Household Leverage and Sovereign Risk*

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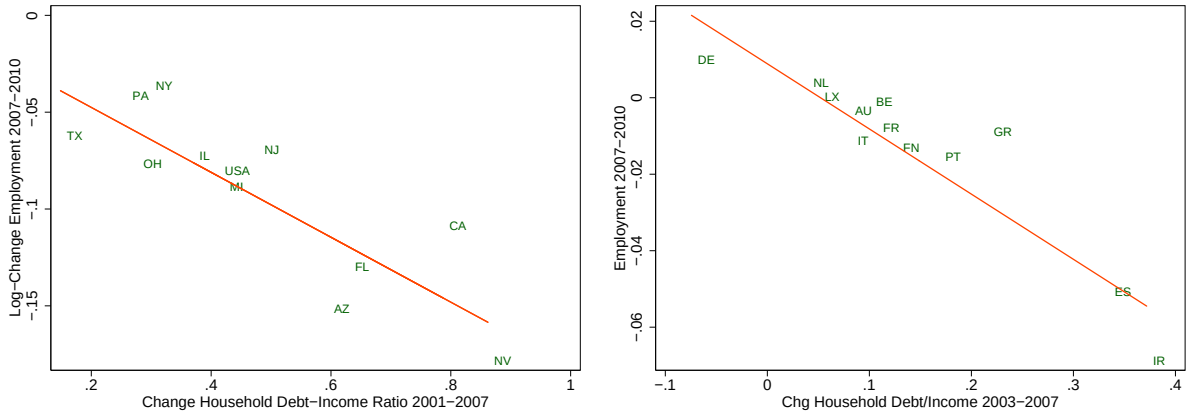
Abstract

We compare the Great Recessions in the U.S. and the Eurozone, and ask: (i) What are the main drivers of the recession? (ii) What can we learn from the way the two currency areas cope with the recession? We find that, from 2007 to 2009, the two recessions are driven by household leverage. In both regions, states that have experienced the largest increases in household leverage during the credit boom experience the largest declines in output and employment. The responses across U.S. states and Eurozone countries are strikingly similar during this first phase, and there is no evidence that one region behaves more like an optimal currency area than the other. These similarities break down in 2010 exactly when sovereign spreads widen across the eurozone. Across the eurozone, the recession is then driven by fiscal policy retrenchment in states where government spending increased during the boom, while the US enters a fairly uniform recovery. We study these facts in a model where macroeconomic dynamics are driven by private and public leverage decisions.

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A salient feature of the recent recession is that regions that have experienced the largest swings in household borrowing have also experienced the largest declines in employment and output. Figure 1 illustrates this feature of the data, by plotting the change in employment during the credit crunch (2007-2010) against the change in household debt-to-income ratios during the preceding boom (2001-2007 for the US, 2003-2007 for the EZ).[1]

Figure 1: First Stage of the Great Recession: Household Borrowing predicts Employment Bust

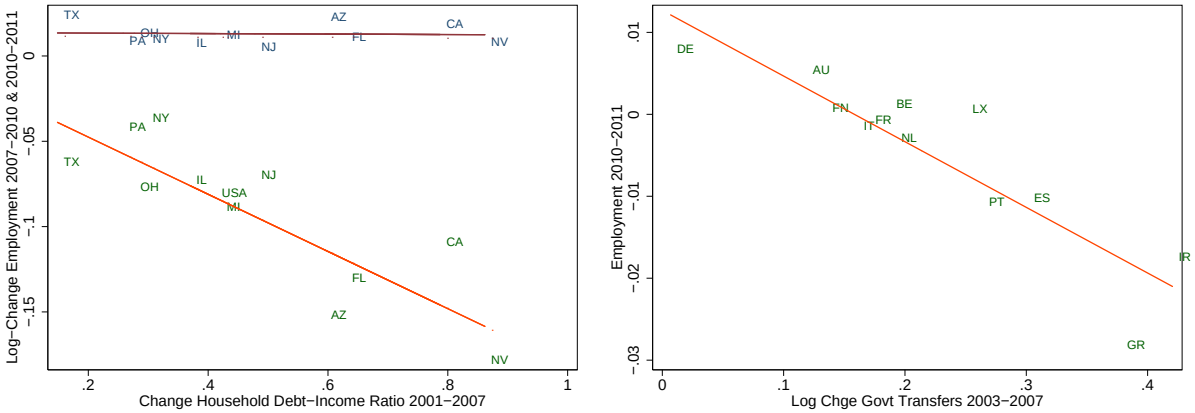


Notes. Employment Growth from 2007 to mid-2010. The change in household debt to income ratio from 2001 to 2007 for the US is from Midrigan and Philippon (2010). For the EU, the change is from 2003 to 2007 because of data limitations.

The American and European experiences look strikingly similar in this respect on the period 2007-2010. This suggests that the shock faced by these two economies were similar in nature. As noted in Midrigan and Philippon (2010), this pattern is at odds with the predictions of standard models of financing frictions. Such models predict that a tightening of borrowing constraints at the household level leads to a decline in consumption but, due to wealth effects, to an increase in the supply of labor. In this paper, we introduce a liquidity shock, that can, both in the US and the economy, broadly reproduce what was observed for employment and private consumption. The nominal credit shock generates a decline in borrowing which tightens the cash-in-advance constraint thus leading to a fall in consumption spending. In addition to the cash-in-advance and collateral constraints, we introduce nominal wage rigidities which translate the decline of nominal expenditures into employment. We also show that, faced with such a shock, governments can counteract it by doing the borrowing themselves and undo some of the private credit shock with nominal transfers to the private sector.

[1]The red lines in Figure 1 are not regression lines, they represented the predicted values from our calibrated model. Data sources are described in the Appendix.

Figure 2: Second Stage of the Great Recession: Government Spending predicts Employment Bust



Notes. Employment Growth from mid-2010 to end of 2011. LHS show US experience, from 2007 to mid 2010 (as in Figure 1), and then from mid 2010 to end of 2011. Right Panel shows EZ experience from mid 2010 to end of 2011, as function of log-change in government transfers from 2003 to 2007.

Figure 2 illustrates the differences between the American and European experiences during the second stage of the recession. Starting in the Spring of 2010, sovereign spreads widen and several European countries find it difficult to borrow on financial markets. The US and EZ experiences then start to diverge. While US states grow (slowly) together, EZ countries experience drastically different growth rates and employment. But the state variable that correlates with labor markets performance is not household leverage anymore, it is government spending during the boom. EZ countries where government spending increased the most from 2003 to 2007 are the ones that are now experiencing severe recessions in the second stage. We model this second stage with a tightening of the borrowing constraint of the government in some European countries. This tightening of the public borrowing constraint reduces nominal transfers at a moment where the private credit shock would require more public borrowing.

Relation to the literature

Our paper is related to four lines of research: (i) macroeconomic models with credit frictions, (ii) monetary economics, (iii) sovereign debt and fiscal policy. We discuss the connections of our paper to each topic. Following (Bernanke and Gertler, 1989; Cooley, Marimon, and Quadrini, 2004; Corsetti and Muller, 2011), many macroeconomic papers introduce credit constraints at the entrepreneur level (Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999)). In all these models, the availability of credit limits *corporate* investment. As a result, credit constraints affect the economy by affecting the size of the capital stock. Gertler and Kiyotaki (2010) study a model where shocks that hit the financial intermediation sector lead to tighter borrowing constraints for entrepreneurs. We model shocks in a similar way. The difference is that our

borrowers are households, not entrepreneurs, and, we argue, this makes a difference for the model's cross-sectional implications. Models that emphasize firm-level frictions cannot reproduce the strong correlation between household-leverage and employment at the micro-level, unless the banking sector is island-specific, as in the small open economy "Sudden Stop" literature (Chari, Kehoe, and McGrattan (2005), Mendoza (2010)). This "local lending channel" does not appear to be operative across U.S. states, however, presumably because business lending is not very localized.[2]In the eurozone, financial integration has also - until the most recent crisis - led to large cross-border lending. On the monetary side, we follow the cash-in-advance literature of Lucas (1980) and Lucas and Stokey (1987). Most closely connected to our paper is the work of Midrigan and Philippon (2010), Guerrieri and Lorenzoni (2010) and Eggertsson and Krugman (2011) who also study the responses of an economy to a household-level credit crunch. Our paper is also related to the literature on sovereign default (see Eaton and Gersovitz,1981, Arellano, 2008 and Mendoza and Yue 2010) that models default as a strategic decision with a tradeoff between gains from forgone repayment and the costs of exclusion from international credit markets. The objective of our paper however is to analyze how the sovereign default risk can affect the real economy through the impact it can have on liquidity available to households. The paper by Corsetti and Muller (2011)considers a "sovereign risk channel," through which sovereign default risk spills over to the rest of the economy, raising funding costs in the private sector.

In Section 1 we present the model. In Section 2 we define the equilibrium and the steady state. In 3, a section still very preliminary, we propose a quantitative calibration and we study the response of the economy to various shocks. Section 4 concludes.

1 Model

We study a closed economy with a continuum of islands that trade with each other. Each island produces tradable and non-tradable goods and is populated by a representative household. Means of payment are provided by the government and by private lenders (banks and shadow banks).

Our model can be interpreted as a large country with a collection of regions (e.g., USA), or a monetary union with a collection of states (e.g., EZ). The key assumption are that these regions share a common currency, and that agents live and work in only one region.

[2]For instance, 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 balanced sheets and were able to draw on existing credit lines (Ivashina and Scharfstein, 2008).

1.1 Households

The household's preferences are given by:

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t u\left(\bar{C}_{i,t}, L_{i,t}\right)$$

where $\bar{C}_{i,t}$ denotes consumption and $L_{i,t}$ is an index of labor supplied. We motivate the demand for money with a constraint à la Clower (1967). An important feature of our model is that households have two sources of liquidity: cash and private credit. In the remaining of the paper, we use the following specification for the utility function:

$$u\left(\bar{C}_{i,t}, L_{i,t}\right) = \log \bar{C}_{i,t} - \frac{L_{i,t}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}.$$

As in all cash-in-advance models, we must specify the timing of trades within a period. We follow the timing proposed by Lucas (1980).[3] Each period is divided into three stages. Households enter the period with cash $M_{i,t-1}$ and assets $B_{i,t-1}$. Cash and financial accounts are segmented. Financial markets open first. The household receives the interest on last period assets $r_{t-1}B_{i,t-1}$ and decides on a net transfer $N_{i,t}$ from its asset account to its cash account. This transfer is added to the cash account only at the *end* of the period and cannot be used to purchase goods until period $t+1$. The household can however obtain short term credit (privately issued means of payment) $\tilde{M}_{i,t}$ from financial intermediaries. Households can use government bonds $B_{i,t-1}$as collateral for getting short term credit. The cash they can borrow using these government bonds as collateral is: $\mu(1-\rho_{i,t})B_{i,t-1}$ where μ is a parameter and $\rho_{i,t}$ is a shock on the riskiness of public debt and can be thought of as the haircut applied on the public debt used as collateral. In reality, governement bonds in Europe are held by banks not households but the key aspect of our modelling is that government bonds are used as collateral to get short term credit and that during the sovereign debt crisis in the euro zone the perceived value of this collateral collapsed and that led to a sharp decrease in private credit.

The government receives income taxes $\tau W_{i,t-1}L_{i,t-1}$ from the previous period, pays interest on outstanding debt, and borrows $B_{i,t} - B_{i,t-1}$.

In the second stage, each household splits into a worker and a shopper. The shopper can spend no more than $M_{i,t-1} + T_{i,t} + \tilde{M}_{i,t} + \mu(1-\rho_{i,t})B_{i,t-1}$, while the worker supplies her labor but is paid only at the

[3]Sargent and Smith (2009) discuss the importance of the timing of tax collection. This issue does not matter when we perform our cross-sectional analysis since we set taxes to zero. It can matter, however, when we consider various monetary policy responses in the last section of the paper. See also Lucas and Stokey (1987).

end of the period. In the last stage of the period, the household receives its labor income (and the profits distributed by the firms if any), repays the private lenders. The transfer $N_{i,t}$ from the asset account arrives in the cash account, and the households carries over $M_{i,t}$ units of cash to the next period. Notice that $\tilde{M}_{i,t}$ is within-period credit. The timing of the model is summarized in Table 1.

Table 1: Timing of Cash and Credit Flows within Time t

	(i)	(ii)	(iii)
	Households		
Cash Account	$M_{i,t-1}$	$\ldots + T_{i,t} + \tilde{M}_{i,t} - \bar{P}_{i,t}\bar{C}_{i,t}$	$\ldots + N_{i,t} - \tilde{M}_{i,t}$
Assets	$(1 + r_{t-1}) B_{i,t-1} - N_{i,t}$	$\ldots$	$B_{i,t}$
Short Term Credit	$+\tilde{M}_{i,t}$	0	$-\tilde{M}_{i,t}$
Net Income	0	$T_{i,t} - \bar{P}_{i,t}\bar{C}_{i,t}$	$(1 - \tau_i) W_{i,t} L_{i,t}$
	Government		
Net Income	$\tau W_{i,t-1} L_{i,t-1} - (1 + r_{t-1}) B_{i,t-1}$	$-T_{i,t}$	$B_{i,t}$

The consumer spends his balances on consumption subject to the cash & credit in advance constraint

$$\bar{P}_{i,t}\bar{C}_{i,t} \leq M_{i,t-1} + T_{i,t} + \tilde{M}_{i,t}, \tag{1}$$

Equation (1) says that firms accept to sell goods in exchange for bills printed by the government as well as units of credit issued by banks. The amount of private credit is subject to the constraint:

$$\tilde{M}_{i,t} \leq \Theta_{i,t} + +\mu(1 - \rho_{i,t}) B_{i,t-1}. \tag{2}$$

As in the search theory of money (see Lagos (2010) for a discussion and references), the idea is that consumers are anonymous to firms, but not to banks. Firms therefore cannot trust consumers to repay but they can go after the banks. There are two sources of collateral: private assets and public bonds. On private assets, banks have the ability to recover $\Theta_{i,t}$ in case the household runs away from its debts. For now we take the parameter $\Theta_{i,t}$ as exogenous. Public bonds can also serve as collateral for short term credit but this collapses during a sovereign debt crisis.

[4] We assume free entry in the banking sector, thus in equilibrium the within period rate is zero. At the end

[4] Midrigan and Philippon (2010) model home equity borrowing. In this case, private credit uses housing wealth as collateral, and the constraint is $\Theta = \theta q H$ where q is the price and H the quantity of housing, and θ a parameter. Also recall that $\tilde{M}$ is

of the period, the consumer repays $\tilde{M}_{i,t}$ to the bank, and the bank pays $\tilde{M}_{i,t}$ to the producer. Finally, we assume that the discount factor β and the lending parameter $\Theta_{i,t}$ are low enough for the constraints (1) and (2) to bind in all islands at all times.

The aggregate model has a unique steady state. In the cross-section of small open economies, however, asset holdings can be indeterminate. Following Schmitt-Grohe and Uribe (2003) and Neumeyer and Perri (2005), we therefore assume that households face a quadratic cost of deviating from the steady state bond position.[5] Let $W_{i,t}$ denote nominal wages (product markets are competitive so there are no profits). At the end of the period, the liquidity position of the household is therefore:

$$M_{i,t} = (1 - \tau_i) W_{i,t} L_{i,t} + M_{i,t-1} + T_{i,t} - \bar{P}_{i,t} \bar{c}_{i,t} + N_{i,t}. \tag{3}$$

The household's position in the asset market evolves according to:

$$B_{i,t} = (1 + r_{t-1}) B_{i,t-1} - N_{i,t} - \frac{1}{2} \psi \left(B_{i,t} - \bar{B}_t \right)^2 + \Psi_t, \tag{4}$$

where r_t is the one-period nominal risk free rate between t and $t+1$. We derive the first-order conditions in the Appendix. With binding CiA constraints, the marginal utility of cash is

$$\alpha_{i,t} = \beta \mathbb{E}_t \left[\frac{1}{P_{i,t+1} C_{i,t+1}} \right], \tag{5}$$

and the Euler equation is

$$\alpha_{i,t} \left(1 + \psi \left(B_{i,t} - \bar{B}_t \right) \right) = \beta (1 + r_t) \mathbb{E}_t \left[\alpha_{i,t+1} \right] + \beta \mu \mathbb{E}_t \left[\gamma_{i,t+1} \left(1 - \rho_{i,t+1} \right) \right]. \tag{6}$$

where $\gamma_{i,t}$ is the multiplier on the cash in advance constraint. In addition to the standard elements of the Euler equation, government bonds enable the consumers to get short term credit in the next period.

1.2 Government

Taxes are received with a one period delay, and for now we ignore real government consumption of goods and services. The government budget constraint is given by:

within-period credit, i.e. credit flowing from workers to shoppers subject to the cash-advance-constraint. In that sense, $\tilde{M}$ is really private money.

[5] For simplicity, we assume that this cost is a rebated to agents through a lump-sum transfer $\Psi_t = \frac{1}{2} \psi \left(A_{i,t} - \bar{A}_t \right)^2$. Hence the resource constraint is unaffected.

$$T_{i,t} = B_{i,t} + \tau W_{i,t-1} L_{i,t-1} - (1 + r_{t-1}) B_{i,t-1} \tag{7}$$

The government chooses transfers and borrowing. We assume (see Corsetti and Muller (2011)) also that the government's reaction function depends on two objectives: macro-economic stabilization and debt sustainability. The following rule captures these two objectives:

$$T_{i,t} = \bar{T}_i + \epsilon_X \left(\bar{X}_i - X_{i,t} \right) + \epsilon_B \left(\kappa_i Z_{i,t} - B_{i,t} \right) \tag{8}$$

The first term of the RHS is a standard counter-cyclical rule according to which the goverment increases transfers when nominal spending is weak, which corresponds to weak employment.

The second objective, captured by $\epsilon_B \left(\kappa_i Z_{i,t} - B_{i,t} \right)$, is debt-sustainability. For simplicity, we assume continuous haircuts. At any time t, the government defaults on a fraction ρ_{t-1} of its debt. At time t, the government repays $\left(1 + \hat{r}_{i,t-1}\right) \left(1 - \rho_{i,t-1}\right) B_{i,t-1}$ where $\hat{r}_{i,t-1}$ is the yield on government debt. The arbitrage condition for investors naturally implies $\left(1 + \hat{r}_{i,t-1}\right) \left(1 - \rho_{i,t-1}\right) = 1 + r_{t-1}$. Note that the budget constraints (4) and (7) are not affected because returns and repayments (net of default) are equal to the risk free return. The assumption of continuous haircuts allows this simplification. Given a tax rate τ_i, assumed constant for now, we define the NPV of tax revenues as $Z_{i,t} \equiv \tau_i \mathbb{E}_t \left[\sum_{s=0}^{\infty} \frac{W_{i,t+s+1} L_{i,t+s+1}}{\prod_{s=0}^{\infty} (1 + \hat{r}_{i,t+s})} \right]$, which is equivalent to:

$$Z_{i,t} \equiv \tau_i \mathbb{E}_t \left[\sum_{s=0}^{\infty} \frac{\prod_{s=0}^{\infty} \left(1 - \rho_{i,t+s}\right)}{\prod_{s=0}^{\infty} \left(1 + r_{t+s}\right)} W_{i,t+s+1} L_{i,t+s+1} \right] \tag{9}$$

The debt sustainabilty constraint is meant to capture pressures from private lenders and public lenders. The shock $\rho_{i,t}$ is a risk premium shock which affects the expected repayments by country i. We assume that there also is a country specific parameter κ_i that characterizes sustainability. If $B_{i,t} > \kappa_i Z_{i,t}$, sustainability is precarious, and transfers decrease.

1.3 Wages

So far we have described the program of households as if there were no frictions in the labor market. In the quantitative experiments below we allow wages to be sticky.[6] We assume partial-adjustment model in which

[6] Alternatively, we could model households as being represented by unions who face a constant hazard of resetting their wages, as in the Calvo model. This alternative specification, though more notationally burdensome, would produce very similar results. Also note that what matters for our cross-sectional result is the stickiness of relative wages across islands. Strictly speaking, our interpretation of rigidities as being nominal – denominated in units of currency common to all islands and controlled by a central bank – only matters when we analyze counter-factual monetary experiments.

a fraction $1-\lambda$ of the gap between the actual and desired wage is closed every period. The wage in island i at time t is given by

$$W_{i,t} = \left(W_{i,t-1}\right)^{\lambda} \left(W_{i,t}^{*}\right)^{1-\lambda} \tag{10}$$

where $W_{i,t}^{*}$ is the the frictionless nominal wage, implicitly defined by the labor-leisure choice:

$$(1-\tau)\,\beta \mathbb{E}_t \left[\frac{u_{C,it+1}}{\bar{P}_{i,t+1}}\right] W_{i,t}^{*} = -u_{L,it}.$$

The parameter λ measures the degree of nominal rigidity. When $\lambda = 1$ wages are fixed, and when $\lambda = 0$ wages are fully flexible. Given the assumptions we have made on preferences, we can write the frictionless wage as:

$$W_{i,t}^{*} = \frac{\left(L_{i,t}\right)^{\frac{1}{\nu}}}{\beta\left(1-\tau_i\right)} \left(\mathbb{E}_t \left[\frac{1}{\bar{P}_{i,t+1}\bar{C}_{i,t+1}}\right]\right)^{-1}. \tag{11}$$

1.4 Consumption

Household's consumption is an aggregate over the consumption of different varieties of tradable and non-tradable goods. We assume that the aggregation function has a constant elasticity of substitution σ between tradables and non tradables:

$$\bar{C}_{i,t} = [\omega^{\frac{1}{\sigma}} \left(\bar{C}_{i,t}^{t}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega)^{\frac{1}{\sigma}} \left(C_{i,t}^{n}\right)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}},$$

where $\bar{C}_{i,t}^{t}$ is the consumption of the tradable good, $C_{i,t}^{n}$ is the consumption of the non-tradable good, and $\omega_c \in (0,1)$ is the weight on tradables in the aggregator. The tradable good is itself an aggregate of the goods produced on different islands, with elasticity of substitution γ between goods produced on different islands:

$$\bar{C}_{i,t}^{t} = \left(\int_j C_{i,t}^{t}(j)^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}}$$

where j denotes the island where the good is produced. Let $\bar{P}_t^t$ denote the price index for tradable goods. It is common to all islands since we assume no trade costs, and it given by $\bar{P}_t^t \equiv \left(\int_i \left(P_{i,t}^{t}\right)^{1-\gamma}\right)^{\frac{1}{1-\gamma}}$, where $P_{i,t}^{t}$ denotes the price at which the tradables produced on island i are sold. Let $P_{i,t}^{n}$ denote the price of non-tradable goods in island i. The total consumption price index on island i is: $\bar{P}_{i,t} \equiv \left[\omega\left(\bar{P}_t^t\right)^{1-\sigma} + (1-\omega)\left(P_{i,t}^{n}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$. Private demand for non-tradables is:

$$C^n_{i,t} = (1-\omega)\left(\frac{P^n_{i,t}}{\bar{P}_{i,t}}\right)^{-\sigma}\bar{C}_{i,t} \tag{12}$$

The demand on island i for tradables produced by island j is:

$$C^t_{i,t}(j) = \omega\left(\frac{P^t_{j,t}}{\bar{P}^t_t}\right)^{-\gamma}\left(\frac{\bar{P}^t_t}{\bar{P}_{i,t}}\right)^{-\sigma}\bar{C}_{i,t} \tag{13}$$

1.5 Production and Market Clearing

We assume perfect competition in both tradables and non-tradables. Each island is inhabited by a continuum of firms that produce a tradable good, and a continuum of firms that produce a non-tradable good. We also assume that labor is the only factor and that production is constant returns to scale:

$$Y^n_{i,t} = L^n_{i,t} \quad \text{and} \quad Y^t_{i,t} = L^t_{i,t} \tag{14}$$

Because of perfect competition the price of both tradable and non-tradable goods is equal to the nominal marginal cost in each sector on the island: $P^t_{i,t} = W^t_{i,t}$, and similarly $P^n_{i,t} = W^n_{i,t}$. Government expenditures are made entirely of non tradable goods so market clearing requires

$$Y^n_{i,t} = C^n_{i,t}, \tag{15}$$

in the non tradable sector, and

$$Y^t_{i,t} = \int_{j\in[0,1]} C^t_{j,t}(i), \tag{16}$$

in the tradable sector.

2 Equilibrium

2.1 Equilibrium conditions

We assume exogenous shocks to the tightness of the borrowing constraint for the private sector $\Theta_{i,t}$ as well as a risk premium shock that affects the expected net present value of government revenues which in turn affects its ability to borrow. Combining the CiA constraint (1) with the collateral constraint equation (2) we obtain a collateralized-credit-in-advance (CCiA) constraint: $\bar{P}_{i,t}\bar{c}_{i,t} = M_{i,t-1} + T_{i,t} + \Theta_{i,t}$. We define $X_{i,t}$

as nominal private spending in island i at time t, $X_{i,t} \equiv \bar{P}_{i,t}\bar{c}_{i,t}$:

$$X_{i,t} = M_{i,t-1} + T_{i,t} + \Theta_{i,t} + \mu(1-\rho_{i,t})B_{i,t-1} \tag{17}$$

To complete the description of the economy, we need to specify monetary and fiscal policy. Cash holdings evolve according to (3) at the island level. At the aggregate level of the currency union, for most of our analysis we simply assume that the stock of currency remains constant, and we normalize it to $M_t \equiv \int M_{it}di = 1$.[7]

Nominal wage setting is given by (10), and labor market clearing in each island implies $L_{i,t} = L^n_{i,t} + L^t_{i,t}$. Using $X_{i,t}$, we can rewrite the labor supply (11) as

$$\left(L^n_{i,t} + L^t_{i,t}\right)^{\frac{1}{\nu}} = \beta\left(1-\tau_i\right) W^*_{i,t}\mathbb{E}_t\left[X^{-1}_{i,t+1}\right]. \tag{18}$$

Trade and technology pin down labor demands. For local goods, we have $L^n_{i,t} = C^n_{i,t}$, which we can rewrite as

$$L^n_{i,t} = (1-\omega)\frac{X_{i,t}W^{-\sigma}_{i,t}}{\bar{P}^{1-\sigma}_{i,t}}. \tag{19}$$

For traded goods, we have $L^t_{i,t} = \int_j c^t_{j,t}(i)dj$ which we can rewrite as

$$L^t_{i,t} = \omega W^{-\gamma}_{i,t}\left(\bar{P}^t_t\right)^{\gamma-\sigma}\int_j \frac{X_{j,t}}{\bar{P}^{1-\sigma}_{j,t}} \tag{20}$$

The price indexes are such that

$$\left(\bar{P}_{i,t}\right)^{1-\sigma} = \omega\left(\bar{P}^t_t\right)^{1-\sigma} + (1-\omega)\left(W_{i,t}\right)^{1-\sigma} \tag{21}$$

and

$$\left(\bar{P}^t_t\right)^{1-\gamma} = \int_j \left(W_{j,t}\right)^{1-\gamma} \tag{22}$$

The equilibrium is described by the 14 endogenous variables $\left\{X_{i,t}, M_{i,t}, r_t, \alpha_{i,t}, A_{i,t}, W_{i,t}, W^*_{i,t}, L^n_{i,t}, L^t_{i,t}, \bar{P}_{i,t}, \bar{P}^t_t, T_{i,t}, B_{i,t}, Z_{i,t}\right\}$ The 14 equations are listed in the Appendix.

[7]Since in the aggregate we have $\int\left(P^T_{i,t-1}y^T_{i,t-1} - \bar{P}^T_{i,t-1}\left(\bar{c}^T_{i,t-1} + \bar{e}^T_{i,t-1}\right)\right)di = 0$ by the resource constraint, we have $\int T_{i,t} = M_t - M_{t-1}$.

2.2 Steady State

We consider a steady state without inflation. In steady state, prices are constant and must be equalized across islands: $P_i = \bar{P} = W = W_i$. The interest rate is given by:

$$1 + r = \frac{1 - \mu\,(1-\rho)\,(1-\beta)}{\beta} \tag{23}$$

so that the interest rate on government bonds falls if they provide good collateral to get short term credit. The labor-leisure condition implies

$$\bar{C}_i L_i^{1/\nu} = \beta\,(1-\tau_i) \tag{24}$$

The government budget constraint is

$$\frac{T_i}{W} + r_i \frac{B_i}{W} = \tau_i L_i.$$

Using $P = W$ in the budget constraint of households, the steady state consumption level is:

$$\bar{C}_i = (1-\tau_i)\,L_i + \frac{T_i}{P} + r\frac{A_i}{P}. \tag{25}$$

Agents consume their after tax labor income plus the transfers plus interest payments. In symmetric steady state, equilibrium on the bonds market implies:

$$A_i = B_i \tag{26}$$

Note that this is only true for symmetric equilibria. Note also that we assume here that all debts are perfect substitutes so that interest rates are equalized on different bonds, so that: $r = r_i$.

Using the government and households' budget constraints, the equilibrium on the bonds market we get

$$\bar{C}_i = L_i \tag{27}$$

so that the current account is balanced in steady state. Therefore from labor supply we get

$$L_i = \left(\beta\,(1-\tau_i)\right)^{\frac{\nu}{1+\nu}}, \tag{28}$$

Finally we must pin down public debt and transfers. From the fiscal rule, in steady state with $T_i = T_{it} = T_{it-1}$

and $L_{it} = L_i$, we must have $B_i = \kappa_i Z_i$. Since $Z_{i,t} = \tau_i \frac{WL_i}{r_i}$ we have:

$$B_i = A_i = \kappa_i \tau_i \frac{WL_i}{r_i}. \tag{29}$$

Then we can back out the steady-state transfers: $T_i = \tau_i WL_i - r_i B_i = \tau_i WL_i(1 - \kappa_i)$.

We define the debt to income ratio as:.

$$b_i \equiv \frac{B_i}{WL_i},$$

we can write the government budget constraint as

$$b_i = \frac{\tau_i}{r_i} - \frac{T_i}{WL_i} \tag{30}$$

Finally, to compute the price level, we aggregate across all islands within the monetary union. We must have $\bar{P} \int \bar{C}_i = \int (M_i + \Theta_i + T_i + \mu(1 - h_i)B_i)$ since we assume no increase in aggregage money. The aggregate price level satisfies a straightforward quantity-theory equation:

$$\bar{P} = \frac{\bar{M} + \bar{\Theta} + \bar{T} + \mu(1 - \rho)\bar{B}}{\int \bar{C}_i}. \tag{31}$$

but where governments play (at least partially) the same role as currency.

3 Calibration and First Stage of the Crisis

THIS PART IS WORK IN PROGRESS.

Table 2: Parameters

Parameter Name		*Value*	*Source/Target*
Annual Discount Factor	β	0.95	
Trade weight	ω	0.5	Trade literature. Distribution adjusted.
Labor Supply Elasticity	ν	2	Hall (2010)
Elasticity of substitution among traded goods	γ	1.5	Trade literature
Elasticity of substitution traded/non traded	σ	0.1	Own estimate

We next describe the cross-sectional experiments we conduct, as well as our choice of the dynamic parameters, λ, θ, that allow our model to match the cross-sectional dynamics in the data. We describe the sources of the cross-sectional and aggregate data we use in detail in the Appendix.

3.1 The Experiment

For the US, Midrigan and Philippon (2010) conduct an experiment where all islands start in the (identical) steady-state with the same credit parameter, $\theta = \bar{\theta}$, in 2001. From 2001 to 2007 islands experiences a gradual, equally-sized, island-specific increase in θ. Finally, in 2008 and 2009 the collateral constraint in each island returns to $\bar{\theta}$ in two equally-sized steps. Hence, as in the data, islands that experience the largest booms prior to 2007 also experience the largest busts after 2007.

For EU, we consider an experiment where islands start with heterogeneous Θ in 2001, experience a convergence in Θ until 2007, and a divergence afterward, back to where they started. During the convergence in Θ, the private borrowings diverge. We put countries in three groups. Those which have retained their AAA rating on sovereign bonds (Germany, Netherlands and Finland). An intermediate group of countries which are not AAA but have not have major difficulties to finance themselves on markets (France, Austria and Belgium). The last group is the one that is experiencing the most severe sovereign crisis (Portugal, Ireland, Italy, Greece and Spain).

We consider three stages:

- Stage 0: 2003-2007: increases in private consumer debt.
- Stage 1: 2008-2009: private deleveraging, counter-cyclical fiscal policy.
- Stage 2: 2010-2012: sovereign debt crisis and fiscal retrenchment.

We simulate the model with shocks to Θ to account for observed changes during stage 0. We then assume that Θ goes back to its initial value. This is what triggers private deleveraging in stage 1. Public debt increases because of the fall in tax revenues and because of the increase in government spending to counteract the fall in private credit.

In stage 2, we assume that risk premia increase and the expected NPV of tax revenues falls for some countries and forcing governments to reduce transfers at a point where its countercyclical objective should lead to increase its transfers.

3.1.1 A shock on private credit

We first present the impulse repulse functions of the two shocks separatly. The positive shock on private lending $\Theta_{i,t}$ is illustrated on the three figures below where deviations from steady states are shown. The shock generates a short term spending/consumption boom. Depending on the parameters in the policy reaction

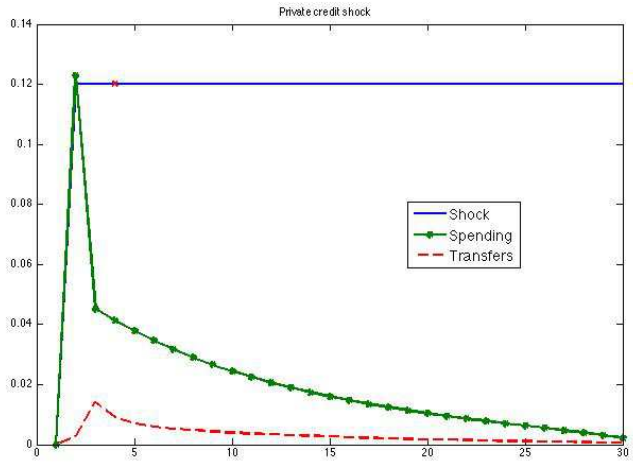


Figure 3:

function that determines transfers, those can fall or increase in the short term. If the parameter that drives the counter-cylical motive is low enough relative to the parameter that drives the debt sustainability concern, transfers increase with the private credit boom. This is the case in figure 3. The reason is that the short term consumption, employment and income boom improve tax revenues and the NPV of the government. Public debt is barely affected as the increase in transfers compensates for the increase in tax revenues. When transfers increase, the consumption and employment booms (figure 4) brought by the private credit shock are magnified by the reaction of the government. Households react by purchasing assets and the government debt is not much affected. The wage rate gradually increases and then goes back to steady state.

3.1.2 A shock on the risk premium

The shock is meant to capture pressures from private lenders and public lenders. We experiment with a shock on $\rho_{i,t}$ which we interpret as a risk premium which affects the expected NPV of country i (see 9). We assume an AR(1) process with persistence so steaddy state values are not affected. The immediate impact of the positive shock on $\rho_{i,t}$ is to reduce the NPV of tax revenues ($Z_{i,t}$) (see figure 6). Due to the policy reaction function, (8) the government reacts to this shock by reducing liquidity transfers to the households (figure 7) and public debt (figure 6). Nominal spending and consumption (figure 7) are affected negativeley through the cash in advance constraint and this negative demand shock depresses employment (figure 8) and income, which further reduces government revenues. Households also react in the short term by selling assets (figure 6).

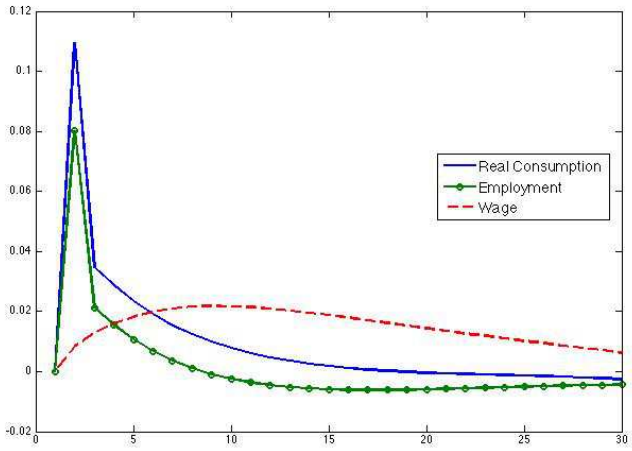


Figure 4:

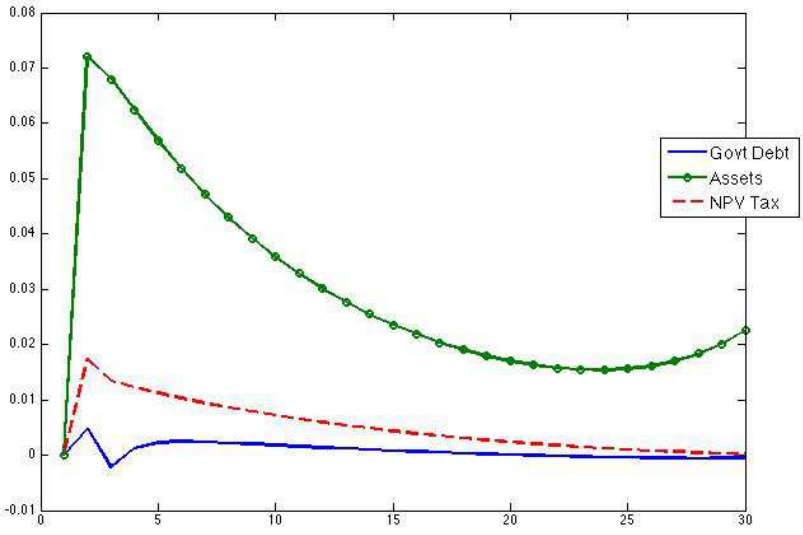


Figure 5:

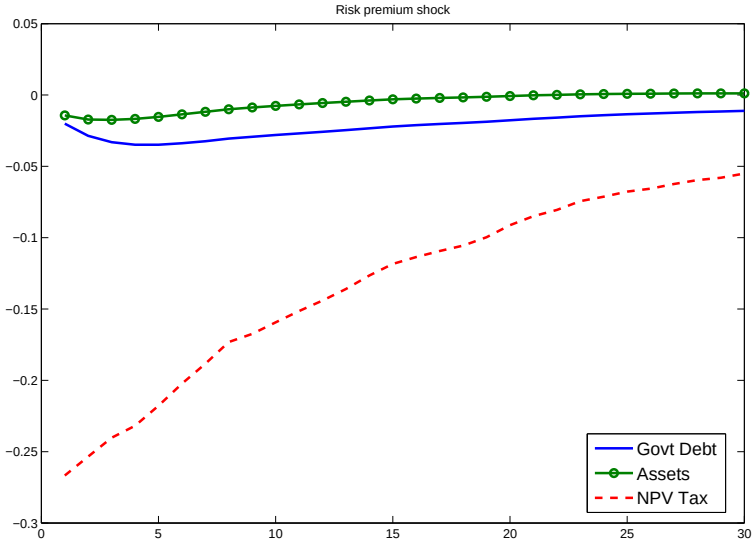


Figure 6:

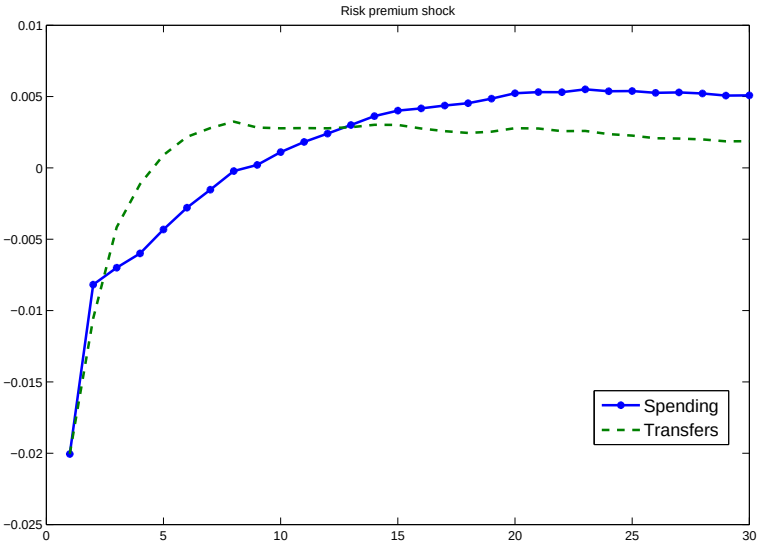


Figure 7:

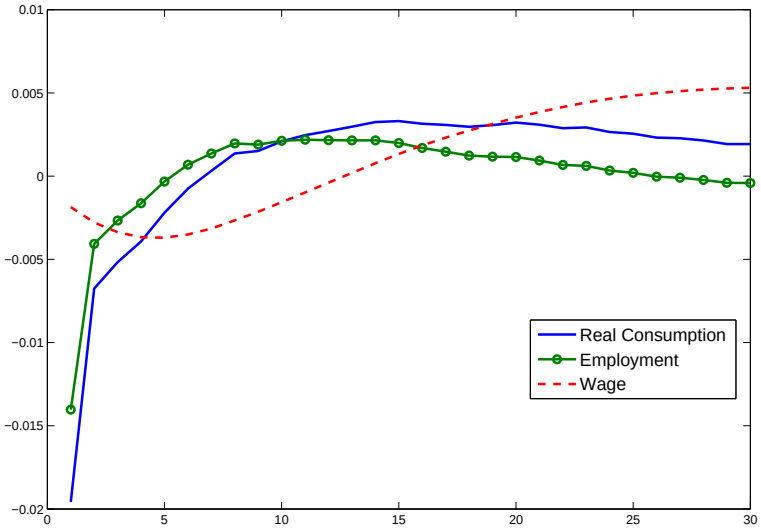


Figure 8:

3.1.3 Comparison with data

We test the model by looking at its prediction for employment, consumption, private and public debt, and government spending in the cross-section. THIS PART IS ALSO STILL WORK IN PROCESS AND AT THIS STAGE THE EXERCISE IS NOT A PROPER QUANTIFICATION.

Figure 9 shows the following experiement (very preliminary) of the three stages: a positive shock on private credit (2003-2007) followed by private deleveraging (2008-2012) and the sovereign debt crisis and fiscal retrenchment (2010-2012). The first stage with the positive credit shock leads to a consumption and employment boom. Government transfers rise during the boom when the credit boom occurs. The reverse occurs when, starting in 2007, the credit boom stops. Note that the first year of the slump, transfers rise because debt sustanability has not yet become an issue and governments use transfers to counteract the credit slump. Starting in 2010 the sovereign shock adds to the slump by obliging governments to conduct fiscal auterity and reducing transfers at the moment where liquidity would be crucial to avert the fall in consumption and employment.

4 Conclusion

TO BE COMPLETED

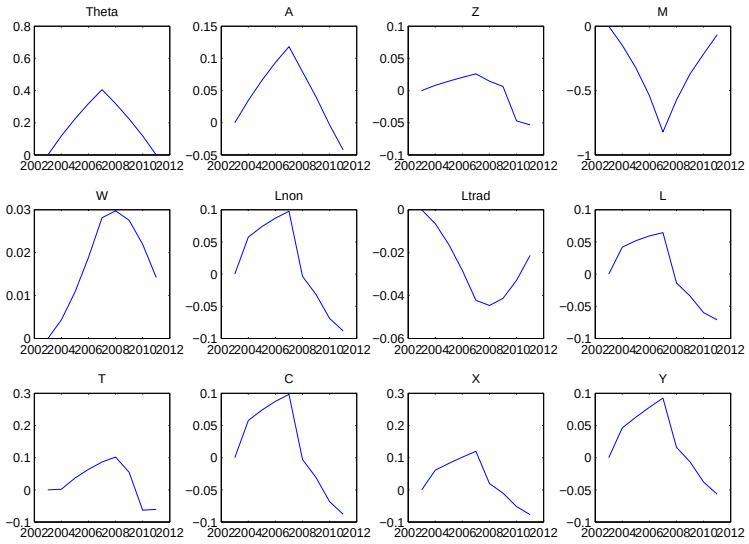


Figure 9:

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Appendix

Households First Order Conditions

Households maximize

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t u\left(\bar{C}_{i,t}, L_{i,t}\right)$$

subject to the contraints the budget constraint (with discounted multiplier α)

$$\beta^t\alpha_{i,t}: \ \left(1-\tau_i\right)W_{i,t}L_{i,t}+M_{i,t-1}+T_{i,t}-\bar{P}_{i,t}\bar{C}_{i,t}+\left(1+r_{t-1}\right)B_{i,t-1}-\frac{1}{2}\psi\left(B_{i,t}-\bar{B}_t\right)^2+\Psi_t-B_{i,t}-M_{i,t} \quad \geq \quad 0$$

and the cash-in-advance and credit constraints

$$\begin{aligned}\beta^t\gamma_{i,t} \quad &: \quad M_{i,t-1}+T_{i,t}+\tilde{M}_{i,t}-\bar{P}_{i,t}\bar{C}_{i,t}\geq 0\\ \beta^t\mu_{i,t} \quad &: \quad \mu\left(1-\rho_{i,t}\right)B_{i,t}+\Theta_{i,t}-\tilde{M}_{i,t}\geq 0\end{aligned}$$

The FOCs are

$$\bar{C}_{it}: \ \frac{u_{c,t}}{\bar{P}_{i,t}}=\alpha_{i,t}+\gamma_{i,t}$$

$$M_{i,t}: \ \alpha_{i,t}=\beta\mathbb{E}_t\left[\alpha_{i,t+1}+\gamma_{i,t+1}\right]$$

$$B_{it}: \ \alpha_{i,t}\left(1+\psi\left(B_{i,t}-\bar{B}_t\right)\right)=\beta(1+r_t)\mathbb{E}_t\left[\alpha_{i,t+1}\right]+\beta\mu\mathbb{E}_t\left[\gamma_{i,t+1}\left(1-\rho_{i,t+1}\right)\right].$$

$$\tilde{M}_{i,t}: \ \gamma_{i,t}=\mu_{i,t}$$

$$L_{it}: \ -u_{L,t}=\left(1-\tau_i\right)W_{i,t}\alpha_{i,t}$$

We consider equilibria where the CiA constraints bind: $\mu_{i,t}>0$ and $\tilde{M}_{i,t}=\Theta_{i,t}$.

Equilibrium Equations

We define

$$X_{it}\equiv\bar{P}_{i,t}\bar{C}_{i,t}$$

The 13 unknowns are $\left\{X_{i,t}, M_{i,t}, r_t, \alpha_{i,t}, W_{i,t}, W^*_{i,t}, L^n_{i,t}, L^t_{i,t}, \bar{P}_{i,t}, \bar{P}^t_t, T_{i,t}, B_{i,t}, Z_{i,t}\right\}$, and the 13 equations are:

$$
\begin{aligned}
X_{i,t} &= M_{i,t-1} + T_{i,t} + \Theta_{i,t} + \mu(1-\rho_{i,t})B_{i,t-1} \\
M_{i,t} + B_{i,t} &= M_{i,t-1} + (1 + r_{i,t-1})\,(1-\rho_{i,t})\,B_{i,t-1} + T_{i,t} + (1-\tau_i)\,W_{i,t}L_{i,t} - X_{i,t} \\
\alpha_{i,t} &= \beta \mathbb{E}_t \left[\frac{1}{X_{i,t+1}} \right] \\
\alpha_{i,t}\left(1 + \psi\left(B_{i,t} - \bar{B}_t\right)\right) &= \beta(1+r_{i,t})\mathbb{E}_t\left[\alpha_{i,t+1}\right] + \mu \mathbb{E}_t\left[\gamma_{i,t+1}\,(1-\rho_{i,t+1})\right] \\
\\
W_{i,t} &= \left(W_{i,t-1}\right)^{\lambda} \left(W^*_{i,t}\right)^{1-\lambda} \\
\left(L^n_{i,t} + L^t_{i,t}\right)^{\frac{1}{\nu}} &= (1-\tau_i)\,\alpha_{i,t} W^*_{i,t} \\
L^n_{i,t} &= (1-\omega)\,\frac{X_{i,t} W_{i,t}^{-\sigma}}{\bar{P}_{i,t}^{1-\sigma}} \\
L^t_{i,t} &= \omega W_{i,t}^{-\gamma} \left(\bar{P}^t_t\right)^{\gamma-\sigma} \int_j \frac{X_{j,t}}{\bar{P}_{j,t}^{1-\sigma}} \\
\left(\bar{P}_{i,t}\right)^{1-\sigma} &= \omega \left(\bar{P}^t_t\right)^{1-\sigma} + (1-\omega)\left(W_{i,t}\right)^{1-\sigma} \\
\left(\bar{P}^t_t\right)^{1-\gamma} &= \int_j \left(W_{j,t}\right)^{1-\gamma} \\
T_{i,t} &= B_{i,t} + \tau W_{i,t-1} L_{i,t-1} - (1+r_{i,t-1}) B_{i,t-1} \\
T_{i,t} &= T_i + \epsilon_B\left(\kappa_i Z_{i,t} - B_{i,t}\right) + \epsilon_X\left(\bar{X}_i - X_{i,t}\right) \\
Z_{i,t} &= \tau_i \mathbb{E}_t \left[\sum_{s=0}^{\infty} \frac{\prod_{s=0}^{\infty}(1-\rho_{i,t+s})}{\prod_{s=0}^{\infty}(1+r_{t+s})} W_{i,t+s+1} L_{i,t+s+1} \right]
\end{aligned}
$$

For a small open economy, we take r_t and $\bar{P}^t_t$ to be exogenous and we drop the constraints $\int_i A_{i,t} = \int_i B_{i,t}$ and that the sum of X's is aggregate nominal spending.