Málaga Economic Theory Research Center Working Papers

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WP 2016-5
November 2016

Departamento de Teoría e Historia Económica
Facultad de Ciencias Económicas y Empresariales
Universidad de Málaga
ISSN 1989-6908

Fiscal Discipline and Defaults *

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Abstract

We develop a general equilibrium model with a detailed structure of government expenditures and revenues, calibrate it to the Greek and German economies, and use it study the link between fiscal discipline and defaults. We show that even if the Greek government had entered the Great Recession with the same structure of government expenditures and revenues as Germany, but with the Greek level of debt, it would still have chosen to default when facing a high interest rate. Alternatively, if the Greek government had kept its structure of government expenditures and revenues, but managed to decrease its debt to the level of Germany, it would not have defaulted. The primacy of debt over the structure of government expenditures and revenues in default decisions is further emphasized by our findings that even if Germany, with a low level of debt, faced the same high interest rate as Greece did, it would still not have defaulted.

JEL Classification: H5; H6.

Keywords: Dynamic General Equilibrium Model, Fiscal Policy, Government Expenditure, Government Default.

*We would like to thank Noelia Cámara, Miguel Cardoso, Juan Carlos Conesa, Mónica Correa, Matt Delventhal, Antonia Díaz, Tim Kehoe, Zach Mahone, Rodolfo Méndez, Juan Pablo Nicolini, Javier Pérez, Luis Puch, Jesús Rodríguez, and seminar participants at the 2011 SAET meeting Faro, Universidad del País Vasco, XXXVIII Simposio of the AEE, MOVE Barcelona Macroeconomics Workshop 2015, 2016 SAET meeting Cambridge, and THUIT-2016 workshop for very helpful comments and suggestions. We thank Pedro Cabrera who provided excellent research assistance. G. F. de-Córdoba and J.L. Torres acknowledge financial support from Proyecto de Excelencia Junta de Andalucia SEJ-1512 and Research Grant ECO2013-48884-C3-3-P. G. F. de-Córdoba thanks Pedro Martín for his discussions and the financial support from a research grant from Bonsabor. Pujolas thanks the Partnership to Study Productivity, Firms and Incomes as supported by the Social Sciences and Humanities Research Council of Canada. All errors are our own.

1 Introduction

A sovereign default crisis arises when the government of a country decides not to pay back its debt. What is the driving force behind this decision? After the 2010 sovereign debt crisis, the Greek government was criticized for its undisciplined handling of fiscal policy. According to this critique, the Greek government was financing large and unnecessary public consumption and investment, making overly generous transfers to its citizens, and financing a very large public wage bill. During that time, the Greek government was supporting a large debt. The criticism states that when a government mishandles its resources, it becomes highly vulnerable to a default in the wake of a spike in the cost of its debt. To avoid this problem, a government has to manage its resources well. A commonly used example of such a government in the European context is that of Germany. Hence, the argument follows, if a country like Greece has a government that manages its finances similarly to how the German government manages its own, default crises can be avoided. The problem with this criticism is that it does not specify what are the ultimate causes of the default. Is it that the government is choosing to spend too many resources in making overly generous transfers instead of financing public investment? Or is the government sustaining a level of debt that is too large? An illustration of this problem can be seen in the Memorandum of Understanding that the European Commission and the Greek government signed in 2010, where the parties agreed to debt relief for Greece, in exchange for government reforms affecting "the labor, product and service markets" and the "implementation of structural spending measures." To make things worse, there is a hard and lengthy process that needs to be followed in order to change fiscal policies and to reduce debt, but a default can be decided in a matter of hours. Thus, the Greek government did not radically change its policies or decide to massively reduce its debt; it simply defaulted.

In this paper, we propose a simple exercise to shed light on the relative importance of the structure of government expenditures and revenues versus the high level of debt in driving the default decision. To this end, we propose a dynamic model where the government has a positive impact on the economy through its expenditures, a negative impact through its taxes, sustains public debt, and may choose to default. We show that the model accurately predicts the default in Greece under Greek fiscal policy and the non-default in Germany under German fiscal policy. We then perform various counter-factual exercises to shed light on how the default could have been avoided. First, we find that if the Greek government had changed its structure of government expenditures and revenues to resemble those in place in Germany, but kept the debt level of Greece, when it faced a spike in the interest rate on its debt, it would still have chosen to default. On the other hand, if the Greek government decreased its debt to a level similar to that of Germany — which coincides with the debt level emphasized by the Maastricht Treaty [1]— but kept its structure of government expenditures and revenues, then it would have paid back its debt in full. Hence, we find that to avoid a default crisis, the government should keep low levels of debt, and that changing the structure of government expenditures and revenues is less important.

Since we are interested in understanding the role of the structure of government expenditures and revenues, the government in our model is characterized by a set of expenditures that have a positive impact on households and a set of taxes that distort the economy. The level of detail in the structure of government expenditures and revenues is key to fully characterize the impact of fiscal policy decisions on the evolution of the economy. In particular, the government decides how much to spend on public consumption (desired by the households), on public investment (used to build public capital, which in turn is used by private firms to produce output), on public employment (also used by private firms to produce output), and on social transfers (used by households to consume and invest). Similarly, the government collects revenues from distortionary taxes on consumption, labor, profits and capital, and receives social security payments.

Besides spending resources in public consumption, investment, employment and transfers, the government also spends resources paying interest on the debt that it sustains. Similarly, besides the revenues collected from taxing the economy, the government also borrows resources from international investors. The government observes, every period, the interest rate that is placed on its bonds, and chooses what policy to follow — either default on its debt, repay debt at maturity, or roll debt over to the next period — in order to maximize household's welfare. If the government chooses to default, then the country suffers a negative and permanent shock to its productivity and is perpetually excluded from international financial markets. If, instead, the government chooses to pay-back at maturity, the government has to implement a sequence of cuts in public spending in order to pay back its debt. Finally, if the government chooses to roll its debt over, then, when the interest rate spikes, the government needs to cut its public expenditure to accommodate the increase in interest payments. The underlying mechanism behind the government decision is the same as Arellano (2008).

We calibrate the model to the Greek and the German economies. Each calibration consists of a set of parameters linked to the structure of government expenditure and revenues, a level of debt, and technological and preference parameters governing the rest of the econ-

[1]The Treaty on the European Union was signed on February 7, 1992 by the members of the European Community in Maastricht, Netherlands. The Treaty led to the creation of the Euro, and established a set of rules imposing control over inflation, public debt and the public deficit, exchange rate stability and the convergence of interest rates. With regard to public finances it imposed an annual limit of 3% in the ratio of government deficit to GDP, and a 60% of gross government debt prior to the entry in the European Monetary Union.

omy. We use these different sets of parameters in our exercises to answer questions such as "if Greece had a government with the structure of expenditures and revenues of Germany, but sustained a debt of the magnitude Greece sustained, would default still occur when the interest rate spiked?"

The first question that we ask, though, is simpler: is our model fit to explain the behavior of the German and Greek government during the Great Recession? The answer to this question is affirmative: if we characterize an economy that only consists of Greek objects — technological and preference parameters from Greece, the government structure of expenditures and revenues from Greece, the debt level from Greece, and the spike in the interest rate that Greece faced — our model dictates that the government chooses to default. Similarly, if the economy only consists of German objects, then the government chooses to roll its debt over.

In the first counter-factual experiment we ask what the German government would have done, had it been in charge of the Greek economy, with the Greek debt level, if it was hit by the observed spike in the interest rate. To this end, we confront the Greek economy with the spike in interest rates, while simultaneously imposing the government structure of expenditures and revenues from Germany and ask whether the default decision would have changed. We find that the government would still have defaulted. The cost of paying back a large level of debt is such that households are better off when the government simply defaults and the whole economy faces a negative productivity shock.

When interpreting our results, we may be concerned that the impact of fiscal policy on the overall economy takes time, and hence imposing German fiscal policy at the peak of the crisis does not adequately capture the benefits of the German fiscal code. We take this into account in our second counter-factual experiment, where we replicate the first experiment with the exception that the German structure of government expenditures and revenues are imposed ten years before the spike in the interest rate — roughly, when Greece joined the European Monetary Union. We find that the government still decides to default in this case. In fact, in this case, output is lower due to reduced public investment.

A spike in interest rates triggered default in our first two counter-factuals. This leads us to investigate whether high interest rates always lead to defaults in the model. To this end, in the third counter-factual experiment we ask what the German government would have done, had it been in charge of the German economy, with the German debt level, if it was hit by the observed spike in the interest rate that occurred in Greece. In spite the high interest rate, we find that the government pays back its debt at maturity. This result highlights that the ultimate cause of the default is not the spike in the interest rate per se: the debt level of the German economy is sufficiently low that defaulting is too costly; however, the level of debt is high enough that rolling debt over is too costly as well. Hence, the government simply pays back its debt and ceases borrowing.

Since our first three counter-factuals suggest that debt levels are key to determine the action of the government, in the fourth counter-factual experiment we ask what the Greek government would have done, had it been in charge of the Greek economy, with the German debt level, if it was hit by the spike in the interest rate faced by Greece. However, we do not allow Greek government debt to simply evaporate; instead, we impose a policy that reduces Greek debt to German levels over the ten years prior to the crisis. With this reduced debt level, in the face of the spike in interest rates, the Greek government pays back its debt at maturity. This result reinforces the idea that the ultimate cause of default is the high debt level rather than the structure of government expenditures and revenues. It is interesting to note that this counter-factual exercise could have been what actually happened, had the Greek government followed the rules of the Maastricht Treaty.

There is one last consideration to be taken into account: when the Greek economy is managed by the German government, there is a fall in public capital, since German public investment as a fraction of total government spending is lower than in Greece. This feature, which is already present in the first two counter-factual exercises, makes the Greeks relatively worse off under the German structure of government expenditures and revenues. We analyze the role that this low level of public investment plays on the decision to avoid a default when the debt level is low. To this end, in the fifth counter-factual experiment we ask what the German government would have done, had it been in charge of the Greek economy, with the German debt level, if it was hit by the spike in the interest rate faced by Greece. Again, we do not allow government debt to simply evaporate; instead, we impose a policy that reduces Greek debt to German levels over the ten years prior to the crisis. With this reduced debt level, in the face of the spike in interest rates, the German government defaults on its debt, since the introduction of German spending acts similarly to a negative productivity shock on Greek firms. This result provides an important insight. While the first four counter-factuals emphasized the key role of debt levels, they suggest that the structure of government expenditure and revenues is of second order. However, this experiment demonstrates the importance of the complementarity between public investment and debt levels. In spite of having low debt, the German government defaults because minimal public investment reduces firm productivity.

Hence, our findings suggest that i) the composition of public expenditure is not the cause of the default, ii) the increase in the interest rate generates defaults in heavily indebted governments, iii) the increase in the interest rate does not generate defaults in governments with low levels of debt, and iv) the ultimate cause of default crisis is that the debt level is excessive, v) the default crisis in Greece could have been avoided had the debt level been similar to that of Germany (which is the same as the one implied by the Maastricht Treaty). Hence, reducing debt levels is the answer to avoid future crises.

Our model is also useful to dig into the question of why a spike in the interest rate did not occur in Germany. Cole and Kehoe (1996, 2000) show that a self-fulfilling crisis can emerge when multiple equilibria co-exist (high interest rate with default and low interest rate with no-default). Our model is silent about why spikes in the interest rate happen, but we use it to analyze the behavior of a government when it is hit by one. In one of our exercises, we find that a country with the economic and debt characteristics of Germany would not default if hit by a spike in the interest rate, suggesting that a self-fulfilling crisis in Germany — driven by investors' panic — could not have happened. This result would suggest that, had Greece lowered its debt level to that of Germany, the crisis would have not happened. This result adds to the results of Bocola and Dovis (2016), who develop a Cole-Kehoe model to disentangle whether a default crisis is related to the fundamentals of the economy or to a panic by investors. Our paper is also in line with the findings in Conesa and Kehoe (2015) who show that investors' panic turns into self-fulfilling crisis when output levels are low — in our case, Greece — but not when output levels are high — in our case, Germany — and with Arellano, Conesa and Kehoe (2012), who also find convincing evidence of the mechanism in Conesa and Kehoe (2015) in the data.

We are not the first ones to look at the Greek sovereign crisis. For instance, Chamley and Pinto (2011) use the Greek case to argue that bailouts tend not to work because they crowd-out international funds. A similar result emerges from a careful comparison between the Euro-zone debt crisis with the Mexican crisis of 1994-1995 in Conesa and Kehoe (2014): even though a bailout worked to solve the problem in Mexico, it seems unlikely that the same can happen in troubled countries in the Euro area.

Finally, our paper is also related to Conesa, Kehoe and Ruhl (2016) who study the role of the timing of tax decisions in a model with sovereign debt subject to roll-over risk. They analyze when it is optimal to implement austerity, while in our paper, we do not analyze what is the optimal fiscal policy, but which of two different fiscal policies — the Greek or the German — is best at dealing with sovereign defaults.

The structure of the rest of the paper is as follows: Section 2 presents the model. Section 3 discusses the calibration exercise. Section 4 shows the results of the various experiments we run. Finally, Section 5 concludes.

2 The model

We develop a model with a representative household deciding to consume, work either in the private or in the public sector, invest, and rent capital to private firms. In the model, there is a representative firm that hires labor and capital to produce a final good, making use of publicly provided capital and labor. There is a government setting taxes on consumption, labor, profits, capital and a social security, and choosing to spend these resources on transfers to households, public employment, public salaries, public consumption and public investment. Finally, there are international investors purchasing government bonds. In Appendix A.1, we show that the model we build satisfies Walras's Law.

2.1 Households

The household derives utility from consuming a public good, a private good and leisure. The household chooses how much to investment, how much to consume of the private good and how much to work by solving the problem

$$\begin{aligned} &\max \sum_{t=0}^{\infty} \beta^t \left(\gamma \log(C_{p,t} + C_{g,t}) + (1-\gamma)\log(\overline{H} - L_{p,t} - L_{g,t})\right) \\ &\text{s.t.:} \quad (1+\tau_t^c)C_{p,t} + K_{p,t} - K_{p,t-1} \\ &\qquad = (1-\tau_t^l)(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) + (1-\tau_t^k)(R_t - \delta)K_{p,t-1} + Z_t + (1-\tau_t^\pi)\Pi_t, \end{aligned} \tag{1}$$

where $C_{p,t}$ is private consumption and $C_{g,t}$ is public consumption, $\overline{H}$ is the time endowment of the individual, $L_{p,t}$ and $L_{g,t}$ are private and public labor; $K_{p,t}$ is stock of private capital, $W_{p,t}$ is the wage paid by the private sector and $W_{g,t}$ is the wage paid by the public sector, R_t is the gross return on capital, δ_p is the depreciation rate of private capital, Z_t is the transfer received from the government and Π_t are profits made by firms; last, $\tau_t^c, \tau_t^l, \tau_t^k, \tau_t^\pi$ are taxes on consumption, labor, capital, and profits, respectively.

All the variables in the household problem are a function of the default decision of the sovereign, z_t. The relationship is not made explicit to economize on notation.

2.2 Firms

The representative firm, owned by the household, hires private capital and private labor in order to maximize profits. The technology employed also uses public capital and public labor, which are provided by the government. Since the technology exhibits constant returns to scale on the four factors of production, the firm makes positive profits, which are rebated back to the household.[2] The firm's problem is

$$\Pi_t = A_t(z) K_{p,t-1}^{\alpha_p} K_{g,t-1}^{\alpha_g} \left(\mu L_{p,t}^{\eta} + (1-\mu) L_{g,t}^{\eta}\right)^{\frac{\alpha_l}{\eta}} - (1+\tau^{SS}) W_{p,t} L_{p,t} - R_t K_{p,t-1}, \tag{2}$$

where $A_t(z)$ is a measure of total-factor productivity that depends on whether the government has defaulted in the past, with $A_t(1) > A_t(0)$, indicating that a default produces a once and for all reduction in TFP. All the other variables in the firm problem are a function of the default decision of the sovereign as well, but the relationship is not made explicit to economize on notation. $K_{g,t}$ is the stock of publicly provided capital, with public capital share α_g; similarly, $K_{p,t}$ is the stock of private capital, with private capital share α_p; finally, the labor share, α_l, satisfies that $\alpha_p + \alpha_g + \alpha_l = 1$. μ measures the weight of public employment relative to private employment and η governs the elasticity of substitution between labor inputs. Finally, τ^{SS} is the social security tax.

2.3 Government

The government in our model makes two separate decisions: the fiscal problem and the default problem. The fiscal problem consists of the government choosing, given a fixed set of taxes and desired public expenditure level, how to allocate its resources between its various expenditures. The default problem of the government consists of choosing, every period, whether or not to default only taking into account the well-being of consumers. The first problem reflects, in reduced form, the long-run decisions that a government makes, in which there is politics involved, and the policies enacted are not necessarily welfare-maximizing. The second problem reflects the instantaneous decisions that a benevolent government makes, taking into account all the decisions from the long run problem. In it, the government decides whether or not its citizens' welfare is going to be maximized if the debt is not honored.

2.3.1 Period expenditure composition

The government in our model has preferences on how to allocate its public expenditure, G_t between public consumption, $C_{g,t}$, public investment, $I_{g,t}$, public wage bill, $E_{g,t}$, and transfers to households, $Z_{g,t}$. The preferences are represented by

$$U_{g,t} = \theta_1 log(C_{g,t}) + \theta_2 log(I_{g,t}) + \theta_3 log(E_{g,t}) + \theta_4 log(Z_{g,t}), \tag{3}$$

[2]See Appendix A.2 for a detailed derivation of marginal products and actual profits in this economy.

where θ_1 is the weight the government places on public consumption, θ_2 is the weight on public investment, θ_3 is the weight on the public wage bill, and θ_4 is the weight on transfers to households. The sum of all weights is equal to 1. The sum of all types of government expenditures is equal to the period government expenditure. Namely,

$$G_t = C_{g,t} + I_{g,t} + E_{g,t} + Z_{g,t}. \tag{4}$$

Hence, for a level of government expenditure, G_t, the government maximizes equation (3) subject to equation (4).

Public consumption, $C_{g,t}$, consists of the purchase of final good by the government, which for the household are perfect substitutes to private consumption — see the utility function of consumers in equation (1). Public investment is used to build more public capital stock, following the law of motion

$$K_{g,t} = (1 - \delta_g)K_{g,t-1} + I_{g,t}, \tag{5}$$

which is analogous to the private capital accumulation process, and where δ_g is the depreciation rate of public capital. The public sector wage bill consists of the public wage, $W_{g,t}$, social security taxes, $(1 + \tau_t^{ss})$, and the amount of public employees hired, $L_{g,t}$. The public wage is set to be the maximum between the private wage and the marginal product of public labor.[3] Given the public wage and the total expenditure in the public employees bill, we get that the total labor in the public sector satisfies

$$L_{g,t} = \frac{E_{g,t}}{W_{g,t}(1 + \tau_t^{ss})}. \tag{6}$$

Finally, government transfers are resources rebated back to consumers directly, which enter in the budget constraint of the household.

The level of total government expenditure depends on the state of the economy. During normal times — when there is no default — the government chooses total expenditure to satisfy a desired level of government expenditure on GDP, $g = G_t/Y_t$. When the government decides to default, total expenditure on GDP is left as the residual that it can finance given the resources that it can levy from the domestic economy.

Finally, the government has taxes that it chooses to fix on the economy. Taxes are on consumption, τ_t^c, labor, τ_t^l, capital, τ_t^k, profits, τ_t^π and social security, τ_t^{ss}. The total fiscal

[3] In the calibration exercise, we show that both Greece and Germany pay higher wages in the public sector than in the private sectors; furthermore, in all the experiments we run, public wage is higher than private wages. The max operator for the public wage salary is set in order to have a well-defined model — workers are always willing to work in the public sector — but has no consequence on the results.

revenue, T_t, of the government is equal to

$$T_t = \tau_t^c C_{p,t} + \tau_t^l (W_{p,t} L_{p,t} + W_{g,t} L_{g,t}) + \tau_t^k (R_t - \delta_p) K_{p,t-1} + \tau_t^{ss} (W_{p,t} L_{p,t} + W_{g,t} L_{g,t}) + \tau_t^{\pi} \Pi_t. \tag{7}$$

Hence, the government budget constraint is given by

$$\Delta B_t + T_t = G_t + R_t^B B_t, \tag{8}$$

where B_t is the net debt position of the government, $R_t^B B_t$ is the interest payments on debt. To simplify the model, we assume that the government debt is such that every period it needs to refinance a fraction $1/N$ of total debt.

2.3.2 Default

Every period, the government decides whether or not to honor its debt obligations comparing the well-being of households under the three alternatives: default, pay-back of its debt when maturity hits, and roll-over of debt. This decision is registered by variable $z = \{0, 1, 2\}$ that takes the value $z = 0$ if the government defaults in the current period or if it has ever defaulted in the past, it takes the value $z = 1$ if the government has always honored its debt and decides to roll-over its debt, and $z = 2$ if the government decides to pay back at maturity. The trade-off when deciding whether or not to honor the debt consists of avoiding to pay the debt against a fall in total factor productivity — as measured by $A_t(z)$ in equation (2), with $A(0) < A(1) = A(2)$ — and perpetual exclusion from the financial markets. If the government decides to pay-back its debt, instead of rolling it over, it suffers a fall in its disposable resources for a few periods, but it has more resources in the future.

Namely, the problem of the government, when deciding whether or not to default in period τ, is given by maximizing the utility function of the household,

$$
\begin{aligned}
\max \sum_{t=0}^{\infty} & \beta^t \left(\gamma \log(C_{p,t}(z) + C_{g,t}(z)) + (1-\gamma) \log(\overline{H} - L_{p,t}(z) - L_{g,t}(z))\right) \\
s.t. \quad & B_s = 0 \text{ if } z_\tau = 0, s \geq \tau, \\
& G_s = T_s \text{ if } z_\tau = 0, s \geq \tau, \\
& G_s = gY_s \text{ if } z_\tau = 1, s \geq \tau, \\
& G_s = \frac{N-(s-\tau+1)}{N} B_\tau + T_s - R_s^B \frac{N-(s-\tau)}{N} B_\tau \text{ if } z_\tau = 2, s \geq \tau, s-\tau \leq N, \\
& B_s = 0 \text{ if } z_\tau = 2, s \geq \tau, s-\tau \geq N, \\
& G_s = Y_s \text{ if } z_\tau = 2, s \geq \tau, s-\tau \geq N,
\end{aligned}
\tag{9}
$$

where $C_{p,t}$, $L_{p,t}$, $L_{g,t}$ and $K_{p,t}$ are the solution to the problem of the households, problem (1), Π_t, $L_{p,t}$ and $K_{p,t}$ are the solution to the problem of firms, problem (2), $C_{g,t}$, $I_{g,t}$, $\mathrm{E}_{g,t}$ and $Z_{g,t}$ solve the period composition allocation of the government, maximizing equation (3) subject to equation (8), $K_{g,t}$ evolve according to equation (5), $W_{g,t}$ is the marginal product of public labor, and $L_{g,t}$ is given by equation (6), R_t guarantee that all capital in the hands of households is used by firms, and $W_{p,t}$ guarantee that all the demand for labor by firms equals the supply of labor to the private sector by households.

Defaulting has positive and negative consequences. The positive consequence is that total debt no longer represents a burden on tax-payers. Hence, all resources levied by the government are only used to finance activities that benefit households, like public consumption and transfers, or that benefit firms, like public investment and public labor. The negative consequence is that there is a fall in total factor productivity, and the total government expenditure can, in principle, be lower than when there is no default, lowering the four objects that households and firms benefit from. Paying back debt at maturity does not have the cost of exclusion from financial markets and the shock to productivity, but it lowers resources for the government for the initial part of the N periods that the debt is being paid-back.

2.4 International investors

The rest of the world for this economy is modeled as a deep-pocketed international investor. The international investor lends money to the government at rate R^B. The interest rate at which the international investor lends, during normal times, satisfies $\beta(1 + R^B) = 1$. However, when a period of crisis arises, the interest rate can have an unexpected spike. If this spike happens, the path of R_t^B is such that borrowing becomes very expensive suddenly.

3 Calibration

In this section, we calibrate the model to the Greek and to the German economies. All targets correspond to 2006, just before the crisis. In what follows, we first explain how we calibrate the government parameters, then move on to calibrate the parameters for the rest of the economy, and we finally explain how we introduce debt maturity into the model.

3.1 Government parameters

The government in our model is defined as a vector of fiscal policy instruments parameters $(\tau^k, \tau^l, \tau^c, \tau^\pi, \tau^{ss}, \theta_1, \theta_2, \theta_3, \theta_4)$, a stock of debt, B, and a fraction of debt that needs to be refinanced every period, N. The first set of parameters are taxes: we pick taxes on capital, labor and consumption directly from Boscá *et al.* (2012), whose results are based on the methodology developed by Mendoza *et al.* (1994); taxes on profits and social security contributions are taken directly from OECD statistics. The second set of parameters are expenditure shares. We take them directly from the National Accounts. For the Greek economy, public investment represents 10.37% of the expenditure, implying $\theta_2 = 0.1037$, while in the German economy public investment accounts for only 4.32%, implying $\theta_2 = 0.0432$. The expenditure share on public consumption is roughly similar for both countries ($\theta_1 = 0.4467$ for Greece and 0.4024 for Germany). The public wage bill, θ_3, is obtained as the public wage bill over total government expenditures $\theta_3 = (1 + \tau^s)W_g L_g/G$, with values of 0.2441 for Greece and 0.1712 for Germany. Putting together the different fractions of government expenditures we obtain as a residual the value of $\theta_4 = 1 - \theta_1 - \theta_2 - \theta_3$ as total transfers to consumers, which are 0.2055 in Greece and 0.3832 in Germany. Finally, public debt in Greece is equal to $B/Y = 1.10$ and in Germany it is 0.656. All the government parameters are summarized in Table 1.

Last, we use average maturity of Greek and German debt at the time of the Great Recession (4 and 6 years, respectively) to pin down the number of periods in which debt payback is followed up. Since each period the government has to refinance a constant fraction $1/N$ of its total debt, the average maturity is equal to

$$\text{maturity} = \frac{1}{N} \times 1 + \frac{1}{N} \times 2 + ... + \frac{1}{N} \times N = \frac{1}{N} \sum_{i}^{N} i = \frac{N+1}{2}.$$

The resulting figures are $N = 7$ for Greece and $N = 11$ Germany.

Table 1: Government parameters			
Parameter	**Definition**	**Value**	
		Greece	Germany
θ_1	Ratio public consumption/total government expenditure	0.4467	0.4024
θ_2	Ratio public investment/total government expenditure	0.1037	0.0432
θ_3	Ratio public wage bill/total government expenditure	0.2441	0.1712
θ_4	Ratio public transfers/total government expenditure	0.2055	0.3832
τ^l	Labor income tax rate	0.4100	0.3810
τ^k	Capital income tax rate	0.1640	0.1810
τ^{ss}	Social security contribution	0.3560	0.3390
τ^π	Profit tax rate	0.2500	0.3870
τ^c	Consumption tax rate	0.1480	0.1240
B/Y	Ratio public debt/output	1.1000	0.6560
N	Fraction of debt refinanced every period	7	11

3.2 Technological and preference parameters

The real return of public bonds is $R^B = 0.041$, which corresponds to the interest rate for the Greek and German ten year bonds in 2006. Standard no-arbitrage condition implies that $\beta = 0.9606$ for both economies.

Computing private and public capital depreciation rates is a difficult task, since it involves computing what types of investments are done, and what is the depreciation rate for each of them. Due to its intrinsic difficulty, we use the estimates of Mas *et al.* (2010) for the Spanish economy, which implies that $\delta_{K_p} = 0.08$ and $\delta_{K_g} = 0.04$ for both countries. The depreciation rate for public capital is lower than for private capital given their different composition, since public capital typically contains more infrastructure, which depreciates more slowly. These calculations imply that, in the steady state, the public capital stock represents around 28% of total capital stock, and that total capital stock is 3.26 times total output for Greece, whereas for Germany these figures are 21% and 2.5.

We use OECD data series on public sector labor and wages. Public and private compensation of employees and public and private employment are taken from OECD Economic Outlook database December 2007 Issue, for the period 1960-2006. The public wage bill is calculated as total final public compensation of employees. In 2006, public employment over private employment is 24.0% for Greece and 13.04% for Germany. The other target is the wage premium, W_g/W_p, which is 1.4935 for Greece and 1.1999 for Germany. Simultaneously, we observe from the same database the ratios of public labor to private labor L_g/L_p which is 0.24 for Greece and 0.13 for Germany. These figures imply that both public employment and public wages are higher in Greece than in Germany. These figures are consistent with the ratio of public wage bill over total government spending for each economy. Since workers are paid their marginal product, we obtain that the ratio of public wages to private wages is

$$\frac{W_{g,t}}{W_{p,t}} = \frac{1-\mu}{\mu}\frac{L_{g,t}^{\eta-1}}{L_{p,t}^{\eta-1}}. \tag{10}$$

The estimation we follow is closely related to Fernández de Córdoba *et al.* (2012), which implies $\eta = 0.4326$ and $\mu = 0.6008$ for Greece, and $\eta = 0.5762$ and $\mu = 0.6640$ for Germany.

We move on to compute factor shares in the production function. We use a standard no-arbitrage condition for capital and bonds to find that

$$R_B = (R_p - \delta_p) \times (1 - \tau^k),$$

where R_p is the return on private capital investment. Given that $R_p = \alpha_p K_p/Y$, we find that α_p is 0.3005 in Greece and 0.2556 in Germany. We use total compensation of employees over GDP to compute α_l, given that in the model $\alpha_l = (W_pL_p+W_gL_g)(1+\tau^{SS})/Y$. We can write this expression as a function of three previous targets as $\alpha_l = ((Wp/Wg)(Lp/Lg)+1)\theta_3 G/Y$. We find that this number is equal to 0.3327 in Greece and 0.6026 in Germany for a G/Y of 0.36 for Greece and 0.48 for Germany. Finally, α_g is found as the residual so the sum of shares equals 1 in each country.

Finally, we calibrate A to normalize output in the economy to 100. To this end, we use expression

$$A = \frac{Y}{K_p^{\alpha_p} K_g^{\alpha_g} [\mu L_p^\eta + (1-\mu) L_g^\eta]^{\frac{(1-\alpha_p-\alpha_g)}{\eta}}},$$

evaluated at Y=100 for the two countries. Similarly, we set γ in order for the labor supply equation to generate observed labor force participation, $L/H = 0.5750$ in Greece and $L/H = 0.7017$ in Germany, using equation

$$\gamma = \frac{C_p + C_g}{C_p + C_g + (H - L_p - L_g) W_p \frac{1-\tau_l}{1+\tau_k}},$$

which implies $\gamma = 0.8956$ in Greece and $\gamma = 0.8792$ in Germany. All the parameters for the economy are reported in Table 2.

Table 2: Calibration of the economy			
Parameter	**Definition**	**Value**	
		Greece	Germany
β	Discount factor	0.9606	0.9606
δ_{Kp}	Private capital depreciation rate	0.0800	0.0800
δ_{Kg}	Public capital depreciation rate	0.0400	0.0400
η	Public-Private labor elasticity of substitution	0.4326	0.5762
μ	Private employment weight	0.6008	0.6640
α_p	Private capital income share	0.3005	0.2556
α_l	Labor share	0.3327	0.6026
α_g	Public capital technical parameter	0.3668	0.1418
A	TFP	1.2015	1.6422
γ	Consumption-leisure preferences	0.8956	0.8792

4 Results

In this section, we use the model to analyze different scenarios: first, we show that the model can account for the observed behavior of the German and Greek governments during the Great Recession. Then, we investigate what are the causes of the Greek default, and how it could have been avoided. We consider the following three alternative decisions by the government: default (D), pay-back (P), and roll-over (R). In the case of default, there is a permanent penalty of 5 per cent of TFP and zero debt in the future. Under pay-back, all debt is paid during a number of periods depending on the average maturity until debt becomes zero. Finally, under roll-over, the amount of debt remains constant over time.

In what follows, when we refer to the Greek or the German economies, we use the technology and preference parameters that characterize each economy. Analogously, when we refer to the government of a given country, we refer to the vector of parameters $(\tau^k, \tau^l, \tau^c, \tau^\pi, \tau^{ss}, \theta_1, \theta_2, \theta_3, \theta_4)$ that summarize the structure of government expenditures and revenues of that country. In each scenario we describe the evolution of interest rates that the government faces, the quantity of debt over GDP, and the maturity of debt. Therefore, when we refer to the Greek economy ruled by the German government, facing the Greek interest rate, with a German debt and German maturity, for instance, we are using the expenditures shares and tax rates of Germany, the preference and technology parameters of Greece, the interest rate that hit Greece during the recession, the debt level and maturity structure of German debt.

The first two experiments show that our model is consistent with the observed behavior of the governments in Greece and in Germany: when each government is in charge of their respective countries and they get shocked by the sequence of interest rates that they faced, Greece chooses to default, experiment E_1, and Germany chooses to roll-over, experiment E_2. The third experiment, E_3, consists of replicating experiment E_1, with the economy, the interest rate, the debt and the maturity of debt being the Greek ones, but with the German government instead; we find that in this case, the government chooses to default. In the fourth experiment, E_4, we replicate experiment E_3 but making the German government to manage the Greek economy ten years before the spike in the interest rate, for the Greek economy to accommodate to new policies. Again, we find that the government defaults. In the fifth experiment, E_5, we ask what would the German government have done, had it been hit with the Greek interest rate. The result is that the government decides to pay back its debt in full at maturity, which implies that there is room to avoid a default, even when the interest rate spikes. In the sixth experiment, E_6, we ask what would have happened, had the Greek government decreased its debt level to that of Germany during the ten years before the crisis — in compliance with the Maastricht Treaty. We find that the government in this case chooses not to default on its debt, but that it instead pays back. In the last experiment, E_7, we ask if that would have also been the case had Germany been in charge of the Greek economy — this experiment is similar to how we run experiment E_4, but making the government to also lower its debt. In this case, though, we find that the German government would have defaulted on its debt. The different outcomes in experiments E_6 and E_7, which are the same exercises but with different tax codes and expenditures, shows that to avoid the default, the Greek economy should be managed by the Greek government, but with a smaller debt, but having German policies in place — other than lowering the debt level — are not helpful. The difference is explained by the little public capital that is sustained under the German rule.

We summarize all the experiments that we run in this section in Table 3. The first column, **Exp.**, has the experiment number. The second column, **Country**, refers to the technological and preference parameters that govern the economy. The third column, **Gov.**, refers to the structure of government expenditures and revenues of the government ruling the economy. The fourth column, **Int. rate**, refers to the interest rate that hits the country when the Great Recession takes place. The fifth column, **Debt**, refers to the percentage of debt over GDP. In the sixth column, **N**, is the number of periods to pay the debt back, which determines the maturity of debt. In the seventh column, **Start**, refers to when the government starts ruling the country, which can either be the year that the spike in the interest rate happens (G. Rec. for Great Recession), or ten years before then (10 yr. bef). Finally, in the eighth column, **Outcome**, there is decision that the government takes.

Exp.	Country	Gov.	Int. rate	Debt	N.	Start	Outcome
E_1	Greece	Greece	19.2%	150%	7	G. Rec.	Default
E_2	Germany	Germany	2.91%	65.6%	11	G. Rec.	Rollover
E_3	Greece	Germany	19.2%	150%	7	G. Rec.	Default
E_4	Greece	Germany	19.2%	110% $\rightarrow$ 150%	7	10 yr. bef.	Default
E_5	Germany	Germany	19.2%	65.6%	11	G. Rec.	Payback
E_6	Greece	Greece	19.2%	110% $\rightarrow$ 65.6%	7	10 yr. bef.	Payback
E_7	Greece	Germany	19.2%	110% $\rightarrow$ 65.6%	7	10 yr. bef.	Default

Table 3: Summary of experiments

Experiments 1 and 2: the model works

The first two experiments (E_1 and E_2) are introduced to demonstrate that our model is capable of reproducing the behavior of the Greek and German governments when they were managing the Greek and German economies respectively during the Great Recession. During that time period, the interest rate on Greek bonds increased to 19.2% while German bonds remained low, at 2.91%.

The first experiment consists of asking what happens when the Greek economy is managed by the Greek government when the bonds increase to observed levels in 2010 ($B_{2010} = 150$); we find that the Greek government prefers to default on its debt, rather than doing rolling-over. Default is also preferred to pay-back, given the relative high level of debt and its maturity structure. The reason for this decision is that rolling-over at such high rate would impose a huge financial burden, much higher that the economic burden imposed by a default. To pay back is also preferred over roll-over, but less so than to default. The ordering is therefore $D > P > R$.

The second experiment consists of asking what happens when the German economy is managed by the German government when the interest rate stays as they stayed in Germany during the crisis; we find that the German government prefers to roll-over its debt, rather than defaulting.

In both cases, the results are in line with what actually happened.

Experiments 3 and 4: the German government would have defaulted on Greek debt (I)

Moving on to experiment E_3, we ask what would have a German government done, had it been in charge of the Greek economy in the wake of a spike in the interest rate similar to the ones Greece faced during the crisis. We find that the German government prefers to default on its debt, rather than doing roll-over. Hence, a German government delivers the same behavior as the Greek government did.

This experiment is performed assuming that the interest rate faced by the Greek economy where those of 2010, the year of the Greek default, with the debt stock and the maturity of debt exactly equal to the one that Greece had. Given these figures, the German government takes the same decision that the Greek government takes in experiment E_1. Default is preferred to pay-back and pay-back preferred to roll-over, i.e., $D > P > R$.

Therefore, we conclude that fiscal policy, either from the fiscal income side or the public spending side, is not the key issue in explaining Greek debt crisis. Furthermore, the change in government from a Greek government to a German one has a negative impact on the Greek economy. As a consequence, we find that Greek welfare is higher under experiment E_1 than under experiment E_3. The reason for the negative impact is explained by the low level of public investment made by the German government compared to the Greek one. Since the public capital stock is not properly maintained under the German expenditures structure, the Greek economy suffers the German government as a huge technology shock.

After the result of the previous experiment, we ask what are the causes for the German government to default on the debt from Greece. One possibility is that the German government did not have enough time to introduce its taxes and expenditure levels on the Greek economy for it to start working. To this end, in experiment E_4 we replicate the previous experiment assuming that German policies start to be enacted in Greece ten years before the Great Recession (roughly, when Greece joined the European Monetary Union). We find that in this case, the German government still decides to default on Greek debt.

Experiments E_3 and E_4 suggest that the driving force behind the default crisis in Greece was linked to the spike in the interest rate, not so much to the tax code or the government expenditure structure.

Experiment 5: a self-fulfilling crisis could not have arisen in Germany

In experiment E_5 we investigate further on whether spikes in the interest rate drive the results of default. Given that a German government alone does not choose differently than a Greek government when managing the Greek economy, we ask whether this behavior is driven by the spike in the interest rate, and whether this would have been the case in Germany, had it been shocked by the interest rate that shocked Greece. We find that this is not the case. Actually, the German government in this case would have preferred to pay back the debt in full at maturity. This result is very important, as it shows that the spike in the interest rate is not the ultimate cause of the default.

This result is consistent with the theory of self-fulfilling crisis in Cole and Kehoe (1995, 2000) later on expanded in Conesa and Kehoe (2015). In the theory of self-fulfilling debt crisis a default emerges when international investors panic, the interest rate spikes, and the government cannot sustain its debt level — although it would have been able to sustain it, had the panic not arisen. The result of our model suggests that Germany did not suffer a default crisis because the German government would have paid its debt.

The result of this experiment points to a new direction as to how the default could have been avoided: decrease the debt level.

Experiment 6: how to avoid a default in Greece

In the sixth experiment, E_6, we ask what would the Greek government do if, while managing the Greek economy, it decreases total debt to the German level and maturity. We have already seen in experiments E_3 and E_4 that the adoption of the German tax code deos not avoid a default in Greece. What about its debt level? In this experiments we set decreasing sequences of debt level from the Greek level to the German level in ten years. Incidentally, this exercise explores what would have happened, had the Maastricht Convergence Criteria Levels been reached by Greece before the default crisis. We find that the government, in this case, chooses not to default on its debt, but to pay it back instead.

Hence, our results points out in a clear direction as to how to avoid future default episodes: the debt level has to be reduced. This result in itself does not answer the question on whether or not to change both, the government debt level and also the tax code and expenditure shares of the government. We answer this question in our next experiment.

Experiment 7: the German government would have defaulted on Greek debt (II)

In the seventh experiment, E_7, we replicate experiment E_6 but introducing the expenditures and tax code of Germany, on top of having the German (and Maastricht Treaty) debt level. We find that in this case, the German government chooses to default on the debt.

The reason for the difference in outcomes between experiment E_6 and experiment E_7 is that when the German government manages the economy, it chooses to invest too little in public capital (as we have seen in experiments E_3 and E_4), which represents a big loss of income for firms.

5 Concluding remarks

The results of our experiments give a sharp recommendation to avoid future crisis similar to the one in the Eurozone: governments have to reduce their debt level. What parts of the economy the government decides to tax and what the government decides to spend its resources on do not seem to be as important.

Finally, the model we develop in this paper has a detailed structure of the government fiscal policy and expenditure. The government in our model distorts the economy, but it also helps firms produce by providing necessary public capital and labor, and households through consumption goods and transfers. We believe this type of model can be useful to analyze questions that have to do with optimal taxation and optimal composition of government expenditure.

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A Appendix

A.1 Walras' Law

Take the budget constraint faced by the consumer:

$$\begin{aligned} & (1+\tau_t^c)C_{p,t} + K_{p,t} - K_{p,t-1} \\ = \; & (1-\tau_t^l)(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) + (1-\tau_t^k)(R_{pt}-\delta)K_{p,t-1} + Z_t + (1-\tau_t^\pi)\Pi_t \end{aligned}$$

And substitute the value of

$$Z_t = G_t - C_{g,t} - (1+\tau_t^{ss})W_{g,t}L_{g,t} - I_{g,t}$$

to obtain:

$$\begin{aligned} & (1+\tau_t^c)C_{p,t} + I_{gt} + K_{p,t} - K_{p,t-1} \\ = \; & (1-\tau_t^l)(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) + (1-\tau_t^k)(R_{p,t}-\delta)K_{p,t-1} \\ & + G_t - C_{g,t} - (1+\tau_t^{ss})W_{g,t}L_{g,t} + (1-\tau_t^\pi)\Pi_t \end{aligned}$$

But, the government identity establishes the following relation:

$$(1+R_t^B)B_t - B_{t+1} = T_t - G_t$$

Direct substitution yields

$$\begin{aligned} & C_{pt} + C_{g,t} + I_{gt} + K_{p,t} - K_{p,t-1} - T_t - B_{t+1} + (1+R_t^B)B_t \\ = \; & -\tau_t^c C_{p,t} + (1-\tau_t^l)(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) + (1-\tau_t^k)\left(R_{pt} - \delta_{K_p}\right)K_{p,t-1} \\ & -(1+\tau_t^{ss})W_{g,t}L_{g,t} + (1-\tau_t^\pi)\Pi_t \end{aligned}$$

Government fiscal income is given by:

$$\begin{aligned} T_t \; = \; & \tau_t^c C_{p,t} + \tau_t^l(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) + \tau_t^k(R_{p,t} - \delta_{K_p})K_{p,t-1} \\ & + \tau_t^{ss}(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) + \tau_t^\pi \Pi_t \end{aligned}$$

substitution

$$
\begin{aligned}
& C_{pt} + C_{g,t} + I_{gt} + K_{p,t} - K_{p,t-1} - B_{t+1} + (1 + R_t^B)B_t \\
& -\tau_t^c C_{p,t} - \tau_t^l (W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) - \tau_t^{ss}(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) - \tau_t^k (R_{p,t} - \delta_{K_p})K_{p,t-1} - \tau_t^\pi \Pi_t \\
= & -\tau_t^c C_{p,t} + (1 - \tau_t^l)[W_{p,t}L_{p,t} + W_{g,t}L_{g,t}] + (1 - \tau_t^k)\left(R_{pt} - \delta_{K_p}\right) K_{p,t-1} - (1 + \tau_t^{ss})W_{g,t}L_{g,t} \\
& +(1 - \tau_t^\pi)\Pi_t
\end{aligned}
$$

and elimination drives to:

$$
\begin{aligned}
& C_{pt} + C_{g,t} + I_{gt} + K_{p,t} - K_{p,t-1} - B_{t+1} + (1 + R_{p,t}^B)B_t - \tau_t^{ss} W_{p,t}L_{p,t} \\
= & W_{p,t}L_{p,t} + \left(R_{p,t} - \delta_{K_p}\right) K_{p,t-1} + \Pi_t
\end{aligned}
$$

From the definition of $I_{p,t}$ we get

$$
\begin{aligned}
& C_{pt} + C_{g,t} + I_{gt} + I_{p,t} - B_{t+1} + (1 + R_t^B)B_t \\
= & (1 + \tau_t^{ss})W_{p,t}L_{p,t} + R_t K_{p,t-1} + \Pi_t
\end{aligned}
$$

From the definition of profits we find that,

$$
\Pi_t = Y_t - (1 + \tau_t^{ss})W_{p,t}L_{p,t} - R_{p,t}K_{p,t}
$$

Substitution yields:

$$
C_{pt} + C_{g,t} + I_{gt} + I_{pt} = Y_t + B_{t+1} - (1 + R_t^B)B_t
$$

Which implies that all uses come from all available resources from an open economy. Therefore, Walras' Law is satisfied at all times.

A.2 Positive profits

In this section, we show that profits in the economy are positive. We build the argument parsimoniously. In our model, the firm that operates this technology has a production function that is homogeneous of degree 1 in the four factors used, yet it only pays for two of these factors; private capital and labor. Suppose, on the contrary, that the firm was to pay for the four factors employed. In this case, the profit function would be

$$
\bar{\Pi}_t = Y_t - (1 + \tau_t^{ss})(W_{p,t}L_{p,t} + W_{g,t}L_{g,t}) - R_{p,t}(K_{p,t-1} + K_{g,t-1}),
$$

where

$$Y_t = A_t(z)K_{p,t-1}^{\alpha_p}K_{g,t-1}^{\alpha_g}[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}]^{\frac{(1-\alpha_p-\alpha_g)}{\eta}}.$$

Given that each factor is paid its marginal product, we get that:

$$(1+\tau_t^{ss})W_{p,t} = \mu(1-\alpha_p-\alpha_g)A_t(z)K_{p,t-1}^{\alpha_p}K_{g,t-1}^{\alpha_g}[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}]^{\frac{(1-\alpha_p-\alpha_g-\eta)}{\eta}}L_{p,t}^{\eta-1} \quad \text{(A.2.1)}$$

$$(1+\tau_t^{ss})W_{g,t} = (1-\mu)(1-\alpha_p-\alpha_g)A_t(z)K_{p,t-1}^{\alpha_p}K_{g,t-1}^{\alpha_g}[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}]^{\frac{(1-\alpha_p-\alpha_g-\eta)}{\eta}}L_{g,t}^{\eta-1} \quad \text{(A.2.2)}$$

$$R_{p,t} = \alpha_p A_t(z)K_{p,t-1}^{\alpha_p-1}K_{g,t-1}^{\alpha_g}[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}]^{\frac{(1-\alpha_p-\alpha_g)}{\eta}}$$

$$R_{g,t} = \alpha_g A_t(z)K_{p,t-1}^{\alpha_p}K_{g,t-1}^{\alpha_g-1}[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}]^{\frac{(1-\alpha_p-\alpha_g)}{\eta}}$$

Division of equation (A.2.1) by (A.2.2) yields equation (10). From the above equations, we obtain all income shares as:

$$\begin{aligned}(1+\tau_t^{ss})W_{p,t}L_{p,t} &= \mu(1-\alpha_p-\alpha_g)A_t(z)K_{p,t-1}^{\alpha_p}K_{g,t-1}^{\alpha_g}[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}]^{\frac{(1-\alpha_p-\alpha_g-\eta)}{\eta}}L_{p,t}^{\eta} \\ &= \frac{\mu(1-\alpha_p-\alpha_g)L_{p,t}^{\eta}}{\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}}Y_t\end{aligned}$$

$$\begin{aligned}(1+\tau_t^{ss})W_{g,t}L_{g,t} &= (1-\mu)(1-\alpha_p-\alpha_g)A_t(z)K_{p,t-1}^{\alpha_p}K_{g,t-1}^{\alpha_g}[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}]^{\frac{(1-\alpha_p-\alpha_g-\eta)}{\eta}}L_{g,t}^{\eta} \\ &= \frac{(1-\mu)(1-\alpha_p-\alpha_g)L_{g,t}^{\eta}}{\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}}Y_t\end{aligned}$$

$$R_{p,t}K_{p,t-1} = \alpha_p Y_t$$

and

$$R_{g,t}K_{g,t-1} = \alpha_g Y_t$$

Since each factor is paid its marginal product and the function is homogeneous of degree 1, profits are zero:

$$\begin{aligned}
\bar{\Pi}_t &= Y_t - \frac{\mu(1-\alpha_p-\alpha_g)L_{p,t}^{\eta}}{\mu L_{p,t}^{\eta}+(1-\mu)L_{g,t}^{\eta}}Y_t - \frac{(1-\mu)(1-\alpha_p-\alpha_g)L_{p,t}^{\eta}}{\mu L_{p,t}^{\eta}+(1-\mu)L_{g,t}^{\eta}}Y - \alpha_p Y_t - \alpha_g Y_t, \\
\bar{\Pi}_t &= Y_t\left(1-(1-\alpha_p-\alpha_g)-\alpha_p-\alpha_g\right) = 0
\end{aligned}$$

Now, suppose that the firm is, as in our model, an entity that only pays for two of the factors employed. Then, profits are positive because they are exactly equal to the shares of the two factors that do not get paid by the firm.

$$\Pi_t = Y_t - R_{p,t}K_{p,t-1} - (1+\tau_t^{ss})W_{p,t}L_{p,t} > 0$$

Substituting private factor incomes yields:

$$\Pi_t = \left[1-\alpha_p - \frac{\mu(1-\alpha_p-\alpha_g)L_{p,t}^{\eta}}{[\mu L_{p,t}^{\eta}+(1-\mu)L_{g,t}^{\eta}]}\right]Y_t > 0$$

A.3 Data Sources

The frequency of the data is annual for the period 2002-2011. The model is calibrated using data for the year 2006, which is selected as the steady state for our model economy. GDP, government expenditure, public debt, private consumption, private investment, public investment and public consumption are taken from the OECD Statistics data base and Eurostat. Data on capital stock are taken from the EU-KLEMS database.

Public and private compensation of employees and public and private employment are taken from OECD Economic Outlook database December 2007 Issue, for the period 1960-2006. Public wage bill is calculated as total final public compensation of employees.

Effective average tax rates are taken from Boscá et al (2012), who use the methodology developed by Mendoza et al. (1994), and from OECD Revenue Statistics.

Finally, the real return of Greek bonds corresponding to the 10-year bond yield are taken from Bloomberg database, and the average maturity of debt can be seen at http://www.pdma.gr/index.php/debt-strategy/public-debt/historical-characteristics/weighted-average-cost-maturity-of-annualfunding