

Smoothing Shocks and Balancing Budgets in a Currency Union*

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ABSTRACT

We study simple fiscal rules for stabilizing the government debt in response to asymmetric demand shocks in a country that belongs to a currency union. We compare debt stabilization through tax rate adjustments with debt stabilization through expenditure changes. While rapid and flexible adjustment of public expenditure might seem institutionally or informationally infeasible, we discuss one concrete way in which this might be implemented: setting salaries of public employees, and social transfers, in an alternative unit of account, and delegating the valuation of this numeraire to an independent fiscal authority.

Using a sticky-price DSGE matching model of a small open economy in a currency union, we compare the business cycle implications of several different fiscal rules that all achieve the same reduction in the standard deviation of the public debt. In our simulations, compared with rules that adjust tax rates, a rule that stabilizes the budget by adjusting public salaries and transfers reduces fluctuations in consumption and employment, thus bringing the market economy closer to the social planner's solution.

JEL: E24, E32, E62, F41.

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1. INTRODUCTION

When a country joins a monetary union, the volatility of its sovereign debt increases, for several reasons. According to the standard textbook analysis (Mundell, 1961), asymmetric demand shocks are amplified in a currency union, since exchange rate adjustments no longer serve as a short-cut to relative price changes. Independent monetary policies can no longer offset these shocks; hence member states have an incentive to use fiscal policy to offset them instead. But large macroeconomic shocks like those of the recent crisis can lead rapidly to budget troubles, even if the previous fiscal stance was responsible. Figures 1-2 show how European debts and deficits have ballooned since the beginning of the crisis, and Figures 3-4 focus specifically on Spain¹. This problem is aggravated by the fact that if a country emits debt in a currency it does not control, it loses the ability to fight off self-fulfilling attacks on its debt (Eichengreen and Hausmann 2005; De Grauwe 2011). It is further aggravated by the instability of cross-border banking flows in a monetary union (Bruche and Suárez, 2010).

The turmoil in European sovereign debt markets since 2009 has amply demonstrated that this volatility is not just a theoretical possibility, but a grave threat to the Eurozone. Policy proposals to deal with the crisis have revolved around two competing interpretations of the concept of “fiscal union”. Many economists and political leaders argue that the crisis demonstrates the inviability of the Economic and Monetary Union unless it is accompanied by a federal fiscal government able to transfer substantial resources countercyclically, from economies in expansion to those in recession². But member states with strong public finances have objected to a “fiscal transfer union”, as they call it, because of the moral hazard it creates³. Fearing that they could end up paying for the fiscal imbalances of others, these members instead advocate a “fiscal stability union”, meaning a stronger

1. Figures 1 and 2 report the debt and deficit situation for an aggregate of the euro area, Belgium, Germany, Ireland, Greece, Spain, France, Italy, Portugal, Sweden and the United Kingdom for 2007 and 2009. All data displayed in figures come from Eurostat. Quantities in Figures 1-2 correspond to government consolidated gross debt as a percentage of GDP, and net lending (+) or borrowing (-) in ESA 1995 as a percentage of GDP, respectively. Note that most of these countries went from surpluses or balance in 2007 into deficits in 2009 (Greece is exceptional in that it was already running a large deficit in 2007).

2. See for example *Financial Times*, 8 December 2010; *Wall Street Journal*, 3 June 2011; or Pisani-Ferry (2012).

3. See *The Economist*, 2 December 2010.

version of the debt and deficit limits, backed by monitoring and sanctions, that constituted the Stability and Growth Pact (SGP).

Figure 1.
International Comparison of Debt-to GDP Ratios

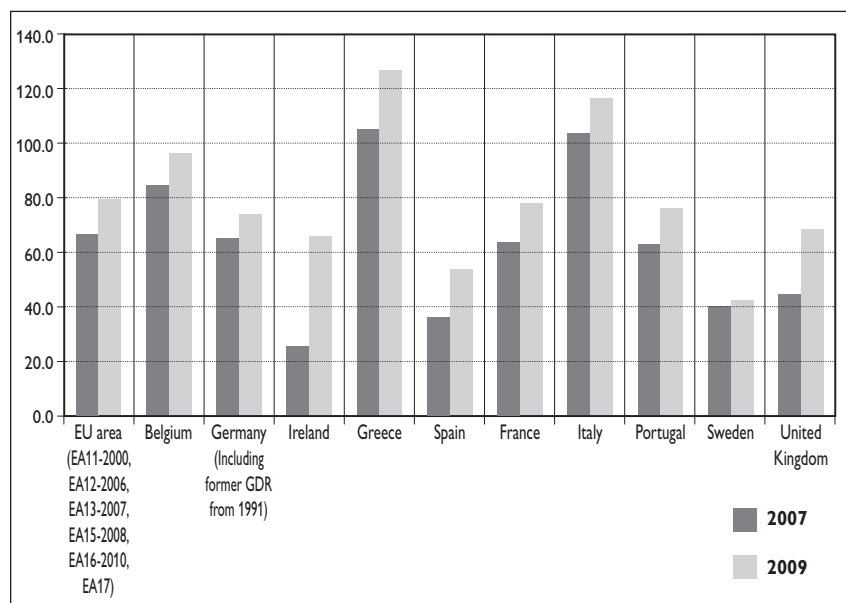
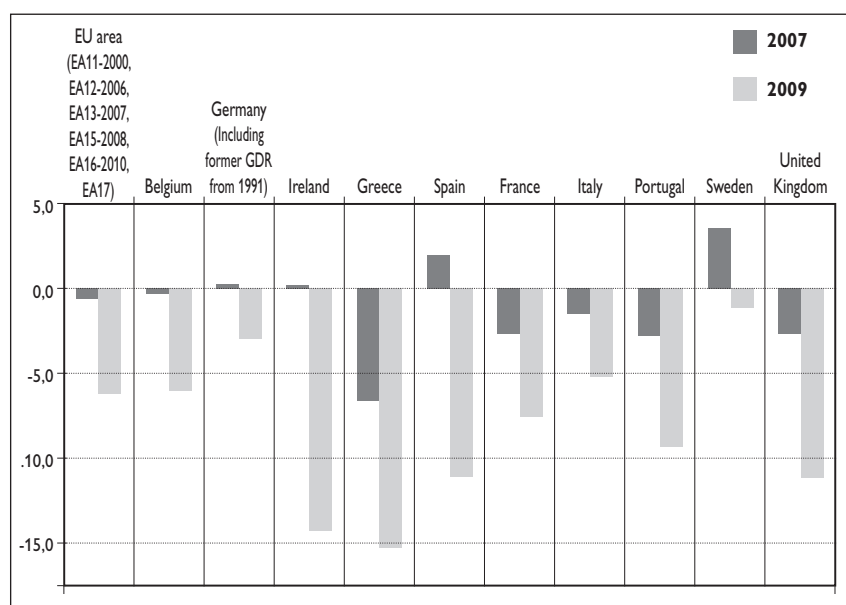


Figure 2.
International Comparison of Deficit-to GDP Ratios



In this paper, we explore a third alternative: the establishment of a more effective class of fiscal rules. Whereas the SGP limited debt and deficit levels without specifying which fiscal instruments should adjust to enforce those limits, we consider rules that would guide specific instruments in response to economic and budgetary conditions. We build a macroeconomic model to compare the stabilization properties of different instruments that could be used to reduce debt fluctuations. Crucially, we find that an appropriate choice of the fiscal rule can eliminate the tradeoff between budget stabilization and cyclical stabilization when the economy is hit by asymmetric demand shocks. While an especially obvious rule to keep debt under control would be one that raised (lowered) taxes whenever the deficit started to rise (fall), such a rule tends to amplify business cycle fluctuations, since it implies tax increases in recessions. Therefore, we also consider adjustments on the spending side of the budget, and we argue that the quickest and most flexible way to adjust spending is to make across-the-board adjustments in all forms of public labor compensation and all gross transfers from the public sector. We show that a rule mandating adjustments of this type (in contrast with tax adjustments) has the beneficial side effect of stabilizing macroeconomic fluctuations at the same time that it stabilizes the debt.

The present paper studies the stabilization properties of different fiscal rules. But these stabilization properties are irrelevant unless it can be guaranteed that the rule is actually followed; and the government's willingness to follow the rule is irrelevant if the rule is too politically, informationally, or administratively difficult to implement. Therefore, in the next subsection, we spell out an institutional framework designed to facilitate the implementation and enforcement of a spending rule like the one described above. First, implementation of the rule would be delegated to an independent fiscal authority with a mandate to guarantee long-term budget balance, leaving all other fiscal decisions up to the government. Second, across-the-board shifts of public salaries and transfers would be simplified by budgeting all these items in an alternative unit of account, which could subsequently be revalued or devalued in terms of euros. The details are discussed in the next subsection, and the relevant political economy issues are analyzed in depth in a companion paper, Costain and de Blas (2012b).

1.1 A Framework for Rapid Adjustments of Public Spending

Establishing a new fiscal rule in law or administrative process does not guarantee that the rule will actually be followed. To gain credibility and avoid crises in the ongoing context of sovereign debt turmoil, eurozone countries need institutions that provide the strongest possible enforcement of their own fiscal rules. Therefore, it is worth recalling that many economists in recent years have proposed enhancing budget stability by delegating some fiscal decisions to an independent authority, modeled along the lines of an independent central bank⁴. Just as most independent central banks are mandated to achieve price stability, before other objectives, making them “conservative” in the sense of Rogoff (1985), an independent fiscal authority could be given a primary mandate of budget stability. Ideally, it would control just a few quantitative levers of fiscal policy with a powerful effect on the budget, while leaving all other tax and spending decisions to the government. Insofar as it focuses solely on the technical and quantitative issue of long-term budget stability, the fiscal authority would not really eliminate any *feasible* profiles of taxes and spending from the government’s choice set. Instead, it would simply decrease the government’s risk of failing to run mutually consistent tax and spending policies, due to technical or political errors. If it thereby lowers the risk premium on the sovereign debt, this may actually expand the set of affordable fiscal policies from which the government can choose.

If a country proposes to reinforce its budgetary stability by establishing an independent fiscal authority, it must still decide which fiscal instruments to delegate to that authority. On one hand, inspired by the SGP, the authority might be mandated to set deficit and debt limits, perhaps with some power to sanction the government if the limits are not respected. But this approach would not really delegate any effective instrument to the authority; neither declaring a limit nor imposing a sanction actually improves budget balance. To actually guarantee budget sustainability, the fiscal authority would need to control some broad budget parameter(s); for example, it might be delegated control of some tax rates. If the

4. Prominent examples include von Hagen and Harden (1995), Blinder (1997), Eichengreen et al. (1999), Calmfors (2003), Wyplosz (2005), and Leeper (2009). The theory of independent fiscal authorities is surveyed by Debrun, Hauner, and Kumar (2009).

Figure 3.
Evolution of Spanish Public Debt: 1995-2009

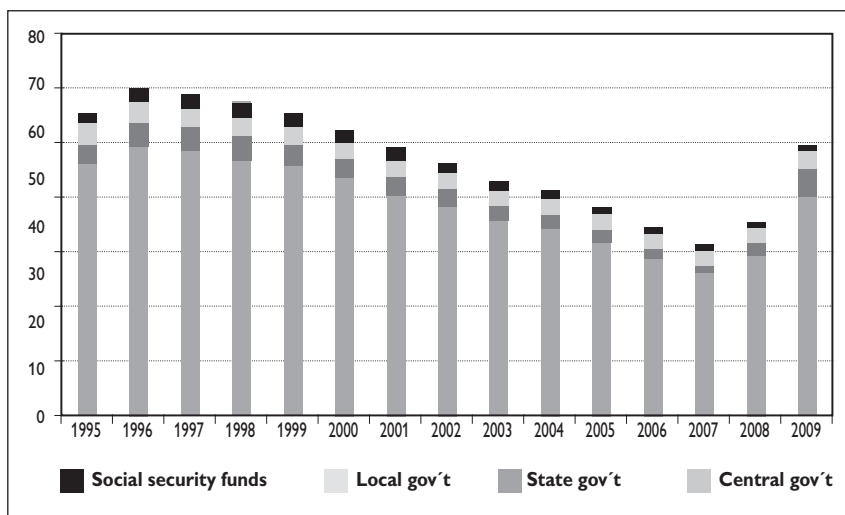
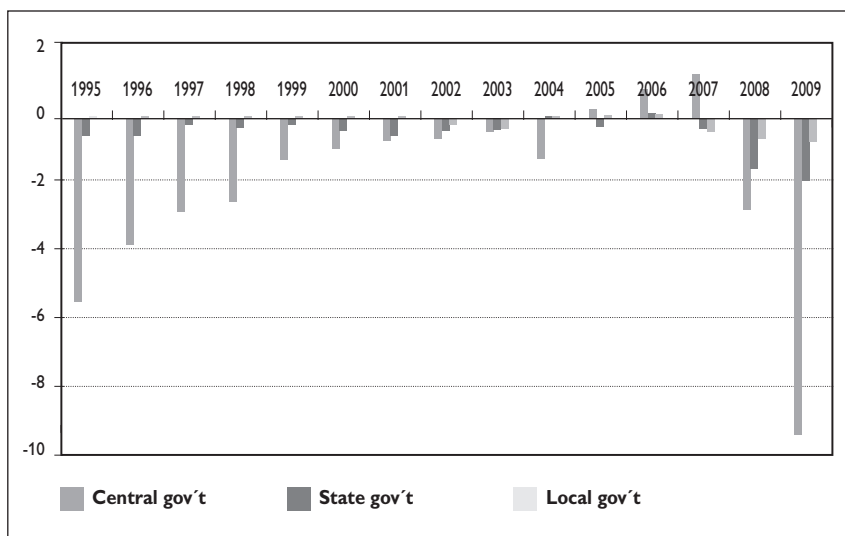


Figure 4.
Evolution of Spanish Public Deficit: 1995-2009



adjustments are to be made on the spending side instead, they could involve shifts of (a) quantities of goods and services purchased by the public sector; or of (b) quantities of labor employed by the public sector; or of (c) quantities of cash transferred to individuals, firms, or lower levels of government; or of (d) the salaries and other forms of compensation paid to public employees. Note that there is

an important difference between options (a)-(b) and options (c)-(d). The public sector purchases a huge variety of goods and services and labor for diverse purposes. Each particular case may involve fixed costs, or adjustment costs, which would need to be considered individually when adjusting the quantity purchased, making across-the-board adjustments of types (a)-(b) extremely inefficient. In contrast, adjusting (c)-(d) need not imply any changes in real public purchases, so these can be shifted across-the-board without disrupting the government's operations⁵. Moreover, as we already pointed out, lowering transfers and public salaries when a recession hits is doubly beneficial, since it both reduces the deficit and stimulates employment by lowering wage pressure. Many governments recently made *ad hoc* adjustments on these margins in response to the crisis; this paper considers a more permanent and automatic mechanism for adjusting them⁶.

Rapid adjustment of the many different forms of public labor compensation and public transfer payments requires the definition of some across-the-board shift parameter affecting all these payments simultaneously. A particularly clear and simple way to do this would be to budget all of these items in an alternative unit of account. This unit might be called, for example, the "public spending unit" (PSU)⁷. The fiscal authority would intermittently reset the "exchange rate" X , the euro value of one PSU. The fiscal authority would take into account tax policy, government expenditure policy, and the state of the business cycle, resetting X regularly for consistency with a long-run target level for public debt. Assuming public wages and social transfers are paid once per month, the fiscal authority could conveniently recalculate the appropriate value of X on a monthly basis, before paychecks are issued. For additional deficit-fighting power, the fiscal authority might also have the mandate, at most once per year, to shift up or down the schedule of income taxes or VAT rates.

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5. We assume throughout that public employees obtain a strictly positive match surplus: that is, they strictly prefer to remain employed by the public sector, instead of searching for a job elsewhere. This is true in equilibrium in our search and matching model. Given a strictly positive match surplus, public employees will continue to work even when they are hit by a small cut in wages.
 6. Gomes (2011) assumes the government can set public sector wages, and shows that the government should optimally decrease them in recessions, or when public spending needs rise. Our model has similar implications, even though we assume that public sector wages are the result of a sticky bargaining process, instead of being freely chosen by the government.
 7. Buitier (2007) studies monetary policy when the medium of exchange differs from the unit of account.

Figure 5.
Evolution of Components of Spanish Public Expenditure: 2007-2009

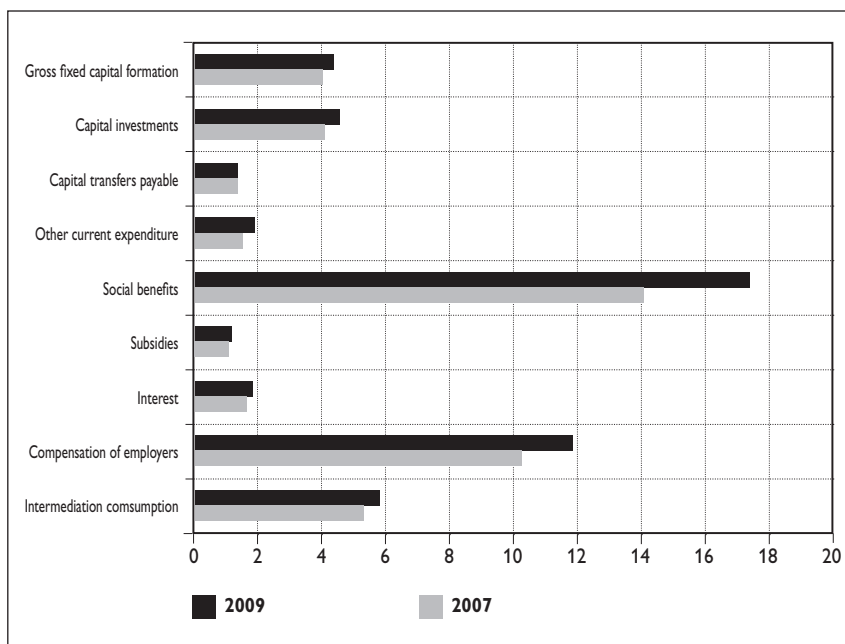
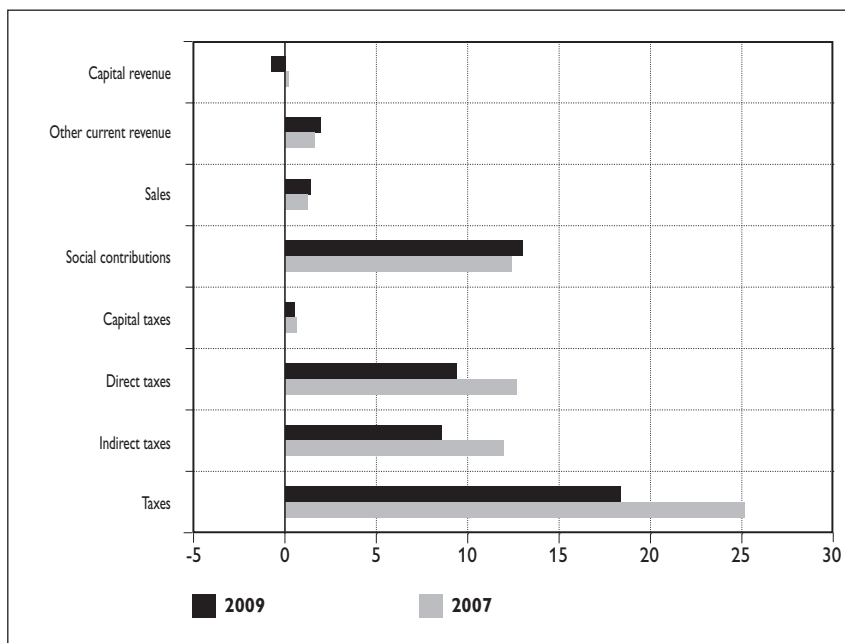


Figure 6.
Evolution of Components of Spanish Public Revenues: 2007-2009



Notice that this system helps prevent the excessive fluctuations associated with a monetary union by directly attacking the root cause of the problem: nominal rigidity in the common currency⁸. By allowing the relative price between private and public purchases to vary with the state of the economy, this system would restore some of the flexibility enjoyed by a country with a floating exchange rate. Defining this relative price by introducing a new unit of account might seem unnecessary, but doing so would greatly simplify policy decisions. Instead of adjusting thousands of prices or quantities of individual public spending items, the fiscal authority would shift the budget by adjusting a single relative price⁹. Moreover, defining a unit of account that differs from the medium of exchange is not an entirely new idea; for example, this was done deliberately in Brazil in 1994¹⁰. In its efforts to end an ongoing hyperinflation, the Brazilian government defined the “unidade real de valor” (URV), which tracked the value of the U.S. dollar. It mandated the conversion of all wages and salaries to URV, to be paid in cruzeiros (the circulating currency) at an official exchange rate that was published daily. Many private firms began to state their prices in URV, and the public quickly learned that these prices were stable. After some months, the government introduced a new currency (the real) with a value equal to one URV. But this example (like many other historical examples from inflationary countries) demonstrates that the public is perfectly capable of dealing in a unit of account different from the currency it uses in exchange. We argue that the flexibility gained by defining a new unit of account is not only useful in inflationary situations, but could also help make a monetary union more resilient in response to shocks.

8. One example of the importance of nominal rigidity in public spending is the continued increase in compensation of Spanish public employees (by 2% of Spanish GDP) in 2007-09 in the midst of the financial crisis, as seen in Figure 5. The figure also shows that compensation of public employees and social transfers make up roughly 60% of total government expenditure in Spain. Thus an adjustment along these two margins represents an across-the-board shift in the large majority of expenditure.

9. Like us, Farhi, Gopinath and Itskhokhi (2011) show that the loss of an independent monetary instrument in a currency union may be undone by considering policy instruments ignored in the standard textbook analysis. However, their proposal requires coordinated changes in four different tax rates in response to shocks; the mechanisms discussed here would be simpler for policy makers to implement.

10. Buiter (2007) studies how macroeconomic policy would differ in an economy with a unit of account distinct from the medium of exchange. See Dornbusch (1997) for a discussion of the “Real Plan” in Brazil.

1.2 Structure of this Paper

In order to compare the macroeconomic effects of the different policy rules we have been discussing, we need a model that distinguishes between public and private employment, in which public and private wages may differ without triggering an instantaneous reallocation of labor across the two sectors¹¹. Therefore, this paper constructs a sticky-price DSGE matching model of a small open economy in the context of a currency union. Bargaining in the private sector takes place in euros; bargaining in the public sector is assumed to take place (by law) in an alternative unit of account, called the PSU. Since workers may find jobs in either sector, a decrease in real public wages due to a devaluation of the PSU will feed across to the private sector as well. This is reinforced by the fact that unemployment benefits are also denominated in PSU. The model represents the action of the fiscal authority by two rules. The first rule sets the exchange rate X —the euro value of one PSU—on a period-by-period basis, following a rule that reacts to the level of public debt, the level of output, and the level of government spending (relative to steady-state output). The second rule sets the tax rate on labor income, τ , as a function of the same variables.

Prior to the current crisis, sovereign bonds from different eurozone countries were regarded as good substitutes, so member states could let their debt levels fluctuate without suffering high risk premia. But today there is little market for cross-border lending, so countries must find ways to reduce the level and variability of their debts, in order to avoid speculative attacks. The policy experiments we study in this paper address this problem, comparing several alternative rules to stabilize government debt. We assume business cycles are driven by shocks to foreign prices, an export demand shifter, government spending, and the interest rate in the rest of the union, since these are asymmetric shocks to which the analysis of Mundell (1961) could apply. To get some initial intuition about the role of nom-

11. We emphasize that this paper compares the macroeconomic effects of different policy rules *without* analyzing the political economy issues involved in their institutional implementation. We review the political economy of fiscal policy delegation in a companion paper, Costain and de Blas (2012b). Other papers that evaluate the potential for independent fiscal agencies include Wren-Lewis (2010) and Wyplosz (2008).

inal rigidity in a monetary union, we first analyze how this rigidity affects the economy's response to shocks. Lower stickiness (of prices or wages) stabilizes total debt and employment, and brings consumption closer to the social planner's solution. Next we fix the degree of nominal rigidity, and compare various policy rules that reduce debt fluctuations, either by adjusting the tax rate τ or the public-sector exchange rate X in response to macroeconomic and/or budgetary conditions. When debt is stabilized by varying the tax rate, fluctuations in consumption and labor are amplified by a nontrivial amount. If debt is stabilized instead by varying the public sector exchange rate X , then the business cycle fluctuations in consumption and labor are reduced too, bringing the dynamics closer to the social planner's solution for the economy.

The remainder of this paper describes our model and uses it to analyze the budgetary and cyclical implications of various fiscal rules. Section 2 defines preferences and technologies and states the social planner's problem. Section 3 describes a decentralized market equilibrium. Section 4 analyzes how the various inefficiencies of the decentralized equilibrium alter the economy's response to shocks. Finally, Section 5 studies different fiscal rules that stabilize government debt in the market economy, comparing how each rule affects the cyclical fluctuations of other macroeconomic variables. Section 6 concludes.

2. A SMALL OPEN ECONOMY FACING ASYMMETRIC DEMAND SHOCKS

In this section we describe a small open economy that suffers business cycles driven by asymmetric demand shocks. Before considering a decentralized market version of the economy, we study the social planner's solution, as a benchmark for comparison.

Since we wish to analyze the effects of adjusting public sector wages, our model distinguishes private -from public- sector employment. We assume that employment cannot be instantly reallocated from one sector to the other; we therefore model employment in terms of a matching technology. This allows us to study an equilibrium in which wages differ (but interact) across sectors.

2.1 Preferences Over Final Goods

There is a unit mass of households in the home country, with the lifetime utility function

$$E_t \sum_{l=0}^{\infty} \beta^{l-t} \left(\frac{c_t^{1-\eta_0} - 1}{1 - \eta_0} - \chi_n \frac{n_t^{1+\psi_n}}{1 + \psi_n} \right) \quad (1)$$

where $0 < \beta < 1$ is a constant discount factor, c_t denotes consumption, and n_t denotes total labor supply.

Following Galí and Monacelli (2005), the final consumption good is a CES aggregate of home and foreign goods:

$$c_t = \left[(1 - \alpha_f)^{\frac{1}{\eta_1}} (c_t^h)^{\frac{\eta_1-1}{\eta_1}} + \alpha_f^{\frac{1}{\eta_1}} (c_t^f)^{\frac{\eta_1-1}{\eta_1}} \right]^{\frac{\eta_1}{\eta_1-1}} \quad (2).$$

Home consumption c_t^h is itself a CES aggregate with elasticity of substitution η_2 , across a unit mass of differentiated home retail goods, indexed by $j \in [0, 1]$:

$$c_t^h = \left(\int_0^1 (c_{j,t}^h)^{\frac{\eta_2-1}{\eta_2}} dj \right)^{\frac{\eta_2}{\eta_2-1}} \quad (3).$$

We assume $\eta_2 > \eta_1$: demand is more elastic across differentiated retail goods than it is between domestic and foreign aggregates.

Foreigners also value the same aggregate of home retail goods that the home households do. Their aggregate purchases of these goods are denoted c_t^x :

$$c_t^x = \left(\int_0^1 (c_{j,t}^x)^{\frac{\eta_2-1}{\eta_2}} dj \right)^{\frac{\eta_2}{\eta_2-1}} \quad (4).$$

Finally, the government also demands a CES aggregate of differentiated goods, which we will call public goods, to distinguish them from the retail goods consumed by the households. For simplicity, we assume the same functional form and the same elasticity in the public sector as in the retail sector. Thus aggregate government consumption g_t is given by

$$g_t = \left(\int_0^1 (g_{j,t})^{\frac{\eta_2-1}{\eta_2}} dj \right)^{\frac{\eta_2}{\eta_2-1}} \quad (5).$$

2.2 Production and Matching Technologies

Differentiated goods are indexed both by sector, $i \in \{h, g\}$, where h indicates the retail sector and g indicates the public sector, and by $j \in [0, 1]$, which refers to a specific good produced in that sector. Production $y_{j,t}^i$ of good j in sector i is given by a trivial linear production function:

$$y_{j,t}^i = k_{j,t}^i \quad (6)$$

where $k_{j,t}^i$ is the quantity of intermediate inputs used to produce $y_{j,t}^i$.

Intermediate inputs k_t^i are sector-specific. They are produced linearly, using labor as the only input, according to the production function

$$k_t^i = a n_t^i \quad (7)$$

where a represents labor productivity, and n_t^i is labor supplied to sector $i \in \{h, g\}$.

Households can only supply labor by finding appropriate jobs, which occurs through a matching technology. The number of jobs filled in period t is given by the matching function

$$a_m (u_t^s)^{\alpha_u} v_t^{1-\alpha_u} \quad (8)$$

where v_t is the number of vacant jobs in the economy, and u_t^s is the number of effective job searchers, with $a_m > 0$ and $\alpha_u \in (0, 1)$. The ratio $\theta_t = v_t/u_t^s$ will be called “labor market tightness”.

We assume all searchers have the same probability of finding a job, so this probability is

$$s_t = a_m \theta_t^{1-\alpha_u} \equiv s(\theta_t) \quad (9).$$

Similarly, the probability of a vacancy being filled is

$$q_t = a_m \theta_t^{-\alpha_u} \equiv q(\theta_t) \quad (10)$$

implying $s(\theta_t) = \theta_t q(\theta_t)$.

Matching is random, so a searcher may find a job in either sector. Thus, if we write vacancies in the private and public sectors as v_t^h and v_t^g , respectively, with $v_t^h + v_t^g = v_t$, then a searcher's probability of finding a job in sector $i \in \{h, g\}$ is

$$s_t^i = s(\theta_t) \frac{v_t^i}{v_t} \quad (11).$$

The dynamics of employment in sector i are

$$n_t^i = (1 - \delta_n)n_{t-1}^i + q(\theta_t)v_t^i \quad (12)$$

where δ_n is an exogenous match separation rate.

Both the workers unemployed at time $t - 1$, and those who just lost their jobs at the end of $t - 1$, are included in the search pool for time t jobs. That is,

$$u_t^s = 1 - n_{t-1} + \delta_n n_{t-1} = 1 - (1 - \delta_n)n_{t-1} \quad (13).$$

This timing implies (as in Blanchard and Galí, 2009) that some workers and vacancies find matches immediately, without spending a full period unemployed, so that employment can adjust to shocks immediately along the extensive margin¹². Following Thomas (2008), the cost of creating v_t^i vacancies in sector i at time t is¹³

$$\frac{\chi_v}{1 + \psi_v} \left(\frac{v_t^i}{n_{t-1}^i} \right)^{\psi_v} v_t^i \quad (14).$$

This cost is denominated in units of the sector- i intermediate good.

2.3 Aggregate Consistency Conditions

Total intermediate goods used in sector i must equal the total quantity produced¹⁴:

$$\int_0^1 k_{j,t}^i dj = k_t^i = a n_t^i - \frac{\chi_v}{1 + \psi_v} \left(\frac{v_t^i}{n_{t-1}^i} \right)^{\psi_v} v_t^i \quad (15).$$

12. Given our quarterly calibration, this timing assumption avoids imposing an unrealistic lower bound on the length of an unemployment spell.

13. This cost function is applicable at all scales. Thus, in the decentralized economy, if a firm l in sector i with lagged employment $n_{l,t-1}^i$ creates $v_{l,t}^i$ vacancies, it pays $\frac{\chi_v}{1 + \psi_v} \left(\frac{v_{l,t}^i}{n_{l,t-1}^i} \right)^{\psi_v} v_{l,t}^i$ units of the sector- i intermediate good to do so.

14. Equation (15) assumes vacancy costs are paid by the planner. When we define the market economy we must integrate these costs across decentralized producers of intermediate goods.

Likewise, for each differentiated good j in each sector, the quantity used must equal the quantity produced:

$$c_{j,t}^h + c_{j,t}^x = y_{j,t}^h = k_{j,t}^h \quad (16)$$

$$g_{j,t} = y_{j,t}^g = k_{j,t}^g \quad (17)$$

respectively. Also, total labor supplied must equal employment in the two sectors:

$$n_t = n_t^h + n_t^g \quad (18).$$

Total income and spending need not be equalized in the small open economy, because it can borrow and lend from the rest of the world. Transactions with the rest of the world are denominated in a currency which we will call the euro. P_t^f will represent the price of the imported consumption good c_t^f , and $P_{j,t}^x$ will be the price of exports of retail good j , so the nominal trade balance will equal $\int_0^1 P_{j,t}^x c_{j,t}^x dj - P_t^f c_t^f$. The price of home country bonds emitted in euros at time t will be $\frac{1}{R_t I_t}$, where $R_t - 1$ is the world interest rate, and $I_t - 1$ is a risk premium on home country bonds. Therefore the dynamics of the debt of the small open economy (in euros) are

$$\frac{D_t}{R_t I_t} = D_{t-1} + P_t^f c_t^f - \int_0^1 P_{j,t}^x c_{j,t}^x dj \quad (19)$$

where D_t is the euro face value of debt emitted at t , to be paid off at time $t + 1$.

The risk premium that makes foreign lenders willing to accept home country debt is assumed to vary with the level of debt¹⁵:

$$I_t = \exp \left(\psi_I \left(\frac{D_t}{P_{ss} Y_{ss}} - \bar{d} \right) \right) \quad (20)$$

where $\psi_I > 0$ and \bar{d} are exogenous parameters. Throughout, we use the subscript ss to represent steady-state values¹⁶. Here, $P_{ss} Y_{ss}$ represents the steady-state home-country output in nominal terms (that is, in euros).

15. Up to a first-order approximation, this premium is equivalent to that assumed by Schmitt-Grohe and Uribe (2003).

16. For simplicity, our model lacks a trend; “steady-state” quantities in the model should be interpreted as “trend” quantities in reality.

2.4 Shock Processes

The home country is regarded as a small open economy; the rest of the world is a monetary union, of which the home country is an infinitesimal member. Since our focus is on the home country, we treat the behavior of the rest of the world as exogenous. Thus, the rest of the world determines the nominal interest rate, which follows an exogenous stochastic process:

$$\frac{R_t}{R^*} = \left(\frac{R_{t-1}}{R^*} \right)^{\rho_R} \exp(\epsilon_t^R) \quad (21)$$

where ϵ_t^R is a mean-zero, normal shock. Likewise, the foreign price level follows an exogenous stochastic process:

$$\frac{P_t^f}{P^{f*}} = \left(\frac{P_{t-1}^f}{P^{f*}} \right)^{\rho_f} \exp(\epsilon_t^f) \quad (22)$$

where ϵ_t^f is a mean-zero normal shock. Gross exports depend negatively on the price of the local good, as well as an exogenous shifter:

$$c_t^x = \chi_t^x \left(\frac{P_t^x}{P_t^f} \right)^{-\eta_3} \quad (23)$$

$$\frac{\chi_t^x}{\chi^{x*}} = \left(\frac{\chi_{t-1}^x}{\chi^{x*}} \right)^{\rho_x} \exp(\epsilon_t^x) \quad (24)$$

where ϵ_t^x is a mean-zero normal shock. It is natural to assume $\eta_2 > \eta_3 > \eta_1$, that is, the elasticity of demand for any given firm's output is greater than that for any given country's output, which is greater than that between domestic and foreign aggregates.

Finally, since our paper focuses mainly on the financing of government purchases, rather than their level, we treat government demand as an exogenous process:

$$\frac{g_t}{g^*} = \left(\frac{g_{t-1}}{g^*} \right)^{\rho_g} \exp(\epsilon_t^g) \quad (25)$$

where ϵ_t^g is a mean-zero normal shock.

2.5 Social Planner's Problem

In order to have an efficient benchmark against which to compare the effects of policy in the decentralized equilibrium, we now consider the problem of a planner who maximizes the welfare (1) of the representative household of the small open economy, taking as given the technology and constraints described in Section 3, including the behavior of the rest of the world.

The planner must respect the exogenous process for government purchases, but can costlessly reassign financial resources across domestic agents (in other words, the planner can levy lump sum taxes). While the planner controls economic activity in the small open economy, it takes as given the behavior of the monetary union (the rest of the world), including the exogenous shock processes governing the interest rate r_t , the foreign price level P_t^f , and the level of demand for domestic exports χ_t^x , as well as foreigners' Dixit-Stiglitz preferences across domestic retail goods. Finally, the planner can borrow and save in international markets in euro-denominated bonds, subject to a risk premium I_t that depends on the real debt-to-output ratio.

In the absence of sticky prices and wages that will affect the decentralized version of this economy, all firms are identical in this model. Therefore the social planner prefers a symmetric solution across all differentiated products. Imposing symmetry, so that $c_{j,t}^h \equiv c_t^h$, $c_{j,t}^x \equiv c_t^x$, and so forth, the social planner's problem is:

$$\max_{D_t, I_t, c_t, c_t^h, c_t^x, P_t^x, v_t^h, v_t^g, n_t^h, n_t^g, \theta_t} E_t \sum_{l=0}^{\infty} \beta^{l-t} \left(\frac{c_t^{1-\eta_0} - 1}{1 - \eta_0} - \chi_n \frac{(n_t^h + n_t^g)^{1+\psi_n}}{1 + \psi_n} \right) \quad (26)$$

$$\text{subject to:} \quad (27)$$

$$\frac{D_t}{R_t I_t} = D_{t-1} + P_t^f c_t^f - P_t^x c_t^x \quad (28)$$

$$c_t = \left[(1 - \alpha_f)^{\frac{1}{\eta_1}} (c_t^h)^{\frac{\eta_1-1}{\eta_1}} + \alpha_f^{\frac{1}{\eta_1}} (c_t^f)^{\frac{\eta_1-1}{\eta_1}} \right]^{\frac{\eta_1}{\eta_1-1}} \quad (29)$$

$$c_t^x = \chi_t^x \left(\frac{P_t^x}{P_t^f} \right)^{-\eta_3} \quad (30)$$

$$c_t^h + c_t^x = a n_t^h - \frac{\chi_v}{1 + \psi_v} \left(\frac{v_t^h}{n_{t-1}^h} \right)^{1+\psi_v} n_{t-1}^h \quad (31)$$

$$g_t = an_t^g - \frac{\chi_v}{1 + \psi_v} \left(\frac{v_t^g}{n_{t-1}^g} \right)^{1+\psi_v} n_{t-1}^g \quad (32)$$

$$n_t^h = (1 - \delta_n)n_{t-1}^h + a_m \theta_t^{-\alpha_u} v_t^h \quad (33)$$

$$n_t^g = (1 - \delta_n)n_{t-1}^g + a_m \theta_t^{-\alpha_u} v_t^g \quad (34)$$

$$\theta_t = \frac{v_t^h + v_t^g}{1 - (1 - \delta_n)(n_{t-1}^h + n_{t-1}^g)} \quad (35)$$

$$\ln I_t = \psi_I \left(\frac{D_t}{P_{ss} Y_{ss}} - \bar{d} \right) \quad (36)$$

and subject to the four shock processes (21), (22), (24), and (25).

Equation (28) states the budget constraint for the social planner: it describes the evolution of total national debt, in euros, as a function of the trade balance. Note that (30) implies that the social planner acts as if the local economy were a monopolistic competitor it chooses the price of the exported good, P_t^x , taking into account the world demand curve for those exports. Equations (33)-(35) describe the matching technology that restricts the planner's ability to reassign labor across sectors; equations (31)-(32) describe total production in the private and public sectors, taking into account the linear production technology. Two key implications of the planner's solution are the Euler equations that govern vacancies in sectors $i \in \{h, g\}$:

$$\lambda_t^{ni} = a\lambda_t^{yi} - \chi_n(n_t)^{\psi_n} + \beta E_t \left[\lambda_{t+1}^{yi} \frac{\chi_v \psi_v}{1 + \psi_v} (z_{t+1}^i)^{1+\psi_v} + (1 - \delta_n)(\lambda_{t+1}^{ni} - \lambda_{t+1}^\theta \theta_{t+1}) \right] \quad (37)$$

where λ_t^{yi} represents the multipliers on constraints (31)-(32), λ_t^{ni} represents the multipliers on constraints (33)-(34), and λ_t^θ is the multiplier on (35).

Shortly, we will analyze impulse responses of the planner's problem with respect to the shocks in the model. But first, we define a market equilibrium of this economy in the context of a monetary union, so that we can compare the two side by side.

3. THE SMALL OPEN ECONOMY IN A CURRENCY UNION

Now that we have defined an optimal allocation in this economic environment, we next consider how a market economy

responds to these shocks. In particular, we assume that the small open economy defined above forms part of a monetary union. Unlike the planner's economy, we assume that the market economy faces nominal rigidities in price and wage adjustment. Since the labor market is subject to search frictions, we will assume that wages are intermittently adjusted through a Nash bargaining process.

3.1 Decision Makers in the Decentralized Economy

In the decentralized economy, *households* choose consumption over time. They supply labor through a random matching technology, and borrow or lend as necessary to finance consumption in response to their fluctuating income.

Retailers purchase intermediate goods, and resell them, monopolistically, as differentiated final goods. One set of retailers acts in the private sector, and another in the public sector.

Intermediate goods producers hire workers through a random matching technology to produce intermediate goods, which they sell in a competitive market. The intermediate good used in the private sector differs from that used in the public sector; one set of producers serves the private sector, while another serves the public sector (we sometimes refer to these public sector producers as “government agencies”).

The government demands an aggregate of differentiated final goods. The total quantity demanded is simply treated as an exogenous stochastic process.

Control of one or more parameters of fiscal policy is assumed to be delegated to a *fiscal authority*. The fiscal authority's decision is represented by a rule that determines the delegated parameter as a function of observable macroeconomic data.

Behavior of the *rest of the world* is exogenous from the point of view of the home economy. It affects the home economy by determining interest rates, determining an interest premium on home country debt as a function of the debt level, supplying an import good, and demanding the home export good.

3.2 Households

Households maximize the utility function (1) subject to the following period budget constraint:

$$\frac{D_t^h}{R_t I_t^h P_t^c} = \frac{D_{t-1}^h}{P_t^c} + c_t - (1 - \tau_t) \left[\int_0^1 w_{l,t}^h n_{l,t}^h dl + \int_0^1 w_{k,t}^g n_{k,t}^g dk \right] - (1 - n_t) b_t - \text{Div}_t \quad (38).$$

Here D_t^h is nominal household debt emitted in period t , and P_t^c is the consumer price index. $R_t I_t^h$ is the gross nominal interest rate, where R_t is the world interest rate, and I_t^h is a risk premium. The household owns the firms, receiving a dividend payment Div_t . The household pays a flat tax rate τ_t on its labor income, which is derived from employment at a continuum of private firms l and a continuum of government agencies k . Employment of household members at firm l is $n_{l,t}^h$, and these workers earn real wage $w_{l,t}^h$; the employment and real wage at agency k are $n_{k,t}^g$ and $w_{k,t}^g$. Unemployed members of the household receive a subsidy b_t ; $n_t = \int_0^1 n_{l,t}^h dl + \int_0^1 n_{k,t}^g dk = n_t^h + n_t^g$ the fraction of household members employed.

Notice that this budget constraint implies that household members insure one another by sharing labor income between the employed and unemployed. The household does not choose employment directly; instead, it is determined in equilibrium by a process of matching and bargaining.

Since the household knows that the interest premium rises with debt, its consumption Euler equation is

$$\left(1 - \frac{D_t^h (I_t^h)' (D_t^h)}{I_t^h} \right) c_t^{-\eta_0} = R_t I_t^h P_t^c \beta E_t \frac{c_{t+1}^{-\eta_0}}{P_{t+1}^c} \quad (39)$$

where $(I_t^h)' (D_t^h)$ is the derivative of I_t^h with respect to D_t^h . The household allocates expenditure across imported goods c_t^f and the home aggregate c_t^h to minimize the cost of attaining its total aggregate consumption c_t , given its aggregation preferences (2). The resulting demand functions are:

$$c_t^h = (1 - \alpha_f) \left(\frac{P_t^h}{P_t^c} \right)^{-\eta_1} c_t, \quad c_t^f = \alpha_f \left(\frac{P_t^f}{P_t^c} \right)^{-\eta_1} c_t \quad (40).$$

Here P_t^h and P_t^f are price aggregates for domestic and foreign goods, and the domestic consumer price index P_t^c is defined as

$$P_t^c = \left[(1 - \alpha_f) (P_t^h)^{1-\eta_1} + \alpha_f (P_t^f)^{1-\eta_1} \right]^{\frac{1}{1-\eta_1}} \quad (41).$$

Likewise, its preferences (3) across differentiated retail goods imply that the demand function for good j is:

$$c_{j,t}^h = \left(\frac{P_{j,t}^h}{P_t^h} \right)^{-\eta_2} c_t^h \quad (42)$$

where $P_{j,t}^h$ denotes the price of the intermediate good j , and P_t^h is a price index for domestically-produced private-sector goods:

$$P_t^h = \left(\int_0^1 (P_{j,t}^h)^{\eta_2-1} dj \right)^{\frac{1}{\eta_2-1}} \quad (43).$$

3.3 Final Goods Producers

Allocation of demand across differentiated products by foreigners and the government is analogous to (42). Therefore, the private retailers and government agencies that produce the differentiated goods j and k , respectively, act as monopolistic competitors facing the following demand curves:

$$Y_{j,t}^h = \left(\frac{P_{j,t}^h}{P_t^h} \right)^{-\eta_2} Y_t^h, \quad \text{where } Y_t^h = c_t^h + c_t^x \quad (44)$$

$$Y_{k,t}^g = \left(\frac{P_{k,t}^g}{P_t^g} \right)^{-\eta_2} g_t, \quad \text{where } Y_t^g \equiv g_t \quad (45).$$

Each of these final producers, in sectors $i \in \{h, g\}$, operates a linear production function that depends on a homogeneous intermediate input, purchased at nominal price $P_t^c \phi_t^i$. As in Calvo (1983), prices are “sticky” for a random number of periods. Each period, a firm gets the chance to adjust its price with probability $1 - \xi_p$, or with probability ξ_p its price remains constant: $P_{j,t}^i = P_{j,t-1}^i$. If it gets to reset its price in period t , it sets its new price $\tilde{P}_{j,t}^i$ to maximize expected discounted profits over the periods in which this price remains fixed. Thus its decision problem is:

$$\max_{\tilde{P}_{j,t}^i} E_t \sum_{s=0}^{\infty} \beta_{t,t+s} (\xi_p)^s \left(\tilde{P}_{j,t}^i - P_{t+s}^c \phi_{t+s}^i \right) \left(\frac{\tilde{P}_{j,t}^i}{P_{t+s}^i} \right)^{-\eta_2} Y_{t+s}^i \quad (46)$$

where $\beta_{t,t+s} = \beta \left(\frac{c_{t+s}}{c_t} \right)^{-\eta_0}$ is the household's stochastic discount factor for aggregate consumption. This implies the following price

setting equation:

$$\frac{\eta_2 - 1}{\eta_2} \tilde{P}_{j,t}^i E_t \sum_{s=0}^{\infty} (\beta \xi_p)^s \frac{c_{t+s}^{-\eta_0}}{c_t^{-\eta_0}} \left(\frac{\tilde{P}_{j,t}^i}{P_{t+s}^i} \right)^{-\eta_2} Y_{t+s}^i = E_t \sum_{s=0}^{\infty} (\beta \xi_p)^s \frac{c_{t+s}^{-\eta_0}}{c_t^{-\eta_0}} \left(\frac{\tilde{P}_{j,t}^i}{P_{t+s}^i} \right)^{-\eta_2} P_{t+s}^c \phi_{t+s}^i Y_{t+s}^i \quad (47)$$

from which it is clear that all firms which reset their price in period t set it at the same level ($\tilde{P}_{j,t}^i = \tilde{P}_t^i$, for all $j \in (0, 1)$).

Given probability ξ_p of updating in any given period, we average over all contracts to express the dynamics of the aggregate price level as follows:

$$P_t^i = \left((1 - \xi_p) \left(\tilde{P}_t^i \right)^{\eta_2 - 1} + \xi_p \left(P_{t-1}^i \right)^{\eta_2 - 1} \right)^{\frac{1}{\eta_2 - 1}} \quad (48).$$

Combining (47) and (48) and log-linearizing around a zero inflation steady state yields the New Keynesian Phillips curve for sector i :

$$\hat{\pi}_t^i = \beta E_t \hat{\pi}_{t+1}^i + \frac{(1 - \xi_p)(1 - \beta \xi_p)}{\xi_p} (\hat{\phi}_t^i + \hat{P}_t^c - \hat{P}_t^i) \quad (49).$$

Also, given prices and quantities in the two sectors, we can define nominal GDP as

$$P_t Y_t = P_t^h (c_t^h + c_t^x) + P_t^g g_t$$

where P_t is the GDP deflator, and Y_t is real GDP. Real GDP can be defined by treating the steady state as the “base year”:

$$Y_t = \frac{P_t^h}{P_{ss}} (c_t^h + c_t^x) + \frac{P_t^g}{P_{ss}} g_t$$

3.4 Intermediate Goods Producers

In the private sector, a continuum of intermediate goods firms, indexed by l , sell their output competitively to the retailers at price $P_t^c \phi_t^l$. For simplicity, we make an analogous assumption for the public sector: a continuum of government agencies produce intermediate goods for the government, valuing their production at the price $P_t^c \phi_t^g$. Each of these producers operates in only one sector (private or public). Without loss of generality, we set the mass of producers in each sector to one¹⁷.

17. The reason this implies no loss of generality is that we assume a technology with constant returns to scale. Thus the model determines the total amount produced in each sector, but has nothing to say about how it is distributed across producers.

In both sectors ($i \in \{h, g\}$), intermediate goods are produced according to a linear production function with labor as the only input:

$$y_{l,t}^i = a n_{l,t}^i \quad (50)$$

where $n_{l,t}^i$ denotes the number of members of the household employed by producer l , in sector i ; and a is the constant level of productivity. We assume that each producer l posts vacancies to hire workers, and bargains with workers to determine the wage. Posting vacancies entails the costs (14), scaled to the level of employment in the firm:

$$\frac{\chi_v}{1 + \psi_v} \left(\frac{v_{l,t}^i}{n_{l,t-1}^i} \right)^{1+\psi_v} n_{l,t-1}^i \quad (51)$$

in units of the intermediate good.

At time t , the firm takes as given its previous employment stock $n_{l,t-1}^i$, and chooses $v_{l,t}^i$ to maximize the present discounted value of current and future profits. In doing so, it takes as given its nominal wage, which is constrained by a Calvo friction, intermittently updated by a Nash bargain that is set in nominal terms. If we write the value of a match with an individual worker as $\mathcal{J}_t^i(W_{l,t}^i)$, then optimal hiring implies:

$$\chi_v \left(\frac{v_{l,t}^i}{n_{l,t-1}^i} \right)^{\psi_v} \phi_t^i = q_t \mathcal{J}_t^i(W_{l,t}^i) \quad (52).$$

3.5 Wage Bargaining

Following Gertler, Sala, and Trigari (2008), we assume that wages are subject to Calvo stickiness at the firm level. That is, all workers in a given firm, including new hires, are paid that firm's previous period's wage with a probability ξ_w , while with probability $1 - \xi_w$ the firm is free to renegotiate nominal wages with its workforce¹⁸. Those firms adjusting to the new nominal wage will in equilibrium set the same wage, W_t^{i*} , given that we have no firm-specific shocks other than the Calvo adjustment process itself.

18. We focus on the case of equal Calvo parameters in the public and private sectors. This assumption is not crucial for our results.

To model our proposed mechanism for fiscal adjustments on the expenditure side, we allow for the possibility that public and private wages are bargained in different units of account. Therefore, we define X_t^i as the exchange rate between the euro and the bargaining currency. For private firms, $X_t^h \equiv 1$ meaning simply that private sector wages are set in euros. For public firms, X_t^g represents euros per PSU, which will vary over time depending on the decisions of the fiscal authority.

Written in the bargaining currency, the law of motion of the average nominal wage is given by:

$$W_t^i = \int_0^1 W_{l,t}^i dl = \xi_w W_{t-1}^i + (1 - \xi_w) W_t^{i*} \quad (53)$$

since fraction $1 - \xi_w$ of firms adjust wages each period. But to fully describe wage dynamics, we must also find an equation for the reset wage W_t^{i*} . To do so, we calculate match surplus for workers and firms, and then derive a Nash bargaining equation.

Given the probabilities of labor market transitions, the value in consumption units of a worker with a job in sector i is:

$$\begin{aligned} \mathcal{W}_{l,t}^i = & (1 - \tau_t) \frac{X_t^i W_{l,t}^i}{P_t^c} - \chi_n n_t^{\psi_n} c_t^{\eta_0} + E_t \beta_{t,t+1} \left[\delta_n (1 - s(\theta_{t+1})) \mathcal{U}_{t+1} + (1 - \delta_n) \mathcal{W}_{l,t+1}^i \right. \\ & \left. + \delta_n s(\theta_{t+1}) \int_0^1 \frac{v_{L,t+1}^h \mathcal{W}_{L,t+1}^h + v_{L,t+1}^g \mathcal{W}_{L,t+1}^g}{v_{t+1}} dL \right]. \end{aligned}$$

On the right-hand side, we see that a worker employed at time t stays in the same producer at time $t+1$ with probability $1 - \delta_n$, and becomes unemployed with probability $\delta_n (1 - s(\theta_{t+1}))$. With probability $\delta_n s(\theta_{t+1})$, the worker finds a job in a new producer, which may either be private (h) or public (g). Here \mathcal{U} represents the value of an unemployed worker, which satisfies:

$$\mathcal{U}_t = b_t + E_t \beta_{t,t+1} \left[(1 - s(\theta_{t+1})) \mathcal{U}_{t+1} + s(\theta_{t+1}) \int_0^1 \frac{v_{L,t+1}^h \mathcal{W}_{L,t+1}^h + v_{L,t+1}^g \mathcal{W}_{L,t+1}^g}{v_{t+1}} dL \right] \quad (54).$$

Subtracting these two equations, the household's surplus, $\mathcal{H}_{l,t}^i \equiv \mathcal{W}_{l,t}^i - \mathcal{U}_t$ will satisfy:

$$\begin{aligned} \mathcal{H}_{l,t}^i = & (1 - \tau_t) \frac{X_t^i W_{l,t}^i}{P_t^c} - b_t - \chi_n n_t^{\psi_n} c_t^{\eta_0} + (1 - \delta_n) E_t \beta_{t,t+1} \mathcal{H}_{l,t+1}^i \\ & - E_t \beta_{t,t+1} (1 - \delta_n) s(\theta_{t+1}) \int_0^1 \frac{v_{L,t+1}^h \mathcal{H}_{L,t+1}^h + v_{L,t+1}^g \mathcal{H}_{L,t+1}^g}{v_{t+1}} dL \end{aligned} \quad (55).$$

Here $s(\theta_{t+1}) \frac{v_{L,t+1}^i}{v_{t+1}^i}$ denotes the probability of becoming matched with producer L in sector i at time $t + 1$.

A similar Bellman equation governs the producer's surplus, $\mathcal{J}_{l,t}^i$ ¹⁹:

$$\mathcal{J}_{l,t}^i = a\phi_t^i - \frac{X_t^i W_{l,t}^i}{P_t^c} + E_t \beta_{t,t+1} \max_z \left[(1 - \delta_n + q_{t+1} z) \mathcal{J}_{l,t+1}^i - \frac{\chi_v}{1 + \psi_v} z^{1+\psi_v} \phi_{t+1}^i \right] \quad (56)$$

or equivalently

$$\mathcal{J}_{l,t}^i = a\phi_t^i - \frac{X_t^i W_{l,t}^i}{P_t^c} + E_t \beta_{t,t+1} \left[(1 - \delta_n) + \frac{\psi_v}{1 + \psi_v} z_{l,t+1}^i q_{t+1} \right] \mathcal{J}_{l,t+1}^i \quad (57).$$

In each period, the wage is renegotiated, in nominal terms, with probability $1 - \xi_w$. Renegotiation is assumed to solve a Nash bargaining problem, with bargaining power σ for the worker. The first-order condition is

$$\sigma \mathcal{J}_t^{i*} \frac{\partial \mathcal{H}_t^{i*}}{\partial W_t^{i*}} = (1 - \sigma) \mathcal{H}_t^{i*} \left| \frac{\partial \mathcal{J}_t^{i*}}{\partial W_t^{i*}} \right| \quad (58).$$

The notation reflects the fact that any firm in sector i that renegotiates at time t sets the same nominal wage W_t^{i*} .

Note that as Gertler, Sala, and Trigari pointed out, a marginal change in the nominal wage is more valuable to the firm than it is to the worker, because it is applicable not only to the current workforce, but also to new employees hired prior to the next wage adjustment. Moreover, the worker's bargaining share is also lowered by the factor $(1 - \tau_t)$, reflecting the fact that given proportional taxes, the worker receives less benefit from one euro of wages than this euro costs to the firm. Using Bellman equations (55) and (57), we can calculate the marginal value of the sticky wage to each bargaining party as follows:

$$\frac{\partial \mathcal{H}_{l,t}^i}{\partial W} = (1 - \tau_t) \frac{X_t^i}{P_t^c} + (1 - \delta_n) \xi_w E_t \beta_{t,t+1} \frac{\partial \mathcal{H}_{l,t+1}^i}{\partial W} \quad (59)$$

$$\left| \frac{\partial \mathcal{J}_{l,t}^i}{\partial W} \right| = \frac{X_t^i}{P_t^c} + \xi_w E_t \beta_{t,t+1} (1 - \delta_n + q_{t+1} z_{l,t+1}^i) \left| \frac{\partial \mathcal{J}_{l,t+1}^i}{\partial W} \right| \quad (60).$$

Solving a matching model with sticky wages is complicated by the fact that the surpluses of workers and firms differ across matches we

19. As is standard in matching models, here we have written the producer's surplus per match after hiring at time t .

need to evaluate the surpluses as a function of the current wage. We solve the model up to a linear approximation, which implies that the surplus functions can be approximated as linear functions of the current wage. The model can then be rewritten in terms of the average wage (and average surplus only). The details are explained in the appendix of our working paper, Costain and de Blas (2012a.)

3.6 Monetary and Fiscal Policy

Three public authorities determine monetary and fiscal policy in the home economy: the central bank of the monetary union, the home country government, and the home country fiscal authority.

The Central Bank

The nominal interest rate is determined by the central bank of the monetary union, and is therefore exogenous from the point of view of the small open economy under consideration. It follows the stochastic process (21), as described earlier.

The Government

We assume the home-country government undertakes a number of complex economic tasks, including various forms of public expenditure, and designing a tax code to finance this expenditure. However, the content of these choices is not crucial for our argument, and will not be modeled. Therefore, for simplicity we just treat real government consumption expenditure as an exogenous stochastic process, given by (25), and we will treat all taxation as if it were just a flat labor income tax, τ_t .

Finally, for realism, we assume the government makes transfer payments to the unemployed. The benefit level b_t is set to a constant fraction \underline{b} of the public sector wage. Given these budget items, the nominal government debt, in euros, evolves as

$$\frac{D_t^g}{R_t I_t^g} = D_{t-1}^g + P_t^g g_t - \tau_t (W_t^h n_t^h + X_t W_t^g n_t^g) + (1 - n_t) X_t W_t^g \underline{b} \quad (61).$$

Here D_{t-1}^g is the government's debt, in euros, at the beginning of t , and I_t^g is a risk premium on government debt; $D_t^g / (R_t I_t^g)$ is

the amount of new euro debt that must be issued at t to roll over the existing debt and to finance the deficit. $P_t^g g_t$ is government spending, in euros. $W_t^h n_t^h h_t^h$ is the labor income of private sector workers, in euros, and $X_t W_t^g n_t^g h_t^g$ is the labor income of public sector workers, in euros. Here the private sector wage W_t^h is denominated directly in euros, whereas the public sector wage W_t^g is denominated in PSU, so it must be multiplied by the “exchange rate” X_t to convert to euros. The last term in the budget constraint represents the payment of the real benefit $b_t = X_t W_t^g b / P_t^c$ to the unemployed.

The Fiscal Authority

Whereas the government is assumed to make some complex but unmodeled decisions, the fiscal authority is assumed to make at most two simple decisions: adjusting a parameter that shifts tax rates, and/or adjusting a parameter that affects the value of public salaries and transfer payments.

We model these two decisions as rules that depend on observable macroeconomic data. The tax rule determines an additive shift of all labor income taxes as a function of deviations of real GDP from its trend level, real public spending from its trend level, and public debt, as a fraction of GDP, from a target level:

$$\tau_t = \tau^* + \tau^y \left(\frac{Y_t - Y_{ss}}{Y_{ss}} \right) + \tau^g \left(\frac{P_{ss}^g}{P_{ss}} \left(\frac{g_t - g_{ss}}{Y_{ss}} \right) \right) + \tau^d \left(\frac{D_t^g}{P_{ss} Y_{ss}} - d^* \right) \quad (62).$$

Formally, in this expression, τ^* represents a steady-state flat tax rate. However, it should be interpreted as a stand-in for the whole tax code. That is, the deviations from τ^* determined by the rule (62) should be interpreted as additive shifts of the whole tax code chosen by the government.

Second, the fiscal authority determines each period’s exchange rate X_t between the public sector and private sector numeraires (the price of one PSU, in euros). We model this decision as a rule that reacts to deviations of real GDP and public spending from their trend levels²⁰.

20. This functional form is largely analogous to that used for the tax rate, except that it is multiplicative rather than additive. The multiplicative nature of the exchange rate rule ensures that X_t is always a positive number, whereas the additive tax rule allows us to consider possibilities such as positive and negative tax rates, or an efficient steady-state tax rate $\tau^* = 0$.

$$X_t = X^* \exp\left(\zeta^y \left(\frac{Y_t - Y_{ss}}{Y_{ss}}\right)\right) \exp\left(\zeta^g \frac{P_{ss}^g}{P_{ss}} \left(\frac{g_t - g_{ss}}{Y_{ss}}\right)\right) \quad (63).$$

3.7 Market Clearing Conditions

Several market clearing conditions that were previously stated in the context of the planner's problem must be restated here to properly aggregate the decisions of decentralized decision-makers.

Aggregating vacancy costs at the firm level, the market clearing conditions for the private and public sector are:

$$c_t^h + c_t^x = an_t^h - \int_0^1 \frac{\chi_v}{1 + \psi_v} (z_{l,t}^h)^{1+\psi_v} n_{l,t-1}^h dl \quad (64)$$

$$g_t = an_t^g - \int_0^1 \left[\frac{\chi_v}{1 + \psi_v} (z_{l,t}^g)^{1+\psi_v} n_{l,t-1}^g \right] dl \quad (65).$$

As with our treatment of wages, aggregation of these heterogeneous hiring expenditures can be simplified by linearizing around a zero-inflation steady state.

In the decentralized market, market willingness to hold the debt of public and private decision makers will depend on the current debt level of each borrower. Thus we assume the following specification for the risk premia I_t^h and I_t^g :

$$\ln I_t^i = \psi_I^i \left(\frac{D_t^i}{P_{ss} Y_{ss}} - \bar{d}^i \right) \quad (66)$$

in sectors $i \in \{h, g\}$. For consistency with the risk premium on the aggregate debt of the planner we assume $\bar{d}^g = \alpha_g \bar{d}$, $\bar{d}^h = (1 - \alpha_g) \bar{d}$, $\psi_I^g = \psi_I / \alpha_g$, and $\psi_I^h = \psi_I / (1 - \alpha_g)$, where α_g represents the fraction of debt capacity attributed to the government.

3.8 Steady State

In steady state, the relation between employment and tightness is

$$\theta_{ss} = \left(\frac{\delta_n n_{ss}}{a_m (1 - (1 - \delta_n) n_{ss})} \right)^{\frac{1}{1-\alpha_u}} \quad (67).$$

Given the steady-state flow relation $\delta_n n_{ss} = q(\theta_{ss}) v_{ss}$, we see that the vacancy-to employment ratio z is equalized across sectors

in steady state:

$$z_{ss}^i = \delta_n / q(\theta_{ss}), \quad i \in \{h, g\} \quad (68)$$

Furthermore, in each sector, the real marginal cost ϕ_{ss}^i , the real wage and the surpluses \mathcal{J}_{ss}^i and \mathcal{H}_{ss}^i are determined by four linear equations: the zero profit condition on vacancies, the Nash bargaining equation, and the Bellman equations for the surpluses:

$$\chi_v z^{\psi_v} \phi_{ss}^i = q(\theta_{ss}) \mathcal{J}_{ss}^i, \quad (69)$$

$$(1 - \beta \xi_w)(1 - \tau_{ss}) \sigma \mathcal{J}_{ss}^i = (1 - \beta \xi_w(1 - \delta_n))(1 - \sigma) \mathcal{H}_{ss}^i \quad (70)$$

$$(1 - \beta(1 - \delta_n)) \mathcal{H}_{ss}^i = (1 - \tau_{ss}) X_{ss}^i W_{ss}^i / P_{ss}^c - \underline{w}_{ss} \quad (71)$$

$$(1 - \beta(1 - \delta_n / (1 + \psi_v))) \mathcal{J}_{ss}^i = a \phi_{ss}^i - X_{ss}^i W_{ss}^i / P_{ss}^c \quad (72).$$

While these equations are sector-specific, note that no other sector-specific variables appear in them. Therefore the steady-state solutions for these four variables must be equalized across sectors: $\phi_{ss}^h = \phi_{ss}^g$, $X_{ss}^h W_{ss}^h / P_{ss}^c = X_{ss}^g W_{ss}^g / P_{ss}^c$, $\mathcal{J}_{ss}^h = \mathcal{J}_{ss}^g$, and $\mathcal{H}_{ss}^h = \mathcal{H}_{ss}^g$. Analogous symmetry holds in the social planner's solution too.

This has an important consequence for our proposed fiscal mechanism. The fact that real wages are equalized across sectors in steady state, regardless of the value X^g of the PSU, implies *that changes in the value of the PSU are neutral in the long run* in this model. Thus, any policy effects obtained from setting the value of the PSU (a purely nominal change) will be only short run effects. This is why we consider a PSU rule that depends only on short-run fluctuations in output and spending, with responses to the slow-moving fluctuations in public debt limited to the tax side.

4. COMPARING PLANNER AND MARKET SOLUTIONS

Comparing the first-order conditions of the planner's problem in any t with the equations that govern the market economy shows five possible sources of inefficiency in the market equilibrium:

1. Existence of labor market inefficiency wedges such as distorting taxes or unemployment subsidies.

2. Possible violation of Hosios' (1990) condition for efficient bargaining in a matching economy.
3. Monopolistic competition in final goods production.
4. Failure to exploit monopoly power in supply of home country exports.
5. Nominal rigidities in price and wage setting.

Several of the effects listed above can be seen by adding the workers' and firms' surplus equations to obtain an equation for total match surplus in the decentralized economy. Defining $S_{l,t}^i \equiv \mathcal{H}_{l,t}^i + \mathcal{J}_{l,t}^i$, we can show that the dynamics of total match surplus are given by

$$S_{l,t}^i = a\phi_t^i - \tau_t \frac{X_t^i W_{l,t}^i}{P_t^c} - b_t - \chi_n n_t^{\psi_n} c_t^{\eta_0} + E_t \beta_{t,t+1} \frac{\psi_v \chi_v}{1 + \psi_v} z_{t+1}^{1+\psi_v} \phi_{t+1}^i + (1 - \delta_n) E_t \beta_{t,t+1} \left[S_{l,t+1}^i - s(\theta_{t+1}) \sigma \int_0^1 \frac{v_{L,t+1}^h S_{L,t+1}^h + v_{L,t+1}^g S_{L,t+1}^g}{v_{t+1}} dL \right] \quad (73).$$

This equation can be compared to the planner's Euler equation (37) if we interpret the match value $S_{l,t}^i$ as a quantity analogous to the planner's marginal value of employment λ_t^{ni} , and marginal cost ϕ_t^i as analogous to planner's marginal value of intermediate goods λ_t^{yi} ²¹.

We first notice that the planner's Euler equation contains no terms analogous to the labor tax and unemployment insurance terms that appear in (73). Thus benefits and labor income taxes should be zero in order to make (37) and (73) equivalent. In turn, this requires some other source of tax revenues to finance government expenditure; to avoid introducing other distortions in the model, these would have to be lump sum taxes. Next, the last term in (73) is the worker's lost search gains upon accepting a match; the last term in (37) is analogous, and can be shown to be algebraically equivalent if the elasticity of the matching function with respect to search, α_u , equals workers' share of match surplus, σ . This is Hosios' (1990) condition for efficiency in matching models.

21. To compare the equations, note that (37) is written in utility units, whereas (73) is written in units of consumption goods.

A third source of inefficiency in the decentralized economy is the fact that the monopolistic producers of differentiated final goods mark them up relative to marginal cost. In steady state, the markup is $\frac{\eta_2}{\eta_2-1}$ (that is, the steady state of the price-setting equation (47) reduces to $P_j^i = \frac{\eta_2}{\eta_2-1} P^c \phi^i$.) This inefficiency could be eliminated by subsidizing the production of differentiated goods at rate $1/\eta_2$. Of course, this remedy is unlikely to be very beneficial unless it can be financed through nondistortionary taxes.

Another monopolistic incentive arises from the fact that we have defined the planner as an agent that represents the well-being of the home economy only. Therefore, the planner has an incentive to restrict trade to exploit the home economy's market power as a monopolistic producer of its export good. Tariff policy could be used to achieve this objective. However, this possibility is not very relevant in the context of this paper, since we are modeling one member of a monetary union which also functions as a free trade area. Therefore we will ignore this difference between the market and planner solutions from here on.

Finally, the market equilibrium differs from the planner's solution because the planner, by assumption, is not subject to any nominal rigidities. We will see that price and wage stickiness and the inefficiency wedges in the value of a job both imply large differences between the planner and market impulse responses.

4.1 Quantifying the Inefficiencies in the Market Economy

To have some idea of the quantitative importance of the various inefficiencies in the market economy, we now provide a rough calibration of the model and calculate impulse response functions comparing the planner's solution and the benchmark decentralized economy to intermediate cases in which some inefficiencies are eliminated.

The parameterization is stated in Table 1. The period is quarterly. We set the worker's bargaining power equal to the unemployment elasticity of matching, thus satisfying Hosios' condition and thereby eliminating one possible source of inefficiency in the model. Vacancy cost parameters are calibrated so that vacancy costs amount to one percent of output, a standard calibration. The separation rate is set at $\delta_n = 0.07$ per quarter, which is high, but is intended to capture the high share of temporary workers in the

Spanish economy. Wage and price persistence are set to 0.9 and 0.6, respectively, which are unlikely to be overestimates, given the high nominal rigidity that exists in Spain. The size of government and the replacement ratio are both set lower than the corresponding figures for Spain, so the overall tax wedge τ^* is also low; we choose these conservative figures because our model becomes somewhat unstable if we raise them further.

Consumption openness is set to 25%, which roughly corresponds to the average of Spanish imports and exports in recent years. Elasticities of substitution are similar to those used in Galí and Monacelli (2005). The debt elasticity of the risk premium is a rounding-off of the one assumed in Schmitt-Grohe and Uribe (2003). The level of debt \bar{d} at which the risk premium factor begins to exceed one is set to 60% of GDP; we attribute half of this debt to the private sector and half to the public sector, so effectively we are assuming that the risk premium kicks in when public debt reaches half of the Maastricht limit. The parameterization of the fiscal authority's rules, which for the benchmark economy sets $\tau^d = 0.01$ and all other fiscal parameters to zero, will be discussed in detail in the next section.

As a first illustration of the impact of the inefficiencies of the market economy, we solve the benchmark market equilibrium and the planner's problem and we compare them to an economy identical to the market benchmark except that all taxes are lump sum. There are large differences in steady state employment: the planner's solution has a 97.6% employment rate, whereas the lump-sum economy has a 96.5% employment rate, and the market benchmark has an 88.7% employment rate. The tax rule in the benchmark case is calculated around a base rate of $\tau^* = 30.95\%$.

Figure 7 reports impulse responses for these three economies with respect to an export demand shock χ^x ²². One notable feature of the impulse responses is that private and public-sector employment are virtually unchanged by the shock under the planner's solution (seen as a thick dashed line). This results from our matching technology, in which vacancies can be filled immediately, and vacancy costs are paid in units of the intermediate goods firms' output. Blanchard and Galí (2009) show that under this technology, the optimal response to a technology shock is for labor to stay

22. The time unit is quarterly in these impulse responses and all other dynamic results in the paper.

Table 1.
Benchmark Parameterization (quarterly)

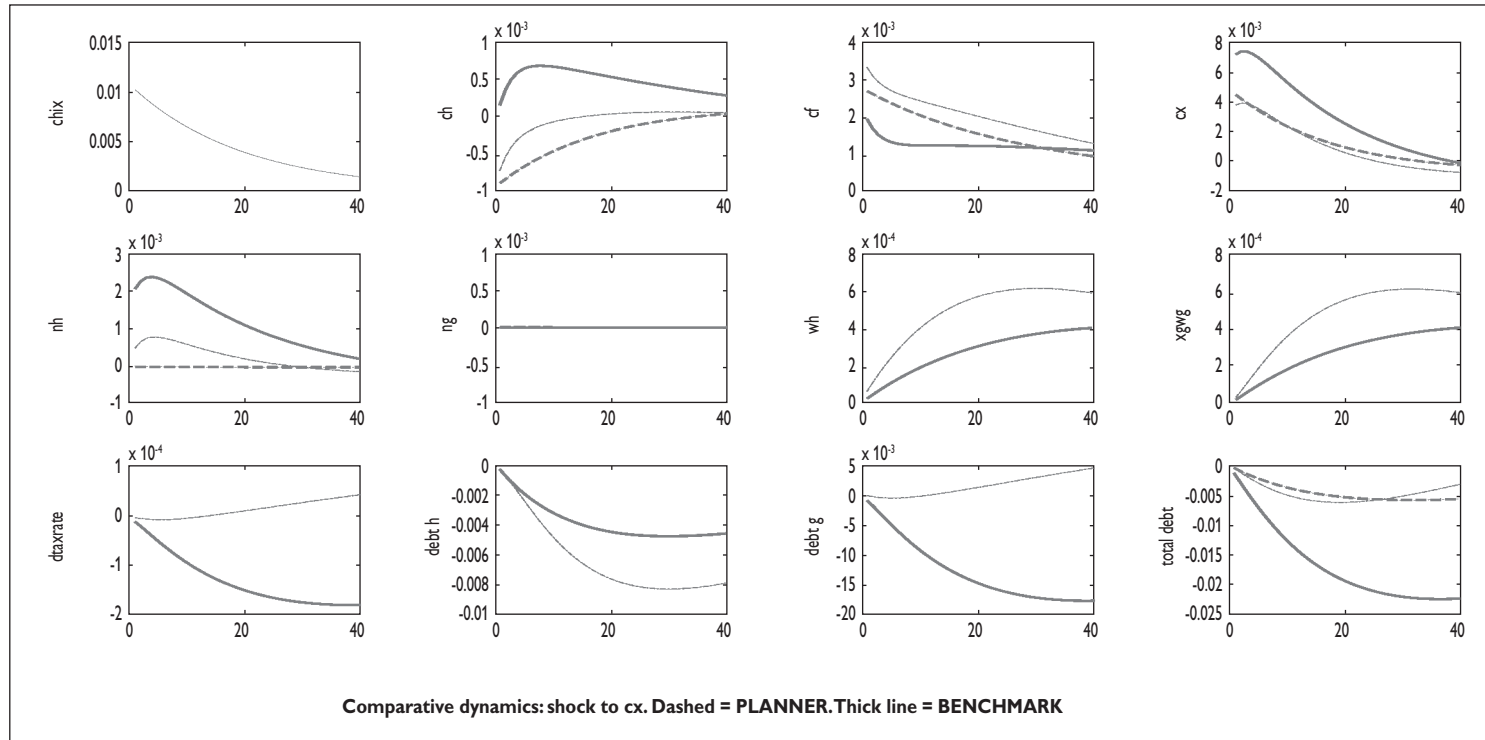
Parameter	Initial value
Preference parameters	
Elasticities	$\eta_0 = 2, \eta_1 = 2, \eta_2 = 8, \eta_3 = 3$
Consumption openness	$\alpha_f = 0.25$
Labor supply	$\chi_n = 0.7, \psi_n = 1$
Output and matching technologies	
Labor productivity	$a = 1$
Vacancy costs	χ_v calibrated: vacancy costs are 1% of output; $\psi_v = 3$
Matching function	a_m calibrated: so that $q_{ss} = 1$; $\alpha_u = 0.5$
Separation rate	$\delta_n = 0.07$
Price adjustment parameters	
Worker bargaining share	$\sigma = \alpha_u$
Adjustment probabilities	$1 - \xi_p = 0.4; 1 - \xi_w = 0.1$
Debt demand parameters	
Level parameters:	$d = 2.4, \alpha_g = 0.5$
Debt elasticity of risk premium	$-\psi_l = 0.001$
Policy parameters	
Replacement rate	$\bar{b} = 0.35$
Level parameters:	$d^* = d, X^* = 1$
Level parameter:	τ^* calibrated: so that $D_{ss}/P_{ss}Y_{ss} = d$
Elasticities of tax rate	$\tau^v = 0$ (varies), $\tau^e = 0$ (varies), $\tau^d = 0.01$ (varies)
Elasticities of public salaries	$\zeta^e = 0$ (varies), $\zeta^v = 0$ (varies)
Shock processes	
	Steady state Persistence Std dev of innovation
Government spending	$g_{ss} = 0.2$ $\rho_g = 0.95$ $\sigma_g = 0.01$
Foreign price level	$P_{ss} = 1$ $\rho_{pf} = 0.95$ $\sigma_{pf} = 0.01$
Export demand level	$\chi_{ss} = \alpha_f$ $\rho_{cx} = 0.95$ $\sigma_{cx} = 0.01$
Interest rate (quarterly)	$r_{ss} = 0.003$ $\rho_r = 0.95$ $\sigma_r = 0.001$

fixed. This result carries over approximately in our more complex model to the case of export demand shocks.

In contrast, in the market benchmark economy (thick line), export demand shocks cause large procyclical swings in private sector employment. While the planner's solution, with unchanged employment, implies that home consumption falls to accommodate increased exports, employment in the market economy expands so much that home consumption *rises*. We also note that the trade balance fluctuates excessively in response to the shock, as exports c^x rise too much but imports c^f do not rise enough.

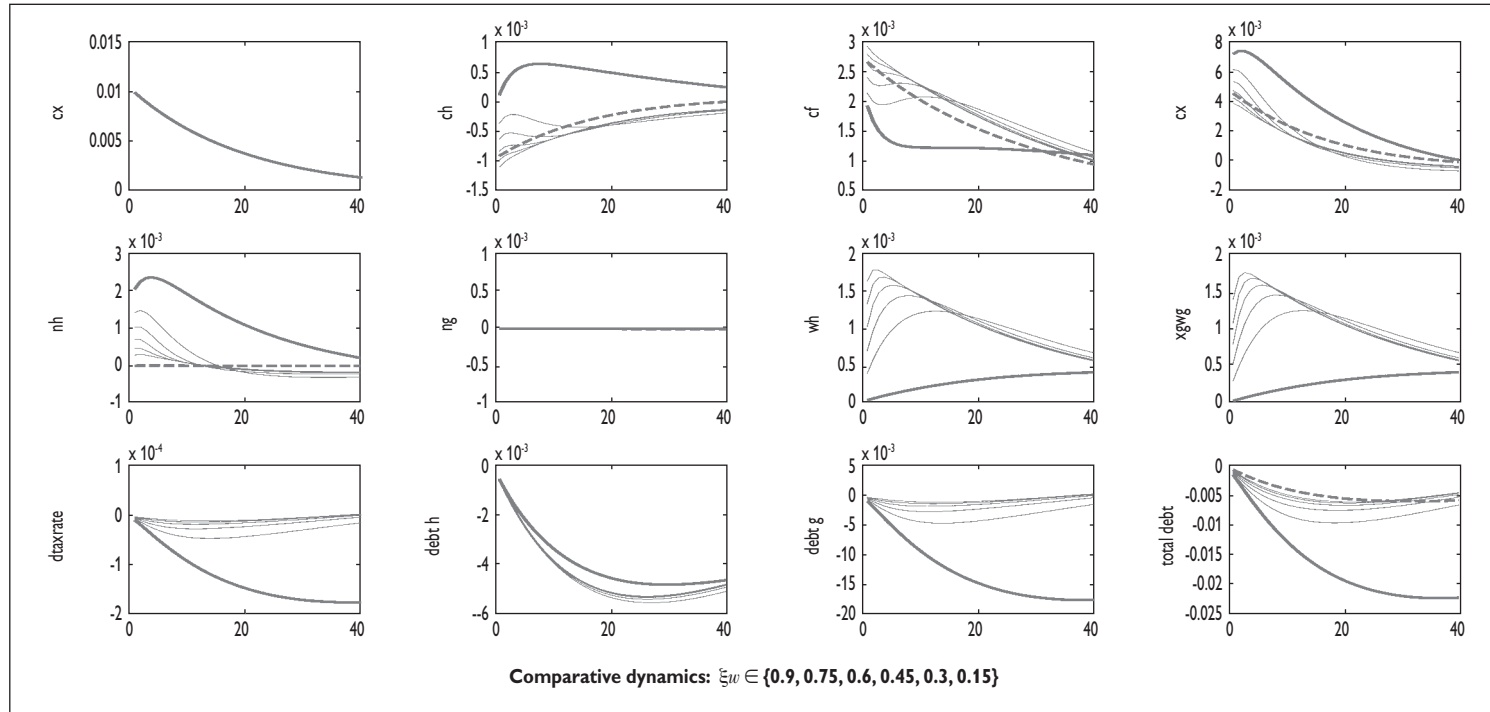
Replacing distorting labor income taxes by lump sum taxes (thin line) eliminates much of these inefficient fluctuations. The rise in n^h is sufficiently reduced so that home consumption now falls, though less than it should under the planner's solution; the fluctuation in exports is more or less on target with respect to the planner's solution. Likewise, for the other three shocks considered in our model,

Figure 7.
Effects of Export Demand Shock: Planner vs. Benchmark vs. Lump Sum Taxes



Note: comparative dynamics after an export demand shock. Dashed line is planner's solution. Thick line is benchmark market economy. Thin line is market economy with lump sum taxes.

Figure 8.
Effects of Export Demand Shock: Decreasing Calvo Stickiness



Note: comparative dynamics after an export demand shock. Dashed line is planner's solution. Thick line is benchmark market economy ($\xi_w = 0.9$). Thin lines are market economy with lower nominal rigidity ($\xi_w < 0.9$).

eliminating distorting labor taxes in favor of lump sum taxes gets rid of most of the inefficient fluctuations of the market economy. Graphs of these cases are available from the authors.

Next, we look at how nominal rigidities affect the fluctuations of the market economy. This is particularly interesting in our context since knowing the effects of nominal rigidities will help us see whether our proposed mechanism for expenditure adjustment acts also, as intended, as a mechanism for reducing the effective nominal rigidities in the economy. Figure 8 compares the impulse responses to an export demand shock across different degrees of nominal rigidity (the same benchmark and planner solutions are shown again, as in the previous figure). The benchmark economy (thick line) has wage persistence $\xi_w = 0.9$ at a quarterly rate and price persistence $\xi_p = 0.6$. The thinner lines report alternative parameterizations of stickiness: $\xi_w \in \{0.75, 0.6, 0.45, 0.3, 0.15\}$, with $\xi_p = \frac{2}{3}\xi_w$ in all cases²³.

The effects of eliminating nominal rigidity are very powerful here. Since there are still other inefficiencies in the model, fully eliminating nominal rigidity drives the impulse responses to a limit that is not exactly equal to the responses of the planner's solution. Nonetheless, the responses are quite close. Just reducing stickiness by one sixth, from 0.9 to 0.75, eliminates more than half the deviation between the market equilibrium and the planner's solution, for all the consumption and labor components.

Eliminating stickiness also stabilizes pushes the dynamics of total debt towards the planner's solution, and almost completely stabilizes government debt and total debt²⁴.

5. DYNAMIC EFFECTS OF SIMPLE FISCAL RULES

5.1 Rules to Stabilize Public Debt

We saw in Section 3.8 that the exchange rate between PSU and euros, being a purely nominal change, is neutral in steady state.

23. Varying either Calvo parameter separately has effects qualitatively similar to varying both jointly; quantitatively the more powerful of the two is ξ_w .

24. While our simulations will treat most variables in log-linear terms, debt will be treated in levels, since its sign need not be positive. Thus our impulse response functions all show debt fluctuations in percentage points of GDP; likewise, they show tax rate fluctuations in percentage points. All other variables are shown in log deviations.

Therefore, while adjustments to the value of the PSU may potentially be a powerful fiscal and/or macroeconomic instrument, they can only have “short-run” effects, with a horizon related to the degree of nominal rigidity. This is why our rule (63) for X depends on current output and/or government spending but is not conditioned on the debt level, which is a slow-moving variable.

Since in our model budgetary adjustments are only possible insofar as they are given by the rules, the *only* way to ensure a “Ricardian” fiscal policy (one in which the public sector commits to pay off any debt it incurs, through future fiscal adjustments) is to ensure that at least one fiscal rule adjusts sufficiently strongly to changes in the debt level²⁵. That is, the response to any increase in debt must adjust other budget items by enough to pay off the increased interest. Since the tax base in this model is labor income, as a rough approximation near the steady state we can say that fiscal policy is Ricardian if

$$X_{ss}W_{ss}n_{ss}\tau^d > R_{ss}I_{ss}^g - 1 \quad (74)$$

($X_{ss}W_{ss}$ needs no superscript since it is equalized across sectors in steady state).

At our steady state, (74) requires $\tau^d > 0.00255$. On the other hand, optimal borrowing and lending requires that debt behave approximately as a random walk; therefore we wish to keep τ^d relatively close to zero, implying that shocks to revenues and expenditure are smoothed out over time by accumulation and decumulation of debt. Therefore, in order to achieve a high degree of tax smoothing while being entirely sure that we stay within the Ricardian regime, we focus on tax rules satisfying $\tau^d = 0.01$, unless specified otherwise.

Our policy analysis will compare the macroeconomic effects of several different fiscal rules that stabilize the public debt. We compare debt stabilization by adjusting tax rates with debt stabilization by means of shifts in the value of public sector wages and transfers, asking how each one affects the volatility of other macroeconomic variables. In particular, we start from a benchmark equilibrium character-

25. Kirsanova and Wren-Lewis (2011) analyze interactions across monetary and fiscal policy across both Ricardian and non-Ricardian regimes. While equilibrium may exist in the non-Ricardian “fiscalist” regime, that regime involves a large decrease in welfare, so we wish to avoid it.

ized by $\tau^d = 0.01$, with all other fiscal parameters set to zero. We then compare alternative rules that decrease the variability of debt relative to the benchmark equilibrium. All rules leave steady state variables unchanged, including the steady-state level of public debt, so our analysis focuses only on the cyclical consequences of each rule.

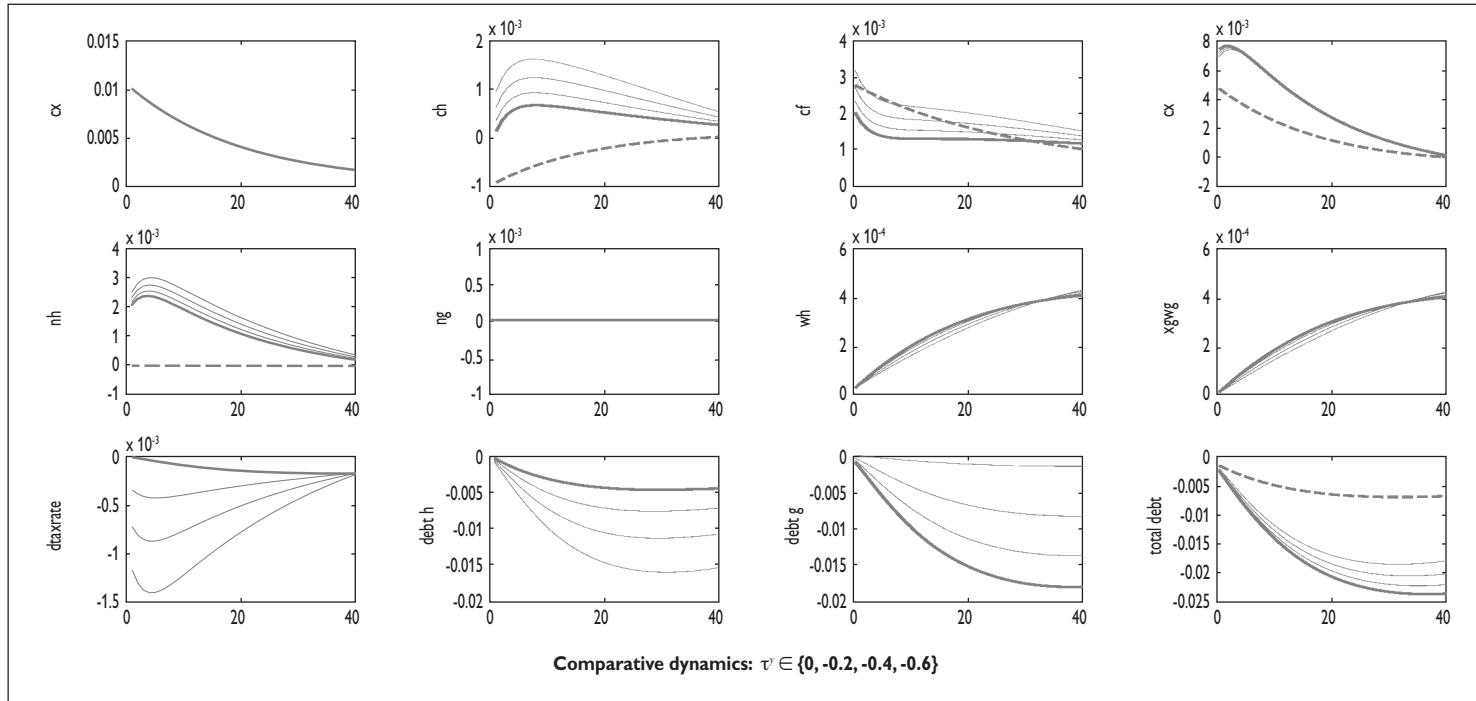
Now, since a fully credible government would like to pursue a debt policy as close as possible to a random walk, one might wonder why we are interested in policies that stabilize debt at all. The reason, of course, is that no government is fully credible, and that European governments in particular seem to have lost a great deal of credibility recently, so that many are now asking themselves which fiscal margins should be adjusted to reduce the level and standard deviation of their debt. This is the spirit of the exercises we will perform in this section. If for some reason it becomes necessary to reduce public debt fluctuations, what are the macroeconomic consequences of various different policies by which this could be achieved?

5.2 Impulse Responses under Different Budget Stabilization Rules

Figure 9 studies the effects of an export demand shock under several different tax rules. It compares the planner's economy and the benchmark economy (where $\tau^y = 0$) against three different rules with $\tau^y < 0$ —that is, rules in which taxes are decreased (increased) in a boom (recession). All rules set the coefficient $\tau^d = 0.01$, unless otherwise stated.

The shock to export demand stimulates output, so without any adjustment in the tax rate the tax base would rise and government debt would begin to fall, as we see in the benchmark case (thick blue line). Thus a rule with $\tau^y < 0$ can stabilize debt in response to a shock of this type, by lowering tax rates as output rises. The figure compares the values $\tau^y \in \{0, -0.2, -0.4, -0.6\}$; in the latter case when nominal GDP is one percentage point above its trend, the tax rate falls by 0.6 percentage points. In the second-to-last panel, we see that $\tau^y = -0.6$ serves to keep government debt approximately unchanged in response to this shock; making τ^y more negative would actually go beyond debt stabilization and instead make public debt *countercyclical*. Note that $\tau^y < 0$ increases the fluctuations in private debt somewhat, but total debt (public plus private) is substantially stabilized, as we see in the last panel of the figure.

Figure 9.
Effects of Export Demand Shock: Tax Rate Falls with Output



Note: comparative dynamics after an export demand shock. Dashed line is planner's solution. Thick line is benchmark market economy ($\tau = 0$). Thin lines are market economy with countercyclical tax rules ($\tau < 0$).

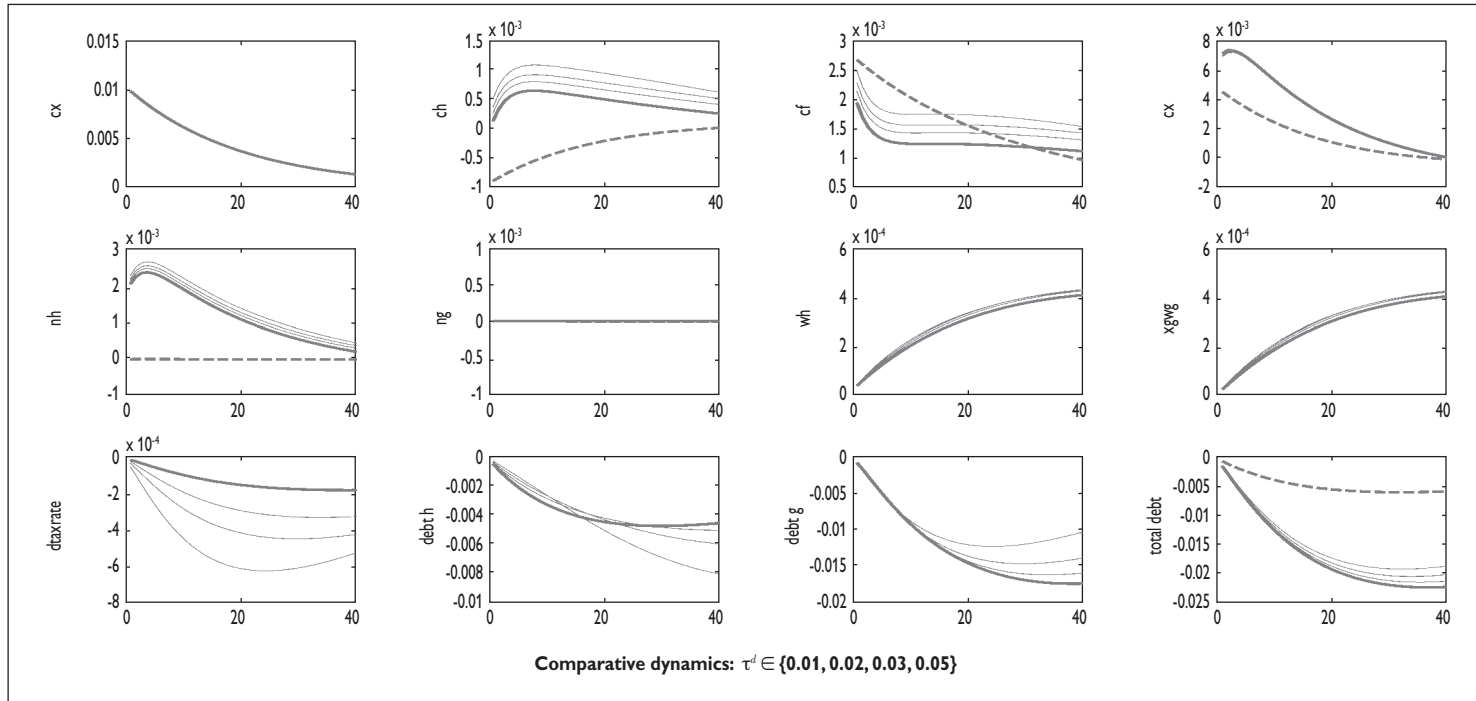
However, while these rules can stabilize public debt in this context, they destabilize business cycle fluctuations. By lowering taxes when demand is rising, the rules with $\tau^y < 0$ amplify the fluctuations in n^h and c^h . Recall that employment remains almost unchanged in the planner's solution, so the tax rule is amplifying fluctuations that are already inefficiently large. The deviation of home consumption c^h from the planner's solution roughly doubles with $\tau^y = -0.6$, and the fluctuations in n^h also increase by a nontrivial amount.

Since stabilizing public debt by making tax rates contingent on output can amplify the fluctuations in output, we might ask whether some other kind of tax rule would have less serious side effects. A minimalist alternative would be to raise taxes only in response to changes in debt. The benchmark economy already sets $\tau^d = 0.01$; we now consider what happens if we smooth the fluctuations in government debt by making taxes respond more strongly to debt. Figure 10 compares $\tau^d \in \{0.01, 0.02, 0.03, 0.05\}$, while setting all other parameters of the fiscal rules to zero ($\tau^y = \tau^g = \zeta^y = \zeta^g = 0$). We see that increasing the response of taxes to public debt significantly decreases the fluctuations in public debt. However, like the previous tax rule, it also amplifies fluctuations in home consumption and home labor. At least in response to this type of shock, this tax rule seems to work no better than the other.

These cyclically destabilizing tendencies of tax adjustments as a tool for budget balance motivate adjustments on the spending side instead. Thus, Figure 11 shows the effects of implementing a rule that adjusts the value of the PSU procyclically, considering the values $\zeta^y \in \{0, 0.5, 1, 1.5, 2, 3\}$. This last parameterization implies a strong reaction of public wages to output: it means public wages rise by three percent when output is one percent above trend. Such a strong wage adjustment suffices to eliminate most of the variation of public debt in response to this shock.

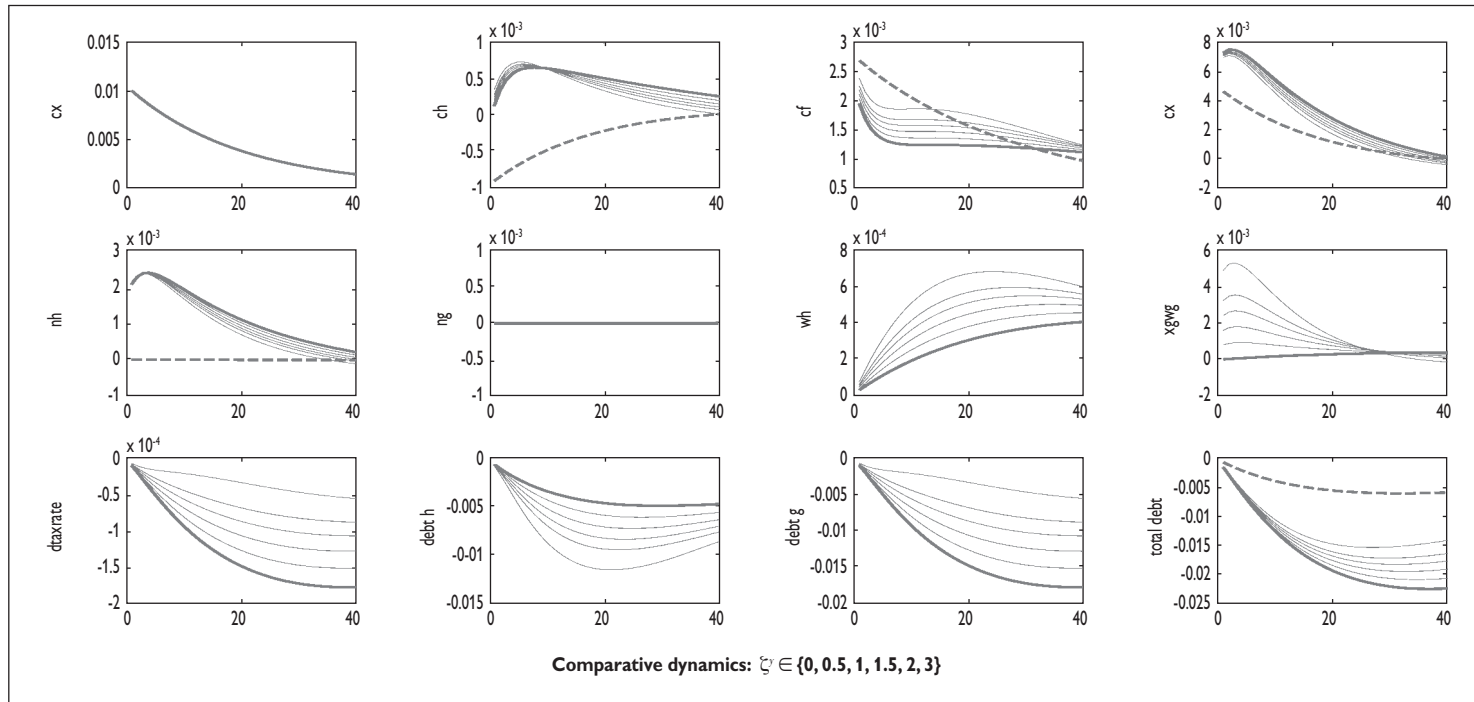
This rise in public wages also “passes through” to the private sector: the private wage rises more than twice as much in response to the demand shock when $\zeta^y = 3$, as compared with the benchmark case where $\zeta^y = 0$. Therefore, private sector employment n^h , and consumption of home goods c^h , both expand less when the PSU rule is active than they do in the benchmark case. Likewise, both sides of the trade balance fluctuate less when the PSU rule is active. This smoothing keeps the economy closer to the planner's solution.

Figure 10.
Effects of Export Demand Shock: Tax Rate Rises with Public Debt



Note: comparative dynamics after an export demand shock. Dashed line is planner's solution. Thick line is benchmark market economy ($\tau^d = 0.01$). Thin lines are market economy with stronger reaction of taxes to debt ($\tau^d < 0.01$).

Figure 11.
Effects of Export Demand Shock: Value of PSU Rises with Output



Note: comparative dynamics after an export demand shock. Dashed line is planner's solution. Thick line is benchmark market economy ($\zeta = 0$). Thin lines are market economy with procyclical public wage rule ($\zeta < 0$).

Intuitively, these PSU rules are stabilizing because they mean that in the event of an expansion, the fiscal authority will implement an *internal revaluation* by raising the wage of public workers (that is, increasing X_t). While this increases the volatility of public and private wages, those wage adjustments tend to stabilize the rest of the economy. This allows for greater tax smoothing, and brings the cyclical dynamics closer to the planner's solution.

Figures 12-15 (at the end of the paper) compare the effects of stabilization through the tax parameter τ^y and the public wage parameter ζ^y in the case of shocks to foreign prices and interest rates (the diagrams show the same range of parameter values for the rules that we saw in the previous figures)²⁶. Our previous results are only reinforced by the shock to P^f , which simultaneously destabilizes n^h , c^h , c^f , and c^x . The results are somewhat muddier in the case of the shock to interest rates, where X has nontrivial budget effects but very little effect on labor and consumption, but our central finding remains true in this case too. Namely, stabilizing the debt level via the tax parameter τ^y further destabilizes the already-inefficient fluctuations in n^h and c^h , whereas stabilizing debt via public wages does not.

Finally, Figures 16-17 study the case of shocks to government spending. The shape of the impulse responses is very different in this case, but they still have the property that eliminating nominal rigidities by shutting down the Calvo frictions brings the responses of employment and consumption closer to the social planners' solution. However, the budgetary implications are reversed with respect to the other demand shocks considered up to now: an expansion caused by an increase in government spending is likely to increase rather than decrease the debt. Therefore, in the context of this shocks, setting $\tau^y < 0$ would be counterproductive from a budgetary perspective: it would decrease tax revenues precisely when government purchases are rising. Likewise, $\zeta^y > 0$ would destabilize the budget: it would make government spending more expensive precisely when government purchases are rising.

Thus, the class of rules we have been considering is unhelpful when fluctuations are driven by government spending shocks.

26. We have also calculated the effects of all these shocks under tax rules that respond to debt only ($\tau^d \geq 0.01$). The results are similar to the tax rules with $\tau^y < 0$, so we do not show the graphs in the paper. Impulse response diagrams for these rules are available from the authors upon request.

Since these shocks are indeed one important cause of fluctuations, we conclude that if tax and public wage rules include terms that react to output, they should include offsetting terms that react to public spending as well. Assuming a fiscal multiplier on the order of magnitude of one, offsetting the counterproductive effects of $\tau^y < 0$ and $\zeta^y > 0$ requires coefficients τ^g and ζ^g that are at least as large in absolute magnitude, but of opposite sign.

5.3 Volatilities under Different Budget Stabilization Rules

Clearly, just looking at shocks one by one, and examining individual impulse responses over a limited time horizon, gives only a partial analysis of the volatility implications of the rules we are considering. For a more complete picture, Table 2 reports the standard deviation of selected variables in the presence of all four shocks, under several alternative scenarios for the rules.

First, we compare volatilities of consumption, labor, and fiscal and wage variables under the social planner solution and under the benchmark economy. In the benchmark economy, the standard deviation of the government debt, as a fraction of output, is 0.8699. Dividing by four since the time period is quarterly, this represents 21.75% of annual GDP. Debt fluctuates slowly, taking time to accumulate and decumulate, but overall the fluctuations are large, with a two-standard-deviation range of fluctuation equalling almost 90% of annual GDP.

These large fluctuations of debt are an implication of tax smoothing, given the small response of taxes to debt in the benchmark economy ($\tau^d = 0.01$). However, if the country has insufficient credibility in the eyes of bondholders, large increases in debt could provoke a speculative attack. Therefore, the country might need to reduce these debt fluctuations. Table 2 compares three possible rules that would stabilize debt, relative to the benchmark economy. Several alternative rules are possible. First, we could maintaining $\tau^d = 0.01$, but make the tax rule respond to debt and spending too, with $0 > \tau^y = -\tau^g$. Alternatively, we could impose a stronger response to debt: $\tau^d > 0.01$. A third possibility would be to maintaining $\tau^d = 0.01$, and stabilize debt through a PSU rule, with $0 < \zeta^y = -\zeta^g$.

In order to make the three experiments comparable, we choose the parameters of the rule in each case to stabilize public debt fluc-

tuations by the same amount. First, we consider a PSU rule with $\zeta^y = 1$, $\zeta^g = -1$. Thus, this rule says that the public wage is raised by 1% when output is 1% above its trend²⁷. In the last column of Table 2, we see that this rule reduces the fluctuations in government debt (as a fraction of quarterly output) from a standard deviation of 0.8699 under the benchmark policy, to 0.7646 under the PSU rule. At the same time, the PSU rule also reduces the variability of consumption and labor slightly with respect to the benchmark economy. The standard deviation of consumption falls from 2.38% in the benchmark economy to 2.35% under the PSU rule; the standard deviation of labor falls from 3.14% to 2.97%. The components of consumption and labor also become less volatile.

Table 2.
Macroeconomic Variability as a Function of Fiscal Regime

Standard Deviations of Key Variables under Different Fiscal Regimes					
	Planner	Benchmark	$\tau^d = 0.01$ $\tau^y = -0.1074$ $\tau^g = 0.1074$	$\tau^d = 0.01621$	$\tau^d = 0.01$ $\zeta^y \gamma = 1$ $\zeta^g = -1$
c	0.0212	0.0238	0.0251	0.0278	0.0235
c^h	0.0169	0.0290	0.0314	0.0328	0.0283
c^f	0.0527	0.0452	0.0435	0.0468	0.0420
c^x	0.0687	0.0858	0.0859	0.0862	0.0790
n	0.0107	0.0314	0.0330	0.0329	0.0297
n^h	0.0186	0.0397	0.0418	0.0419	0.0374
n^g	0.0302	0.0320	0.0320	0.0320	0.0320
τ		0.0087*	0.0092*	0.0124*	0.0076*
D^h/PY_{ss}		0.2019*	0.2217*	0.2162*	0.2235*
D^g/PY_{ss}		0.8699*	0.7646*	0.7646*	0.7646*
D/PY_{ss}	0.1928*	0.9434*	0.8669*	0.8452*	0.8501*
$(1-\tau)w^hn^h$		0.0500	0.0549	0.0574	0.0482
$(1-\tau)Xw^gn^g$		0.0416	0.0413	0.0443	0.0461

Note: quantities with asterisks are stated in levels. All other variables are expressed in logs.

Simulation assumes economy is driven by shocks ϵ^{cx} , ϵ^{pf} , ϵ^g and ϵ^r with standard deviations 0.01, 0.01, 0.01, and 0.001 respectively.

While these volatility reductions are small, they contrast strongly with the effects of a tax rule. We show two versions of the tax rule. The first maintains $\tau^d = 0.01$, and sets $\tau^y = -0.1074$, $\tau^g = 0.1074$. The second sets $\tau^d = 0.01621$, $\tau^y = 0$, and $\tau^g = 0$. These two parameterizations are chosen because they both stabilize public debt to the same degree that the previous PSU rule does: the standard deviation of public debt (as a fraction of quarterly output) is 0.7646 in both cases. Both versions of the tax rule destabi-

lize the macroeconomy. The volatility of consumption rises from 2.38% under the benchmark specification to 2.51% under the rule with countercyclical taxes, it rises further, to 2.78%, when $\tau^d = 0.01621$. The volatility of employment rises from 3.14% under the benchmark to 3.30% or 3.29% under the two tax rules.

The difference in volatility across these economies can be understood in terms of tax smoothing. The benchmark policy has fairly smooth taxes, and therefore debt exhibits large fluctuations. Implementing a PSU rule smooths the cost of the government purchases. Thus it decreases the fluctuations of government debt, without any change in the benchmark tax rule. The realized fluctuations in tax rates, consumption, and labor are all smaller. If the government instead decreases debt fluctuations by a stronger tax rule, then taxes must fluctuate more. These time-varying distortions cause consumption and labor to fluctuate more too.

In summary, a rule to shift public wages and other public prices, like the PSU rule considered here, is likely to form part of the optimal stabilization policy in an economy of this kind. Our simple analytical approach in this paper, based on linear simulations, cannot provide social welfare calculations (which would require a nonlinear simulation). But the fact that the PSU rule pushes the dynamics closer to the social planner's solution, whereas the tax rules push the dynamics away, strongly suggest that using a PSU rule instead of a tax rule will improve welfare. By itself, a rule adjusting the PSU can only reduce the fluctuations in public debt by a relatively limited amount. Therefore, if a high degree of debt stabilization is required, tax adjustments are also likely to be part of the solution. But insofar as part of the stabilization is performed by wage adjustments rather than tax adjustments, social welfare will improve.

6. CONCLUSIONS

This paper has studied simple fiscal rules for stabilizing the government debt level in response to asymmetric demand shocks in a small open economy that forms part of a currency union. In particular, starting from a baseline fiscal policy with large fluctuations in the public debt, we compare the business cycle effects of several different rules that reduce the fluctuations in the public debt (the

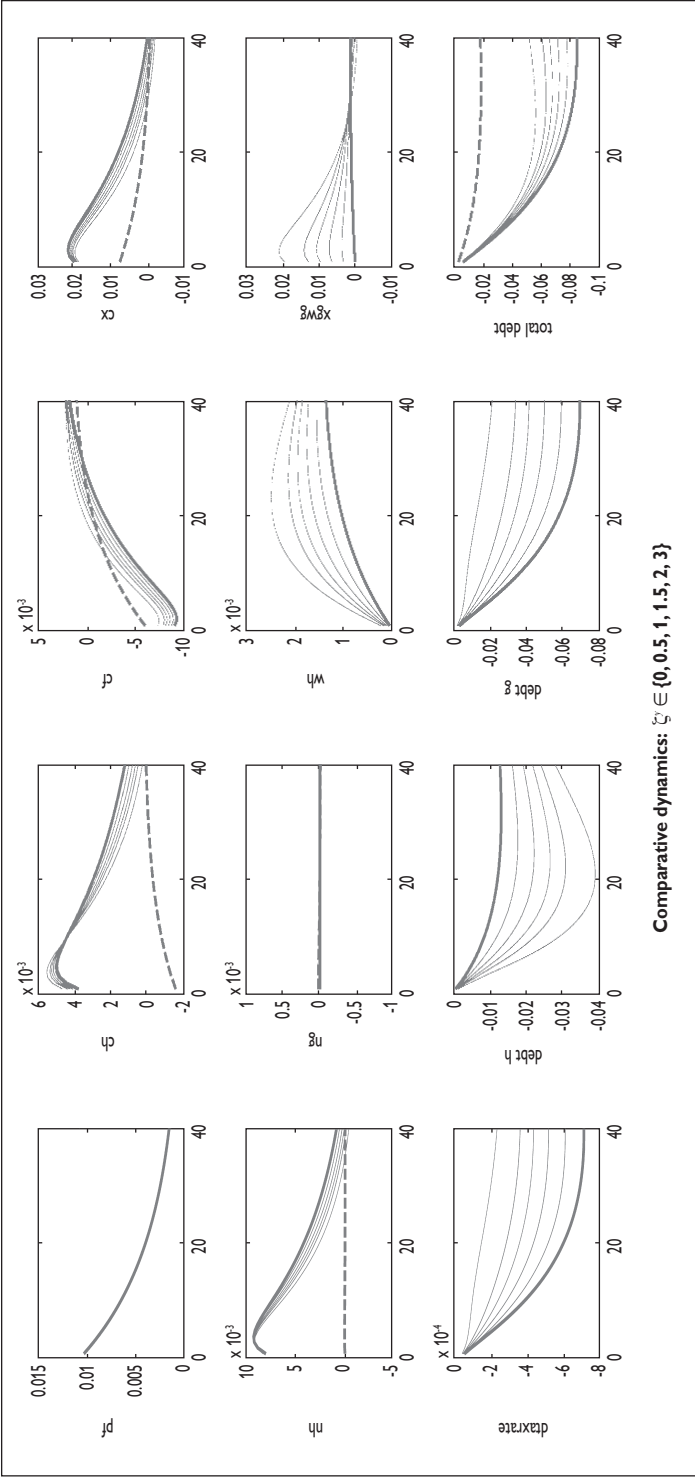
steady state level of public debt is held fixed across all cases we compare). We consider stabilizing public debt either by adjustments on the revenue side, or on the expenditure side. We have argued that an informationally feasible way of adjusting expenditure frequently and flexibly would be to make across-the-board shifts in public salaries and transfer payments.

Our simulations are based on a DSGE matching model with nominal rigidities, with business cycles driven by several types of asymmetric demand shocks. We show that stabilizing public debt by adjusting public salaries and transfers slightly reduces the fluctuations in consumption and labor, whereas stabilizing public debt by adjusting taxes strongly amplifies the fluctuations in both variables. Intuitively, this way of stabilizing debt on the expenditure side amounts to an internal devaluation when the economy enters into a recession. Thus, this particular expenditure-based mechanism for stabilizing the government debt keeps the economy closer to the first-best social planner's solution than adjusting taxes does.

While this study is a first step towards understanding how policy-making could be improved in the context of a monetary union, there are many issues still to be explored. It would be interesting to study other fiscal instruments not considered here, such as consumption taxes, or copayments for public services, as well as alternative versions of the fiscal rules. More generally, it would be interesting to find ways of aggregating the model we have used here beyond a linear approximation, in order to calculate welfare gains and/or study Ramsey optimal policy.

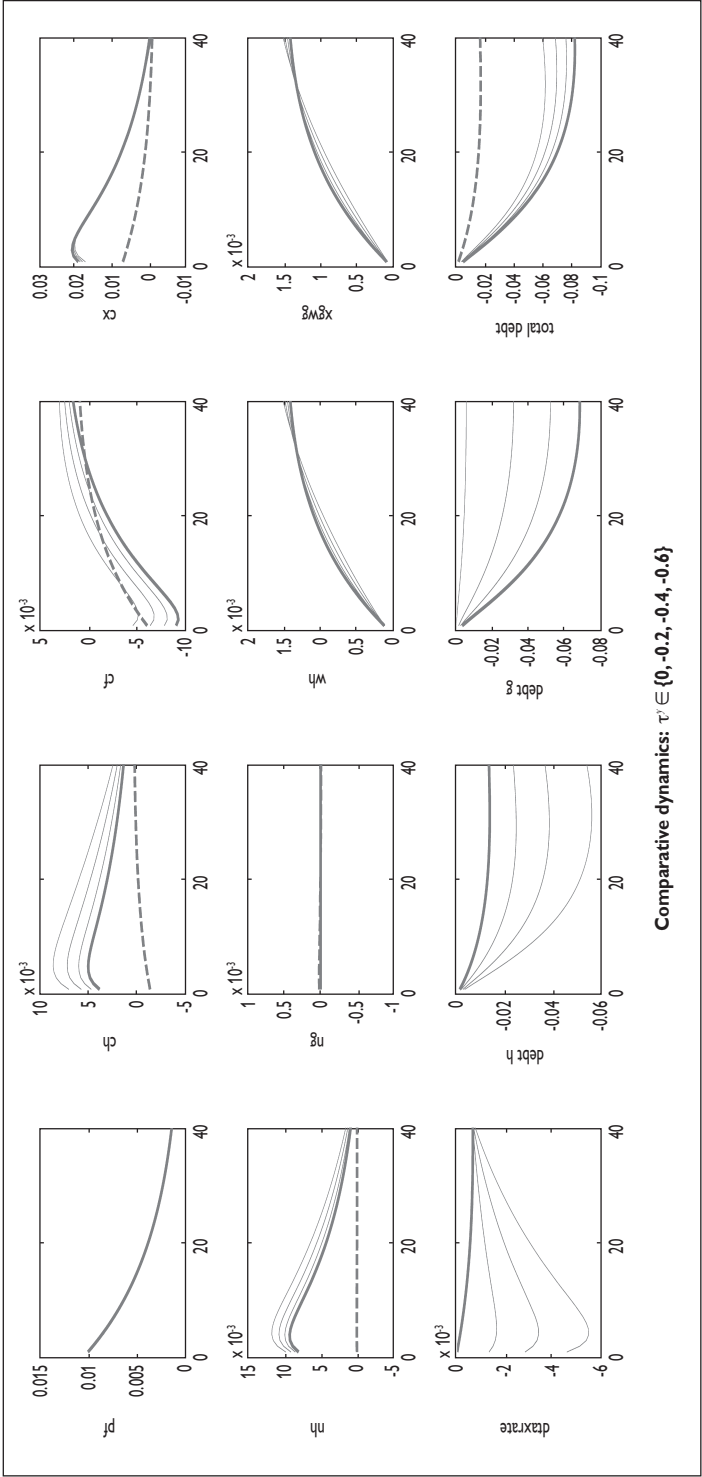
In today's context, it is possible that quick progress towards a fiscal union in Europe will make the issue of sovereign debt seem less urgent. But even if an agreement on fiscal union is reached soon, countries will have to decide which fiscal margins to adjust in order to meet their commitments under the new agreement. Also, countries that wish to maintain as much sovereignty as possible over their own fiscal decisions may prefer to undertake institutional reforms to guarantee that their public debts never reach levels that would imply European sanctions. Thus the policy innovations discussed here may be considered complementary to fiscal union, rather than mutually exclusive.

Figure 12.
Effects of Foreign Price Shock: Value of PSU Rises with Output



Note: comparative dynamics after a foreign price shock. Dashed line is planner's solution. Thick line is benchmark market economy. Thin lines are market economy with procyclical public wage.

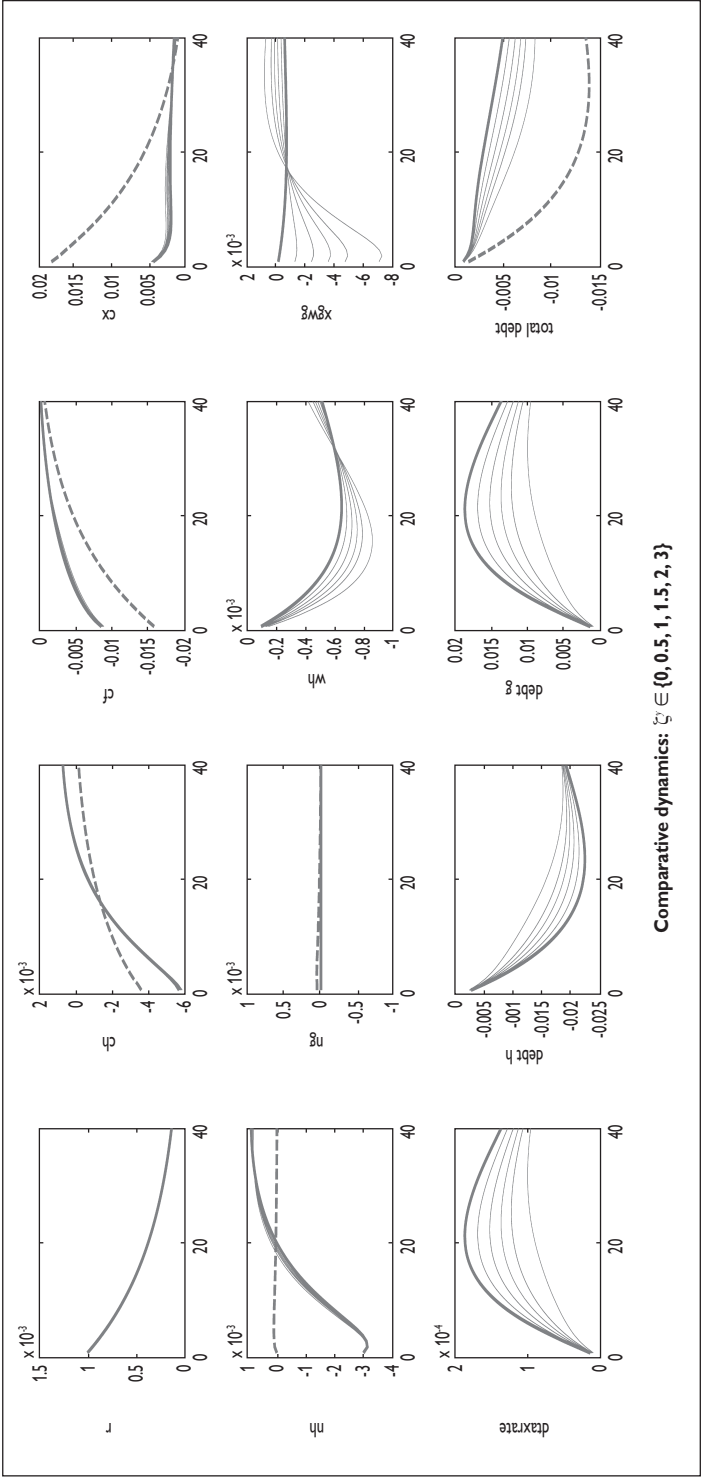
Figure 13.
Effects of Foreign Price Shock: Tax Rate Falls with Output



Comparative dynamics: $\tau' \in \{0, -0.2, -0.4, -0.6\}$

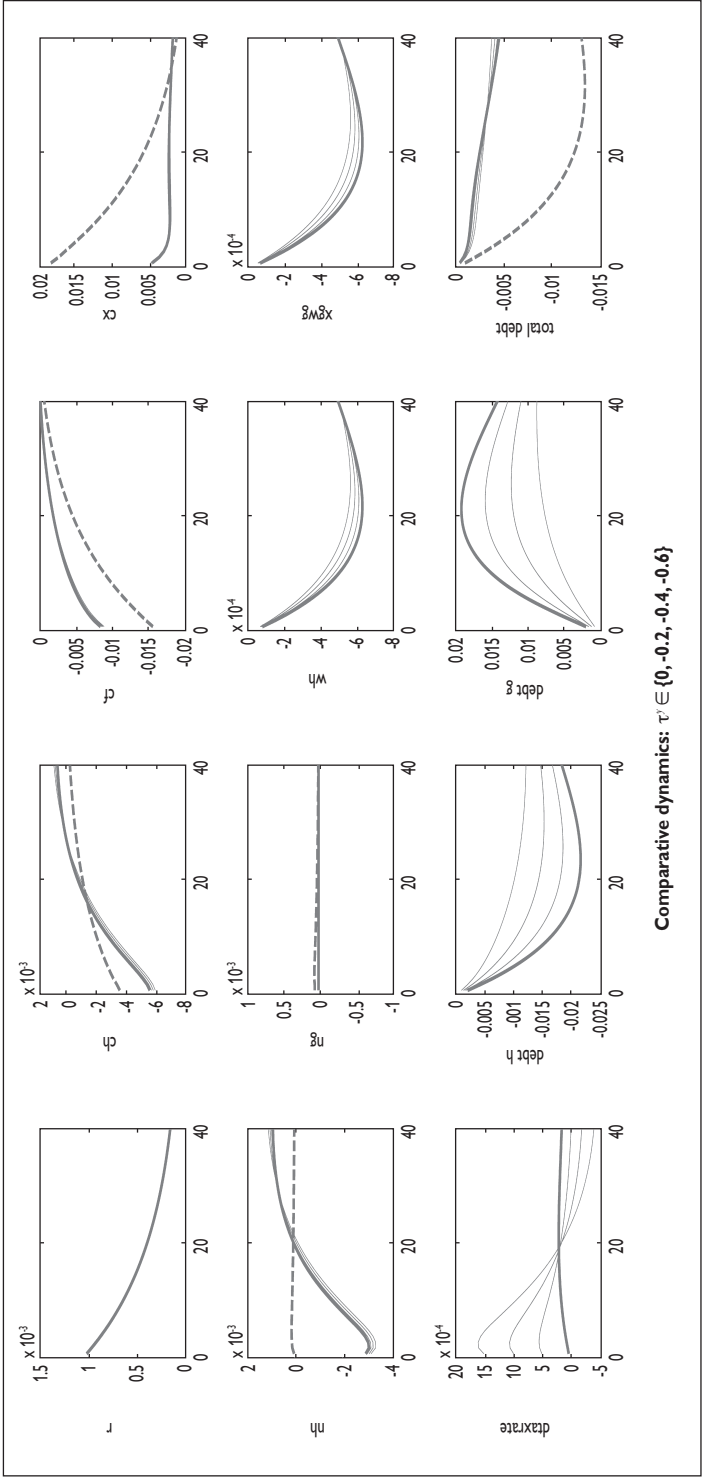
Note: comparative dynamics after a foreign price shock. Dashed line is planner's solution. Thick line is benchmark market economy. Thin lines are market economy with countercyclical taxes.

Figure 14.
Effects of Interest Rate Shock: Value of PSU Rises with Output



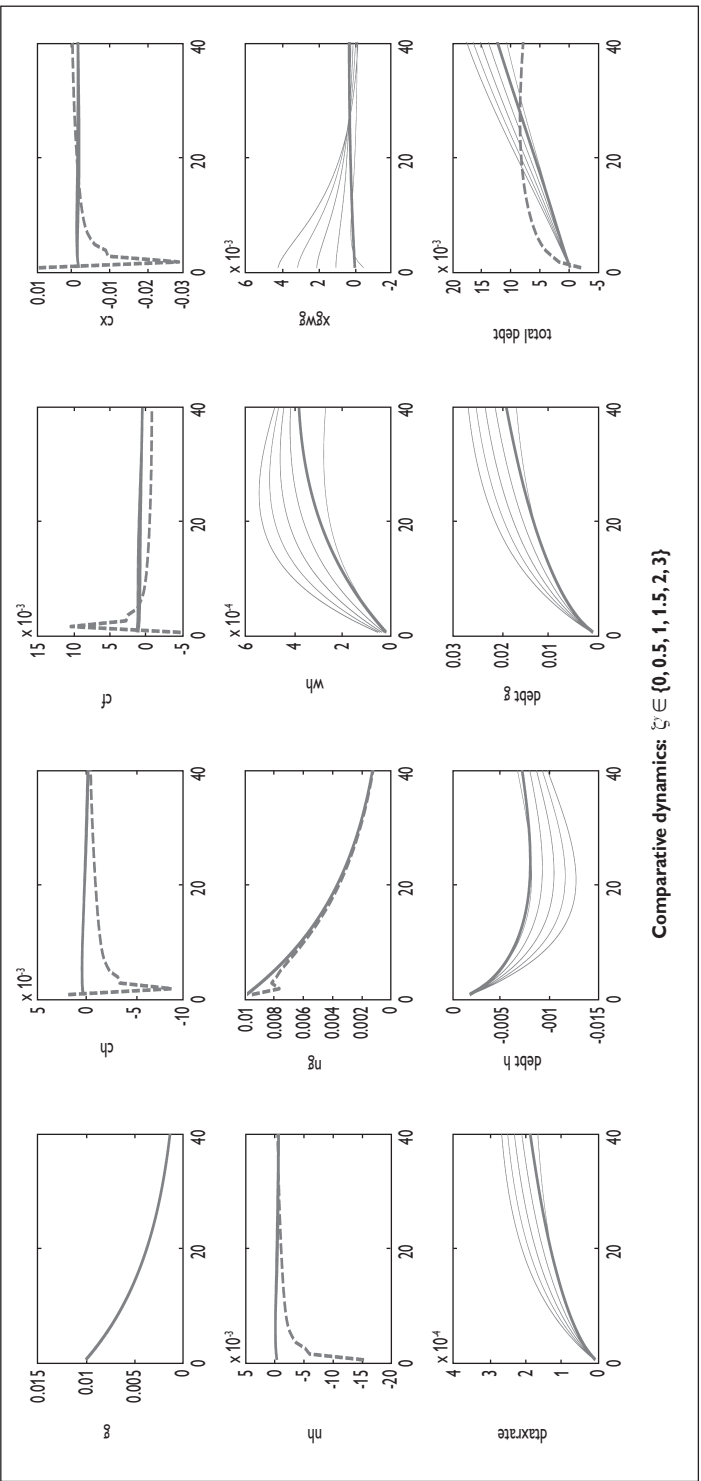
Note: comparative dynamics after interest rate shock. Dashed line is planner's solution. Thin lines are market economy with pro-cyclical public wage.

Figure 15.
Effects of Interest Rate Shock: Tax Rate Falls with Output



Note: comparative dynamics after interest rate shock. Dashed line is planner's solution. Thick line is benchmark market economy. Thin lines are market economy with countercyclical taxes.

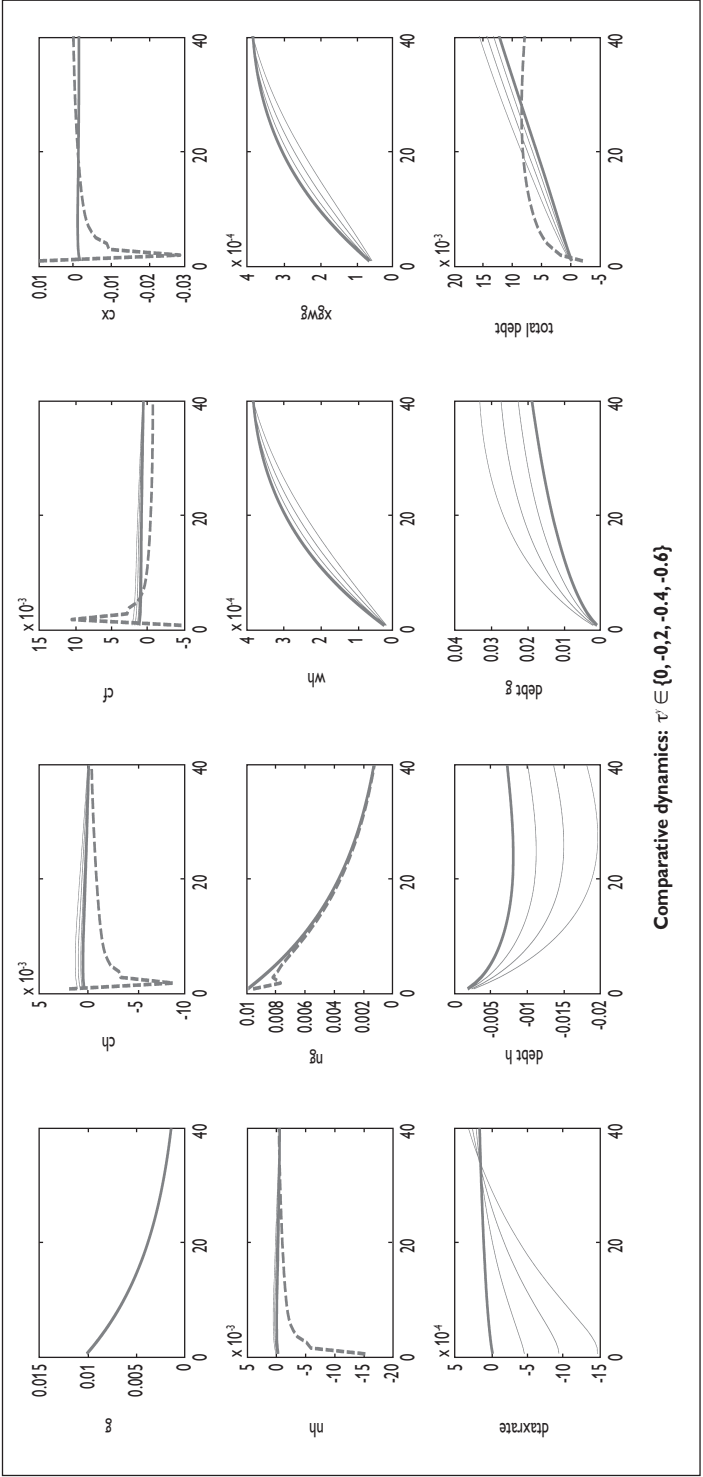
Figure 16.
Effects of Government Spending Shock: Value of PSU Rises with Output



Comparative dynamics: $\zeta \in \{0, 0.5, 1, 1.5, 2, 3\}$

Note: comparative dynamics after public spending shock. Dashed line is planner's solution. Thick line is benchmark market economy. Thin lines are market economy with procyclical public wage.

Figure 17.
Effects of Government Spending Shock: Tax Rate Falls With Output



Note: comparative dynamics after public spending shock. Dashed line is planner's solution. Thin lines are market economy with countercyclical taxes.

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