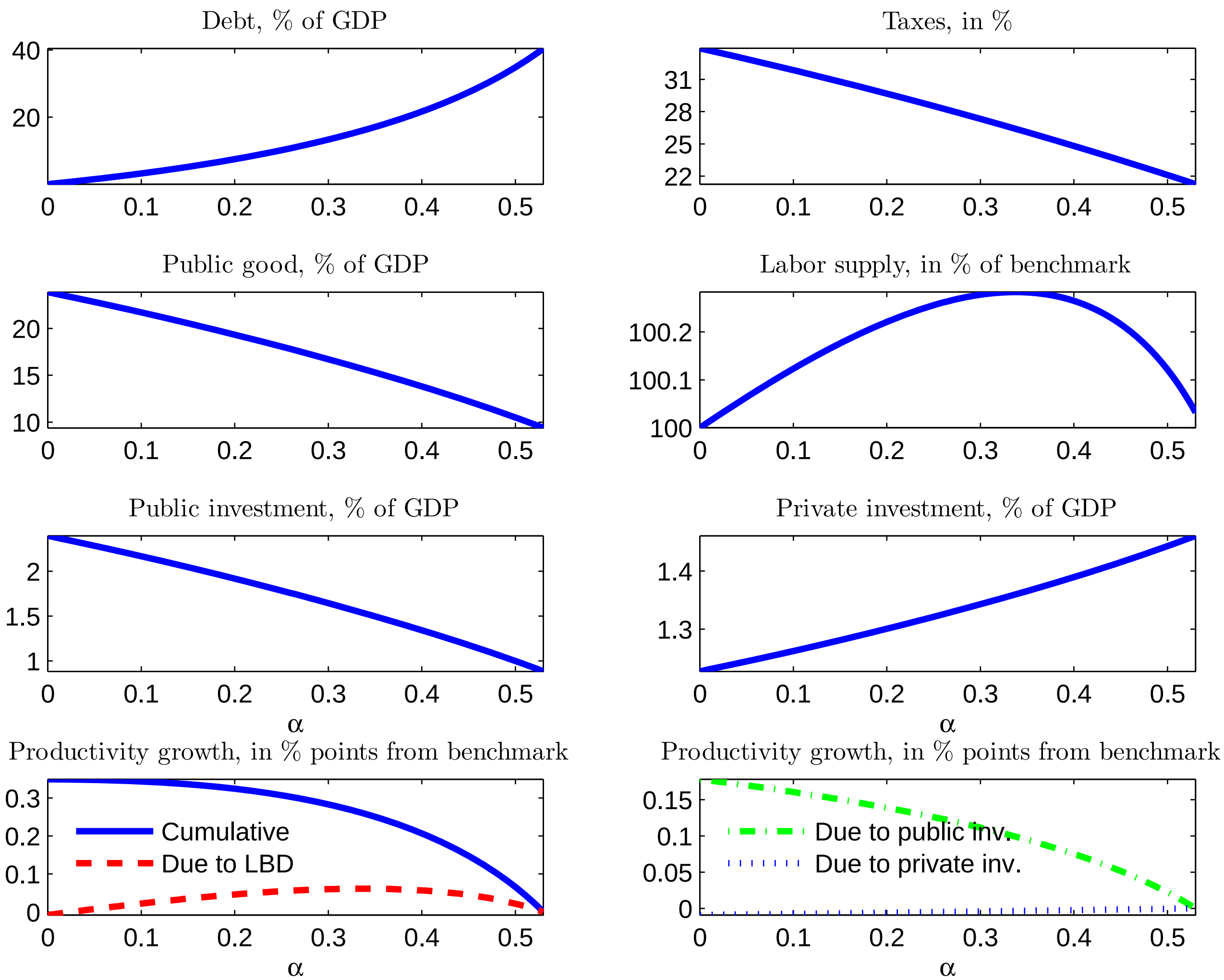

Figure 4: Political Conflict, Fiscal Policy and Economic Outcomes.

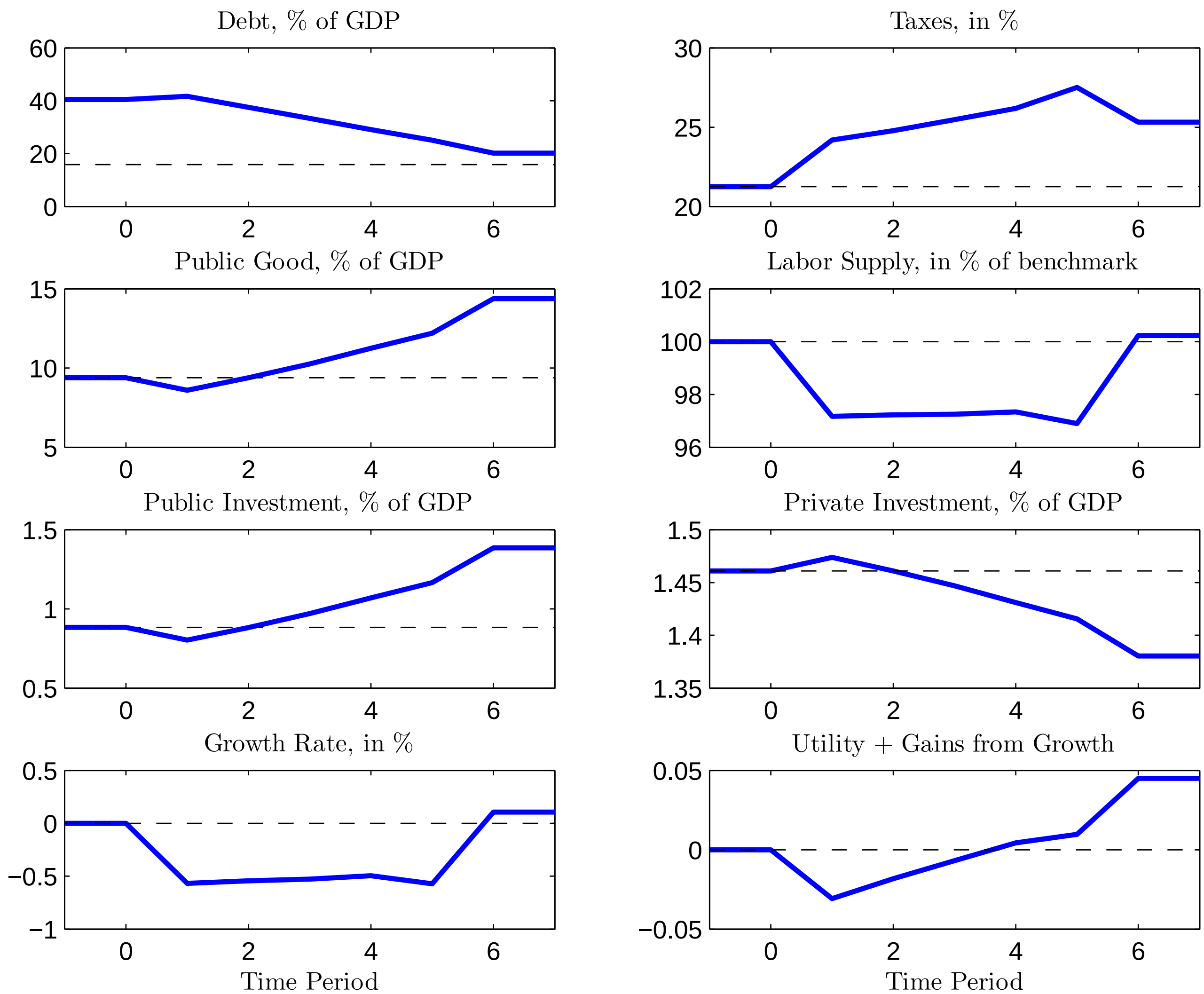

Figure 5: Evolution of the economy during the optimal austerity program.

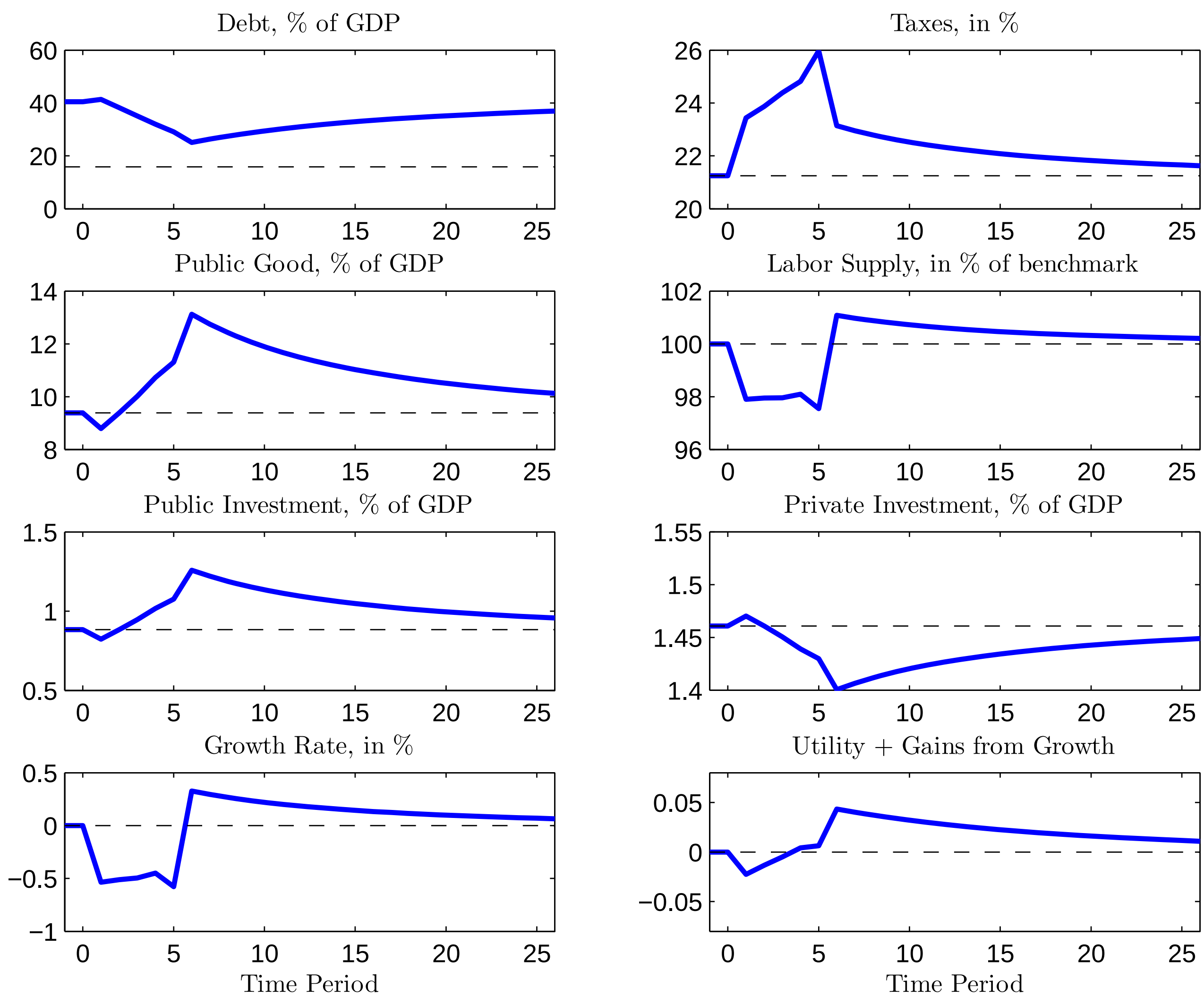

Figure 6: Evolution of the economy during the temporary austerity program.