Fiscal delegation in a monetary union with decentralized public spending*

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Abstract: In a monetary union, the interaction between several governments and a single central bank is plagued by several sources of deficit bias, including common pool problems. Each government has strong preferences over local spending and taxation but suffers only part of the costs of union-wide inflation and of higher interest rates, creating a tendency towards excessive debt. Motivated by the evident failure of fiscal rules to avert this bias in the European context, this paper analyzes an alternative fiscal regime in which the control of sovereign debt issuance is delegated to an independent authority, while public spending decisions remain decentralized.

Using a symmetric perfect-foresight model to compare the long-run policy biases affecting a typical country across different institutional arrangements, we identify three distinct ways in which an independent fiscal authority could restrain debt. First, insofar as the authority's mandate makes it debt-averse, it will tend to target a lower steady-state debt level. Second, if the authority is established at the union level instead of the national level, it internalizes the common pool problems associated with decentralized fiscal choices. Third, assuming it is not subject to the electoral process, the authority is likely to be less impatient than the government. Furthermore, we show that this institutional device is more effective in avoiding excessive debt, and more informationally efficient, than the establishment of a federal government which would centralize fiscal decisions.

Keywords: Fiscal authority, delegation, decentralization, monetary union, sovereign debt
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1 Introduction

The lingering sovereign debt crisis in the Eurozone highlights the challenges a monetary union faces to ensure fiscal discipline and avoid speculative attacks in bond markets when credible union-wide fiscal institutions are lacking. While many countries suffer budgetary problems today, fiscal indiscipline is especially problematic in a monetary union: member countries may overexploit the joint budget as a common resource; members may expect others to rescue them if they get into trouble; speculative flows in the banking system may be amplified by doubts about sovereign fiscal strength; and market doubts about any member's solvency may spread contagiously across the union. While the central bank, by acting in government bond markets, may be able to conjure up a cap on the risk premium, this will eventually be inflationary if peripheral countries fail to balance their budgets over the longer term. Therefore a monetary mechanism to prevent speculative attacks must be accompanied by an adequate fiscal regime if it is to ensure the stability of the Eurozone.

Proposals for fiscal reform in the EU have revolved around two competing interpretations of "fiscal union". Federalists argue that it is time to consummate the vision of a strong European government able to transfer resources countercyclically, from economies in expansion to those in recession.[1] But European electorates are skeptical of placing more power in the hands of Brussels. And core member states with healthy public finances have objected to a "fiscal transfer union", as they call it, fearing that they could end up paying for the fiscal imbalances of others.[2] These members instead advocate a "fiscal stability union", meaning a reinforcement of the debt and deficit limits, backed by monitoring and sanctions, that constituted the Stability and Growth Pact. But there is little consensus about how to avoid a slide back into serial rule-breaking, and indeed the appropriateness of strict deficit rules remains hotly debated.[3]

However, "transfer union" and "stability union" are not the only options for greater fiscal discipline in Europe. As a voluntary association of nation states with large governments and distinct cultures, the EMU is *sui generis*, so its optimal institutional configuration may look very different from frameworks seen elsewhere.[4] Therefore, this

[1]See for example Financial Times (8 December 2010), Pisani-Ferry (2012), or European Commission (22 June 2015).

[2]See The Economist (2 December 2010).

[3]For example, Münchau (19 October 2015), Financial Times.

[4]In particular, the US experience may be uninformative, for two main reasons. First, there is less consensus for political integration in Europe than in the US; in fact, the crisis may be widening European divisions. Second, the fiscal role of member states in the EMU is much larger than that of US states, making deficit limits costlier (and less credible) in the EMU than in the US.

paper asks whether a narrower form of integration might reinforce fiscal discipline without requiring excessive centralization of decision-making. Concretely, we analyze the possibility of delegating executive control over one or more powerful fiscal instruments to an independent institution with a mandate to ensure long-run budget balance. We are motivated to study fiscal delegation by Rogoff's (1985) analysis of central bank independence: delegating discretionary control of monetary instruments can solve the problem of inflationary bias, without requiring an inflexible commitment to low inflation under all circumstances, as long as the central bank's preferences incorporate a countervailing, anti-inflationary bias. Likewise, an independent authority with a mandate for low debt or low deficits might successfully combat deficit bias, as long as it controls instruments of sufficient power to make debt control feasible. While this possibility has not featured prominently in the current Eurozone debate, frameworks like this have been proposed for many countries and regions, including Australia and New Zealand (Ball (1996), Gruen (1997)); the US (Blinder (1997), Seidman and Lewis (2002)); Latin America (Eichengreen, Hausmann, and von Hagen (1999)); and the European Union (von Hagen and Harden (1995); Wren-Lewis (2002); Wren-Lewis (2011); Calmfors (2003); Wyplosz (2005); Costain and de Blas (2012a)). But despite these many proposals, there has been very little theoretical work to evaluate the effects of policy delegation in a fiscal context.[5]

Our model, stated in Section 3, analyzes the long-run effects of Rogoff-style delegation of fiscal powers in the context of a monetary union, where a single central bank interacts with many national (or regional) governments, building on Beetsma and Bovenberg (1999, henceforth BB99). Monetary policy is characterized by the classic time inconsistency problem: a surprise increase in inflation stimulates output, giving the central bank an incentive to choose an inflation rate higher than the public expects. Moreover, due to the presence of nominal debt, surprise inflation also reduces the government's cost of debt service. Finally, we also incorporate the possibility of contagion across governments' borrowing rates; each member state's interest rate depends on its own debt, but also on the debt levels of the other members. We show that inside a monetary union the inflation bias, arising from output stimulus and nominal debt, gives rise to deficit bias by way of a common pool problem: while governments know that the central bank will be tempted to inflate away the public debt, each individual national government ignores the impact of its own debt, since this is only a

[5]Persson and Tabellini (1994) explore a different aspect of fiscal policy delegation. They point out that representative democracy is a form of policy delegation, and in line with Rogoff (1985), they argue that the median voter may prefer a representative with a relatively "conservative" view of capital taxation, in order to offset the problem of time inconsistency.

small part of the total. Interest rate contagion implies another common pool problem that generates a similar debt bias: each government feels the full benefit when it runs a higher deficit, but the resulting higher borrowing costs are shared across all members. For these reasons, Beetsma and Bovenberg (1999) and other analyses have advocated the establishment of rules limiting debt or deficits. However, this argument is built around a strange inconsistency: it is unclear why it is taken for granted that the central bank must act under discretion while assuming that the government's fiscal decisions can (and advocating that they should) be bound by a commitment to rules.[6]

We strive for a more consistent treatment of rules versus discretion. We assume that no policy makers can commit – that is, given the risk of unforeseen future contingencies, no institution can irreversibly oblige itself to follow a rule. But we also assume, consistent with Rogoff (1985) and with the recent history of central banking, that an institution may be designed to show a strong preference for achieving some clear, simple, quantitative goal. Just as contemporary central banks display a strong aversion to inflation, consistent with their mandate, we consider a hypothetical independent budgetary authority with a strong aversion to debt. In Section 4, we compare the baseline scenario of a monetary union in which the central bank has discretionary control of inflation and national governments have discretionary control of all fiscal decisions, with an alternative institutional arrangement in which governments control the allocation of public spending, but an independent fiscal authority controls the emission of debt. We show that delegating control of debt issuance to an independent authority in each member state decreases steady state debt, relative to the baseline scenario. This follows from the greater debt aversion and lower impatience of the fiscal authority, compared with a democratic government. Delegating instead to a single independent authority at the level of the union further decreases equilibrium debt, because a union-level authority internalizes common pool problems associated with decentralized fiscal decisions. At the same time, this alternative institutional setup maintains the advantages of subsidiarity, by leaving the allocation of public spending to be decided at the national level, where information is better and democratic legitimacy is greater.

[6]Many models offered around the time of the introduction of the euro as theoretical analysis of the Stability and Growth Pact simply assumed that rules, once established, would be followed. See for example Buti, Roeger, and In't Veld (2001).

2 Political feasibility and literature review

2.1 Political feasibility

It is crucial to ask, from the outset, whether delegation of fiscal instruments is politically realistic. While the idea might seem new and exotic, our analysis highlights a clear formula for political feasibility, which we discuss in greater detail in Section 5. Member states with precarious debt levels would benefit from a European system to prevent speculative attacks; member states with strong finances fear providing this sort of guarantee precisely because they worry that it would allow weaker members to continue running excessive budget deficits. Therefore, a *quid pro quo* in which the ECB stops speculative attacks only for countries that have adopted a truly credible budget balance regime appears politically viable.

The "Fiscal Compact" adopted in the aftermath of the recent crisis mandated the creation of fiscal monitoring agencies in all EMU states (European Council (2012)); the "Five Presidents' Report" (J. Juncker et al. (2015)) proposes an additional supranational agency, to be created in 2017, to oversee the national ones. Thus, much of the institutional grounding for the framework we analyze here is already under construction. What is still missing is the creation, in national legislation, of fiscal levers for quickly implementing across-the-board adjustments in national fiscal stance. There are many ways this could be done: shift parameters could be defined in the tax code, or in legislation governing transfer payments or public sector labor contracts, to prepare for broad-based fiscal adjustments, when necessary, on the revenue side or on the spending side. While delegating any instrument of this sort to an independent authority represents some cession of power by the national government, this is insignificant compared with the huge loss of sovereignty associated with a full fiscal union (likewise, the new legislation required is negligible compared with that needed to construct a fiscal union). Thus, delegation of fiscal instruments might provide a shortcut to credible fiscal backing for the monetary union. Nonetheless, it could also prove durable, since any fiscally weak member state that attempted to reverse its decision to delegate fiscal instruments would likely face the wrath of the debt markets.[7]

[7]See de Blas (7 June 2012, VoxEU) for further discussion of institutional implementation.

2.2 Related literature

Economists from Mundell (1961) to Farhi and Werning (2015) have emphasized the fiscal challenges implied by joining a monetary union. Many recent analyses focus on speculative attacks: by giving up their ability to emit currency independently, member states (like emerging economies that suffer from "original sin") become vulnerable to attacks on their sovereign debt (Eichengreen and Wyplosz (1998); De Grauwe (2012)), and to a "doom loop" between the banking sector and the public sector (Bruche and Suarez (2010); Pisani-Ferry (2012)). The literature on monetary and fiscal interactions (*e.g.* Leeper (1991); Sims (2013)) also points to the fragility of monetary unions: the set of monetary and fiscal rules consistent with solvency and equilibrium determinacy is likely to be reduced by joining a monetary union (Bergin (1998); Sims (1999); Leith and Wren-Lewis (2011)). Further analysis of the fiscal vulnerability of monetary unions comes from the literature on deficit bias. While Dixit and Lambertini (2003) constructed an example in which joining a monetary union has no effect on policy outcomes if all policy makers have identical objective functions, many other authors argue that monetary union increases deficit bias when policy makers' preferences differ in plausible ways (Beetsma and Bovenberg (1999); Buti, Roeger, and In't Veld (2001); Beetsma and Jensen (2005); Chari and Kehoe (2007)).

Like inflation bias, deficit bias arises when policy makers are excessively impatient or have incentives to break past promises; thus it is natural to ask whether Rogoff's (1985) proposal to combat inflation bias through policy delegation might also apply to deficit bias. Like Rogoff, we model institutional differences parsimoniously by assuming different weight parameters in institutions' objective functions. First, we assume democratic politics makes elected policy makers impatient (relative to society). This reflects widespread findings in the political economy literature: for example, Alesina and Tabellini (1990) show how alternating parties of opposing ideology may act impatiently, while Battaglini (2011) shows how impatience may vary with the debt level. Second, we model the effects of a policy mandate by placing extra weight on the mandated objective in the institution's preferences (relative to society).[8] For a simple and quantifiable objective, this seems reasonable; central banks mandated to achieve low inflation do indeed appear to attach great importance to this objective.[9] Persson

[8] Adam and Billi (2008) show, in a microfounded New Keynesian model, that the benefits of "conservative" central banking extend to an economy with endogenous fiscal policy. Their model shares some features with ours: they assume that the central bank's preferences reflect those of society, but place additional weight on inflation stabilization; and they consider the Markov perfect equilibria of a simultaneous game between monetary and fiscal policy makers, under discretion.

[9] Alesina and Tabellini (2007) show that this may reflect the career concerns of the technically-skilled bureaucrats who lead them.

and Tabellini (1993) argue that central banks might achieve better macroeconomic stabilization (and higher social welfare) if they had more complex objectives in their mandates (or preferences). The tradeoff between simple and complex objectives is an interesting issue, but probably requires a deeper model of the effects of the mandate on institutions' decisions. For the current paper, which focuses on how policy delegation affects long-run biases, Rogoff's reduced-form approach provides useful insights.

Since the 1990s, as inflation fell and public debts grew worldwide, many economists have suggested delegating some fiscal responsibilities to an institution independent of the government (see Debrun, Hauner, and Kumar (2009); Hagemann (2010); and Costain and de Blas (2012a) for surveys). The literature distinguishes *fiscal councils*— which monitor but do not implement fiscal policy actions— from *independent fiscal authorities* (IFAs), which would make some of the fiscal decisions currently taken by the government. Fiscal councils are widespread today, and are mandated by the recent European "Fiscal Compact" treaty (European Council (2012)), but IFAs remain hypothetical. Two main types of IFA have been proposed. On one hand, the IFA might set a deficit target, at the start of the annual budget cycle, which the government is bound to respect; alternatively, it might exercise executive control over some fiscal instrument with a strong budgetary impact.[10] Some authors (see Hagemann (2010), Sec. II.C; or Calmfors (2011), Sec. 1) take the present nonexistence of IFAs as proof of their inviability, arguing that delegation is less appropriate for fiscal than for monetary policy since fiscal decisions are multidimensional, complex, and political. However, the validity of this claim depends on *which* fiscal decisions are considered for delegation.[11] Our model stresses the multidimensionality of fiscal policy, but assumes that only a single, quantitative decision is delegated: the choice of the current deficit. This leaves the allocation of spending across different public services (involving political and distributional choices) within the democratic process.

In contrast, many high-profile calls for European monetary mechanisms to prevent speculative attacks or banking crises have assumed that this requires moves towards full political integration; *e.g.* De Grauwe (2012), Soros (10 April 2013), or Pisani-Ferry (2012). We agree that fiscal reforms are crucial for strengthening monetary policy, but we argue that the necessary reforms are more limited than is commonly supposed.

[10] Proposals in the first class include von Hagen and Harden (1995); Eichengreen, Hausmann, and von Hagen (1999); and Wyplosz (2005); those in the second class include Ball (1996); Gruen (1997); Seidman and Lewis (2002); Wren-Lewis (2002); and Costain and de Blas (2012a). Calmfors (2003) considers proposals of both types.

[11] Alesina and Tabellini (2007) and Eggertsson and Borgne (2010) discuss which kinds of choices are appropriate for delegation from politicians to unelected technocrats.

What is essential is that European authorities must be able to ensure long-run national budget balance, and for this they must control at least *one* fiscal instrument of sufficient power in each member state. In accord with the principle of subsidiarity, all other fiscal decisions can remain at the national level. Sims (September 20, 2012) likewise stresses that fiscal discipline requires delegating to Europe some instrument with a strong impact on each national budget, but argues that further fiscal integration is neither necessary nor likely to prove politically feasible. Similarly, some limited European tax powers form an essential backstop for banking union in the analyses of Schoenmaker and Gros (2012) and Obstfeld (2013), but further fiscal integration is not required under these proposals.

3 The economic environment

Our setup extends the reduced-form model of Beetsma and Bovenberg (1999, BB99), generalizing it to an infinite horizon context, and augmenting it by including nominal debt and variation in interest rates. Our paper does not attempt to explain the imperfections in public institutions' decisions, such as excessive impatience or deficit bias, which have been discussed extensively in the political economy literature. Instead, our aim is to model these features parsimoniously in order to study how equilibrium outcomes differ across games in which policy variables are controlled by different sets of institutions. In particular, we investigate how systematic policy biases are damped or enhanced by different institutional configurations, for a typical country in a monetary union. To address systematic biases, we compare steady states, assuming perfect-foresight equilibrium.[12] To address the effects on a typical country, we assume all countries are symmetric (both assumptions also simplify the math).[13]

Time is discrete. Several regions $j \in \{1, 2, ...J\}$ each benefit from local public spending, and face region-specific budget constraints. These regions might be considered nations, or subnational areas. Together, they form a monetary union, in which a single inflation rate applies.

[12]Our decision to study systematic biases analytically in a reduced-form model implies that we do not address the stabilization of shocks. Addressing optimal stabilization raises important additional issues that are likely to require further microfoundations. These include the tradeoff between simple and complex institutional objectives (Persson and Tabellini (1993)), and incentives that affect the optimal speed of response to shocks, such as the impact of taxes on competitiveness in a monetary union (Leith and Wren-Lewis (2011)).

[13]Small asymmetries between countries leave our results qualitatively unchanged; see footnote 18. For differences in country size and in the form of interest rate contagion, see footnotes 25 and 16.

3.1 Social welfare and budget constraints

Let time t private-sector output in country j be $x_{j,t}$. We distinguish actual private output from its target value $\tilde{x}_{j,t}$ (the bliss point). Our main assumption about the macroeconomy is that actual output rises if inflation π_t is higher than expected inflation, π_t^e, and that it falls with distorting taxes $\tau_{j,t}$:

$$x_{j,t} \;=\; \nu(\pi_t - \pi_t^e - \tau_{j,t}). \tag{1}$$

Social welfare decreases quadratically as output, inflation, and government services $g_{j,t}$ deviate from their bliss points. The bliss point for inflation is assumed to be zero. The loss function for region j is[14]

$$L_{Sj} \;=\; \sum_{t=0}^{T} \beta_S^t \left\{ \alpha_{\pi S} \pi_t^2 + (x_{j,t} - \tilde{x}_{j,t})^2 + \alpha_{gS} \left(g_{j,t} - \tilde{g}_{j,t} \right)^2 \right\}. \tag{2}$$

Here $\tilde{g}_{j,t}$ is the bliss point for government spending.[15] The weights $\alpha_{\pi S} > 0$ and $\alpha_{gS} > 0$ represent the relative importance of deviations of inflation and public services from their bliss points; without loss of generality the weight on output deviations is set equal to one. The discount factor for social welfare is $\beta_S < 1$.

Since we are modeling a set of independent states that lack consensus for full political integration, we assume that policy is constrained by a budget constraint for each region. We write total government expenditure in region j at time t as $p_{j,t}^g g_{j,t}$, where $g_{j,t}$ is the amount of public services delivered, and $p_{j,t}^g$ is the price (in consumption units) of public services. Region j has only two sources of revenues for its expenditures, both of which are distortionary: tax revenues $\tau_{j,t}$, and seignorage revenues $\kappa\pi_t$ (assumed to be linear in inflation). Now, let $\bar{d}_{t-1} = \frac{1}{J}\sum_{j=1}^{J} d_{j,t-1}$ be the real average debt level in the monetary union at the end of period $t-1$, where $d_{j,t-1}$ represents the real debt of region j. We impose the following budget constraint on region j:

$$d_{j,t} = \left[R(\bar{d}_{t-1}) + \chi(\pi_t^e - \pi_t) \right] d_{j,t-1} + p_{j,t}^g g_{j,t} - \tau_{j,t} - \kappa\pi_t. \tag{3}$$

Here, $R(\bar{d}_{t-1})$ represents the expected real interest rate, while $R(\bar{d}_{t-1}) + \chi(\pi_t^e - \pi_t)$ is the *ex post* real interest rate, after inflation is realized. This formulation represents an assumption that fraction $\chi \in [0,1]$ of debt is nominal, and therefore loses real value

[14] Alesina and Tabellini (1987) derive an output relation of the form (1) from a more complete model. Leith and Wren-Lewis (2011) derive a social welfare function of the form (2) from a New Keynesian framework with government spending in the utility function.

[15] The bliss points $\tilde{x}_{j,t}$ and $\tilde{g}_{j,t}$ should be interpreted as extremely high levels of private and public consumption that are unlikely to be budget-feasible.

in response to surprise inflation. The expected real interest rate increases with real average debt: $R'(d) > 0$. When applied to a single country ($J = 1$), this means that the real interest rate depends on that country's own debt. When applied to a monetary union ($J > 1$), this represents a stark and simple model of interest rate contagion; it says that increased debt of region j raises the interest rate on bonds issued by all union members (and likewise their debt affects the interest rate facing region j).[16] In addition to (3), debt must respect an infinite horizon "no-Ponzi" condition:

$$\lim_{t\to\infty} \frac{d_{j,t}}{\Pi_t^{\infty}\left[R(\bar{d}_{t-1}) + \chi(\pi_t^e - \pi_t)\right]} \leqslant 0, \tag{4}$$

which says that interest payments on debt are sufficient to make it worthwhile for the private sector (with the appropriate discount rate) to hold the bonds.

Total public services in region j, $g_{j,t}$, are a constant-elasticity aggregate of a variety of differentiated services $g_{j,k,t}$:

$$g_{j,t} = \left(\int_0^1 \omega_{j,k,t}\left(g_{j,k,t}\right)^{\frac{\eta-1}{\eta}} dk\right)^{\frac{\eta}{\eta-1}}. \tag{5}$$

where $\eta > 1$, and $\omega_{j,k,t} > 0$ are weights on the different services k. Total government spending is a sum over all public goods, $\int_0^1 g_{j,k,t}dk$. Spending is allocated to minimize the cost of the aggregate public services provided:

$$p_{j,t}^g g_{j,t} \equiv \min_{\{g_{j,k,t}\}_{k=0}^1} \int_0^1 g_{j,k,t}dk \quad \text{s.t.} \quad \left(\int_0^1 \omega_{j,k,t}\left(g_{j,k,t}\right)^{\frac{\eta-1}{\eta}} dk\right)^{\frac{\eta}{\eta-1}} \geqslant g_{j,t}. \tag{6}$$

Equation (6) serves to define the price of government services, $p_{j,t}^g$. We assume that $\omega_{j,k,t}$ is independently and identically distributed for all j, k, and t.

We consider two possible scenarios for the public spending decision. On one hand, the fiscal policy maker may know the distribution of $\omega_{j,k,t}$, but not observe its realization. Then it is optimal to allocate spending equally across all goods, so that

$$p_{j,t}^g = q^H \equiv (E\omega)^{\frac{\eta}{1-\eta}}. \tag{7}$$

At the opposite extreme, the policy maker may observe $w_{j,k,t}$ before choosing $g_{j,k,t}$. In this case, it is optimal to allocate more spending to the most-demanded services, according to the first-order condition

$$\frac{g_{j,k,t}}{g_{j,l,t}} = \left(\frac{\omega_{j,k,t}}{\omega_{j,l,t}}\right)^{\eta}. \tag{8}$$

[16] Broto and Perez-Quiros (2013) present empirical evidence on interest rate contagion in Europe. Our formulation oversimplifies contagion; in practice some countries have been "safe havens", benefitting form *lower* interest rates when the market began to distrust peripheral European debt. Our interest rate specification is best seen as representing contagion across peripheral countries. Delegation to a fiscal authority might be less relevant for a safe-haven country; but the presence of a safe-haven country does not negate our analysis of the role of fiscal delegation for peripheral countries.

This more efficient allocation makes aggregate public services less expensive:

$$p^g_{j,t} \;=\; q^L \;=\; (E\omega^\eta)^{\frac{1}{1-\eta}} \;<\; q^H. \tag{9}$$

3.2 An omniscient, committed, cooperative Pareto planner

Given these objectives and constraints, we next establish a welfare benchmark for our economy. For relevance in the European context, we consider a Ramsey planner who maximizes social welfare taking market equilibrium conditions *and region-specific budget constraints* as given. Our planner does not represent any existing European institution, as it has unrealistic advantages in information and decision-making, but it is useful as a benchmark against which hypothetical institutions can be compared, when budgets are not aggregated across regions. For this purpose, we study an *omniscient, committed, cooperative Pareto planner*:

- *Omniscient*: the planner observes $\omega_{j,k,t}$ before choosing $g_{j,k,t}$. This makes aggregate public spending relatively inexpensive: $p^g_{j,t} = q^L$.
- *Committed*: the planner can credibly commit to choose the inflation rate it has previously announced. Therefore the inflation rate chosen by the planner is the rate expected by the public: $\pi_t = \pi^e_t$.
- *Cooperative*: the planner chooses the policy variables for all regions $j \in \{1, ..., J\}$, and thus internalizes any externalities across borders.
- *Pareto*: the planner obeys a distinct budget constraint for each region, maximizing social welfare insofar as this does not require transfers across regions.

Let $\vec{d}_{t-1} \equiv \{d_{j,t-1}\}_{j=1}^J$ be the vector of real debts of all the regions in the monetary union at the beginning of period t. We write the planner's value function as $V_{P,t}(\vec{d}_{t-1})$, the maximized value of $-L_{Sj}$, summed across all regions j. The value attainable satisfies the following Bellman equation:

$$V_{P,t}\left(\vec{d}_{t-1}\right) \;=\; \max_{\pi_t,\,\{d_{j,t},\,\tau_{j,t}\}_{j=1}^J} \frac{-1}{2}\left\{\alpha_{\pi S}\pi_t^2 + \frac{1}{J}\sum_{j=1}^J\left[\left(\nu\tau_{j,t} + \tilde{x}_{j,t}\right)^2\right.\right.$$
$$\left.\left. + \alpha_{gS}\left(\frac{d_{j,t} - R\left(\bar{d}_{t-1}\right)d_{j,t-1} + \tau_{j,t} + \kappa\pi_t}{q_L} - \tilde{g}_{j,t}\right)^2\right]\right\} + \beta_S V_{P,t+1}\left(\vec{d}_t\right). \tag{10}$$

In this equation, current public services $g_{j,t}$ have been substituted out using the period budget constraint:

$$d_{j,t} \;=\; R\left(\bar{d}_{t-1}\right)d_{j,t-1} + q_L g_{j,t} - \tau_{j,t} - \kappa\pi_t. \tag{11}$$

The first-order conditions for inflation and for region-j taxes are

$$\alpha_{\pi S}\pi_t \;+\; \frac{1}{J}\sum_{j=1}^{J}\frac{\kappa\alpha_{gS}}{q_L}\left(g_{j,t}-\tilde{g}_{j,t}\right) \;=\; 0, \tag{12}$$

$$\nu\left(\nu\tau_{j,t}+\tilde{x}_{j,t}\right)+\frac{\alpha_{gS}}{q_L}\left(g_{j,t}-\tilde{g}_{j,t}\right) \;=\; 0. \tag{13}$$

Over the infinite horizon, debt must satisfy the transversality condition (4). At all finite times $t<\infty$, $d_{j,t}$ is chosen to satisfy an Euler equation for public spending in each region:[17]

$$g_{j,t}-\tilde{g}_{j,t} \;=\; \beta_S R(\bar{d}_t)(g_{j,t+1}-\tilde{g}_{j,t+1})+\beta_S R'(\bar{d}_t)\sum_{k=1}^{J}\frac{d_{k,t}}{J}(g_{k,t+1}-\tilde{g}_{k,t+1}). \tag{14}$$

Equation (14) states the intertemporal tradeoff between region-j public expenditures at times t and $t+1$, while also accounting for the impact of increased region-j debt on the interest rate faced by all regions k.

Two *intratemporal* properties of the planner's solution are easily seen from the first-order conditions. In each period and region, the marginal cost of tax distortions is equated to the marginal benefit of public spending, according to a simple linear relationship:

$$\nu\hat{x}_{j,t} \;=\; \frac{\alpha_{gS}}{q_L}\hat{g}_{j,t}, \tag{15}$$

where $\hat{x}_{j,t}=x_{j,t}-\tilde{x}_{j,t}$ and $\hat{g}_{j,t}=g_{j,t}-\tilde{g}_{j,t}$ and are the deviations of output and public spending from their bliss points. And at each time, the marginal cost of inflation is equated to the *average* marginal benefit of public spending:

$$\alpha_{\pi S}\pi_t \;=\; -\frac{\kappa\alpha_{gS}}{q_L}\bar{\hat{g}}_t, \tag{16}$$

where $\bar{\hat{g}}_t=J^{-1}\sum_j\hat{g}_{j,t}$. Thus, while (15) trades off distortions within region j at time t, (16) links region-specific distortions with the union-wide inflation distortion: inflation is positive unless all countries are achieving their bliss points in public expenditure.

Assuming all regions are symmetric, we can use the first-order conditions that link country-level distortions with aggregate inflation to rewrite the dynamics of the social planner's solution in aggregate terms. The budget constraints aggregate into a single

[17] Euler equations are derived in the Online Appendix, which is available here: `https://sites.google.com/site/hsbasso/research`.

equation for the average debt level, and we can use (16) to express the Euler equation in terms of inflation only:[18]

$$\bar{d}_t = R(\bar{d}_{t-1})\bar{d}_{t-1} - \tilde{\kappa}_P \pi_t + \bar{\tilde{z}}_t, \tag{17}$$

$$\pi_t = \beta_S \left(R(\bar{d}_t) + R'(\bar{d}_t)\bar{d}_t \right) \pi_{t+1}, \tag{18}$$

where $\bar{\tilde{z}}_t = J^{-1} \sum_j (\tilde{x}_{j,t}/\nu + q_L \tilde{g}_{j,t})$ is a union-wide demand indicator, and

$$\tilde{\kappa}_P = \kappa + \frac{\alpha_{\pi S}}{\kappa \alpha_{gS}} \left(q_L^2 + \frac{\alpha_{gS}}{\nu^2} \right). \tag{19}$$

Finally, to obtain analytical formulas for the steady state of the economy under various institutional configurations, we assume a specific functional form for the real interest rate R:

$$R(\bar{d}_t) = 1 + r_0 + \delta \bar{d}_t = \frac{1}{\beta_S} + \delta \bar{d}_t. \tag{20}$$

This assumption says that savers are willing to hold a "target" level of debt $\bar{d}^* \equiv 0$ when the interest rate just compensates their time preference rate.[19] Together, (18) and (20) imply that the planner sets steady state debt to zero. Given the steady-state level of the demand shifter $\bar{\tilde{z}}$, we can also calculate the planner's steady state inflation rate using the budget constraint (17):

$$\bar{d}_P^{SS} = 0, \quad \text{and} \quad \pi_P^{SS} = \frac{\bar{\tilde{z}}}{\tilde{\kappa}_P}. \tag{21}$$

In the next section, we will compare the steady state of this benchmark planning solution with the steady state equilibria implied by several different policy-making configurations. In Basso and Costain (2013) we study the simpler case where $\chi = 0$ (debt is real) and $\delta = 0$ (no interest rate contagion). Under those restricions the policy functions are linear, making the calculations more tractable. We can then rank the *debt paths* over time (comparing equilibrium paths under different institutional frameworks, starting in all cases from the same initial level of debt). The rankings of debt paths shown in that version of the paper are the same as the ranking of steady-state debt levels that we report here.

[18] If countries are not symmetric, then (18) only holds approximately. The exact equation is then $\pi_t = \beta_S \left(R(\bar{d}_t) + R'(\bar{d}_t)\bar{d}_t \right) \pi_{t+1} - \beta_S R'(\bar{d}_t) \frac{\alpha_{gS}\kappa}{\alpha_{\pi S} q_L} Cov_{t+1}(\hat{g}_{k,t+1}, d_{k,t})$. But the covariance term is negligible when differences between countries are small, so all results stated in this paper are robust to small cross-country differences.

[19] But this is just a normalization. Assuming $R(\bar{d}_t) = \frac{1}{\beta_S} + \delta(\bar{d}_t - \bar{d}^*)$, where $\bar{d}^*$ is an arbitrary target for debt, does not alter the qualitative results. So for simplicity, we set the target to zero.

4 Policy games

4.1 Policy makers' objectives

Next, we study equilibrium outcomes when several policy-making institutions interact. Each one acts to minimize a loss function that resembles (2), but they may have different discount factors or different weighting coefficients on the loss terms. As we mentioned in the introduction, our preference assumptions reflect two simple principles. Policy makers subject to democratic election are assumed to be impatient; and policy makers subject to a mandate reflecting a simple, quantitative goal are assumed to value that goal more strongly than society at large.

First, there is a central bank C, which chooses inflation for the whole monetary union. The bank sums losses symmetrically across all J regions:

$$L_C = \sum_{t=0}^{T} \beta_C^t \left\{ J\alpha_{\pi C}\pi_t^2 + \sum_{j=1}^{J} \left[(x_{j,t} - \tilde{x}_{j,t})^2 + \alpha_{gC} (g_{j,t} - \tilde{g}_{j,t})^2 \right] \right\}. \tag{22}$$

Second, each region j has a government G_j which chooses each type of public spending $g_{j,k,t}$, and thereby chooses aggregate public services $g_{j,t}$. It may also be responsible for choosing the tax rate, depending on the scenario considered. The government's loss function L_{Gj} only includes terms related to region j:

$$L_{Gj} = \sum_{t=0}^{T} \beta_G^t \left\{ \alpha_{\pi G}\pi_t^2 + (x_{j,t} - \tilde{x}_{j,t})^2 + \alpha_{gG} (g_{j,t} - \tilde{g}_{j,t})^2 \right\}. \tag{23}$$

Later we will instead consider a single government G that allocates all types of public spending $g_{j,k,t}$ across all regions j. The union-wide government cares equally about all J regions:

$$L_G = \sum_{t=0}^{T} \beta_G^t \left\{ J\alpha_{\pi G}\pi_t^2 + \sum_{j=1}^{J} \left[(x_{j,t} - \tilde{x}_{j,t})^2 + \alpha_{gG} (g_{j,t} - \tilde{g}_{j,t})^2 \right] \right\}. \tag{24}$$

Third, we also study the possibility of a debt-averse fiscal authority. The fiscal authority may be established by and for region j, in which case we will call it F_j, or it may be a union-wide institution, in which case we will call it F. A regional authority F_j is assumed to care only about regional variables, having the loss function

$$L_{Fj} = \sum_{t=0}^{T} \beta_F^t \left\{ \alpha_{\pi F}\pi_t^2 + \alpha_{dF} \left(d_{j,t} - \tilde{d}_{j,t} \right)^2 + (x_{j,t} - \tilde{x}_{j,t})^2 + \alpha_{gF} (g_{j,t} - \tilde{g}_{j,t})^2 \right\}. \tag{25}$$

This authority cares about the same terms as the society and government of region j, but it also cares about the region's debt $d_{j,t}$, suffering a loss if debt deviates from its

target value $\tilde{d}_{j,t}$. The level of the target plays little role in the analysis, so we simply set $\tilde{d}_{j,t} = 0$. A debt term in the fiscal authority's preferences is consistent with a mandate for long-run budget balance, since respecting an intertemporal budget constraint means that real debt cannot be too explosive. In contrast, the intertemporal budget constraint says little about the time path of the deficit; indeed, optimal taxation theory highlights the role of the deficit as a shock absorber, which may fluctuate strongly in order to allow other, distorting instruments to be smoothed.

Alternatively, if there is a single union-wide fiscal authority, we assume that it sums losses symmetrically across all regions:

$$L_F = \sum_{t=0}^{T} \beta_F^t \left\{ J\alpha_{\pi F}\pi_t^2 + \sum_{j=1}^{J} \left[\alpha_{dF} \left(d_{j,t} - \tilde{d}_{j,t} \right)^2 + (x_{j,t} - \tilde{x}_{j,t})^2 + \alpha_{gF} \left(g_{j,t} - \tilde{g}_{j,t} \right)^2 \right] \right\} \tag{26}$$

Note that this function includes a separate term for each region's debt, reflecting a concern for budget balance in each individual region, above and beyond its concern for union-wide budget balance. In this way, the fiscal authority is "Paretian", like the OCCPP planner.

4.1.1 Parameter assumptions

All these policy institutions are essentially benevolent, valuing the same goals as society and the planner. However, we assume their different roles may imply some differences in priorities, reflected in the coefficients in Table 1. The government is more impatient than society, due to the short time horizons of electoral politics. Since the fiscal authority is insulated from political pressures, it is more patient than the government (at most, equally patient as the social planner). This is one of the reasons why the fiscal authority may display less deficit bias than the government. All three institutions $i \in \{C, G, F\}$ value public spending to the same degree as society. But the central bank is assumed to have a mandate to achieve a target inflation rate; it therefore dislikes inflation variability more strongly than society does.[20] Likewise, even though the debt level has no direct impact on social welfare, we assume that the fiscal authority has a mandate to stabilize debt around some target level, and that this is reflected in its preferences. Therefore its objective includes a positive coefficient on deviations of debt from its target, while other agents place zero weight on this term.

[20] Alesina and Tabellini (2007) discuss why society may prefer to delegate tasks with quantifiable objectives to bureaucrats, instead of leaving them up to the democratic government.

Table 1: *Baseline parameter assumptions**

	Society and planner	Central bank	Government	Fiscal authority
Discount factor β_i	$0 < \beta_S < 1$ $\beta_S R(0) = 1$	$\beta_C = \beta_S$	$0 < \beta_G < \beta_S$	$\beta_G < \beta_F \leqslant \beta_S$
Spending coefficient α_{gi}	$\alpha_{gS} > 0$	$\alpha_{gC} = \alpha_{gS}$	$\alpha_{gG} = \alpha_{gS}$	$\alpha_{gF} = \alpha_{gS}$
Inflation coefficient $\alpha_{\pi i}$	$\alpha_{\pi S} > 0$	$\alpha_{\pi C} > \alpha_{\pi S}$	$\alpha_{\pi G} = \alpha_{\pi S}$	$\alpha_{\pi F} = \alpha_{\pi S}$
Debt coefficient α_{di}	$\alpha_{dS} = 0$	$\alpha_{dC} = 0$	$\alpha_{dG} = 0$	$\alpha_{dF} > 0$

*Coefficients of loss functions for agents $i \in \{S, C, G, F\}$.

Given the abstract nature of our quadratic objective functions, the baseline assumptions in Table 1 do not guarantee the existence of an equilibrium with intuitively reasonable properties. This requires several other natural restrictions.

- We say that the central bank exhibits *moderate inflation aversion* when its preferences satisfy the following inequality:

$$\alpha_{\pi C} \ < \ \frac{1+\kappa}{\kappa}\alpha_{\pi S}. \tag{27}$$

  As in Chari and Kehoe (2007) and BB99, governments anticipate that the central bank will adjust inflation in response to their debt choices. *Moderate inflation aversion* implies that inflation rises *more than is optimal* when debt increases. This inflation response underlies one of the common pool problems that generate debt biases in our model. A central bank exhibits *efficient inflation aversion* if (27) holds with equality (in this case the inflationary bias due to inefficiently low output is corrected.)

- Furthermore, we assume that steady-state assets of the public sector are not excessively large:

$$R(d_{ss}) + R'(d_{ss})d_{ss} \ > \ 1, \tag{28}$$

  and

$$d_{ss} \ > \ -\frac{\varpi}{\chi\kappa}, \tag{29}$$

  where $\varpi = \kappa\left(\frac{\alpha_{gG}}{\alpha_{gC}} + \kappa\right) + \frac{\alpha_{\pi C}}{\alpha_{gC}}\left(q_L^2 + \frac{\alpha_{gG}}{\nu^2}\right)$. When (28) does *not* hold, this means assets are so large that *saving less in steady state* would imply *more interest income in steady state.*[21] Likewise, (29) must hold under a reasonable parameterization, because as $d \to -\frac{\varpi}{\chi\kappa}$ government wealth is becoming so large that the central bank wishes to create an arbitrarily large surprise *deflation* in order to increase the real value of public assets.

[21] Assuming that (20) holds (a linear interest rate), (28) is equivalent to $d_{ss} > -\frac{r_0}{2\delta}$.

- Finally, since the objective function is quadratic, if the interest rate declines very slowly with assets there may exist a steady-state public asset level sufficient to finance the utility bliss point out of interest income alone. This unrealistic scenario is ruled out by assuming *scarcity*, defined as follows:

$$\bar{\tilde{z}} > \frac{r_0^2}{4\delta}. \tag{30}$$

4.2 Policy games: monetary delegation

First, consider an economy in which the central bank chooses π_t, and the governments G_j choose τ_{jt} and d_{jt}, in each period t. Thus, only monetary policy is delegated. Each government then spends the resources it has available, given budget constraint (3). The market's inflation expectations π_t^e are determined at the beginning of t, rationally anticipating the outcome of the game between the bank and the governments. For $J = 1$, this setup represents a single country with its own independent central bank; for $J > 1$ it represents a monetary union with an independent central bank, such as the Eurozone.

Each policy maker's value is a function of the state of the economy, which includes the debt of each region j. We construct an equilibrium in which no other state variable is needed; that is, we rule out equilibria with more complex forms of history dependence, such as reputational effects. We call the central bank's value function $V_{C,t}$. Eliminating $x_{j,t}$ and $g_{j,t}$ using (1) and (3), its Bellman equation is:

$$\begin{aligned} V_{C,t}\left(\vec{d}_{t-1}\right) = \max_{\pi_t} \frac{-1}{2} \Bigg\{ \alpha_{\pi C}\pi_t^2 + \frac{1}{J}\sum_{j=1}^{J} \Bigg[\left(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}\right)^2 \\ + \alpha_{gC}\left(\frac{d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right) d_{j,t-1} + \tau_{j,t} + \kappa\pi_t}{q_L} - \tilde{g}_{j,t} \right)^2 \Bigg] \Bigg\} + \beta_C V_{C,t+1}\left(\vec{d}_t\right). \end{aligned} \tag{31}$$

Since policy makers cannot commit, this problem distinguishes actual inflation π_t from expected inflation π_t^e. The first-order condition for inflation is

$$\alpha_{\pi C}\pi_t + \frac{1}{J}\sum_{j=1}^{J}\left[\nu\left(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}\right) + \frac{\alpha_{gC}}{q_L}(\kappa + \chi d_{j,t-1})\left(g_{j,t} - \tilde{g}_{j,t}\right)\right] = 0. \tag{32}$$

Compared with the social planner's necessary condition (12), we see two additional terms, relating to the central bank's incentive to set inflation unexpectedly high, boosting output and decreasing the real interest rate payments on nominal debt.

Government j's value $V_{Gj,t}$ is governed by a similar Bellman equation, which determines taxes and debt for country j:

$$V_{Gj,t}\left(\vec{d}_{t-1}\right) = \max_{\tau_{j,t},\, d_{j,t}} \frac{-1}{2}\Bigg\{\alpha_{\pi G}\pi_t^2 + \left(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}\right)^2$$

$$+\,\alpha_{gG}\left(\frac{d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right) d_{j,t-1} + \tau_{j,t} + \kappa\pi_t}{q_L} - \tilde{g}_{j,t}\right)^2\Bigg\} + \beta_G V_{Gj,t+1}\left(\vec{d}_t\right). \tag{33}$$

As in the central bank's problem, current spending $g_{j,t}$ is substituted out of the Bellman equation using the period budget constraint:

$$d_{j,t} = q_L g_{j,t} + \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right) d_{j,t-1} - \tau_{j,t} - \kappa\pi_t. \tag{34}$$

Government j's optimality condition for taxes is

$$-\nu\left(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}\right) + \frac{\alpha_{gG}}{q_L}\left(g_{j,t} - \tilde{g}_{j,t}\right) = 0. \tag{35}$$

which simplifies to

$$\nu\hat{x}_{j,t} = \frac{\alpha_{gG}}{q_L}\hat{g}_{j,t}, \tag{36}$$

which is the same as the first-order condition of the social planner as long as $\alpha_{gG} = \alpha_{gS}$. Combining (36) with (32) and simplifying using the restrictions in Table 1, we can also calculate the intratemporal relation between inflation and public spending:

$$\alpha_{\pi C}\pi_t = -\frac{\alpha_{gS}}{q_L}\left(1 + \kappa + \chi\bar{d}_{t-1}\right)\bar{\hat{g}}_t. \tag{37}$$

Like the social planner's condition (16), this equation shows that inflation is positive whenever public spending is below its bliss point (except when there is a very large stock of public assets, $\bar{d}_{t-1} < -\frac{1+\kappa}{\chi}$).[22] However, (37) differs due to the central bank's lack of commitment: the central bank tends to choose higher inflation (relative to the OCCPP solution), especially when debt is positive.

The presence of multiple policy makers of non-negligible size complicates the government's Euler equation, relative to that of the social planner. When government j chooses its debt level $d_{j,t}$, it must take into account how this changes other players' incentives: in particular, it must consider how inflation and other regions' debt levels will respond to its choice of $d_{j,t}$. The Euler equation is therefore especially complex when multiple governments interact. It is simplified by considering either of two polar cases: an equilibrium with $J = \infty$ in which each government is negligible relative to the aggregate, or the case $J = 1$, in which the single government interacts with the central bank only. We consider these two cases in turn.[23]

[22] Just as nominal public debt gives the central bank an incentive for surprise inflation, the presence of nominal public assets gives it an incentive for surprise *deflation*. If public assets are sufficiently large, this could, in principle, outweigh the seignorage incentive and the output stimulus incentive.

[23] In Basso and Costain (2013) we computed numerical examples with $1 < J < \infty$. The results are intermediate between the single economy and $J = \infty$ cases, and come close to the $J = \infty$ limit except when the number of players is very small.

4.2.1 $J = \infty$: A large monetary union

We start by considering a "large" monetary union ($J = \infty$). Then if each region j is negligibly small, neither inflation nor other regions' debt will react to region j's debt.[24] In this case, the government's Euler equation is simply

$$\hat{g}_{j,t} \;=\; \beta_G R(\bar{d}_t)\hat{g}_{j,t+1}. \tag{38}$$

Summing across countries and using (37) we can write the dynamics in terms of inflation and average debt:

$$\bar{d}_t = R(\bar{d}_{t-1})\bar{d}_{t-1} - \tilde{\kappa}(\bar{d}_{t-1})\pi_t + \bar{\tilde{z}}_t \tag{39}$$

$$\pi_t = \beta_G R(\bar{d}_t)\left(\frac{1+\kappa+\chi\bar{d}_{t-1}}{1+\kappa+\chi\bar{d}_t}\right)\pi_{t+1}, \tag{40}$$

where $\bar{d}_t$ and $\bar{\tilde{z}}_t$ were defined earlier, and

$$\tilde{\kappa}(\bar{d}_{t-1}) \;\equiv\; \kappa + \frac{\alpha_{\pi C}}{\alpha_{gS}(1+\kappa+\chi\bar{d}_{t-1})}\left(q_L^2 + \frac{\alpha_{gS}}{\nu^2}\right). \tag{41}$$

Note that under the baseline parameterization of Table 1, if $\bar{d}_{t-1} \geq 0$ and the central bank exhibits *moderate inflation aversion*, then $\tilde{\kappa}_P > \tilde{\kappa}(\bar{d}_{t-1})$ strictly. Hence, given any $\bar{d}_{t-1} \geq 0$ and any π_t, the resulting level of debt $\bar{d}_t$ is lower under the social planner's solution than it is in a monetary union. This effect follows from two distinct manifestations of inflationary bias. The first, stressed by Chari and Kehoe (2007), relies on the assumption that inflation aversion of the central bank is less than the "efficient" level, which implies that the inflationary bias resulting from the temptation to boost output leads also to a deficit bias. The second is due the presence of nominal debt, which gives the central bank an incentive to increase inflation when $\bar{d}_{t-1} > 0$.

Also, comparing (40) with (18), we see two factors that make inflation grow faster in a monetary union than it does in the social planner's solution. First, governments are less patient than the planner ($\beta_G < \beta_S$), and second, they do not internalize the effect of their debt on the interest rate (so the term $R'(d)d$ drops out of (40)). Faster inflation growth can be viewed as a sign of deficit bias, because it is a symptom of accumulating debt in order to postpone costly distortions. Since inflation is linked to other distortions via (37), high inflation growth corresponds to an equilibrium in which inflation and taxes are initially low, and public spending is initially high, financed by higher inflation and taxes, and lower spending, in the long run.

[24] In the $J = \infty$ case, symmetry across regions is sufficient (but not necessary) to make all regions negligible.

High long-run distortions are a symptom of high steady-state debt. To speak of a steady state, we must assume $\bar{\tilde{z}}$ is constant; then (40) implies that the steady state interest rate satisfies $R(\bar{d}_{MU}^{SS}) = 1/\beta_G$. Then, if interest rates depend on debt according to (20), the steady state average debt level set by the governments and inflation set by the central bank are

$$\bar{d}_{MU}^{SS} = \frac{1}{\delta}\left(\frac{1}{\beta_G} - \frac{1}{\beta_S}\right), \quad \text{and} \quad \pi_{MU}^{SS} = \frac{\bar{\tilde{z}} + r_0 \bar{d}_{MU}^{SS} + \delta(\bar{d}_{MU}^{SS})^2}{\tilde{\kappa}(\bar{d}_{MU}^{SS})}, \tag{42}$$

where $r_0 \equiv 1/\beta_S - 1$ is the real interest rate when debt is zero. These long-run implications are summarized in Proposition 1 (see the Online Appendix for proofs).

Proposition 1. Suppose the central bank exhibits *moderate or efficient inflation aversion*, and that $\beta_G < \beta_S$. Then the steady state in a monetary union with $J = \infty$ has a higher level of debt and a higher inflation rate than the steady state chosen by the OCCPP planner.

4.2.2 $J = 1$: Country-specific monetary policy

Now consider instead the case $J = 1$, a single country (denoted SI) in which monetary policy is delegated to the central bank and fiscal policy is controlled by the government. There is no longer any free-riding problem, since the government recognizes the effect of its debt on the interest rate, and on the central bank's inflation decision. Omitting the subscript $j = 1$, and simplifying according to Table 1, the Euler equation is

$$\hat{g}_t \;=\; \left(R\left(d_t\right) + R'(d_t)d_t + \left(\gamma + \chi\frac{\alpha_{\pi G}}{\alpha_{\pi C}}d_t\right)\frac{\partial \pi_{t+1}}{\partial d_t}\right)\hat{g}_{t+1}. \tag{43}$$

Rewriting the Euler equation in terms of inflation, using (37), we have

$$d_t = R(d_{t-1})d_{t-1} - \tilde{\kappa}(d_{t-1})\pi_t + \bar{\tilde{z}}_t, \tag{44}$$

$$\pi_t = \beta_G\left(R(d_t) + R'(d_t)d_t + \left(\gamma + \chi\frac{\alpha_{\pi G}}{\alpha_{\pi C}}\right)\frac{\partial \pi_{t+1}}{\partial d_t}\right)\left(\frac{1+\kappa+\chi d_{t-1}}{1+\kappa+\chi d_t}\right)\pi_{t+1}, \tag{45}$$

where $\tilde{\kappa}(d_{t-1})$ and $\bar{\tilde{z}}_t$ were defined earlier, and

$$\gamma \;=\; \kappa\left(\frac{\alpha_{\pi G}}{\alpha_{\pi C}}\left(\frac{1+\kappa}{\kappa}\right) - 1\right). \tag{46}$$

Note that if the baseline parameter assumptions of Table 1 hold, then $\gamma < 1$. Moreover, $\gamma > 0$ if and only if the central bank displays *moderate inflation aversion.*

Given that the budget constraint (39) for *average* debt in a monetary union is identical to the budget constraint (44) for a single economy, for any pair (d_{t-1}, π_t), the

resulting level of debt d_t is the same in both cases. However, the single country inflation path, determined by (45), differs significantly from inflation in a monetary union. Since the government internalizes the impact of its debt on the interest rate, it prefers avoid debt accumulation, and the associated inflation growth. Also, recognizing that the central bank may inflate the economy to boost output (under moderate inflation aversion) and to reduce the interest costs of servicing the nominal debt, the government may choose lower debt at time t in order to correct for the monetary authority's bias at $t+1$. This effect kicks in if and only if $\frac{\partial \pi_{t+1}}{\partial d_t} > 0$, that is, if the central bank decreases inflation in response to smaller debt. Lemma 1 shows that unless public saving is so excessive that lower saving would *increase* interest income, then $\frac{\partial \pi_{t+1}}{\partial d_t} > 0$ around the steady state debt level.

Lemma 1. Suppose the economy satisfies the budget constraint (44) and the first-order condition (37), and that assumption (28) holds. Then in equilibrium the response of inflation to debt $\frac{\partial \pi}{\partial d}$ is positive at any stable steady-state with positive debt and inflation.

Lemma 1 remains true in all the institutional configurations we consider, because (44) and (37), or analogous equations, continue to apply in other versions of our model.

Now suppose that $\bar{\tilde{z}}$ is constant, so that a steady state exists, and that interest rates satisfy (20). Then the steady state of the single economy with government control of debt and central bank control of inflation is:

$$\bar{d}_{SI}^{SS} = \frac{1}{2\delta + \chi \frac{\alpha_{\pi G}}{\alpha_{\pi C}} \frac{\partial \pi}{\partial d}} \left(\frac{1}{\beta_G} - \frac{1}{\beta_S} - \gamma \frac{\partial \pi}{\partial d} \right), \quad \text{and} \quad \pi_{SI}^{SS} = \frac{\bar{\tilde{z}} + r_0 \bar{d}_{SI}^{SS} + \delta (\bar{d}_{SI}^{SS})^2}{\tilde{\kappa}(\bar{d}_{SI}^{SS})}. \tag{47}$$

Proposition 2 summarizes how joining a monetary union affects debt and inflation.

Proposition 2. Suppose that (27)-(29) hold, and that $\beta_G < \beta_S$. Then the steady state in a monetary union with $J = \infty$ has higher *per capita* debt and a higher inflation rate than the steady state chosen in a single country with delegated monetary policy and the same degree of inflation aversion $\alpha_{\pi C}$.

A comparison of steady state debt levels in a single country and in a monetary union reveals several forms of debt bias caused by lack of commitment and lack of cooperation.[25] First, due to lack of commitment, the central bank has an incentive

[25]The contrast between the $J = 1$ and $J = \infty$ cases is also informative about the behavior of large countries in a monetary union. Even with arbitrarily many members, some members may have nontrivial size. A country that makes up a substantial fraction of the union will take into account the impact of its debt decisions on union-wide inflation and interest rates, less strongly than a single country would, but not falling into total free-riding as a country of negligible size does.

to create surprise inflation (i) to boost output and (ii) to decrease the real cost of servicing nominal debt. The strength of these incentives goes through parameters γ and χ, respectively.[26] The government knows that its debt influences central bank inflation and, hence, decreases debt levels to correct for the inflation bias (when $\frac{\partial \pi}{\partial d} > 0$). In a monetary union, governments could collectively decrease debt to correct for this same bias. But each region would then have an incentive to free-ride, increasing spending and reducing taxes, leaving the other regions to control their debt. This results in a common pool problem, in which the only equilibrium is that all countries accumulate higher levels of debt. Finally, another common pool problem goes through interest rates. If all countries collectively reduce their debt issuance, the interest rate paid on debt is reduced. This incentive is internalized by the government in the $J = 1$ case, but in a large monetary union each country regards its own debt as a negligible part of the total, and therefore free-rides and accumulates more debt. Comparing (42) with (47), this effect is reflected in a larger denominator (the factor 2δ in place of δ) in the formula for the steady state debt of a single country with its own monetary policy.

4.3 Policy games: fiscal delegation

We now consider policy games in which the central bank chooses inflation for the union, while regional governments decide taxes and public spending, but the debt decision is delegated to a fiscal authority. The central bank's Bellman equation is given by (31), as in the previous policy games, so its first-order condition, (32), remains the same. The Bellman equation of government j is identical to (33), except that now the only choice variable is τ_{jt} (which given the other policy choices implicitly determines expenditure). As a result, the condition that determines government j taxes also remains unchanged. Thus, the conditions that link public spending to the output gap, (36), and to inflation, (37) continue to hold. Spending can then be calculated from (34).

We will consider two distinct fiscal institutional designs. In the first, the choice of debt is delegated from region's j government to a regional fiscal authority (denoted FA_j). In the second, all regions delegate control of their debt to a central, union-wide authority (denoted FA).

[26] As the central bank becomes more inflation averse (higher $\alpha_{\pi C}$), the lower this nominal debt effect will be. Moreover, if contrary to the assumptions of Table 1, the central bank does *not* care about government spending ($\alpha_{gC} = 0$) then the χ term disappears, so this bias ceases to exist.

4.3.1 Regional Fiscal Authority (FA_j)

A fiscal authority in region j would be described by the following Bellman equation:

$$V_{Fj,t}\left(\vec{d}_{t-1}\right) = \max_{d_{j,t}} \frac{-1}{2}\Bigg\{\alpha_{\pi F}\pi_t^2 + \alpha_{dF}d_{j,t}^2 + (\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t})^2$$

$$+ \alpha_{gF}\left(\frac{d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right)d_{j,t-1} + \tau_{j,t} + \kappa\pi_t}{q_L} - \tilde{g}_{j,t}\right)^2\Bigg\} + \beta_F V_{Fj,t+1}\left(\vec{d}_t\right) \tag{48}$$

In any period t, the fiscal authority chooses debt to satisfy

$$-\frac{\alpha_{gF}}{q_L}\left(g_{j,t} - \tilde{g}_{j,t}\right) - \alpha_{dF}d_{j,t} + \beta_F\frac{\partial V_{Fj,t+1}}{\partial d_{j,t}}\left(\vec{d}_t\right) = 0. \tag{49}$$

As in the previous policy game, analysis is greatly simplified by considering a symmetric equilibrium with many small countries. Formally, assuming all countries are symmetric and $J = \infty$ implies that each country is infinitesimal, so it ignores the impact of its own debt on interest rates, inflation, and other countries' debt. Then the Euler equation is

$$\hat{g}_{j,t} + \frac{q_L\alpha_{dF}}{\alpha_{gF}}d_{j,t} = \beta_F R(\bar{d}_t)\hat{g}_{j,t+1}. \tag{50}$$

Assuming a symmetric equilibrium, we can then rewrite the dynamics in terms of inflation and average debt:

$$\bar{d}_t = R(\bar{d}_{t-1})\bar{d}_{t-1} - \tilde{\kappa}(\bar{d}_{t-1})\pi_t + \bar{\tilde{z}}_t \tag{51}$$

$$\frac{\pi_t}{1+\kappa+\chi\bar{d}_{t-1}} = \frac{\alpha_{dF}}{\alpha_{\pi C}}\bar{d}_t + \beta_F R(\bar{d}_t)\frac{\pi_{t+1}}{1+\kappa+\chi\bar{d}_t}, \tag{52}$$

where $\bar{d}_t$, $\tilde{\kappa}(d_{t-1})$ and $\bar{\tilde{z}}_t$ were defined earlier, and we have simplified using the restrictions from Table 1. Comparing (39)-(40), the equilibrium system under a monetary union, with (51)-(52), we see two effects of the fiscal authority that inhibit inflation growth. First, for a given $\bar{d}_t$, inflation grows more slowly in the presence of the fiscal authority if $\beta_G < \beta_F$, that is, if the government is less patient than the fiscal authority. Second, for any $\bar{d}_t > 0$, inflation grows more slowly in the presence of the fiscal authority as long as $\alpha_{dF} > 0$, that is, if the fiscal authority dislikes debt.

As we discussed in Section 4.2.1, lower inflation growth is a sign of decreased deficit bias and lower steady state debt. To calculate the steady state equilibrium, we again assume that interest rates follow (20). It is convenient to make the change of variables $\breve{\pi} \equiv \frac{\pi}{1+\kappa+\chi\bar{d}}$. In terms of this new "modified inflation" variable $\breve{\pi}$, the steady state equilibrium lies at the crossing of the following two curves:

$$EE^{FA_j}: \qquad \bar{d} = \frac{\breve{\pi}(1-\beta_F/\beta_S)}{\alpha_{dF}/\alpha_{\pi C} + \beta_F\delta\breve{\pi}}, \tag{53}$$

$$BC: \qquad \breve{\pi} = \frac{\bar{\tilde{z}} + r_0\bar{d} + \delta\bar{d}^2}{\varpi + \kappa\chi\bar{d}}, \tag{54}$$

where ϖ, which was defined in Sec. 4.1.1, simplifies to $\varpi = \kappa(1+\kappa) + \frac{\alpha_{\pi C}}{\alpha_{gS}}\left(q_L^2 + \frac{\alpha_{gS}}{\nu^2}\right)$ under the parameter assumptions of Table 1. Curves BC and EE^{FA_j} represent the steady states of the budget constraint (51), and the Euler equation (52). The curves (graphed in the Online Appendix) allow us to characterize the steady state in this case.

Proposition 3. Suppose the economy satisfies (27)-(30), and assume $\beta_G < \beta_F < \beta_S$. Then the steady state debt $\bar{d}^{SS}_{FA_j}$ and inflation $\pi^{SS}_{FA_j}$ of the economy with regional fiscal authorities (FA_j with $J = \infty$) must lie between the corresponding values in the planner's solution and the monetary union:

$$0 < \bar{d}^{SS}_{FA_j} < \frac{1}{\delta}\left(\frac{1}{\beta_F} - \frac{1}{\beta_S}\right) < \frac{1}{\delta}\left(\frac{1}{\beta_G} - \frac{1}{\beta_S}\right) = \bar{d}^{SS}_{MU}, \tag{55}$$

$$\pi^{SS}_P < \pi^{SS}_{FA_j} < \pi^{SS}_{MU}. \tag{56}$$

At least one such steady state exists; if α_{dF} is sufficiently large, then there is exactly one such steady state.

4.3.2 Union-wide Fiscal Authority

A fiscal authority for the union as a whole would select borrowing for all regions j according to:

$$\begin{aligned} V_{F,t}\left(\vec{d}_{t-1}\right) \;=\; & \max_{\{d_{j,t}\}_{j=1}^J} \frac{-1}{2}\Bigg\{\alpha_{\pi F}\pi_t^2 + \frac{1}{J}\sum_{j=1}^J \Bigg[\alpha_{dF} d_{j,t}^2 + \left(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}\right)^2 \\ & + \alpha_{gF}\left(\frac{d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right) d_{j,t-1} + \tau_{j,t} + \kappa\pi_t}{q_L} - \tilde{g}_{j,t}\right)^2\Bigg]\Bigg\} + \beta_F V_{F,t+1}\left(\vec{d}_t\right). \end{aligned} \tag{57}$$

The authority's first-order condition for debt is then

$$-\frac{1}{J}\frac{\alpha_{gF}}{q_L}\left(g_{j,t} - \tilde{g}_{j,t}\right) - \frac{1}{J}\alpha_{dF} d_{j,t} + \beta_F \frac{\partial V_{F,t+1}}{\partial d_{j,t}}\left(\vec{d}_t\right) \;=\; 0. \tag{58}$$

Calculating the value derivative (see the Online Appendix), the factor $1/J$ cancels out of the Euler equation:

$$\frac{\alpha_{gF}}{q_L}\hat{g}_{j,t} + \alpha_{dF} d_{j,t} \;=\; \beta_F\left(R(\bar{d}_{t-1}) + R'(\bar{d}_{t-1})\bar{d}_{t-1}\right)\frac{\alpha_{gF}}{q_L}\hat{g}_{j,t+1} - \beta_F\left(\alpha_{\pi F}\pi_{t+1} + \frac{\kappa\alpha_{gF}}{q_L}\bar{\hat{g}}_{t+1}\right)\frac{\partial \pi_{t+1}}{\partial \bar{d}_t}. \tag{59}$$

Thus, if debt is controlled by a single fiscal authority at the union level, the dynamics are independent of the number of regions J (so there is no need to consider the $J = \infty$ limit in order to characterize this case).

Now, using (34), (36), (37), (91) and summing debt across regions, we obtain the system of difference equations that determine inflation and average debt

$$\bar{d}_t = R(\bar{d}_{t-1})\bar{d}_{t-1} - \tilde{\kappa}(\bar{d}_{t-1})\pi_t + \bar{\tilde{z}}_t, \tag{60}$$

$$\frac{\pi_t}{1+\kappa+\chi\bar{d}_{t-1}} = \frac{\alpha_{dF}}{\alpha_{\pi C}}\bar{d}_t + \beta_F \frac{\left(R(\bar{d}_t) + R'(\bar{d}_t)\bar{d}_t + \left(\gamma + \chi\frac{\alpha_{\pi G}}{\alpha_{\pi C}}\right)\frac{\partial \pi_{t+1}}{\partial \bar{d}_t}\right)}{1+\kappa+\chi\bar{d}_t}\pi_{t+1}. \tag{61}$$

These equations are simplified using the parameter assumptions in Table 1; $\bar{d}_t$, $\tilde{\kappa}(d_{t-1})$, $\bar{\tilde{z}}_t$, and γ were defined earlier.

This system combines two properties we have seen before. Like a model with fiscal authorities at the regional level, debt slows down inflation growth, as long as the fiscal authority is debt averse ($\alpha_{dF} > 0$). But in addition, inflation growth is affected by the impact of debt on interest rate (R') and inflation ($\frac{\partial \pi_{t+1}}{\partial \bar{d}_t}$), as in the single economy case. If inflation responds positively to a rise in debt, and the central bank exhibits moderate inflation aversion (implying $\gamma > 0$), then inflation growth is reduced under a monetary union with a central fiscal authority.

Again, we will solve for the steady state of the economy when interest rates are given by (20), using the change of variables $\breve{\pi} \equiv \frac{\pi}{1+\kappa+\chi\bar{d}}$. The system that determines the steady state level of average debt and inflation becomes

$$EE^{FA}: \qquad \bar{d} = \frac{\breve{\pi}(1-\beta_F/\beta_S - \beta_F\gamma\partial\pi/\partial\bar{d})}{\alpha_{dF}/\alpha_{\pi C} + \beta_F(2\delta + (\gamma + \chi\frac{\alpha_{\pi G}}{\alpha_{\pi C}})\partial\pi/\partial\bar{d})\breve{\pi}}, \tag{62}$$

$$BC: \qquad \breve{\pi} = \frac{\bar{\tilde{z}} + r_0\bar{d} + \delta\bar{d}^2}{\varpi + \kappa\chi\bar{d}}. \tag{63}$$

We obtain:

Proposition 4. Suppose the economy satisfies (27), (28), and (30), and assume $\beta_G < \beta_F < \beta_S$. Then the steady state debt of the economy with a union-wide fiscal authority (FA) may be positive or negative, but is less than the debt under regional fiscal authorities (FA_j with $J = \infty$), as is its inflation:

$$\bar{d}^{SS}_{FA} < \bar{d}^{SS}_{FA_j}, \tag{64}$$

$$\pi^{SS}_{FA} < \pi^{SS}_{FA_j}. \tag{65}$$

At least one such steady state exists; if α_{dF} is sufficiently large, then there is exactly one such steady state.

We can now summarize the results of Props. 1, 3, and 4. A monetary union in which the government controls all aspects of fiscal policy has higher debt than a monetary union with national fiscal authorities, which in turn has higher debt than a monetary union with a centralized fiscal authority. The debt with national fiscal authorities is higher than that in the social planner solution; but with a centralized fiscal authority debt may either be too low (Case 1) or too high (Case 2):

$$\bar{d}^{SS}_{FA_1} < 0 < \bar{d}^{SS}_{FA_2} < \bar{d}^{SS}_{FA_j} < \bar{d}^{SS}_{MU}, \tag{66}$$

where $\bar{d}^{SS}_{FA_1}$ and $\bar{d}^{SS}_{FA_2}$ are the debt levels in Cases 1 and 2 under the centralized authority.

In fact, under certain knife-edge parameter combinations, the union-wide fiscal authority may choose exactly zero debt, like the social planner. If, furthermore, the central bank exhibits *efficient inflation aversion*, then $\kappa^P = \tilde{\kappa}(0)$, so the market budget constraint coincides with the planner's budget constraint (17) at $\bar{d} = 0$. In this case, the equilibrium achieves the planner's steady-state solution for the payoff-relevant variables– inflation, spending, and output– as well as for debt.

However, *efficient inflation aversion* implies $\gamma = 0$, so the fiscal authority only chooses zero steady-state debt if it is just as patient as the planner, $\beta_F = \beta_S$. So ultimately, the key property for achieving the planner's solution is simply an adequately patient fiscal decision-maker, combined with a sufficiently inflation-averse central bank. But therefore, the same solution can also be achieved by regional fiscal authorities FA_j, as long as $\beta_F = \beta_S$, accompanied by a central bank with *efficient inflation aversion.*

Rather than taking very seriously the possibility that these parameter configurations allow a steady-state social optimum to be achieved, we prefer to stress our conclusion that a union-wide fiscal authority is potentially a very powerful framework for controlling debt over the long run, and could thereby also help maintain low and stable inflation. But Case 1 should be kept in mind as a caveat: the fiscal authority could also overshoot, towards debt levels below those of the planner's solution.

4.4 A game with a federal government

Finally, we also compare the behavior of an independent fiscal authority solely concerned with budget balance to the behavior of a European federal government that would control all aspects of fiscal policy. For consistency with our description of the previous games, we now impose the following budget constraint:

$$d_{j,t} \;=\; \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi^e_t - \pi_t)\right) d_{j,t-1} + q_H g_{j,t} - \tau_{j,t} - s_{j,t} - \kappa\pi_t. \tag{67}$$

Government services now cost $q_H > q_L$, because taking all fiscal decisions at the union level implies a loss of local knowledge about spending needs. The budget constraint also reflects the possibility of transfers $s_{j,t}$ across regions. We could assume that the government remains "Paretian", so that regions remain fully responsible for their own budgets, setting

$$s_{j,t} = 0 \tag{68}$$

for all j. But we could also consider a full "fiscal transfer union", in which transfers are constrained only by

$$\sum_{j=1}^{J} s_{j,t} = 0. \tag{69}$$

The central bank's Bellman equation now becomes:

$$V_{C,t}\left(\vec{d}_{t-1}\right) = \max_{\pi_t} \frac{-1}{2}\left\{\alpha_{\pi C}\pi_t^2 + \frac{1}{J}\sum_{j=1}^{J}\left[\left(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}\right)^2\right.\right.$$
$$\left.\left. + \alpha_{gC}\left(\frac{d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right)d_{j,t-1} + \tau_{j,t} + s_{j,t} + \kappa\pi_t}{q_L} - \tilde{g}_{j,t}\right)^2\right]\right\} + \beta_C V_{C,t+1}\left(\vec{d}_t\right) \tag{70}$$

The government solves

$$V_{G,t}\left(\vec{d}_{t-1}\right) = \max_{\tau_{j,t},\, d_{j,t}} \frac{-1}{2}\left\{\alpha_{\pi G}\pi_t^2 + \frac{1}{J}\sum_{j=1}^{J}\left[\left(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}\right)^2\right.\right.$$
$$\left.\left. + \alpha_{gG}\left(\frac{d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right)d_{j,t-1} + \tau_{j,t} + s_{j,t} + \kappa\pi_t}{q_L} - \tilde{g}_{j,t}\right)^2\right]\right\} + \beta_G V_{G,t+1}\left(\vec{d}_t\right) \tag{71}$$

subject either to (68) or (69). Note that (71) is based on the assumption that the European federal government is democratic. Consistent with our earlier assumptions, we suppose that electoral politics tends to make the government more impatient than society as a whole. And since the government must choose between many competing uses of funds, there is no reason for it to be biased against debt, any more than an individual region's government would be.

Given our previous results, it is easy to see how this setup will behave. If the government is Paretian, in the aggregate it acts just like our previous model of a single government (with composite preferences) interacting with a single central bank. Thus the dynamics are analogous to (44)-(45), except that they now refer to average debt over the whole union:

$$\bar{d}_t = R(\bar{d}_{t-1})\bar{d}_{t-1} - \tilde{\kappa}^G(\bar{d}_{t-1})\pi_t + \bar{\tilde{z}}_t^G \tag{72}$$

$$\pi_t = \beta_G\left(R(\bar{d}_t) + R'(\bar{d}_t)\bar{d}_t + \left(\gamma + \chi\frac{\alpha_{\pi G}}{\alpha_{\pi C}}\right)\frac{\partial\pi_{t+1}}{\partial\bar{d}_t}\right)\left(\frac{1+\kappa+\chi\bar{d}_{t-1}}{1+\kappa+\chi\bar{d}_t}\right)\pi_{t+1}. \tag{73}$$

Here we have simplified according to Table 1; $\bar{d}_t$ and γ were defined earlier, and

$$\tilde{\kappa}^G(\bar{d}_{t-1}) \equiv \kappa + \frac{\alpha_{\pi C}}{\alpha_{gS}(1+\kappa+\chi\bar{d}_{t-1})}\left(q_H^2 + \frac{\alpha_{gG}}{\nu^2}\right) \tag{74}$$

$$\bar{\tilde{z}}_t^G = J^{-1}\sum_j(\hat{x}_{j,t}/\nu + q_H\hat{g}_{j,t}). \tag{75}$$

Note that these dynamics are independent of the number of regions, because the federal government acts as a single decision-maker that internalizes the common pool problem across regions. This is why the terms $(\gamma + \chi\frac{\alpha_{\pi G}}{\alpha_{\pi C}})\frac{\partial\pi_{t+1}}{\partial\bar{d}_t}$ and $R'\bar{d}_t$ appear in the inflation dynamics, as they do in the single region case ($J = 1$), slowing down the explosion of inflation by counteracting the impatience of the government.

A major disadvantage of this setup is the loss of "subsidiarity": spending decisions are taken at the union level, where less information is available, and therefore public services are more expensive than they would be if they were allocated locally. The relation between inflation, public spending, and output would be

$$\bar{\hat{g}}_t = -\left(\frac{\alpha_{\pi C}q_H}{\alpha_{gS}(1+\kappa+\chi\bar{d}_{t-1})}\right)\pi_t, \tag{76}$$

$$\bar{\hat{x}}_t = -\left(\frac{\alpha_{\pi C}}{\nu(1+\kappa+\chi\bar{d}_{t-1})}\right)\pi_t \tag{77}$$

Comparing with the corresponding relations for the monetary union, (36)-(37), which also apply in the economy with a fiscal authority, (76) and (77) show that the relation between inflation and output is unchanged, but that for any given level of inflation and debt, the distance of government services from their bliss point is increased.

We can summarize these observations as follows.

- Like a union-wide fiscal authority, a federal government for the monetary union would internalize the common pool problem across regions. On the other hand, the federal government would tend to accumulate more debt insofar as democratic politics makes it more impatient and less debt averse than the fiscal authority.

- For a given level of inflation, the federal government would achieve the same level of output, but a lower level of government services, compared with the fiscal authority (and with the monetary union case).

Intuitively, three forces restrain debt in the union-wide fiscal authority case: increased patience, debt aversion and elimination of the common-pool problem. In the federal government case, only the last of these three mechanisms applies. But beyond the effects on the debt level, the federal government also causes a decrease in the efficiency of public spending, insofar as less information is available at the centralized level for correctly allocating spending decisions.

4.4.1 Fiscal transfer union

If we instead consider a "fiscal transfer union", in which nonzero transfers across regions occur, the aggregate dynamics are still given by (72)-(73). The only difference is at the regional level, at which all differences in distortions are eliminated. That is, $\hat{g}_{j,t}$ and $\hat{x}_{j,t}$ are equalized across all regions, so that the marginal utilities of output and public spending do not differ with j. This raises the level of social welfare in the aggregate, but it is not a Pareto improvement: regions with higher debt (or less favorable shocks $\tilde{g}_{j,t}$ or $\tilde{x}_{j,t}$) benefit at the expense of regions with less debt or more favorable shocks, from whom they receive transfers.[27]

5 Policy implications

Fear of moral hazard continues to hold back agreements on possible mechanisms to prevent self-fulfilling attacks on Eurozone states' sovereign debt (such as Eurobonds) and cross-border panics in the European banking system (such as a Single Deposit Insurance Mechanism). The basic fear is that any mechanism capable of preventing crises opens the door to irresponsible fiscal policies that count on future bailouts instead of maintaining long-run national budget balance. Thus, designing an institutional framework capable of ensuring long-run fiscal discipline is a crucial counterpart to the establishment of a crisis prevention mechanisms, so an adequate fiscal framework could prove to be the key to the long-run stability of the Eurozone.

An independent fiscal authority for EMU

Our model points to one powerful framework for fiscal discipline: the establishment of a budgetary agency within the European Commision, mandated to ensure long-run budget balance, which for the sake of concreteness we will call the European Fiscal Authority (EFA). What exactly would the EFA do? First, it would necessarily take the form of a forecasting agency, monitoring and predicting fiscal trends in each member state. Second, it could provide advice to member governments about the likely fiscal impact of new policy proposals. In these ways it would resemble the national fiscal councils mandated under the "Fiscal Compact" treaty (European Council (2012)).

But our concept of the EFA would go beyond the monitoring and advisory role foreseen in the "Five Presidents' Report" (J. Juncker et al. (2015)), by exercising executive control over one or more national fiscal instruments. Importantly, these

[27] Since the transfers $s_{j,t}$ are lump sum, only the present discounted value of transfers is determined by the model, not the actual time path of transfers.

should be instruments with a sufficiently strong budgetary impact to give it effective control over the path of each member state's public debt. Our model suggests that this setup would decrease debt accumulation in three ways. First, as a technical arm of the European bureaucracy, the EFA would be unlikely to suffer the impatience typical of elected bodies. Second, controlling just a few instruments under a mandate to maintain long-run budget balance, it would be likely to care more about the debt level than a government charged with balancing the concerns of countless competing interest groups. Third, by taking its decisions at the union level, it would internalize the common pool problems in member states' budget choices.

Together, according to our model, these three mechanisms imply that debt is lower in an economy with a union-wide fiscal authority than it is in an economy with national fiscal authorities (Prop. 4), which in turn is lower than the debt level in a large monetary union (Prop. 3). Decreasing debt relative to the level observed in a monetary union is beneficial, since we have seen that it is excessively high, compared with the social planner's solution (Prop. 1). Although our model does *not* rule out the possibility that a union-wide fiscal authority may go too far, increasing public saving beyond the social optimum, we showed that a system of country-specific fiscal authorities is insufficient, by itself, to reach the social planner's preferred debt level (Prop. 3).

Our analysis is founded on the assumption that no policy makers can commit to follow a rule. Thus, from the beginning we discard the possibility that the path of debt may be altered by imposing rules on Eurozone member states. This aspect of our analysis is more consistent than that of BB99, who build their model on the assumption that the central bank cannot commit to follow a monetary policy rule, but then go on to argue that governments could and should commit to a fiscal rule. Instead, in our model all policy decisions represent equilibrium outcomes of games between policy makers with different instruments and different preferences.[28] Following Rogoff (1985), we assume that institutional design may affect institutional preferences. In particular, we assume that a budgetary agency with a mandate to maintain long-run budget balance, given control over a few instruments that make this mandate feasible, will act in a debt-averse manner. This is consistent with the apparent inflation aversion of central banks that are mandated to maintain low inflation and control instruments that make low inflation feasible.[29]

[28]In our deterministic model, there is no equilibrium role for rules. An interesting extension would be a stochastic model of "sustainable equilibria", which might allow us to incorporate rules and punishments as equilibrium outcomes, along the lines of Chari and Kehoe (1990). See Basso (2009) for an analysis of monetary delegation in a sustainable equilibrium model.

[29]Blinder (1998) interprets the Rogoff (1985) model as an argument about the effects of delegating instruments to an independent central bank, instead of the simplistic interpretation that the bank should "hire a conservative" as its governor.

Our model also considers the alternative of establishing a federal government that makes all fiscal decisions at the union level. A European government would internalize the common pool problem in member states' budget decisions. But unlike the EFA framework, a federal government would be subject to the budgetary disadvantages of the democratic political process: electoral politics would make it impatient, and it would display no more debt aversion than any other democratic government. At the same time, it would give up the advantages of the European principle of "subsidiarity": by taking fiscal decisions at a more centralized level, it would lose local information and thus would be likely to spend less efficiently. Our model shows that this inefficient spending also tends to raise debt accumulation. For all these reasons, the EFA would likely provide stronger fiscal discipline than a European federal government. Moreover, keeping fiscal decisions as close as possible to the local level is also a way of increasing their political legitimacy. In this sense, an unelected European body charged *only* with ensuring long-run budget balance might actually produce a more democratic outcome than would an elected European government with wider fiscal powers.

A credible quid pro quo

If we accept that this strong form of fiscal discipline is indeed beneficial, and compatible with democracy, several further questions arise. First, is it politically feasible? Second, can effective fiscal instruments be established, in practice? And finally, which fiscal instrument(s) would be most appropriate for delegation to a hypothetical European Fiscal Agency?

Although delegation of fiscal instruments is not standard practice today, it does seem politically feasible in the European context. Fiscally fragile countries in the Eurozone still need backing from the monetary authorities in order to avoid the risk of speculative attacks and banking panics. The monetary authorities could protect member states against speculative attacks in a variety of ways: one obvious possibility would be to intervene in debt markets to cap the risk premium on a member state's sovereign bonds, but there are many other alternatives. However, fiscally strong European countries oppose monetary protection against speculative attacks, because they fear moral hazard: the weaker countries might fail to balance their budgets if they take ECB protection for granted.

These considerations point to a politically feasible *quid pro quo*. Assuming that a European budget forecasting agency is established, as the "Five Presidents' Report" (J. Juncker et al. (2015)) proposes, then member states could be given the option to delegate one or more fiscal instruments to that agency, on a purely voluntary basis. The agency, which we will call the European Fiscal Authority (EFA), would then evaluate

whether the instruments proposed for delegation by a given member state are powerful enough and agile enough to give it effective control of that member state's debt. When the EFA judges that it has been granted effective control of the member state's debt level— including setting up the legal and administrative framework for control of the proposed instruments by the EFA— the member state would become immediately eligible for ECB protection against speculative attacks (by whatever mechanism the ECB judges appropriate).

Crucially, protection would remain contingent at all times on continuing approval from the EFA. If at any time the EFA judges that its delegated instruments are less powerful than expected, or if it judges that a member state has begun to "game the system" in some way that makes it unable to control that state's debt level, the EFA would publicly revoke its approval of the delegated instruments (probably, but not necessarily, after adequate advance warning to the member state). The ECB would then be obliged to cease backing that state's sovereign debt. One might question whether it is credible to threaten to eliminate a member state's protection against speculative attacks. There could be scope for moral hazard if eliminating protection of the bonds of one country caused contagion to others. But as long as the other fiscally fragile countries are themselves participating in the EFA system, scope for contagion would be greatly mitigated.

Which instruments to delegate?

Finally, we come to the question of which instrument(s), if any, would be appropriate for delegating control of long-term budget balance to the European Commission. By assumption, in our model, the fiscal authority actually issues each member state's sovereign debt; the member government is then free to spend the cash proceeds.[30] But this is unrealistic, assumed only for mathematical convenience (and for comparability with the BB99 paper). Most forms of public spending involve long-term projects and long-term contracts that are costly and difficult to adjust rapidly; therefore, in practice, most public spending decisions are planned long in advance, and sovereign debt issuance is typically a residual, chosen after spending and taxes to compensate any difference between the two. Indeed, formal control of debt issuance may not suffice for *de facto* control of the debt. A recent example was the discussion of the issuance of "platinum coins" as a way to get around the US Congress' legal control over the US debt level. Likewise, in recent years many countries and regions have resorted to issuing scrip or

[30] When instead the authority is decreasing the debt stock in nominal terms, the implicit assumption is that the fiscal authority is the first claimant on all period t tax revenues of region j until it achieves its desired debt level $d_{j,t}$.

IOUs— or simply delaying payments— when for some reason they have been unable to formally issue more sovereign debt.

On the other hand, formal control of debt issuance may also not be *necessary* to achieve *de facto* control of the debt, as long as the EFA controls another instrument that has a rapid and powerful effect on the current deficit. There are many possible ways to construct a powerful budgetary instrument of this sort. Probably the simplest idea is that of Gruen (1997), who proposed defining a multiplicative shift factor in the Australian tax code. He proposed applying this shift factor to income taxes, VAT taxes, and all other types of taxes. Tax rates would take whatever complicated functional form the Australian government chose, but would subsequently by multiplied by a factor X_t, which would initially be set to one but would thereafter be adjusted by an independent fiscal authority to ensure control of the debt level.

Another instrument is implicit in the analysis of Gomes (2011), who shows that public sector wages should optimally be state-contingent, rising in times of fiscal plenty and falling when the budget is tight. Across-the-board shifts in public labor compensation would have a powerful budgetary impact, and could in principle be performed very quickly (particularly if a shift factor were spelled out explicitly *ex ante* in public contracts, instead of being an *ad hoc* crisis response, as was the case in Spain and Portugal during the crisis). Costain and de Blas (2012a,b) go a step further and point out that *all public sector prices* could be made effectively state-contingent by budgeting them in an alternative unit of account, the value of which would be determined by the fiscal authority. In the European context, this could be a way of reestablishing some of the nominal flexibility that is usually assumed lost upon joining a monetary union.[31] Finally, it is increasingly common that pension systems automatically depend on demographic adjustment factors in determining retirement ages or benefit levels. Additional adjustment factors related to long-term budget trends offer another potentially powerful lever that could be delegated to an independent fiscal authority.[32]

Whether or not to participate in the EFA mechanism, and if so, which instrument(s) to delegate to the fiscal authority, is ultimately a political decision that should be taken democratically in each member state. Each possible instrument has different political, economic, and distributional effects; a particularly important question is how different budget stabilization instruments facilitate or conflict with short-run stabilization of

[31]Dornbusch (1997) discusses a historical precedent for the idea of establishing a unit of account different from the medium of exchange: Brazil's successful disinflation program of 1994.

[32]In a recent pension reform, the Spanish government established a "Factor de Revalorización Anual" that will be applied annually to automatically adjust pensions in response to any persistent deficits or surpluses in the pension system; see Sánchez (2014).

macroeconomic shocks.[33] But from the point of view of the political *quid pro quo* between member states, the only essential question is whether a given instrument has a sufficient budgetary impact to enable the EFA to adequately control long-run debt. The only decision in the hands of the fiscal authority itself would be the technical and quantitative question of what setting of its delegated instrument is consistent with long-run budget balance under its forecasts, given the policies of the member government.[34] All other fiscal instruments would remain under the control of the member government, consistent with the European principal of "subsidiarity".

6 Conclusions

This paper has analyzed the potential for the delegation of fiscal instruments to offset systematic deficit bias in the fiscal decisions of democratic governments, with particular attention to the context of a monetary union. That is, we ask to what extent deficit bias could be reduced by a fiscal authority that is independent of government and has a mandate for long-run budget balance, just as independent, inflation-averse central banks have helped reduce inflation bias. We follow the simple modeling strategy of Rogoff (1985), characterizing differences across institutions by different weight parameters in their objective functions. First, we assume electoral politics induces impatience in democratic institutions, relative to society's discount rate; second, we assume that mandating an institution to pursue a single, simple, quantitative objective skews its preferences in favor of that objective, relative to the social welfare function.

This parsimonious treatment of institutions allows us to derive strong analytical results comparing equilibrium outcomes across different institutional configurations. We focus on symmetric perfect-foresight equilibria, in order to shed light on systematic biases. We start from a baseline institutional framework, building on Beetsma and Bovenberg (1999), in which a single central bank controls inflation for all the regions in a monetary union, while region-specific democratic governments make all fiscal decisions in each region. We compare several alternative configurations: (1) in each region, debt is issued by a debt-averse regional fiscal authority, leaving all other fiscal decisions up to

[33] In future work we intend to study delegation of a variety of other instruments, such as those discussed in this section. But this will make it important to examine cyclical stabilization issues that go beyond our current focus on the long-run sustainability implications of different policy regimes.

[34] Since debt rather than deficits *per se* is the relevant issue for intertemporal budget balance, deficits may fluctuate substantially even when they are controlled by the EFA. There may even be circumstances when a short-run deficit favors long-run budget balance, for example if a temporary deficit enables productive investments, or if the economy appears to be temporarily beyond the maximum of its Laffer curve.

the regional governments; (2) debt is issued for each region by a union-wide debt-averse fiscal authority, leaving all other fiscal decisions up to the regional governments; (3) the regional governments are replaced by a single, union-wide government. We show (a) per capita debt is higher in the baseline scenario than it would be for a single country with an independent monetary policy; (b) debt is excessive in the baseline scenario, relative to a social planner's solution; (c) debt is lower under region-specific fiscal authorities than it is in the baseline scenario, and (d) it is lower still under a single, union-wide fiscal authority. Under the scenario with a union-wide government (but no fiscal authority), there is a tendency to accumulate less debt than in the baseline scenario, because the common-pool problems in deficit choice are internalized, but the other debt-reducing properties of the fiscal authority are lost, and public spending attains less bang for the buck due to a loss of informational efficiency.

Going beyond the model, Section 5 discussed the role that fiscal delegation might play in resolving the ongoing Eurozone crisis, where a disciplined fiscal regime is a crucial counterpart (both economically and politically) to most of the monetary and financial mechanisms currently under debate. A European Fiscal Authority controlling at least one sufficiently powerful fiscal instrument in a member state could guarantee that state's long-run budget balance. The member state itself would decide which instrument to delegate, while the EFA would evaluate whether it is "sufficiently powerful". Delegation to the EFA would be attractive if it made member states eligible for ECB protection against speculative attacks; but even without such a guarantee it could be attractive as a way of improving fiscal credibility and lowering risk premia. Therefore we have stressed that these institutions could be constructed in a voluntary, step-by-step fashion. As long as fears of moral hazard persist, peripheral countries can do little to achieve a union-wide agreement that would protect them against any future shocks to the Eurozone. Reforming their fiscal institutions— possibly unilaterally— is one way peripheral countries could jumpstart the negotiations for such an agreement.

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Online Appendix: "Fiscal delegation in a monetary union with decentralized public spending"

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A Envelope calculations.

Deriving the Euler equation for each institutional configuration requires us to calculate some value function derivatives, using the envelope theorem, as follows.

Social planner.
The OCCPP planner's first-order condition for region j debt $d_{j,t}$ is

$$-\frac{1}{J}\frac{\alpha_{gS}}{q_L}\left(g_{j,t}-\tilde{g}_{j,t}\right)+\beta_S\frac{\partial V_{P,t+1}}{\partial d_{j,t}}\left(\{d_{k,t}\}_{k=1}^{J}\right) \;=\; 0. \tag{78}$$

The unknown derivative in (78) can be eliminated using the envelope condition:

$$\frac{\partial V_{P,t}}{\partial d_{j,t-1}}\left(\vec{d}_{t-1}\right) \;=\; \frac{R(\bar{d}_{t-1})\alpha_{gS}}{Jq_L}(g_{j,t}-\tilde{g}_{j,t})+\frac{R'(\bar{d}_{t-1})\alpha_{gS}}{Jq_L}\sum_{k=1}^{J}\frac{d_{k,t-1}}{J}(g_{k,t}-\tilde{g}_{k,t}). \tag{79}$$

Together, (78) and (79) imply the Euler equation (14).

Monetary policy delegation.
Government j chooses debt $d_{j,t}$ so that

$$-\frac{\alpha_{gG}}{q_L}\left(g_{j,t}-\tilde{g}_{j,t}\right)+\beta_G\frac{\partial V_{Gj,t+1}}{\partial d_{j,t}}\left(\vec{d}_t\right) \;=\; 0, \tag{80}$$

To compute the value derivative in (80), we can ignore how $d_{j,t}$ impacts $\tau_{j,t+1}$ and $d_{j,t+1}$; these effects have zero marginal value, by the envelope theorem. But we cannot ignore the fact that changing $d_{j,t}$ will alter the central bank's choice of π_{t+1}, and other regions' debt choices $d_{k,t+1}$, for $k \neq j$; these interactions alter the marginal value of changing $d_{j,t}$. Differentiating (33), we obtain:

$$\begin{aligned}\frac{\partial V_{Gj,t}}{\partial d_{j,t-1}} \;=\;& \frac{R\left(\bar{d}_{t-1}\right)\alpha_{gG}}{q_L}\left(g_{j,t}-\tilde{g}_{j,t}\right)+\frac{R'(\bar{d}_{t-1})\alpha_{gG}}{q_L}\frac{d_{j,t-1}}{J}(g_{j,t}-\tilde{g}_{j,t})\\ &-\left(\alpha_{\pi G}\pi_t+\frac{\kappa\alpha_{gG}}{q_L}(g_{j,t}-\tilde{g}_{j,t})\right)\frac{\partial\pi_t}{\partial d_{j,t-1}}+\beta_G\sum_{k\neq j}\frac{\partial V_{Gj,t+1}}{\partial d_{k,t}}\frac{\partial d_{k,t}}{\partial d_{j,t-1}}.\end{aligned} \tag{81}$$

We do not need to track how π_t^e varies with $d_{j,t-1}$; any change in π_t^e will cancel with a corresponding change in π_t, since under rational expectations $\pi_t^e = \pi_t$ for *any* value of $d_{j,t-1}$.[35] Next, another value derivative appears in (81): the marginal effect $\frac{\partial V_{Gj,t+1}}{\partial d_{k,t}}$ of region k's debt on government j's value. Differentiating (33) again yields:

$$\begin{aligned}\frac{\partial V_{Gj,t}}{\partial d_{k,t-1}} &= \frac{R'(\bar{d}_{t-1})\alpha_{gG}}{q_L}\frac{d_{j,t-1}}{J}(g_{j,t}-\tilde{g}_{j,t}) \\ &\quad -\left(\alpha_{\pi G}\pi_t + \frac{\kappa\alpha_{gG}}{q_L}(g_{j,t}-\tilde{g}_{j,t})\right)\frac{\partial \pi_t}{\partial d_{k,t-1}} + \beta_G \sum_{l\neq j}\frac{\partial V_{Gj,t+1}}{\partial d_{l,t}}\frac{\partial d_{l,t}}{\partial d_{k,t-1}}.\end{aligned} \tag{82}$$

As $J \to \infty$, the terms $\frac{d_{j,t-1}}{J}$, $\frac{\partial \pi_t}{\partial d_{k,t-1}}$, and $\frac{\partial d_{l,t}}{\partial d_{k,t-1}}$ all become negligible, so the value derivative (81) simplifies to

$$\frac{\partial V_{Gj,t}}{\partial d_{j,t-1}} = \frac{R(\bar{d}_{t-1})\alpha_{gG}}{q_L}\left(g_{j,t}-\tilde{g}_{j,t}\right), \tag{83}$$

and we obtain the Euler equation (38).

When we instead consider the case of a single government in a country that operates its own monetary policy ($J = 1$), then only the last term in (81) disappears. Using (37) we obtain

$$\frac{\partial V_{G,t}}{\partial d_{t-1}} = \left(\frac{R\left(d_{t-1}\right)\alpha_{gG}}{q_L} + \frac{R'(d_{t-1})\alpha_{gG}}{q_L}d_{t-1} + \frac{\alpha_{gG}}{q_L}\left(\gamma + \tilde{\chi}d_{t-1}\right)\frac{\partial \pi_t}{\partial d_{t-1}}\right)\left(g_t - \tilde{g}_t\right). \tag{84}$$

In this case, we obtain the Euler equation (43).

Regional fiscal authority.

Since the players are not infinitesimal, each takes into account how its moves affect future moves by other players. Thus, the fiscal authority's marginal value of debt includes its impact on future inflation and taxes, and on other regions' future debts:

$$\begin{aligned}\frac{\partial V_{Fj,t}}{\partial d_{j,t-1}} &= \frac{R(\bar{d}_{t-1})\alpha_{gF}}{q_L}\left(g_{j,t}-\tilde{g}_{j,t}\right) + \frac{R'(\bar{d}_{t-1})\alpha_{gG}}{q_L}\frac{d_{j,t-1}}{J}(g_{j,t}-\tilde{g}_{j,t}) - \left(\alpha_{\pi F}\pi_t + \frac{\kappa\alpha_{gF}}{q_L}(g_{j,t}-\tilde{g}_{j,t})\right)\frac{\partial \pi_t}{\partial d_{j,t-1}} \\ &\quad + \left[\nu(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}) - \frac{\alpha_{gF}}{q_L}(g_{j,t}-\tilde{g}_{j,t})\right]\frac{\partial \tau_{j,t}}{\partial d_{j,t-1}} + \beta_F \sum_{k\neq j}\frac{\partial V_{Fj,t+1}}{\partial d_{k,t}}\frac{\partial d_{k,t}}{\partial d_{j,t-1}} \\ &= \frac{\left(R(\bar{d}_{t-1}) + R'(\bar{d}_{t-1})\frac{d_{j,t-1}}{J}\right)\alpha_{gF}}{q_L}\hat{g}_{j,t} - \left(\alpha_{\pi F}\pi_t + \frac{\kappa\alpha_{gF}}{q_L}\hat{g}_{j,t}\right)\frac{\partial \pi_t}{\partial d_{j,t-1}} + \beta_F \sum_{k\neq j}\frac{\partial V_{Fj,t+1}}{\partial d_{k,t}}\frac{\partial d_{k,t}}{\partial d_{j,t-1}}\end{aligned} \tag{85}$$

[35] Here, as in BB99, π_t^e represents an expectation at the beginning of t, after time $t-1$ choices and time t shocks have been revealed.

The terms proportional to $\frac{\partial \tau}{\partial d}$ cancel out of (85) using the baseline parameter assumptions from Table 1. Specifically, assuming $\alpha_{gG} = \alpha_{gF}$, they match the terms in the government's first-order condition (35), and therefore sum to zero.

Evaluating (85) also requires expressions for some cross derivatives, representing the marginal value to F_j of region k's debt, for $k \neq j$. Again, the derivatives simplify if $\alpha_{gG} = \alpha_{gF}$:

$$\begin{aligned}
\frac{\partial V_{Fj,t}}{\partial d_{k,t-1}} &= \frac{R'(\bar{d}_{t-1})\alpha_{gG}}{q_L}\frac{d_{j,t-1}}{J}(g_{j,t} - \tilde{g}_{j,t}) - \left(\alpha_{\pi F}\pi_t + \frac{\kappa\alpha_{gF}}{q_L}(g_{j,t} - \tilde{g}_{j,t})\right)\frac{\partial \pi_t}{\partial d_{k,t-1}} \\
&\quad + \left[\nu(\nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}_{j,t}) - \frac{\alpha_{gF}}{q_L}(g_{j,t} - \tilde{g}_{j,t})\right]\frac{\partial \tau_{j,t}}{\partial d_{k,t-1}} + \beta_F \sum_{l \neq j} \frac{\partial V_{Fj,t+1}}{\partial d_{l,t}}\frac{\partial d_{l,t}}{\partial d_{k,t-1}} \\
&= \frac{\left(R'(\bar{d}_{t-1})\frac{d_{j,t-1}}{J}\right)\alpha_{gF}}{q_L}\hat{g}_{j,t} - \left(\alpha_{\pi F}\pi_t + \frac{\kappa\alpha_{gF}}{q_L}\hat{g}_{j,t}\right)\frac{\partial \pi_t}{\partial d_{k,t-1}} + \beta_F \sum_{l \neq j} \frac{\partial V_{Fj,t+1}}{\partial d_{l,t}}\frac{\partial d_{l,t}}{\partial d_{k,t-1}}.
\end{aligned} \tag{86}$$

If we now consider the limiting case $J = \infty$, in which each region is infinitesimal, then neither inflation nor other regions' debt will respond to region j's debt. Then (85) simplifies to

$$\frac{\partial V_{Fj,t}}{\partial d_{j,t-1}} = \frac{R(\bar{d}_{t-1})\alpha_{gF}}{q_L}(g_{j,t} - \tilde{g}_{j,t}), \tag{87}$$

which implies the Euler equation (50).

Union-wide fiscal authority.

If instead the fiscal authority is a union-wide institution, for $t < T$ it sets:

$$-\frac{1}{J}\frac{\alpha_{gF}}{q_L}(g_{j,t} - \tilde{g}_{j,t}) - \frac{1}{J}\alpha_{dF}d_{j,t} + \beta_F \frac{\partial V_{F,t+1}}{\partial d_{j,t}}\left(\vec{d}_t\right) = 0. \tag{88}$$

Using (57), the marginal value of country j's debt, after using $\alpha_{gG} = \alpha_{gF}$ and (35) to eliminate the $\frac{\partial \tau}{\partial d}$ terms, is given by[36]

$$\begin{aligned}
\frac{\partial V_{F,t}}{\partial d_{j,t-1}} &= \frac{R(\bar{d}_{t-1})\alpha_{gF}}{q_L}\frac{1}{J}(g_{j,t} - \tilde{g}_{j,t}) + \frac{1}{J}\sum_{k=1}^{J}\left(\frac{R'(\bar{d}_{t-1})\alpha_{gG}}{q_L}\frac{d_{k,t-1}}{J}(g_{k,t} - \tilde{g}_{k,t})\right) \\
&\quad - \frac{1}{J}\sum_{k=1}^{J}\left(\alpha_{\pi F}\pi_t + \frac{\kappa\alpha_{gF}}{q_L}(g_{j,t} - \tilde{g}_{j,t})\right)\frac{\partial \pi_t}{\partial d_{j,t-1}} \\
&= \frac{R(\bar{d}_{t-1})\alpha_{gF}}{Jq_L}\hat{g}_{j,t} - \frac{1}{J}\sum_{k=1}^{J}\left(\alpha_{\pi F}\pi_t + \frac{\kappa\alpha_{gF}}{q_L}\hat{g}_{j,t}\right)\frac{\partial \pi_t}{\partial d_{j,t-1}}.
\end{aligned} \tag{89}$$

[36]Notice also that no value function derivatives occur on the right-hand side of (89); they are eliminated using the envelope theorem.

Assuming a symmetric equilibrium, the response of inflation to any given country's debt must be $1/J$ times its response to aggregate debt.[37] Thus the envelope condition (89) becomes

$$\frac{\partial V_{F,t}}{\partial d_{j,t-1}} = \frac{1}{J}\frac{R(\bar{d}_{t-1})\alpha_{gF}}{q_L}\hat{g}_{j,t} + \frac{R'(\bar{d}_{t-1})\alpha_{gG}}{q_L}\frac{\bar{d}_{t-1}}{J}\bar{\hat{g}}_t - \left(\alpha_{\pi F}\pi_t + \frac{\kappa\alpha_{gF}}{q_L}\bar{\hat{g}}_t\right)\frac{1}{J}\frac{\partial \pi_t}{\partial \bar{d}_{t-1}}, \quad (90)$$

so that the factor $1/J$ cancels out of the Euler equation:

$$\frac{\alpha_{gF}}{q_L}\hat{g}_{j,t} + \alpha_{dF}d_{j,t} = \beta_F\left(R(\bar{d}_{t-1}) + R'(\bar{d}_{t-1})\bar{d}_{t-1}\right)\frac{\alpha_{gF}}{q_L}\hat{g}_{j,t+1} - \beta_F\left(\alpha_{\pi F}\pi_{t+1} + \frac{\kappa\alpha_{gF}}{q_L}\bar{\hat{g}}_{t+1}\right)\frac{\partial \pi_{t+1}}{\partial \bar{d}_t}. \quad (91)$$

B Proofs.

Proof of Proposition 1. Since $\beta_G < \beta_S$, (42) implies $\bar{d}^{SS}_{MU} > 0$. Moderate or efficient inflation inversion means $\alpha_{\pi C} \leqslant \frac{1+\kappa}{\kappa}\alpha_{\pi S}$; together with $\bar{d}^{SS}_{MU} > 0$ this implies $\tilde{\kappa}_P > \tilde{\kappa}(\bar{d}^{SS}_{MU})$. Then, since $r_0\bar{d}^{SS}_{MU} + \delta(\bar{d}^{SS}_{MU})^2 > 0$, we have $\pi^{SS}_{MU} > \pi^{SS}_P$. **QED.**

Proof of Lemma 1. Let $\pi = \Pi(d)$ be the equilibrium relation between debt and inflation. Let $d' = B(d)$ be the gross borrowing function (equilibrium debt next period, as a function of debt this period), which is described by the right-hand side of (44), implying that these functions are related as follows:

$$B(d) = R(d)d - \tilde{\kappa}(d)\Pi(d) + \tilde{z} \quad (92)$$

Differentiating and rearranging, we must have

$$\Pi'(d) = \tilde{\kappa}(d)^{-1}\left(R(d) + R'(d)d - B'(d)\right) - \tilde{\kappa}'(d)\Pi(d). \quad (93)$$

where $\tilde{\kappa}'(d) = -\frac{\alpha_{\pi C}\kappa}{(1+\kappa+\chi d)^2}(q_L^2 + \alpha_{gS}/\nu^2) < 0$. A *stable* steady state d_{ss} is a point $d_{ss} = B(d_{ss})$ characterized by $B'(d_{ss}) < 1$. For any d, total interest payments are $(R(d)-1)d$. Therefore interest payments are increasing in debt if and only if $R'(d)d + R(d) - 1 > 0$; this is true at steady state if (28) holds. Note that $d_{ss} > 0$ is sufficient (but not necessary) for $\tilde{\kappa}(d) > 0$; thus, at a stable steady state with positive debt and inflation, the right-hand side of (93) is positive. **QED.**

Note that this proof relies only on (44) and (37), which apply to all the models from Sec. 4.2.1-4.3.2, so the lemma holds in the scenarios labelled MU, SI, FA_J, and

[37] This simplification would no longer be valid if we allowed for other parameter differences across regions, other than their initial debt level.

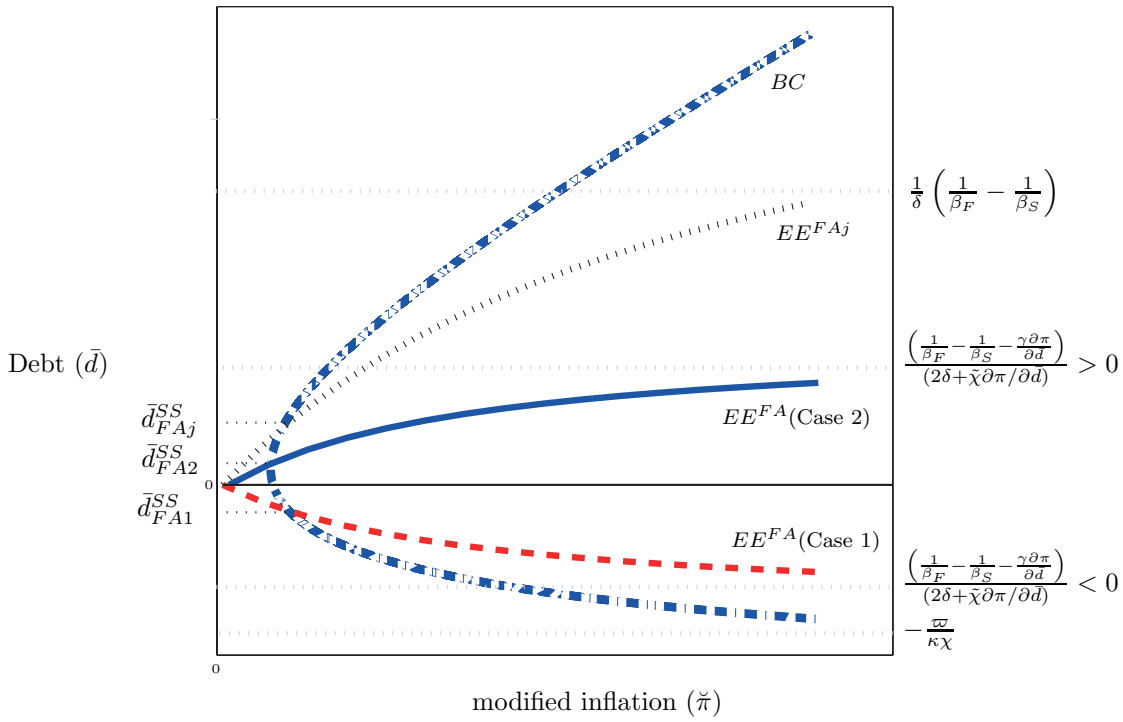

Figure 1: *Representation of curves BC, EE^{FA_j}, and EE^{FA}*

Note: Figure 1 graphs the curves BC and EE^{FA_j}, as discussed in Prop. 3, as well as EE^{FA} for Cases 1 and 2 of Prop. 4. The horizontal axis graphs the modified inflation variable $\breve{\pi} \equiv \frac{\pi}{1+\kappa+\chi d}$, and the vertical axis represents debt $\bar{d}$. The example shown assumes (30) holds, so curve BC never crosses the vertical axis.

FA. For the case of a federal government, an analogous result can be derived from (72)-(76).

Proof of Proposition 2. Note that $\chi > 0$, and under *moderate or efficient inflation aversion*, we have $\gamma \geqslant 0$. Then $\bar{d}^{SS}_{MU} > \bar{d}^{SS}_{SI}$, either because $\bar{d}^{SS}_{SI} < 0$, or by Lemma 1. Next, the numerator of the inflation formula in (47) obviously increases with $\bar{d}$ when $\bar{d} > 0$; it remains increasing as long as (28) holds. The denominator obviously decreases with $\bar{d}$ when $\bar{d} > 0$; it is also decreasing if (29) holds. Thus, both the numerator and the denominator of the formula lead to $\pi^{SS}_{MU} > \pi^{SS}_{SI}$. **QED.**

Proof of Proposition 3. Curve BC, shown in Figure 1, plots the points at which $\bar{d}_t = \bar{d}_{t-1}$ conditional on a given value of modified inflation ($\breve{\pi}_t \equiv \frac{\pi_t}{1+\kappa+\chi d_{t-1}}$), according to the budget constraint (54). Curve EE^{FA_j} plots the points where $\breve{\pi}_{t+1} = \breve{\pi}_t$ conditional on a given value of debt $\bar{d}_t$, according to the Euler equation (53). Any crossing of these two isoclines is a steady state of the FA_j economy.

By (30), $\bar{\tilde{z}} + (r_0 + \delta\bar{d})\bar{d} > 0$ for all d, so the minimum value of $\breve{\pi}$ on curve BC is positive. Thus a graph of the curve with $\breve{\pi}$ on the horizontal axis never crosses the vertical axis; it is shaped like a letter "C", with a lower asymptote at $\bar{d} = -\frac{\varpi}{\kappa\chi}$, and an upper branch that tends to $d \to \infty$ as $\varpi \to \infty$. BC enters the positive quadrant at a point where $\bar{d} = 0$ and $\breve{\pi} > 0$, and eventually increases without bound.

EE^{FA_j} is a weakly increasing function of $\breve{\pi}$, and passes through the origin. As $\breve{\pi} \to \infty$, the value of debt along EE^{FA_j} tends to the upper bound $\delta^{-1}(\beta_F^{-1} - \beta_S^{-1}) > 0$. If instead we consider $\bar{d} \to -\infty$, the value of modified inflation along EE^{FA_j} tends to the lower bound $-\frac{\alpha_{dF}}{\delta\beta_F\alpha_{\pi C}}$.

Since BC increases without bound as $\breve{\pi} \to \infty$, while EE^{FA_j} passes through the origin and tends to a finite upper bound, the two curves must cross at a debt level $\bar{d}^{SS}_{FA_j}$ that satisfies

$$0 < \bar{d}^{SS}_{FA_j} < \delta^{-1}(\beta_F^{-1} - \beta_S^{-1}) < \delta^{-1}(\beta_G^{-1} - \beta_S^{-1}). \tag{94}$$

This crossing is saddle-path stable if it is unique. To see this, note that the direction of flow of (51)-(52) is leftwards at any point above EE^{FA_j}, and downwards at any point to the right of BC that lies above the asymptote $\bar{d} = -\frac{\varpi}{\kappa\chi}$. By continuity, there exists a unique saddle path that converges into the steady state instead of crossing one of these isoclines (starting from any $\bar{d}$ above the asymptote).[38]

Several possible parameter conditions suffice to ensure that the steady state $\bar{d}^{SS}_{FA_j}$ is unique. In particular, curve BC is independent of the parameter α_{dF}, but increasing α_{dF} makes curve EE^{FA_j} flatter. Hence, fixing BC, we can choose α_{dF} large enough so that there is exactly one positive $\bar{d}$ at which BC and EE^{FA_j} cross.

While modified inflation $\breve{\pi}$ is not necessarily an increasing function of $\bar{d}$, inflation π does increase with $\bar{d}$ for all $\bar{d} > 0$, by (44). Thus inflation has the same ranking as debt across institutional scenarios. **QED.**

Proof of Proposition 4. The aggregate budget constraint for *per capita* debt is the same under a union-wide fiscal authority as it is under region-specific authorities. Hence the curve BC shown in Fig. 1 still applies.

As in Prop. 3, we can bound steady-state debt by considering a curve EE^{FA} that represents the Euler equation. This curve passes through the origin. As $\breve{\pi} \to \infty$, it asymptotes to $\bar{d} = \frac{1}{(2\delta + \tilde{\chi}\partial\pi/\partial d)}\left(\frac{1}{\beta_F} - \frac{1}{\beta_S} - \frac{\gamma\partial\pi}{\partial d}\right)$, which is finite and ambiguous in

[38] Analogous arguments apply under the other institutional configurations considered in this paper. Also, if the crossing is not unique, then the first and last crossings satisfying (94) are saddle-path stable, and the economy converges to one of these stable steady states from any initial $\bar{d} > -\frac{\varpi}{\kappa\chi}$.

sign. Thus, BC and EE^{FA} must cross at some positive value of $\breve{\pi}$. As before, BC is unaffected by α_{dF}, but EE^{FA} becomes flatter around the origin as α_{dF} increases. Hence, fixing BC, a sufficiently large α_{dF} implies that the crossing of BC and EE^{FA} is unique.

There are two possible cases for this crossing, as illustrated in Figure 1.

Case 1: If $\bar{d} \equiv EE^{FA}(\breve{\pi}) < 0$ at the point of crossing, then in steady state the debt with a union-wide fiscal authority is less than the debt with regional fiscal authorities (which is positive) and the debt under the planning solution (which is zero): $\bar{d}^{SS}_{FA} < 0 < \bar{d}^{SS}_{FA_j}$. In this case governments hold positive assets (negative debt) in steady state. Inflation can then be ranked by the same arguments used in Prop. 2.

Case 2: If $\bar{d} \equiv EE^{FA}(\breve{\pi}) > 0$ at the point of crossing, then by Lemma 1, $EE^{FA}(\breve{\pi})$ lies below $EE^{FA_j}(\breve{\pi})$ at the point of crossing. (The curves can be ranked both because $\partial\pi/\partial\bar{d} > 0$ at the point of crossing, and because of the factor of 2 in the denominator of (62).) Therefore EE^{FA} crosses BC at a lower (but still positive) level of debt than EE^{FA_j} in this case: $0 < \bar{d}^{SS}_{FA} < \bar{d}^{SS}_{FA_j}$. **QED.**