Fiscal delegation in a monetary union: Instrument assignment and stabilization properties[*]

Henrique S. Basso and James Costain

Banco de España, Calle Alcalá 48, 28014 Madrid, Spain

henrique.basso@bde.es, james.costain@bde.es

November 2016

Abstract. Motivated by the failure of fiscal rules to eliminate deficit bias in Europe, this paper analyzes an alternative policy regime in which each member state government delegates at least one fiscal instrument to an independent authority with a mandate to avoid excessive debt. Other fiscal decisions remain in the hands of member governments, including the allocation of spending across different public goods, and the composition of taxation. We study the short- and long-run properties of dynamic games representing different institutional configurations in a monetary union. Delegation of budget balance responsibilities to a national or union-wide fiscal authority implies large long-run welfare gains due to much lower steady-state debt. The presence of the fiscal authority also *reduces* the welfare cost of fluctuations in the demand for public spending, in spite of the fact that the authority imposes considerable "austerity" when it responds to fiscal shocks.

Keywords: Fiscal authority, delegation, decentralization, monetary union, sovereign debt
JEL classification: E61, E62, F41, H63

1 Introduction

The legacy of high debt in the aftermath of recent global financial crises leaves policy makers searching for stronger frameworks to ensure fiscal sustainability, especially in Europe. In this context, many countries have now established agencies independent of government with a mandate to monitor fiscal trends and to assess compliance with fiscal rules. In this paper, we study the effects of a more ambitious form of fiscal delegation, in which an independent authority is given direct control of one or more fiscal instruments, with a mandate to ensure long-run budget balance.

That is, we study a regime in which member state governments maintain control of almost all their fiscal decisions, except for a single instrument, which would instead be set by an outside agency, independent of the government, with the goal of avoiding excessive debt accumulation. While this type of fiscal delegation might benefit any country that suffers from deficit bias, at the present time it may be more politically realistic in Europe, where core countries worry about ballooning peripheral debt, while peripheral countries fret about their inability to protect themselves unilaterally against financial panics and speculative attacks. These concerns highlight the possibility of a mutually beneficial accord, in which institutions to prevent the propagation of sovereign and banking risks are made available to any peripheral countries that delegate control of at least one powerful fiscal instrument to an agency of the European Union, such as the new European Fiscal Board.[1] Compared with existing fiscal rules and the intrusive monitoring that comes with activation of the Excessive Deficit Procedure, delegating a fiscal instrument to Brussels could both prove to be a more credible guarantee of fiscal sustainability from creditors' point of view, and simultaneously, a less burdensome constraint on national fiscal sovereignty from debtors' point of view.

In previous work (Basso and Costain, 2016) we studied how delegation of fiscal instruments to an independent authority affects long-run, steady-state debt accumulation in a monetary union. We identified several distinct mechanisms through which an independent fiscal authority would tend to restrain debt growth: first, the debt aversion induced by its mandate; second, its greater patience, compared with the elected government; and third, the internalization of free-riding problems associated with decentralized fiscal choices in a monetary union. We extend this analysis in two crucial dimensions. First, we investigate whether correcting long-term debt biases hinders the cyclical stabilization of fluctuations in the demand for public spending. Second, we relax the (probably unrealistic) assumption that an independent fiscal authority could

---

[1]For a description of the European Fiscal Board, see European Commission (19 October 2016).

control debt issuance directly, and instead consider dynamic games where the control variables are public spending and taxes, while debt is determined as a residual.

We carry out our analysis in a reduced-form macroeconomic model in which output is decreased by taxes and increased by surprise inflation, under the assumption that society values low inflation, high output, and high public spending. We study how the equilibrium of the dynamic policy game differs depending on which instruments are controlled by each of the institutions considered (member state governments, the central bank of the monetary union, and independent fiscal authorities either at the national or union-wide level). All policy-making institutions are assumed to be benevolent planners, but (as in Rogoff, 1985) we assume that their different mandates lead them to weight the components of social welfare differently. In particular, we make two mild assumptions about institutional preferences: (1) elected institutions are more impatient than nonelected ones, and (2) an institution mandated to achieve a simple, feasible, quantitative goal will value that goal more strongly than the rest of society does. Since institutions differ in their preferences, the irrelevance of instrument assignment found by Dixit and Lambertini (2003a) does not apply.

Building on a simple macroeconomic model and a simple approach to institutional preferences has two big advantages. First, it allows us to solve our dynamic game in a fully nonlinear way, computing the economic dynamics and welfare implications in steady state and along transition paths and in response to stochastic shocks. In our numerical simulations, delegation to a fiscal authority implies a large decrease in steady-state debt, inflation, and tax burdens, and raises social welfare almost to the level achieved by a committed social planner. On the other hand, one might conjecture that these long-run gains from fiscal discipline come at the cost of less effective stabilization policy. However, this is not true: we find instead that establishing a fiscal authority *reduces* the welfare cost of fluctuations in the demand for public spending, in spite of the fact that the authority imposes considerable "austerity" when it responds to fiscal shocks. We evaluate the cost of fluctuations both from an *ex ante* perspective (expected losses due to future variance around the mean path), and also from an *ex post* perspective (the welfare loss due to suffering a large negative shock to the fiscal balance). From either perspective, the welfare cost of fluctuations is smaller in an economy with a fiscal authority than it is in the *status quo* monetary union.

A second advantage of our simple setup is that we can focus on the details of the policy game, in terms of instrument assignment and the timing of moves. Each policy maker in our framework acts as a discretionary Ramsey planner, and in equilibrium each planner must anticipate how its own control variables impact debt and thereby affect the future choices of the other planners. A crucial observation is that the Euler

equation(s) determining debt dynamics reflects the impatience of the policy maker(s) that actually chooses debt. So when we assume that the government or the fiscal authority controls the debt, that agent's discount factor enters the formula for the long-run deficit level. But under the more realistic assumption that the government chooses public spending, the fiscal authority chooses taxes, and the central bank chooses the inflation rate, all three of these instruments determine debt jointly, and three Euler equations reflecting three different discount factors all play a role in the dynamics. Inflation bias becomes more severe in this case, and the fiscal authority becomes less effective at controlling debt. Nonetheless, our main conclusions about the advantages of fiscal delegation remain unchanged.

In the remainder of this section, we briefly review the related literature. We then define the economic environment of our model. In Section 3, we define a series of policy games representing different institutional configurations; we compute equilibria of these games and discuss their long-run and short-run implications for debt, inflation, and social welfare. Section 4 discusses how fiscal delegation might be implemented, in practice, in the European context. Finally, Section 5 concludes.

1.1 Related literature

Economists from Mundell (1961) to Eichengreen and Wyplosz (1998) and Farhi and Werning (2015) have emphasized the fiscal challenges implied by losing the freedom to set monetary policy independently as a consequence of joining a monetary union. The literature on monetary and fiscal interactions (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). Yet another factor that may increase the fiscal vulnerability of monetary unions is deficit bias. Dixit and Lambertini (2003b) constructed an example in which joining a monetary union has no effect on policy outcomes if all policy makers have identical objective functions. But when policy makers' preferences differ in plausible ways, for instance due to the effects of electoral politics (Alesina and Tabellini, 1990; Battaglini, 2011), then joining a monetary union can increase deficit bias, as multiple authors have shown (Beetsma and Bovenberg, 1999; Buti, Roeger, and In't Veld, 2001; Beetsma and Jensen, 2005; Chari and Kehoe, 2007).

Following the logic of Rogoff (1985), policy delegation may be an effective solution for the biases that arise when excessively impatient policy makers face incentives to break past promises. This insight is potentially applicable to deficit bias, as well

as inflation bias. Hence, over recent decades, as monetary policy delegation to independent central banks has become the norm, many economists have also advocated delegating some fiscal responsibilities to institutions independent of government. The literature distinguishes *fiscal councils*— which monitor but do not implement fiscal policy actions— from *independent fiscal authorities* (IFAs), which would actually control some of the fiscal decisions that are currently in the hands of government.[2] Fiscal councils are by now common, and are mandated under the recent European "Fiscal Compact" treaty (European Council, 2012), but IFAs remain hypothetical.

Two main classes 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 (somehow) bound to respect; proposals of this type include von Hagen and Harden (1995); Eichengreen, Hausmann, and von Hagen (1999); and Wyplosz (2005). Alternatively, an IFA might exercise executive control over some fiscal instrument with a strong budgetary impact; proposals include Ball (1997); Gruen (1997); Seidman and Lewis (2002); Wren-Lewis (2002); and Costain and de Blas (2012a). These numerous practical proposals contrast with the dearth of theoretical work to model the effects of fiscal policy delegation. Some authors take the nonexistence of IFAs today as evidence that fiscal delegation is not feasible, because fiscal decisions are multidimensional, complex, and inherently political due to their redistributive implications.[3] But this argument does not apply to the fiscal framework considered in our model, for several reasons. First, we assume that only one instrument (or a small subset of instruments) is delegated. Second, we consider instruments with an across-the-board budget impact; concretely, we compare delegation of debt issuance to delegating control of the overall level of taxes. Third, we assume the mandate of the IFA reflects a largely quantitative goal, such as maintaining long-run solvency, thus minimizing distributional issues.[4]

Even if fiscal delegation proves effective for reducing deficit bias, it is also important to ask how it affects the stabilization of shocks, which may require countercyclical policies and accommodative changes in debt levels. Leith and Wren-Lewis (2011) look at monetary and fiscal interactions when sovereign debt is present. They find that stabilization of fiscal shocks is heavily influenced by the effect of inflation on the competitiveness of each union member, requiring optimal policy from a country

---

[2]See Debrun, Hauner, and Kumar (2009); Hagemann (2010); and Costain and de Blas (2012a) for surveys of fiscal policy delegation.

[3]See Hagemann (2010), Sec. II.C; or Calmfors (2011), Sec. 1.

[4]From a political economy perspective, Alesina and Tabellini (2007), Eggertsson and Borgne (2010), and Maskin (September 29, 2016) discuss the reasons why a democratic society may prefer to delegate certain types of decisions from politicians to unelected technocrats.

perspective to change debt gradually. Our reduced form model does not have variations of terms of trade, which could amplify the shortcomings of fiscal delegation in providing adequate stabilization. However, as opposed to the framework there, we solve for both the dynamics and the steady state under discretion and find that the debt biases under a monetary union are strong such that any gains of using debt issuance during the transition is offset such that welfare is higher under fiscal delegation. Gnocchi and Lambertini (2016) also focus on public debt under a distortionary steady state, but as opposed to us they always retain monetary policy commitment. Leeper, Leith, and Liu (2016) also stress the importance of non-linear effects incorporated in models of monetary-fiscal policy interaction solved using global methods. They find that in a single country model, lack of commitment generates debt stabilization bias, as is the case in our model. Interestingly, they find that for high levels of debt, monetary policy is used more heavily; inflation and lower rates are used to reduce debt.

In contrast to the framework we study here, many high-profile calls for European institutional reforms have assumed that achieving adequate protection against speculative attacks and banking crises makes full political integration inevitable (see De Grauwe, 2012; Soros, 10 April 2013; or Pisani-Ferry, 2012). We agree that getting fiscal policy right is crucial for strengthening monetary policy, but we argue that the necessary reforms are more limited than is commonly supposed. 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 European control over some powerful budget instrument in each member state, arguing that further fiscal integration is neither necessary nor politically plausible. Similarly, some limited European tax powers form an essential backstop for banking union, as envisioned by Schoenmaker and Gros (2012) or Obstfeld (2013), but further fiscal integration is not required under these proposals.

2   The economic environment

Our setup extends the reduced-form framework of Beetsma and Bovenberg (1999) and Basso and Costain (2016). 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, we aim 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 the effects on a typical country (and to simplify the math), we assume all countries are symmetric.[5]

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.

2.1 Social welfare and budget constraints

Let time t private-sector output in country j be $x_{j,t}$. Our main macroeconomic assumptions are that inflation π_t stimulates output when it is unexpectedly high ($\pi_t > \pi_t^e \equiv E_{t-1}\pi_t$), and that distorting taxes $\tau_{j,t}$ decrease output relative to its "natural" level $\underline{x}$. That is,

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

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, and that for output is a constant $\tilde{x} > 0$. The bliss point for public spending, $\tilde{g}_{j,t}$, varies stochastically over time:[6]

$$\tilde{g}_{j,t} = \tilde{g} + s_{j,t}, \tag{2}$$

$$s_{j,t} = \rho s_{j,t-1} + \epsilon_{j,t}, \tag{3}$$

where $\tilde{g} > 0$ is a constant and $\epsilon_{j,t}$ is normal $i.i.d.$ shock with mean zero and variance σ^2. The loss function for region j is[7]

$$L_{Sj} = E_0 \sum_{t=0}^{T} \beta_S^t \left\{ \alpha_{\pi S} \pi_t^2 + (x_{j,t} - \tilde{x})^2 + \alpha_{gS} \left(g_{j,t} - \tilde{g}_{j,t} \right)^2 \right\}. \tag{4}$$

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 one. The discount factor for social welfare is $\beta_S < 1$.

---

[5]Small asymmetries between countries leave our results qualitatively unchanged; see footnote 15.

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

[7]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 (4) from a New Keynesian framework with government spending in the utility function.

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

$$d_{j,t} = \left[R(\bar{d}_{t-1}) + \chi(\pi_t^e - \pi_t)\right] d_{j,t-1} + q_{j,t}g_{j,t} - \tau_{j,t} - \kappa\pi_t. \tag{5}$$

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 embodies two key assumptions: nominal debt, and interest rate contagion. Parameter $\chi \in [0,1]$ can be interpreted as the fraction of debt that is nominal, and which therefore loses real value in response to surprise inflation. Contagion is modeled by making the interest rate a function of average debt in the union, $\bar{d}_{t-1}$, rather than country j's own debt. Thus, 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).[8] For simplicity, we assume a linear functional form:

$$R(\bar{d}_t) = 1 + r_0 + \delta\bar{d}_t = \frac{1}{\beta_S} + \delta\bar{d}_t, \tag{6}$$

which says that savers are willing to hold a "target" debt level $\bar{d}^* \equiv 0$ when the interest rate just compensates their impatience.[9] In addition to (5), debt must respect an infinite horizon "no-Ponzi" condition, which simply means that expected interest payments suffice to make it worthwhile for the private sector (with the appropriate discount rate) to hold the bonds.

---

[8]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.

[9]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.

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

$$g_{j,t} = \left(\int_0^1 \omega_{j,k,t} \left(g_{j,k,t} \right)^{\frac{\eta-1}{\eta}} dk \right)^{\frac{\eta}{\eta-1}}. \tag{7}$$

where $\eta > 1$, and $\omega_{j,k,t} > 0$ are *i.i.d.* 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:

$$q_{j,t} g_{j,t} \equiv \min_{\{g_{j,k,t}\}_{k=0}^1} \int_0^1 g_{j,k,t} dk \quad \text{s.t.} \quad \left(\int_0^1 \omega_{j,k,t} \left(g_{j,k,t} \right)^{\frac{\eta-1}{\eta}} dk \right)^{\frac{\eta}{\eta-1}} \geqslant g_{j,t}. \tag{8}$$

Equation (8) serves to define the price of government services, $q_{j,t}$.

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

$$q_{j,t} = q_H \equiv (E\omega)^{\frac{\eta}{1-\eta}}. \tag{9}$$

At the opposite extreme, the policy maker may observe $w_{j,k,t}$ before choosing $g_{j,k,t}$. It is then optimal to spend more on the most-demanded services, according to

$$\frac{g_{j,k,t}}{g_{j,l,t}} = \left(\frac{\omega_{j,k,t}}{\omega_{j,l,t}} \right)^{\eta}. \tag{10}$$

This more efficient allocation makes aggregate public services less expensive:

$$q_{j,t} = q_L = (E\omega^{\eta})^{\frac{1}{1-\eta}} < q_H. \tag{11}$$

3 Policy games

3.1 Policy makers' objectives

Next, we study equilibrium outcomes in scenarios S where several policy institutions I interact. While all policy makers are essentially benevolent, the weights in their loss functions L_I differ from (4) in accordance with two realistic principles. First, policy makers subject to democratic election are assumed to be impatient; second, policy makers subject to a simple, quantitative mandate are assumed to value that goal more strongly than society at large.

Our *status quo* monetary union scenario supposes a central bank C that interacts with many regional governments G_j. The central bank chooses inflation for the whole

monetary union. It sums losses symmetrically across all J regions, with weight $\alpha_{\pi C} > \alpha_{\pi S}$ on inflation, weight $\alpha_{xC} \equiv 1$ on output, and weight $\alpha_{gC} = \alpha_{gS}$ on public spending. Each regional government G_j chooses some fiscal variables for region j, and its loss function L_{Gj} only considers terms related to region j. It places weight $\alpha_{\pi G} = \alpha_{\pi S}$ on inflation, weight $\alpha_{xG} \equiv 1$ on output, and weight $\alpha_{gG} = \alpha_{gS}$ on public spending.

Our alternative institutional scenarios will include other types of players. One environment considered is the replacement of the regional governments by a single federal government G that controls fiscal variables in all regions j. The federal government's loss function includes terms for all regions j, with the same weights as the regional governments in the status quo scenario: $\alpha_{\pi G} = \alpha_{\pi S}$, $\alpha_{xG} \equiv 1$, and $\alpha_{gG} = \alpha_{gS}$.

We also study economies in which some fiscal instruments are delegated to a debt-averse fiscal authority. This authority may be established by and for region j, in which case we will call it F_j, and its loss function will include region j terms only. Alternatively, it may be a union-wide institution, in which case we will call it F, and we will assume that it sums losses across all regions. The loss coefficients of F_j and F are $\alpha_{\pi F} = \alpha_{\pi S}$ on inflation, $\alpha_{xF} \equiv 1$ on output, $\alpha_{gF} = \alpha_{gS}$ on public spending, and $\alpha_{dF} > 0$ on debt. Note that the fiscal authority is the only player that cares specifically about the debt level, which does not appear in the social welfare function. We will sometimes use the notation $\alpha_{dC} = \alpha_{dG} \equiv 0$ to emphasize the fact that the central bank and the governments do not care specifically about debt.

Hence, while all policy institutions are assumed to value the same goals as society and the planner, their different roles imply some differences in priorities, reflected in the weighting coefficients shown in Table 1. The government is more impatient than society, due to the short time horizons of electoral politics. Since the central bank and the fiscal authority are insulated from political pressures, they are more patient than the government. Moreover, since the central bank has a mandate to achieve a target inflation rate, it dislikes inflation variability more than society does.[10] Likewise, we assume that the fiscal authority has a mandate to stabilize debt around some target level, so it has a positive debt coefficient.

To obtain an equilibrium with intuitively reasonable properties, we impose a set of natural restrictions on the quadratic objective functions.[11]

---

[10] 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.

[11] The role of these restrictions is discussed in depth in Basso and Costain (2016).

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 $i \in \{S, C, G, F\}$.

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

$$\gamma \equiv (1 + \kappa)\frac{\alpha_{\pi S}}{\alpha_{\pi C}} - \kappa > 0 \tag{12}$$

As in Chari and Kehoe (2007) and Beetsma and Bovenberg (1999), governments anticipate that the central bank will adjust inflation in response to debt issuance. *Moderate inflation aversion* implies that inflation rises *more than is optimal* when debt increases. This excessive inflation response underlies one of the common pool problems that generate debt bias in our model. A central bank exhibits *efficient inflation aversion* if $\gamma = 0$ (in this case the inflationary bias caused by the temptation to raise output is corrected.)

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

$$R(d_{ss}) + R'(d_{ss})d_{ss} > 1, \tag{13}$$

and

$$d_{ss} > -\left(\frac{1+\kappa}{\chi}\right) - \frac{\xi}{\kappa\chi}, \tag{14}$$

where $\xi \equiv \frac{\alpha_{\pi C}}{\alpha_{gS}}\left(q_L^2 + \frac{\alpha_{gS}}{\nu^2}\right)$. When (13) does *not* hold, this means assets are so large that *saving less in steady state* would imply *more interest income in steady state*. Likewise, (14) holds under any reasonable calibration, because otherwise the government is so wealthy that the central bank would wish to create a large surprise *deflation* in order to increase the real value of public assets.

- 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:

$$\tilde{z} \equiv \frac{\tilde{x} - \underline{x}}{\nu} + q_L \tilde{g} > \frac{r_0^2}{4\delta}. \tag{15}$$

3.2 The generic policy game

To describe policy-makers' optimization problems in each institutional scenario S, 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, and similarly let $\vec{s}_{t-1}$ and $\vec{\epsilon}_t$ be vectors describing the shocks to the government spending bliss point (its level at $t-1$, and the innovation at t). These three variables obviously affect equilibrium quantities. Pre-existing debt shifts the current budget constraint; the lagged shock $s_{j,t-1}$ shifts the expected demand for public spending at the time expectations π_t^e are formed; and thereafter the innovation $\epsilon_{j,t}$ determines the new level of public demand, $\tilde{g}_{j,t} = \tilde{g} + \rho s_{j,t-1} + \epsilon_{j,t}$. Here we will study equilibria that depend on the set of state variables $\vec{\Omega}_t \equiv (\vec{d}_{t-1}, \vec{s}_{t-1}, \vec{\epsilon}_t)$, but no others. By restricting attention in this paper to equilibria that depend only on the minimal state $\vec{\Omega}_t$, we rule out equilibria with more complex forms of history dependence, such as reputational effects.

Thus, consider a policy maker I_j who acts in region j only, where $I \in \{G, F\}$. The generic decision problem of such a policy maker can be written as:

$$
V^{Ij}(\vec{\Omega}_t) = \max_{\Theta_t^{Ij}} \frac{-1}{2} \left\{ \alpha_{\pi I} \pi_t^2 + \left(\underline{x}_{j,t} + \nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x} \right)^2 + \alpha_{gI} \left(g_{j,t} - \tilde{g}_{j,t} \right)^2 + \alpha_{dI} d_{j,t}^2 \right\}
$$
$$
+ \beta_I E_t V^{Ij}(\vec{\Omega}_{t+1}) + \Lambda_t^{Ij} \left[d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t) \right) d_{j,t-1} + \tau_{j,t} + \kappa \pi_t - q_{j,t} g_{j,t} \right].
$$
(16)

This problem may represent the decision of a local government G_j or a local fiscal authority F_j. The objective function contains quadratic losses as inflation, output, and public spending deviate from their bliss points, with preference weights as described in Table 1. We also allow for a loss term on debt, because we model the fiscal authority's mandate by assuming that it dislikes debt accumulation ($\alpha_{dF} > 0$). The set of instruments controlled by this policy institution at time t is denoted Θ_t^{Ij}, and the multiplier on its budget constraint is Λ_t^{Ij}. The price of public services $g_{j,t}$ differs with instrument assignment, with $q_{j,t} = q_L$ if public spending is allocated across services by a local decision maker, or $q_{j,t} = q_H$ if spending is instead chosen by some central authority of the monetary union.

Alternatively, we may consider a policy maker $I \in \{C, G, F\}$ that controls instruments affecting all regions j:

$$
V^I(\vec{\Omega}_t) = \max_{\Theta_t^I} \frac{-1}{2} \left\{ \alpha_{\pi I} \pi_t^2 + \frac{1}{J} \sum_{j=1}^{J} \left[\left(\underline{x}_{j,t} + \nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x} \right)^2 + \alpha_{gI} \left(g_{j,t} - \tilde{g}_{j,t} \right)^2 + \alpha_{dI} d_{j,t}^2 \right] \right\}
$$

$$+ \beta_I E_t V^I(\vec{\Omega}_{t+1}) + \frac{1}{J} \sum_{j=1}^{J} \Lambda_{j,t}^I \left[d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right) d_{j,t-1} + \tau_{j,t} + \kappa\pi_t - q_{j,t}g_{j,t}\right]. \quad (17)$$

This institution's preferences reflect losses in all regions j, and its decision must respect a separate budget constraint for each region.

Finding a symmetric solution

We will derive Euler equation systems to characterize the policy functions implied by each institutional scenario S. We restrict attention to symmetric equilibria in which all regions j face the same parameters and the same initial conditions, and shocks, if any, affect all regions equally. In a symmetric equilibrium, the state reduces to an ordered triple of scalars, $\Omega_t \equiv (d_{t-1}, s_{t-1}, \epsilon_t)$, as there is no longer any variation in debt or shocks across j.[12] Equilibrium under scenario S can then be characterized by four policy functions: inflation $\pi_t = I^S(\Omega_t)$, gross borrowing $d_t = B^S(\Omega_t)$, output $x_t = X^S(\Omega_t)$, and government expenditure $g_t = G^S(\Omega_t)$.

For each policy game we solve the functional equations implied by the Euler system, approximating the policy functions as Chebyshev polynomials, and evaluating expectations using Gauss-Hermite quadrature. Reducing the dimension of the state space by imposing symmetry makes it much easier to solve these nonlinear functional equations. Given the policy functions, we can then simulate the dynamics and calculate some statistics. For example, we can calculate steady-state debt, defined as the fixed point of the gross borrowing function when shocks are zero:[13]

$$d_{ss}^S = B^S(d_{ss}^S, 0, 0). \quad (18)$$

Controls versus residuals

We have written policy makers' problems supposing that all the variables affected by the choices of player $I \in \{G_j, F_j, C, G, F\}$ are included in that player's choice set, Θ_t^I. But two cases should be distinguished. If a given variable y_t appears *only* in the choice set of one particular player I, then this means that I can unilaterally determine the value of y_t. In this case, we will refer to y_t as a *control variable* of player I.

---

[12]No bars or j-subscripts are necessary on these variables since in a symmetric situation there is no distinction between region-specific variables and cross-region averages.

[13]The fixed point of (18) using the borrowing function B^S from our stochastic simulation, denoted d_{ss}^S, is the "stochastic steady state", meaning the point to which the dynamics converge conditional on an arbitrarily long sequence of shocks equal to zero. For some simulations, we compute equilibrium assuming that the shocks ϵ have zero variance, making the model deterministic; then the fixed point, denoted d_{ns}^S, is the nonstochastic steady state of the model.

But sometimes a variable y_t appears in the choice sets Θ_t^I and $\Theta_t^{I'}$ of two distinct players I and I'. In particular, the binding budget constraint at each t means that some variable y_t must be determined by the constraint, conditional on the controls chosen by the players. We will then call y_t a *residual variable*. For example, in some games studied in section 3.3, inflation is chosen by the central bank, while taxes and debt are chosen by the government(s); the quantity of public spending is then determined as the equilibrium outcome of these simultaneous choices subject to the budget constraint. Hence, in these games, public spending $g_{j,t}$ will be a residual, appearing in the choice sets of government G_j and the central bank C. In some of the games of section 3.4, inflation is chosen by the central bank, while taxes and spending are chosen by the government(s); new debt issuance $d_{j,t}$ is then a residual variable determined in equilibrium by the budget constraint, appearing in the choice sets $\Theta_t^{G_j}$ and Θ_t^C. These differences in instrument assignment turn out to be quantitatively important.

Welfare measures

To compare policy implications across regimes, it is useful to define notation for the social welfare function. Each region's welfare depends both on the policy regime, and on the debts and shocks of all regions in the union; we define overall social welfare by aggregating across all regions. Therefore, we calculate welfare as

$$W^S(\vec{\Omega}) \;=\; -\frac{1}{J}\sum_{j=1}^{J} L_{Sj}, \tag{19}$$

the negative of the sum of the loss functions L_{Sj}, evaluated in the equilibrium that occurs under institutional framework S, when the aggregate state is $\vec{\Omega} \equiv (\vec{d}_{t-1}, \vec{s}_{t-1}, \vec{\epsilon}_t)$.

In a symmetric situation, equilibrium can be simplified by writing it as a function of the ordered triple $\Omega_t = (d_{t-1}, s_{t-1}, \epsilon_t)$ rather than the full state variable $\vec{\Omega}$ that characterizes an asymmetric situation. We use the subscript ss to represent a stochastic symmetric steady state. As such when we compare institutional scenarios S, we will report debt d_{ss}^S and inflation π_{ss}^S. While most of our reported results come from stochastic simulations, to calculate business cycle costs we also perform some nonstochastic simulations, keeping the symmetry assumption. Welfare in the nonstochastic scenarios is indicated by subscript n. The subscript ns will distinguish non-stochastic steady states from stochastic steady states (subscripted ss). Hence:

$$W_{ns}^S \;\equiv\; W_n^S(d_{ns}^S, 0, 0), \tag{20}$$

$$W_{ss}^S \;\equiv\; W^S(d_{ss}^S, 0, 0). \tag{21}$$

A social planning problem

Before comparing equilibria across policy regimes, we 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 consider a planner that is *omniscient*, thus it observes $\omega_{j,k,t}$; *committed* to a state-contingent inflation function; *cooperative*, internalizing any externalities across borders; and *Paretian*, maximizing welfare while obeying a distinct budget constraint for each region.

Since the planner commits to state-contingent policies that vary with the realization of $\vec{\epsilon}_t$, we write the planner's value function in terms of variables known at $t-1$, as $V^P(\vec{d}_{t-1}, \vec{s}_{t-1})$, The ability to commit means that the planner chooses expected inflation π_t^e, subject to the constraint that this represents a rational expectation.

$$
V^P\left(\vec{d}_{t-1}, \vec{s}_{t-1}\right) = \max_{\pi_t^e, \Theta_t^P} \frac{-1}{2} E_{t-1} \left\{ \alpha_{\pi S} \pi_t^2 + \frac{1}{J} \sum_{j=1}^{J} \left[\left(\underline{x}_{j,t} + \nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x}\right)^2 + \alpha_{gS} \left(g_{j,t} - \tilde{g}_{j,t}\right)^2 \right] \right\}
$$

$$
+ \beta_S E_{t-1} V^P\left(\vec{d}_t, \vec{s}_t\right) + \frac{1}{J} \sum_{j=1}^{J} \Lambda_{j,t}^P \left[d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t)\right) d_{j,t-1} + \tau_{j,t} + \kappa \pi_t - q_L g_{j,t} \right]
$$

$$
\text{s.t.} \quad \pi_t^e = E_{t-1} \pi_t. \tag{22}
$$

The controls $\Theta_t^P = \{\pi_t, \{g_{j,t}, \tau_{j,t}, d_{j,t}\}_{j=1}^J\}$ should be understood as contingent plans that vary with $\vec{\epsilon}_t$, while π_t^e is an expectation computed prior to the realization of $\vec{\epsilon}_t$.

The details of the solution to the planner problem are shown in the appendix. By setting $\vec{\epsilon}_t = 0$ for all t, we can find the steady state analytically:

$$
\bar{d}_{ss}^P = 0 \quad \text{and} \quad \pi_{ss}^P = \frac{\bar{z}}{\tilde{\kappa}_P}, \tag{23}
$$

where

$$
\bar{z}_t = \frac{1}{J} \sum_{j=1}^{J} \left(\frac{\tilde{x}_{j,t} - \underline{x}_{j,t}}{\nu} + q_L \tilde{g}_{j,t} \right), \tag{24}
$$

$$
\tilde{\kappa}_P = \kappa + \frac{\alpha_{\pi S}}{\kappa \alpha_{gS}} \left(q_L^2 + \frac{\alpha_{gS}}{\nu^2} \right). \tag{25}
$$

3.3 Policy games with debt as a control variable

We now compare several policy environments in which some decision maker directly controls debt emission. Since budget constraints must bind at all times, treating debt as a control implies that some other variable must be determined at each t by the constraint, as a residual. The games studied here assume that the variable which adjusts, to ensure the constraint holds, is public spending.

3.3.1 Institutional scenarios

Scenario M: Status quo model of a large monetary union

First, consider a scenario resembling the Eurozone today, with a single central bank that chooses inflation π_t for the whole union, while J governments G_j each choose regional taxes τ_{jt} and regional debt d_{jt}. Given τ_{jt}, d_{jt}, and π_t, government j spends the resources it has available, according to budget constraint (5), so public spending g_{jt} is determined as a residual. Thus, the central bank's choice set is $\Theta_t^C \equiv \{\pi_t, \{g_{j,t}\}_{j=1}^J\}$, and government j's choice set is $\Theta_t^{G_j} \equiv \{\tau_{jt}, d_{jt}, g_{j,t}\}$. The market's inflation expectations π_t^e are set at the end of $t-1$, rationally anticipating the outcome of the game between the bank and the governments, but all policy makers act under discretion.

In each period and region, the marginal cost of tax distortions is set equal to the marginal benefit of public spending according to a simple linear relation:

$$\nu \hat{x}_{j,t} = \frac{\alpha_{gS}}{q_L} \hat{g}_{j,t}, \tag{26}$$

where $\hat{x}_{j,t} = x_{j,t} - \tilde{x}$ 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.

Since the central bank cannot commit, it is tempted to choose higher inflation than that expected by the public. Its resulting tradeoff between inflation and union-wide mean public spending is

$$\frac{\alpha_{gS}}{q_L} \bar{\hat{g}}_t = -\frac{\alpha_{\pi C} \pi_t}{1 + \kappa + \chi \bar{d}_{t-1}} \equiv -\alpha_{\pi C} \breve{\pi}_t, \tag{27}$$

where we again use a bar to represent a cross-region mean, and have defined an adjusted inflation variable, $\breve{\pi}_t \equiv \frac{\pi_t}{1 + \kappa + \chi \bar{d}_{t-1}}$.

When solving the planner's problem (see the appendix) we find that it equates the marginal cost of inflation to the *average* marginal benefit of public spending, so that $\frac{\alpha_{gS}}{q_L} \bar{\hat{g}}_t = -\frac{\alpha_{\pi S}}{\kappa} \pi_t$. Thus, as long as $\alpha_{gG} = \alpha_{gS}$, the government trades off output versus public spending just as the planner does. But the dynamics of the monetary union differ from those of the planning problem in several intuitive ways. We see that the

central bank tends to choose more inflation than the planner would, especially when debt is high. On the other hand, if it dislikes inflation more than the public and the planner do ($\alpha_{\pi C} > \alpha_{\pi S}$), this will partially offset the inflation bias caused by its lack of commitment.

Plugging (26) and (27) into the period budget constraint (5), we find that average debt in the monetary union evolves according to

$$\bar{d}_t = R\left(\bar{d}_{t-1}\right)\bar{d}_{t-1} + (1 + \chi\bar{d}_{t-1})(\pi_t^e - \pi_t) - \breve{\kappa}(\bar{d}_{t-1})\breve{\pi}_t + \bar{z}_t, \tag{28}$$

where $\breve{\kappa}\left(\bar{d}_{t-1}\right) \equiv \kappa(1 + \kappa + \chi\bar{d}_{t-1}) + \frac{\alpha_{\pi C}}{\alpha_{gS}}\left(q_L^2 + \frac{\alpha_{gS}}{\nu^2}\right)$. Under the parameter assumptions of Table 1, if $\bar{d}_{t-1} \geq 0$ and the central bank exhibits *moderate inflation aversion*, then $\breve{\kappa}(\bar{d}_{t-1}) < (1 + \kappa + \chi\bar{d}_{t-1})\tilde{\kappa}_P$, which says that due to the central bank's lack of commitment, the monetary union has more inflation, relative to its level of private output and public spending, than the planner's solution does.

Next, consider the Euler equation that governs fiscal policy over time. If country j is large, its choice of d_{jt} will affect the interest rate (both for its own debt and for other union members); its debt will also influence the choices of other decision makers at time $t + 1$. But we will simplify by focusing on the limit of a large monetary union ($J = \infty$) in which each individual country is infinitesimal. In this case, government j ignores all the spillovers from its debt, and the region-j Euler equation simplifies to[14]

$$\hat{g}_{j,t} = \beta_G R(\bar{d}_t) E_t \hat{g}_{j,t+1}. \tag{29}$$

When all countries are symmetric, we can use (27) to rewrite the Euler equation in terms of inflation:[15]

$$\breve{\pi}_t = \beta_G R(d_t) E_t \breve{\pi}_{t+1}. \tag{30}$$

Note that since government j controls debt, (30) reflects the government's discount factor, in contrast with the planner's solution, where society's discount factor appears. Second, since country j's debt is a negligible part of the debt of the union, government j simply takes the interest rate as given. This differs from the planner's solution, in which an R' term appears, because the planner realizes that choosing higher debt in all

---

[14]The online appendix to Basso and Costain (2016) states the Euler equations for the finite J case, in which each country j is non-negligible, so that the effects of its debt decision on subsequent choices cannot be ignored.

[15]Again, we drop the bars on variables since there is no distinction between country-specific variables and cross-sectional averages. Note that if there are instead some asymmetries across regions, then (30) only holds approximately. The exact equation is then $\breve{\pi}_t = \beta_S(R(\bar{d}_t))\breve{\pi}_{t+1} - \beta_S R'(\bar{d}_t)\frac{\alpha_{gS}\kappa}{\alpha_{\pi S}q_L}Cov_{t+1}(\hat{g}_{k,t+1}, d_{k,t})$. But the covariance term is negligible when differences between countries are small, so all results in this paper are robust to small cross-country differences.

regions raises the interest rate (see (79) in the appendix). Both of these effects imply faster inflation growth in the monetary union than what we observe in the planner's solution; since (26) and (27) link inflation to $\hat{x}_t$ and $\hat{g}_t$, the output and public spending loss terms also grow more quickly in the monetary union than the planner would wish. Rapid growth of these distortions represents deficit bias: it means that the economy suffers relatively small distortions in the near term, but finances the resulting deficit by accumulating debt, which must be paid off in the future by suffering larger distortions in the long run.

Illustrating our solution methodology, the symmetric solution of this scenario can then be characterized by policy functions $B^M(\Omega_t)$, $I^M(\Omega_t)$, and $\breve{I}^M(\Omega_t) = \frac{I^M(\Omega_t)}{1+\kappa+\chi\bar{d}_{t-1}}$ such that the following equations hold:

$$B^M(\Omega_t) = R(d_{t-1}) d_{t-1} + (1 + \chi d_{t-1})(E_{t-1}[I^M(\Omega_t)] - I^M(\Omega_t)) - \breve{\kappa}\breve{I}^M(\Omega_t) + \tilde{z}_t, \quad (31)$$

$$\breve{I}^M(\Omega_t) = \beta_G \left(\beta_S^{-1} + \delta B^M(\Omega_t) \right) E_t \breve{I}^M(B^M(\Omega_t), s_t, \epsilon_{t+1}). \quad (32)$$

where $\tilde{z}_t \equiv \nu^{-1}(\tilde{x} - \underline{x}) + q_L \tilde{g}_t$. Government spending and output can then be calculated from $\frac{\alpha_{gS}}{q_L} \hat{G}^M(\Omega_t) = -\alpha_{\pi C} \breve{I}^M(\Omega_t)$ and $\nu \hat{X}^M(\Omega_t) = \frac{\alpha_{gS}}{q_L} \hat{G}^M(\Omega_t)$.

Scenario I: A single country with its own monetary policy

The deficit bias suffered by a monetary union can also be seen by comparing it to the case of a single country with its own independent central bank. The instrument assignment is identical to the monetary union environment ($\Theta_t^C \equiv \{\pi_t, g_t\}$, $\Theta_t^G \equiv \{\tau_t, d_t, g_t\}$) but we focus on the case $J = 1$, instead of the opposite extreme $J = \infty$.

The tradeoffs between output, public spending, and inflation are unchanged, so (26) and (27) still apply. Therefore the equation governing per capita debt is the same as in the monetary union:

$$d_t = R(d_{t-1}) d_{t-1} + (1 + \chi d_{t-1})(\pi_t^e - \pi_t) - \breve{\kappa}(d_{t-1})\breve{\pi}_t + \tilde{z}_t. \quad (33)$$

The differences show up in the Euler equation, which becomes[16]

$$\breve{\pi}_t = \beta_G E_t \left(R(d_t) + R'(d_t)d_t + \left(\gamma + \chi\frac{\alpha_{\pi G}}{\alpha_{\pi C}}d_t \right) \frac{\partial \pi_{t+1}}{\partial d_t} \right) \breve{\pi}_{t+1}. \quad (34)$$

The parameter γ, defined in (12), indexes the strength of the central bank's preference for surprise inflation.

As in scenario M, the discount factor in the Euler equation is β_G, reflecting government impatience, which raises inflation growth. But other terms in the Euler equation

---

[16]To solve equations (33)-(34), we can rewrite them in terms of d and $\breve{\pi}$ only, using the fact that $\pi(d) = (1 + \kappa + \chi d)\breve{\pi}(d)$ to substitute out $\pi'(d) = (1 + \kappa + \chi d)\breve{\pi}'(d) + \chi\breve{\pi}(d)$.

slow down inflation growth, relative to a monetary union. The government of a single country recognizes that its debt affects the interest rate it pays, so the term $R'(d_t)d_t$ appears in the Euler equation, which reduces inflation growth whenever $d_t > 0$. Second, the central bank has an incentive 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 the parameters γ and χ, respectively.[17] Given the bank's lack of commitment, the government of a single country knows that its debt will influence central bank inflation, and hence it cuts its deficit to correct for these inflation bias terms. Again, this reduces inflation growth, compared with scenario M, where each government regards the impact of its own debt as negligible.

Scenario G: A federal government for a monetary union

Creating a single government for the monetary union makes its political structure formally identical to a single country, so our analysis of the $J = 1$ case applies. Therefore, as we argued above, two forms of deficit bias should disappear when a monetary union adopts a single government. Like a single country, but unlike a small member of a monetary union, a federal government internalizes the effect of its debt on the interest rate it pays. This gives it an incentive to accumulate less debt than member states of a monetary union do. Similarly, the federal government recognizes the fact that the central bank will raise inflation in response to any rise in the average debt level, whereas small member states in a monetary union would fail to internalize this effect and would therefore choose more debt on average.

However, in the European context, this setup has a major disadvantage. It gives up "subsidiarity": spending decisions are taken at the union level, where less information is available. This raises the price of public services to $q_H > q_L$, more expensive than they would be if they were allocated locally. The conditions linking inflation, public spending, and output would then be

$$\bar{\breve{g}}_t = -\frac{\alpha_{\pi C} q_H}{\alpha_{gS}} \breve{\pi}_t, \tag{35}$$

$$\bar{\breve{x}}_t = -\frac{\alpha_{\pi C}}{\nu} \breve{\pi}_t. \tag{36}$$

Comparing with the corresponding relations for the monetary union, (26) and (27), (35)-(36) 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.

---

[17]Under the parameter assumptions of Sec. 3.1, including *moderate inflation aversion*, we have $0 < \gamma < 1$. It can also be shown, under weak assumptions, that $\frac{\partial \pi}{\partial d} > 0$. Therefore these additional terms in the Euler equation reduce inflation growth.

Summarizing, the dynamics of the symmetric case are analogous to (33)-(34), except that they now refer to *per capita* debt in the whole union.

$$d_t = R(d_{t-1})d_{t-1} + (1+\chi d_{t-1})(\pi_t^e - \pi_t) - \breve{\kappa}^G(d_{t-1})\breve{\pi}_t + \tilde{z}_t^G, \tag{37}$$

$$\breve{\pi}_t = \beta_G E_t \left(R(d_t) + R'(d_t)d_t + \left(\gamma + \chi \frac{\alpha_{\pi G}}{\alpha_{\pi C}}d_t \right) \frac{\partial \pi_{t+1}}{\partial \bar{d}_t} \right) \breve{\pi}_{t+1}, \tag{38}$$

The only difference from scenario I is that public services are more expensive, which alters the parameters in the equations as follows:

$$\breve{\kappa}^G(d_{t-1}) \equiv \kappa(1 + \kappa + \chi d_{t-1}) + \frac{\alpha_{\pi C}}{\alpha_{gS}}\left(q_H^2 + \frac{\alpha_{gG}}{\nu^2} \right), \tag{39}$$

$$\tilde{z}_t^G \equiv \nu^{-1}(\tilde{x} - \underline{x}) + q_H \tilde{g}_t. \tag{40}$$

Scenario Fj: Delegation to regional fiscal authorities

While a federal government would avoid some aspects of the deficit bias that plagues a monetary union, establishing such a government seems a very distant prospect in Europe today. Just to mention a few of the most critical problems involved, setting up a central or federal government for Europe would require (1) convincing local politicians to give up power in favor of new central institutions; (2) harmonizing local laws and constitutions sufficiently to permit European governance; and (3) finding ways to efficiently address local decisions via central or federal institutions. Even if these challenges could be overcome (slowly) from a technical perspective, establishing legitimacy of new European institutions would remain (insurmountably?) difficult, all the more so as nationalism has grown with recent crises.

This motivates us to ask instead whether delegation of fiscal instruments might serve as a shortcut to credible long-run debt sustainability, avoiding many of the dilemmas listed above. Delegating just one (or a few) effectively-designed fiscal instruments might have a very large impact on budget balance, but would involve less surrender of power by local politicians than the establishment of a federal government. Relatively fewer changes to laws and constitutions would be required, and most local fiscal decisions would remain under local control. Therefore, we now analyze the macroeconomic implications of some policy games involving delegated fiscal powers.

First, we consider region-specific delegation. Concretely, we consider policy games in which the central bank chooses inflation for the union, and regional governments choose taxes and allocate public spending, but the choice of how much debt to issue is delegated to an independent regional fiscal authority F_j. The overall quantity of local public spending is treated as a residual variable; thus the instrument assignments are given by $\Theta_t^C \equiv \{\pi_t, \{g_{j,t}\}_{j=1}^J\}$, $\Theta_t^{G_j} \equiv \{\tau_{jt}, g_{j,t}\}$, and $\Theta_t^{F_j} \equiv \{d_{jt}, g_{j,t}\}$. That is to say,

the amount of money spent by government G_j is only partly under its control (through its choice of taxes), but the allocation of these funds across different uses is left entirely in its hands.

As in scenario M, 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

$$\hat{g}_{j,t} + \frac{q_L \alpha_{dF}}{\alpha_{gF}} d_{j,t} = \beta_F R(\bar{d}_t) E_t \hat{g}_{j,t+1}. \tag{41}$$

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

$$d_t = R(d_{t-1}) d_{t-1} + (1 + \chi d_{t-1})(\pi_t^e - \pi_t) - \breve{\kappa}(d_{t-1})\breve{\pi}_t + \tilde{z}_t \tag{42}$$

$$\breve{\pi}_t = \frac{\alpha_{dF}}{\alpha_{\pi C}} d_t + \beta_F R(d_t) E_t \breve{\pi}_{t+1}. \tag{43}$$

Comparing (28)-(30), the equilibrium system for scenario M, with (42)-(43), we see two effects of the fiscal authority that inhibit inflation growth. First, for a given d_t, inflation grows more slowly in the presence of the fiscal authority if the government is less patient than the fiscal authority ($\beta_G < \beta_F$). Second, inflation grows more slowly in the presence of the fiscal authority whenever $d_t > 0$, as long as the fiscal authority dislikes debt ($\alpha_{dF} > 0$).

Scenario F: Delegation to a union-wide fiscal authority

Rather than delegating debt issuance to a fiscal authority F_j within each region, a possibly better alternative might be to delegate the issuance of each country's debt to a single authority F established for the union as a whole. Such an authority would have an incentive to take externalities across regions into account. In this case, the symmetric dynamics are given by

$$d_t = R(d_{t-1}) d_{t-1} + (1 + \chi d_{t-1})(\pi_t^e - \pi_t) - \breve{\kappa}(d_{t-1})\breve{\pi}_t + \tilde{z}_t, \tag{44}$$

$$\breve{\pi}_t = \frac{\alpha_{dF}}{\alpha_{\pi C}} d_t + \beta_F E_t \left(R(d_t) + R'(d_t) d_t + \left(\gamma + \chi \frac{\alpha_{\pi G}}{\alpha_{\pi C}} d_t \right) \frac{\partial \pi_{t+1}}{\partial \bar{d}_t} \right) \breve{\pi}_{t+1}. \tag{45}$$

These equations are simplified using the parameter assumptions in Table 1.

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 the interest rate (R') and on inflation ($\frac{\partial \pi_{t+1}}{\partial \bar{d}_t}$), because the union-wide fiscal authority knows it can alter aggregate debt, just as the government did in scenario I. Since inflation responds positively to a rise in debt, and the central bank is assumed to exhibits moderate inflation aversion (implying $\gamma > 0$), inflation growth is further reduced in this scenario, compared with scenario Fj.

3.3.2 Results

Parameters

We choose parameters so that our quantitative results can be given a plausible economic interpretation, in spite of the reduced-form nature of our model. Specifically, we calibrate with reference to the nonstochastic steady state of the baseline monetary union scenario, taking care to respect the restrictions stated in Section 3.1.

The time unit is a year, and the goods unit is normalized so that annual private output x_{ns}^M is one in the nonstochastic steady state of scenario M. We set the discount rate to $\beta_S = 1.02^{-1}$, and set $\delta = 0.03$, so that the annual real interest rate is 2% when debt is zero and 5% when debt is one (100% of output). Since European debt levels still appear to have a strong tendency to increase, we assume that steady state debt in scenario M is substantially higher, at $d_{ns}^M = 2$. This is consistent with $\beta_G = 1.08^{-1}$. We set the fiscal authority's discount rate halfway between those of the planner and the government: $\beta_F = (\beta_S + \beta_G)/2$. We assume that half of debt is nominal, $\chi = 0.5$.

We set $\nu = 1$, implying that a one percentage point rise in tax rates decreases output by 1%. Steady state taxes must be mutually consistent with steady state output; assuming steady-state taxes are $\tau_{ns}^M = 0.5$, we must have $\bar{x} = x_{ns}^M + \nu \tau_{ns}^M = 1.5$. We assume that inflation will rise to 10% ($\pi_{ns}^M = 0.1$) in the steady state of the monetary union,[18] and that $\kappa = 0.2$, meaning that each percentage point of inflation generates revenues equal to 0.2% of output. Given our assumptions so far, if locally-produced public goods cost the same as private goods, we can infer that steady-state public services in the monetary union are $g_{ns}^M = \frac{1}{q_L}\left(\tau_{ns}^M + \kappa \pi_{ns}^M - r_0 d_{ns}^M - \delta (d_{ns}^M)^2\right) = 0.36$. We assume that centralized provision of public goods is 50% more costly, $q_H = 1.5$.

The bliss points $\tilde{x}$ and $\tilde{g}$ are hard to infer from steady-state behavior alone. We set both to a level far above actual output, $\tilde{x} = \tilde{g} = 5$, and we confirm through robustness calculations that large changes in these bliss points ($\tilde{x} = \tilde{g} = 3$ or 10) leave our results qualitatively unchanged. Given our calibration targets and parameters thus far, the first-order condition between public and private output requires $\alpha_{gS} = \nu q_L (x_{ns}^M - \tilde{x})/(g_{ns}^M - \tilde{g}) = 0.8621$. Likewise, the first-order condition between output and inflation requires $\alpha_{\pi C} = -|x_{ns}^M - \tilde{x}|(1 + \kappa + \chi d_{ns}^M)/\pi_{ns}^M = 88$. We calibrate the social cost of inflation so that the planner's solution has 2% inflation in steady state, which implies $\alpha_{\pi S} = 39.3333$. Finally, we set the fiscal authority's loss coefficient on deviations of debt from target to $\alpha_{dF} = 0.5$.

---

[18]Note that we have abstracted from default. Hence, steady-state inflation is a stand-in for the many costs associated with excessive debt, which is why we choose a rather high calibration target for π_{ns}^M.

Figure 1: *Borrowing and inflation policies. Comparing institutional scenarios*
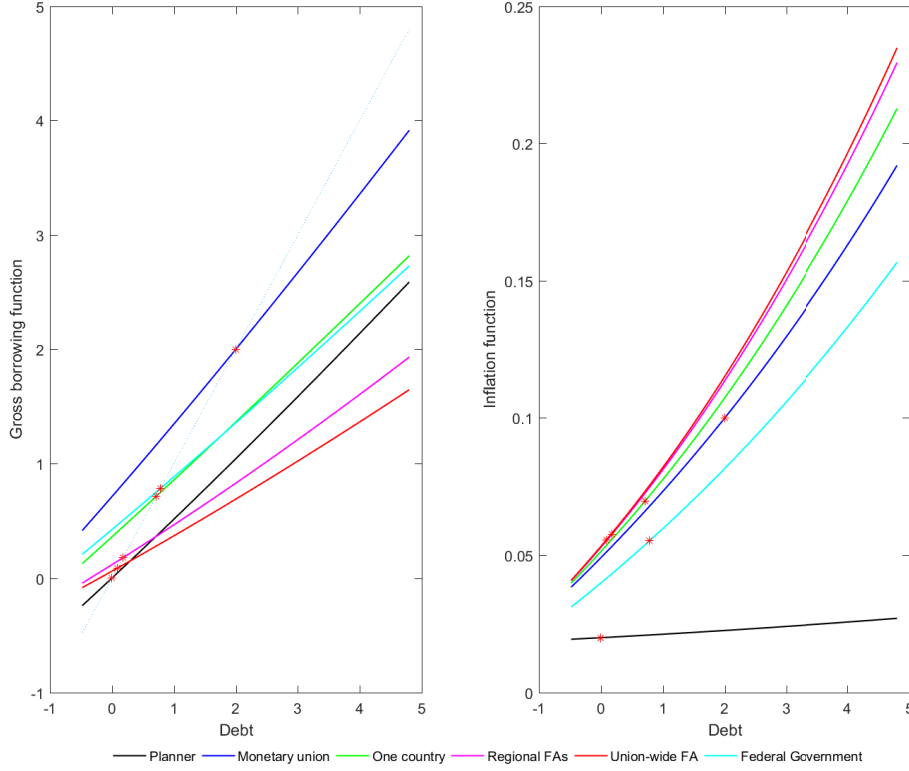
Notes: Comparing policy functions across institutional scenarios, assuming debt is a control variable.
Left: Gross borrowing: debt d_t as a function of d_{t-1}.
Right: Inflation π_t as a function of d_{t-1}.
Black: planner. Blue: monetary union. Green: one country. Magenta: regional FAs. Red: Union-wide
FA. Cyan: federal government. Red stars: steady states.

Policy functions

We characterize the behavior of each scenario S by calculating the nonlinear policy
functions $d_t = B^S(\Omega_t)$ and $\pi_t = I^S(\Omega_t)$ consistent with the Euler equations derived
from that scenario. In this subsection we report the results for two specifications, both
of which are stochastic: an *i.i.d.* and an autocorrelated version. In the simulations, the
public spending demand shock ϵ_t affects all regions j symmetrically and is assumed
to have mean zero, standard deviation 0.02. For the autocorrelated version, we set
$\rho = 0.7$, so shocks to the spending bliss point die out fairly slowly.[19]

Figure 1 shows the policy functions under the *i.i.d.* specification, for scenarios P
(black), M (blue), I (green), Fj (magenta), F (red), and G (cyan). The right-hand

---

[19]For comparison when we calculate the costs of business cycles, we will also calculate a fully
nonstochastic specification. The nonstochastic case can be computed by assuming that ϵ_t has mean
and variance equal zero, or by dropping ϵ_t entirely from the model so that the policy functions depend
on debt only. We have run the calculations both ways, and obtained virtually identical results.

panel shows that the planner chooses nonzero inflation ($\pi_{ss}^{P} = 0.02$) in the steady state ($d_{ss}^{P} = 0$). Lacking any nondistortionary revenue source, the planner collects a small amount of seignorage, increasing very slightly with debt, to optimally trade off the marginal losses from inflation and from distortionary taxes. In the left panel, the borrowing function $d_t = B^P(d_{t-1}, 0, 0)$ has a slope of roughly 0.5. That is, when the current debt level is one percentage point higher, the planner pays off half within one period and carries the other half over to the next period.

Relative to the planner's policies (black), the green curves that represent the equilibrium policies of a single country (scenario I) are shifted upwards. The inflation function I^I is both higher and steeper than the planner's policy I^P, because monetary policy in scenario I is a discretionary decision, and the temptation to create surprise inflation becomes stronger as debt increases. The borrowing function B^I lies above the planner's policy B^P because the impatience of the democratic government in scenario I leads to more borrowing. In steady state, debt in scenario I rises to $d_{ss}^I = 71.5\%$ of output, with an inflation rate of 7% (see Table 2 for the numbers.)

The policy biases affecting scenario I are reinforced by free-riding effects in the *status quo* monetary union scenario M (blue). The borrowing policy B^M lies everywhere above B^I, because governments in scenario M ignore how their debt affects the interest rate and the incentives of the central bank. Steady-state debt rises to $d_{ss}^M = 199.9\%$ of output. On the other hand, the inflation policy I^M lies slightly below I^I, because the central bank recognizes that government incentives are worse in the monetary union than in a single country, so it restrains inflation at any given debt level. Nonetheless, since steady-state debt is so much higher in the monetary union, steady-state inflation also rises in scenario M, to $\pi_{ss}^M = 10.0\%$.

In contrast, establishing a fiscal authority shifts the borrowing function down. The borrowing function of scenario Fj lies below that of scenario M, both because the regional fiscal authorities are more patient than regional governments, and because the fiscal authorities are averse to debt. Steady-state debt therefore falls to $d_{ss}^{Fj} = 0.179$.[20] Also, the borrowing function B^{Fj} is less steeply sloped than B^M (slope 0.3 rather than 0.5). This is a sign of austerity: when debt increases for any reason, it converges back to its steady state more quickly in the economy with a fiscal authority than it does in the *status quo* monetary union. Moreover, although the inflation policy I^{Fj} lies (slightly) above I^I and I^M, the lower steady state debt in scenario Fj also reduces steady-state inflation, to $\pi_{ss}^{Fj} = 0.058$.

---

[20]The fact that B^{Fj} lies below B^I is calibration-specific; it is not a general result.

Table 2: *Debt, inflation, and welfare in scenarios S where debt is a control variable**

Debt[a]	Inflation	Welfare[b]	Transition gain[b]	Crisis cost[b,c]	Crisis cost,[b,c] fixing debt	Cyclical cost[b,d]
d_{ss}^S	π_{ss}^S	$W_{ss}^S - W_{ss}^M$	$W^S(d_{ss}^M,0,0)-W_{ss}^M$	$W^S(d_{ss}^S,0,\epsilon_0^g)-W_{ss}^S$	$W^S(0,0,\epsilon_0^g)-W^S(0,0,0)$	$W_{ss}^S-W_n^S(d_{ss}^S,0,0)$
Temporary shocks (autocorrelation 0)						
Scenario P: Planner						
0.1%	2.0%	+19.5%	+14.9%	−0.39%	−0.39%	−0.12%
Scenario I: single country with independent central bank						
71.5%	7.0%	+15.2%	+12.0%	−0.41%	−0.39%	−0.12%
Scenario M: status quo monetary union						
199.9%	10.0%	0%	0%	−0.48%	−0.42%	−0.13%
Scenario Fj: Monetary union with regional fiscal authorities						
17.9%	5.8%	+18.3%	+13.9%	−0.39%	−0.39%	−0.13%
Scenario F: Monetary union with union-wide fiscal authority						
8.7%	5.6%	+18.6%	+14.1%	−0.39%	−0.39%	−0.13%
Scenario G: Monetary union with union-wide federal government						
78.4%	5.5%	+14.9%	+12.6%	−0.47%	−0.45%	−0.17%

[a]Debt expressed as a fraction of steady state private output of baseline scenario M.

[b]All welfare changes stated as equivalent variations of private output, starting from nonstochastic steady state of baseline scenario M.

[c]"Crisis" refers to a four-percent rise in public goods demand at time 0, $\epsilon_0^g = 0.02$.

[d]Comparing stochastic economy with $\epsilon_t^g \sim N(0,0.02)$ to nonstochastic economy ($\epsilon_t^g \equiv 0$).

Table 3: *Debt, inflation, and welfare in scenarios S where debt is a control variable*[*]

Debt[a]	Inflation	Welfare[b]	Transition gain[b]	Crisis cost[b,c]	Crisis cost,[b,c] fixing debt	Cyclical cost[b,d]
d_{ss}^S	π_{ss}^S	$W_{ss}^S - W_{ss}^M$	$W^S(d_{ss}^M,0,0) - W_{ss}^M$	$W^S(d_{ss}^S,0,\epsilon_0^g) - W_{ss}^S$	$W^S(0,0,\epsilon_0^g) - W^S(0,0,0)$	$W_{ss}^S - W_n^S(d_{ss}^S,0,0)$
Correlated shocks (autocorrelation 0.7)						
Scenario P: Planner						
0.1%	2.0%	+19.4%	+14.8%	−0.75%	−0.75%	−0.86%
Scenario I: single country with independent central bank						
71.4%	7.0%	+15.3%	+12.2%	−0.78%	−0.75%	−0.68%
Scenario M: status quo monetary union						
199.7%	10.0%	0%	0%	−0.90%	−0.82%	−0.83%
Scenario Fj: Monetary union with regional fiscal authorities						
17.9%	5.8%	+18.4%	+14.1%	−0.75%	−0.74%	−0.70%
Scenario F: Monetary union with union-wide fiscal authority						
8.7%	5.6%	+18.7%	+14.2%	−0.75%	−0.75%	−0.71%
Scenario G: Monetary union with union-wide federal government						
78.3%	5.5%	14.8%	+12.6%	−0.90%	−0.88%	−0.95%

[a]Debt expressed as a fraction of steady state private output of baseline scenario M.

[b]All welfare changes stated as equivalent variations of private output, starting from nonstochastic steady state of baseline scenario M.

[c]"Crisis" refers to a four-percent rise in public goods demand at time 0, $\epsilon_0^g = 0.02$.

[d]Comparing stochastic economy with $\epsilon_t^g \sim N(0,0.02)$ to nonstochastic economy ($\epsilon_t^g \equiv 0$).

Finally, scenario F combines the debt-reducing incentives of scenarios I and F_j. Like the regional fiscal authorities, a union-wide fiscal authority is less impatient than national governments, and dislikes debt accumulation (the weights on *per capita* debt in the loss functions in scenarios F and Fj are assumed equal). Like the government of a single country, the union-wide fiscal authority internalizes the impact of its debt on the interest rate and on central bank behavior (the effects of *per capita* debt on the interest rate and on central bank preferences are assumed equal in scenarios F and I). Therefore the borrowing function in scenario F lies below curves B^I and B^{Fj}, which both lie below B^M. The resulting steady state debt level is $d_{ss}^F = 0.056$, slightly below that in scenario Fj.[21]

Interpreting the effects on debt

The steady-state debt ranking depicted in Figure 1 can be understood by considering the underlying biases that operate in each institutional scenario. The social planner sets $d_{ss}^P = 0$, the optimal steady-state debt. A decentralized economy where all institutions have the same preferences, and where the time inconsistency problem is offset to the appropriate degree that eliminates inflation bias, would also achieve this optimal level of debt. In our set-up these conditions are represented by the parameterization $\beta_G = \beta_S$ and $\gamma = 0$.[22] However, under the more realistic assumption that democratically elected officials act as if they are less patient than society as a whole, a positive bias pushes up steady state debt. In a single country economy, this increase in debt levels due to impatience is curtailed because the government is aware that (i) higher debt worsens inflation bias in equilibrium, since it makes the central bank more willing to raise inflation to boost output and inflate away nominal debt, and (ii) high levels of debt increase real interest rates (see Beetsma and Bovenberg, 1999, and Leith and Wren-Lewis, 2013, for discussion of these debt attenuation motives).

While the members of a monetary union would benefit, in principle, from cooperatively restraining debt for the reasons just mentioned, in equilibrium each member has an incentive to free-ride, increasing spending and reducing taxes, leaving debt control to the others. This represents a classic common pool problem, in which the only equilibrium is that members accumulate too much debt because they fail to internalize

---

[21]As we discussed in Basso and Costain (2016), steady state debt in scenario Fj can be proved higher than steady state debt in the planner's solution, and steady state debt in scenario F is lower than that in scenario Fj. But the ranking of debt between scenarios P and F is ambiguous: a union-wide fiscal authority may actually choose a steady-state debt level that is inefficiently *low* compared with the social planner.

[22]See Dixit and Lambertini (2003a), Chari and Kehoe (2008), and Basso and Costain (2016), Section 4.3.2, for in-depth discussion of these points.

the effects on interest rates and inflation. Regional fiscal delegation, by shifting control of debt to an institution that is more impatient and less debt tolerant, provides a countervailing force that limits the biases caused by democratic and non-cooperative decision processes. Union-wide fiscal delegation has the same effects, but in addition internalizes the impact of each member's debt on equilibrium, directly taking account of the tragedy of the commons.

Welfare implications

Besides lowering debt and inflation, Tables 2-3 also show that delegation to a fiscal authority implies a large improvement in social welfare (see the third columns of the tables). The steady-state social welfare W_{ss}^S of scenario S is reported as an equivalent variation in private sector output x, compared with scenario M (hence the welfare level in scenario M is shown as zero, by construction). The planner's solution has the highest steady-state welfare, representing a 19.5% permanent increase in private sector output, relative to scenario M. This welfare gain both reflects the fact that it is calculated at the lowest steady-state debt in the table, and the fact that, by definition, it is the policy that optimizes social welfare at any given debt level. We have also seen that the scenarios with higher steady-state debt have higher steady-state inflation. In scenarios M, I, Fj, and F, inflation is related to public and private spending by (26) and (27), linking higher inflation with larger gaps of public and private spending from their bliss points. Therefore the ranking of social welfare across these scenarios is the opposite of their debt ranking: $W_{ss}^M < W_{ss}^I < W_{ss}^{Fj} < W_{ss}^F$. Crucially, the fiscal delegation scenarios lie substantially closer to the planner's welfare level than to that of the monetary union.

Of course, these welfare comparisons only apply in steady state; switching to a new institutional regime does not produce welfare gains as large as those seen in the third column of the tables immediately. Instead, for an economy that starts with a large stock of debt, delegating fiscal responsibilities (or implementing the planner's solution) initially implies a costly transition period in which existing debt is paid off. To take the costs of this initial austerity into account, the fourth columns of Tables 2 and 3 report the gains of moving to each possible alternative scenario S, starting from the steady state debt level of scenario M. That is, we compare the welfare each alternative S evaluated at the debt level inherited from the monetary union, $W^S(d_{ss}^M, 0, 0)$, with the welfare $W_{ss}^M \equiv W^M(d_{ss}^M, 0, 0)$ of remaining in scenario M.

Even taking into account transition costs, the benefits of delegating instruments to a fiscal authority are very large, roughly equivalent to a 14% permanent increase in private sector output, relative to the monetary union. This represents most of the

potential welfare gain from moving to the planner's solution, which (including transition costs) is equivalent to a 15% output increase, relative to scenario M. Subtracting the numbers in the third and fourth columns of Tables 2-3, we see that the initial austerity cost of fiscal delegation is also large (roughly 4% of output), but the gains from delegation are sufficient to overwhelm these costs.

Considering that we are solving a reduced-form model, these welfare numbers should be taken as a qualitative illustration of the effects of fiscal delegation, rather than a precise quantitative assessment of those effects. Nonetheless, finding welfare gains that are orders of magnitude larger than Lucas' (1987) estimate of the cost of business cycles is unsurprising, because interest payments on sovereign debt (owned by foreigners) are subtracted off of national income, directly affecting the budget available for consumption. Hence, the welfare difference between scenarios M and S, when expressed as an equivalent output variation, is at least as large as the steady-state change in the sovereign interest burden, $r(d_{ss}^M)d_{ss}^M - r(d_{ss}^S)d_{ss}^S$. Moreover, besides the reduction in the sovereign interest burden, moving from scenario M to any of the other scenarios considered here also implies a large decrease in tax distortions and inflation.
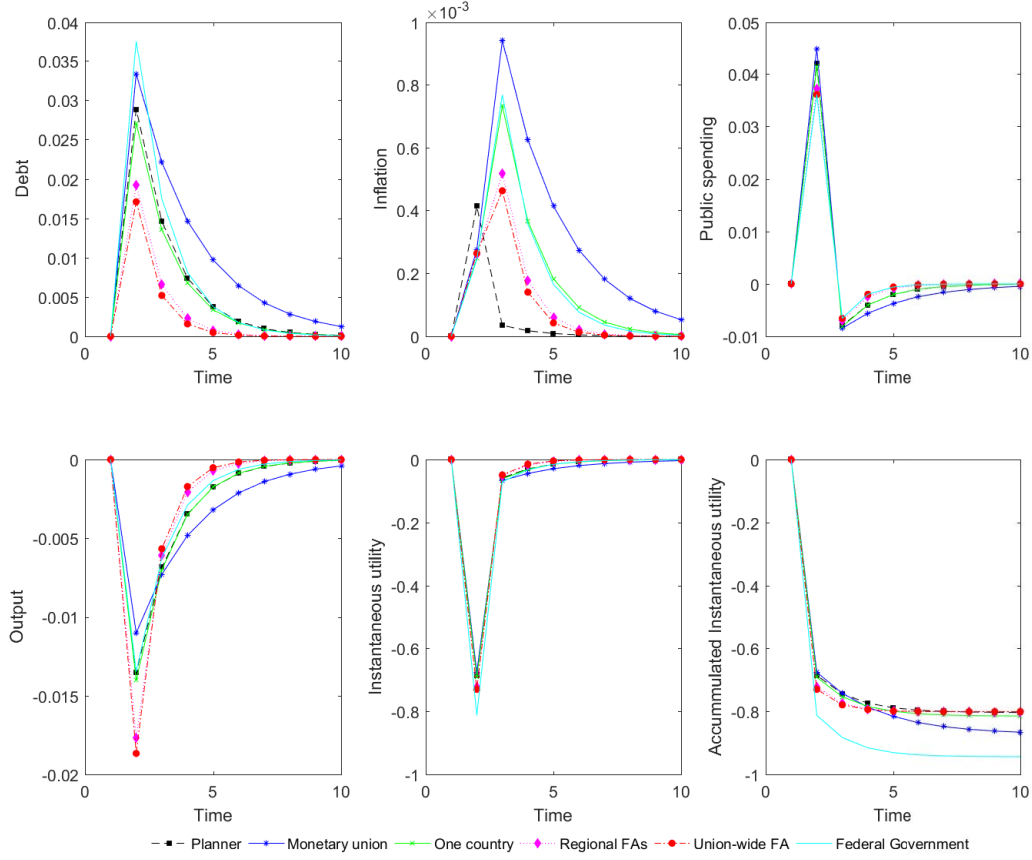
Impulse responses

The results thus far suggest that fiscal delegation improves welfare by reducing long-run debt. But debt accumulation offers a smoothing mechanism that may improve welfare in response to shocks; so it is important to ask whether fiscal delegation eliminates or weakens a buffer that protects the economy against excessive fluctuation of payoff-relevant variables. To this end, Figures 2 and 3 compare impulse responses to shocks to the demand for public spending across scenarios P (black with squares), M (blue with stars), I (green with "x"), Fj (magenta with diamonds), F (red with dots), and G (cyan line). We think of an increase in the demand for public spending as a reasonable stand-in for recent crises in Europe and other advanced economies, where large amounts of state funds were used to recapitalize banking systems, in an effort to avoid a major contraction of credit supply to the private sector.

Concretely, the figures suppose a 4% increase in $\tilde{g}_{j,t}$ (from 5 to 5.2) at time 2 (the initial steady state position is shown at time 1, for reference).[23] In Fig. 2, the shock is assumed to be uncorrelated over time (as in Table 2), while in Fig. 3, it has autocorrelation $\rho = 0.7$. We report the impulse responses as deviations from steady state (rather than log deviations) so that the absolute size of each response can be visually compared across scenarios S.

---

[23]This is a big shock. Since the bliss point $\tilde{g}$ is far above equilibrium public spending, fully accomodating this demand shock (raising spending by 0.2) would require much more than a 4% percentage increase in public spending.

Figure 2: *Temporary public demand shock. Comparing institutional scenarios.*

Notes: Impulse responses of debt, inflation, government spending, output, and instantaneous and cumulated utility to a temporary 4% increase in the public spending bliss point $\tilde{g}$, assuming debt is a control variable.

In the planner's solution of the uncorrelated specification (black in Fig. 2), government spending rises from approximately 0.36 to 0.40 at the time of the shock. To finance this increase, debt rises from $d_1 = d_{ss}^P = 0$ to $d_2 = 0.03$, postponing almost three quarters of the financing to the future. Therefore, there is a persistent decrease in public spending for $t \geq 3$, and a persistent decrease in output at times $t \geq 2$, reflecting increased taxes. Also, the planner imposes a small burst of surprise inflation on impact, raising the inflation rate temporarily from 2% to 2.04%. Since output and public spending both fall relative to their bliss points, and inflation rises, the flow of utility falls on impact by 0.7 utils.[24]

---

[24]The figures illustrate the welfare impact as measured in utils. For welfare measures expressed as equivalent output variations, see the fifth columns of Tables 2-3.

Turning next to scenario M, the public demand shock is again accommodated, to roughly the same extent that it was in the planner's solution. But the monetary union relies less on increased taxation, so the fall in output is slightly smaller (by 0.011) than it is in the planner's problem (where output falls by 0.014 on impact). Instead, the monetary union issues slightly more debt than the planner does (it runs a deficit of 0.034, raising the debt stock from $d_{ss}^M = 1.999$ to $d = 2.033$ on impact). More importantly, debt is much more persistent in scenario M than it is in scenario P, so the shock has greater medium-term effects. Unlike the planner's solution, where inflation rises only on impact (when it is unexpected), inflation in the monetary union responds strongly to increased debt, so there is a persistent rise in inflation and fall in utility. The last two panels of the graph show the utility loss– the fifth panel shows the deviation in utility from its steady state level, and the sixth cumulates this utility loss over time. While the utility loss is smaller on impact in scenario M than it is in scenario P, the ranking is reversed in the following period; the persistent losses in the monetary union eventually cumulate to a total utility loss of roughly 0.9 utils, while in the planner's solution the cumulated losses are only 0.8.

Thus, scenarios M and P both permit a substantial rise in public spending, and both delay most of the financing to the future, but the deficit bias in scenario M makes the costs much more persistent. If we now compare what happens in the fiscal delegation scenarios (magenta and red lines), we see that the response is less accomodative; public spending rises by approximately 0.035 rather than 0.04 on impact. Also, there is less smoothing over time; the rise in debt is around one-third smaller than it is in scenarios M and P. Hence, more of the fiscal impact must be absorbed on impact by raising taxes, so the fall in private sector output is much larger (it decreases by 0.18 under fiscal delegation, rather than 0.11 in scenario M). Hence, instantaneous utility falls more on impact under fiscal delegation than it does in the other scenarios considered; but the advantage of this austerity is that debt becomes much less persistent. Just one period after the shock, output and instantaneous utility are already higher in scenarios Fj and F than they are in scenarios M and P. And when we sum the utility impact of the shock over time, the overall loss in the fiscal delegation scenarios is virtually indistinguishable from that in the planner's solution, but is somewhat less than the cumulated loss in the monetary union. In other words, while the fiscal authorities impose painful austerity on impact, this is compensated by a rapid recovery of utility, so in intertemporal terms they perform almost as well as the social planner.

These welfare conclusions are restated numerically in Table 2. The fifth column reports the welfare impact of a four percent rise in public spending demand, starting from steady state, in each scenario. That is, it reports $W^S(d_{ss}^S, 0, \epsilon_0^g) - W^S(d_{ss}^S, 0, 0)$ for

each scenario S, where $\epsilon_0^g = 0.02$, which is the present discounted value of the utility losses caused by the shock graphed in Fig. 2. Unsurprisingly, the intertemporal welfare loss is smallest in the social planner's solution. But strikingly, even though output falls more sharply on impact in the fiscal delegation scenarios than it does in scenario M, the intertemporal welfare cost of the shock is approximately equal in the fiscal delegation scenarios and in the planner's solution, roughly equivalent in both cases to a 0.39% permanent decrease in private output.[25] In contrast, the smoother but more persistent fall in output and rise in inflation implied by scenario M is somewhat more costly, equivalent to a permanent loss of 0.42.% of private output.

We reach similar conclusions when we consider the impact of an autocorrelated demand shock, in Table 3 and Fig. 3. Again, public spending accommodates the demand shock more fully in the *status quo* monetary union than it does in the fiscal delegation scenarios. Much more debt accumulates in scenario M than in the fiscal delegation scenarios; the fiscal authorities raise taxes more in response to the shock, causing private output to fall further over the first three periods of impact than it does in scenario M.[26] But again, the greater austerity of the fiscal authorities makes debt less persistent, so from the fourth period onwards, instantaneous utility is higher in scenarios Fj and F than it is in scenario M. Cumulating utility over time, the overall utility loss caused by the crisis is similar in the fiscal delegation scenarios and in the planner's solution (Table 3, column five shows that it valued like a permanent 0.75% decrease in private output), but is substantially larger in scenario M (representing a permanent 0.90% decrease in private output).

A caveat to these results is that we have performed all these calculations at the steady states corresponding to each scenario S. Steady state debt and inflation are highest in scenario M, and steady state public and private consumption are correspondingly lower. Since the utility function is concave, the marginal cost of any given fluctuation in π, $\hat{g}$, or $\hat{x}$ is higher in the *status quo* monetary union than it is in the other scenarios. To control for this difference, the sixth columns of Tables 2 and 3 compare the cost of a public spending demand shock across scenarios, starting at a fixed level of debt, namely the planner's steady state $d_{ns}^P = 0$. Therefore we report the welfare cost $W^S(0, 0, \epsilon_0^g) - W^S(0, 0, 0)$, with $\epsilon_0^g = 0.02$. Controlling for debt in this

---

[25]To facilitate comparison of all the welfare changes that we report, equivalent variations are always calculated as changes relative to the nonstochastic steady state of the monetary union scenario.

[26]An important qualitative difference in this case is that the planner does not use debt to smooth the shock. When the shock is sufficiently persistent, the planner chooses to avoid running a deficit, in order to avoid paying off the accumulated debt while public sector demand remains high. But our comparison between scenario M and the fiscal delegation scenarios is essentially unchanged.

Figure 3: *Autocorrelated public demand shock. Comparing institutional scenarios.*
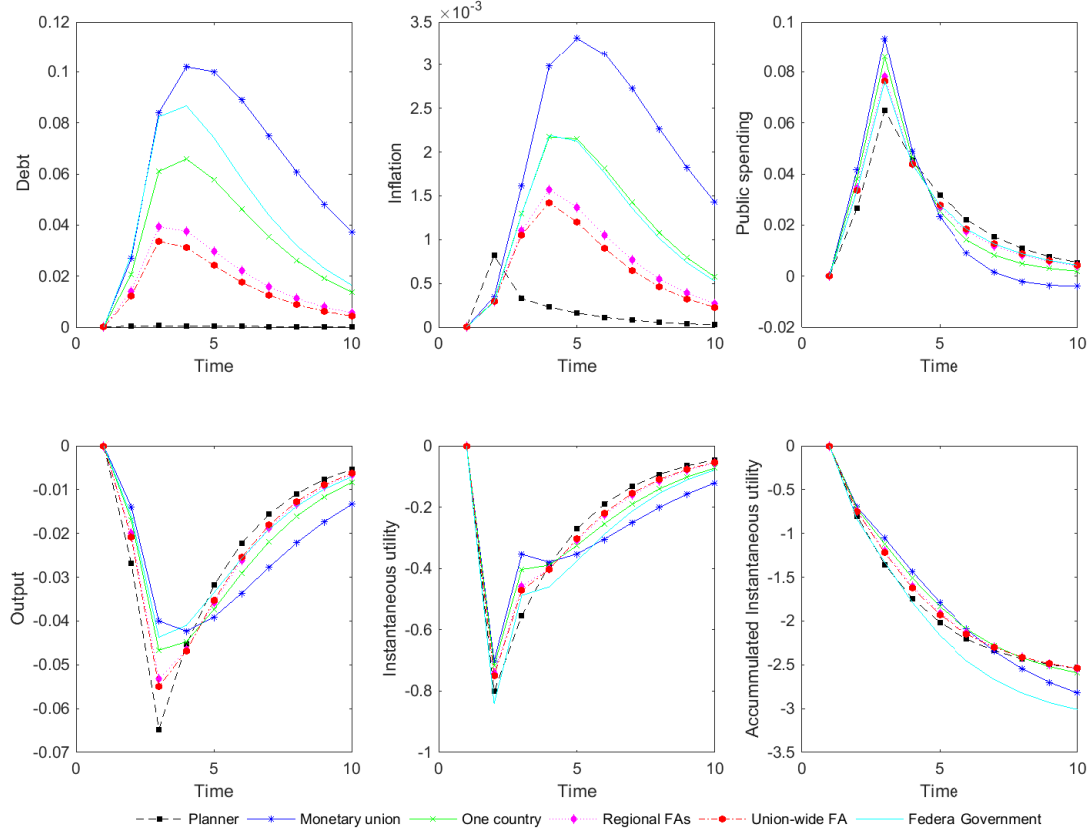
Notes: Impulse responses of debt, inflation, government spending, output, and instantaneous and cumulated utility to a 4% increase in the public spending bliss point $\tilde{g}$ (autocorrelation $\rho = 0.7$), assuming debt is a control variable.

way decreases the difference in the costs associated with the shock across scenarios, but even here the shock is substantially more costly in scenario M, compared with the fiscal delegation scenarios and with the planner, both for the *i.i.d.* and the autocorrelated shock specifications.

Finally, rather than considering a one-time "crisis", an alternative way to evaluate the impact of fiscal delegation on countercyclical policy is to calculate the costs of business cycles in the sense of Lucas (1987). To do so, we recalculate the equilibrium of each scenario S under the assumption that shocks have variance zero, to define the nonstochastic value function $W_n^S(d, 0, 0)$. We then calculate the difference in social welfare between the stochastic and nonstochastic economies, evaluated at the same debt level and conditioning on the same level of public sector demand, as if someone could simply flip a switch to eliminate all uncertainty in the economy. Concretely, we perform the calculation starting from the stochastic steady-state debt d_{ss}^S level of

33

scenario S, assuming public demand is at its steady state ($s = \epsilon = 0$), so we report the welfare difference $W_n^S(d_{ss}^S, 0, 0) - W^S(d_{ss}^S, 0, 0)$, again expressed as an equivalent variation of private-sector output. In the *i.i.d.* specification (Table 2, column seven), the cost of business cycles is roughly equal in the *status quo* monetary union and in the fiscal delegation scenarios, valued like a 0.13% permanent decrease in private sector output. In the autocorrelated specification (Table 3), the welfare cost of business cycles is 0.83% of output in the monetary union scenario, falling to 0.70% of output in scenario Fj, and 0.71% of output in scenario F.

In summary, all our simulations show that the "austere" policies of the fiscal authority are not very costly in intertemporal terms. Of course, we are not claiming that fiscal delegation is a much better mechanism for smoothing shocks. Rather, what we found initially surprising is the absence of a tradeoff between the long-run welfare gains from lower debt and the short-run implications for countercyclical policy. By eliminating much of the deficit bias associated with discretionary fiscal decisions, the fiscal delegation regime achieves a large increase in long-run welfare, but it also slightly reduces the losses associated with public demand shocks.

3.4   Games with debt as a residual

Thus far, our policy games have assumed that either the government or the fiscal authority could unilaterally control time t debt issuance, and that public spending would adjust as necessary to satisfy the budget constraint, given debt issuance and tax revenues. While this assumption is not uncommon in macroeconomic models, it is rather unrealistic. After all, standard budget procedures typically authorize spending programs and set tax rates early in the fiscal year, issuing debt later in the budget cycle as necessary to adjust for any unexpected imbalances between revenues and spending. In such an environment, neither the government nor a hypothetical independent fiscal authority has as much control over the debt as our results thus far have assumed. Therefore, in this section, we investigate how our previous results are altered when debt is a residual. Concretely, we now assume that expenditure, inflation, and taxes are control variables of the players in our game, while debt is the residual variable that adjusts to ensure that the budget constraint is satisfied in equilibrium.

3.4.1   Institutional scenarios

Scenario Md: Status quo model of a large monetary union, with debt as a residual

We start by looking at a large monetary union, with a single central bank that chooses inflation π_t for the whole union, while J regional governments G_j each choose

regional taxes τ_{jt} and government expenditure g_{jt}; d_{jt} is then given by the budget constraint (5). Thus, the central bank's choice set is $\Theta_t^C \equiv \{\pi_t, \{d_{j,t}\}_{j=1}^J\}$, and government j's choice set is $\Theta_t^{G_j} \equiv \{\tau_{jt}, d_{jt}, g_{j,t}\}$. As before, all policy makers act under discretion. While previously the central bank recognized that high inflation implied higher contempraneous output and public services, now it knows that raising inflation raises output and lowers debt. This complicates its Euler equation, since it foresees the impact of changing debt on other players' choices in the next period:

$$
\begin{aligned}
\alpha_{\pi C}\pi_t + \nu\bar{\hat{x}}_t = {} & \beta_S \frac{\chi\bar{d}_{t-1} + \kappa}{\chi\bar{d}_t + \kappa} E_t \Bigg[(\alpha_{\pi C}\pi_{t+1} + \nu\bar{\hat{x}}_{t+1})(R(d_t) + R'(d_t)d_t) + \\
& + \left(\frac{1}{\nu} + \frac{q_L^2\nu}{\alpha_{gC}} \right) (\alpha_{\pi C}\pi_{t+1} + (1 + \chi\bar{d}_t + \kappa)\nu\bar{\hat{x}}_{t+1})\frac{\partial\bar{x}_{t+1}}{\partial d_t} + \\
& + (\chi\bar{d}_t\alpha_{\pi C}\pi_{t+1} - \nu\bar{\hat{x}}_{t+1})\frac{\partial\pi_{t+1}}{\partial d_t} \Bigg].
\end{aligned} \tag{46}
$$

Next, consider the Euler equation that governs fiscal policy over time. The government still trades off its impact on public and private spending according to (26). Also, we continue to focus on the limit of a large monetary union ($J = \infty$) in which each individual country is infinitesimal, so government j ignores all the spillovers from its decisions. Then its Euler equation simplifies to

$$
\hat{x}_{j,t} = \beta_G R(\bar{d}_t) E_t \hat{x}_{j,t+1}. \tag{47}
$$

Previously, to calculate the symmetric solution of scenario M, we solved for two policy functions. Now, equilibrium can be characterized by three policy functions: gross borrowing $d_t = B^{Md}(\Omega_t)$, inflation $\pi_t = I^{Md}(\Omega_t)$, and the output deviation $\hat{X}^{Md}(\Omega_t) \equiv x_t - \tilde{x}$. Using (6), we can write the budget constraint and the Euler equations as follows:

$$
\begin{aligned}
B^{Md}(\Omega_t) = {} & (\beta_S^{-1} + \delta d_{t-1})d_{t-1} + (1 + \chi d_{t-1})(E_{t-1}[I^{Md}(\Omega_t)] - I^{Md}(\Omega_t)) + \\
& \left(\frac{1}{\nu} + \frac{q_L^2\nu}{\alpha_{gC}} \right) \hat{X}^{Md}(\Omega_t) - \kappa I^{Md}(\Omega_t) + \tilde{z}_t, \tag{48}
\end{aligned}
$$

$$
\hat{X}^{Md}(\Omega_t) = \beta_G \left(\beta_S^{-1} + \delta d_{t-1} \right) E_t \hat{X}^{Md}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}), \tag{49}
$$

$$
\alpha_{\pi C} I^{Md}(\Omega_t) + \nu\hat{X}^{Md}(\Omega_t) =
$$

$$
\begin{aligned}
\beta_S \frac{\chi d_{t-1} + \kappa}{\chi B^{Md}(\Omega_t) + \kappa} \Bigg\{ & \left[\alpha_{\pi C} I^{Md}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) + \nu\hat{X}^{Md}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) \right] (\beta_S^{-1} + 2\delta B^{Md}(\Omega_t)) + \\
& \left(\frac{1}{\nu} + \frac{q_L^2\nu}{\alpha_{gC}} \right) \left[\alpha_{\pi C} I^{Md}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) + (1 + \chi B^{Md}(\Omega_t) + \kappa)\nu\hat{X}^{Md}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) \right] \frac{\partial\hat{X}^{Md}}{\partial d_t}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) \\
& + \left[\chi d_t\alpha_{\pi C} I^{Md}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) - \nu\hat{X}^{Md}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) \right] \frac{\partial I^{Md}}{\partial d_t}(B^{Md}(\Omega_t), s_t, \epsilon_{t+1}) \Bigg\}. \tag{50}
\end{aligned}
$$

Finally, given $B^{Md}(\Omega_t)$, $^{Md}(\Omega_t)$, and $\hat{X}^{Md}(\Omega_t)$, public spending calculated from (26).

Scenario Fjd: Delegation of the tax rate to regional fiscal authorities, with debt as a residual

Next, we consider the effect of delegating control of taxes to an independent regional fiscal authority F_j, while regional governments choose public spending. As before, the central bank controls union-wide inflation. Debt is treated as a residual by all policy makers, so $\Theta_t^C \equiv \{\pi_t, \{d_{j,t}\}_{j=1}^J\}$, $\Theta_t^{G_j} \equiv \{g_{j,t}, d_{j,t}\}$, and $\Theta_t^{F_j} \equiv \{\tau_{jt}, d_{jt}\}$. As in previous policy games, we consider a symmetric equilibrium with many small countries.

The central bank's decision problem is the same as in Scenario Md. But since taxes and spending are now chosen by different policy makers, the linear equation (26) that related output to public spending in previous scenarios no longer holds. Hence, the central bank's Euler equation is now given by

$$
\alpha_{\pi C}\pi_t + \nu\bar{\hat{x}}_t = \beta_S \frac{\chi\bar{d}_{t-1} + \kappa}{\chi\bar{d}_t + \kappa} E_t \left[(\alpha_{\pi C}\pi_{t+1} + \nu\bar{\hat{x}}_{t+1})(R(d_t) + R'(d_t)d_t) + \right.
$$
$$
+ (\alpha_{gC}\bar{\hat{g}}_{t+1}(1 + \chi\bar{d}_t) + q_L(\alpha_{\pi C}\pi_{t+1} + \nu\bar{\hat{x}}_{t+1}))\frac{\partial\bar{\hat{g}}_{t+1}}{\partial d_t} +
$$
$$
+ \left(\frac{1}{\nu}\right)(\alpha_{\pi C}\pi_{t+1} + (1 + \chi\bar{d}_t + \kappa)\nu\bar{\hat{x}}_{t+1})\frac{\partial\bar{\hat{x}}_{t+1}}{\partial d_t} +
$$
$$
\left. + (\chi\bar{d}_t\alpha_{\pi C}\pi_{t+1} - \nu\bar{\hat{x}}_{t+1})\frac{\partial\pi_{t+1}}{\partial d_t} \right]. \tag{51}
$$

Next, the region-j government Euler equation can be simplified to

$$
\hat{g}_{j,t} = \beta_G E_t \left[R(\bar{d}_t)\hat{g}_{j,t+1} - \left(\frac{q_L}{\alpha_{gG}}\hat{x}_{j,t+1} - \frac{1}{\nu}\hat{g}_{j,t+1}\right)\frac{\partial\bar{x}_{t+1}}{\partial d_t} \right], \tag{52}
$$

and the regional fiscal authorities set taxes, or implicitly output, such that

$$
\nu\hat{x}_{j,t} + \alpha_{dF}d_{j,t} = \beta_F E_t \left[\nu\hat{x}_{j,t+1}R(\bar{d}_t) + (q_L\nu\hat{x}_{j,t+1} - \alpha_{gG}\hat{g}_{j,t+1})\frac{\partial g_{j,t+1}}{\partial d_t} \right]. \tag{53}
$$

The final equilibrium condition is given by the budget constraint. We must now solve simultaneously for four policy functions: for the gross borrowing function, the inflation function, and the output function, as in scenario Md, plus the policy function that determines government expenditure, $\bar{g}_t = G^{Fjd}(\bar{d}_{t-1}, \bar{s}_{t-1}, \epsilon_t)$.

Scenario Fd: Delegation of tax rates to a union-wide fiscal authority, with debt as a residual

Finally, we consider delegating control of all regions' taxes to a union-wide fiscal authority, under the assumption that debt is a residual. The instrument allocation

is $\Theta_t^C \equiv \{\pi_t, \{d_{j,t}\}_{j=1}^J\}$, $\Theta_t^{G_j} \equiv \{g_{j,t}, d_{j,t}\}$, and $\Theta_t^F \equiv \{\{\tau_{jt}, d_{jt}\}_{j=1}^J\}$. As in scenario Fjd, equilibrium is characterized by (51) for the central bank, and (52) and a budget constraint for each regional government. Finally, (53) is replaced by an analogous first-order condition for the union-wide fiscal authority:

$$
\nu\bar{\hat{x}}_t + \alpha_{dF}\bar{d}_t = \beta_F E_t\Bigg[\nu\bar{\hat{x}}_{t+1}(R(\bar{d}_t) + R'(d_t)d_t)
$$

$$
+ \left(q_L\nu\bar{\hat{x}}_{t+1} - \alpha_{gG}\bar{\hat{g}}_{t+1}\right)\frac{\partial\bar{g}_{t+1}}{\partial d_t} - (\alpha_{\pi F}\pi_{t+1} + \nu\bar{\hat{x}}_{t+1}\kappa)\frac{\partial\pi_{t+1}}{\partial d_t}\Bigg]. \quad (54)
$$

Here again we must solve for four policy functions simultaneously.

3.4.2 Results

The key messages from our previous analysis in which debt was a control variable were (i) delegation of budget balance responsibilities to a national or union-wide fiscal authority achieves a large reduction in debt, inflation, and tax burdens in steady state, and thereby raises steady-state welfare and (ii) in response to a public demand shock, the fiscal authority imposes greater austerity on impact than the *status quo* scenario would imply, but the overall welfare cost of the shock is lower, because the presence of the fiscal authority makes discretion less costly. Those conclusions remain true when the control variable that may be delegated is taxes instead of debt. Figure 4 depicts the policy functions; as before, fiscal authorities reduce debt and inflation relative to the monetary union, but they do not allow as much smoothing of shocks (the borrowing functions become flatter). As illustrated by Fig. 5, the inflation and debt responses after a positive public spending shock are subdued by fiscal delegation, while output falls more sharply. Again, the utility loss on impact is greater under a fiscal authority than it is in the *status quo* monetary union, but the overall intertemporal welfare cost of the shock is reduced by fiscal delegation, as we saw earlier in Fig. 3.

Nonetheless we see important differences when treating debt as a residual or as a control variable. To highlight these differences, Fig. 4 displays the specifications with debt as a residual and debt as a control in the same graph, comparing the policy functions under the *status quo* (scenarios M and Md) and under regional fiscal delegation (scenarios Fj and Fjd). Firstly, comparing scenarios M and Md, we see that if debt is a residual (so that the central bank can directly affect the new quantity of debt) then the inflationary bias resulting from lack of commitment increases substantially. The welfare loss of the monetary union relative to the planner's solution is therefore larger in scenario Md (21.2% of output, as seen in Table 4) than it was in scenario M (19.4%).

Figure 4: *Borrowing and inflation. Comparing debt as a residual to debt as a control*
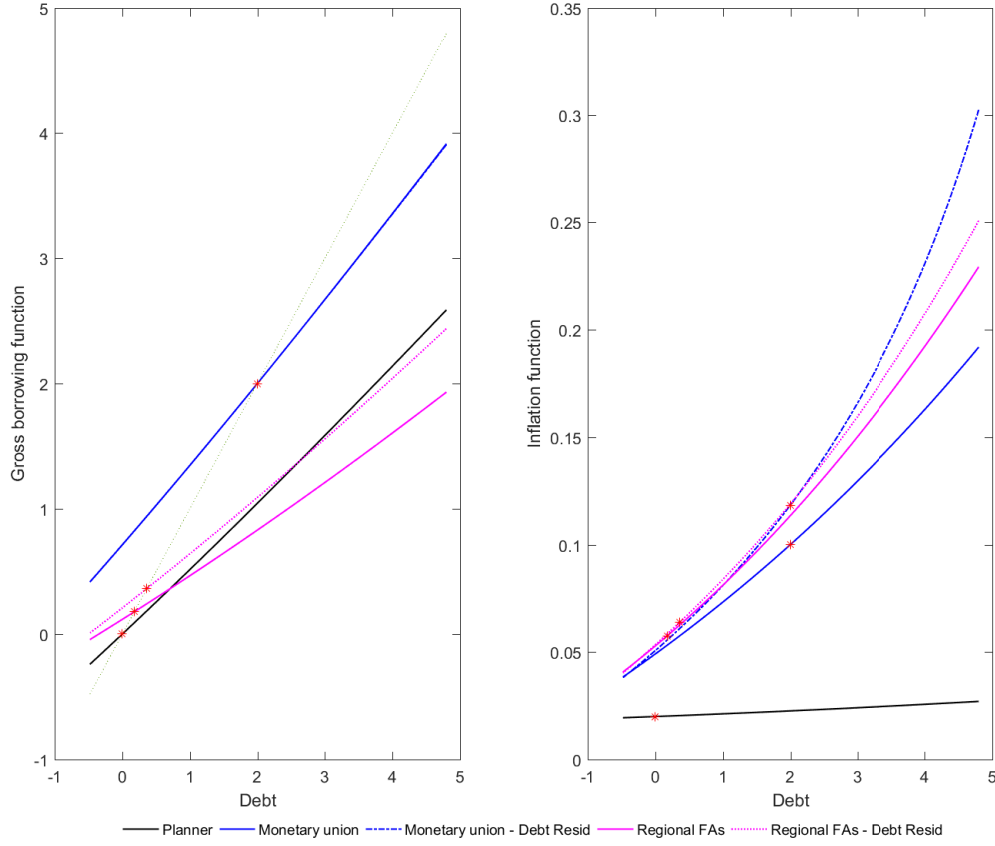
Notes: Comparing policies across institutional scenarios, treating debt as a control or as a residual.
Left: Gross borrowing: debt d_t as a function of d_{t-1}.
Right: Inflation π_t as a function of d_{t-1}.
Black: Planner's solution. Blue: Scenarios M (solid) and Md (dashed).
Magenta: Scenarios Fj (solid) and Fjd (dashed). Red stars: steady states.

Given the amplification of inflation bias, a regional FA with the same debt aversion is now less effective in reducing steady state inflation and debt, so these lie further away from their optimal levels (comparing scenarios Fj and Fjd to the planner's solution, which is again shown in black). Therefore the welfare level achieved by fiscal delegation is further from that of the planner's solution in scenarios Fjd and Fd than it was in scenarios Fj and F. Nonetheless, as a slightly less effective solution to a more serious problem, the welfare gains from establishing a fiscal authority in a monetary union are larger when debt is a residual (varying between 18.8% and 19.9% of private output, in the four specifications reported in Table 4) than they were in our previous calculations with debt as a control.

Table 4: *Debt, inflation, and welfare in scenarios S where debt is a residual*

Debt[a]	Inflation	Welfare[b]	Transition gain[b]	Crisis cost[b,c]	Crisis cost,[b,c] fixing debt	Cyclical cost[b,d]
d_{ss}^S	π_{ss}^S	$W_{ss}^S - W_{ss}^M$	$W^S(d_{ss}^M,0,0)-W_{ss}^M$	$W^S(d_{ss}^S,0,\epsilon_0^g)-W_{ss}^S$	$W^S(0,0,\epsilon_0^g)-W^S(0,0,0)$	$W_{ss}^S-W_n^S(d_{ss}^S,0,0)$

Temporary shocks (autocorrelation 0)

Scenario P: Planner

| 0.1% | 2.0% | 21.2% | +16.5% | −0.39% | −0.39% | −0.12% |

Scenario Md: status quo monetary union

| 199.9% | 11.8% | 0% | 0% | −0.49% | −0.43% | −0.14% |

Scenario Fjd: Monetary union with regional fiscal authorities

| 36.4% | 6.4% | 18.8% | +14.8% | −0.40% | −0.39% | −0.12% |

Scenario Fd: Monetary union with union-wide fiscal authority

| 15.5% | 5.9% | 19.7% | +15.2% | −0.39% | −0.39% | −0.13% |

Correlated shocks (autocorrelation 0.7)

Scenario P: Planner

| 0.1% | 2.0% | +21.2% | +16.6% | −0.75% | −0.75% | −0.86% |

Scenario Md: status quo monetary union

| 199.7% | 11.8% | 0% | 0% | −0.91% | −0.83% | −0.90% |

Scenario Fjd: Monetary union with regional fiscal authorities

| 36.4% | 6.4% | +18.9% | +14.9% | −0.76% | −0.75% | −0.74% |

Scenario Fd: Monetary union with union-wide fiscal authority

| 15.7% | 5.9% | +19.9% | +15.4% | −0.76% | −0.75% | −0.77% |

[a]Debt expressed as a fraction of steady state private output of baseline scenario M.

[b]All welfare changes stated as equivalent variations of private output, starting from nonstochastic steady state of baseline scenario M.

[c]"Crisis" refers to a four-percent rise in public goods demand at time 0, $\epsilon_0^g = 0.02$.

[d]Comparing stochastic economy with $\epsilon_t^g \sim N(0, 0.02)$ to nonstochastic economy ($\epsilon_t^g \equiv 0$).

As for the effects of a public demand shock, Figure 5 graphs the effects of a 4% increase in the public spending bliss point $\tilde{g}$, with autocorrelation 0.7, under the assumption that debt is a residual, comparing scenarios P, Md, Fjd, and Fd. This is comparable to Fig. 3, which studied the same shock but assumed that debt was a control variable. The biggest quantitative differences between the specifications with debt as a residual and as a control are seen in the output and inflation responses. The fiscal authority reduces output more sharply in response to the shock in Fig. 5, where it controls the tax rate, than it did in Fig. 3, where it was assumed to control debt directly. On the other hand, because inflation bias is worse when debt is a residual, the rise in inflation associated with the monetary union scenario Md (the blue curve in Fig. 5) is greater than it was in scenario M (the blue curve in Fig. 3). Summing the countervailing effects on output and inflation over time, public demand shocks are less costly under the fiscal delegation scenarios Fjd and Fd than they are in the monetary union scenario Md, as Fig. 5 and Table 4 both show.

4   Policy implications

Fear of moral hazard continues to hold back agreement 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 problem 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 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 a potentially powerful recipe for fiscal discipline: the establishment of a budgetary agency within the European Commission, 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. These are tasks it would share with the national fiscal councils that have been established in compliance with the "Fiscal Compact" treaty (European Council, 2012).

Figure 5: *Autocorrelated public demand shock. Comparing scenarios when debt is a residual.*
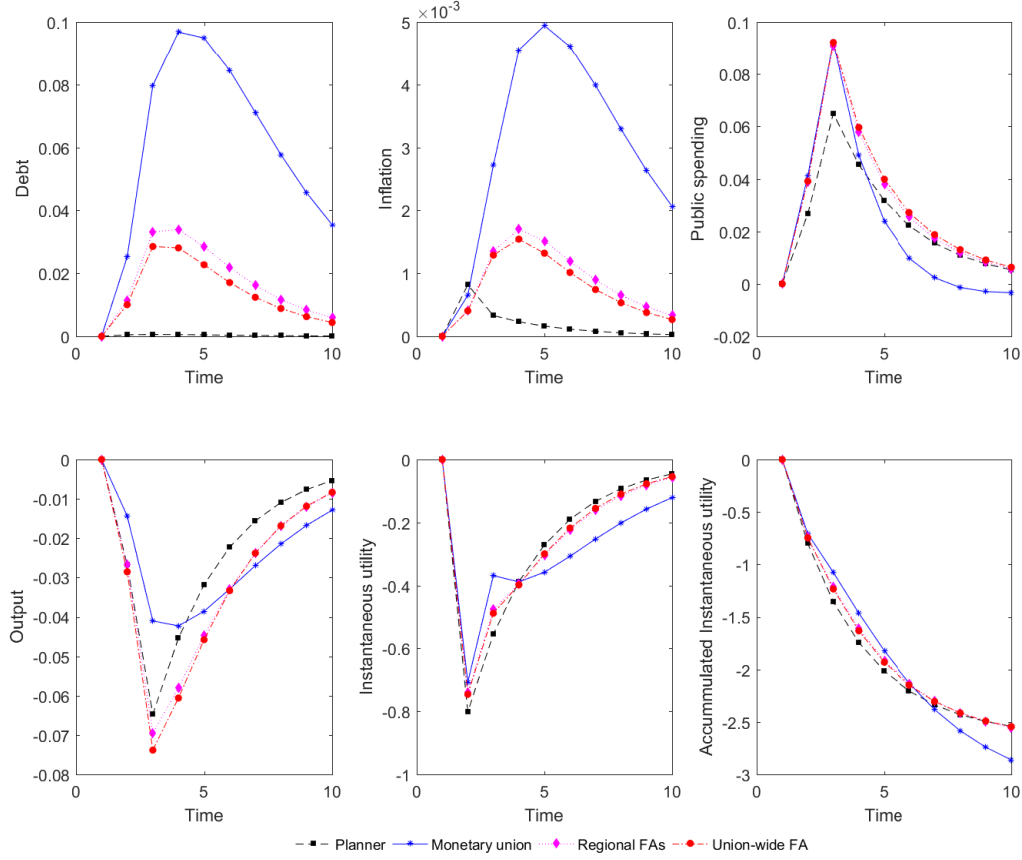
Notes: Impulse responses of debt, inflation, government spending, output, and instantaneous and cumulated utility to a 4% increase in the public spending bliss point $\tilde{g}$ (autocorrelation $\rho = 0.7$), assuming debt is a residual.

Indeed, the "Five Presidents' Report" (J. Juncker et al., 2015) has led to the creation of a similar monitoring council at the EU level. The new European Fiscal Board will begin work in 2017, with a small staff and a mandate explicitly limited to monitoring and advice (European Commission, 19 October 2016). Nonetheless, if member state governments wish it, this institutional seed could grow into something larger, with expanded powers. Our concept of the EFA would go further, exercising executive control over one or more national fiscal instruments delegated to it by member states. Importantly, these would have to 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 by correcting biases caused by lack of commitment, this setup would decrease debt accumulation, and might decrease the cost of economic fluctuations even if it means that some shocks have sharper effects on impact.

41

In our model, all policy decisions are equilibrium outcomes of games between policy makers with different instruments and preferences, representing different institutional designs. Thus, our analysis is founded on the assumption that no policy makers can truly commit to follow a rule, treating fiscal and monetary policies in a consistent way.[27] Considering how pliable European fiscal rules have proved in practice, a model based on discretion seems more informative than one based on commitment. But beyond its role as a modeling device, we would also argue that granting discretion to fiscally "conservative" institutions (in the sense of Rogoff, 1985) is a more realistic path for Europe today than forever trying to make rules more binding. Just as independent central banks may consider multiple short-run objectives while stabilizing inflation in the long run, the EFA could take many short-run factors into account while nudging its fiscal instrument(s) in the right direction to control debt in the long run. We emphasize long-run budget balance because avoiding permanent unidirectional transfers is essential to maintaining a long-run voluntary relationship between sovereign states. This contrasts with the emphasis on uniform short-run deficit rules originally embodied in the Maastricht Treaty of 1992, which have little justification in economic theory.

Likewise, we focus on strengthening the credibility of long-run budget balance rather than centralizing fiscal decisions because the former seems a more realistic path for Europe. Restricting the mandate of the EFA to fiscal sustainability leaves most fiscal policy-making at the local level. Creating a federal government would instead centralize fiscal policy, losing local information and hence decreasing the efficiency of spending. Likewise, the decisions of a distant federal government might be perceived as less legitimate and democratic. In this way, 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 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?

---

[27]In our 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.

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, which the ECB is able to provide. 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*. Let us suppose that the mandate of the European Fiscal Board is expanded beyond an advisory role, to ensuring long-run fiscal sustainability of member states by appropriately setting the fiscal instruments that those member states choose to delegate to it. We will call this hypothetical, more powerful agency the EFA. The first task of the EFA would be to whether the instruments proposed for delegation by any given member state are powerful enough and agile enough to give it effective control of that member state's debt. Once the EFA judges that it has been granted effective control of a given member state's debt level— including setting up the legal and administrative framework for control of the proposed instruments by the EFA— then that 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. Our paper has modeled instrument delegation in two ways. The simpler assumption is that the fiscal authority actually issues each member state's sovereign debt; the member

government is then free to spend the cash proceeds.[28] We show that delegation of debt issuance is very effective in reducing biases generated in a monetary union, theoretically being the preferred option.

However, 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. The *de facto* debt level may be affected by hidden securitization of future public revenues, by off-balance sheet exposures (unfunded pensions, guarantees given to social security or other state entities), or even by more explicit measures such as the issuance of scrip, "platinum coins" (an instrument recently discussed in the US) or IOUs— or simply delaying payments. These measures have in fact have been used quite frequently by countries unable to formally issue more sovereign debt. As such we also consider the delegation of taxes or government expenditure, instead of debt issuance *per se*. While delegation is somewhat less effective in this case, it still significantly reduces debt biases without imposing further constraints on stabilization.

An EFA could be granted control over taxes or government expenditure in a wide variety of ways. In the case of taxes, 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.

As for controlling government expenditure, Gomes (2011) argues that public sector wages should optimally be state-contingent, rising in times of fiscal plenty and falling when the budget is tight. Adjustments of this type 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. Additional adjustment factors related to long-term budget trends offer another potentially powerful lever that could be delegated to an independent fiscal authority. For example, in a recent

---

[28]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 $d_{j,t}$.

pension reform, the Spanish government established a "Factor de Revalorización Anual" that will be automatically adjust pensions each year in response to any persistent deficits or surpluses in the pension system; see Sánchez (2014). However, any spending adjustment that affects only part of the government budget could imply large distributional consequences across different groups in the population. Therefore, 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 could be determined by a fiscal authority.

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. 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.[29] All other fiscal instruments would remain under the control of the member government, consistent with the European principal of "subsidiarity".

5 Conclusions

Motivated by the failure of fiscal rules to avoid deficit bias in Europe, this paper has analyzed an alternative policy regime in which each member state government delegates at least one fiscal instrument to an independent authority with a mandate to avoid excessive debt. Other fiscal decisions remain in the hands of member governments, including the allocation of spending across different public goods, and the composition of taxation.

We have compared long run debt accumulation and the response to public spending shocks in dynamic games representing several different institutional configurations, including a *status quo* monetary union scenario with many local governments, a monetary union with a single federal government, and various fiscal delegation scenarios, as well as a social planner's solution. We made two simple assumptions to discipline

---

[29]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.

our treatment of different types of institutions: first, that elected institutions are relatively impatient, and second, that an institution mandated to achieve a simple, feasible, quantitative goal will value that goal more strongly than the rest of the society does.

In our numerical simulations, delegation of budget balance responsibilities to a national or union-wide fiscal authority reduces debt, inflation, and tax burdens in steady state, and thereby raises steady-state welfare, compared with the *status quo* scenario. The welfare gains are large in our model, and it is plausible to suppose that they could be large in practice too, because they are driven primarily by the fact that a large change in steady-state debt implies a large reduction in the interest burden on public debt, and hence on the burden of tax distortions. These conclusions hold regardless of whether the fiscal authority chooses debt directly, or whether it instead chooses the tax rate, implying that debt is determined as a budget residual.

In response to a public spending shock, the fiscal authority imposes greater austerity on impact than the *status quo* scenario would imply. Nonetheless, we find that the overall welfare cost of the shock is lower under the fiscal authority, because its presence makes lack of commitment less costly, so that paying back the initial debt increase is much less distortionary. Similarly, the transition path when a fiscal authority is established imposes substantial austerity as the high initial debt is paid down. Nonetheless, the long-run welfare gains are so large that establishing a fiscal authority is preferred, from an *ex ante* social welfare perspective, even when the economy starts at the high steady-state debt level of the monetary union.

Going beyond the model, Section 4 discussed the role that fiscal delegation might play in Eurozone reform, where a disciplined fiscal regime is a crucial counterpart (both economically and politically) to most of the monetary and financial mechanisms currently under consideration to stabilize European economies and financial markets. 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.

References

ALESINA, A., AND G. TABELLINI (1987): "Rules and Discretion with Noncoordinated Monetary and Fiscal Policies," *Economic Inquiry*, 25(4), 619–30.

——— (1990): "A Positive Theory of Fiscal Deficits and Government Debt," *Review of Economic Studies*, 57(3), 403–14.

——— (2007): "Bureaucrats or Politicians? Part I: A Single Policy Task," *American Economic Review*, 97(1), 169–179.

BALL, L. (1997): "A Proposal for the Next Macroeconomic Reform," *Victoria Economic Commentaries*, 14(1), 1–7.

BASSO, H. S. (2009): "Delegation, time inconsistency and sustainable equilibrium," *Journal of Economic Dynamics and Control*, 33, 1617–1629.

BASSO, H. S., AND J. COSTAIN (2016): "Fiscal delegation in a monetary union with decentralized public spending," *CESifo Economic Studies*, Forthcoming.

BATTAGLINI, M. (2011): "The Political Economy of Public Debt," *Annual Review of Economics*, 3(1), 161–189.

BEETSMA, R. M., AND H. JENSEN (2005): "Monetary and fiscal policy interactions in a micro-founded model of a monetary union," *Journal of International Economics*, 67(2), 320–352.

BEETSMA, R. M. W. J., AND A. L. BOVENBERG (1999): "Does monetary unification lead to excessive debt accumulation?," *Journal of Public Economics*, 74(3), 299–325.

BERGIN, P. (1998): "Fiscal solvency and price level determination in a monetary union," *Journal of Monetary Economics*, 45, 37–53.

BROTO, C., AND G. PEREZ-QUIROS (2013): "Disentangling contagion among sovereign cds spreads during the european debt crisis," Banco de España Working Papers 1314, Banco de España.

BUTI, M., W. ROEGER, AND J. IN'T VELD (2001): "Stabilizing Output and Inflation: Policy Conflicts and Co-operation under a Stability Pact," *Journal of Common Market Studies*, 39(5), 801–828.

CALMFORS, L. (2011): "The Role of Independent Fiscal Policy Institutions," CESifo Working Paper Series 3367, CESifo Group Munich.

CHARI, V. V., AND P. J. KEHOE (1990): "Sustainable Plans," *Journal of Political Economy*, 98(4), 783–802.

——— (2007): "On the need for fiscal constraints in a monetary union," *Journal of Monetary Economics*, 54(8), 2399 – 2408.

——— (2008): "Time Inconsistency and Free-Riding in a Monetary Union," *Journal of Money, Credit and Banking*, 40(7), 1329–1356.

COSTAIN, J., AND B. DE BLAS (2012a): "The role of fiscal delegation in a monetary union: a survey of the political economy issues," Working Papers in Economic Theory 2012/11, Universidad Autónoma de Madrid.

——— (2012b): "Smoothing shocks and balancing budgets in a currency union," *Moneda y Crédito*, 234, 37–91.

DE GRAUWE, P. (2012): "The Governance of a Fragile Eurozone," *Australian Economic Review*, 45(3), 255–268.

DEBRUN, X., D. HAUNER, AND M. S. KUMAR (2009): "Independent Fiscal Agencies," *Journal of Economic Surveys*, 23(1), 44–81.

DIXIT, A., AND L. LAMBERTINI (2003a): "Interactions of Commitment and Discretion in Monetary and Fiscal Policies," *American Economic Review*, 93(5), 1522–1542.

——— (2003b): "Symbiosis of monetary and fiscal policies in a monetary union," *Journal of International Economics*, 60(2), 235–247.

EGGERTSSON, G., AND E. L. BORGNE (2010): "A political agencies theory of central bank independence," *Journal of Money, Credit and Banking*, 42(4), 647–677.

EICHENGREEN, B., R. HAUSMANN, AND J. VON HAGEN (1999): "Reforming Budgetary Institutions in Latin America: The Case for a National Fiscal Council," *Open Economies Review*, 10(4), 415–442.

EICHENGREEN, B., AND C. WYPLOSZ (1998): "The Stability Pact: more than a minor nuisance?," *Economic Policy*, pp. 66–113.

European Commission (19 October 2016): "The European Fiscal Board: Questions and Answers," Press release, European Commission.

European Council (2012): "Treaty on Stability, Coordination, and Governance in the Economic and Monetary Union," .

FARHI, E., AND I. WERNING (2015): "Fiscal Unions," Manuscript, Harvard University.

GNOCCHI, S., AND L. LAMBERTINI (2016): "Monetary Commitment and the Level of Public Debt," Discussion paper.

GOMES, P. (2011): "Fiscal policy and the labour market: the effects of public sector employment and wages," European Economy - Economic Papers 439, Directorate General Economic and Monetary Affairs (DG ECFIN), European Commission.

GRUEN, N. (1997): "Making Fiscal Policy Flexibly Independent of Government," *Agenda*, 4(3), 297–307.

HAGEMANN, R. (2010): "Improving Fiscal Performance Through Fiscal Councils," OECD Economics Department Working Papers 829, OECD Publishing.

J. Juncker et al. (2015): "Completing Europe's Economic and Monetary Union," European Commission.

LEEPER, E. M. (1991): "Equilibria under 'active' and 'passive' monetary and fiscal policies," *Journal of Monetary Economics*, 27(1), 129–147.

LEEPER, E. M., C. LEITH, AND D. LIU (2016): "Optimal Time-Consistent Monetary, Fiscal and Debt Maturity Policy," Working Papers 2016-04, Business School - Economics, University of Glasgow.

LEITH, C., AND S. WREN-LEWIS (2011): "Discretionary policy in a monetary union with sovereign debt," *European Economic Review*, 55(1), 93–117.

———— (2013): "Fiscal Sustainability in a New Keynesian Model," *Journal of Money, Credit and Banking*, 45(8), 1477–1516.

LUCAS, R. S. (1987): *Models of Business Cycles*. Wiley-Blackwell.

MASKIN, E. (September 29, 2016): "Should Fiscal Policy be Set by Politicians?," Seminar slides, ECB Annual Research Conference - Jean Monnet Lecture.

MUNDELL, R. (1961): "A Theory of Optimum Currency Areas," *American Economic Review*, 51(4), 657–665.

OBSTFELD, M. (2013): "Finance at Center Stage: Some Lessons of the Euro Crisis," European Economy Economic Papers 493, European Commission.

PISANI-FERRY, J. (2012): "The Euro crisis and the new impossible trinity," Policy Contributions 674, Bruegel.

ROGOFF, K. (1985): "The Optimal Degree of Commitment to an Intermediate Monetary Target," *The Quarterly Journal of Economics*, 100(4), 1169–89.

SÁNCHEZ, A. R. (2014): "The automatic adjustment of pension expenditures in Spain: an evaluation of the 2013 pension reform," Banco de España Working Papers 1420, Banco de España.

SCHOENMAKER, D., AND D. GROS (2012): "A European Deposit Insurance and Resolution Fund," Working Document 364, CEPS.

SEIDMAN, L. S., AND K. A. LEWIS (2002): "A New Design for Automatic Fiscal Policy," *International Finance*, 5(2), 251–84.

SIMS, C. A. (1999): "The Precarious Fiscal Foundations of EMU," *De Economist*, 147, 415–436.

——— (2013): "Paper money," *American Economic Review*, 103, 563–584.

——— (September 20, 2012): "A least unlikely path to a sustainable EMU," Seminar slides, EABCN conference on "Fiscal and Monetary Policy in the Euro Area".

SOROS, G. (10 April 2013): "A European solution to the Eurozone's problem," Project Syndicate.

VON HAGEN, J., AND I. J. HARDEN (1995): "Budget processes and commitment to fiscal discipline," *European Economic Review*, 39(3-4), 771–779.

WREN-LEWIS, S. (2002): "Fiscal policy, inflation, and stabilisation in EMU," Mimeo, Exeter University.

WYPLOSZ, C. (2005): "Fiscal Policy: Institutions versus Rules," *National Institute Economic Review*, 191(1), 64–78.

A Appendix: Deriving the Euler equations and computing equilibrium

For each institution scenario considered, we construct a equilibrium in terms of the state variables $\vec{\Omega}_t \equiv (\vec{d}_{t-1}, \vec{s}_{t-1}, \vec{\epsilon}_t)$. To calculate the first-order conditions we must initially allow for off-equilibrium deviations that would result in asymmetric states, but ultimately we assume shocks are symmetric and solve for the resulting symmetric equilibrium in terms of the reduced state $\Omega_t \equiv (d_{t-1}, s_{t-1}, \epsilon_t)$. In this appendix, we derive the functional equations that define the equilibrium policies for scenario M, and then explain how we solve them. Our methodology is similar for other scenarios.

Scenario M treats debt, taxes, and inflation as controls, and public spending as a residual. Thus, when we apply the generic decision problems (16)-(17) to scenario M, $g_{j,t}$ shows up in *both* the choice sets Θ_t^C and Θ_t^{Gj}:

Central bank: $\Theta_t^C = \{\pi_t, \{g_{j,t}\}_{j=1}^J\}$

$$
V^C(\vec{\Omega}_t) = \max_{\Theta_t^C} \frac{-1}{2} \left\{ \alpha_{\pi C} \pi_t^2 + \frac{1}{J} \sum_{j=1}^J \left[\left(\underline{x}_{j,t} + \nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x} \right)^2 + \alpha_{gC} \left(g_{j,t} - \tilde{g}_{j,t} \right)^2 \right] \right\}
$$

$$
+ \beta_C E_t V^C(\vec{\Omega}_{t+1}) + \frac{1}{J} \sum_{j=1}^J \Lambda_{j,t}^C \left[d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t) \right) d_{j,t-1} + \tau_{j,t} + \kappa \pi_t - q_L g_{j,t} \right]. \quad (55)
$$

Regional government: $\Theta_t^{Gj} = \{d_{j,t}, \tau_{j,t}, g_{j,t}\}$

$$
V^{Gj}(\vec{\Omega}_t) = \max_{\Theta_t^{Gj}} \frac{-1}{2} \left\{ \alpha_{\pi G} \pi_t^2 + \left(\underline{x}_{j,t} + \nu(\pi_t - \pi_t^e - \tau_{j,t}) - \tilde{x} \right)^2 + \alpha_{gG} \left(g_{j,t} - \tilde{g}_{j,t} \right)^2 \right\}
$$

$$
+ \beta_G E_t V^{Gj}(\vec{\Omega}_{t+1}) + \Lambda_t^{Gj} \left[d_{j,t} - \left(R\left(\bar{d}_{t-1}\right) + \chi(\pi_t^e - \pi_t) \right) d_{j,t-1} + \tau_{j,t} + \kappa \pi_t - q_L g_{j,t} \right]. \quad (56)
$$

In equilibrium, each policy maker knows the strategies played by the others. To make this explicit, we can write the decision problems showing that the variables not chosen by C are instead given by G_j's policy function, and *vice versa*. Hence, we define $\Pi(\vec{\Omega}_t)$ as the central bank's inflation function, and $T_j(\vec{\Omega}_t)$ as the tax policy function of government G_j.

To write the Bellman equations precisely, we also write the gross borrowing function of G_j as $B_j(\vec{\Omega}_t)$, and we define the list of all country-specific borrowing functions,

$$
\vec{B}(\vec{\Omega}_t) \equiv (B_1(\vec{\Omega}_t), B_2(\vec{\Omega}_t), \dots B_J(\vec{\Omega}_t)).
$$

But also, to allow for deviations from the policy function by country j, we define the list $\vec{B}_{-j}(\vec{\Omega}_t)$ which is identical to $\vec{B}(\vec{\Omega}_t)$, except that it contains an arbitrary borrowing choice $d_{j,t}$ in position j:

$$\vec{B}_{-j}(\vec{\Omega}_t) \equiv (B_1(\vec{\Omega}_t), \ldots, d_{j,t}, \ldots B_J(\vec{\Omega}_t)).$$

Then the Bellman equations can be rewritten as follows.

Central bank: $\Theta_t^C = \{\pi_t, \{g_{j,t}\}_{j=1}^J\}$

$$V^C(\vec{\Omega}_t) = \max_{\Theta_t^C} \frac{-1}{2}\left\{\alpha_{\pi C}\pi_t^2 + \frac{1}{J}\sum_{j=1}^J\left[\left(\underline{x}_{j,t} + \nu\left(\pi_t - E_{t-1}\Pi(\vec{\Omega}_t) - T_j(\vec{\Omega}_t)\right) - \tilde{x}\right)^2 + \alpha_{gC}\left(g_{j,t} - \tilde{g}_{j,t}\right)^2\right]\right\}$$

$$+ \beta_C E_t V^C\left(\vec{B}(\vec{\Omega}_t), \vec{s}_t, \vec{\epsilon}_{t+1}\right) + \frac{1}{J}\sum_{j=1}^J \Lambda_{j,t}^C\left\{B_j(\vec{\Omega}_t) - \left[R(d_{t-1}) + \chi\left(E_{t-1}\Pi(\vec{\Omega}_t) - \pi_t\right)\right]d_{j,t-1} + T_j(\vec{\Omega}) + \kappa\pi_t - q_L g_{j,t}\right\}.$$
$$(57)$$

Notice that the effects of surprise inflation are calculated relative to rational expectations formed at time $t-1$.

Regional government: $\Theta_t^{Gj} = \{d_{j,t}, \tau_{j,t}, g_{j,t}\}$

$$V_t^{Gj}(\vec{\Omega}_t) = \max_{\Theta_t^{Gj}} \frac{-1}{2}\left\{\alpha_{\pi G}\Pi(\vec{\Omega}_t)^2 + \left(\underline{x}_{j,t} + \nu\left(\Pi(\vec{\Omega}_t) - E_{t-1}\Pi(\vec{\Omega}_t) - \tau_{j,t}\right) - \tilde{x}\right)^2 + \alpha_{gG}\left(g_{j,t} - \tilde{g}_{j,t}\right)^2\right\}$$

$$+ \beta_G E_t V_{t+1}^{Gj}\left(\vec{B}_{-j}(\vec{\Omega}_t), \vec{s}_t, \vec{\epsilon}_{t+1}\right) + \Lambda_t^{Gj}\left\{d_{j,t} - \left[R(\bar{d}_{t-1}) + \chi\left(E_{t-1}\Pi(\vec{\Omega}_t) - \Pi(\vec{\Omega}_t)\right)\right]d_{j,t-1} + \tau_{j,t} + \kappa\Pi(\vec{\Omega}_t) - q_L g_{j,t}\right\}.$$
$$(58)$$

The first-order conditions are easily seen to be

$$0 = -\alpha_{\pi C}\pi_t - \frac{1}{J}\sum_j \nu(x_{j,t} - \tilde{x}) + \frac{1}{J}\sum_j \Lambda_{j,t}^C(\chi d_{j,t-1} + \kappa), \tag{59}$$

$$0 = -\alpha_{gC}(g_{j,t} - \tilde{g}_{j,t}) - \Lambda_{j,t}^C q_L, \tag{60}$$

$$0 = \beta_G E_t \frac{\partial V_{t+1}^{Gj}}{\partial d_{j,t}} + \Lambda_t^{Gj}, \tag{61}$$

$$0 = \nu(x_{j,t} - \tilde{x}) + \Lambda_t^{Gj}, \tag{62}$$

$$0 = -\alpha_{gG}(g_{j,t} - \tilde{g}_{j,t}) - \Lambda_t^{Gj} q_L. \tag{63}$$

Now, to derive a system of difference equations, we will need to eliminate $\frac{\partial V_{t+1}^{Gj}}{\partial d_{j,t}}$. The envelope theorem implies that we can ignore all of government G_j's own choice variables

when calculating $\frac{\partial V_t^{Gj}}{\partial d_{j,t-1}}$, but we cannot ignore the impact of $d_{j,t-1}$ on other players' choices. Thus we obtain

$$
\begin{aligned}
\frac{\partial V_t^{Gj}}{\partial d_{j,t-1}} = & -\Lambda_t^{Gj}\left(R(\bar{d}_{t-1}) + \chi(E_{t-1}\Pi(\vec{\Omega}_t) - \Pi(\vec{\Omega}_t)) + \frac{1}{J}R'(\bar{d}_{t-1})d_{j,t-1}\right) \\
& - \left\{\alpha_{\pi G}\Pi(\vec{\Omega}_t) - \kappa\Lambda_t^{Gj}\right\}\frac{\partial\Pi}{\partial d_{j,t-1}} \\
& - \left\{\nu(x_{j,t} - \tilde{x}) - \chi\Lambda_t^{Gj}d_{j,t-1}\right\}\left(\frac{\partial\Pi}{\partial d_{j,t-1}} - E_{t-1}\frac{\partial\Pi}{\partial d_{j,t-1}}\right) \\
& + \beta_G\sum_{k\neq j}E_t\frac{\partial V_{t+1}^{Gj}}{\partial d_{k,t}}\frac{\partial B_k}{\partial d_{j,t-1}}.
\end{aligned} \tag{64}
$$

Taking expectations, the surprise inflation terms drop out. Therefore, (61) becomes

$$
\Lambda_t^{Gj} = \beta_G E_t\left\{\Lambda_{t+1}^{Gj}\left(R(\bar{d}_t) + \frac{1}{J}R'(\bar{d}_t)d_{j,t}\right) + \left\{\alpha_{\pi G}\Pi(B(\vec{\Omega}_t),\vec{s}_t,\vec{\epsilon}_{t+1}) - \kappa\Lambda_{t+1}^{Gj}\right\}\frac{\partial\Pi}{\partial d_{j,t}} - \beta_G\sum_{k\neq j}E_t\frac{\partial V_{t+2}^{Gj}}{\partial d_{k,t+1}}\frac{\partial B_k}{\partial d_{j,t}}\right\}. \tag{65}
$$

In general, to evaluate this equation we would need to take another envelope condition in order to eliminate the derivative $\frac{\partial V_{t+2}^{Gj}}{\partial d_{k,t+1}}$. However, note that the factors $\frac{\partial\Pi}{\partial d_{j,t}}$, $\frac{\partial V_{t+2}^{Gj}}{\partial d_{k,t+1}}$ and $\frac{\partial B_k}{\partial d_{j,t}}$ all scale proportionally to $\frac{1}{J}$, while the summation operator in (65) scales proportionally to J. Therefore, in the limit as $J \to \infty$, (65) reduces to

$$
\Lambda_t^{Gj} = \beta_G R(\bar{B}(\vec{\Omega}_t))E_t\Lambda_{t+1}^{Gj}, \tag{66}
$$

because all the other terms in the equation are of order $\frac{1}{J}$. From here, simple algebra leads to equations (28) and (30). Next, we restrict our calculations to the case of symmetric shocks ($\epsilon_{j,t} = \epsilon_t$ for all j), in which case the state of the economy can be reduced from $\vec{\Omega}_t = (\vec{d}_{t-1}, \vec{s}_{t-1}, \vec{\epsilon}_t)$ to the scalar triple $\Omega_t = (d_{t-1}, s_{t-1}, \epsilon_t)$. We therefore search for a symmetric solution, $B_j(\vec{\Omega}) = B(\Omega)$ for all j, which must satisfy the following functional equations:

$$
B^M(\Omega_t) = R(d_{t-1})d_{t-1} + (1 + \chi d_{t-1})\left[E_{t-1}[I^M(\Omega_t)] - I^M(\Omega_t)\right] - \breve{\kappa}\breve{I}^M(\Omega_t) + \tilde{z}_t, \tag{67}
$$

$$
\breve{I}^M(\Omega_t) = \beta_S\left(\beta_S^{-1} + \delta B^M(\Omega_t)\right)E_t\breve{I}^M(B^M(\Omega_t), s_t, \epsilon_{t+1}). \tag{68}
$$

We approximate the functions $B(\Omega)$ and $\breve{I}(\Omega)$ with Chebyshev polynomials, and evaluate the integral in (68) by Gauss-Hermite quadrature. We solve the model by searching for Chebyshev coefficients such that (67)-(68) hold with sufficient accuracy.

A.1 Planner's problem

Since the planner can commit, it can be viewed as choosing a plan, contingent on ϵ_t, for each time t choice variable, including π_t. Unlike the other environments, the equation $\pi_t^e = E_t \pi_t$ not only holds as an equilibrium relation, but also enters as a constraint on the planner's problem. We will call the multiplier on this constraint λ_t. This multiplier constrains the problem prior to the realization of ϵ_t, so in the planner's solution it is given by a function $\lambda_t = \lambda(\vec{d}_{t-1}, \vec{s}_{t-1})$ which does not depend on ϵ_t.

Solving problem (22), the following conditions must hold for any realization of the shocks ϵ_t:

$$0 = -\alpha_{\pi S}\pi_t - \frac{1}{J}\sum \nu\hat{x}_{j,t} + \frac{1}{J}\Lambda_{j,t}^P(\chi d_{j,t-1} + \kappa) - \lambda_t \tag{69}$$

$$0 = -\alpha_{gS}\hat{g}_{j,t} - \Lambda_{j,t}^P q_L \tag{70}$$

$$0 = \beta_S E_t \frac{\partial V_{t+1}^P}{\partial d_{j,t}} + \frac{1}{J}\Lambda_{j,t}^P \tag{71}$$

$$0 = \nu\hat{x}_{j,t} + \Lambda_{j,t}^P \tag{72}$$

$$d_{j,t} = (R(\bar{d}_{t-1}) + \chi(\pi_t^e - \pi_t))d_{j,t-1} + q_L g_{j,t} - \tau_{j,t} - \kappa\pi_t \tag{73}$$

$$\pi_t^e = E_{t-1}\pi_t \tag{74}$$

$$\frac{\partial V_t^P}{\partial d_{j,t-1}} = -\frac{1}{J}\Lambda_{j,t}^P\left(R(\bar{d}_{t-1}) + \chi(\pi_t^e - \pi_t)\right) - \frac{1}{J^2}\sum_k R'(\bar{d}_{t-1})d_{k,t-1}\Lambda_{k,t}^P. \tag{75}$$

By committing to π_t as a function of ϵ_t, the planner is also committing (at $t-1$) to an expected inflation rate $\pi_t^e = E_{t-1}\pi_t$. The first-order condition for π_t^e is

$$0 = \lambda_t + E_{t-1}\frac{1}{J}\sum_j \left(\nu\hat{x}_{j,t} - \chi\Lambda_{j,t}^P d_{j,t-1}\right)\hat{g}_{j,t}. \tag{76}$$

Simplifying, we see the usual intertemporal relation between $\hat{x}$ and $\hat{g}$:

$$\nu\hat{x}_{j,t} = \frac{\alpha_{gS}}{q_L}\hat{g}_{j,t}. \tag{77}$$

Imposing symmetry to eliminate a covariance term, we can solve for λ_t:[30]

$$\lambda_t = -(1 + \chi d_{t-1})\frac{\alpha_{gS}}{q_L}\hat{g}_t^e, \tag{78}$$

where $\hat{g}_t^e \equiv E_{t-1}\hat{g}_t$. Likewise, a symmetric equilibrium implies an Euler equation for aggregate public spending:

$$\hat{g}_t = \beta_S\left(R(d_t) + R'(d_t)d_t\right)E_t\hat{g}_{t+1}. \tag{79}$$

---

[30]For comparability with our policy games, which were solved under the assumption of symmetric shocks to all regions at all times, we likewise solve the planner's solution under a symmetric scenario. Therefore the planner's policies depend on the ordered triple Ω_t.

In contrast, there is no longer an analogous Euler equation for inflation, because π_t is shifted by the multiplier λ_t. Assuming symmetry, the first-order condition for inflation is

$$-\alpha_{\pi S}\pi_t \;=\; \frac{\alpha_{gS}}{q_L}(1+\kappa+\chi d_{t-1})\hat{g}_t + \lambda_t \;=\; \frac{\kappa\alpha_{gS}}{q_L}\hat{g}_t + (1+\chi d_{t-1})\frac{\alpha_{gS}}{q_L}\left(\hat{g}_t - \hat{g}_t^e\right). \quad (80)$$

Note that λ_t is positive, and hence lowers the inflation rate π_t chosen by the planner. The inflation condition (80) can also be written as a relation between surprise inflation and surprise public spending:

$$-\alpha_{\pi S}\left(\pi_t - \pi_t^e\right) \;=\; \frac{\alpha_{gS}}{q_L}(1+\kappa+\chi d_{t-1})\left(\hat{g}_t - \hat{g}_t^e\right) \quad (81)$$

The budget constraint for aggregate debt can be written as

$$d_t \;=\; \left(R(d_{t-1} + \chi(\pi_t^e - \pi_t))\right)d_{t-1} + (\pi_t^e - \pi_t) + q^*\hat{g}_t - \frac{\kappa\alpha_{gS}}{q_L\alpha_{\pi S}}(1+\chi d_{t-1})\hat{g}_t^e + \tilde{z}, \quad (82)$$

where

$$q^* \;=\; q_L + \frac{\alpha_{gS}}{q_L}\left(\frac{1}{\nu^2} + \frac{\kappa}{\alpha_{\pi S}}(1+\kappa+\chi d_{t-1})\right). \quad (83)$$

We now have three equations, (79), (80), and (82), to solve for the three policy functions $\hat{G}(\Omega)$, $B(\Omega_t)$, and $\Pi(\Omega_t)$. Alternatively, we can eliminate inflation from the budget constraint using (81):

$$
\begin{aligned}
d_t &= R(d_{t-1})d_{t-1} + (1+\chi d_{t-1})(\pi_t^e - \pi_t) + q^*\hat{g}_t - \frac{\kappa\alpha_{gS}}{q_L\alpha_{\pi S}}(1+\chi d_{t-1})\hat{g}_t^e + \tilde{z}_t \\
&= R(d_{t-1})d_{t-1} - \frac{\alpha_{gS}}{q_L\alpha_{\pi S}}(1+\chi d_{t-1})(1+\kappa+\chi d_{t-1})\left(\hat{g}_t - \hat{g}_t^e\right) + q^*\hat{g}_t - \frac{\kappa\alpha_{gS}}{q_L\alpha_{\pi S}}(1+\chi d_{t-1})\hat{g}_t^e + \tilde{z}_t \\
&= R(d_{t-1})d_{t-1} + \left(q_L + \frac{\alpha_{gS}}{\nu^2 q_L}\right)\hat{g}_t + \frac{\kappa^2\alpha_{gS}}{q_L\alpha_{\pi S}}\hat{g}_t^e + \frac{\alpha_{gS}}{q_L\alpha_{\pi S}}(\kappa^2 - (1+\chi d_{t-1})^2)\left(\hat{g}_t - \hat{g}_t^e\right) + \tilde{z}_t.
\end{aligned}
$$
$$\quad (84)$$

Now (79) and (84) suffice to determine the planner's policies $\hat{G}(\Omega_t)$ and $B(\Omega_t)$. The relevant functional equations are:[31]

$$\hat{G}(\Omega_t) \;=\; \beta_S\left(\beta_S^{-1} + 2\delta B(\Omega_t)\right) E_t\hat{G}(B(\Omega_t), s_t, \epsilon_{t+1}), \quad (85)$$

$$
\begin{aligned}
B(\Omega_t) \;=\; R(d_{t-1})d_{t-1} + \left(q_L + \frac{\alpha_{gS}}{\nu^2 q_L}\right)\hat{G}(\Omega_t) + \frac{\kappa^2\alpha_{gS}}{q_L\alpha_{\pi S}}E_{t-1}\hat{G}(\Omega_t) \\
+ \frac{\alpha_{gS}}{q_L\alpha_{\pi S}}(\kappa^2 - (1+\chi d_{t-1})^2)\left(\hat{G}(\Omega_t) - E_{t-1}\hat{G}(\Omega_t)\right) + \tilde{z}_t.
\end{aligned}
$$
$$\quad (86)$$

---

[31]A non-stochastic version of these two equations can be solved first, to find non-stochastic policy functions $\hat{G}_t(d_{t-1}, s_{t-1})$ and $B_t(d_{t-1}, s_{t-1})$, which can then be used as an initial guess for solving the stochastic equations (79) and (84).