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Inspecting the Mechanism: Leverage and the Great Recession in the Eurozone†

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We provide a comprehensive account of the dynamics of eurozone countries from 2000 to 2012. We analyze private leverage, fiscal policy, labor costs, and spreads, and we propose a model and an identification strategy to separate the impact of credit cycles, excessive government spending, and sudden stops. We then ask how periphery countries would have fared with different policies. We find that countries could have stabilized their employment if they had followed more conservative fiscal policies during the boom. Macroprudential policies and an early intervention by the central bank to prevent market segmentation and reduce fiscal austerity would also have significantly reduced the recession. (*JEL* E24, E32, E58, E62, F33, F42, H61)

The lesson to be learned from the crisis is that a currency union needs ironclad budget discipline to avert a boom-and-bust cycle in the first place.
Sinn (2010)

On the eve of the crisis [Spain] had low debt and a budget surplus. Unfortunately, it also had an enormous housing bubble, a bubble made possible in large part by huge loans from German banks to their Spanish counterparts.
Krugman (2012)

The situation of Spain is reminiscent of the situation of emerging economies that have to borrow in a foreign currency (…) they can suddenly

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> *be confronted with a "sudden stop" when capital inflows suddenly stop leading to a liquidity crisis.*
>
> De Grauwe (2011)

> *Countries which lost competitiveness prior to the crisis experienced the lowest growth after the crisis.*
>
> Bini Smaghi (2013)

These quotes illustrate a persistent disagreement about the best way to interpret the eurozone crisis. Some argue that the crisis stems from a lack of fiscal discipline, some emphasize excessive private leverage, while others focus on sudden stops or competitiveness divergence due to fixed exchange rates. Most observers understand that all these factors have played a role, but do not offer a way to quantify their respective importance. In this context it is difficult to frame policy prescriptions on macroeconomic policies and on reforms of the eurozone. Moreover, given the scale of the crisis, understanding the dynamics of the eurozone is one of the major challenges for macroeconomics today. In this context, we propose a quantitative model to understand the dynamics of countries within the eurozone.

We analyze the dynamics of private debt, fiscal policy, and funding costs in a collection of small open economies within a monetary union. Each economy has an independent fiscal authority and is populated by patient and impatient agents. Impatient agents borrow from patient agents at home and abroad, and are subject to time-varying borrowing limits. Governments borrow, tax, and spend. Funding costs are linked to private and public debt sustainability. Nominal wages adjust slowly and changes in nominal expenditures affect employment.

The ultimate goal of this paper is to perform counterfactual experiments. For instance, we want to understand what would have happened to a particular country if it had run a different fiscal or macroprudential policy during the boom years, or if the eurozone had been able to prevent sudden stops. Our contribution is to propose a model and an identification strategy to provide a quantitative answer to these questions. Needless to say, this is a difficult task that requires several steps: (i) specify a model and collect the data; (ii) find an identification strategy; (iii) run counterfactual experiments.

It is important to emphasize that we focus on the dynamics of each country *relative to the eurozone average*. This approach helps us identify the model by netting out some aspects of monetary policy and exchange rate fluctuations. For instance, we seek to explain relative employment and inflation in Spain, but not aggregate employment and inflation in the eurozone.

To perform these counterfactual experiments, we need to quantify the mechanisms that caused the recessions in different countries. But the three mechanisms we focus on—private debt, fiscal policy, and funding costs—are all endogenous equilibrium objects. We need to go further and identify *sudden stop* shocks, *credit cycle* shocks, and *discretionary* fiscal choices. All of these shocks affect interest rates, private and public debt dynamics, and, via general equilibrium effects and policy responses, output, wages, and employment. We therefore need an identification strategy.

Identification Strategy.—The strategy we propose is based on a combination of model-based restrictions, instrumental variable regressions, and the use of US states as a control group.

We specify the decision rule that pins down government spending and transfers as a function of the state of the economy. We assume that the government seeks to stabilize employment near its natural rate, cuts spending and transfers in response to an increase in borrowing costs and in response to an increase in public debt, and is subject to a country-specific political economy spending and transfer bias. The first three components of the decision rule are the same in all countries. The last component contains one parameter per country, which is the bias needed to reconcile actual and predicted average spending and transfers during the boom. We estimate a political economy bias in the four periphery countries (Spain, Greece, Ireland, and Portugal) which is especially large in Greece.

We then model sudden stops as a common risk factor that increases after 2008, and we show that it materializes in countries with high public and private debts, including implicit liabilities linked to bank recapitalization costs. We use instrumental variables to estimate the impact of public and private debts on the economy's cost of funds, assuming that governments did not anticipate that a crisis would come at the end of the boom.

The last identification issue is the most difficult. We need to ascertain how the sudden stop affects the dynamics of private debt. This is complicated because private deleveraging can happen even without sudden stop and because we are not willing to impose the same restrictions regarding functional forms and anticipations on private agents as we impose on governments. Our key idea instead is to use the United States as a control group. The US experience is both similar and different from the eurozone experience. A salient feature of the Great Recession in both monetary unions is that regions that have experienced large swings in private borrowing have also experienced large declines in employment and output. Figure 1 shows that the change in households' debt-to-income ratios during the boom (2003–2007) predicts the change in employment during the *private* credit crunch (2007–2010).[1] The important point for our purpose is that, until 2010, the US and European experiences look strikingly similar. In both cases, there is a significant dispersion of leverage and employment, a very good fit, and (almost) the same slopes. This suggests similar structural parameters governing the endogenous propagation mechanism.

A significant difference between the two regions appears only after 2010 when the eurozone experiences sudden stops, financial fragmentation, and sovereign debt crises coupled with the risk of a breakup of the currency union.[2] States within the United States do not experience sudden stops and no such breakup risk, but they reduce their private leverage nonetheless. Our identification strategy is then to use *actual* private debt dynamics across the United States to construct *predicted* debt series across eurozone countries. We argue that these are the private debt dynamics

[1] The figure is for the largest US states and eurozone countries. State-level household debt for the United States comes from the Federal Reserve Bank of New York: see Midrigan and Philippon (2010). The mean changes are different since the private boom/bust cycle is a bit larger in the United States, but this is not an issue for us since, as explained earlier, we focus on dynamics relative to the average.

[2] Sudden stops were frequent in the nineteenth and twentieth centuries but we do not know of any other historical example of a sudden stop inside of a monetary union. See Accominotti and Eichengreen (2016).

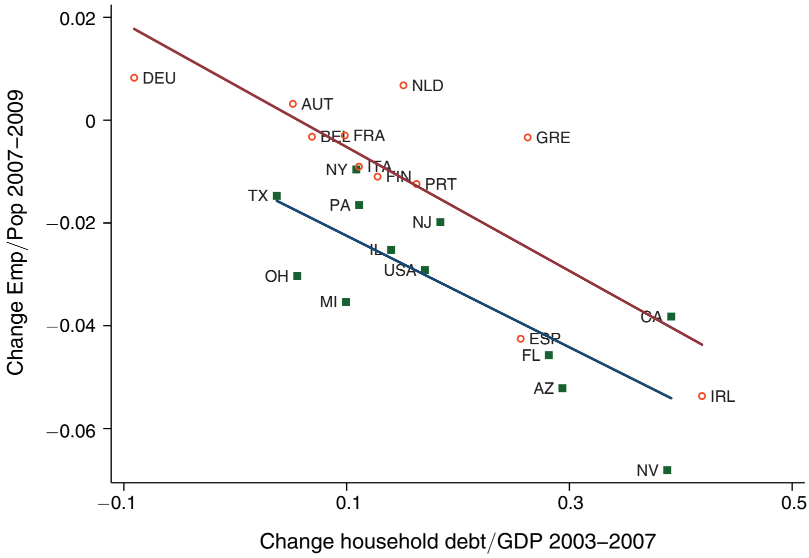

Figure 1. First Stage of the Great Recession: Household Borrowing Predicts Employment Bust in the United States and the Eurozone

that would have prevailed in the eurozone without financial fragmentation and sudden stop. Importantly, these predicted debt series are far from constant and failure to recognize this fact would lead to severe biases in the estimations of the true causes of the eurozone crisis.

Data Fit of the Model and Counterfactual Experiments.—Our model therefore features endogenous private debt, fiscal policy, and cost of funds. The exogenous driving forces are a time-varying risk of sudden stop (one time series), country-specific political economy biases (one number per country), and the predicted private debt series (one time series per country). We show that this model fits the data well. Given the exogenous driving forces, the model predicts well the relative paths of gross domestic product (GDP), employment, inflation, spreads, net exports, and public debt from 2000 to 2012. This is a demanding exercise since we ask the model to predict the booms, the turning points, and the busts for all the series and all the countries.

Using our model, we then perform four counterfactual experiments on the four periphery countries (Spain, Greece, Ireland, and Portugal). We first ask how these countries would have fared if they had followed more conservative fiscal policies during the boom. To do so, we shut down the *political economy bias* of our model. We find that such policies lead to lower spreads and less fiscal austerity during the bust. Periphery countries partially stabilize their employment. This is especially true for Greece, and to a lesser extent for Portugal, Ireland, and Spain. For Ireland, however, this more conservative policy requires buying back the entire stock of public debt, which suggests that fiscal policy is unlikely to be sufficient as a stabilization tool against a large credit boom.

We then ask how these countries would have fared if they had conducted macroprudential policies to limit the increase in private debt. This policy stabilizes private demand and therefore employment, and it reduces the need for bank recapitalization, leading to lower spreads and more room for countercyclical fiscal policy, especially in Ireland and Spain.

Our third experiment uncovers an interesting interaction between fiscal and macroprudential policies. A biased government substitutes public debt for private debt in response to restrictive macroprudential policy, thereby undoing some of the macroprudential benefits. This suggests a complementarity between fiscal rules and macroprudential rules. Indeed, we find that a combination of conservative fiscal and macroprudential policies in the boom would have been successful in stabilizing employment and debt.

In a fourth counterfactual experiment, we assume that the European Central Bank's (ECB) Outright Monetary Transactions (OMT) program (and Mario Draghi's "Whatever It Takes" speech) is announced in 2008 rather than in 2012. This reduces the risk of a breakup of the eurozone, prevents the increase in spreads and financial fragmentation, reduces fiscal austerity, and allows the four periphery countries to stabilize employment after 2010. The experience of the eurozone then becomes similar a well functioning monetary union such as the United States with a recession due to private deleveraging (especially in Spain and Ireland) in 2008 but with a pickup in growth starting in 2010.

Literature Review.—Our paper is most directly related to three lines of research: macroeconomic models with credit frictions, in particular that of Eggertsson and Krugman (2012); open-economy models with interest rates shocks, as in Neumeyer and Perri (2005); and analyses of the eurozone crisis such as, for instance, Lane (2012).

Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999), and Gertler and Kiyotaki (2010) consider credit constraints that limit corporate investment, while we put more emphasis on household credit, as in Mian and Sufi (2014), Midrigan and Philippon (2010), and Eggertsson and Krugman (2012). This difference matters mostly when we fit the model with cross-sectional data. A striking feature of the data is the strong correlation between household leverage and employment at the micro level. Mian and Sufi (2014) show that differences in household debt overhang explains why unemployment is higher in some counties than in others. These facts are not easily explained by a *local lending channel* or by credit constraints that operate only at the firm level, presumably because business lending is not very localized in the United States.[3]

The literature on sudden stops in emerging markets focuses on the rapid imposition of an external credit constraint, and usually emphasizes Fisherian amplification when debts and incomes are denominated in different currencies (see Christiano, Gust, and Roldos 2004; Chari, Kehoe, and McGrattan 2005; Mendoza and Smith 2006; Mendoza 2010; Korinek and Mendoza 2013). The sudden stops themselves

[3] Mian and Sufi (2010) find that the predictive power of household borrowing remains the same in counties dominated by national banks. It is also well known that businesses entered the recession with historically strong balance sheets and were able to draw on existing credit lines, as shown by Ivashina and Scharfstein (2010). On the other hand, our model is perfectly consistent with firm-level credit constraints *in addition* to household-level credit constraints, as discussed recently by Giroud and Mueller (2015). Our approach is also consistent with the lending constraints view of Justiniano, Primiceri, and Tambalotti (2015).

can be explained by multiple equilibria in international financial markets with transaction costs, as in Martin and Rey (2006). By contrast, we focus on countries that belong to a monetary union and our model integrates, for the first time to our knowledge, both domestic and external debt dynamics. This is critical for understanding the eurozone crisis since, as we have explained, private deleveraging would have created a recession even without an external credit constraint. In Neumeyer and Perri (2005), interest rates shocks, either exogenous or induced by productivity shocks, generate sudden stops and current account reversals because they induce a working capital shortage. In our model, the increase in interest rates generates a demand shock through a fall in private and public expenditures.

While most of the sudden stop literature has emphasized credit constraints, Gopinath (2004) and Aguiar and Gopinath (2007) have focused on total factor productivity (TFP) shocks. In Aguiar and Gopinath (2007), a negative shock to trend growth leads to a fall in consumption and an increase in the trade balance.[4] TFP shocks are certainly important in emerging markets, but they do not seem to explain the dynamics of euro area countries during the great recession (see Gavilán et al. 2011 on this issue as well as the role of demographic factors in Spain). Countries hit by sudden stops (Greece, Ireland, Italy, Spain, Portugal) do not experience the largest reversals in trend TFP growth, and there is no correlation between changes in TFP growth and employment losses during the recession (see Figure 3 in online Appendix B1). In fact, the only country that shows signs of TFP growth during the boom years is Greece, but the reliability of these numbers is questionable.

Our paper is related to the literature on sovereign credit risk (see Eaton and Gersovitz 1982; Arellano 2008; and Aguiar and Amador 2014 for a survey) but we do not actually model strategic default decisions. We focus instead on how sovereign default risk affects the real economy. Corsetti et al. (2013) model such a *sovereign risk channel* through which sovereign default risk raises the private sector cost of funds. A high cost of funds forces the government to cut spending and our model is qualitatively and quantitatively consistent with the recent research on fiscal multipliers at the regional level (see Nakamura and Steinsson 2014; Farhi and Werning 2013).

The papers by Lane (2012) and Shambaugh (2012) provide a thorough description of the four dimensions of the eurozone crisis: public debt, private debt, sudden stop, and competitiveness. The specific role of the boom/bust cycle in capital flows is analyzed by Lane (2013) while Gourinchas and Obstfeld (2012) show that domestic credit expansion is the most robust predictor of financial crises. Battistini, Pagano, and Simonelli (2014) argue that the perceived risk of a eurozone breakup is a key driver of financial fragmentation during the crisis. Schmitt-Grohé and Uribe (2016) emphasize the role of downward wage rigidity. Some papers also compare and describe the specific circumstances of individual countries. Fernández Villaverde, Garicano, and Santos (2013) argue that loose financing conditions and capital inflows following the creation of the euro relaxed the pressure for reforms in

[4] Gopinath (2004) proposes a model with a search friction to generate asymmetric responses to symmetric shocks. A search friction in foreign investors' entry decision into emerging markets creates an asymmetry in the adjustment process of the economy: An increase in traded sector productivity raises GDP on impact, and it continues to grow to a higher long-run level. On the other hand, a decline in traded sector productivity causes GDP to contract in the short run by more than it does in the long run. Aguiar and Gopinath (2007) do not study the response of the labor market but it is well known that income effects tend move consumption and hours in opposite directions.

the four periphery countries. Reis (2013) argues that capital misallocation explains the low growth of Portugal between 2000 and 2007 and Gopinath et al. (2015) show the link between capital inflows and low productivity due to misallocation in some periphery countries. Whelan (2014) stresses the role of cheap credit and lax banking regulation in Ireland, and Cuñat and Guadalupe (2009) analyzes the lending behavior of the Spanish Cajas in the run up to the crisis. Gourinchas, Philippon, and Vayanos (2017) focus on Greece. While our model cannot do justice to the specificities of every single country, it nonetheless gives a quantitative interpretation of the crisis that is consistent with many of the views expressed in these various papers.

The remainder of the paper is organized as follows. In Section I we present the model and in Section II we describe the calibration and empirical identification strategies as well as the fit of the structural model. The structural model is used to conduct our counterfactual experiments in Section III. Section IV concludes. There are also several online Appendices presenting the simulations, some details of the model, the data sources, and the various adjustments that need to be made to the raw data.

I. Model

The basic structure of the model follows Galí and Monacelli (2008). We study a set of small open economies in a monetary union. Each country (or region) j produces a tradable good and is populated by households who consume the domestic good and a basket of foreign goods. Each country in the monetary union is small in the sense that country-specific shocks do not affect aggregate dynamics.[5] Saving and borrowing can be done domestically and internationally and are measured in units of the common currency. We also abstract from housing and from corporate investment.[6] Sections IA to ID present the dynamic stochastic general equilibrium (DSGE) model. Section IE departs from the DSGE approach and posits equations that we later estimate with instrumental variables.

A. *Government*

The government of country j imposes a flat and constant tax τ_j on income, spends $G_{j,t}$ on goods and services and makes social transfers $T_{j,t}$. In our notations, both G and T are nominal values. Let $B^g_{j,t-1}$ be the face value (in units of the common currency) of the debt issued at time $t-1$ and due at time t. The nominal budget constraint of the government is

$$\text{(1)} \qquad \frac{B^g_{j,t}}{R_{j,t}} + \tau_j Y_{j,t} = G_{j,t} + T_{j,t} + B^g_{j,t-1},$$

[5] To be clear, this means that foreign demand for the goods produced by region j does not depend on the GDP of region j. This assumption greatly simplifies our analysis. Given our focus on Spain, Ireland, Portugal, and Greece in the counterfactuals, we believe that direct *trade* spillovers are probably not very large, except perhaps between Spain and Portugal. On the other hand, financial spillovers may not be small even if a country is small relative to the currency union. For instance, suppose that Greece had improved its fiscal situation earlier, then perhaps risk premia on Portugal would have risen by less, and this in turn might have reduced the sudden stop in Greece. Our model misses this kind of financial feedback, and our estimates of gains from counterfactual policies that lead to reduced spreads are therefore probably biased downward.

[6] See Midrigan and Philippon (2010) for a model with housing, and Gourinchas, Philippon, and Vayanos (2017) for a model with investment.

where $Y_{j,t}$ is nominal GDP and $R_{j,t}$ is the nominal interest rate. We assume that the government spends only on domestic goods.

B. *Households*

Following Mankiw (2000) and more recently Eggertsson and Krugman (2012), we assume that households are heterogeneous in their degree of time preference. More precisely, in region j, there is a fraction χ_j of impatient households, and $1 - \chi_j$ of patient ones. Patient households will be net savers in equilibrium. They are indexed by $i = s$ for savers and have a higher discount factor than borrowers, indexed by $i = b$: $\beta \equiv \beta_s > \beta_b$. Household i in country j maximizes lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_i^t \left(\log C_{i,j,t} - \frac{N_{i,j,t}^{1+\varphi}}{1+\varphi} \right),$$

where

$$\log C_{i,j,t} = \alpha_j \log\left(\frac{C_{i,j,t}^h}{\alpha_j}\right) + (1 - \alpha_j) \log\left(\frac{C_{i,j,t}^f}{1-\alpha_j}\right)$$

and $C_{i,j,t}^h$ is consumption of home good and $C_{i,j,t}^f$ is consumption of (a basket of) foreign goods; $N_{i,j,t}$ is labor of household i in country j. With these preferences, households of region j spend a fraction α_j of their income on home goods, and $1 - \alpha_j$ on foreign goods. There are alternative modeling choices to introduce a measure of openness such as trade costs or the introduction of a non-traded sector. Our modeling choice is the simplest although it means we cannot discuss issues such as the resource misallocation between the tradable and the nontradable sectors (see Gopinath et al. 2015 on this issue).

Let $X_{i,j,t} \equiv P_{j,t} C_{i,j,t}^h + P_t^f C_{i,j,t}^f$ denote nominal spending. The Euler equation of patient households is

$$\frac{1}{X_{s,j,t}} = \mathbb{E}_t\left[\frac{\beta R_{j,t}}{X_{s,j,t+1}}\right], \tag{2}$$

where $R_{j,t}$ is the nominal return between t and $t+1$. We will explain later how the cost of funds depends on the risk of a *sudden stop*. Savers are residual claimants in the economy and they own the domestic firms. Impatient households are subject to the borrowing limit $B_{j,t}^h$:

$$B_{j,t} \leq B_{j,t}^h, \tag{3}$$

and their budget constraint is[7]

$$X_{b,j,t} = \frac{B_{j,t}}{R_{j,t}} + (1 - \tau_j) W_{j,t} N_{b,j,t} + T_{b,j,t} - B_{j,t-1}, \tag{4}$$

[7] Notice that the budget constraint for the borrowers is written without the possibility of default. In such a case, and without taking into account issues of market liquidity, the cost of fund is the same as the *interest rate*. When we discuss the model, we therefore refer to $R_{j,t}$ as the interest rate. But when we turn to the data, it is obviously critical to remember that $R_{j,t}$ is really meant to capture the cost of funds.

where $W_{j,t}$ are nominal wages. We explain later how the debt limit $B^h_{j,t}$ evolves. We consider equilibria where shocks are not too large and the borrowing constraint (3) holds with equality. Note that borrowers do not own shares so their only income is labor income.[8] Finally, aggregate private spending is

$$X_{j,t} = \chi_j X_{b,j,t} + \left(1 - \chi_j\right) X_{s,j,t}. \tag{5}$$

C. *Market Clearing*

The market clearing constraint for domestic goods is

$$Y_{j,t} = \alpha_j X_{j,t} + F_{j,t} + G_{j,t}, \tag{6}$$

where $F_{j,t}$ are nominal exports. Notice that we assume here that foreign demand for the home good has a unit elasticity with respect to export price $P^h_{j,t}$. As a result $F_{j,t}$ is exogenous from the perspective of country j. Production is linear in labor $N_{j,t}$:

$$Y_{j,t} = P_{j,t} N_{j,t}. \tag{7}$$

We will describe shortly how wages and prices are set. Nominal exports are $F_{j,t}$ and nominal imports are $\left(1 - \alpha_j\right) X_{j,t}$ since the government does not buy imported goods, so net exports are

$$E_{j,t} = F_{j,t} - \left(1 - \alpha_j\right) X_{j,t}. \tag{8}$$

Let $A_{j,t}$ be the net foreign asset position of the country at the *end of period t*. The current account is then simply[9]

$$\frac{A_{j,t}}{R_{j,t}} - A_{j,t-1} = E_{j,t}. \tag{9}$$

D. *Scaling*, *Spreads*, *and Inflation*

An important point of our analysis is that we study the dynamics of the different regions *relative* to the eurozone average. This allows us to abstract from common aggregate shocks. To take advantage of this idea, we measure deviations from the eurozone average, denoted by *, as

$$x_{s,j,t} \equiv \frac{X_{s,j,t}}{X^*_{s,t}} \tag{10}$$

[8] We also let the transfer be type-specific to make sure that labor supply is the same for all agents in steady state. This is a very small adjustment that simplifies the notations of the model because we do not need to keep track of two quantities of labor.

[9] Denoting $S_{j,t}$ the patient agents' saving, Walras' law then implies the savers' budget constraint: $X_{s,j,t} = \left(1 - \tau_j\right) \left[\left(P_{j,t} - W_{j,t}\right)/\left(1 - \chi_j\right)\right] N_{j,t} + \left(1 - \tau_j\right) W_{j,t} N_{s,j,t} + T_{s,j,t} + S_{j,t-1} - S_{j,t}/R_{j,t}$ which states that savers income comes from net of tax profits received from firms, labor income, and transfers.

for relative savers spending (in lower case), and similarly for all our macroeconomic variables. We define the funding cost spread as

$$\rho_{j,t} \equiv \frac{R_{j,t}}{R_t^*} - 1, \tag{11}$$

where R_t^* is the interest rate for the monetary union as a whole. Finally, we assume a standard New-Keynesian model of price and wage dynamics à la Calvo, following the textbook treatment in Woodford (2003) and Galí (2008). Let $w_{j,t}$ be the log-real wage (deflated by the consumer price index (CPI)). For domestic relative log-price inflation $\pi_{j,t}^h$ we have

$$\pi_{j,t}^h = \beta \mathbb{E}_t\left[\pi_{j,t+1}^h\right] + \lambda^p\left(w_{j,t} - \left(1 - \alpha_j\right)\log p_{j,t}^h\right). \tag{12}$$

Similarly, in the labor market, a representative union sets wages and we have

$$\pi_{j,t}^w = \beta \mathbb{E}_t\left[\pi_{j,t+1}^w\right] + \lambda^w\left(\log c_{j,t} + \varphi \log \frac{n_{j,t}}{\bar{n}_j} - w_{j,t}\right), \tag{13}$$

$$\pi_{j,t} = \alpha_j \pi_{j,t}^h,$$

$$w_{j,t} = w_{j,t-1} + \pi_{j,t}^w - \pi_{j,t},$$

where $\pi_{j,t}^w$ is log-wage inflation and $\pi_{j,t}$ is log-CPI inflation.[10] Note that we have differenced out foreign inflation (equivalently, normalized the foreign price to one) so $-p_{j,t}^h$ really measures the terms of trade. There are a few important points to discuss about this specification.[11] First, we assume that the natural rate $\bar{n}_j$ is constant within country. This is probably not a good assumption for Germany following the Hartz labor market reforms of 2003–2005, and indeed our model underpredicts relative employment in Germany. But in other countries it seems to work fine. Another important assumption is that $\left(\lambda^p, \lambda^w\right)$ is the same in all regions. This assumption is motivated by existing research, notably Montoya and Döhring (2011) who find fairly similar Phillips curve coefficients across eurozone countries.[12]

E. *Three Driving Forces*

We now describe the three mechanisms that are at the core of our analysis of the eurozone crisis. The first one is a boom/bust cycle in private debt, which we call

[10] The inflation elasticities are defined as usual: $\lambda_p \equiv \left[\left(1 - \vartheta_p\right)\left(1 - \beta\vartheta_p\right)\right]/\vartheta_p$ and $\lambda^w \equiv \left(\left[\left(1 - \beta\vartheta_w\right) \times \left(1 - \vartheta_w\right)\right]/\vartheta_w\right)\left(1/\left(1 + \varphi\epsilon_w\right)\right)$ where ϑ_p and ϑ_w are the Calvo stickiness probabilities, and ϵ_w is the elasticity of substitution between different types of labor inputs.

[11] Note that all households work the same amount. As explained earlier, we normalize relative transfers so that the steady-state labor supply is the same for borrowers and savers. We maintain this assumption in the dynamics by rationing the labor market uniformly across households. See Midrigan and Philippon (2010) for a discussion.

[12] Montoya and Döhring (2011, p. 18) find that the estimates for the Member States "are fairly well in line with the estimates for the euro area aggregate." For the main coefficient of interest, only two countries have estimates above or below one standard deviation of the euro area estimate. Importantly, there is no geographical pattern in the distribution of the coefficients, which we interpret as saying that the differences are probably just noise.

credit cycle for short. The second one is a *political economy* bias in government spending that creates fiscal imbalances. The third is a *sudden stop* that threatens the stability of the eurozone.

In each case, we argue that the driving forces have an endogenous component and an exogenous component. We do not provide microfoundations for this part of the model. Given the range of data and economic forces that we need to capture, this is not feasible. Our choices of modeling of these three mechanisms are driven by the empirical feasibility of identification as well as by theoretical relations that have been discussed in the literature. For example, as in Corsetti et al. (2013, 2014), higher government debt (through past low output or high public expenditures) increases spreads (sovereign and private) and in turn these spreads affect private borrowing and the real activity. Contrary to Corsetti et al. (2013, 2014), we do not model precisely the feedback loop between the fiscal outlook (the probability of sovereign default) and public and private spreads but our modeling captures, in a reduced form, similar fundamental relations. In addition, our model captures how fiscal policy (and its countercyclical role) is constrained by spreads.

The Credit Cycle.—We assume that the household borrowing limit is given by

$$b_{j,t}^{h} = \hat{b}_{j,t}^{h} + \lambda^{\rho,h}\rho_{j,t} \tag{14}$$

where $\lambda^{\rho,h}$ is a (negative) parameter, $\rho_{j,t}$ captures the impact of the (relative) funding costs on the (relative) private credit market, and $\hat{b}_{j,t}^{h}$ is the (relative) credit cycle that would prevail even without financial segmentation. The spread $\rho_{j,t}$ is endogenous and depends, among other things, on private and public leverage. We will explain in details how we can use the United States to construct $\hat{b}_{j,t}^{h}$ and how we estimate $\lambda^{\rho,h}$ using instrumental variables.

The Political Economy Bias.—We assume that the government follows a fiscal rule for expenditures $g_{j,t}$ and transfers $t_{j,t}$:

$$g_{j,t} = \tilde{g}_{j,t} + \gamma^{n}(n_{j,t} - \bar{n}_{j}) + \gamma^{\rho}\rho_{j,t} + \gamma^{\rho,b_g}b_{j,t}^{g}, \tag{15}$$

$$t_{j,t} = \tilde{t}_{j,t} + \gamma^{n}(n_{j,t} - \bar{n}_{j}) + \gamma^{\rho}\rho_{j,t} + \gamma^{\rho,b_g}b_{j,t}^{g},$$

where γ^{n}, γ^{ρ}, and γ^{ρ,b_g} are all negative parameters. The rule has three components. The first is an exogenous country-specific political economy bias $\tilde{g}_{j,t}$ and $\tilde{t}_{j,t}$. The second corresponds to an objective to stabilize employment $n_{j,t}$ close to its natural level $\bar{n}_{j}$. The third is a funding constraint that forces the government to cut spending when the spread $\rho_{j,t}$ is positive or when public debt $b_{j,t}^{g}$ is high. The parameter γ^{ρ} plays an important role in our analysis, while γ^{ρ,b_g} is only needed to ensure long run stability of the system, and can be small.

The Sudden Stop.—We assume that the country-specific spread in funding costs is given by

$$\rho_{j,t} = \sigma_{t} \times \left[\lambda_{0}^{\rho} + \lambda^{g,\rho}b_{j,t}^{g} + \lambda^{h,\rho}b_{j,t}^{h} + \lambda^{rec,\rho}recap_{j,t}\right] + \lambda^{a}a_{j,t}, \tag{16}$$

where σ_t captures the *aggregate* time-varying risk of a sudden stop. This equation says that funding costs start to diverge when there is a sudden stop in the eurozone and that the extent to which this happens in different countries depends on public debt $b^g_{j,t}$, private debt $b^h_{j,t}$, and the recapitalization needs of the financial sector $(recap_{j,t})$.[13] In addition, we introduce a small effect of net foreign assets to ensure long run stationarity.[14] The sensitivity of spreads to these common and local factors is measured by the parameters λ. This is a fairly standard equation that emphasizes the interaction between a common risk factor (σ_t) and local sensitivities (debt levels). The time-varying risk is needed to explain rapid changes in spreads while debt levels tend to be very persistent. The local sensitivities are needed because not all countries are hit by sudden stops. Our specification captures financial frictions associated with high leverage (debt overhang, risk shifting, adverse selection, runs, etc.).

In the model, we assume that recapitalization needs are driven by nonperforming loans (NPL) and depend on an exogenous shock $\xi_{j,t}$ and on the amount of private credit extended by the banks in past years, relative to steady state $\bar{b}^h_j$:

$$recap_{j,t} = \xi_{j,t}\Big(1 + \kappa\Big(b^h_{j,t-1} - b^h_j\Big)\Big), \tag{17}$$

which says that a reduction of past private debt by one euro reduces future recapitalization needs by a factor κ. The lag l could be 1 or more depending on the application.[15] We choose a particular lag structure that fits the data well in our macroprudential counterfactual experiment in Section IIIB.

F. *Equilibrium*

To summarize, our model has six exogenous driving forces: $\hat{b}^h_{j,t}$, $\tilde{g}_{j,t}$, $\tilde{t}_{j,t}$, σ_t, $\xi_{j,t}$, $f_{j,t}$. All of these are assumed to be autoregressive processes. An equilibrium of the model is then a sequence for the exogenous driving forces and for the endogenous variables $(c, n, w, p, \dots)$ that satisfies the equations of the model (1) to (14), as well as the structural equations (14) to (17).

The most important driving forces are the private credit cycle $\hat{b}^h_{j,t}$, government spending $(\tilde{g}_{j,t}, \tilde{t}_{j,t})$, and the sudden stop σ_t. We will spend much time explaining exactly how we measure these shocks and how we estimate equations (14), (15), and (16). By contrast relative foreign demand $f_{j,t}$ does not play a big role and is included only because it reduces the noise in the estimation. Financial markets clearly pay attention to recapitalization expenditures and the shock $\xi_{j,t}$ helps us match the timing of the release of information about bank losses and therefore the timing of spread

[13] Favero (2013) also finds that fiscal fundamentals matter for eurozone spreads in interaction with the time-varying perceived risk of a eurozone breakup.

[14] It is well known that net foreign assets are not stationary in a small open economy. To solve this issue, we follow Schmitt-Grohé and Uribe (2003) and assume a small penalty on spreads for deviating from a long-run NFA/GDP ratio.

[15] Equation (17) is the simplest one that fits the data. We could also estimate an equation that predicts nonperforming loans using outstanding debt relative to disposable income, as in Gourinchas, Philippon, and Vayanos (2017). This would not change our analysis because the main virtue of equation (17) is to capture differences between countries in the timing of the release of information about bank losses. This then helps explain the within-country timing of spreads in equation (16).

Table 1—Parameters

Parameter name	Value	
Annual discount factor (patient)	β	0.98
Home bias	α_j	country-specific
Share of impatient households	χ_j	country-specific
Calvo parameters	ϑ_p and ϑ_w	0.5
Frisch elasticity	φ^{-1}	1
Persistence of spreads shocks	θ	0.5

increases. Our main conclusions, however, are not sensitive to the inclusion of $recap_{j,t}$ because they are driven by variations in $b^h_{j,t}$ across our counterfactual experiments.

II. Calibration and Empirical Identification

For the simulation, we use data from 11 eurozone countries for the period 2000 to 2012: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Netherlands, and Portugal, and calibrate the shocks on the observed data. The data sources are described in online Appendix B1.

A. *Calibration*

The parameters used in the simulations are presented in Table 1. The discount factor (of patient households) and the Philipps curve parameter are standard. The country-specific parameters (share of credit-constrained households χ_j, and degree of home bias α_j) are shown in Figure 2.

For the country-specific domestic share of consumption, α_j, we rely on Bussiere et al. (2011) who compute the total import content of consumption expenditures, including the value of indirect imports. For our sample of countries, the average implied domestic share in 2005 (the latest date in their study) is 72.7 percent. The lowest is 66.4 percent for Belgium and the highest is 78.7 percent for Italy. For foreign demand $F_{j,t}$, given the absence of an intermediate goods sector in our model, we take the domestic value-added that is associated with final consumption in the rest of the world, which corresponds to value-added-based exports. As detailed in online Appendix B1, we use the data from the OECD-WTO Trade in Value-Added (TiVA) initiative to measure this. The scaled value-added based exports are shown in Figure 8 in online Appendix B3. Finally, we take into account net EU transfers, which are the difference between EU spending in the country and the country contribution to the European Union. In our model, such transfers play exactly the same role as foreign demand, so we add European Union net transfers to exports in the goods market equation.

Share of Constrained Households.—For the country-specific share of credit-constrained households, χ_j, we use a measure based on the Eurosystem Household Finance and Consumption Survey (HFCS).[16] For each country, we use the fraction

[16] The survey took place in 2010. In Greece and Spain, the data were collected in 2009 and 2008–2009, respectively. This survey has been used recently by Kaplan, Violante, and Weidner (2014) to quantify the share of hand-to-mouth households. They define these as consumers who spend all of their available resources in every pay-period,

Figure 2. Share of Credit-Constrained Households (χ_j) and Domestic Share of Consumption (α_j)

of households with liquid assets below two months of total household gross income to approximate the share of credit-constrained households.[17] The average for our set of countries is 48 percent with a maximum of 64.8 percent for Greece and a minimum of 34.7 percent for Austria. Ireland did not participate in the survey so for this country we use the average of the eurozone. Note that $b_{j,t}^h$ in the model is debt per impatient household so the counterpart to the empirical measure of aggregate debt is $\chi_j b_{j,t}^h$.

Funding Costs.—The cost of fund $\rho_{j,t}$ enters the Euler equation of unconstrained agents. It represents the expected return of savers, the funding cost of firms, etc. The true cost of funds is not directly observable and we base our estimates on several interest rates: (i) loans rates for small and medium enterprises (SMEs); (ii) deposit rates; (iii) wholesale bank funding costs; and (iv) yields on ten-year government bonds. In all cases we compute the difference between the rate in country j and the median of the eurozone in year t.

The link between interest rate spreads and funding costs can be complicated. On the one hand, interest rates are not expected returns because they include expected credit losses. On the other hand, we know from a large literature in finance that

and hence do not carry any wealth across periods. They argue that measuring this behavior using data on net worth (as consistent with heterogeneous-agent macroeconomic models) is misleading because this misses what they call the wealthy hand-to-mouth households. These are households who hold sizable amounts of wealth in illiquid assets (such as housing or retirement accounts), but very little or no liquid wealth, and therefore consume all of their disposable income every period. They define hand-to-mouth consumers as those households in the survey whose average balances of liquid wealth are positive but equal to or less than one-half of their earnings.

[17] We thank Caterina Mendicino from the ECB who provided us with the data. At the eurozone level, the median household has 18.6 percent of its annual income (equivalent to just above two months' income) available in the form of liquid assets (see ECB-HFCS 2013). Net liquid assets are the sum of deposits, mutual funds, bonds, non-self-employment business wealth, (publicly traded) shares and managed accounts, net of credit line/overdraft debt, credit card debt and other nonmortgage debt.

credit spreads create significant differences in funding costs. This is the basic point of all models with distress costs, agency costs, debt overhang, safety premia, etc. All of these models predict that funding costs are increasing in credit spreads, but less than one-for-one. Banks clearly play a special role during the crisis. Many borrowers depend on bank loans and the funding costs of banks are therefore critical for the economy. We use data on banks' credit default swaps (CDSs) to estimate wholesale funding costs. Deposit rates are also informative even though they tend to move more slowly than market rates. They also depend on the credibility of the deposit insurance system. Debt overhang in the banking sector makes it more attractive for banks to invest in the debt of their home sovereign, and this can crowd out private lending.[18] For tractability reasons, we collapse the banking sector with the rest of the private sector. Banks are potentially important for two reasons. First, banking losses can end up on the government balance sheet through recapitalization needs. We capture this in our framework to the extent that the losses are driven by domestic loans. Our model can capture the issues of domestic nonperforming loans. This is probably a good model of losses in the periphery countries, since we think that banks' capital shortfalls are indeed driven by domestic NPLs. This would not necessarily be a good model for Germany for instance, where German lenders made significant losses on their foreign operations. The second is the feedback from sovereign risk to banks' funding costs. This is part of our model as well. The main drawback of not having an explicit banking sector is that we cannot address the welfare consequences of banks' bailouts. In that sense, this is not so much that our counterfactuals are biased, it's more that there are other interesting counterfactuals that we cannot perform.

We want our synthetic measure to be as broad as possible, so ideally we want to use the average of (i) loans rates for SMEs; (ii) deposit rates; and (iii) wholesale bank funding costs. Unfortunately we are severely constrained by data availability, as explained in online Appendix B1. The only series that are available for all countries and all years are the spreads on government bonds. We therefore project our three spreads (SME loans, deposits, wholesale funding) on the sovereign spreads and we take the average of the projected values:[19]

$$\rho_{j,t} \equiv \frac{1}{3}\Big(\widehat{SME}_{j,t} + \widehat{DEPO}_{j,t} + \widehat{WHOLE}_{j,t}\Big).$$

Figure 8 in online Appendix B3 shows the government bond spreads and our synthetic measure $\rho_{j,t}$. They are of course strongly correlated, but the important point is that $\rho_{j,t}$ is a lot less volatile than the government spread. In the case of Greece for instance, the sovereign spreads exceed 20 percent in some years, and this is clearly a reflection of credit risk. Using this raw number in the simulations would make no sense and would lead to too much volatility in spending. As we show below, our synthetic measure seems to perform reasonably well in the simulations.

[18] In the limit of a model à la Myers (1977), the bank may end up treating the entire yield as an expected return because it only cares about the nondefault state. See Philippon and Schnabl (2013) for a discussion of debt overhang.

[19] We regress each of the country-specific interest spreads (loans for SMEs, deposit rates, and wholesale bank funding costs captured by CDS rates) on a piecewise linear function of the ten-year government bonds spread. We then take the simple average of the predicted values.

Finally, agents in our model need to have an estimate of the persistence parameter θ for the $\rho_{j,t}$ series. A higher persistence amplifies the effect of a given spread shock because it increases its impact on the net present value of future income. It is clearly important to use a longer sample to estimate the persistence so we extend all our spreads series to 2014 and we estimate θ by running a panel regression with year and country fixed effects. We estimate θ to be 0.5, which means that if the spread is 100bps this year, agents anticipate that it will be 50bps next year.

Scaling.—We scale the data in a manner consistent with equation (10). We construct the following benchmark level of nominal GDP for country j at time t:

$$\hat{Y}_{j,t} \equiv \frac{Y_{j,t_0}}{L_{j,t_0}} \frac{\bar{L}_{t_0}}{\bar{Y}_{t_0}} \frac{\bar{Y}_t}{\bar{L}_t} L_{j,t},$$

where t_0 is the base year (2002 in our simulations), $Y_{j,t}$ is nominal GDP, $L_{j,t}$ is population, and $\bar{Y}_t$ and $\bar{L}_t$ denote the aggregate GDP and population for the eurozone. In words, the benchmark is the nominal GDP the country would have if it had the same per-capita growth rate as the eurozone together with its actual population growth. The key point is that the only country level time-varying variable that we take as exogenous is population growth. We scale all our variables in euros by the benchmark GDP. For GDP itself, we define

$$y_{j,t} \equiv \frac{Y_{j,t}}{\hat{Y}_{j,t}},$$

which is one in the base year. For sovereign debt, we define

$$b^g_{j,t} \equiv \log\left(\frac{B^g_{j,t}}{\hat{Y}_{j,t}}\right),$$

which is equal to the actual debt to GDP *ratio* in the base year t_0, but then tracks the *level* of debt for $t > t_0$, as in the model $b^g_{j,t}$.[20] This is important when we consider deleveraging. With large fiscal multipliers, a reduction in debt might leave the debt to GDP ratio unchanged in the short run. Ratios often give a misleading view of deleveraging efforts. Figure 6 in online Appendix B3 shows the scaled private and sovereign debt series. Figure 6 shows scaled public spending and transfers. Note also that government spending is adjusted for expenditures on bank recapitalization. For wages we use the unit labor cost relative to the average unit labor cost in the eurozone. For employment, we use employment per capita in deviation to the eurozone average and the base year:

$$n_{i,t} = \frac{N_{j,t}/L_{j,t}}{N_{j,2002}/L_{j,2002}} \frac{N^*_{j,2002}/L^*_{j,2002}}{N^*_{j,t}/L^*_{j,t}}.$$

[20] Instead of using government debt directly from data, we construct a simulated government debt series in order to avoid including factors that affect government debt in the data but are not in the model, such as bank recapitalizations, default, revenues from privatizations, etc. The simulated debt series is constructed by adding to $t-1$ period debt government expenditures including interest payments and subtracting tax revenues. The tax rate τ_j is constant but different in each country. It is set such that the government budget constraint in the base year (2002) is satisfied.

B. *Identification*

Using the United States to Identify Private Debt Dynamics.—We now explain how we estimate equation (14). A serious identification challenge when we consider private debt dynamics is to distinguish what comes from sudden stops and what comes from a standard leverage cycle. It is clear that even without a sudden stop, those eurozone countries that had increased their private leverage during the boom would have experienced private deleveraging thereafter. But exactly how fast and how much, we do not know. It is also rather intuitive that places that experience the largest increase in debt during the boom experience the largest decrease during the bust. This makes it particularly difficult to identify the impact of the sudden stop. Our identification strategy is then to use the United States as a control group to estimate what (relative) deleveraging without sudden stop should look like. We estimate the following model for deleveraging in a panel of US states:

$$b_{j,t}^{h,US} = \hat{\alpha}_1 b_{j,t-1}^{h,US} + \sum_{k=2002,2005,2008} \hat{\alpha}_k b_{j,k}^{h,US} + \epsilon_{j,t}$$

for $t = 2009, \ldots, 2012, j = 1, \ldots, 52$, and $b_{j,t}^{h}$ is household debt in state j at time t, rescaled exactly as explained above for the eurozone.[21] The idea is that these private leverage cycles reflect various global and financial factors: low real rates, financial innovations, regulatory arbitrage of the Basel rules by banks, real estate bubbles, bank governance, etc.[22] To a large extent these forces are present both in Europe and in the United States. The main difference is that there was no sudden stop within the United States, and that there was never any risk of a breakup of the US monetary union. Hence, we interpret the US experience as representative of a deleveraging outcome in a monetary union without sudden stops and with zero spreads, which is consistent with the evidence (see, for instance, Hurst et al. 2015).[23] Our assumption is therefore that, if the eurozone had not experienced a sudden stop, the difference in private leverage between two eurozone countries (for example, Ireland and Germany) would have been reduced at the same *speed* as the difference between two US states (for example, California and Texas). Technically, we need the US-based estimate $\hat{b}_{j,t}^{h}$ as a control in equation (14) and as an instrument in equation (16). Notice that we do not need to assume that the aggregate private leverage cycle was the same in the United States and Europe, and we also do not need to assume that monetary policy was the same.

The estimated coefficients $\hat{\alpha}_k$ capture the fact that states that accumulate more private debt during the boom and deleverage more during the bust. We then take the estimated coefficients $\hat{\alpha}_k$ and use them to construct predicted deleveraging in eurozone countries $\hat{b}_{j,t}^{h}$ that is used for the credit cycle shock in equation (14):

$$\hat{b}_{j,t}^{h} = \hat{\alpha}_1 b_{j,t-1}^{h} + \sum_{k=2002,2005,2008} \hat{\alpha}_k b_{j,k}^{h},$$

[21] One issue we have to deal with is that mortgage defaults are much more prevalent in the United States, because of differences in mortgage regulations. Deleveraging in the model does not happen via default, so we must add to the series of household debt in US states the amount of debt which has been defaulted upon.

[22] See Cuñat and Garicano (2010) on the case of Spain.

[23] We discuss differences in local fiscal policy in online Appendix B2.

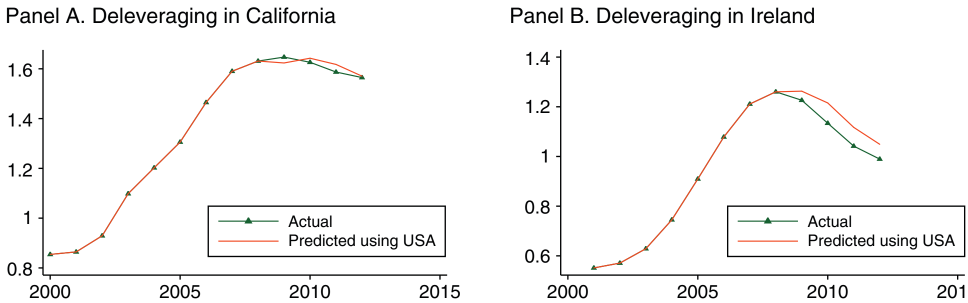

FIGURE 3. PRIVATE DELEVERAGING

for $t = 2009, \ldots 2012$ and $j = 1, \ldots 11$.

Figure 3 illustrates the results for California and Ireland. Figure 3 suggests that the Irish private sector paid back its debts faster than one would expect if Ireland had been a US state. This is also the case for other countries that experienced a sudden stop.

Finally, we need to estimate the parameter $\lambda^{\rho,h}$ in equation (14) on the period 2008–2012 for the 11 eurozone countries. To do so, we use government debt in 2007 as an instrument for $\rho_{j,t}$. Initial government debt is a good predictor of future spreads and we use 2007 to capture the part of debt that is not influenced by the crisis itself.[24]

Funding Costs, Sudden Stops, and Recapitalization.—To capture the possibility and the size of a sudden stop in the eurozone, we measure the coefficient σ_t as the mean of the observed absolute value of spreads in the eurozone. As expected, it is close to 0 up to 2007 and starts increasing in 2008 with a maximum in 2012. As for equation (14), we use instrumental variables to estimate equation (16). For government and private debt $b^g_{j,t}$ and $b^h_{j,t}$ and recapitalization ($recap_{j,t}$), we use government debt levels ($b^g_{j,t}$) lagged three years, the exogenous component of private debt (and its lag) predicted by the US experience $\hat{b}^h_{j,t}$. We choose $\lambda^a = -0.001$ for the cost on the net foreign asset position (NFA) necessary to obtain a stationary net foreign asset position.

The estimated coefficients λ in equations (14) and (16) estimated on the period 2008–2012 for the 11 eurozone countries are shown in Table 2.

[24] The main issue is that fiscal policy and private leverage react to the same shocks during the recession. This is why we measure government debt in 2007, before any increase in $\rho_{j,t}$. The remaining (probably less important) concern is that government debt in 2007 might be correlated with past increases in private debt. According to our fiscal rule, countries with high private debt growth should have tighter fiscal policy, and, all else equal, less government debt at the end of the boom. Indeed, there is a negative correlation between public and private debt across countries in 2007. Countries with less government debt are then also countries where there might be more of a need for private deleveraging. Note that this bias works against us because it pushes $\lambda^{\rho,h}$ toward zero, but still, we want to address this issue. We do so in two ways. First, it is important to remember that we control for predicted private deleveraging using our US estimates, so we actually know which countries want to deleverage more. Second, we have constructed a model-based instrument by taking the level of debt in 2002 plus the model-based drifts δ^g_i, δ^t_i. This instrument is the most consistent with our model. The drifts provide a theoretically valid instrument precisely because they capture the exogenous part of government expenditures and transfers. Using this instrument we find $\lambda^{\rho,h}$ around -2.1 instead of -1.9. Since the estimated elasticity does not change much, we prefer to simply use public debt in 2007 because it is more transparent and can be readily replicated (while the other one requires using the model-based drifts).

Table 2—Coefficients Estimated with Instrumental Variables

$\lambda^{\rho,h}$	λ_0^{ρ}	$\lambda^{g,\rho}$	$\lambda^{h,\rho}$	$\lambda^{rec,\rho}$
−1.9	−2.8	2.1	1.2	18.2
(0.18)	(0.54)	(0.4)	(0.3)	(5.8)

Note: Standard errors in parentheses.

One purpose of equation (17) is to capture differences between countries in the timing of the release of information about bank losses. This then helps explain the within-country timing of spreads in equation (16). In order to match the timing of recapitalization, we choose the shock $\xi_{j,t}$ so that $recap_{j,t}$ matches the observed recapitalization in the data. The second purpose of equation (17) is to perform the macroprudential counterfactual where we do not allow private leverage to increase during the boom years which in turn reduces recapitalization needs in the bust. What matters is that the size of recapitalization depends on the growth of private credit in the boom years, so it could be any function of lagged private credit $(b^h_{j,t-2}, b^h_{j,t-3}, \ldots)$. We interpret $b^h_{j,t-i}$ to be the private debt in 2007 at the end of the boom but this particular date does not matter directly for the estimation. The difference $(b^h_{j,t-i} - \bar{b}^h_j)$ in the equation (17) is then the difference between the chosen value in the particular simulation of $b^h_{j,t-i}$ at the end of the boom in 2007 and the observed value in 2007, $(b^h_{j,2007} - b^{h,data}_{j,2007})$. Note that, except in the macroprudential counterfactual, this difference is zero given that up to 2008, $b^h_{j,t}$ is simply the observed value of private debt. We then need to estimate the parameter κ. Using a cross-sectional regression for equation (17), we estimate κ to be 0.25.

Fiscal Policy.—Our strategy for equation (16) is different from the one we used with the previous two structural equations. When dealing with private debt choices and with market prices, we worry a lot about reverse causality and omitted variables, and we do not pretend that we know the true model. In the case of government policy, on the other hand, we are willing to impose stronger restrictions and rely on the model to interpret the data. So we impose the policy rule (16) and we choose parameters that best replicate the dynamics of spending, transfers, and debt.[25] Obviously, we need to restrict the country-specific shocks $\tilde{g}_{j,t}$ and $\tilde{t}_{j,t}$. We simply assume a constant annual bias during the boom years:

$$\tilde{g}_{j,t} = g_{j,0} + \delta^g_j\big(\min(t,t_1) - t_0\big) - \delta^g_j \max(t - t_1, 0), \tag{18}$$

$$\tilde{t}_{j,t} = t_{j,0} + \delta^t_j\big(\min(t,t_1) - t_0\big) - \delta^t_j \max(t - t_1, 0),$$

with $t_0 = 2002$ and $t_1 = 2008$. Hence, δ^g_j represents the average *excess* annual spending growth rate during the boom years. We interpret this drift as a political bias in spending decisions. In (18) we assume that the bias is reversed after 2008

[25] In equation (16) we use the lagged spread simply because it fits better, which probably reflects implementation lags in fiscal policy. This is not related to the identification of the model and our results are not sensitive to this detail. Note also that we are exploiting the fact that public expenditures and transfers do not move spreads other than through debt and so are excluded from the spread equation (16). This makes (16) a valid regression.

Table 3—Fiscal Policy Coefficients

γ^n	γ^ρ	γ^{ρ, b_g}
−0.2	−1.8	−0.02

Table 4—Biases in Government Spending (*Percent*)

δ_j^t			
Spain	Greece	Ireland	Portugal
1.2	3.0	1.2	1.5

but our results are not sensitive to this choice.[26] Countries display different degrees of spending bias during the boom years, and we want to analyze to what extent this spending drift during the boom years contributes to the crisis.

The parameters γ^n, γ^ρ, and γ^{ρ, b_g} and the spending drift coefficients δ_j given in Tables 3 and 4 are those that best replicate the observed dynamics of spending, taxes, and debt (γ^{ρ, b_g} is only required for stationarity and does not matter for the dynamics that we study). The automatic fiscal rule in Table 3 is as expected. Governments want to stabilize employment but are constrained by their funding cost. For the biases, we focus on the four countries that are hit most harshly by the crisis, namely Spain, Greece, Ireland, and Portugal and on which we will run our counterfactuals. The bias necessary to reproduce the debt dynamics is concentrated on transfers rather than spending. We find that the model fits best with $\delta^g = 0$ and $\delta^t > 0$. This may reflect the high growth rate of wages of existing employees in the public sector and the impact of the pension system in the boom years (see Fernández Villaverde, Garicano, and Santos 2013). The bias is larger in Greece than in the other periphery countries. Finally, to reproduce the Greek debt dynamics, we need to take into account the Greek debt restructuring. Greece benefits from low interest rates, extended repayment periods for the EU and IMF rescue package, and a large reduction of outstanding debt. Altogether, we estimate that this is equivalent to a decrease of 50 points of GDP of debt in the budget constraint, mostly in 2012.

C. *Fit of the Model*

Figure 4 and Table 5 show the fit of the model. Figure 4 compares the actual and predicted series for nominal GDP, employment, public debt, and funding costs in the four periphery countries. The observed and predicted net exports are shown in Figure 1 in the online Appendix. For all predicted series, we add the difference

[26] The fact that it is reversed is not very important for our results. We could assume that the fiscal biases stay constant after t_1 and our simulations would be similar. In fact, our counterfactual results would be stronger since the model would then choose a larger γ^ρ to fit the data. But, given that the tax rate τ_j is constant, this can create issues of debt sustainability if we simulate the model beyond 2012 and we assume that the spreads normalize. In practice we also see that governments are trying to reverse some of the spending decisions they made during the boom years. The change in political bias might come from new fiscal rules agreed at the EU level, from explicit requirements for countries in a program, or more broadly from a shift in attitudes and beliefs about fiscal responsibility. So we feel that the reversal assumption is both simple and safe and this is why we use it as our benchmark.

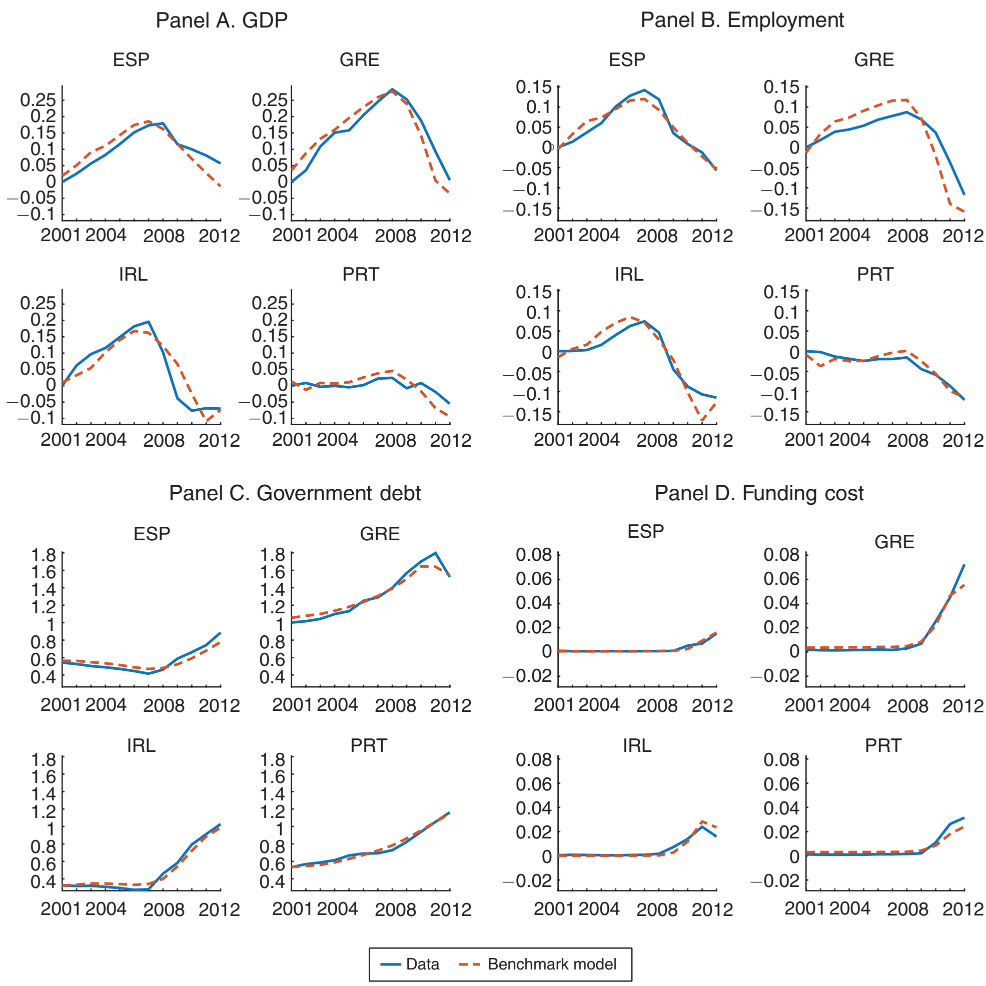

Figure 4. Model Fit

Table 5—Goodness of Fit

	ESP	GRE	IRL	PRT
$y_{j,t}$	0.67	0.82	0.81	0.34
$n_{j,t}$	0.93	0.65	0.87	0.83
$p_{j,t}$	0.54	0.10	0.49	0.17
$b^g_{j,t}$	0.75	0.93	0.97	0.98
$\rho_{j,t}$	0.94	0.93	0.88	0.82
$e_{j,t}$	0.87	0.45	0.55	0.56

Notes: Goodness of fit is measured as $1 - 2[rss_j/(tss_j + \widehat{tss}_j)]$, where tss_j and $\widehat{tss}_j$ are the total sum of squares in the data and in the model, and rss_j is the residual sum of squares. For instance, for GDP, we have $tss_j \equiv \sum_{t=2001}^{2012}(y_{j,t} - \bar{y}_j)^2$, where $y_{j,t}$ and $\bar{y}_j$ are the actual GDP and its sample mean, $\widehat{tss}_j \equiv \sum_{t=2001}^{2012}(\hat{y}_{j,t} - \bar{\hat{y}}_j)^2$, and $rss_j \equiv \sum_{t=2001}^{2012}[y_{j,t} - \hat{y}_{j,t} + \bar{\hat{y}}_j - \bar{y}_j]^2$, where $\hat{y}_{j,t}$ is the prediction of the model and $\bar{\hat{y}}_j$ its sample mean. Hence, the goodness of fit is 1 if the model fits perfectly with the data, and 0 if orthogonal to the data.

between the mean of the data and the mean of the model. The model accounts well for the timing and amplitude of the boom and bust episodes.

Table 5 reports the goodness of fit of the model, defined as the share of the variance explained by the model. The goodness of fit is a number between -1 and 1. It is positive if the model helps reduce the unexplained variance, and it is 1 if the model fits perfectly. The fit is good especially for public debt and funding costs. It does well to reproduce the boom and bust for Ireland, Spain, and Greece where the reversal is most dramatic. But there are some issues. The model overpredicts the boom and bust in Greece. The model overpredicts a little bit of the movements of Irish net exports. In Portugal, the model predicts too much movement in GDP and underestimates funding costs during the crisis. But, overall, the goodness of fit makes us confident that we can use the model to perform our counterfactual experiments.[27]

We are now ready to perform counterfactual experiments. Their validity clearly depends on the hypothesis that our estimated parameters are invariant, which relies on our identification strategy. We were most worried about the issues discussed in the identification section. For instance, because of the private leverage cycle, there is a high risk of overestimating the impact of the sudden stop. For the sudden stop, the obvious issue is that bad news can drive up both the debt and the spreads. We are fully aware that there are other potential biases that we ignore. We think that two issues in particular deserve explicit caveats. The first is that we ignore the contagion from the risk of a particular country to the aggregate risk. This means that we keep the process σ_t constant across our experiment. For instance, this approach misses potential important learning effects by creditors, learning about exit risk (if Greece leaves, creditors learn a country can leave, and then reprice the risk of other countries), and learning about the implementation of EU rules that affects creditors' recovery (in particular, of course, Bank Recovery and Resolution Directive (BRRD) and State Aid rules). The second is the assumption in the fiscal rule that the political economy bias is driven by deep political structures and preferences that are not affected by our counterfactuals. This, we admit, is a limit to our analysis as one can argue that political institutions and preferences may themselves be affected by the financial crisis and our counterfactuals.

III. Counterfactual Experiments

The goal of this section is to provide counterfactual simulations of what would happen to Greece, Spain, Ireland, and Portugal if they followed a different set of policies. We consider four counterfactuals:

- Fiscal policy: what happens with more conservative fiscal policies before 2008?
- Macroprudential policies: what happens with limits on private debt before 2008?

[27] It might be worth emphasizing that the fit is absolutely not mechanical. Recall that our model has no productivity shock, which means that we do not extract any information from the actual GDP series. Another important fact, that we do not have the space to discuss here, is that all these results change dramatically if we use the wrong series. For instance, he goodness of fit turns negative if we do not use Trade in Value-Added to estimate foreign demand shocks, or (even worse) if we use the raw government spread as an estimate of ρ, or if we do not account properly for bank recapitalization expenditures.

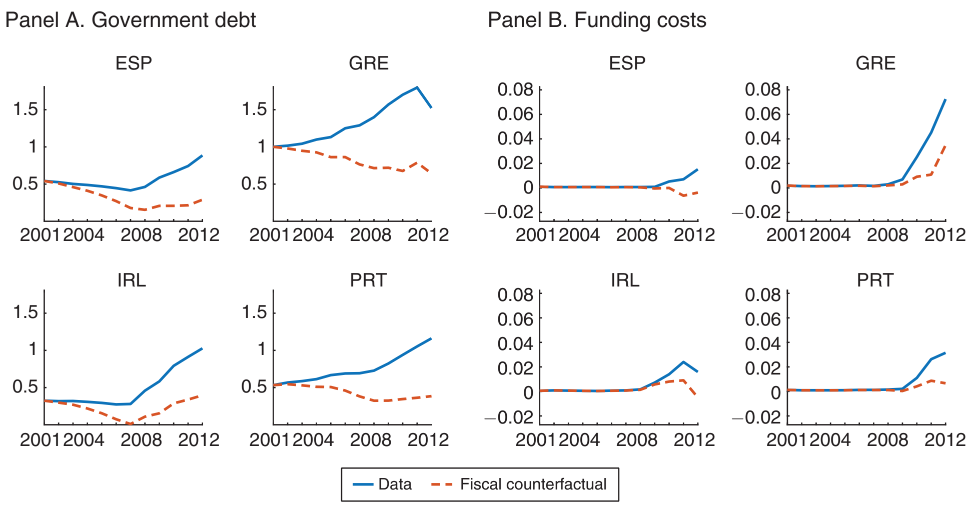

Figure 5. Conservative Fiscal Policy Experiment

- Fiscal and macroprudential policies: what happens when both conservative fiscal and macroprudential policies above are used?
- Monetary policy: what happens if ECB prevents the sudden stop in 2008?

For the counterfactual experiments, we use the equations of the model with the estimated coefficients discussed above but feed it with different exogenous shocks. In all of our experiments, we report on the same graph the actual data and the predicted counterfactual series.[28] The simulations generate series for public debt, private debt, employment, nominal GDP, net exports, and spreads on the period 2001–2012, using debt in 2000 as an initial point.

A. *Counterfactual with a More Conservative Fiscal Policy in the Boom*

How would countries have fared if they had followed more conservative fiscal policies during the boom? We answer this question by setting δ_j^t equal to 0 for the four periphery countries. For Spain, Ireland, and Portugal, all of the other benchmark parameters are left unchanged. For Greece, we need to deal with the debt relief issue. Given that the counterfactual conservative fiscal policy generates debt to GDP ratios much lower than in the data in 2011 and 2012, we assume that debt relief would not have taken place. Hence, for Greece the counterfactual is the combination of a more conservative fiscal policy but also the elimination of a transfer of around 50 percent of nominal GDP in 2011–2012.

Figure 5 shows that the elimination of the spending bias dramatically changes the public debt accumulation in Greece (remember that this more conservative fiscal policy in Greece also means that it does not benefit from the debt relief at the end of the period). It also has a significant impact in Ireland and Spain and Portugal.

[28] The predicted series is defined as data + (model with counterfactual parameters − model with benchmark parameters).

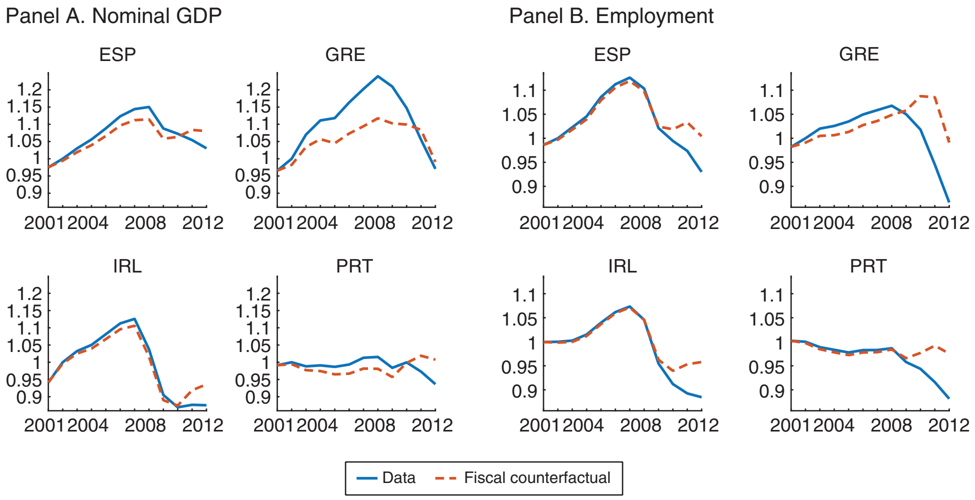

Figure 6. Conservative Fiscal Policy Experiment

This large change in the public debt in turn reduces funding costs during the sudden stop in Ireland and Spain but a spike remains at the end of the period in Greece and to a lower extent in Portugal as shown in panel B of Figure 5 because Greece and Portugal still have a relatively high level of debt when hit by the sudden stop. Lower funding costs reduce the need for fiscal austerity during the bust in all four countries; this is partly the reason for the Spanish and Irish increases in public debt at the end of the period. This change in the profile of fiscal policy means that both the boom in GDP in the years 2000–2008 and the bust afterward are dampened in particular in Greece as shown in panel A of Figure 6. In our model, fiscal policy affects aggregate spending directly but also indirectly because a fiscal stimulus, by raising employment and disposable income of constrained borrowers, enables them to consume more. Unconstrained savers, however, do not react to an increase in government spending by raising nominal expenditures because being Ricardian they save more. Moreover, because a more conservative fiscal policy reduces the employment boom during the 2000–2008 period, it also lowers the increase in wages and prices and the competitiveness loss.

Panel B of Figure 6 shows that a conservative fiscal policy allows Greece to improve its employment dynamics. In the data, the employment loss was 20 percentage points (relative to the eurozone average) between 2008 and 2012. There is still an employment loss with the counterfactual policy during the crisis but a much lower one. The employment gains are lower for Spain, Ireland, and Portugal but still sizable and the counterfactual fiscal policy does not eliminate the boom-bust cycle in employment, but allows for an earlier exit from the recession, especially in Ireland. In Portugal, the conservative fiscal policy also stabilizes employment.

Finally, an important caveat to the conservative fiscal policy counterfactual in Spain and Ireland is that it requires a reduction in debt which we think is unrealistic. Ireland eliminates all its public debt by the end of the boom, and Spain reduces its public debt to around 20 percent of GDP. This suggests that fiscal policy is unlikely

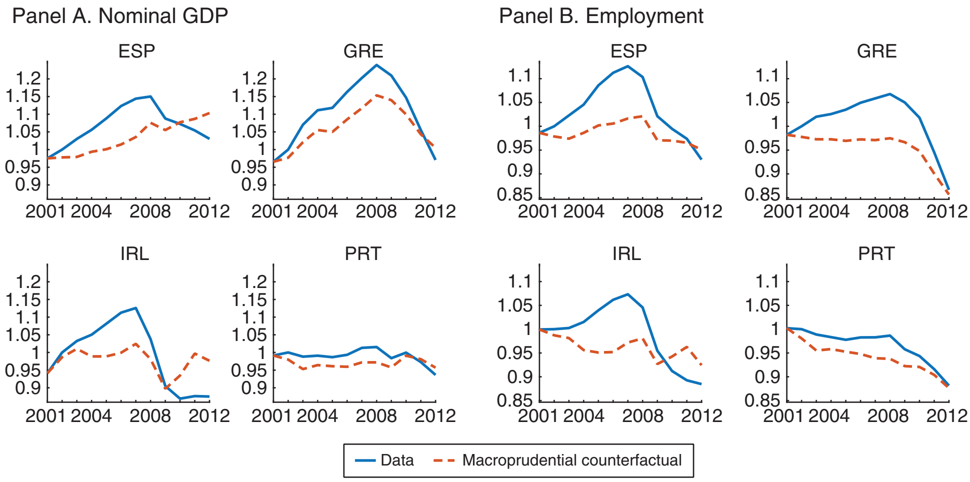

Figure 7. Macroprudential Experiment

to be enough to stabilize an economy subject to a large buildup of private debt. We therefore now turn to macroprudential policies.

B. *Counterfactual with Macroprudential Policies in the Boom*

In this counterfactual we imagine that countries are able to prevent the private leverage boom. We assume that $b_{j,t}^h$ remains constant at its 2001 level. The impact in our model is to dampen the boom because impatient constrained households cannot increase their consumption through leverage.[29] As explained earlier, it is important for this counterfactual to take into account the impact of such policy on the recapitalization of financial institutions during the bust as explained in Section IIB. Hence, we do not use recapitalization in the observed data $(recap_{j,t}^{data})$ but instead a predicted series using equation (17). In our macroprudential experiment we have $b_{j,2007}^h < b_{j,2007}^{h,data}$ and the recapitalization needs are smaller. The timing of recapitalization is unchanged but all the values are scaled down.

The macroprudential policy in the boom therefore reduces recapitalization needs. Figure 7 shows that this macroprudential policy partially stabilizes GDP and employment in all four countries. This is the case in Ireland and Spain. Not surprisingly, given that there was little private leverage boom in Portugal, the impact of a counterfactual macroprudential policy is small in this country. Given that the fiscal drifts are not affected in this counterfactual, the fiscal rule (that contains both a spending and transfer drift and a countercyclical component) induces a larger buildup of public debt (see panel A of Figure 8) than in a situation without macroprudential policy. A second reason public debt increases in this counterfactual is the dampening of the boom in GDP and therefore tax revenues on the period 2002–2008.

[29] Savers expenditures are affected by the path of private leverage only indirectly through its effect on spreads. Savers understand that the net present value (in euros) of their disposable income has not changed when income moves temporarily because of a change in private leverage.

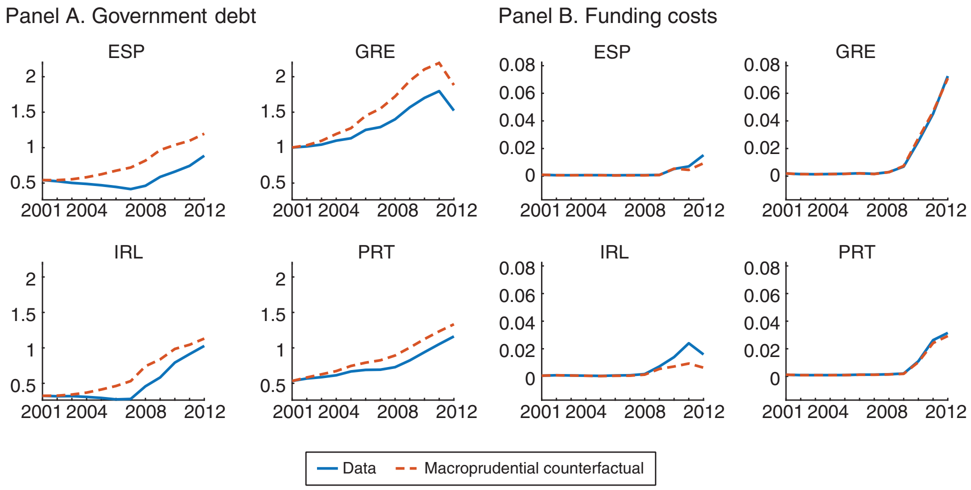

Figure 8. Macroprudential Experiment

An important result therefore is that larger public debt is substituted to private debt to achieve the employment target given that the fiscal bias is still present. There are two opposite effects on spreads: on the one hand the reduction in private leverage and induced bank recapitalization reduces spreads. On the other hand, the larger buildup of public debt pushes spreads upward. In Ireland and Spain, the first effect dominates as spreads are reduced in this counterfactual (see Figure 8). In the other two countries, this is not the case because spreads are driven mostly by the public debt levels. This counterfactual strongly suggests that macroprudential policies that do not come with a more prudent fiscal rule may not have been sufficient to generate a fiscally sustainable stabilization of employment. In this sense, macroprudential policies to constrain private leverage and prudent fiscal policies to constrain public debt are complements, not substitutes.

C. *Counterfactual with Both Conservative Fiscal and Macroprudential Policies in the Boom*

To illustrate this complementarity, we now show a counterfactual that combines both the conservative fiscal and macroprudential policies in the boom. As shown in Figures 9 and 10, this allows to better stabilize GDP, employment, public debt, and spreads. Interestingly in this case, the conservative fiscal policy does not generate an unrealistic elimination of public debt in Ireland.

D. *Counterfactual with "Whatever It Takes" in 2008*

In this counterfactual we ask the following question: what would have happened if the announcements of July 2012 (Mario Draghi's declaration "Whatever it takes") and September 2012 (the OMT program) had come earlier? These announcements were successful in reducing the risk of a euro breakup, financial fragmentation, and the sudden stop. The experiment is to imagine that these actions were implemented

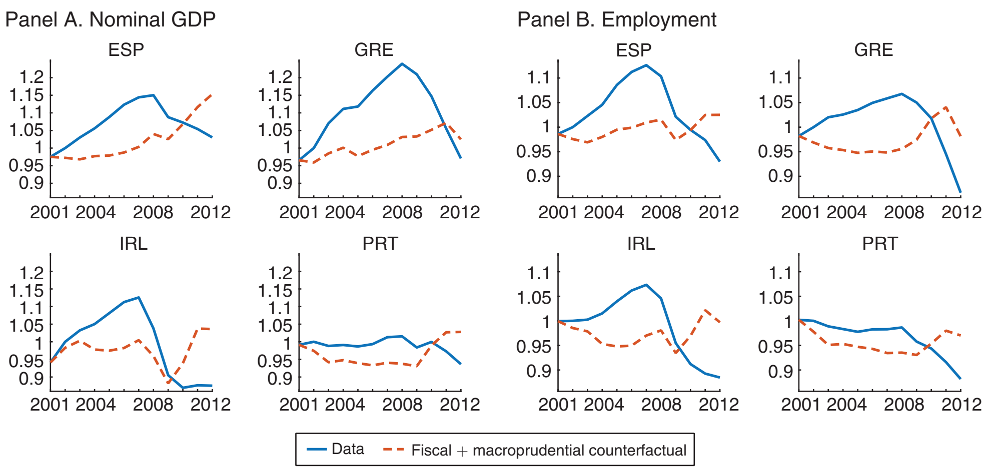

Figure 9. Fiscal and Macroprudential Policies

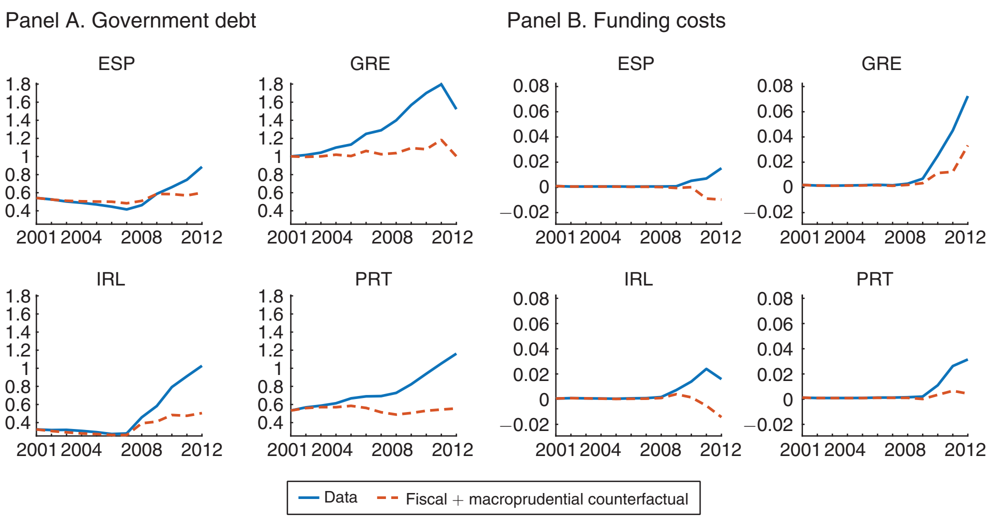

Figure 10. Fiscal and Macroprudential Policies

and successful in 2008 rather than 2012. Specifically, we assume that σ_t, the mean of the absolute value of spreads in the eurozone, in equation (16), is kept at its low 2007 level from 2008 on. Note that this experiment in monetary policy is fundamentally different in our model from a standard monetary policy such as a reduction of interest rates. Remember that our analysis is always conducted on the dynamics of each country *relative to the eurozone average* so that we eliminate the impact of standard monetary policy which is common to all countries. Here, we analyze a policy that reduces the spreads in the eurozone. This experiment indeed effectively eliminates (in Spain and Ireland) or strongly reduces (in Greece and Portugal) the dramatic rise in funding costs as illustrated in panel A of Figure 11.

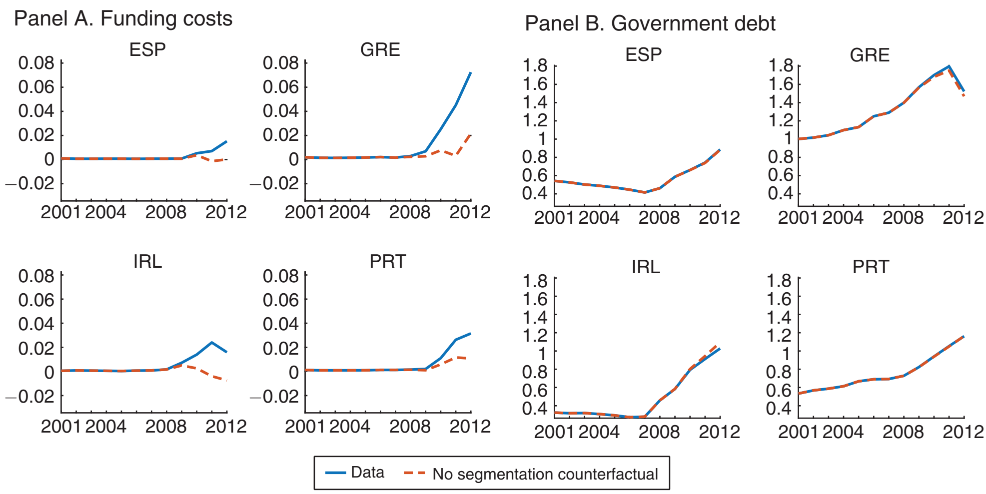

Figure 11. Early ECB Intervention Experiment

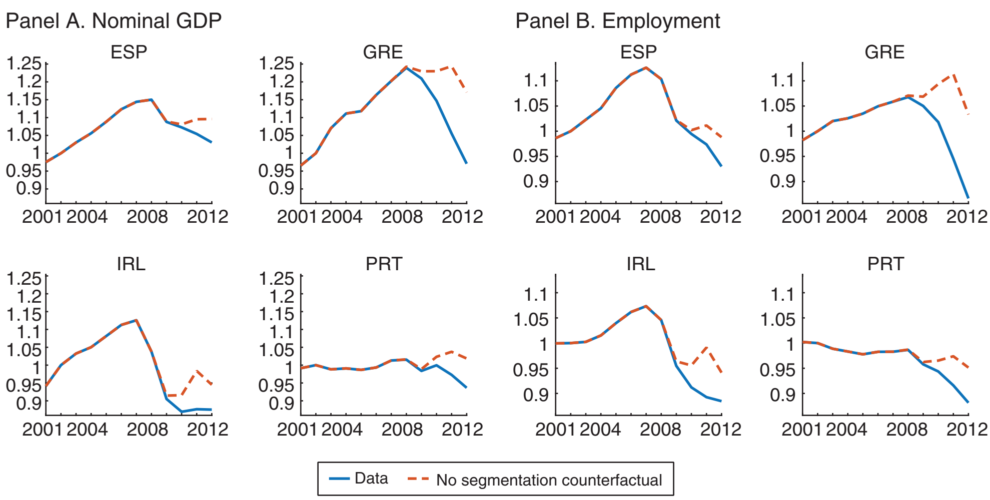

Figure 12. Early ECB Intervention Experiment

The lower funding costs enable countries to dramatically improve nominal GDP and employment when the ECB policy starts in 2008 (see Figure 12). Finally, although not stabilized, public debt is similar to what is observed in the data as illustrated in Figure 11. This is due to larger fiscal receipts thanks to better GDP growth. Lower funding costs affect aggregate spending and employment through three channels: (i) savers do not slash spending as much (see the Euler equation (2)); (ii) the leverage of borrowers does not fall as much (see equation (14)) which in turn positively affects their spending; (iii) fiscal austerity is reduced as fiscal policy (16) is less constrained by the funding costs. In the online Appendix, we report experiments where we remove each channel sequentially to check the relative importance of each. Quantitatively, we find that the fiscal austerity channel is the most important channel through which lower funding costs help stabilize employment. The two other channels are present but are less important. Our conclusion is therefore that, although it would not have stabilized public debt and would not have eliminated the negative consequences of private deleveraging, an early ECB intervention would have dramatically improved employment because fiscal austerity would have been averted in these countries.

IV. Conclusion

Understanding the dynamics of the eurozone is a major challenge for macroeconomics. Eurozone countries have experienced extraordinary levels of real and financial volatility. Unemployment rates have diverged to an extent that no one anticipated. While most observers recognize that private leverage, fiscal policy, sudden stops, and loss of competitiveness all played a role, it has proven challenging to analyze them jointly and even more difficult to disentangle them.

Our paper makes three contributions. We present a model that accounts simultaneously for domestic credit, fiscal policy, and current account dynamics. We create a dataset for 11 countries over 13 years that covers the variables of interest and deals with the various accounting issues. And we propose a new identification strategy that allows us to run counterfactual experiments regarding fiscal policy, macroprudential policy, and ECB interventions. The results from our counterfactual experiments on employment are summarized in Table 6. We report the actual change in employment and the change predicted by the structural model on the period 2008–2012, as in Figure 4. Stronger fiscal discipline during the boom would have made the recession less severe, especially in the case of Greece where we estimate that the employment loss between 2008 and 2012 would have been one-half of the observed one (again relative to the eurozone average). The impact is very large in Portugal too. In the case of Spain and even more so Ireland, the conservative fiscal policies in the boom help to partially stabilize employment but seem unrealistic since they require buying back almost the entire stock of public debt. A macroprudential policy to limit private leverage during the boom would have helped to stabilize employment especially in Ireland and Spain but would not have been sufficient. In the absence of a more prudent fiscal policy, this could have induced a larger buildup in public debt which would have partly undone the benefits of lower private debt. In Greece and Portugal, given the political fiscal bias, the gains from macroprudential policy would have been partly undone by looser fiscal policy in the boom. One lesson we take from this exercise is therefore that, due to political economy reasons, fiscal and macroprudential policies are complement rather than substitute when it comes to stabilizing the economy. In all four countries, the combination of conservative fiscal and macroprudential policies is the only one that enables them to stabilize employment and public debt. Another contribution of the paper is to show that the sudden stop episode dramatically worsened the crisis by constraining governments fiscal policy during the bust. If the ECB had successfully reduced the spreads early in the crisis, the employment losses between 2008 and 2012 would have been significantly smaller in all four countries. Without financial fragmentation, the eurozone would have experienced a boom-and-bust cycle similar to the one in the United States. However, this policy alone would not have avoided the large buildup in public debt.

TABLE 6—COUNTERFACTUAL EMPLOYMENT DYNAMICS (*Percent*)

	ESP	GRE	IRL	PRT
Actual change in employment, 2008–2012	−17.3	−20.1	−16.1	−10.5
Counterfactual employment changes 2008–2012				
Conservative fiscal policy during boom	−7.9	−9.7	−8.5	−1.8
Macroprudential policy during boom	−5.1	−14.1	−5.2	−6.5
Conservative fiscal and macroprudential	+4.3	−3.6	+2.3	+2.2
No financial segmentation after 2008	−10.5	−8.2	−10.2	−4.2

Notes: Spain lost 17.3 percentage points of employment—more than the eurozone average—between 2008 and 2012. If Spain had run a successful macroprudential policy during the boom, its employment loss between 2008 and 2012 would have been −7.9 percentage points instead of −17.3. This prediction takes into account the fact that the baseline structural model does not fit perfectly. So we compute $\Delta n^{pred} = \Delta n^{counter}(\Delta n^{data}/\Delta n^{baseline})$. If the baseline fit was perfect, $\Delta n^{data}/\Delta n^{baseline} = 1$, and this would simply be $\Delta n^{counter}$. Otherwise, we use the relative change. In the case of Greece, for instance, the model overpredicts Δn, so $\Delta n^{data}/\Delta n^{baseline} < 1$.

In a previous version of this article (Martin and Philippon 2014), we performed an additional counterfactual where we analyzed the impact of fiscal devaluation in 2009 that enables periphery countries to recoup part of the competitiveness they had lost during lost during the boom years. For this exercise which is detailed in the online Appendix, we use a similar model but with a simpler Philipps curve and the fiscal devaluation is achieved through the combination of a valued-added tax (VAT) tax on all domestic expenditures (private and public) and a payroll subsidy on wages. The VAT is paid by firms and rebated to exporters. The payroll subsidy on labor (equal to the VAT rate) is paid to domestic firms. The impact of the fiscal devaluation is that export prices fall, foreign demand increases, while domestic prices for domestic consumers remain unchanged.[30] In this counterfactual, we found that the increase in exports attenuates the fall in employment in all countries. This comes directly but also because both borrowers and savers consume more following the increase in foreign demand. Another effect of the fiscal devaluation is that the improved employment figures induce governments to cut spending and transfers. Because of this and because of the stimulative effect of the fiscal devaluation on income taxes, the trajectory of public debt is improved. This suggests that a condition for a successful fiscal adjustment is that countries can engineer such a change in relative prices even in a monetary union. We leave for further research to analyze more in detail the conditions of such a fiscal adjustment.

The contribution of our paper is to provide a coherent and quantitative framework to study the eurozone crisis, and this requires integrating various strands of the literature. On the other hand, the weakness of our analysis is that we are forced to treat some deep issues rather superficially. In our view, political economy issues and sovereign default decisions deserve a much deeper analysis. In our model, political economy issues are captured by a bias in the fiscal rules. This is a useful starting point but it is not a satisfactory answer. For instance, Fernández Villaverde, Garicano, and Santos (2013) argue that financial booms can lead to weaker monitoring and

[30] The fiscal devaluation is made fiscally neutral through a lump sum transfer to households so that the revenues from the VAT equal the cost of the payroll subsidy and the transfer. However, the indirect effects on income tax revenues that arise from the stimulative effects of a fiscal devaluation on output remain as would be the case of an exchange rate devaluation.

a deterioration in governance. Technically, this violates our identifying restriction since we assume that the political economy bias and the leverage boom do not affect each other directly. But more important, it shows that we need a deeper understanding of the interaction between governments and financial markets. For tractability reasons, we have also abstracted from a full analysis of investment both housing and business capital expenditures. This is clearly another avenue for future research.[31]

Similarly, we summarize sovereign default risk by a bond pricing equation. We are of course careful to estimate this equation with plausible instruments and to make sure that it fits well, which is critical for our experiments. But this clearly is not a satisfactory treatment of strategic sovereign default. Moreover, this approach does not help us to analyze reforms that would sever the link between sovereign risk and the private cost of funds. A sensible goal for the eurozone is to ensure that governments can default within the currency union and without destroying private financial markets. Understanding what is required to reach this goal is an important avenue for future research.

Appendix

A. *Simulation of the Model*

To run the simulations, we first need to set the initial conditions in a particular year. We use 2002 as our base year t_0.

(i) Natural employment and prices (which are equal to wages) are normalized to $n^* = 1$ and $p^h_{j,t_0} = 1$ so nominal GDP is normalized in the base year to $y_{j,t_0} = 1$.

(ii) Variables set to their observed values are b^h_{j,t_0}, t_{j,t_0}, g_{j,t_0}, b^g_{j,t_0}, b^g_{j,t_0-1}, r_{j,t_0}. Foreign demand is set using data on exports in value-added terms for 2001–2012, normalized so that the level of foreign demand in 2002 satisfies goods market clearing in the model. The tax rate is constant at its 2002 level and equal to total government revenues as a percentage of GDP.

   (a) Foreign demand f_{j,t_0} is chosen so as to match net exports $e_{j,t_0} = \frac{1}{\alpha_j}\left(f_{j,t_0} - \left(1-\alpha_j\right)\left(y_{j,t_0} - g_{j,t_0}\right)\right)$.

   (b) We get τ_j from the government budget constraint $g_{j,t_0} + t_{j,t_0} - \tau_j y_{j,t_0} = \frac{b^g_{j,t_{0+1}}}{1+r_{j,t_0}} - b^g_{j,t_0}$.

The structural shocks are $\hat{b}^h_{j,t}$, σ_t, $\tilde{g}_{j,t}$ and $\tilde{t}_{j,t}$ as well as foreign nominal demand shocks $f_{j,t}$. For each country, we then simulate the path between 2001 and 2012 of nominal GDP $y_{j,t}$, employment $n_{j,t}$, wages $w_{j,t}$, net exports $e_{j,t}$, and public debt $b^g_{j,t}$.

[31] Gourinchas, Philippon, and Vayanos (2017) introduce capital accumulation in a similar model for Greece. This opens a host of interesting and complicated issues. Despite these differences, their main conclusions for Greece are rather similar to ours.

Given the fiscal rule, the budget constraint determines the evolution of public debt. Given that the tax rate τ_j is constant but different for each country, debt sustainability is insured by our choice of parameters of the fiscal rule, in particular the fact that the spending drift is reversed after 2008.[32]

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