Time Consistent Fiscal Policy in a Debt Crisis

VERY PRELIMINARY

Neele Balke[1] and Morten O. Ravn[1,2,3]

University College London[1], Centre for Macroeconomics[2],

and the Centre for Economic Policy Research[3]

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Abstract

We study a small open economy model in which a benevolent government aims at maximizing social welfare but lacks commitment to all its fiscal instruments including payroll taxes, unemployment benefits and government spending rather than to debt repayment only. We consider a production economy in which policy choices impact on the amount of resources available and introduce heterogeneity amongst households by allowing them to differ in their employment and income states. The policy maker may be able to smooth the budget by international borrowing and lending and would like to insure households against unemployment risk and against wage risk which occurs due to productivity shocks. We derive optimal fiscal policies in this environment by studying Markov-perfect equilibria. The model is calibrated to emulate the conditions of Greece. We show that the time-consistent policies involve countercyclical payroll taxes and mildly procyclical government spending in normal times when the risk of default is negligible. In crisis times, the government is willing to further distort the economy by providing less insurance against unemployment, increasing payroll taxes and cutting public goods provision to limit rising debt.

1 Introduction

The financial crisis led to severe crises in much of Southern Europe that generated deep economic problems that still have not been resolved. Many of these economies (Greece, Italy, Spain and Portugal) witnessed not only large drops in aggregate activity but also rising levels of debt and falling debt prices which made financing of deficits very costly and triggered concerns about sovereign defaults. A large literature has considered environments in which large negative shocks can generate risk of default because sovereign governments lack commitment to debt. However, much of this literature either assumes that government has commitment to all other fiscal instruments or that these are exogenously determined. Therefore, it is unclear whether adjustment of other instruments – for example cuts in public spending or tax hikes – may not be preferable to default. Moreover, this literature typically does not allow for feedback from the fiscal instruments to the state of the economy beyond those triggered by punishment mechanisms in case of a sovereign default. Thus, these models are not useful for understanding richer questions regarding the adjustment of fiscal policy in crisis times.

This paper takes a first step in addressing these issues. We study a small open economy model in which a benevolent government aims at maximizing social welfare but lacks commitment to all its fiscal instruments. The economy consists of a government, households, firms and foreign lenders. Households derive utility from consumption of private goods, leisure and from government provided public goods. They differ in their labor market status because of matching frictions. Some households work and earn labor income. The government imposes a payroll tax on these households. Other households are unemployed when their costly search effort was without success. Households cannot purchase unemployment insurance contracts but receive government financed unemployment transfers. Firms post vacancies to hire workers and there is free entry. There is an aggregate productivity shock and wages are determined by a non-cooperative Nash bargaining game between firms and households. The government chooses payroll taxes, unemployment benefits, government spending and may be able to smooth the budget by international borrowing and lending. International lenders are risk-neutral and charge an interest rate which takes into account that governments may choose to default. If a government defaults it is excluded from international financial markets for a stochastic number of periods and it may suffer a loss of productivity whilst excluded from international lending.

The government in this economy faces several trade-offs. It would like to insure households against unemployment risk and against wage risk which occurs due to productivity shocks. However, more generous unemployment insurance gives households less incentive to search for jobs and therefore produces higher unemployment and a smaller tax base. In order to insure employed households against wage risk, the government would like to cut payroll taxes when productivity falls but this implies rising debt. The government also attempts to equalize the marginal utility of private and public consumption but cannot do so perfectly because of household heterogeneity. In this economy, falling productivity produces difficult choices since it puts a pressure on the government budget due to rising unemployment and a smaller tax base which produces an incentive for increasing government borrowing. However, rising debt levels may eventually impact on the price of debt because lenders perceive a risk of a sovereign default. For that reason, the government will eventually have to make a hard choice about whether to default on its debt which means it will have to balance its budget (and possibly suffer a drop in productivity), cut unemployment transfers which harms the unemployed, increase payroll taxes which harms the employed and produces higher unemployment, or cut government spending which lowers utility of households.

We derive optimal fiscal policies in this environment by studying Markov-perfect equilibria. The model is calibrated to emulate the conditions of Greece. We show that the time-consistent policies involve countercyclical payroll taxes and mildly procyclical government spending in normal times when the risk of default is negligible. In crisis times, the government is willing to further distort the economy by providing less insurance against unemployment, increasing payroll taxes and cutting public goods provision to limit rising debt. However, once a default becomes inevitable, the government partially lifts such austerity measures since it ceases to be concerned about honouring its outstanding debt.

2 The model

We study a small open economy model of sovereign default. In the tradition of Eaton and Gersovitz (1981) and Arellano (2008) we assume that debt is non-state contingent, that lenders are risk-neutral, and that sovereign lacks commitment to repay its debt. In this setting, default risk is reflected in the price of sovereign debt and, depending on the punishment mechanism, there may be default in equilibrium.

There are three distinguishing features of our analysis. First, we consider a production economy in which policy choices impact on the amount of resources available. Much of the sovereign default literature instead considers exchange economies in which policy choices do not impact on the amount of output produced by the sovereign state apart from default possibly decreasing endowments. We instead take into account that spending and tax choices affect behavior so that substituting debt issuance with variations in other fiscal instruments has consequences for resources. Second, we introduce heterogeneity amongst households by allowing households to differ in their employment and income states. For this reason, the government not only has to worry about smoothing resources over time but also about intratemporal reallocation of resources between different types of households. Third, we assume that the government lacks commitment to all its instruments rather than to debt only. It is implicit in much of the sovereign debt literature that governments can commit to instruments other than debt but it is unclear exactly how the government can commit to one instrument but not to another. Whilst it is possible that there may be some variation in the extent to which governments can commit to different types of instruments, we explore the implications of assuming that the government cannot commit to any of its instruments. We focus on Markov-perfect equilibria.

2.1 Environment

Households. The economy has a continuum of mass 1 of infinitely lived households indexed by $i \in [0,1]$. Households have rational expectations and maximize their expected discounted lifetime utility.

Households can neither save nor borrow but their consumption streams may be smoothed through government policies. A household is either employed or unemployed. Employed households work one unit of time, earn a real wage w and pay a proportional income tax τw. Households cannot purchase unemployment insurance contracts but unemployed households receive government provided unemployment benefits $\mu \leq (1-\tau)\, w$.

Employment contracts last one period. Households start each period searching for a job in an anonymous matching market. By exerting e units of search effort households find jobs with probability $pe \in [0,1]$. $p \in [0,1]$ is the job finding rate per unit of search intensity which households take for given. The assumptions of one-period employment contracts and lack of household savings imply that households start each period as ex-ante identical but are ex-post heterogeneous due to unemployment risk.

Households derive utility from consuming goods, c, from government provision of public goods, G, and disutility from labor market search and from working. They maximize their expected present discounted utility stream:

$$\mathcal{U}_{i,t} = \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\mathbf{u}\left(c_{i,s}, e_{i,s}, G_s\right) - \kappa \mathbf{n}_{i,s} \right] \tag{1}$$

where $\mathbb{E}$ is the mathematical expectations operator, $\beta \in (0,1)$ is the subjective discount factor, $\kappa \in \mathbb{R}_{++}$ denotes a fixed cost of working. $\mathbf{u}$ is the instantaneous felicity function which is assumed strictly increasing and concave in c, non-decreasing in G, and strictly decreasing and convex in e. $\mathbf{n}_{i,s}$ is an indicator function which summarizes the household's labor market status:

$$\mathbf{n}_{i,s} = \begin{cases} 0 \text{ if the household is unemployed} \\ 1 \text{ if the household is employed} \end{cases} \tag{2}$$

We will from now drop the date notation unless necessary.

Households choose consumption and search effort subject to a sequence of budget constraints:

$$c_i = (1-\tau)\, w\mathbf{n}_i + (1-\mathbf{n}_i)\, \mu + \pi \tag{3}$$

where π denotes the household's receipts of dividends from the firms. It follows that

$$c_i^w = (1-\tau)\, w + \pi \tag{4}$$

$$c_i^u = \mu + \pi \tag{5}$$

where c_i^w denotes consumption of an employed household and c_i^u is consumption of an unemployed household.

The first-order necessary condition for search effort is:

$$p\left[\mathbf{u}\left(c_i^w, e_i, G\right) - \mathbf{u}\left(c_i^u, e_i, G\right) - \kappa\right] = pe_i \mathbf{u}_e\left(c_i^w, e_i, G\right) + (1 - pe_i)\, \mathbf{u}_e\left(c_i^u, e_i, G\right) \tag{6}$$

Condition (6) equalizes the expected marginal utility gain from searching (the left hand side) to the expected marginal utility cost of searching (the right hand side). Since households are ex-ante identical, they all choose the same search effort, e^*. It follows that aggregate employment is simply given by the proportion of households which find a job at this optimal identical level of search effort, $n = \int_i \mathbf{n}_i di = pe^*$.

Firms. Output is produced by a continuum of identical competitive firms indexed by j each of which employ one worker. There is free entry into the industry. The (common) output of each firm j is given by $\mathbf{x}(z, h')$ which depends on an exogenous aggregate productivity shock, z, and on the country's end of period credit history h':

$$h' = \begin{cases} 0 \text{ if the country has access to financial markets} \\ 1 \text{ if the country is in autarky} \end{cases}$$

The aggregate productivity shock $z \in \Omega_z \subset \mathbb{R}^N_{++}$ follows a first-order homogeneous Markov process. We assume that $\mathbf{x}(z, 0) \geq \mathbf{x}(z, 1)$ so that firms in countries that are excluded from international financial markets experience lower productivity ceteris paribus. The idea is that financial autarky may impact on productivity for example because high quality imported intermediary goods are substituted with lower quality domestic alternatives, see e.g. Mendoza and Yue (2012).

v_j denotes vacancies and $a \in \mathbb{R}_{++}$ is a constant proportional vacancy posting cost. Vacancies are filled with probability $q \in [0, 1]$. The value of a filled job, $\mathcal{R}^f$, and the value of a vacancy, $\mathcal{R}^v$, are given as, respectively:

$$\mathcal{R}^f = \mathbf{x}\left(z, h'\right) - w \tag{7}$$

$$\mathcal{R}^v = q\mathcal{R}^f\left(w, z, h'\right) - a \tag{8}$$

Free entry drives the value of vacancies to zero:

$$\mathbf{x}\left(z, h'\right) - w = \frac{a}{q} \tag{9}$$

so that, in equilibrium, the value of a filled job equals the expected cost of hiring a worker:

Labor Market. The measure of new matches between workers and firms, which in our setting also equals aggregate employment, is determined by a Cobb-Douglas matching function:

$$n = \psi e^{\phi} v^{1-\phi} \tag{10}$$

where $v = \int v_j dj$ is the aggregate measure of vacancies, $e = \int e_i di$ is the measure of search effort and $\phi, \psi \in \mathbb{R}_{++}$ are constant parameters.

Wages are determined according to a non-cooperative Nash bargaining game between workers and firms. Since matches last one period, the surplus of a matched household is given by the instantaneous utility gain from being employed:

$$\mathcal{S}^w = \mathbf{u}\left(c^w, e^*, G\right) - \mathbf{u}\left(c^u, e^*, G\right) - \kappa \tag{11}$$

where e^* denotes the optimal search intensity determined by condition (6) above. Due to free entry, the surplus to firms from having filled job is the within-period return $\mathcal{R}^f$. The wage is then the solution to:

$$w = \arg\max \left(\mathcal{S}^w\right)^{\lambda} \left(\mathcal{R}^f\right)^{1-\lambda} \tag{12}$$

where $\lambda \in \mathbb{R}_{++}$ denotes the households' bargaining power. Using (11) and (7) the first-order necessary condition can be expressed as:

$$w = \mathbf{x}\left(z, h'\right) - \frac{1-\lambda}{\lambda} \frac{\mathbf{u}\left(c^w, e^*, G\right) - \mathbf{u}\left(c^u, e^*, G\right) - \kappa}{\left(1-\tau\right) \mathbf{u}_c\left(c^w, e^*, G\right)} \tag{13}$$

Government. The government chooses policies to maximize social welfare. The policy variables at its disposal are income taxes, transfers to unemployed households, public goods provision, and government debt.

The government enters the period with B units of outstanding debt, productivity level z, and credit history h. At the beginning of the period, a country with a bad credit record, $h = 1$, is readmitted to international financial markets with probability $(1 - \alpha) \in (0, 1)$. The government then chooses policies. A country with a good credit score can choose whether or not to default on its outstanding debt. If it does not default, $d = 0$, the government can issue new debt B' at the price $R(B', z)$ and it will have a good end of period credit score, $h' = 0$. If the country defaults, it cannot issue new debt, it may experience a drop in productivity, and its end of period credit score is bad, $h' = 1$. A country with a bad beginning of period credit score, $h = 1$, that is not readmitted to international financial markets is in autarky, has low productivity and must run a balanced budget. A country with a bad credit history that *is* readmitted to international financial markets faces the same problem as a government with a good beginning of period credit score (but never defaults since it has no debt).

The government maximizes a utilitarian social welfare function:

$$\mathcal{U}_t^G = \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \mathbf{u}^G \left(c_s^w, c_s^u, e_s, n_s, G_s\right) \tag{14}$$

where $\mathbf{u}^G$ is assumed to be given by a population weighted average of the flow utility of employed and unemployed households:

$$\mathbf{u}^G \left(c^w, c^u, e, n, G\right) \overset{def}{=} n \left[\mathbf{u}\left(c^w, e, G\right) - \kappa\right] + (1 - n)\, \mathbf{u}\left(c^u, e, G\right) \tag{15}$$

Define the aggregate state vector as $S = (z, B, h)$. The government's policy vector is $\Omega(S) = [\tau, \mu, G, d, B']$ which it chooses optimally taking into account the behavior of the private sector and the price of debt. We express the social welfare function as $\mathcal{U}^s(Y, \Omega, S)$ where $Y = (e, c^w, v)$ and we express other endogenous variables as implicit functions of (Y, Ω, S).[1] The government must respect the government budget constraint and the economy-wide resource constraint which are given, respectively, as:

$$G + (1 - \mathbf{n}(Y, \Omega, S))\, \mu = \tau \mathbf{w}(Y, \Omega, S)\, \mathbf{n}(Y, \Omega, S) + R\left(B', z\right) B' - B \tag{16a}$$

$$\mathbf{x}(z, h')\mathbf{n}(Y, \Omega, S) - av + R\left(B', z\right) B' = \mathbf{n}(Y, \Omega, S)\, c^w + (1 - \mathbf{n}(Y, \Omega, S))\, \mathbf{c}^u(Y, \Omega, S) + G + B \tag{17a}$$

The government must also observe implementability constraints:

$$\begin{aligned} & \mathbf{u}\left(c^w, e, G\right) - \mathbf{u}\left(\mathbf{c}^u(Y, \Omega, S), e, G\right) - \kappa \\ = \quad & e\mathbf{u}_e\left(c^w, e, G\right) + \frac{(1 - \mathbf{p}(Y, \Omega, S)\, e)}{\mathbf{p}(Y, \Omega, S)} \mathbf{u}_e\left(\mathbf{c}^u(Y, \Omega, S), e, G\right) \end{aligned} \tag{18}$$

[1] See Appendix 1 for a definition of these implicit functions.

$$\mathbf{w}(Y,\Omega,S) = \mathbf{x}(z,h') - \frac{1-\lambda}{\lambda}\frac{\mathbf{u}(c^w,e,G) - \mathbf{u}(\mathbf{c}^u(Y,\Omega,S),e,G) - \kappa}{(1-\tau)\,\mathbf{u}_c(c^w,e,G)} \tag{19}$$

$$\mathbf{w}(Y,\Omega,S) = \mathbf{x}(z,h') - \frac{a}{\mathbf{q}(Y,\Omega,S)} \tag{20}$$

where (18) is the first-order condition for optimal search effort, (19) is the Nash bargaining solution for the real wage, and (20) is the free entry condition.

Let $\mathcal{Q}^{aut}(z)$ denote the value of a government which is excluded from international financial markets and $Q^i(B,z)$ the value of a government that has access to international financial markets. Note that the autarky value is independent of B since the country is in default and therefore has no debt. The value of autarky, $\mathcal{Q}^{aut}(z)$, is given as:

$$\mathcal{Q}^{aut}(z) = \max_{Y,\Omega_0} \mathbf{u}^G(Y,\Omega_0,S_0(z)) + \beta\mathbb{E}\left[\alpha\mathcal{Q}^{aut}(z') + (1-\alpha)\mathcal{Q}^i(0,z')\right] \tag{21}$$

where $S_0(z)$ is the state vector S setting $B=0$ and $h=1$ and Ω_0 indicates that the country cannot issue any debt, $B'=0$ and is in default at the end of the period $h'=1$. The value is maximized subject to the government budget constraint and the aggregate resource constraint and the implementability conditions $(18)-(20)$ setting $S=S_0(z)$ thus imposing budget balance on the government and that domestic absorption equals domestic output.[2] Thus, a government with a bad credit history cannot smooth the deficit through foreign borrowing and may have low productivity. Next period it remains in autarky with probability α and gains access to international financial markets with probability $1-\alpha$.

A government with a good credit history $h=0$ has first to decide whether to honor its debt or not:

$$\mathcal{Q}^i(B,z) = \max\left[\mathcal{Q}^{i,nd}(B,z), \mathcal{Q}^{i,d}(B,z)\right] \tag{22}$$

where $\mathcal{Q}^{i,nd}(B,z)$ is the value of the government's objective when choosing not to default and $\mathcal{Q}^{i,d}(B,z)$ is the value when it chooses to default. The value of not defaulting is:

$$\mathcal{Q}^{i,nd}(B,z) = \max_{Y,\Omega} \mathbf{u}^G(Y,\Omega,S_1(z,B)) + \beta\mathbb{E}\mathcal{Q}^i(B',z') \tag{23}$$

where $S_1(z,B) = S(z,B,h=0)$, subject to the budget and resource constraints $(16a)$-$(17a)$ and to the implementability constraints (18)-(20) setting $S=S_1(z,B)$ and $h=h'=0$. Hence, when the government does not default it can issue new debt, it retains high productivity (relative to the autarky states), and it also keeps open the option of borrowing next period.

The value of default $\mathcal{Q}^{i,d}(B,z)$ is given as:

$$\mathcal{Q}^{i,d}(B,z) = \max_{Y,\Omega} \mathbf{u}^G(Y,\Omega,S_1(z,B)) + \beta\mathbb{E}\left[\alpha\mathcal{Q}^{aut}(z') + (1-\alpha)\mathcal{Q}^i(B'=0,z')\right] \tag{24}$$

[2] The government budget constraint is $G + (1-\mathbf{n}(Y,\Omega,S))\,\mu = \tau\mathbf{w}(Y,\Omega,S)\,\mathbf{n}(Y,\Omega,S)$.

subject to the government budget constraint and the aggregate resource constraint and the implementability conditions $(18)-(20)$ for $h'=1$ and $B=B'=0$. Thus, while the government does not pay its current creditors, it cannot issue new debt, it may experience a drop in productivity, and remains in autarky next period with probability α.

Lenders. There is a large amount of identical risk neutral international lenders and we assume free entry. A lender purchases b' bonds at the price $R(B',z)$ and receives b' in the subsequent period unless the sovereign defaults. We assume that lenders can alternatively invest in a risk-free asset which delivers a real return $1+r$. For an individual lender, the expected present value of the revenue from lending b' to the sovereign is therefore:

$$\Lambda = -R\left(B',z\right)b' + \mathbb{E}\frac{1-d'}{1+r}b'$$

Thus, free entry implies the expected payoff from lending to the government must equal the risk-free rate:

$$R\left(B',z\right) = \frac{1-\mathbb{E}d'}{1+r} \tag{25}$$

This expression sets the expected return on lending to the sovereign equal to the default risk-adjusted risk-free rate. Note that when default is inevitable, $\mathbb{E}d'=1$, the bond price falls to zero and the country is de facto excluded from international debt markets.

Equilibrium. We assume that the government lacks commitment and we focus on Markov-perfect equilibria. The lack of commitment refers not only to its debt policy but also to its other instruments. It will therefore have to set policies that are self-reinforcing in a game between its current self, the future government and foreign lenders. In choosing its policies it will maximize the weighted average welfare of households taking into account its actions impact future welfare and choices.

Formally, we focus upon:

Definition 1 *A Markov-perfect equilibrium is a set of policies $\Omega(S)$, an allocation $Y(S,\Omega)$ and a set of future policies $\Omega'(S)$ such that:*

(i) The policies and the allocations solve $(21)-(24)$;

(ii) The bond price is given by (25); and

(iii) $\Omega(S)=\Omega'(S)$;

Given the solutions for $\Omega(S)$ and $Y(S,\Omega)$, we can use conditions (28)-(32) to solve for (p,q,n,c^u,w).

Discussion. The policy maker faces a number of trade-offs in this economy. Households are unable to insure against unemployment shocks and cannot smooth consumption over time in response to fluctuations in productivity. Therefore, the policy maker would like to redistribute income from employed to unemployed households to insure the latter against unemployment, and it would like to shift resources from high productivity states to low productivity states in order to insure against adverse productivity shocks. However, redistribution is costly because it may disincentivate job search and therefore can lower employment and output. In order to smooth consumption in response to technology shocks the government has to vary marginal tax rates but this comes at the cost of increasing government debt in times of low productivity. Higher debt, in turn, may lower the price of debt which produces an intertemporal wedge. If debt rises sufficiently much the government may prefer to default on its debt in which case it will be unable to provide intertemporal insurance and also suffers a loss in productivity. Finally, the government would like to provide an efficient amount of public goods which would require it to equalize the marginal utility of private and public consumption. However, provision of public goods requires raising the finances through either income taxes or through cutting unemployment benefits, both of which are costly.

We focus upon Markov-perfect equilibria which means that the government cannot commit to future policy choices and its actions are taken as if it plays a game against a future policy maker. In this setting, the government cannot credibly trade-off current policy choices (of e.g. high levels of spending or low levels of unemployment insurance) against promises of future policies unless these choices are self-reinforcing.

To insure the households against negative productivity shocks the government has an incentive to impose procyclical marginal tax rates. In booms, when wages are high, the incentive problem to work is relatively small allowing for higher tax rates and higher transfers in order to align the consumption levels of the employed and unemployed. Absent any distortion on search effort, the government would equalize their consumption levels and thus perfectly insure them against unemployment risk. In contrast, if job search is endogenous the consumption level of the unemployed is strictly below the consumption level of the employed, otherwise there is no incentive to search and work at a utility cost. The degree of the consumption dispersion depends on the preference specification.

When productivity drops two opposing effects alter employment. On the one hand, a lower productivity diminishes the period return of a firm which has less incentives to post vacancies. Fewer vacancies imply a smaller job finding rate discouraging workers from searching for jobs which results in less employment and a large drop in output. On the other hand, the government has an insurance motive to smooth the consumption of the employed against negative productivity shocks by lowering the payroll tax in recessions. Lower taxes boost job search and via a higher vacancy filling rate mitigate the decline in vacancies such that it results in more employment.

The impact of productivity shocks on government debt is crucially influenced by the commitment ability of the government. Lower productivity implies lower government expenditures and lower tax revenues because both income drops and because of procyclical tax rates. Transfer payments have to fall accordingly. With commitment to debt the government would try to attenuate this effect by increasing debt in bad times and repaying in good times. However, since the government lacks commitment and has a higher incentive to default in recessions the spread on public bonds increases sharply in low productivity states. Therefore, in addition of lower revenues the government is confronted with more expensive debt issuance making it optimal to lower public indebtedness.

3 Quantitative Analysis

In this section we analyze the properties of the model by solving numerically a calibrated version of the model. We calibrate the model to represent a developed economy.

Calibration. One period corresponds to a quarter. We specify preferences and the productivity costs of default by the functions:

$$\mathbf{u}(c,e,G) = \frac{c^{1-\sigma_c}-1}{1-\sigma_c} - \vartheta\frac{e^{1+\sigma_e}-1}{1+\sigma_e} + \xi \log G \tag{26}$$

$$\mathbf{x}(z,h') = \begin{cases} z \text{ if } h'=0 \\ z \text{ if } h'=1 \wedge z<\widehat{z} \\ \widehat{z} \text{ if } h'=1 \wedge z \geq \widehat{z} \end{cases} \tag{27}$$

Equation (27) implies that the productivity loss from default is weakly increasing in productivity with no loss for low levels of productivity. Thus, it limits the incentive to default at high productivity levels.

Table 1: Calibration strategy and baseline results

Parameter	Description	Value	Source/Target	Baseline
r	Risk-free rate	0.010	Arellano and Bai (2014)	
σ_c	Risk aversion	2.000	Standard	
σ_e	Search cost	3.000	Mukoyama et al. (2013)	
λ	Bargaining power	0.400	Merz (1995)	
ϕ	Match elasticity	0.400	Merz (1995)	
ρ	Persistence	0.880	Arellano and Bai (2014)	
σ_ϵ	Std. deviation	0.030	Arellano and Bai (2014)	
α	Reentry prob.	0.083	Dias and Richmond (2009)	
β	Discount factor	0.850	3% default probability	3.08%
a	Vacancy costs	0.039	4.5% vacancy cost/wage	4.51%
ϑ	Search costs	0.203	7% average unemployment	6.82%
κ	Disutility of work	0.030	10% consumption loss	10.53%
ζ	Utility of spending	0.389	33% spending/consumption	32.93%
ψ	Match efficiency	0.450	1.4% average spread	0.73%
$\widehat{z}$	Productivity loss	0.895	5% output loss	5.05%

We calibrate a first set of parameters to standard values in the literature. We assume that $\sigma_c = 2$ and that $\sigma_e = 3$. The calibration of σ_c implies value of the intertemporal elasticity of substitution of consumption in the mid-range of empirical estimates. We assume that $\phi = \lambda = 0.4$ so that the workers' bargaining power coincides with the elasticity of the matching function to search effort. The risk-free interest rate is set to 1 percent to match the average German yield. Finally, for the productivity we target the moments of an autoregressive process for the logarithm of z with persistence of 0.88 and innovation standard deviation of 3 percent.[3] These values of the persistence and variance of TFP correspond to estimates of Arellano and Bai (2014) for Greece. The probability of readmittance to financial markets, α, is estimated to be equal to 8.3 percent implying that a country stays in default for three years on average.

The remaining parameters, $\Gamma = (\beta, \vartheta, \xi, \kappa, a, \psi, \widehat{z})$, are calibrated as by imposing the following set of targets. First, we assume that vacancy costs account for on average of 4.5 percent of the quarterly wage

[3]The innovations are assumed to be normally distributed with mean 0.

bill, a standard estimate in the literature (see e.g. Silva and Toledo, 2009). We assume that consumption of the unemployed is equal to 90 percent of the employed households' consumption expenditure implying a moderate 10 percent consumption loss associated with unemployment. This is a conservative estimate but close to Hurd and Rohwedder's (2010) estimates for the U.S. We target a 7 percent mean unemployment rate which is in line with values observed in many developed economies. The mean value of government public goods provision is set equal to 33 percent of private consumption which is consistent with government spending accounting for around 20 percent of GDP and consumption accounting for 60 percent, values that are in line with long run averages in the postwar period for many developed economies. The remaining targets concern various moments of debt. As Arellano (2008) we target an output loss in default of 5 percent. The default probability target is 3 percent per quarter and, finally, we introduce a target for the mean sovereign bond spread of 1.4 percent, see Arellano and Bai (2014).

We match these targets by simulated methods of moments giving each of the targets equal weights. Table 1 summarizes the resulting estimates of Γ together with the targets and the values of these implied by the model. The model matches many of the targets very well but implies a default premium that is somewhat lower than its target, a problem that is common to the literature, see e.g. Mendoza and Yue (2012). The (dis)utility weight on search costs is 0.203 and the disutility of work, κ, is 0.03. The value of the utility weight on government provided goods is found to be $\xi = 0.39$. On the technology side, we find an estimate of the vacancy posting cost $a = 0.039$ and of the match efficiency parameter $\psi = 0.49$.

More interesting are the implied values of the productivity loss in default, $\widehat{z}$, and the discount factor of the households. We find $\widehat{z} = 0.895$ so that productivity is capped 10.5 percent below its unconditional mean for a country in default. This loss in TFP is larger than the 5 percent loss in (mean) output. We find $\beta = 0.85$, a value lower than typically assumed in complete markets models but similar to calibrations adopted in the sovereign debt literature. The high discounting stems from the fact that targeting a 5 percent mean output loss in default while imposing a long exclusion punishment makes default only optimal for very impatient agents. We fix the probability of a country being readmitted to international financial markets to 8.3 percent per quarter which implies that default is on average associated with slightly more than 12 quarters of autarky. This probability is substantially lower than the value assumed by Arellano (2008) who calibrates this parameter to 28 percent per quarter thus inducing a significantly more severe punishment of default on the part of international investors.

Table 2 reports some further statistics of the model that are not targeted in the calibration. The implied long-run statistics of the baseline model are shown for times in which the country has access to international credit markets but is either in good times with negligible interest rate spreads or in bad

Table 2: Long-run statistics

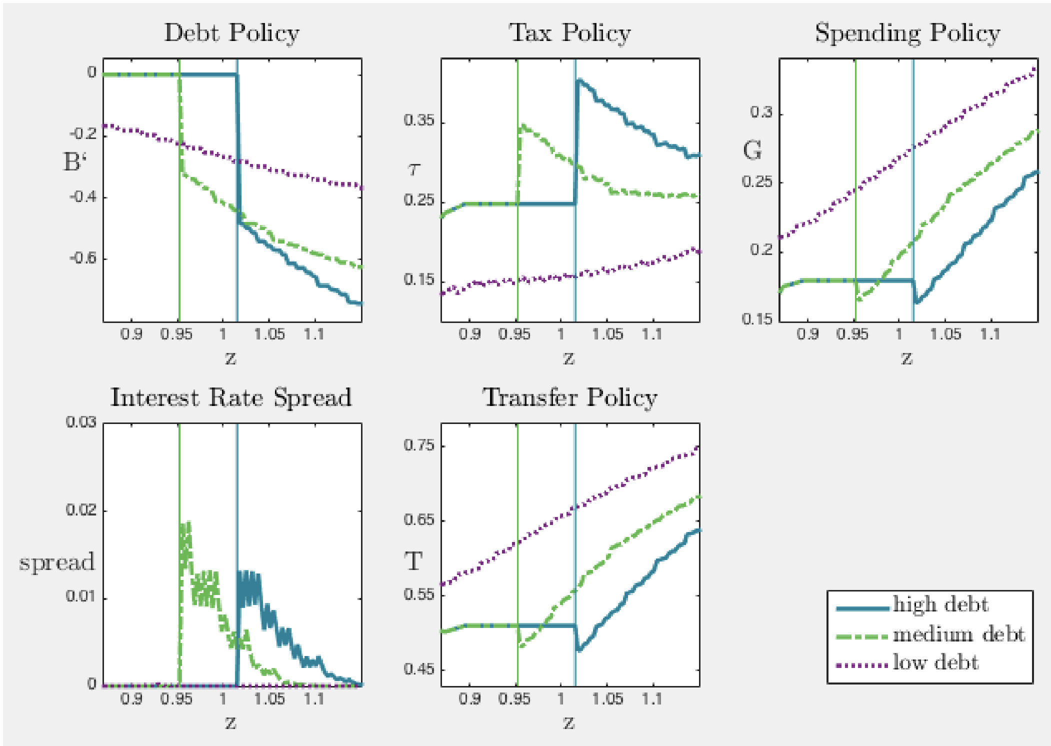
Moment	Good times	Bad times
Mean spread	0.56%	1.51%
Mean debt-to-gdp	46%	42%
Debt service to gdp	−0.45%	5.02%
Volatility of spread	0.27%	1.51%
Relative volatilities of consumption to gdp	1.41	1.04
Relative volatilities of public spending to gdp	0.83	0.54

times with nontrivial default risk. The model matches Greek data[4] particularly well when compared to productivity states that are slightly below average. Specifically, in contrast to the overall spread in the baseline model that is slightly too low compared to the empirical average of 1.4%, when focusing on relatively bad times the bond spread manages to even exceed this value being 1.51% on average. The average debt-to-gdp ratio is around 45%, however, it is difficult to compare this to the data because Greece has increasingly built up deficits and any data average depends on the length of the time series. Interestingly, the debt service to output ratio is slightly negative in good times indicating capital inflows into the economy while in bad times it is with 5.02% closely in line with the average debt service to gdp ratio of 5.2% in Greek data. Similarly, the volatility of private consumption relative to the volatility of output matches with 1.04 in bad times the empirical counterpart very well while in good times the relative consumption volatility is a bit too high. Only with respect to relative volatility of government spending the model-implied value in booms is closer to the data and matches its empirical equivalent of 0.83 exactly.

Results. Figure 1 shows the policy results for our baseline calibration for different debt levels along changes in exogenous productivity. Vertical lines indicate the productivity threshold level at which the government chooses to default at given debt levels indicating that the government is more prone to default in high debt and low productivity states. Government debt decreases in the crisis region in which the spread increases because debt becomes more expensive. The pressure on the government budget stemming from lower productivity and lower capital inflows is solved by increasing taxes and decreasing transfers and pubic expenditures.

[4]Reported empirical statistics are taken from Arellano and Bai (2014).

Figure 1: Baseline, government policies



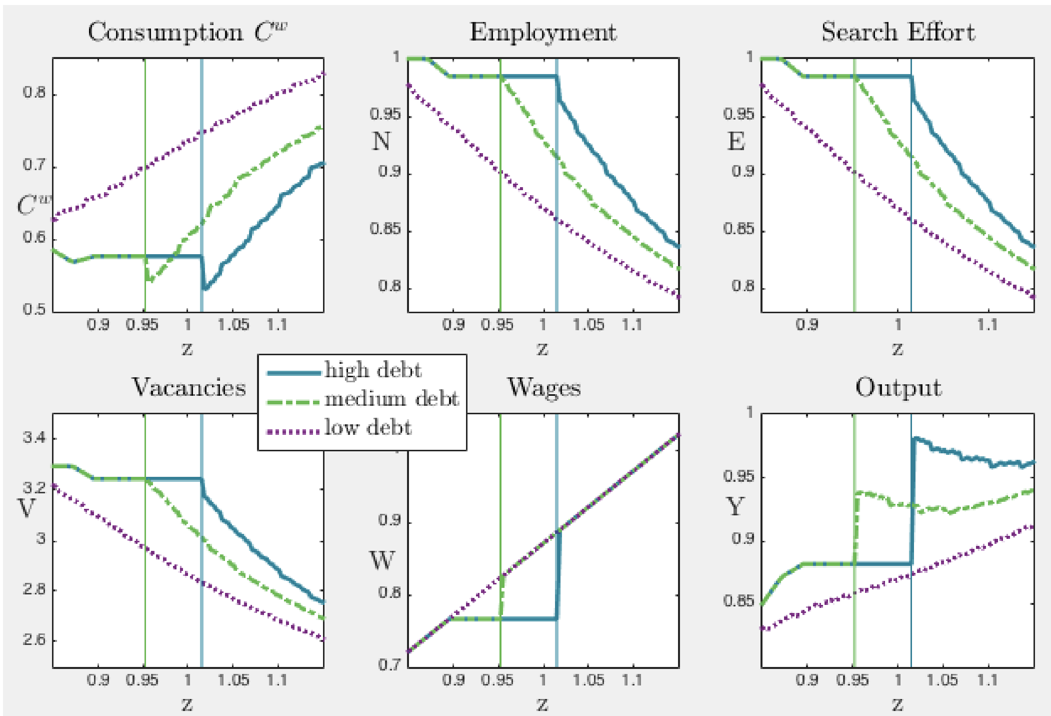
Cutting government spending hurts both employed and unemployed households equally when rising spreads call for sacrificing the household's utility. However, the heterogeneity of households influences the shape of the optimal tax and transfers policies. In normal times when spreads are insignificant, payroll taxes and transfers rise with productivity because the government can provide insurance easily given relatively small incentive problems. However, in a debt crisis with rising spreads taxes increase sharply in response to falling productivity because insurance against unemployment risk is more expensive due to bigger incentive problems in the labor market as well as higher budgetary pressure when productivity falls. The heterogeneity among households therefore is responsible for non-monotone tax rates.

However, as soon as default is inevitable some of the austerity measures can be lifted. Taxes are lower and government spending and transfers are higher in autarky compared to the region of severe debt crisis when the government is integrated in financial markets but faces elevated default risk premia on its bonds. The reason is that the capital outflow from interest payments stops.

The relief from austerity in default at very low productivity levels also shows up in private consumption (figure 2) which increases in productivity except for the discrete jump at the default threshold.

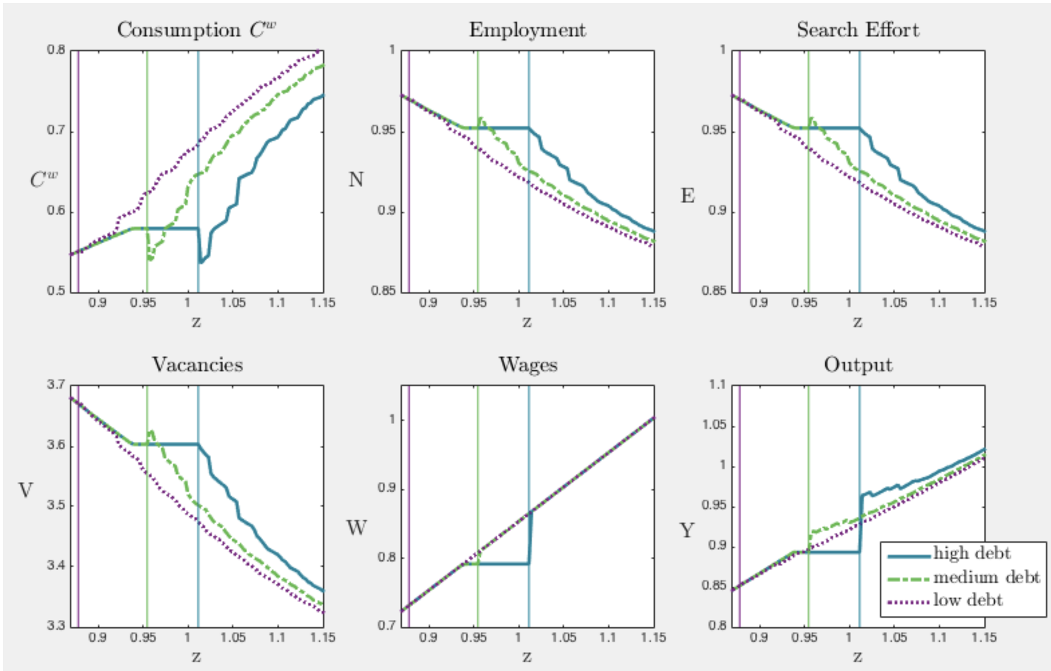
In contrast to this, wages increase in productivity over the entire range of productivity levels and also reflect the additional productivity loss that hits the economy if the policy maker defaults in relatively good states.

Figure 2: Baseline, real economy



How moving from an endowment to a production economy alters the shape of optimal fiscal policy becomes clear when looking at the other labor market variables. High productivity does not only make it more attractive for firms to post vacancies but at the same time also makes the provision of unemployment insurance easier with opposing effects on job search. The fact that it is cheaper for the government to provide transfers in good times dominates and this drives down search effort and therefore employment.

Figure 3: Lower search elasticity, real economy



Therefore, output does not monotonically decreases when productivity falls over the entire range of productivity levels. We re-calibrate the model to the target values for a lower elasticity of search effort ($\sigma_e = 7$) and find that although employment still decreases in productivity output increases with a lower elasticity, see figure 3. The policy functions of the government look similar and are thus not shown here.

Experiments. The role of commitment is highlighted in figure 4. Removing the ability of the government to commit to fiscal policy tomorrow crucially affects the cost of borrowing today. Since the price of debt is always equal to the risk-free rate in the commitment case, i.e. the spread is always zero, the government only has to take into account shifting resources intertemporally. The calibration implies, however, that the households are too impatient relative to the risk-free interest rate which gives an extra incentive to frontload consumption. The government runs down its assets to any exogenous borrowing limit and from then onwards runs a balanced budget. For high debt states, the speed of this draw down does not depend on the productivity level. We show the implied policy functions of the government in figure 4 for the case of an exogenous borrowing limit equal to the highest debt chosen by the government without the ability to commit.

Figure 4: Commitment

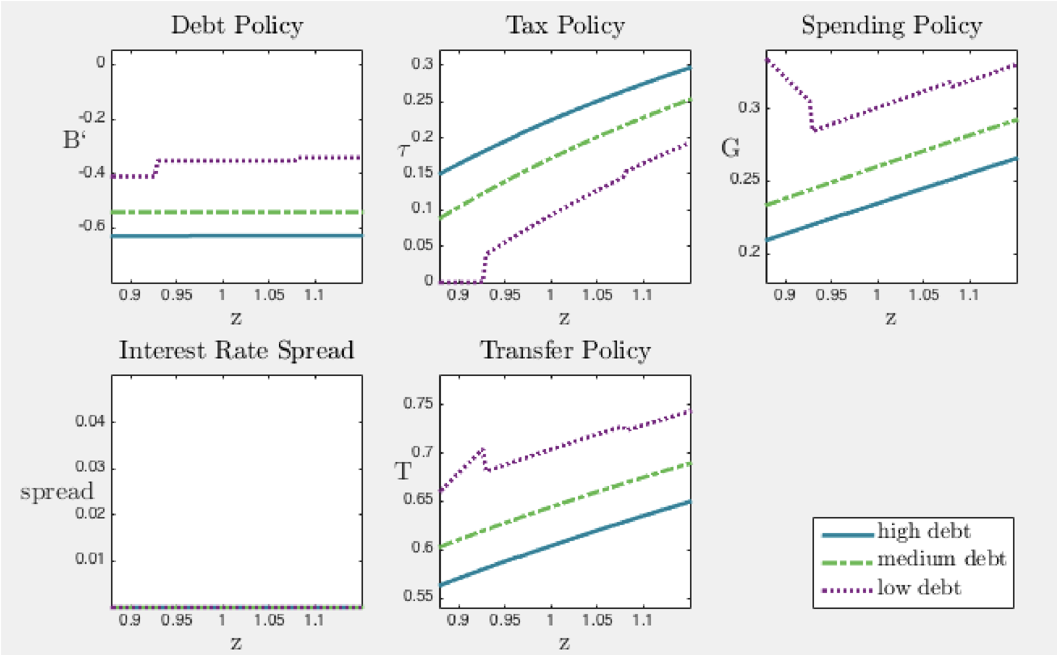


Figure 5: Income pooling

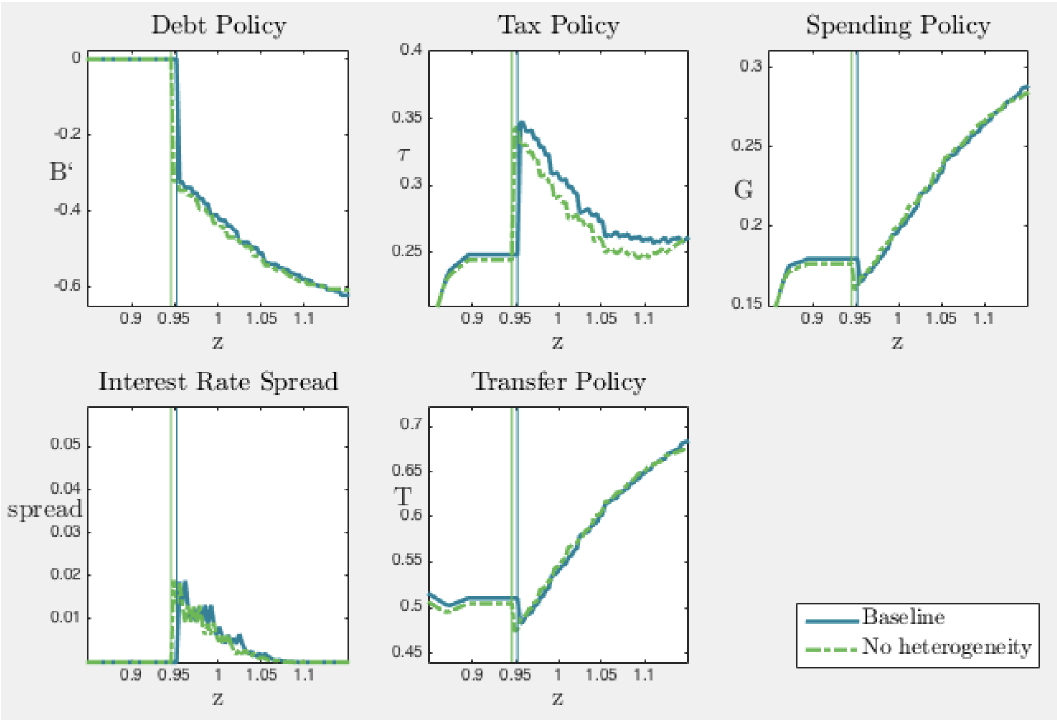
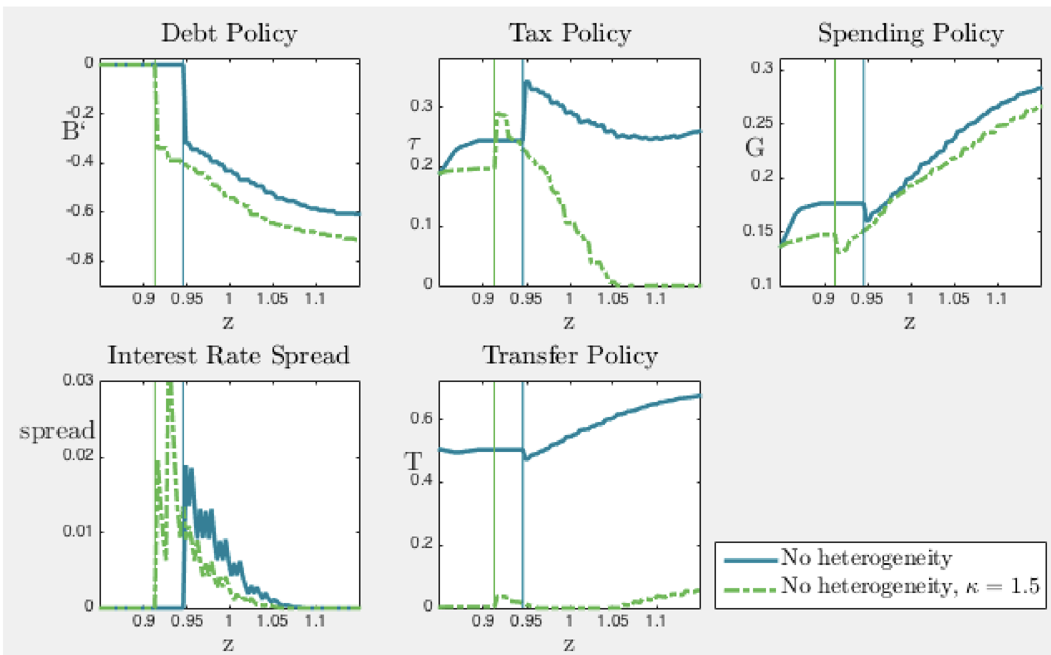


Figure 5 shows the baseline case together with a version of the model in which unemployed and employed workers are part of a family in which income is pooled and consumption is equalized. This is equivalent to assuming full insurance against unemployment risk among the households within a period. Interestingly, the government policies do not deviate much from the baseline policies for the given parameter values of the baseline calibration. However, lower taxes imply higher average consumption levels.

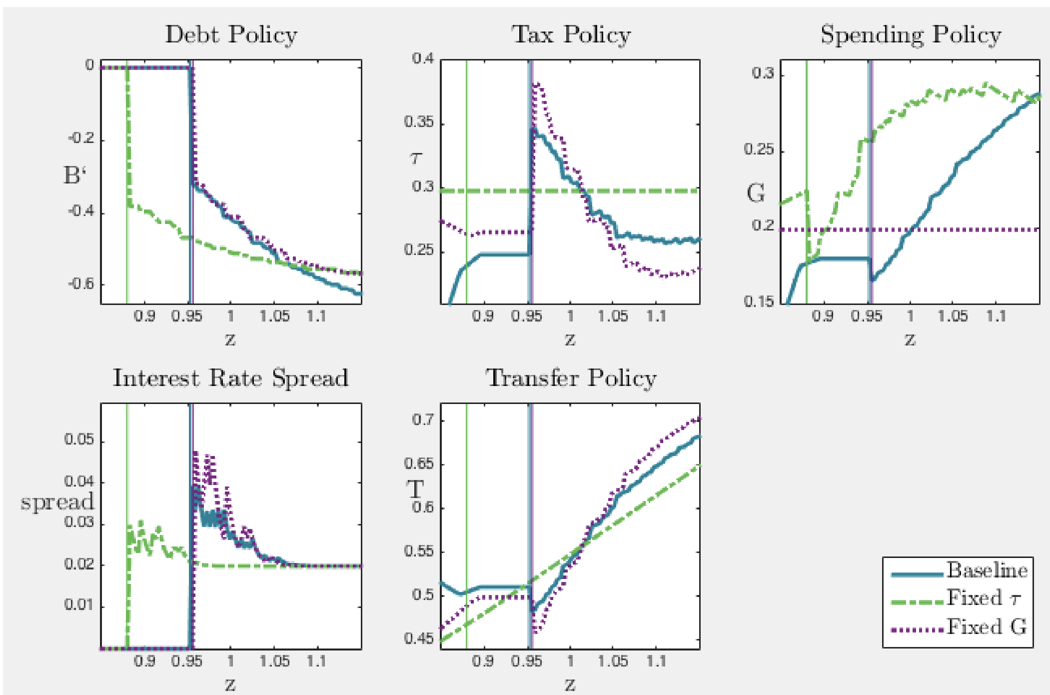
Figure 6: Income pooling, higher disutility from work



This changes drastically as soon as we change the parameter value governing the disutility of work. In the baseline calibration we get a very low constant disutility from work in order to achieve a moderate consumption drop in unemployment of 10%. If we increase this parameter (figure 6), the policies differ substantially highlighting the fact that for identifying the optimal policy it is crucial to take into account inequality. In particular, since the government does not have to explicitly provide insurance by raising the funds for unemployment transfers from the employed the tax level is lower while the transfers drop to zero. For very good states the government even relies entirely on capital inflows from abroad which allows for zero tax rates and at the same time for positive transfers. The inefficient governmental insurance mechanism involving distortionary taxation is replaced by efficient unemployment insurance on household levels. However, empirical evidence shows that households cannot perfectly insure themselves against unemployment risk, hence omitting the heterogeneity is a serious omission when looking at public policies.

Comparing the baseline calibration to model variants where we fix either the labor tax rate or public expenditures to the averages of the baseline case reveals another interesting implication. Figure 7 shows that fixing government policies exogenously calls for even stronger austerity measures in the crisis zone. Taxes hike and transfers shrink more strongly when government spending is fixed. Noticeably, the default threshold is shifted far out and default becomes less attractive for the government that cannot adjust tax rates.

Figure 7: Exogenous policies



Differences in default threshold also show up in different default probabilities and average bond spreads. As reported in table 3 both long-run averages are much lower in the model with exogenous tax rates but higher with exogenously fixed spending. Adding another policy instrument does not automatically imply that the government is more likely to hold off on defaulting. Apart from these two changes the extent to which the economy suffers from output losses in autarky is strongly dependent on the policy instruments available while most other model-implied moments are relatively similar. This indicates that the type and number of endogenous government policies are particularly relevant for default-related variables.

Table 3: Model variants with exogenous policies

Moment	Baseline	Fixed τ	Fixed G
Default probability	3.08%	1.74%	3.50%
Hiring cost/wage ratio;	4.51%	4.49%	4.52%
Average unemployment	6.82%	7.16%	6.72%
Consumption ratio	89.47%	89.51%	89.46%
Spending/consumption ratio	32.93%	32.26%	33.13%
Average spread	0.73%	0.44%	0.81%
Output loss in default	5.05%	3.33%	4.24%

4 Conclusion

This paper outlines a model that captures the conditions in Southern Europe in terms of sovereign default risk, unemployment and endogenous production to analyze the effects of adverse economic shocks in a debt crisis. We solve for the optimal fiscal policy of a government that lacks the ability to commit to both debt repayment and all other fiscal instrument including government expenditures, payroll taxes and unemployment benefits. We demonstrated that the optimal fiscal policy is crucially affected by the assumption that the government can commit to its policies and by exogenously fixing government spending or payroll taxes.

Our main results show that, first, removing the ability of the government to commit to fiscal policy tomorrow crucially affects the cost of borrowing today. Second, moving from endowment to production economy alters the shape of optimal fiscal policy due to the feedback effect of policy to the real economy. Third, in normal times heterogeneity among households makes countercyclical payroll taxes and high transfers optimal because insurance against unemployment risk is relatively cheap and the incentive problem is small. Fourth, in a debt crisis default risk leads to higher optimal labor taxes, lower government spending and less insurance against unemployment risk.

5 References

Arellano, Cristina. "Default Risk and Income Fluctuations in Emerging Economies." 2009. *American Economic Review* 98, 690-712.

Dias, Daniel A., and Christine Richmond. "Duration of Capital Market Exclusion: An Empirical Investigation." 2009. *Unpublished Paper, UCLA*.

Eaton, Jonathan, and Mark Gersovitz. "Debt with Potential Repudiation: Theoretical and Empirical Analysis." 1981. *Review of Economic Studies* 48, 289-309.

Hurd, Michael, and Susann Rohwedder. "Effects of the Financial Crisis and Great Recession on American Households. " 2010. *NBER Working Papers 16407, National Bureau of Economic Research, Inc*.

Mendoza, Enrique G. and Vivian Z. Yue. "A General Equilibrium Model of Sovereign Default and Business Cycles." 2012. *Quarterly Journal of Economics* 127, 889-946.

Merz, Monika. "Search in the labor market and the real business cycle. " 1995. *Journal of Monetary Economics, Elsevier* 36(2), 269-300.

Mukoyama, Toshihiko, Christina Patterson and Aysegul Sahin. "Job Search Behavior over the Business Cycle. " 2013. *Meeting Papers 988, Society for Economic Dynamics*.

Silva, Jos Ignacio, and Manuel Toledo. "Labor Turnover Costs And The Cyclical Behavior Of Vacancies And Unemployment. " 2009. *Macroeconomic Dynamics, Cambridge University Press* 13(S1), 76-96.

Yue, Vivian Zhanwei. "Sovereign Default and Debt Renegotiation." 2010. *Journal of International Economics* 80, 176-187.

6 Appendix

$$
\begin{aligned}
& \max_{w_t} \left(\mathbf{u}\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)-\mathbf{u}\left(\mu_t+\pi_t,e^*_{t,}G_t\right)\right)^{\lambda}\left(x\left(z_t,d_t\right)-w_t\right)^{1-\lambda} \\
\Rightarrow\ & (1-\tau_t)\,\lambda\mathbf{u}_c\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)\left(\mathbf{u}\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)-\mathbf{u}\left(\mu_t+\pi_t,e^*_{t,}G_t\right)\right)^{\lambda-1} \\
=\ & (1-\lambda)\left(\mathbf{u}\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)-\mathbf{u}\left(\mu_t+\pi_t,e^*_{t,}G_t\right)\right)^{\lambda}\left(x\left(z_t,d_t\right)-w_t\right)^{-\lambda} \\
\Rightarrow\ & (1-\tau_t)\,\lambda\mathbf{u}_c\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)\left(x\left(z_t,d_t\right)-w_t\right)=(1-\lambda)\left(\mathbf{u}\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)-\mathbf{u}\left(\mu_t+\pi_t,e^*_{t,}G_t\right)\right) \\
\Rightarrow\ & w_t=x\left(z_t,d_t\right)-\frac{1-\lambda}{\lambda}\frac{\mathbf{u}\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)-\mathbf{u}\left(\mu_t+\pi_t,e^*_{t,}G_t\right)}{(1-\tau_t)\,\mathbf{u}_c\left((1-\tau_t)\,w_t+\pi_t,e^*_{t,}G_t\right)}
\end{aligned}
$$

Notice that other relevant variables can be expressed as functions of (Y, Θ, S) since:

$$\begin{aligned} n &= pe && (28) \\ p &= \left(1 + \left(\frac{v}{e}\right)^{-\phi}\right)^{-1/\phi} && (29) \\ q &= \frac{n}{v} && (30) \\ c^u &= \mu && (31) \\ w &= c^w / (1 - \tau) && (32) \end{aligned}$$

where we have used that the free entry condition, $x(z, h) - w = a/q$, implies that $\pi = \int \pi_j dj = 0$ since $v_j = 1/q$.