

Fiscal Austerity during Debt Crises*

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Abstract

This paper constructs a dynamic model of government borrowing and default. The government faces a fiscal constraint in that it cannot raise tax rates. By defaulting on the debt, the government can increase domestic consumption. Two types of default arise in this environment: fiscal defaults and aggregate defaults. Fiscal defaults occur because the government cannot service the debt due to its inability to raise tax revenues. Aggregate defaults occur even if the government could raise tax revenues; debt is simply too high to be sustainable. In a quantitative exercise calibrated to Greece, we find that our model can predict the recent default, but that increasing taxes would not have prevented the default. In fact, increasing taxes would have made the recession deeper because of the distortionary effects of taxation.

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1 Introduction

The recent European debt crisis has prompted an active debate in financial and policy circles on fiscal austerity. One side of the debate considers fiscal austerity plans to be beneficial because by increasing taxes, the government can avoid a default by more easily servicing and reducing the debt.¹ The other side of the debate considers fiscal austerity plans to be detrimental because higher taxes can lead to more severe recessions and a deepening of the debt crisis.² Here, we evaluate the interconnection between fiscal constraints and sovereign defaults in a quantitative dynamic model.

This paper constructs a dynamic model of government borrowing, default, and renegotiation. The government faces a fiscal constraint in that it cannot raise tax rates. By defaulting on the debt, the government can increase domestic consumption. Two types of defaults arise in this environment: fiscal defaults and aggregate defaults. Fiscal defaults occur because the government cannot service the debt due to its inability to raise tax revenues. Aggregate defaults occur even if the government could raise tax revenues; debt is simply too high to be sustainable. In a quantitative exercise calibrated to Greece, we find that our model can predict the recent default, but that increasing taxes would not have prevented the default. In fact, increasing taxes would have made the recession deeper because of the distortionary effects of taxation.

The government in our model is benevolent and lacks commitment to repay the debt. It collects distortionary consumption and labor taxes, provides transfers to the private sector, decides on public consumption, and issues defaultable bonds in international financial markets. Default entails costs in terms of output and financial market access. After default, the government can renegotiate the debt by paying a recovery. Renegotiation lifts all default costs. The price of debt compensates risk neutral lenders for the expected loss from default. Domestic agents consume private and public consumption goods, provide labor for production, pay taxes, and receive transfers from the government. The economy is subject to productivity shocks.

The government faces two constraints when deciding whether to default: the fiscal constraint and the economy's resource constraint. The fiscal constraint limits public consumption to be less than tax revenues net of the international debt operations. Default can be beneficial for fiscal reasons. It relaxes the fiscal constraint and allows public consumption to be higher

¹"*Delaying fiscal consolidation is no free lunch. It means higher debt levels. And this has real costs in the euro area where public debts are already very high*" European Central Bank Executive Board member Jorg Asmussen, speaking at the Economist's Bellwether Europe Summit in London, April 25, 2013.

²Paul Krugman, "Myths of Uncertainty" (editorial), New York Times, July 1, 2010.

. The resource constraint limits public and private consumption to be less than output net of the international debt operations. Default can also be beneficial for aggregate reasons. Default relaxes the resource constraint and allows total consumption to be higher. The first takeaway from our analysis is that fiscal austerity proposals that raise taxes can help only with fiscal defaults. If defaults happen for aggregate reasons, no fiscal reform could prevent them. The second takeaway is that fiscal austerity programs that increase distortionary taxes can actually make the debt crisis worse. Raising taxes during a crisis can deepen the recession, which increases default risk especially for aggregate defaults.

We calibrate our model to Greece and use it as a laboratory in which to evaluate a fiscal austerity reform that increases taxes. The calibrated model can match the mean and volatility of the Greek spreads and in an event analysis can predict the recent Greek default. Specifically, we feed into the model the sequence of productivity shocks that leads to output dynamics as observed in Greece since 2001. The model predicts a default in 2011. Recall that Greece defaulted in March 2012.

With the calibrated model at hand, we perform three experiments. First, we analyze an increase in consumption taxes from the baseline of 0.14 to 0.20. Second, we increase labor taxes from the baseline of 0.33 to 0.40. Third, we maintain tax rates as in the baseline but allow the government to freely adjust lump sum taxes. The first two experiments are more aggressive versions of policies that have been considered for Greece. The third experiment constitutes a reference model that lifts the fiscal constraint without incurring the costs of distortionary taxation.

We find that higher taxes increase debt sustainability. The set of debt positions for which the economy repays is larger when taxes are high than when taxes are low. The larger debt sustainability feeds into more favorable borrowing conditions. In the long run, however, the larger debt sustainability actually increases default probabilities, by about 1%. These experiments suggest that higher taxes can alleviate a debt crisis in the short run, but in the long run they might actually increase default risk.

We use our model to ask whether a fiscal reform in Greece in 2011 could have prevented the default. Through the lens of our model, we see that increasing labor or consumption taxes would not have prevented the default. In the event analysis, we unexpectedly increase tax rates in 2011, and the economy continues to default despite the larger tax revenues. The extra tax revenues are used in 2011 for higher government consumption and higher transfers. Moreover, increasing taxes in 2011 makes the recession deeper.

Finally we compare the benchmark model with one where the government does not have the fiscal constraint and can freely adjust lump sum taxes. An economy with no fiscal con-

straint also has more debt sustainability. In the long run, this economy borrows more but also defaults more. In the event analysis, however, lifting the fiscal constraint permanently prevents the Greece default of 2011. The government services the debt in this experiment with a lump sum tax of 2% of output. Lifting the fiscal constraint not only raises government revenues but also allows the government to do it in a nondistortionary way. It is the combination of higher revenues and not lower output that allows the economy to navigate through 2011 without defaulting.

Our paper builds on the literature that studies the relation between debt crises and fiscal policy. Bi (2012) studies how fiscal policy determines debt limits that arise endogenously from dynamic Laffer curves. She finds that only long run fiscal austerity measures can alleviate default risk. In this paper, however, default is determined by an ad hoc rule that depends only on the level of debt and other variables of the economy. Mendoza, Tesar, and Zhang (2013) study the impact of tax hikes when countries face large debt shocks and compete for capital flows using taxation. They find that for the GIIPS countries (Greece, Ireland, Italy, Portugal, and Spain) in Europe, increasing labor taxes could restore solvency when facing large debt shocks, but such a response is costly because capital flows to lower tax economies. Their paper, however, abstracts from default as an equilibrium outcome, which was a key concern for Europe.

Our paper is also related to the literature on endogenous default risk. Eaton and Gersovitz (1981) and Arellano (2008) study sovereign default that arises from high debt and low income. These papers, however, abstract from fiscal constraints. Cuadra, Sanchez, and Saprizza (2010) and Pouzo (2013) study economies with endogenous default with flexible and varying labor taxes. They find that with endogeneous default, debt is less useful for the government to smooth fluctuations, and taxes are more volatile and can become procyclical. In our paper, we focus on how the rigidity of labor taxes can induce default because of the government's inability to raise enough revenue.

2 Model

We consider a small open economy model with a representative firm, a continuum of consumers, and a benevolent government. The representative firm produces final output using labor ℓ with a production function $f(z, \ell)$. The firm faces productivity shocks that are Markov with transition matrix $\mu(z'|z)$. Consumers derive utility from private consumption c and pub-

lic consumption g , and have disutility of labor ℓ . The preferences are given by

$$E \sum_{t=0}^{\infty} \beta^t u(c_t, g_t, \ell_t),$$

where β is the discount factor, $0 < \beta < 1$. Every period, the consumers provide labor and receive wage income $w_t \ell_t$ and dividend income π_t from the firm. Consumers also pay consumption and labor taxes with tax rates τ_c and τ_ℓ , and receive transfers κ_t from the government. The budget constraint for consumers is

$$(1 + \tau_c)c_t = (1 - \tau_\ell)w_t \ell_t + \pi_t + \kappa_t. \quad (1)$$

The government purchases public goods, collects revenue from consumption and labor taxes, makes transfer to the consumers, and borrows internationally. The government faces a *fiscal constraint* because it cannot change tax rates and cannot levy a lump sum tax on private sectors. The fiscal constraint requires transfers to be positive, $\kappa_t \geq 0$. The government is active in international markets, where it borrows uncontingent bonds b' from international lenders. International financial contracts, however, have limited enforcement in that the government can default on its debt due b . If the government defaults, the economy receives a bad credit standing, it is excluded from international markets, and it suffers a direct productivity cost. If the economy is in bad credit standing, the government can renegotiate its debt and bargain over the debt recovery. After renegotiation, the economy regains a good credit standing, and all default costs are lifted. In our model, active government policies π are a quadruple consisting of borrowing b' , default and renegotiation d , public consumption goods g , and transfers κ , $\pi = \{b', d, g, \kappa\}$. Default and renegotiation decisions affect economy-wide productivity. We let \tilde{z} denote the effective productivity of the economy, and output produced is the production function evaluated at effective productivity, $f(\tilde{z}, \ell)$.

A *domestic competitive equilibrium* is a set of allocations $\{c, \ell\}$ such that given the government's policies π , consumers and the representative firm optimize. The domestic competitive equilibrium is characterized by the optimal consumption-leisure choice condition

$$\frac{u_\ell}{u_c} = \frac{(1 - \tau_\ell)}{(1 + \tau_c)} f_\ell(\tilde{z}, \ell) \quad (2)$$

and the budget constraint (1).

2.1 Recursive Problem

We now set up the optimal policy program for the government. We consider a Markov equilibrium. The government starts each period with a state s that consists of the productivity shock z , the debt due b , and the credit standing h , $s = \{z, b, h\}$. The credit standing is a binary variable and encodes a past default or renegotiation such that $h = 0$ when the credit standing is good and $h = 1$ when the credit standing is bad. The government chooses optimal policy $\pi = \{b', d, g, \kappa\}$ to maximize the utility of consumers, taking as given the future government's policy functions $\Pi(s')$.

The recursive problem of the government can be formulated directly in terms of choosing allocations in addition to choosing public consumption, borrowing, and default policies as the government internalizes the competitive equilibrium conditions.

A government in good credit chooses first to repay or default on its debt, as follows:

$$v(z, b, h = 0) = \max_{d \in \{0,1\}} \{(1 - d)v^r(z, b, h) + dv^d(z, b, h)\}, \quad (3)$$

where $d = 1$ denotes default and $d = 0$ denotes repay. If the government repays, the credit standing next period is good, $h' = 0$. Here, the government chooses private and public consumption, labor, and borrowing:

$$v^r(z, b, h) = \max_{c, g, \ell, b'} u(c, g, \ell) + \beta E v(z', b', h' = 0) \quad (4)$$

subject to the economy-wide resource constraint

$$c + g \leq f(\tilde{z}, \ell) + q(z, b')b' - b, \quad (5)$$

the fiscal constraint

$$\tau_\ell f_\ell \ell + \tau_c c - b + q(z, b')b' \geq g, \quad (6)$$

and the private sector optimality condition (2). The fiscal constraint (6) summarizes the fiscal limitations of the government from transferring resources to and from the private sector. Mechanically, the government can freely transfer positive net new borrowing $q(z, b')b' - b > 0$ by using transfers κ . The government cannot, however, extract more resources from the private sector beyond those obtained from tax revenues $\tau_\ell f_\ell \ell + \tau_c c$.

The bond price schedule $q(z, b')$, described below, compensates the loss for lenders in case of default and depends on the current shock and the borrowing level. The government takes as given the bond price schedule, as it depends on the default decisions of future governments.

If the government defaults, the government does not have to pay the debt due and cannot borrow, and the credit standing becomes bad next period. Here, the government chooses the labor, private, and public consumption to maximize the value

$$v^d(z, b, h) = \max_{c, g, \ell} u(c, g, \ell) + \beta E v(z', b', h' = 1) \quad (7)$$

subject to the resource and fiscal constraints

$$c + g \leq f(\tilde{z}, \ell),$$

the fiscal constraint

$$\tau_\ell f_\ell \ell + \tau_c c \geq g,$$

and the implementability condition from the private sectors (2).

A government with a the bad credit standing has the option to renegotiate and pay the recovery $\phi(z, b)$. Here, $d = 0$ indicates renegotiation and $d = 1$ indicates no renegotiation. During renegotiation the productivity costs from default are eliminated and the government's credit switches to good the following period. Taking as given the recovery function, the government chooses whether to renegotiate:

$$v(z, b, h = 1) = \max_{d \in \{0, 1\}} \{(1 - d)v^g(z, b, h) + dv^d(z, b, h)\}. \quad (8)$$

The renegotiating value satisfies

$$v^g(z, b, h) = \max_{c, g, \ell} u(c, g, \ell) + \beta E v(z', b' = 0, h' = 0)$$

subject to the resource constraint,

$$c + g \leq f(z, \ell) - \phi(z, b),$$

the fiscal constraint

$$\tau_\ell f_\ell \ell + \tau_c c - \phi(z, b) \geq g,$$

and the implementability condition from the private sectors (2). If the government does not renegotiate, it gets a value equal to the value of defaulting $v^d(z, b, h = 1) = v^d(z, b, h = 1)$.

2.2 Bond Price and Recovery

International lenders are risk neutral and competitive and have a constant opportunity cost of lending r . The bond price schedule compensates all losses due to future default

$$q(z, b') = \frac{1}{1+r} E[(1 - d(z', b')) + d(z', b')\xi(z', b')]. \quad (9)$$

where ξ is the discounted, expected recovery rate depending on future renegotiation,

$$\xi(z, b) = \frac{1}{1+r} E[(1 - d(z', b))\phi(z', b) + d(z', b)\xi(z', b)]. \quad (10)$$

The bond price summarizes that in repayment states tomorrow where $d(z', b') = 0$, the government pays one unit for every bond borrowed. In default states tomorrow where $d(z', b') = 1$, the government does not pay anything, but in present value it pays the value of the recovery $\xi(z', b')$. The recovery present value in turn satisfies the functional equation (10) that depends on future decisions to renegotiate. The value of the recovery encodes that in states with renegotiations $d(z', b) = 0$, the government pays the recovery $\phi(z', b)$.

During renegotiation, the government bargains with a committee of lenders over the recovery ϕ with Nash bargaining,

$$\phi \in \operatorname{argmax} [v^g(z, b, h = 1; \phi) - v^{\text{aut}}(z)]^\alpha \phi^{1-\alpha}, \quad (11)$$

where α is the bargaining power of the government. In case of renegotiation failure, the government is in autarky forever and faces the productivity costs from default, $v^{\text{aut}}(z)$, and lenders get zero. The value of autarky is similar to the solution of the problem in (7) but with a continuation value that is equal to the default value thereafter.

We now define the equilibrium.

Definition 1. *A Markov equilibrium is a set of policies $\pi(z, b)$ and private allocations for consumption $c(z, b, \pi)$ and $\ell(z, b, \pi)$ together with future policy rules $\Pi(z, b)$ such that*

1. *The set of policies and private allocations for the government solve (3) and (8).*
2. *The bond price and recovery functions satisfy (9) and (11).*
3. *The optimal π policy given (z, b) coincides with the rule from tomorrow on,*

$$\pi(z, b) = \Pi(z, b).$$

2.3 Fiscal and Aggregate Defaults

Default allows the government to avoid paying the debt and have more resources for domestic consumption. In fact, defaulting on debt b is optimal only if under no default, the economy must experience capital outflows, $-b + q(z, b')b' < 0$. In this model, however, default relaxes two constraints: the economy-wide resource constraint and the fiscal constraint. An important aspect of our analysis is to evaluate whether default happens mainly to relax the fiscal constraint or economy-wide resource constraint, which we label as *fiscal default* or *aggregate default*, respectively.

A fiscal default happens because it is too costly to satisfy the fiscal constraint if debt is to be repaid. Recall that the fiscal constraint limits the government from transferring resources from the private sector to the public sector, since tax rates are fixed and lump sum taxes are not allowed. In this context, if the government has a large enough level of debt such that rolling it over is not possible, it must cut public consumption enough to service the debt. Such a reduction in public consumption might be too costly, in which case default is preferable. Fiscal defaults can be prevented if the government could raise more tax revenues by increasing tax rates.

The second class of default is an aggregate default, which is the type of default commonly analyzed in the literature of sovereign default (Arellano (2008)). An aggregate default happens because it is too costly to satisfy the resource constraint if debt is to be repaid. Here, default is preferred to avoid a reduction if both private consumption and public consumption are needed to service the debt. During aggregate defaults, increasing tax revenues is of no use in preventing defaults. In fact, increasing tax rates will lead to more defaults because of the larger distortions and lower output that result from the high tax rate.

We define a default as fiscal if it happens because of the fiscal constraint (6) and a default as aggregate if it happens even when the fiscal constraint is lifted. Formally, for each state $\{z, b\}$ when $h = 0$, we resolve program (3) without imposing the fiscal constraint (6) for this period only. In future periods, we assume the fiscal constraint is satisfied as encoded in the continuation value function. We label the resulting default decision from this experiment as $d_a(z, b)$. If the original default decision is equal to the default decision from this experiment, such default is aggregate. If the original default decision is changed with the experiment, then such default is fiscal:

$$\begin{aligned}
 \text{Fiscal Default} & : d(z, b) = 1 \text{ and } d_a(z, b) = 0 & (12) \\
 \text{Aggregate Default} & : d(z, b) = 1 \text{ and } d_a(z, b) = 1
 \end{aligned}$$

3 Quantitative Analysis

We now analyze the quantitative implications of the model. We calibrate the model to Greek data and show that our model can predict the recent default in Greece. Our model predicts that increasing consumption or labor taxes would not have prevented the default. Nevertheless, if the Greek government would have had access to lump-sum taxes, the default could have been prevented.

3.1 Parametrization

We assume the production function of the economy is given by $f(z, \ell) = z\ell^\theta$ with a labor share parameter equal to θ . The utility function is

$$u(c, g, \ell) = \frac{(c - \frac{\ell^{1+1/\nu}}{1+1/\nu})^{1-\sigma} - 1}{1-\sigma} + \eta \frac{g^{1-\sigma}}{1-\sigma},$$

where σ is the risk aversion parameter and ν is the Frisch elasticity. We choose $\sigma = 2$, $\nu = 2$, and $\theta = 0.67$, as common in the macroeconomics literature. The risk-free rate is chosen to be 1% to match the average quarterly German yield. We take the consumption tax rate $\tau_c = 0.14$ and labor tax rate $\tau_\ell = 0.33$ from the average effective tax rates that Mendoza, Tesar, and Zhang (2013) found for across the GIIPS countries. The weight on the relative utility from the public consumption, η , is difficult to identify, so we set it to 0.5 but conduct sensitivity on this parameter. We assume the productivity process z follows an AR(1) process,

$$\log(z_t) = \rho \log(z_{t-1}) + \sigma_z \epsilon_t.$$

We use Greek detrended GDP data to calibrate this process and find a persistence parameter ρ of 0.88 and a standard deviation σ_z of 0.03.

The productivity loss from default follows the functional form in Arellano (2008). Effective productivity after default is $\tilde{z} = \begin{cases} \lambda E(z) & \text{if } z \leq \lambda E(z) \\ z & \text{otherwise} \end{cases}$.

We calibrate three parameters: the productivity loss after default λ , the discount factor β , and the bargaining power of the government θ such that the model reproduces the mean and volatility of the spread in Greece of 1.4 and 2.6 percent respectively, and the historical average recovery rate of 60% reported in Cruces and Trebesch (2013). Table 1 summarizes the parameter values.

	Value	Target
Output cost after default	$\lambda = 0.016$	} Greek mean spread: mean and volatility Recovery rate
Borrowers' discount factor	$\beta = 0.82$	
Bargaining power	$\theta = 0.38$	

3.2 Default Sets and Decision Rules

Before showing the quantitative results, we find that it is useful to analyze the decision rules from the model. We first present default sets and repayment sets. For the case when credit is good, $h = 0$, the state space $\{z, b\}$ can be divided into states where default is chosen, $d(z, b) = 1$, and states where repayment is chosen, $d(z, b) = 0$. The solid line in Figure 1 divides the state space into these two sets. The government is more likely to default when it has large debt or lower productivity.

We also subdivide the default set into fiscal defaults and aggregate defaults, defined in (12). Aggregate defaults happen when debt is sufficiently high or productivity sufficiently low. Here, the government defaults even if the fiscal constraint is lifted for one period. The idea is that repayment is too costly in these states because private and public consumption would have to be decreased too much in order to service the debt. The figure also shows that fiscal defaults happen for smaller levels of debt and higher levels of productivity. Here, the government is defaulting because of the fiscal constraint; if the constraint could be lifted and the government could transfer more resources from the private sector to the public sector, then the default would be avoided.

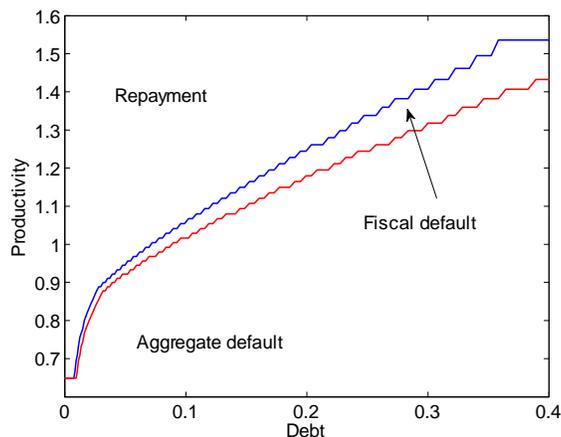


Figure 1: Default Sets

In Figures 2 and 3 we plot the decision rules for the public consumption, private con-

sumption, and transfers as a function of debt b relative to income when productivity is at its median and credit standing is good. As Figure 2 shows, public consumption declines with debt because servicing a larger amount of debt requires a reduction in public consumption. As debt increases, the fiscal constraint starts to bind, which causes public consumption to decline at a faster rate with debt. When debt is sufficiently high, default is preferred. At the debt-default threshold, public consumption jumps up, reflecting the fact that the government is no longer servicing the debt. Public consumption is flat thereafter.

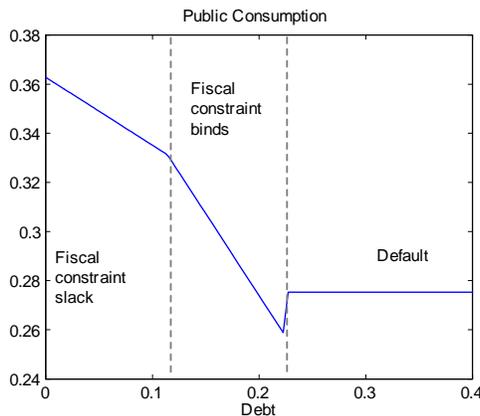


Figure 2: Public Consumption

Figure 3 shows that private consumption also decreases with debt when the fiscal constraint is not binding. When debt is small, the government borrows from abroad and transfers resources to the private sector. When debt is zero, government transfers are significant and equal to about 4% of output. As debt increases, private consumption falls because the government reduces transfers in order to service a larger stock of debt. When transfers reach zero, the fiscal constraint binds, and private consumption remains constant as a function of debt. When the government defaults, private consumption falls because of the drop in productivity associated with default.

3.3 Benchmark Model and Greek Default

We now present the simulation results. We present long-run averages and simulate a default event that resembles the one from Greece.

Table 2 shows averages and standard deviations of the variables of interest in the long-run distribution of the benchmark model. The default frequency in the economy is close to 4% and the average spread is 1.6%, which is similar to the average Greek spread of 1.4%. Default probabilities are so much larger than spreads because of an average recovery of 0.6, which



Figure 3: Policy Rules

equals the historical average recovery rate across defaults since 1980. Debt service relative to output equals 5.2% on average and public consumption about 30% of output. Transfers on average are small and equal 0.1% of output. The country always renegotiates in our model after the default. In terms of volatilities, the model generates volatile spreads with a standard deviation equal to 1.4%, which is somewhat smaller than the volatility in Greek spreads of 2.6%. The volatility of public consumption relative to the volatility of output equals 1.1, which is a bit higher than the volatility in Greek data of 0.83. Private consumption is about as volatile as output, which is similar to Greek data, and transfers are more than 2.7 times more volatile than output.

Table 2: Statistics in Long-Run Distribution of Benchmark Model

	mean(x)	std(x)
Spread	1.6	1.40
Public Consump (%)	30.5	1.13
Transfers (%)	0.1	2.70
Private Consumption (%)	70.4	1.00
Default prob	3.9	
Recovery	62	
Debt Service (%)	5.2	

We now conduct an event analysis. We feed into the model a sequence of shock realizations such that the model's output resembles the one observed in Greece since 2002. We then

compare the resulting default decisions and spread series that the model generates with those in the data. The black lines in Figure 4 correspond to the time series for output and spreads for Greece. In 2011, Greek GDP decreased to about 15% below trend and the interest spread increased by 12%. In 2012, Greece defaulted. The blue lines are the model simulated series. The productivity series chosen allow the model to match closely the output fluctuations in Greece. The model predicts the default in Greece, although a year earlier. In anticipation of such default, the model predicts a rise in spreads. The model, however, generates a more modest rise in spreads than the one observed in the data.

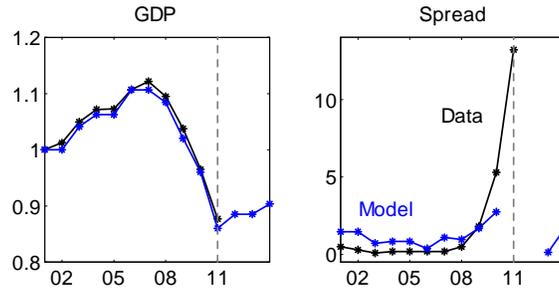


Figure 4: Greek Crisis: Data and Model

3.4 Experiments: Effects of Fiscal Austerity

A heated discussion surrounding the Greek debt crisis is whether Greece should have adopted an austerity plan that increases taxes in order to alleviate the crisis. Our model provides a laboratory in which to study the impact of increases in taxes. We use the model to conduct three counterfactual experiments. In the first one, we increase the consumption tax from 0.14 to 0.20 while keeping the labor tax constant. In the second one, we increase the labor tax from 0.33 to 0.40 while keeping the consumption tax constant. (These experiments constitute larger changes than the ones considered in different proposals.)

Finally, as a reference model we consider an economy without a fiscal constraint where we maintain the tax rates as in the benchmark, but the government can freely adjust lump sum taxes and transfers. In these experiments, we keep all other parameters as in the benchmark model. We analyze the effects of these changes in tax policies on decision rules, long-run outcomes, and the default event.

Let us first consider the experiments where the economy has higher tax rates. Higher taxes shrink default sets. Figure 5 compares the default set in the models with higher consumption taxes with the benchmark model. The figure shows that with higher taxes, the government can sustain more debt for every productivity level without defaulting. The smaller default

sets with higher taxes imply that bond price schedules in the economy with higher taxes are more lenient, as shown in Figure 6. Higher taxes also lead to higher public consumption for every debt level as illustrated in Figure 6. Moreover, higher taxes shrink the set of debt for which the fiscal constraint is binding, as seen in the smaller range of steeply declining public consumption.

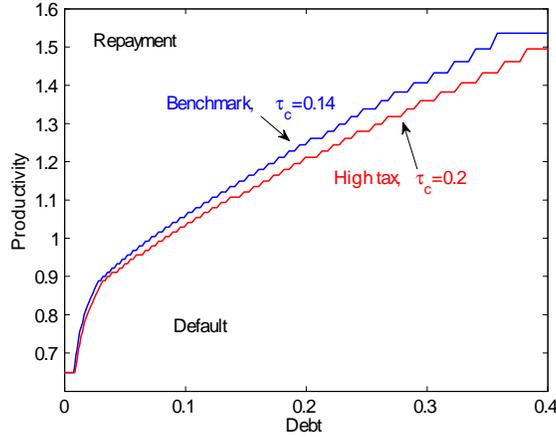


Figure 5: Default Set and Taxes

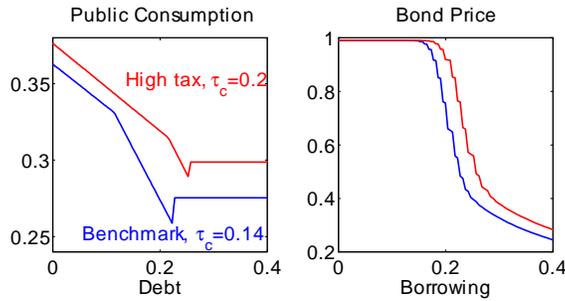


Figure 6: Policy Rules and Taxes

Increasing labor taxes in the benchmark model has similar effects on default sets and decision rules as increasing consumption taxes. When the government can freely adjust lump sum taxes, the distortions from the fiscal constraint are removed and default sets shrink, bond prices become more lenient, and the declines in private consumption and public consumption with debt are less steep.

Table 3 presents long-run average statistics from these three experiments and compares them with the benchmark model. Economies with higher taxes have larger default probabilities and higher spreads. The average default probability is 1% higher in the economy with

consumption taxes equal to 0.2 than in the benchmark economy with consumption taxes equal to 0.14. The reason is that although default sets are smaller in these economies, the equilibrium level of debt is higher, which leads to more default in equilibrium. Economies with higher tax rates have more depressed output because taxes are distortionary. The hike in consumption taxes from 0.14 to 0.20 depresses output by 3%, whereas the hike in labor taxes from 0.33 to 0.40 depress output by 7%. Economies with higher taxes also have larger shares of public consumption and transfers. The volatility of public consumption relative to output is lower in the economies with higher taxes, reflecting the fact that the government can use debt more actively as bond price schedules are more lenient.

Table 3: Statistics in Long-Run Distribution of Benchmark Model

	Bench $\tau_c = 0.14$ $\tau_L = 0.33$	High τ_C $\tau_c = 0.2$	High τ_L $\tau_L = 0.4$	No fiscal constraint
Default prob	3.9	4.8	4.6	4.7
Spread (%)	1.6	1.9	1.9	1.9
Output	1.0	0.97	0.93	1.0
Debt/Output (%)	5.2	6.4	6.4	6.7
G/Output (%)	30.5	32.5	33.1	32.1
Transfers/Output (%)	0.1	1.5	1.2	-1.5
std (G)/std(y)	1.13	1.04	0.96	0.96

Table 3 also provides the long-run average for the reference economy that has tax rates equal to the benchmark but where the government can freely change lump sum taxes and transfers. This economy has higher default probabilities and spreads than in the benchmark economy that has the fiscal constraint because the government here borrows more. Output, of course, is equal to the benchmark because distortions are held constant. Public consumption relative to output is nevertheless about 2% higher, is more stable, and is financed with an average lump sum tax of 1.5%.

A comparison across these economies casts doubt that fiscal austerity proposals that raise taxes would reduce the incidence of defaults in the long run. Within the context of our model, fiscal austerity proposals increase debt sustainability because the government has more revenues with which to service the debt. Nevertheless, it is precisely this larger debt capacity that leads to more default in equilibrium. Faced with more lenient bond price schedules, governments borrow more and in equilibrium default more often.

We now analyze the effects of increasing taxes unexpectedly in the Greek event. The specific question we ask is whether the Greek default could have been avoided if Greece had implemented a fiscal austerity program that raised taxes. Specifically, we repeat the event

analysis described above in the benchmark model, but in 2011 we raise consumption (or labor) taxes and check whether such a reform could have prevented the default. The tax increase in 2011 is assumed to be unexpected and permanent.

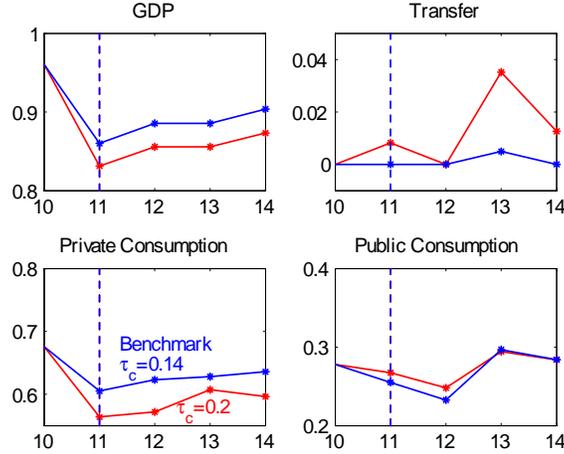


Figure 7: Default Event and Taxes

Our model predicts that neither increasing consumption taxes from 0.14 to 0.20 nor increasing labor taxes from 0.33 to 0.40 in 2011 would have prevented the default. In these two experiments, the model continues to predict a default in 2011. Debt is just too high and productivity is too low for such a reform to contain the default.

Figure 7 shows the time paths for output, public and private consumption, and transfers starting in 2011 for the benchmark model and for the experiment when consumption taxes permanently increase in 2011. Increasing taxes in 2011 depresses output further because taxes are distortionary. The government uses the extra tax revenues in 2011 to raise public consumption and increase transfers. The increase in transfers, however, is not enough to prevent the decline in private consumption arising from the larger tax bill and the reduction in output. In period 2012, output recovers and both economies renegotiate the debt. Transfers are zero and public consumption is lower, despite the output recovery, because the government pays the debt recovery. In 2013, the government reenters financial markets in both economies and borrows. The economy with higher taxes borrows more and the government transfers these resources to the private sector, illustrated by the large transfers in 2013.

Finally, we consider the experiment that in 2011, the fiscal constraint is lifted permanently. This reform does prevent the default in 2011. Figure 8 illustrates the time paths for the variables of interest in this experiment relative to the benchmark. In order to prevent the default and service the debt, the government raises about 2% of output in revenue using lump-sum taxes, which lowers private consumption. Public consumption is more constant

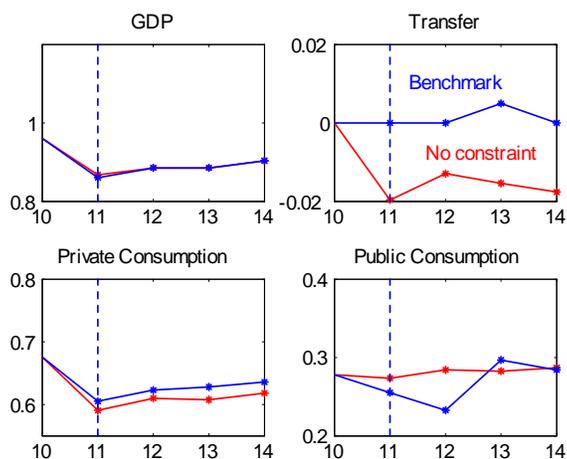


Figure 8: Default Event without Fiscal Constraint

over time when the government does not face the fiscal constraint. Although we do not view such a reform as possible, we still find it informative that our model predicts that about 2% of output in nondistortionary taxes would have prevented the Greek default.

4 Conclusion

The paper developed a dynamic model of borrowing and default where fiscal constraints can induce governments to default. By defaulting, the government can increase domestic consumption. We show that increasing tax rates increases debt sustainability because it relaxes the government's fiscal constraint. In the long run, however, the government borrows more and default risk rises due to larger debt.

We parameterized the model to Greece and found that the model can predict the recent default. We also found that increasing consumption or labor taxes would not have prevented the default. The main reason is that increasing taxes would have made the recession deeper because taxes distort employment.

References

- [1] Arellano, Cristina. 2008. Default Risk and Income Fluctuations in Emerging Economies. *American Economic Review*, 98(3): 690–712.
- [2] Bi, Huixin. 2012. Sovereign Default Risk Premia, Fiscal Limits, and Fiscal Policy. *European Economic Review*, 56(3): 389-410.

- [3] Cruces, Juan J., and Christoph Trebesch. 2013. Sovereign Defaults: The Price of Haircuts. *American Economic Journal: Macroeconomics*, 5(3): 85-117.
- [4] Cuadra, Gabriel, Juan M. Sanchez, and Horacio Sapriza. 2010. Fiscal Policy and Default Risk in Emerging Markets. *Review of Economic Dynamics*, 13(2): 452-469.
- [5] Eaton, Jonathan, and Mark Gersovitz. 1981. Debt with Potential Repudiation: Theoretical and Empirical Analysis. *Review of Economic Studies*, 48(2): 289–309.
- [6] Mendoza, Enrique, Linda Tesar, and Jing Zhang. 2013. Saving Europe? The Unpleasant Arithmetic of Fiscal Austerity in Integrated Economies. University of Pennsylvania. Working paper.
- [7] Pouzo, Demian. 2013. Optimal Taxation with Endogenous Default under Incomplete Markets. University of California Berkeley. Working paper.