Fiscal Rules in a Monetary Union*

by
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Abstract

The Economic and Monetary Union of Europe has failed to apply the sanctions established by the Stability and Growth Pact (SGP), which puts limits on budget deficits. The future of the SGP is in doubt and this raises the question of what type of fiscal rule, if any, should replace it. This paper studies optimal fiscal policy rules in a monetary union where monetary policy is decided by an independent central bank. We consider a two-country model that trade in goods and assets, augmented with sticky prices, labor income taxes and stochastic government consumption. In this setting the optimal fiscal policy depends in a simple way from lagged deficits and the underlying current shocks to the economy. It is optimal to finance an increase in government spending in part by running deficits that lead to an increase in real public debt and in part by raising income taxes, even though these are distortionary. Hence, real public debt and taxes follow a near-random walk behavior. The optimal response of taxes to deficits grows larger with the level of public debt so that fiscal policy is tighter for countries with higher debt-to-GDP ratios. Interestingly, optimal fiscal policy when monetary policy is run by an independent central bank is remarkably similar to that run by a government that decides both fiscal and monetary policy. The optimal fiscal policy welfare-dominates, on average, a deficit limit á la Stability and Growth Pact because it generates lower variability of the income tax rate; however, it leads to higher debt levels and therefore to higher tax rates in the steady state. Hence, a welfare comparison between the Stability and Growth Pact and the optimal fiscal policy boils down to a comparison of short-run versus long-run benefits.

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1 Introduction

The creation of the Economic and Monetary Union (EMU) in Europe has put much emphasis on the design of monetary and fiscal institutions. The Maastricht Treaty and its subsequent pacts stipulate that the European Central Bank (ECB) should be independent of the fiscal authorities and that it should pursue a 2 percent inflation target. The Stability and Growth Pact (SGP) stipulates that EMU members should not run deficits in excess of 3 percent of GDP, except in deep recessions, that fiscal policy should aim to bring the debt to GDP ratio to about 0.6 and balance the budget over the business cycle after that.

The SGP has been criticized for being too strict and for hampering automatic stabilizers, especially for those countries that joined EMU with high debt levels. On the other hand, many recognize that some form of fiscal restraint may be necessary in a monetary union to avoid excessive deficits that could raise inflation expectations and harm the credibility of the ECB. The SGP was in fact a necessary condition for the participation in EMU of countries with a good reputation in terms of fighting inflation such as Germany.

Early in 2004 the Council decided not to apply the sanctions stipulated by the SGP against Germany and France, which broke the three percent limit in the fiscal year 2003. This decision has raised doubts over the relevance of the SGP and it has opened a debate over whether fiscal limits should be abandoned altogether in EMU or whether they should be replaced and by what.

The goal of this paper is to study optimal fiscal policy in a monetary union. We find the optimal fiscal policy that can be achieved by commitment by solving the Ramsey problem. We consider a two-country model that trade in goods and assets augmented with sticky prices; both countries belong to a monetary union and the common monetary policy is decided by an independent central bank. Government spending as well as technology are stochastic and each government decides fiscal policy in its own country by setting the labor income tax and by deciding how much public debt to issue. Governments can commit to their policies.

We find that optimal fiscal policy is a simple function of the lagged deficit and the current shocks. Hence, optimal fiscal policy can be expressed as a simple and transparent rule. In response to a government spending shock, it is optimal to finance it in part by running a deficit and in part by raising income taxes. The deficit leads to a long-run increase in real public debt that also raises the income tax rate in the long run. Hence, real public debt and taxes display a random walk behavior.

Optimal fiscal policy calls for an increase in the labor income tax in response to a deficit; interestingly, this response gets stronger as the debt to GDP ratio gets higher. This implies that countries starting with higher debt levels follow tighter fiscal policies. We characterize the optimal tax schedule by finding the optimal income tax for various debt levels.

In our model monetary policy is run by an independent central bank that follows an interest rate rule. We compare the optimal fiscal policy in this setup with that of a model where the government chooses both fiscal and monetary policy optimally and find little differences in the two. If the governments choose monetary policy, they would be more aggressive in raising inflation in response to a government spending shock than a central bank following an interest rate rule. However, the cost in terms of welfare is small – about 0.9 percent of steady state consumption.

Optimal fiscal policy in one country of the monetary union is sensitive to shocks in the other country of the union. For example, the optimal fiscal policy in the home country in response to a government spending shock in the foreign country demands an increase in the home tax rate and the magnitude is sixty percent the increase in response to a government spending shock in the home country. The international dimension, namely the responsiveness of optimal domestic fiscal policy to shocks in other countries of the monetary union, is important even though it depends from the degree of integration among the countries in the trade of goods and assets.

We compare social welfare under optimal fiscal policy and under deficit limits as dictated by the SGP and we find that, on average, optimal fiscal policy welfare-dominates the SGP for low and medium debt levels while optimal fiscal policy is welfare-dominated by the SGP for high debt levels. The average welfare cost of the SGP for medium debt levels is small, about 0.002 percent of steady state consumption. In fact, optimal fiscal policy does not welfare-dominate the SGP in *all* simulations. Intuitively, optimal fiscal policy delivers lower variability of the tax rate with respect to the SGP; since labor income taxes are distortionary, this improves welfare over the SGP. However, by putting a cap on deficits the SGP leads to lower debt levels and lower tax rates in the steady state, thereby improving welfare in the long run. The welfare comparison between optimal fiscal policy and the SGP therefore amounts to a comparison between short-run benefits (higher under the optimal fiscal policy because tax rates are less variable) and long-run benefits (higher under the SGP because steady state taxes are lower).

This paper builds on the existing literature on optimal monetary and fiscal policy. This literature studies the determination of optimal monetary and fiscal policy when the government problem is to finance an exogenous stream of public consumption by levying taxes and issuing debt and money so as to maximize welfare. Optimal monetary and fiscal policies depend on the environment in which they operate. When prices are flexible, competition is perfect and government debt is state contingent, as in Lucas and Stokey (1983) and Correia and Teles (1996), government debt and tax rates have the same stochastic process of the exogenous shocks to the economy. When government debt is nominally non-state-contingent, as in Chari et al. (1991), the government finds it optimal to use inflation as a lump-sum tax on financial wealth; as a result inflation is highly volatile while the tax rate remains stable over the business cycle. Schmitt-Grohe and Uribe (2003) consider a setting with imperfect competition where the government cannot implement production subsidies to undo the distortions stemming from it; government debt is nominally non-state-contingent. They find that, as in the perfectly competitive case, the labor tax rate is smooth and inflation is highly volatile because the government uses changes in the price level as a lump-sum tax on wealth.

A number of recent papers have focused on studying optimal monetary policy in an environment with nominal rigidities and monopolistic competition. Part of his literature assumes that the government has access to lump-sum taxes to finance its consumption and that it can implement a production subsidy that eliminates the inefficiency stemming from monopolistic competition.[1] As a result, the optimal inflation rate is stable and close to zero. Intuitively, lump-sum taxes are used to finance government spending without creating distortions and prices can remain stable to minimize the costs of inflation in an environment with price rigidities. Schmitt-Grohe and Uribe (2002) depart from this literature by studying optimal monetary and fiscal policy in a model where the government can only resort to distortionary income taxation and it can issue only nominal non-state-contingent bonds. Schmitt-Grohe and Uribe find that optimal inflation volatility is almost zero even if taxation is distortionary and even for low degrees of price stickiness. Moreover, shocks to the economy induce random walk behavior in government debt and tax rates. Correia et al. (2001) enrich the set of fiscal instruments and find that the set of frontier implementable allocations is the same and it does not depend on the degree of price stickiness.

We study optimal fiscal policy when monetary policy is decided by a central bank that follows a Taylor-type rule; similarly to Schmitt-Grohe and Uribe (2002), we consider an environment with monopolistic competition, distortionary income taxation and nominal non-state-contingent government debt; our setting, however, envisions two countries in a monetary union. The random walk behavior of government debt and tax rates in our international setting in response to shocks, both domestic and foreign, is alike that in Schmitt-Grohe and Uribe (2002), confirming that it is the assumption of market incompleteness that lies at the core of such behavior. Recent work by Marcet et al. (2002) also confirms this result, as it finds a near unit-root component in government debt and tax rates in a model that retains the characteristics of Lucas and Stokey's original piece but the bond market, which is assumed to be incomplete in that the government can only buy or sell one period risk-free bonds.

A number of papers analyze the interaction of monetary and fiscal policies to determine the optimal design of monetary and fiscal institutions. Dixit and Lambertini (2003a) and Lambertini (2004) study the interaction between a conservative and independent central bank and a benevolent fiscal authority that maximizes social welfare in models where purpose of fiscal policy is to stabilize prices and output. In such setting, equilibrium outcomes are suboptimal when one or both policies are discretionary. The optimal design of institutions assigns non-conflicting goals to the authorities and, if policies are discretionary, it assigns a price goals that is appropriately conservative. Dixit and Lambertini (2001, 2003b) extend this analysis to a monetary union and find that the spillover of one country's fiscal policy on others exacerbates the suboptimality of the equilibrium. Sibert (1992), Levine and Brociner (1994) and Beetsma and Bovenberg (1998) consider monetary-fiscal interactions in a monetary union where the purpose of fiscal policy is to provide public goods. Chari and Kehoe (2004) conclude that fiscal limits are desirable in a monetary union when the central bank cannot commit in advance. We depart from this literature in two ways. First we assume that government spending is exogenous and stochastic and that the problem faced by the fiscal authority is how to finance such spending stream in the least disruptive way. Second, we

[1] See Erceg et al. (2000), Gali and Monacelli (2000), Khan et a. (2000), Rotemberg and Woodford (1999) and Woodford (2000, 2003).

assume that the fiscal authority can commit to its policies.

A vast literature focuses on the Stability Growth Pact. Among these contributions, Eichengreen and Wyplosz (1998) suggest that the Stability Pact is likely to affect the fiscal behavior of the EMU members and that it is likely to partly hamper automatic stabilizers,[2] thereby wondering if the SGP will only be a "minor nuisance". Our numerical analysis shows that, indeed, the SGP is a minor nuisance, if any, because the welfare costs of harmstrung automatic stabilizers have to be weighted against the welfare gains stemming from lower long-run debt levels. Wyplosz

Several proposals to change the SGP or parts of it are being discussed – see, for example, De Grauwe (2002), Wyplosz (200, 2003), Aghion et al. (2003) and Uhlig (2002). Our paper contributes to this literature and makes a concrete proposal for a fiscal rule.

Fiscal Policy: Institutions versus Rules, Aghion et al. (2003): An Agenda for a Growing Europe Uhlig (2002) suggests strengthening the SGP to avoid the free-riding problem of fiscal policies in a monetary union and argues for automatic rules. For example, Wyplosz (2002) reviews the features of the SGP and argues for an institutional solution by creating fiscal policy committees.

2 The Model

We consider a world economy that consists of two countries, country 1 and country 2. These two countries are in a monetary union and therefore share a common currency. They have separate governments that run fiscal policies; monetary policy, on the other hand, is decided by a common and independent central bank. We now proceed to model country 1; country 2 is symmetric.

2.1 Consumers

The representative household in country 1 maximizes the discounted sum of utilities of the form

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_{1,t}, N_{1,t}, m_{1,t}\right) \tag{1}$$

where $C_{1,t}$ is consumption and $m_{1,t} \equiv M_{1,t}/P_t$ are real balances. $0 < \beta < 1$ is a discount factor. $N_{1,t}$ is labor supply

$$N_{1,t} = \int_0^n N_{1,t}(i)di$$

and $N_{1,t}(i)$ is the quantity of labor of type i supplied by the representative individual to domestic firms. It is assumed that each differentiated good uses a specialized labor input in its production and the individual supplies labor input to all domestic firms. This assumption

[2]Gali and Perotti (2003), however, find no empirical evidence that the SGP has impaired fiscal stabilization.

is not necessary but convenient, as households with identical initial assets supply the same quantities of labor and receive the same labor income.

There is a continuum of differentiated goods distributed over the interval $[0,1]$; a fraction n of these goods is produced in country 1 while the fraction $1-n$ is produced in country 2. $C_{1,t}$ is the real consumption index

$$C_{1,t} = \left[\int_0^1 C_{1,t}(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}, \tag{2}$$

where $C_{1,t}(i)$ is consumption of good i at time t and $\theta > 1$ is the constant elasticity of substitution among the individual goods. The representative household consumes all goods produced in the world economy. The price index P_t corresponding to the consumption index $C_{1,t}$ is

$$P_t = \left[\int_0^n P_{1,t}(i)^{1-\theta} di + \int_n^1 P_{2,t}(i)^{1-\theta} di\right]^{\frac{1}{1-\theta}}, \tag{3}$$

which is the minimum cost of a unit of the aggregate consumption good defined by (2), given the individual goods prices $P_{1,t}(i), P_{2,t}(i)$.

The representative household in country 2 has symmetric preferences to those in (1) and (2). All households in country 1 begin with the same amount of financial assets. Hence, they will have the same intertemporal budget constraints and will therefore choose the same sequences of consumption, real balances and efforts. The budget constraint for the representative agent in country 1 is

$$\frac{B^p_{1,t}}{P_t(1+i_t)} + \frac{M_{1,t}}{P_t} + C_{1,t} = \frac{B^p_{1,t-1}}{P_t} + \frac{M_{1,t-1}}{P_t} + \int_0^n \frac{W_{1,t}}{P_t}(1-\tau_{1,t})N_{1,t}(i)di + \int_0^n \Pi_{1,t}(i)di + \tau^m_{1,t}. \tag{4}$$

Here $B_{1,t}$ is the purchase of a riskless, non-contingent nominal bond. This bond is the only asset available for borrowing or lending between the two countries and $1+i_t$ is the gross nominal interest rate. $W_{1,t}(i)$ is the nominal wage of labor of type i in period t and $\Pi_{1,t}(i)$ are real profits of the country 1 firm producing good i. We assume that each household in country 1 owns an equal share of all the firms in the country, but no shares in the firms in country 2. $\tau^m_{1,t}$ are transfers received from the household in country 1 at time t and $\tau_{1,t}$ is a distortionary tax levied by the government of country 1 at time t on the labor income of citizens of that country.

The budget constraint can be divided by P_t and be written in real terms as

$$\frac{b^p_{1,t}}{1+i_t} + m_{1,t} + C_{1,t} = b^p_{1,t-1} + m_{1,t-1} + \int_0^n w_{1,t}(1-\tau_{1,t})N_{1,t} + \int_0^n \Pi_{1,t}(i)di + \tau^m_{1,t}. \tag{5}$$

where

$$b^p_t \equiv \frac{B^p_{1,t}}{P_t}, \quad w_t \equiv \frac{W_{1,t}}{P_t}.$$

The household solves the problem

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_{1,t}, N_{1,t}, m_{1,t}) - \lambda_{1,t}\left[\frac{b^p_{1,t}}{1+i_t} + m_{1,t} + C_{1,t} - b^p_{1,t} - m_{1,t-1} - \right. \tag{6}$$

$$-w_{1,t}(1-\tau_{1,t})N_{1,t} - \int_0^n \Pi_{1,t}(i)di - \tau_{1,t}^m \Big]$$

where $\lambda_{1,t}$ is the lagrangean multiplier on the agent's budget constraint (5), taking $\{i_t, w_t, \tau_t^m, \Pi_t(i), P_t(i), P_t\}$ as given. The agent faces five choices; the first-order conditions are

$$C_{1,t}(i) = \left(\frac{P_{j,t}(i)}{P_t}\right)^{-\theta} C_{1,t}, \tag{7}$$

$$U_c(C_{1,t}, N_{1,t}, m_{1,t}) = \lambda_{1,t}, \tag{8}$$

$$U_m(C_{1,t}, N_{1,t}, m_{1,t}) = \lambda_{1,t} - \beta E_t \frac{\lambda_{1,t+1}}{\pi_{t+1}}, \tag{9}$$

$$\frac{\lambda_{1,t}}{1+i_t} = \beta E_t \frac{\lambda_{1,t+1}}{\pi_{t+1}}, \tag{10}$$

$$-U_N(C_{1,t}, N_{1,t}, m_{1,t}) = \lambda_{1,t} w_{1,t}(1-\tau_{1,t}), \tag{11}$$

First, the agent chooses how to allocate consumption across the differentiated goods. This is described by (7): the optimal consumption of good i produced in country j falls as its relative price rises. The agent also optimizes with respect to $C_{1,t}$, as described in (8). The first-order condition with respect while (9) describes is the demand of real balances $m_{1,t}$, which depends negatively on the nominal interest rate. (10) is the Euler equation that describes the optimal choice of $b_{1,t}^p$ and (11) is the first-order condition with respect to $N_{1,t}(i)$ that describes the household's decision of how much labor to supply to the production of good i. Notice that this equation does not depend on i.

2.2 Firms

Goods are produced making use of labor. The production function for the goods produced in country 1 is given by

$$Y_{1,t}(i) = A_{1,t} N_{1,t}(i), \tag{12}$$

where $A_{1,t}$ is an exogenous stochastic technological factor common to all firms in country 1. Country 2 has a similar production function.

Firms maximize the present value of current and future profits. Firm i in country 1 maximizes

$$E_0 \sum_t^{\infty} \lambda_{1,t} P_t \Pi_{1,t}(i) \tag{13}$$

where$\lambda_{1,t}$ is the stochastic discount factor for country 1 and real profits are described by

$$\Pi_{1,t}(i) = \frac{P_{1,t}(i)}{P_t} Y_{1,t}(i) - w_{1,t} N_{1,t}(i). \tag{14}$$

Real profits are the revenues from selling the goods minus the cost of producing them, which is the real wage bill for the employed labor. The firm takes the real wage as given.

The demand faced by $i-$th producer in country 1 is

$$Y_{1,t}(i)^d = \left[\frac{P_{1,t}(i)}{P_t}\right]^{-\theta}(C_t + G_t) \tag{15}$$

where $C_t \equiv nC_{1,t}+(1-n)C_{2,t}$ is union-wide private consumption and $G_t \equiv nG_{1,t}+(1-n)G_{2,t}$ is union-wide public consumption that will be decribed in detail later.

If prices are flexible, firm i chooses its relative price every period to maximize (13). Hence, the firm chooses the current relative price so as to maximize current profits. The first-order condition implies that

$$p_{1,t} = \frac{\theta}{\theta-1}\frac{w_{1,t}}{A_{1,t}}, \tag{16}$$

where $p_{1,t} = P_{1,t}/P_t$ is the relative price of country 1. The optimal relative prices is the markup $\theta/(\theta-1)$ over the marginal cost. The markup falls as θ, the monopolistic power of the firm, becomes smaller. Notice also that the optimal relative price does not depend on i, which implies that all firms that can set new prices choose the same price.

We assume that prices are sticky à la Calvo (1983). Every period, a fraction $\phi \in [0,1)$ of randomly chosen firms is not allowed to change the nominal prices of the goods they produce. The remaining fraction $1-\phi$ of firms set their prices optimally so as to maximize the expected present discounted value of real profits

$$E_0 \sum_{t}^{\infty} \phi^t \lambda_{1,t} P_t \Pi_{1,t}(i) \tag{17}$$

and the associated first-order condition with respect to $P_{1,t}(i)$ is

$$\theta E_t \sum_{s=t}^{\infty} \lambda_s Y_s^w \frac{w_s}{A_s}\left(\frac{P_{1,t}(i)}{P_s}\right)^{-\theta-1} = (\theta-1)E_t \sum_{s=t}^{\infty} \lambda_s Y_s \left(\frac{P_{1,t}(i)}{P_s}\right)^{-\theta}, \tag{18}$$

where $Y_t = C_t + G_t$ is aggregate demand, which the firm takes as given. The optimal price is an average of current and expected future marginal cost and revenues.

We can simplify (18) by introducing two variables. Let $\tilde{p}_{1,t} \equiv \tilde{P}_{1,t}/P_t$ and

$$x_{1,t} = E_t \sum_{s=t}^{\infty} \lambda_s Y_s \left(\frac{P_{1,t}(i)}{P_s}\right)^{-\theta}, \tag{19}$$

and

$$v_{1,t} = E_t \sum_{s=t}^{\infty} \lambda_s Y_s^w \frac{w_s}{A_s}\left(\frac{P_{1,t}(i)}{P_s}\right)^{-\theta-1}. \tag{20}$$

It is easy to see that

$$x_{1,t} = \lambda_{1,t} Y_t \tilde{p}_{1,t}^{-\theta} + \phi\beta x_{1,t+1}$$

and

$$v_{1,t} = \lambda_{1,t} Y_t \frac{w_t}{A_t} \tilde{p}_{1,t}^{-\theta-1} + \phi\beta v_{1,t+1}$$

so that

$$\tilde{p}_{1,t} = \frac{\theta}{\theta - 1} \frac{v_{1,t}}{x_{1,t}}. \tag{21}$$

and similarly for country 2.

Under the Calvo formulation, the dynamics of prices is

$$1 = \phi \pi_t^{\theta-1} + (1-\phi) \left[n \tilde{p}_{1,t}^{1-\theta} + (1-n) \tilde{p}_{2,t}^{1-\theta} \right] \tag{22}$$

where $\pi_t = P_t / P_{t-1}$ is the gross inflation rate and $\tilde{p}_{1,t}$ is described in (21).

2.3 Policymakers

There is a common central bank that runs monetary policy for the monetary union; in addition, there is a government that decides fiscal policy in each country. The central bank is instrument-independent in the sense that it chooses monetary policy freely and it does not share the government budget constraints. We assume that the central bank follows the interest rate rule

$$i_t = \bar{i} + \phi_y \left(\frac{Y_t - Y}{Y} \right) + \phi_\pi \left(\frac{\pi_t - \pi}{\pi} \right), \tag{23}$$

where $\bar{i}$ is the steady-state value of the nominal interest rate. (23) describes a Taylor rule whereby the central bank sets the nominal rate as a function of the deviations of monetary union-wide output and inflation from their steady state values. It is typically assumed that the coefficient on inflation ϕ_y is greater than one, which implies that the central bank raises the nominal interest rate in response to an increase in inflation.

The budget constraint for the central bank is

$$n \tau_{1,t}^m + (1-n) \tau_{2,t}^m = \frac{M_t - M_{t-1}}{P_t}. \tag{24}$$

The central bank rebates seignorage back to households in the two countries. Most importantly, the central bank does not share the budget constraint of the fiscal authorities.

The government in each country decides how to finance an exogenous and stochastic stream of public consumption. Government spending $G_{1,t}$ is stochastic and takes the form

$$G_{1,t} = \left[\int_0^1 G_{1,t}(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \tag{25}$$

and similarly for country 2, and the government demand for good i is therefore

$$G_{1,t}(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\theta} G_{1,t}, \tag{26}$$

for all $i \in [0,1]$.

2.4 Equilibrium

In equilibrium, firms meet demand. Aggregate output in country 1 is

$$Y_{1,t} \equiv \int_0^n p_{1,t}(i) Y_{1,t}(i)\, di, \tag{27}$$

and similarly in country 2. The real net asset position of country 1 and 2 are

$$b_{1,t} = b^p_{1,t} - b^g_{1,t}, \qquad b_{2,t} = b^p_{2,t} - b^g_{2,t}. \tag{28}$$

Clearing on the bond market requires

$$nb_{1,t} + (1-n)b_{2,t} = 0, \qquad \forall t. \tag{29}$$

This implies clearing in the goods market

$$C_t + G_t = Y_t, \tag{30}$$

where

$$Y_t = nY_{1,t} + (1-n)Y_{2,t}.$$

3 The Ramsey Problem

Each period the government decides how to finance the exogenous stream of public spending. The optimal fiscal policy is therefore the sequence of tax rates $\{\tau_t\}$ associated with the equilibrium described above that maximizes the utility of the representative agent.

Formally, the lagrangean of the Ramsey problem is

$$\mathcal{L}_t = E_0 \sum_{t=0}^{\infty} \beta^t \sum_{i=1}^{2} \Big\{ U(C_{i,t}, N_{i,t}, m_{i,t}) + \lambda^c_{i,t} \left[U_{c,i}(t) - \lambda_{i,t} \right] + \tag{31}$$

$$\lambda^m_{i,t} \left[\frac{b_{i,t}}{1+i_t} + w_{i,t} N_{i,t} \left(1 + \frac{U_{N,i}(t)}{U_{c,i}(t) w_{i,t}} \right) - \frac{b_{i,t-1}}{\pi_t} - G_{i,t} \right] + \lambda^p_{i,t} \left[\tilde{p}_{i,t} - \frac{\theta}{\theta-1} \frac{v_{i,t}}{x_{i,t}} \right] +$$

$$\lambda^{int}_{i,t} \left[i_t - \frac{U_{m,i}(t)}{\lambda_{i,t} - U_{m,i}(t)} \right] + \lambda^r_t \left[C_t + G_t - Y_t \right] + \lambda^\pi_t \left[\phi \pi_t^{\theta-1} + (1-\phi) \left(n \tilde{p}_{1,t}^{1-\theta} + (1-n) \tilde{p}_{2,t}^{1-\theta} - 1 \right) \right] +$$

$$\lambda^b_t \left[-i_t + \frac{\pi}{\beta} - 1 + \phi_y \left(\frac{Y_t - Y}{Y} \right) + \phi_\pi \left(\frac{\pi_t - \pi}{\pi} \right) \right] + \lambda^x_{i,t} \left[x_{i,t} - \lambda_{1,t} Y_t - \phi \beta x_{i,t+1} (\pi_{t+1} \tilde{p}_{i,t+1})^\theta \right]$$

$$+ \lambda^v_{i,t} \left[v_{i,t} - \lambda_{i,t} Y_t \frac{w_{i,t}}{A_t} - \phi \beta v_{i,t+1} (\pi_{t+1} \tilde{p}_{i,t+1})^{\theta+1} \right] \Big\}$$

given $B_{1,-1}, B_{2,-1}, M_{1,-1}, M_{2,-1}, P_{-1}$. The first-order conditions of the Ramsey problem are spelled out in Appendix A.

In an environment with flexible prices, it is optimal for the government to inflate the nominal debt away in period 0 by choosing an infinite price level. This amounts to a lump-sum on financial wealth that is preferable to the use of distortionary taxation. To avoid this unrealistic policy, the literature on optimal policy typically assumes that the initial price level P_0 is given. To maintain comparability with the existing literature, we also assume that the initial price level is given and that inflation remains equal to zero in the first period. Notice, however, that in this setting the government would not find it optimal to choose an infinite price level at time 0: with price stickyness, a large increase in P_0 generates persistent price dispersion, which reduces welfare.

The Ramsey's policy functions form a dynamic system that cannot be solved analytically. We linearize the model around the non-stochastic steady state and present quantitative results.

4 Calibration

Table 4 summarizes the parameter values used in our simulation. The time unit is a year. We assume that, in period 0, the monetary union is at the non-stochastic steady state associated with the equilibrium described in 2.4. Hence, the monetary union is at an equilibrium with constant consumption, output, taxes, government spending and inflation rate. In our setup, the optimal inflation rate is zero: inflation creates price dispersion that harms social welfare. We assume that the central bank's inflation goal is indeed zero. The debt-to-GDP ratio in country 1 is assumed to be 0.4 in the benchmark simulation; however, we are going to consider and simulate our economies for different debt-to-GDP ratios. Government consumption is assumed to be 20% of GDP in the steady state in both countries, as consistent with post-war Germany. We set the discount factor β to 0.98, which is consistent with a steady-state real rate of return of 2 percent a year.

We assume a period utility function

$$U(C, N, m) = \log C + d \log(1 - N) + \chi \log m.$$

We set the parameter χ in the utility function so that real balances are 5 percent of consumption in the steady state. The parameter d is set equal to 2, which implies that the representative agent works one third of her total time in the steady state. The parameter ϕ that summarizes the degree of price staggering is set equal to 0.185; this implies that firms on average change their prices every three quarters, which is in line with a number of empirical studies. The mark-up parameter θ is set equal to 11, so that steady-state mark-up is 10 percent, as consistent with the work of Basu and Fernald (1997) and as used in other works that assume price staggering (see for example Gali (2001) and Schmitt-Grohe and Uribe (2003)).

Government spending is assumed to follow the stochastic process

$$\ln G_{i,t} = (1 - \rho_g) \ln G_i + \rho_g \ln G_{i,t-1} + \epsilon^g_{i,t}, \quad i = 1, 2. \tag{32}$$

Parameter	Value	Description
β	0.98	Subjective discount factor
π	1.0	Gross inflation rate
d	2	Calibrated to match $N = 0.3$
χ	0.001	Calibrated to match $m = 0.05C$
g/Y	0.2	Government consumption to GDP ratio
b/Y	0.4	Debt to GDP ratio
θ	11	Calibrated to match 1.1 gross value-added markup
ϕ	0.185	Degree of price stickiness
n	0.5	Size of country 1
ϕ_y	0.5	Coefficient on output
ϕ_π	1.5	Coefficient on inflation
ρ_g	0.88	Serial correlation of $\ln g_t$
σ_g	0.02	Standard deviation of innovation to $\ln g_t$
ρ_a	0.95	Serial correlation of $\ln a_t$
σ_a	0.01	Standard deviation of innovation to $\ln a_t$

$\epsilon^g_{i,t}$ are i.i.d with normal distribution with mean 0 and standard deviation 0.02; we assume that $\rho_g = 0.88$. This calibration is consistent with the government consumption process of post-war Germany. Technology is assumed to follow the process

$$\ln A_{i,t} = (1 - \rho_a) \ln A_i + \rho_a \ln A_{i,t-1} + \epsilon^a_{i,t}, \quad i = 1, 2. \tag{33}$$

$\epsilon^a_{i,t}$ are i.i.d with normal distribution with mean 0 and standard deviation 0.01; ρ_a is set equal to 0.95. The central bank is assumed to follow a Taylor rule; the parameter ϕ_y is set equal to 0.5 and the parameter ϕ_π is set equal to 1.5. These are the values suggested by Taylor that have been shown to represent well monetary policy in the U.S. as well as other industrialized countries – see Clarida, Gali and Gertler (1998).

Table 4 summarizes our choices for the parameters of the model.

5 Results

Figure 1 shows the impulse response function for country 1 in response to a one standard deviation percentage increase in government consumption in country 1. Remember that, in period 0, we constrain prices and therefore inflation and the nominal interest rate not to change in response to a government consumption shock. This explains why there is no response of inflation and the nominal interest rate to the government spending shock at time 0. If we were to eliminate this restriction, the nominal interest rate and inflation would increase at time 0 without changing much the impulse response function of the other variables. It is optimal for the government to finance an increase in government consumption in partartially by running deficits and partially by raising the labor income tax. The intuition is simple. A sharp increase in the tax rate to balance the government budget in response to

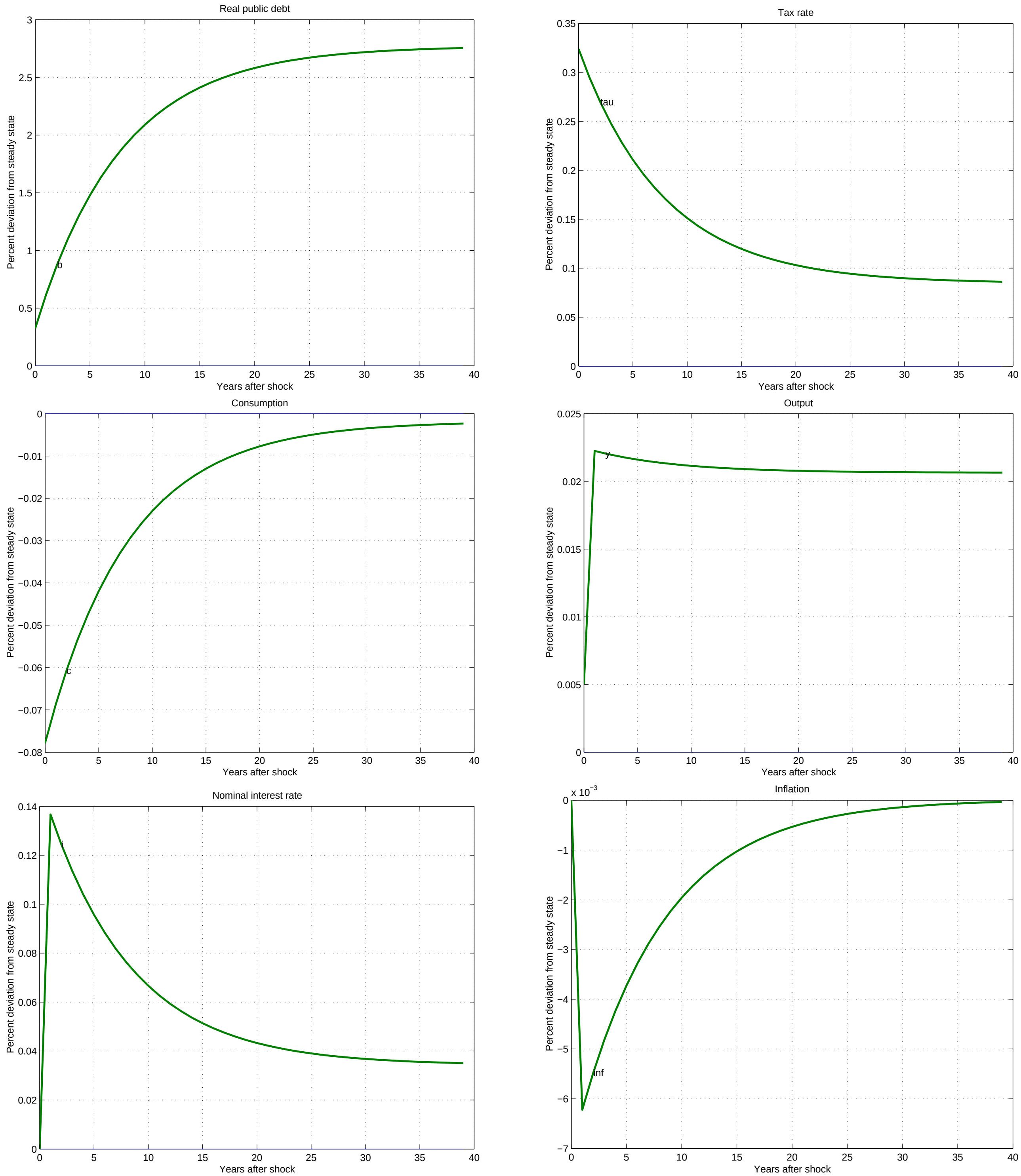

Figure 1: Impulse response to an iid government consumption shock

a spending shock would reduce labor. On the other hand, an increase in public debt does mitigates the need for a sharp increase in taxation and allows the government to spread the tax distortions over time.

The household anticipates that public debt and the tax rate will be higher in the new steady state. As a result, consumption falls on impact while labor increases, even though current taxes are higher than future ones. The increase in government spending boosts demand which, in turn, raises output in country 1 as well as in country 2. In this setup, a number of producers are unable to adjust their prices in response to a demand shock but instead increase production to meet demand at the established price. Hence, government spending is expansionary here.

Following an increase in government consumption in country 1, monetary-union wide output and inflation raise above their steady state levels. The central bank tightens moneary policy by raising the nominal interest rate.

In Chari et al. (1991), where prices are fully flexible, the government finds it optimal to respond to a government consumption shock by changing prices and making inflation volatile but keeping labor income taxes remarkably constant. There two important difference between our environment and the one in Chari et al.İn our model monetary policy is run by a central bank that follows an interest rate rule. Second, volatile inflation is bad here because price changes are persistent and distort consumption choices for the household and labor choices for the firms.

Schmitt-Grohe and Uribe (2003) also find that it is optimal for the government to run deficits and raise labor tax rates. Our model, however, is different from theirs in a number of dimensions. We have price staggering while they have a price adjustment cost and our model has a different production structure. Moreover, in our model monetary policy is run by a central bank that follows an interest rate rule.

In our model real public debt and taxes display random walk behavior. Following a shock to government consumption, real public debt increases to a new steady state level; as a result, the steady-state tax rate must also increase, thereby affecting labor, consumption and prices. In fact, labor increases while consumption falls in the new steady state. This implies that our local approximation technique becomes more inaccurate the longer the horizon of our simulations.

6 Welfare Comparisons

We wish to compare welfare under alternative policy specifications. To do so, we assume that the economy is at a steady state at time zero. Let the sequence of consumption, labor and real balances under policy specification a be labeled as c_t^a, N_t^a, m_t^a, respectively. Welfare under policy specification a is therefore

$$W_0^a \equiv E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^a, N_t^a, m_t^a). \tag{34}$$

This is the utility of the representative agent from time zero on under policy specification a. Assuming the economy is at time zero at the same steady state, welfare under policy specification b is

$$W_0^b \equiv E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^b, N_t^b, m_t^b). \tag{35}$$

Let Ψ denote the welfare cost of adopting policy b instead of a. We measure Ψ as the percent reduction in steady-state consumption under policy a the agent is willing to forgo to switch to policy b:

$$\Psi = (1-\beta)(W^b - W^a) \times 100. \tag{36}$$

.

7 Monetary Policy Delegation

It is natural to ask how different monetary and fiscal policy would be if the benevolent government were in charge not only of fiscal but also of monetary policy. Under this scenario, the Taylor rule of (23) does not hold, the government chooses directly monetary policy and seignorage becomes part of the revenues of the government.

Figure 2 compares the impulse response functions to a government spending shock in country 1 when the government chooses monetary as well as fiscal policy and when government chooses only fiscal policy. We assume that the economy is at the same non-stochastic steady state of section 4; the parameters are also assumed to be those of table 4.

If the government can choose monetary policy, it is more aggressive in raising inflation and therefore the nominal interest rate in response to a government spending shock than a central bank following a Taylor rule. On the fiscal side, the government reduces the tax rate on impact so that output (not plotted) increases in response to a government spending shock; as a result, real public debt increases more than under scenario of section 4

We expect welfare to be higher if monetary and fiscal policies are optimally chosen by the government. In fact, $\Psi = 0.9$. This means that the representative household is willing to cut her steady-state consumption by 0.9% to switch from the regime where monetary and fiscal policy are chosen optimally by the government to the regime where monetary policy is delegated to a central bank that follows the Taylor rule (23).

8 Robustness

The solution to the Ramsey problem gives the optimal fiscal policy associated with a given initial steady state of the economy. It is interesting to investigate the robustness of the optimal fiscal policy with respect to different initial conditions. In this section we compare the optimal fiscal policies associated with different levels of the initial debt to GDP ratio.

Figure 3 shows the debt and tax rate response to a government spending shock associated with four different initial levels of the debt to GDP ratio: 0.40, 0.60, 0.80 and 1. The optimal

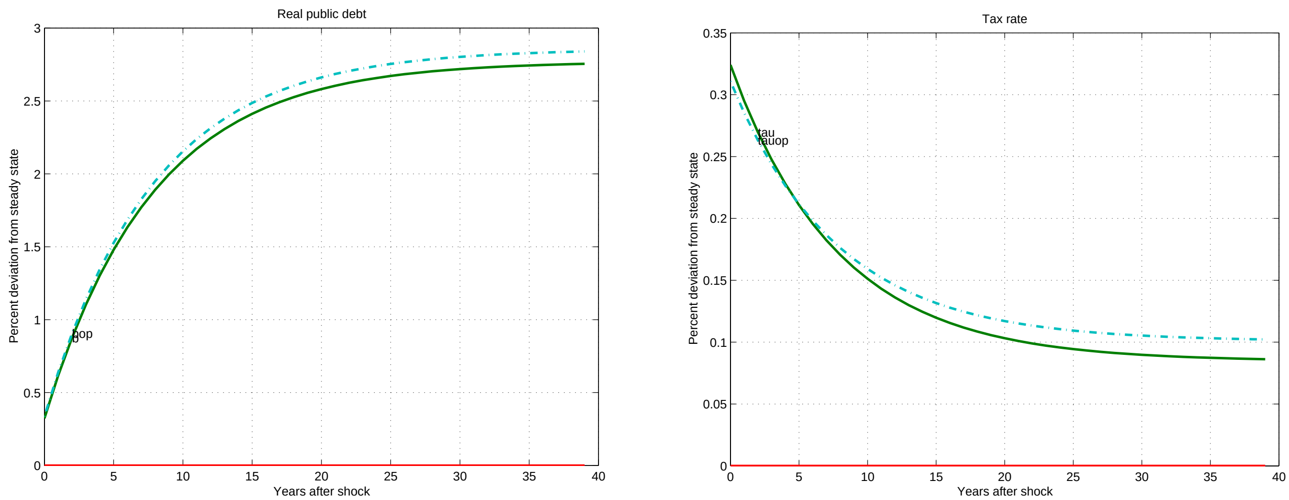

Figure 2: Impulse response to an iid government consumption shock
— government chooses fiscal policy, monetary policy follows interest rate rule
-.-. government chooses monetary and fiscal policy

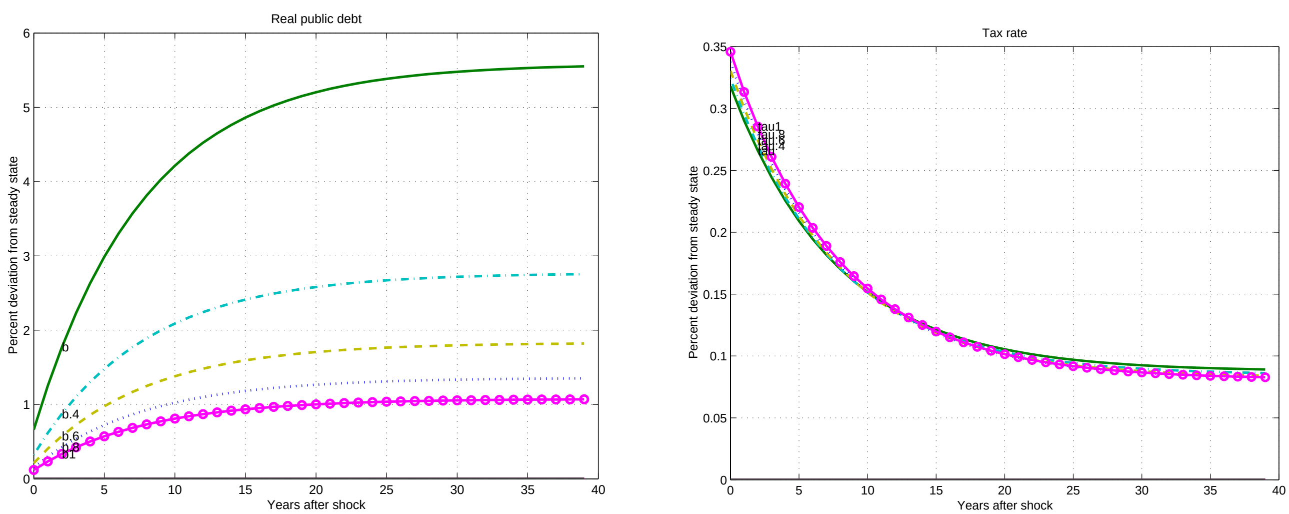

Figure 3: Impulse response to an iid government consumption shock; debt to GDP ratio:
— 0.2 -.-. 0.4 - - 0.6 ..... 0.8 •- 1

fiscal policy always consists of raising the tax rate and running budget deficits. However, the tax response is stronger at lower debt to GDP ratios, which makes the

budget deficits are larger and the tax increases are smaller as the debt to GDP ratio falls. Intuitively, a lower debt to GDP ratio implies a lower tax rate in the steady state, which gives more flexibility for running budget deficits and increasing tax rates in response to a shock.

Debt to GDP ratio	Δ	Ω_1	Ω_2	Ω_3	Ω_4
0.2	0.016	2.24	0.37	-1.11	0.26
0.4	0.030	2.17	0.36	-1.08	0.25
0.6	0.044	2.10	0.35	-1.06	0.25
0.8	0.058	2.03	0.34	-1.04	0.23
1	0.070	2.00	0.33	-1.01	0.22

9 Fiscal Policy Rules

The optimal fiscal policy is a function of the state variables of the economy;when we log-linearize our model, optimal fiscal policy is a linear function of the state variables. The optimal tax rate can be written as

$$\tau_t = \Delta x_{t-1} + \Omega z_t, \tag{37}$$

where x_{t-1} is a column vector of the state variables, lagged once, of the system and ω is a column vector of the exogenous stochastic variables. For the benchmark economy of table 4,

$$x_{t-1} = [b_{t-1}]$$

and

$$z_t^{'} = [a_{1,t}, g_{1,t}, a_{2,t}, g_{2,t}].$$

The row vector Δ summarizes the impact of the state variables on the current tax rate and the row vector Ω describes the impact of the exogenous stochastic variables on the current tax rate. For our economy:

$$\tau_t = \Delta b_{t-1} + \Omega z_t, \tag{38}$$

where, for the benchmark economy of table 4:

$$\Delta = 0.0302 \qquad \Omega^{'} = [2.17, 0.36, -1.08, 0.25]$$

In words, the optimal tax increases 0.03 percent with respect to its steady state value in response to a one percent deviation of lagged real public debt from its steady state value and 0.36 percent in response to a government spending shock in country 1. The other elements of the matrix Ω have a similar interpretation.

Let $\Omega^{'} = [\Omega_1, \Omega_2, \Omega_3, \Omega_4]$; we can repeat the exercise above for different steady state levels of the debt to GDP ratio. This gives a tax schedule with parameter values that change with steady state of the economy. The parameter values are summarized in table 9.

The optimal tax responds positively to an increase in real public debt and this response becomes stronger as the steady-state-debt to GDP ratio is higher. A one percent deviation of last period real public debt from its steady state value triggers a 0.016 percent deviation of the tax rate if debt is 20 percent of GDP, a 0.03 percent deviation if debt is 40 percent of GDP, a 0.044 percent if debt is 60 percent of GDP, 0.058 percent if debt is 80 percent of GDP and 0.07 percent if debt is 100 percent of GDP. Hence, the optimal tax response increases more than proportionally to an increase in real public debt.

The optimal tax policy also responds contemporaneously to the exogenous shocks in the economy. An increase in government spending at home calls for an increase in the tax rate because it is optimal to finance it in part by raising tax revenues and in part by running budget deficits. An unanticipated technological improvement at home also requires an increase in domestic labor income taxes. Intuitively, labor supply raises at home in response to a temporary technological shock that raises productivity and wages in the short run while consumption and leisure fall; as a result, the optimal labor tax increases leading to budget surpluses and an improved net asset position for the country. In fact, the optimal tax typically moves in the same direction as wages in our setting: when the real wage improves, it is optimal to raise the tax rate.

10 The International Dimension

Optimal fiscal policy responds to shocks at home as well as in the other member country in the monetary union. The interest rale we have postulated for the economy responds to output and inflation movements in the monetary union; by its own design, the interest response to idiosyncratic shocks in a monetary union is smaller than it would arise if each country had its own independent monetary policy; at the same time, the interest rate response to a shock in the other country in the union is typically larger than it would be if country 1 had its own and independent monetary policy.

Table 9 shows that the optimal response to a technological improvement in country 2 requires a contemporaneous reduction in the labor tax rate in country 1; as debt in country 1 grows, the tax rate will increase to reach a new and higher steady state level. In fact, a technological improvement in country 2 while technology is unchanged in country 1 raises the relative price of country 1 goods, thereby curtailing the demand for goods produced in it. Since labor demand falls, real wage also falls in country 1. A reduction in the labor tax rate raises the incentive to work and smoothes the labor supply response and, as a result, the output response. However, public finances deteriorate in this process so that the tax rate must be higher in the new steady state.

Similarly, a government spending increase in country 2 is optimally matched by an increase in the tax rate in country 1. Country 1 experiences an increase in the demand of its goods, which in turn raises output, labor and wages and makes it optimal to raise taxes in the short run. The government in country 1 runs budget surpluses that improve the country's long run net asset position, thereby leading to higher private consumption, lower labor supply and lower income tax rates at the new steady state.

The two countries of our model interact on the asset and on the good markets; a current account surplus in country 1 must be necessarily matched by a current account deficit of the same size in country 2. Extending the model to more countries is likely to reduce the responsiveness of optimal policy in a country to idiosyncratic shocks occurring in the other countries, even if these countries are all members of a monetary union. Nevertheless, we believe that the qualitative features of our analysis will remain in a more general framework.

11 The Stability and Growth Pact

The Maastricht Treaty established that the members of EMU should not have deficits in excess of 3 percent of GDP except during sharp recessions. More precisely, the Stability and Growth Pact (SGP) dictated that deficits in excess of 3 percent of GDP could be run only in years when GDP growth is - 2 percent or lower;[3] failure to do so would result in sanctions equal to 0.2 percent of GDP, which would then be turned into fines if the excessive deficit has in the view of the Council not been corrected.

The SGP has been criticized for being too strict and forcing member countries to run primary surpluses even during recessions. A Country with a high debt-to-GDP ratios must commit a larger component of its budget for interest payment on the debt, thereby leaving less or no room at all for primary deficits. This was the case for Italy, which run primary surpluses between 3 and 6 percent of GDP between 1999 and 2003 even though real GDP grew very little, in the order of 0.3 percent in the years 2002 and 2003. On the other hand, the SGP has been welcomed by some as a mean to obtain fiscal discipline in the Eurozone and enhance the credibility of the ECB. At the end of 2003 the SGP has been effectively suspended through the reluctance of France and Germany to accept the recommendationis of the European Central Bank and the Commission to manage their budget deficits to below 3 percent limit.

This section studies the welfare implications of fiscal limits as stipulated by the SGP. We characterize the economy with fiscal limits, simulate it and then compare social welfare with the SGP and without it.

The limit imposed by the SGP for country 1 can be written formally as:

$$B_{1,t} - B_{1,t-3} \leq 0.03 \times Y_{1,t} p_{1,t} P_t \qquad \text{if} \qquad \frac{Y_{1,t} p_{1,t} P_t}{Y_{1,t-3} p_{1,t-3} P_{t-3}} - 1 \geq 0.02, \tag{39}$$

for t that coincides with the fourth quarter in a calendar year; for all other quarters, the SGP does not impose any constraint. In words, the SGP imposes a deficit limit for each calendar year. Hence, the deficit limit (39) binds only in the fourth quarters of each year. Notice also that the deficit limit imposed by the SGP needs to be specified in quarterly terms, which is the time unit of our data and simulations. We have assumed that the overall annual deficit cannot exceed 3 percent of current nominal GDP; we experimented by letting the relevant GDP concept be the quarterly average in the fiscal year and it barely changed the quantitative results. Finally, we have assumed that the tax change necessary to satisfy the deficit limit in (39) is carried out entirely in the fourth quarter. In other words, if constraint (39) is binding (and it can only bind in the fourth quarter of a calendar year), the current tax is adjusted so as to bring the deficit in line with the SGP requirement. One could argue

[3] Or -0.75 percent with the concurrence of the Council.

that if governments anticipate with some probability that the SGP will be binding, they will find it optimal to engage in precautionary saving and run higher surpluses early in the year, which allows to keep the labor income profile smooth. However, we believe it is realistic to consider the case where the fiscal adjustment is carried out only in the fourth quarter and we therefore abstract from precautionary saving in what follows.

In real terms, the left-hand side of (39) can be rewritten as

$$b_{1,t} - \frac{b_{1,t-3}}{\Pi_{s=0}^{3}\pi_{t-s}} \leq 0.03Y_{1,t}p_{1,t}. \tag{40}$$

The SGP adds the non-negativity constraint (40) to the Ramsey problem only for the end-of-the-year quarters; for such quarters, the Ramsey problem becomes

$$\begin{gathered}\mathcal{L}_t = E_0 \sum_{t=0}^{\infty} \beta^t \sum_{i=1}^{2} \Big\{ U(C_{i,t}, N_{i,t}, m_{i,t}) + \lambda_{i,t}^{c} \left[U_{c,i}(t) - \lambda_{i,t}\right] + \\ \lambda_{i,t}^{m} \left[\frac{b_{i,t}}{1+i_t} + w_{i,t}N_{i,t}\left(1 + \frac{U_{N,i}(t)}{U_{c,i}(t)w_{i,t}}\right) - \frac{b_{i,t-1}}{\pi_t} - G_{i,t} \right] + \\ \lambda_{i,t}^{p}\left[p_{i,t} - \tilde{p}_{i,t}\right] + \lambda_{i,t}^{int}\left[i_t + \frac{U_{m,i}(t)}{\lambda_{i,t} - U_{m,i}(t)} \right] + \lambda_t^{r}\left[C_t + G_t - Y_t\right] \\ +\lambda_t^{\pi}\left[\phi\pi_t^{\theta-1} + (1-\phi)\left(n\tilde{p}_{1,t}^{1-\theta} + (1-n)\tilde{p}_{2,t}^{1-\theta} - 1\right)\right] + \\ \lambda_t^{b}\left[-i_t + \frac{\pi}{\beta} - 1 + \phi_y\left(\frac{Y_t - Y}{Y}\right) + \phi_\pi\left(\frac{\pi_t - \pi}{\pi}\right) \right] + \\ \lambda_{i,t}^{sgp}\left[-b_{i,t} + \frac{b_{1,t-3}}{\Pi_{s=0}^{3}\pi_{t-s}} + 0.03Y_{i,t}p_{i,t} \right] \Big\},\end{gathered}$$

where the last constraint is binding if and only if the right-hand side of (39) is satisfied, i.e. if GDP growth rate is below 2 percent. This problem can be solved applying the Kuhn-Tucker theorem, which adds condition (31) and

$$\lambda_{i,t}^{sgp} \leq 0 \tag{41}$$

for all $i = 1, 2$. Intuitively, the lagrangean multiplier $\lambda_{i,t}^{sgp}$ is positive in period t if the constraint is binding for country i and is equal to zero otherwise. Hence, the optimal tax rate increases when the SGP is binding, thereby reducing the budget deficit enough to satisfy constraint (40); when the SGP is not binding, the optimal tax rate is equivalent to the unconstrained one.

This model allows us to analyze the welfare consequences of a fiscal limit as in (40); we will refer to such limit as the SGP. First of all, we can ask how often would the SGP bind in our model where fiscal policy is chosen optimally and we can determine if the SGP binds more often for countries with a higher debt-to-GDP ratio in the steady state. Second, we can measure the welfare cost of the SGP.

Debt to GDP in country 1	% binding in country 1	% binding in country 2	Ψ_1	Ψ_2
	average	average	average	average
0.2	9	8	0.00216	-0.00211
0.4	9	8	0.00099	-0.00098
0.6	9	8	0.00015	-0.00017
0.8	9	8	-0.00050	0.00043
1	9	8	-0.00103	0.00091

Table 1: The Stability Growth Pact

We run 1000 simulations for the economy with a steady-state debt to GDP ratio of 0.2. Each simulation has 140 periods (quarters); in the first 100 periods the economies are hit by random technology and government shocks with processes as in (32) and (33); the last 40 periods there are no shocks and the economy converges to its new steady state. First, we run our simulations for the unconstrained economy, i.e. for the economy *without* the SGP; for each simulation we calculate the steady state to which the economy converges after the shocks and the change in social welfare. Notice that the change in social welfare is calculated with respect to the initial steady state; this means that such measure of welfare is composed of two parts: the change in welfare associated with the transition to the new steady state (this is the welfare change in first 140 periods) and the change in welfare associated with the change in steady state (this is the welfare change from period 140 to infinity). We then run our simulations with the *same* sequence of technology and government shocks for the economy with the SGP. For each simulation, we keep track of how often the SGP binds; we then calculate the steady state to which the economy converges after the shocks and the change in social welfare. Finally, we repeat this exercise for the economies with a steady-state debt to GDP ratio of 0.4, 0.6, 0.8 and 1.

Table 11 summarizes our findings. The first column is the debt-to-GDP ratio at the initial steady state; the second column of table 11 reports the average (over the 1000 simulations) number of years the SGP was binding for country 1.[4] This figure can be interpreted as the probability for the SGP to be binding for country 1, given its initial level of the debt. The third column of table 11 reports the average for country 2. The last two columns of table 11 show the welfare cost (or gain) of the SGP; this figure is the average difference in social welfare in the unconstrained economy and the economy with the SGP; more precisely, this column shows the average of Ψ over the 100 simulations. Column four shows the welfare cost for country 1, Ψ_1 while column five shows the welfare cost for country 2, Ψ_2;

Consider first the economy where country 1 has a 0.2 debt-to-GDP ratio at the initial steady state. The SGP binds on average 9 percent of time for country 1; this means that over the 35 year in our simulations, the SGP binds on average a little more than three years for country 1. Interestingly, the SGP binds on average 7 percent of the years for country 2,

[4]The average is calculated over the first 100 periods in which the economy is hit by shocks, namely over 25 years.

which is a net creditor at the initial steady state. This suggests that the initial debt level plays a role in whether the SGP constraints optimal fiscal policy but not a large one. This intuition is further confirmed by looking at the other rows of table 11: the average percentage times the SGP binds does not vary with the initial debt-to-GDP ratio. The interpretation of this finding is that, if EMU members run optimal fiscal policies, the SGP is expected to bind more often on countries with larger debt-to-GDP ratios, but only marginally so. This result should not be surprising because optimal fiscal policy becomes increasingly tighter as the level of public debt increases: figure 3 shows that optimal deficits become smaller as debt level increases.

Column four and five of table 11 report the welfare cost (+) or gain (-) of deficit limits. For the economy with a debt-to-GDP ratio of 0.2, the welfare cost of the SGP is 0.00216. The welfare cost Ψ_1 is calculated as in (36) and it means that the representative household of country 1 is willing to give up 0.00216 percent of her unconstrained consumption process to avoid switching to an economy with the SGP. This is a very small number.

The welfare cost for country 1 is zero if the SGP never binds for either country. If the SGP binds for country 1, the welfare of country 1 is affected in two ways. On impact, the sharp increase in the tax rate reduces labor and raises consumption in country 1; the deficit reduction, however, leads to a lower debt and a lower tax rate in the new steady state, which in turn imply higher consumption and lower labor supply in the new steady state. Country 2 is affected in the opposite way if the SGP binds for country 1. These effects are of general equilibrium nature and arise because the two countries are connected via assets and goods markets. In fact, because country 1 must reduce its deficit, equilibrium in the assets market requires country 2 to reduce its surplus; hence, country 2 will reduce its tax rate, raise labor supply and reduce consumption on impact while the ensuing deterioration of its long-run asset position implies lower consumption and higher labor supply in the new steady state.

The overall welfare effect of the SGP on the country for which it binds depends on the balance between the long-run benefits of a lower debt and the short-run costs of tax non-smoothing; our simulations suggest that the costs do not always outweight the benefits, even if on average this is the case. The welfare cost of the SGP is a very small number. Moreover, table 11 shows that the welfare cost of the SGP falls as the debt-to-GDP ratio increases and it even becomes negative (i.e. there is a welfare gain of the SGP) for debt-to-GDP ratios equal and greater than 0.8. Once again, the intuition for why the SGP becomes more efficient for higher debt levels is that optimal fiscal policy also gets tighter as the debt level increases.

Figure 4 plots real public debt and taxes in country 1 for the unconstrained economy and for the economy with the SGP for one of our simulations. In this simulation, the SGP binds for two consecutive years for country 1, in quarter 72 and 76. The labor tax rate jumps up and the debt falls in both periods under the SGP; after that, the dynamics of debt and taxes is the same in the two scenarios even though their levels are higher in the unconstrained economy.

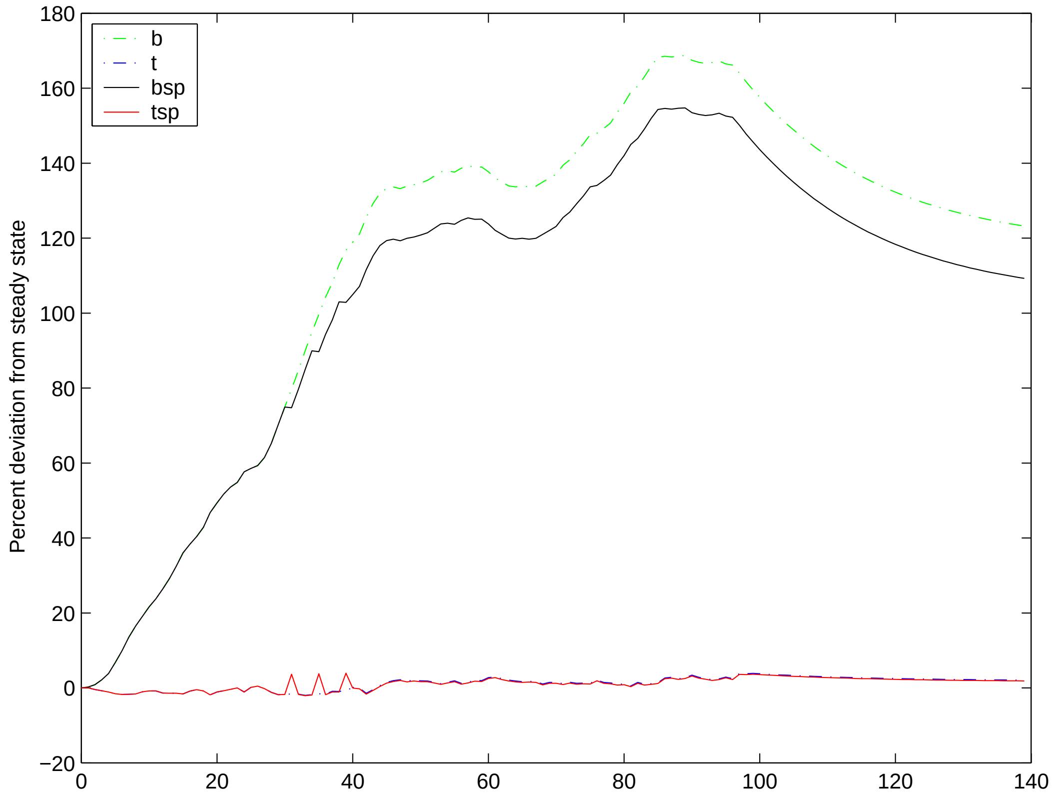

Figure 4: Debt and tax rate with and without the SGP

12 Conclusions

We have studied optimal fiscal policy in an economy with sticky prices that consists of two countries belonging to a monetary union. The main findings of our work can be summarized as follows. First, in response to a government spending shock, it is optimal to raise taxes and run budget deficits in the country where the shock originates; the other country finds it optimal to also raise tax rates that lead to budget surpluses and an improved long run equilibrium. Second, real public debt and taxes display random walk behavior. Following a government shock, for example, the optimal fiscal policy implies an increase in real debt and therefore a worsening of the net asset position of the country. Third, the optimal fiscal policy changes with the level of debt. Optimal fiscal policy becomes tighter as the steady state debt-to-GDP ratio increases, which means that budget deficits gets smaller in response to shocks. Fourth, inflation is remains remarkably stable. Fifth, optimal fiscal policy when monetary policy is run by an independent central bank that follows a Taylor rule is not much different from the optimal fiscal policy run by a central planner in command of both monetary and fiscal policy. Sixth, fiscal limits as dictated by the SGP have very small welfare effects. The SGP imposes short-run costs stemming from higher variability of taxes but it also entails benefits stemming from lower debt and tax rates in the long run. These costs and benefits cancel each other out, roughly speaking; however, the benefits get larger with the level of debt.

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Appendix

A The Ramsey Problem