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FISCAL BUFFERS, PRIVATE DEBT AND RECESSION: THE GOOD, THE BAD AND THE UGLY

by Nicoletta Batini*, Giovanni Melina* and Stefania Villa**

Abstract

Focusing on Euro-Area countries, we show empirically that higher private debt leads to deeper recessions while higher public debt does not, unless its level is especially high. We then build a general equilibrium model that replicates these dynamics and use it to design a policy that can mitigate the recessionary consequences of private deleveraging. In the model, in the aftermath of financial shocks, recessions are milder and public debt is more contained when the government lends directly to those households and firms that face binding borrowing constraints. As a consequence, large fiscal buffers are critical to enhance macroeconomic resilience to financial shocks.

JEL Classification: E44, E62, H63.
Keywords: private debt, public debt, financial crisis, financial shocks, borrowing constraints, fiscal limits.

Contents

* International Monetary Fund. E-mail: nbatini@imf.org and gmelina@imf.org. ** Fellow at the Bank of Italy, Directorate General for Economics, Statistics and Research. E-mail: stefania.villa@esterni.bancaditalia.it.

1 Introduction[1]

The global financial crisis followed an extraordinary upward swing in the leverage cycle in a number of advanced countries (Geanakoplos et al., 2012). When the bubble burst, the massive debt accumulation in the private sector sparked a typical debt deflation (Fisher, 1933; Minsky, 1982) that propelled the ratio of public debt-to-GDP very rapidly. This reflected, on one side, the recession-induced decline in government revenues and prices, including those of assets; and, on the other side, governments directly taking over private debt gone sour.

Spurred by such economic developments, late empirical studies have started to focus increasingly more on the relationship between private debt and the macroeconomy. Part of this literature documents the links between rapid credit growth – especially credit to households – and financial crises in the advanced world (Glick and Lansing, 2010; Dell'Ariccia et al., 2012; IMF, 2012; Schularick and Taylor, 2012; Taylor, 2012; Jordà et al., 2013; Mian and Sufi, 2014; Jordà et al., 2014). The key messages from this body of research are that excessive credit growth predicts financial crises and that, conditional on having a recession, stronger credit growth predicts deeper recessions. Mian et al. (2017) take these results a level further, finding unconditional negative correlations between household debt changes and future growth in a panel of advanced and emerging market economies. In addition, they demonstrate that rises in public debt are not associated with lower future output growth.

Theoretical economic modeling has flanked the empirical research, at least up to a certain point. Building upon the modern macroeconomic model-based literature on collateral and leverage cycles (pioneered by Bernanke et al., 1999; Kiyotaki and Moore, 1997; and Iacoviello, 2005) a number of recent papers in macro-finance have

[1]The views expressed in this paper are those of the authors and do not necessarily represent those of Bank of Italy, the International Monetary Fund or IMF policy. We are grateful to Antonio Bassanetti, Olivier Blanchard, Giovanni Callegari, Alessandro Cantelmo, Efrem Castelnuovo, Pietro Catte, Jacopo Cimadomo, Riccardo Cristadoro, Lorenzo Forni, Vitor Gaspar, Matteo Iacoviello, Alejandro Justiniano, Prakash Loungani, Daniela Marconi, Valerio Nispi Landi, Francesco Nucci, Maurice Obstfeld; seminar participants at Banca d'Italia, Federal Reserve Board and IMF; conference participants at the 2015 ECB Conference on "Debt overhang, macroeconomic adjustment and EMU economic governance", the IMAEF 2016 Conference, the 12th Dynare Conference, the 2017 ICMAIF conference, the "Finance and Economic Growth in the Aftermath of the Crisis" conference at the University of Milan, the "Secular Stagnation and Financial Cycles" conference at Banca d'Italia, and the 2017 "Macroeconomic Policy Meetings" at the Melbourne Institute for useful comments. All remaining errors are ours.

focused on how to reproduce mechanisms through which excessive indebtedness in the private sector can harm the economy (e.g. Eggertsson and Krugman, 2012; Farhi and Werning, 2016; Korinek and Simsek, 2016; Guerrieri and Lorenzoni, 2017; Martin and Philippon, 2017).

However, there are important gaps in the literature. First, none of these contributions studies the macro-financial interlinkages between private and public balance sheets that so distinctly characterized both the evolution and the recovery phases of the recent crisis in the advanced world. Second, models featuring a fully-fledged public sector facing fiscal limits (such as Cantore et al., 2018) do not factor in the role of the government as a lender of last resort during protracted phases of financial stress. And third, research so far – starting with Gertler and Karadi (2011) – has focused exclusively on the impact of central bank lending to banks during a financial crisis, abstracting from other equally effective policy tools, like the possibility – observed during the financial crisis – that the government lends directly to financially-constrained agents.

In this paper we move forward by making positive and normative additions to the existing literature to fill these gaps. Focusing on the Euro Area, an economy in which the loop between private and public debt has played a particularly important role during the Great Recession, we begin by highlighting three stylized facts. The first two reaffirm those unveiled by Mian et al. (2017) for a broader set of countries, i.e. a negative correlation between increases in private debt and future levels of output, and a lack of correlation between a rise in public debt and the severity of future recessions. However, we show that in those Euro-Area countries where the level of public debt is especially elevated, increases in public debt lead more severe recessions.

We then build a dynamic stochastic general equilibrium (DSGE) model calibrated on the Euro Area that reproduces these stylized facts and can help us both examine the macroeconomic effects of a financial-crisis-style event leading to private deleveraging and conduct policy experiments.[2] The basic structure of the model embeds Iacoviello (2005)'s features of borrowing constraints in the housing market within a New-Keynesian setting. The model is enriched with a fiscal bloc that tracks changes in the stock of government debt and captures the links between this and the sovereign risk premium, as in Cantore et al. (2018). In this set up, through the

[2]We do not, however, attempt to explicitly model the global financial crisis, nor the sovereign debt crisis. Modeling the systemic aspect of the financial risk is beyond the scope of this paper.

financial accelerator, private deleveraging depresses output and prices, which in turn depresses government revenues, accelerating the accumulation of public debt. Crucially, we assume that the government can alleviate private borrowing constraints via targeted lending operations (dubbed henceforth "targeted interventions"), which impinge on debt-to-GDP dynamics by affecting output and deficits. By virtue of these features, the model can mimic well the key links between debt and output that characterized the recent financial crisis in the Euro Area.

Model simulations suggest that, running into a financial shock with high private debt is as, or possibly more, worrisome than confronting such a shock with high public debt. They also suggest that government loans to borrowing-constrained agents during deleveraging phases mitigates the adverse recessionary effects of financial shocks on output, whilst offering net gains for the government medium-run fiscal position. At the same time, these results do not call for limitless financial assistance to the private sector. In fact, we unveil clear trade-offs between costs and benefits of targeted interventions. For countries closer to their fiscal limit, the benefits are more muted because they are undone by subsequent tax hikes necessary to preserve fiscal sustainability. It follows that one of the key benefits of having fiscal buffers is the greater macroeconomic resilience to financial shocks.

The remainder of the paper is organized as follows. Section 2 presents stylized facts on the links between debt, both private and public, and future output in the Euro Area. Section 3 describes the model. Section 4 discusses the model calibration and validation. Section 5 studies a deleveraging episode and government targeted intervention. Finally, Section 6 concludes. Technical details and robustness checks are appended to the paper.

2 Stylized facts

To pin down the relationship between private debt, public debt and future output for the Euro Area, in this section we fit a panel regression to an unbalanced annual panel dataset encompassing eleven countries and stretching from 1960 to 2014 (Appendix A.1 reports summary statistics and the sample period available for private and public debt for each country).[3]

[3]Data on private debt are taken from the BIS dataset "Long series on total credit to the private non-financial sector". Private debt is computed as the sum of total credit (financed by domestic and foreign banks as well as nonbank financial institutions) to households and non-

We use the same dynamic structure as in the baseline specification proposed by Mian et al. (2017) who, without trying to prove causality, study correlations between past private and public debt, and future GDP in a panel of thirty advanced and emerging market economies. Our analysis differs from theirs along three dimensions: (i) we focus exclusively on the eleven Euro Area countries; (ii) for consistency with our DSGE model, we study the interlinkages between the cyclical components (HP-filtered) of private and public debt-to-GDP ratios and output, as opposed to debt and output growth rates (as we show below, our results hold also using growth rates); and, finally, (iii) we repeat the econometric analysis for two subsamples of countries grouped by levels of public debt.

Both the empirical analysis reported in this section and the model-based simulations reported in the remainder of the paper focus on business cycle considerations. This is why the main objects of the study are short-term fluctuations of macro variables. Appendix B investigates the correlations between private debt and GDP growth at different frequencies, putting these into the context of the broader growth literature.

Our panel regression equation is as follows:

$$\hat{y}_{it+3} = \alpha_i + \beta_{prd}\left(\frac{P\hat{R}D}{Y}\right)_{i,t} + \beta_{pud}\left(\frac{P\hat{U}D}{Y}\right)_{i,t} + u_{i,t}, \tag{1}$$

where the dependent variable is future, three year-out detrended real GDP, $\hat{y}_{i,t+3}$, in line with previous studies;[4] while the two regressors are the detrended total private debt-to-GDP ratio, $\left(\frac{P\hat{R}D}{Y}\right)_{i,t}$, and the detrended public debt-to-GDP ratio; i indexes a generic country; α_i indicates country-specific constants; β_{prd} and β_{pud} are our coefficients of interest, and $u_{i,t}$ is the error term.

Table 1, column 1, shows that the cyclical component of private debt is inversely related to that of future output. Likewise, column 2 shows that the cyclical component of the public debt-to-GDP ratio is not correlated to that of output three years

financial corporations. For public debt we use data from the IMF World Economic Outlook dataset. Real output is taken from IMF International Financial Statistics.

[4]The rationale for the choice of the three-year horizon is based on: (i) the empirical evidence provided by Mian et al. (2017), who justify the three-year horizon to examine the effect of credit expansion in the households' sector on output in a VAR setting; (ii) findings of optimal lag in terms of strongest predictive power found by Baron and Xiong (2017) who, more similarly to us, use total bank credit to GDP instead of household vs. non-financial corporations' debt separately; and (iii) work by Dell'Ariccia et al. (2012) who show that the median bank credit boom lasts three years.

Table 1: Cyclical Fluctuations of Private and Public Debt and Subsequent Cyclical Fluctuations of Real GDP

	Dependent variable: $\hat{y}_{it+3}$			
	(1)	(2)	(3)	(4)
$\left(\frac{\hat{PRD}}{Y}\right)_{it}$	-0.133***	-0.132***	-0.130***	-0.151***
	(0.018)	(0.019)	(0.019)	(0.050)
$\left(\frac{\hat{PUD}}{Y}\right)_{it}$		0.002	0.069**	-0.127***
		(0.027)	(0.032)	(0.045)
"Low" public debt	✓	✓	✓	
"High" public debt	✓	✓		✓
R^2	0.157	0.171	0.249	0.154
Country fixed effects	✓	✓	✓	✓
Observations	317	257	154	103

Notes: Estimates are obtained via panel regressions of deviations of real GDP from HP(100) trend in $t + 3$ on the detrended private and public debt to GDP ratio in t. All specifications include country fixed effects. *,**,*** denote significance at the 0.1, 0.05, 0.01 level, respectively.

later when we condition on the level of total private debt. These results for the Euro Area confirm more general results obtained by Mian et al. (2017) for a wider sample of countries and with a different transformation of the data.

In columns 3 and 4 we try to uncover possible nonlinearities in the relationship depending on the average level of public debt over GDP. To do so, we divide our sample into two groups: a "low" public debt group, including only countries with public debt below or equal to the Euro Area median value of 63.2 percent of GDP[5] (Finland, France, Germany, Ireland, Netherlands and Spain), and a "high" public debt group, including only countries with public debt above the Euro Area median (Austria, Belgium, Greece, Italy and Portugal). Results indicate that in both groups private debt remains consistently negatively associated with future GDP. Instead, in those countries where the level of public debt is "low", the public debt ratio is positively correlated with subsequent GDP (column 3). In contrast, in those countries where the level of public debt is "high", the public debt ratio is negatively correlated with subsequent GDP (column 4).

As a robustness check, we re-run the regressions using the same data transformation as Mian et al. (2017). Specifically, the dependent variable is future output

[5]The median value is computed as the median of the mean values of public debt-to-GDP for each EA country over the sample period.

growth over three years, $\Delta_3 y_{i,t+3}$, while the two regressors are the change in total private debt-to-GDP ratio in the previous three years, $\Delta_3 \left(\frac{PRD}{Y}\right)_{i,t-1}$, and the change in public debt-to-GDP ratio, again in the previous three years, $\Delta_3 \left(\frac{PUD}{Y}\right)_{i,t-1}$. Columns 1 and 2 in Table 2 confirm, for the Euro Area sample, that also under this specification changes in private debt are inversely related to output growth in the near future, while changes in the ratio of public debt-to-GDP are insignificantly related to future output growth. The non-linear effect of the relationship with respect to the average level of public debt re-emerges as well in this specification, with "low" public debt countries exhibiting a positive correlation between public debt and growth, and "high" public debt countries exhibiting an inverse relation.

Our results are reminiscent of those of Schularick and Taylor (2012), Taylor (2012) and Jordà et al. (2013) who find that the bigger the credit boom going bust, the more painful the subsequent recession, a pain that is proportionally worse for countries also saddled with an adverse fiscal position (Jordà et al., 2014). One important corollary that can be drawn from these stylized facts is that countries with larger fiscal buffers are better positioned to weather a financial crisis, both because they have the room needed to allow automatic stabilizers to work fully and because they can, in case, offer stabilizing fiscal support to credit-constrained agents. To formally analyze these issues we use the DSGE model outlined in the following section.

3 Model

We build a model featuring financial frictions in the Kiyotaki and Moore (1997)-Iacoviello (2005) closed-economy tradition. We innovate upon this framework by extending the basic structure to account for fiscal policy, government debt and the sovereign risk premium. These additional features enable us to spell out clearly how the interlinkages between private and public debt play out.

The economy is populated by patient households (lenders), impatient households (borrowers), entrepreneurs, the government and the central bank. Patient households work, consume, buy housing, invest in riskless private bonds and in government bond holdings. Impatient households work, consume, and borrow subject to collateral constraints. Entrepreneurs also borrow subject to a collateral constraint and produce in monopolistic competition. The government finances its expenditures by

Table 2: Private and Public Debt and Subsequent Real GDP Growth

	Dependent variable: $\Delta_3 y_{i,t+3}$			
	(1)	(2)	(3)	(4)
$\Delta_3 \left(\frac{PRD}{Y}\right)_{i,t-1}$	-0.239***	-0.219***	-0.195***	-0.362***
	(0.024)	(0.029)	(0.029)	(0.068)
$\Delta_3 \left(\frac{PUD}{Y}\right)_{i,t-1}$		-0.016	0.064*	-0.214***
		(0.036)	(0.038)	(0.067)
"Low" public debt	✓	✓	✓	
"High" public debt	✓	✓		✓
R^2	0.261	0.232	0.273	0.346
Country fixed effects	✓	✓	✓	✓
Observations	283	218	131	87

Notes: Estimates are obtained via panel regressions of real GDP growth from t to $t+3$ on either the change in private and public debt to GDP from $t-4$ to $t-1$ or the level of private and public debt in $t-1$. All specifications include country fixed effects. *,**,*** denote significance at the 0.1, 0.05, 0.01 level, respectively.

raising a mix of lump-sum and distortionary taxes and by issuing government bonds. Holding government debt is subject to sovereign default risk and the fiscal limit is calibrated in line with the Greek default case as in Cantore et al. (2018), among others. The government also has a role as a lender of last resort. So beyond being tasked – as usual – with the provision of public goods financed through taxation and with standard tools to smooth the economic cycle, it may also lend to credit-constrained agents in the aftermath of financial shocks. Monetary policy follows a Taylor-type rule, while the fiscal rule is set such that government expenditures and taxes react to stabilize public debt compatibly with the government's fiscal limits. Finally, to keep the model simple, but without loss of generality, we do not include banks.[6]

It is important to note a few, but important definitional conventions in the paper. By *leverage cycle* we denote an increase (decrease) in private indebtedness caused

[6] Financial intermediaries are essentially intermediaries between the ultimate lenders and borrowers. Their debt reduction does not influence the assessment of sustainability of the debt burden to the economy, which is the focus of this work. Including banks would add financial frictions, and under certain modeling assumptions, could be set in a way as to magnify leverage cycles by allowing a greater mismatch between debt maturities and risk between ultimate borrowers and lenders. If at all, this would buttress the economic forces driving our results, not lessen them. Therefore, if anything, our policy implications are starker in that we underestimate the financial accelerator effect.

by a loosening (tightening) of borrowing constraints when the collateral of both impatient households and entrepreneurs appreciates (depreciates) in value. With the term *deleveraging,* we indicate a reduction in liabilities achieved through cuts to borrowing to keep these in line with the value of the collateral. A *crisis* occurs when a drop in the value of the collateral reduces the availability of credit to borrow out of future income. In the paper, *targeted intervention* refers to credit extended by the government to financially-constrained agents to alleviate their borrowing constraints.

The model simulations reported throughout the paper are produced with perturbation methods, taking a first-order linear approximation of the model's equilibrium conditions around the deterministic steady state. The subsections below provide more details about the model equations. Appendix C reports the full set of equilibrium conditions.

3.1 Patient households

Households are infinitely-lived and solve an intertemporal utility maximization problem. Each household's preferences are represented by the following intertemporal utility function:

$$U_t = E_t \sum_{s=0}^{\infty} \beta^{t+s} \left(\ln X'_{t+s} + e^H_{t+s} \zeta \ln h'_{t+s} - \frac{\left(L'_{t+s}\right)^{\eta}}{\eta} \right), \tag{2}$$

where $\beta \in (0,1)$ is the discount factor, X'_t is habit-adjusted consumption, e^H_t is a housing shock as in Iacoviello (2015), h'_t are housing holdings, L'_t is labor supply, ζ is a housing preference parameter, and η measures the elasticity of labor with respect to the real wage. In particular, X'_t is given by:

$$X_t{}' = C'_t - \theta C'_{t-1}, \tag{3}$$

where C'_t is the level of consumption, and $\theta \in (0,1)$ is the degree of habit formation. We assume that habit formation is external, i.e. households take time $t-1$ (average) consumption as given when they maximize the intertemporal utility.[7]

Households buy consumption goods, C'_t and housing, h'_t. The relative price of

[7]To make notation simpler we do not distinguish between average and individual consumption level, which are the same in the symmetric equilibrium.

housing is q_t. In addition, they invest in riskless private bonds, B'_t, and in nominal government bond holdings, B^G_t; pay a mixture of lump-sum, τ^L_t, and distortionary taxes, τ^C_t and τ^W_t, on consumption and labor income, respectively. Each household receives: (i) the hourly wage, W'_t; (ii) the nominal return on private bond holdings, R_t; (iii) the nominal return on government bond holdings, R^G_t, discounted at the *ex-ante* expected haircut rate, Δ^G_t; and (iv) government transfers, Ξ_t. Therefore, the households' budget constraint is:

$$\begin{aligned}&\left(1+\tau^C_t\right)C'_t + q_t\Delta h'_t + \frac{B'_t}{P_t} + \frac{B^G_t}{P_t} + \tau^L_t \\ &\leq \left(1-\tau^W_t\right)\frac{W'_t}{P_t}L'_t + \frac{R_{t-1}B'_{t-1}}{P_t} + \left(1-\Delta^G_t\right)\frac{R^G_{t-1}B^G_{t-1}}{P_t} + \Xi_t,\end{aligned} \tag{4}$$

where P_t is the price level.

3.2 Impatient households

Impatient households choose consumption, C''_t, housing, h''_t, and labor, L''_t, to maximize the following inter-temporal utility function:

$$E_t\sum_{s=0}^{\infty}\left(\beta''\right)^{t+s}\left(\ln X''_{t+s} + e^H_t\zeta\ln h''_{t+s} - \frac{\left(L''_{t+s}\right)^{\eta}}{\eta}\right), \tag{5}$$

where $\beta'' < \beta$ is the discount factor, and the external habit-adjusted consumption, X''_t, is given by:

$$X_t{}'' = C''_t - \theta C''_{t-1}. \tag{6}$$

Impatient households face two constraints in their optimization problem. First, in deciding their expenditure and work/leisure plans they need to comply with the following flow of funds equation:

$$\begin{aligned}&\left(1+\tau^C_t\right)C''_t + q_t\Delta h''_t + \frac{R_{t-1}B''_{t-1}}{\Pi_t} + \frac{R_{t-1}B''_{g,t-1}}{\Pi_t} \leq \\ &\qquad\left(1-\tau^W_t\right)\frac{W''_t}{P_t}L''_t + B''_t + B''_{g,t},\end{aligned} \tag{7}$$

where B''_t is what they borrow from patient households, $B''_{g,t}$ denotes the amount of credit received if the government chooses to mitigate deleveraging in the private sector, $\Pi_t \equiv P_t/P_{t-1}$ is the gross inflation rate, and W''_t is their wage rate. The interest rate paid to the government is the market rate, R_{t-1}.

Second, impatient households face a limit on their obligations towards patient households arising from the fact that, if borrowers repudiate their debt obligations, lenders have the ability to repossess their assets minus a proportional transaction cost. Therefore, impatient households face a borrowing constraint, which limits what they can borrow to a fraction of the present discounted value of housing holdings:

$$B''_t \leq m'' E_t \left[\frac{q_{t+1} h''_t \Pi_{t+1}}{R_t} \right]. \tag{8}$$

The interesting case is a steady state in which the return to savings is above the interest rate. In such a case, borrowing constraint (8) holds with equality and ensures that private borrowing by impatient households, B''_t, equals the present discounted value of housing holdings. As such, parameter m'' denotes the loan-to-value (LTV) ratio. Moreover, $\beta'' < \beta$ ensures that impatient households will not postpone consumption and accumulate enough wealth to make the borrowing constraint not binding.

3.3 Entrepreneurs

Entrepreneurs are distributed over the unit interval $e \in (0,1)$ and produce a differentiated goods $Y_{e,t}$ using households' labor, capital and housing as inputs. They operate under monopolistic competition, facing a Dixit-Stiglitz firm-specific demand:

$$Y_{e,t} = \left(\frac{P_{e,t}}{P_t} \right)^{-e_t^P \chi} Y_t, \tag{9}$$

where χ is the intertemporal elasticity of substitution across varieties of goods, and e_t^P is an inflation shock.

Their production function specializes as:

$$Y_{e,t} = e_t^A K_{e,t-1}^{\omega} h_{e,t-1}^{\nu} \left(L'_{e,t} \right)^{\alpha(1-\omega-\nu)} \left(L''_{e,t} \right)^{(1-\alpha)(1-\omega-\nu)}, \tag{10}$$

where $K_{e,t}$ is capital, $h_{e,t}$ is the real estate input, and $L'_{e,t}$ and $L''_{e,t}$ are the labor inputs provided by patient and impatient households, respectively,[8] and e_t^A is a

[8] We assume that hours of the two households enter the production function in a Cobb-Douglas fashion, as standard in this literature (see, e.g., Iacoviello, 2005; Gerali et al., 2010; Iacoviello and

technology shock. While parameters ω and ν are the elasticities of output to capital and real estate, respectively, α represents the contribution of patient households to the labor share.

Like impatient households, entrepreneurs discount the future more heavily than patient households. Hence the discount factor of the former is lower than that of the latter, $\gamma < \beta$. This means that entrepreneurs borrow as well. Entrepreneurs only care about their own consumption, $C_{e,t}$, and maximize the following inter-temporal utility function:

$$U_t = E_t \sum_{s=0}^{\infty} \gamma^{t+s} \ln \left(X_{e,t+s} \right), \tag{11}$$

where external habit-adjusted consumption, $X_{e,t}$, is given by:

$$X_{e,t} = C_{e,t} - \theta C_{e,t-1}, \tag{12}$$

subject to the entrepreneurial flow of funds:

$$\begin{aligned}\frac{P_{e,t}}{P_t} Y_{e,t} + B_{e,t} + B_{ge,t} = \left(1 + \tau_t^C\right) C_{e,t} + q_t \Delta h_{e,t} + \frac{R_{t-1} B_{e,t-1}}{\Pi_t} \\ + \frac{R_{t-1} B_{ge,t-1}}{\Pi_t} + w_t' L_{e,t}' + w_t'' L_{e,t}'' + I_{e,t} + \xi_{K,t} + \xi_{P,t},\end{aligned} \tag{13}$$

where $w_t' \equiv \frac{W_t'}{P_t}$; $w_t'' \equiv \frac{W_t''}{P_t}$; $B_{e,t}$ represents their debt obligations towards private agents; $B_{ge,t}$ is the credit directly intermediated by the government in case of targeted intervention (analogously to the case of impatient households); $I_{e,t}$ is investment in capital goods following law of motion:

$$I_{e,t} = K_{e,t} - (1 - \delta) K_{e,t-1}, \tag{14}$$

and $\xi_{K,t} \equiv \frac{\psi_K}{2\delta} \left(\frac{I_{e,t}}{K_{e,t-1}} - \delta \right)^2 K_{e,t-1}$ and $\xi_{P,t} \equiv \frac{\psi_P}{2} \left(\frac{P_{e,t}}{P_{e,t-1}} - 1 \right)^2 Y_t$ are quadratic costs of adjusting the capital stock and resetting the price level, respectively.

Neri, 2010; Angelini et al., 2014; Justiniano et al., 2015; Alpanda and Zubairy, 2017; Guerrieri and Iacoviello, 2017; Lambertini et al., 2017; Cantelmo and Melina, 2018, among others). This implies imperfect substitutability across the labor skills of the two groups and allows obtaining a closed-form solution for the steady state of the model. As noted by Iacoviello and Neri (2010), perfect substitutability of labor inputs causes a more complex interaction between the borrowing constraint of impatient households and the labor supply decision, hence our choice to adopt a Cobb-Douglas specification.

Also entrepreneurs face a limit on their obligations towards patient households:[9]

$$B_{e,t} \leq mE_t \left[\frac{q_{t+1} h_{e,t} \Pi_{t+1}}{R_t} \right]. \tag{15}$$

3.4 Government

The government finances its expenditures, G_t, by levying taxes, T_t, and by issuing bonds, B_t^G. It promises to repay one-period bonds the next period and the gross nominal interest rate applied is R_t^G. However, in order to introduce a sovereign risk premium, we assume that government bond contracts are not enforceable, and use to that end the same modeling strategy as in Cantore et al. (2018). Each period, a stochastic fiscal limit expressed in terms of government debt-to-GDP ratio and denoted by Γ_t^*, is drawn from a distribution, the cumulative density function (CDF) of which is represented by a logistic function, p_t^*, with parameters η_1 and η_2:

$$p_t^* = P\left(\Gamma_t^* \leq \Gamma_t\right) = \frac{\exp\left(\eta_1 + \eta_2 \Gamma_t\right)}{1 + \exp\left(\eta_1 + \eta_2 \Gamma_t\right)}, \tag{16}$$

where $\Gamma_t \equiv B_t^G / Y_t$.[10] If government-debt-to-GDP exceeds the fiscal limit, i.e. $\Gamma_t \geq \Gamma_t^*$, then the government defaults. Hence p_t^* represents the probability of default. This occurs in the form of an haircut $\Delta_t^G \in [0,1]$ applied as a proportion to the outstanding stock of government debt. Agents consider the *ex-ante* expected haircut rate,

$$\Delta_t^G = \begin{cases} 0 & \text{with probability } 1 - p_t^* \\ \bar{\Delta}^G & \text{with probability } p_t^* \end{cases}, \tag{17}$$

where $\bar{\Delta}^G \in (0,1]$ is the haircut rate applied in the case of default.[11] In other words:

$$\Delta_t^G = p_t^* \bar{\Delta}^G. \tag{18}$$

This mechanism is akin to that of Ghosh et al. (2013) who determine a "debt limit" beyond which fiscal solvency is in doubt. Following what they call "primary

[9] Following Iacoviello (2005) we assume that, just like households, firms only use housing as collateral. For a model in which physical capital is also a collateralized asset see Liu et al. (2013).

[10] Also Bi and Traum (2014) assume the same functional form for the CDF of the fiscal limit.

[11] While the model captures a convex increase in the risk premium as the level of government debt approaches the fiscal limit, it is solved within a region of fiscal solvency, with possibly a very small fiscal space.

balance rule", governments increase primary (i.e. non-interest) fiscal surpluses in response to rising debt service, so that the public debt-to-GDP ratio will converge to its long-run value. This fiscal reaction function – analogous to our equations (23) and (24) below – is consistent with the empirical findings of Mendoza and Ostry (2008) for a sample of industrial and emerging market economies.[12] In response to shocks, the debt ratio will be stabilized if the primary balance increases to offset the higher interest rate bill. However, at sufficiently high levels of debt, the occurrence of large shocks may require a very sizable increase in the primary balance. Even assuming an interest rate inelastic to government indebtedness, there will be a debt level beyond which dynamics turn explosive and the government will default. In fact, default will occur at a level of debt below this threshold because, as the probability of default rises, financial market participants will require higher and higher risk premia, making it more unlikely that the primary surplus will be enough to meet debt obligations, and in turn increasing the default probability even further. Azariadis (2016), among others, indeed shows that expectations regarding future debt prices affect public debt sustainability.

Furthermore, Ghosh et al. (2013) empirically find that other factors determining fiscal limits are economic growth, inflation, trade openness and the country's structural characteristics such as political stability and institutionalized fiscal rules. It should also be noted that, according to conventional wisdom, political economy considerations may hinder fiscal adjustments, although Alesina et al. (2012) find no evidence of systematic turnover of governments implementing large reductions of budget deficits.

In sum, both financial market reactions and policymakers' decisions are surrounded by uncertainty, which makes fiscal limits far from being deterministic. Therefore, assuming stochastic fiscal limits that depend on the debt ratio seems a reasonable and tractable way to capture these complex phenomena.

In some experiments, we give the government the option to conduct "targeted interventions", namely to intermediate funds towards financially constrained agents, using a mechanism similar to that proposed by Gertler and Karadi (2011) for unconventional monetary policy. In the case of a targeted intervention, the government issues additional bonds $B_t^{int} \equiv B''_{g,t} + B_{g,t}$, that pay the gross nominal interest rate

[12] The response of the primary balance to debt is estimated to be stronger in emerging economies than in advanced countries, likely because the riskier financial and fiscal conditions of the former make a stronger response necessary to maintain fiscal solvency.

R_t^G, and lends the raised funds to the private sector at the market rate R_t. This operation is assumed to imply some inefficiency costs equal to κ per unit supplied capturing the fact that public intermediation is likely to be less efficient than private intermediation. The inefficiency cost affecting the government budget constraint is then $\Upsilon_t \equiv \kappa B_t^{int}$, which is a dead weight loss.

Simple rules define how the government intervention takes place, and link government intervention to deleveraging, to an extent controlled by parameter ϵ:

$$b''_{g,t} = -\epsilon b''_t, \tag{19}$$

$$b_{g,t} = -\epsilon b_t, \tag{20}$$

where lower-case letters indicate deviations of debt variables from their respective steady state, relative to steady-state output, $x_t \equiv \frac{X_t - X}{Y}$. We assume that, at the steady state, no government intervention occurs ($B''_g = B_g = 0$). If $\epsilon = 0$, the model collapses to the standard case in which funds are intermediated only by the private sector.

One key point of departure from the mechanism of Gertler and Karadi (2011) relates to the assumption that in our model the government is subject to fiscal limits and that these generate a sovereign risk premium. This assumption introduces an additional cost, given by the spread $\left(R_t^G - R_t\right)$ times the units of funds intermediated B_t^{int}, in the government flow of funds:

$$B_t^G = \left(1 - \Delta_t^G\right) \frac{R_{t-1}^G B_{t-1}^G}{\Pi_t} + G_t + \frac{\left(R_{t-1}^G - R_{t-1}\right) B_{t-1}^{int}}{\Pi_t} + \Upsilon_t - T_t + \Xi_t. \tag{21}$$

Note that the government borrows from patients agents and lends to impatient agents within the same period. Thus, the total cost of targeted intervention is given by the sum of the inefficiency cost and the increment in debt servicing costs associated with the additional borrowing needed to extend credit to the private sector. Also note that each period transfers are set in a way that sovereign default does not alter the actual debt level, $\Xi_t \equiv \Delta_t^G \frac{R_{t-1}^G B_{t-1}^G}{\Pi_t}$.[13]

[13] This approach is also followed by Corsetti et al. (2013). The absence of such transfers would imply lower risk premia prior to default, as the lower post-default debt stock would already be taken into account.

Total government revenue T_t is given by:

$$T_t = \tau_t^C \left(C_t' + C_t'' + C_t\right) + \tau_t^W \left(w_t' L_t' + w_t'' L_t''\right) + \tau_t^L. \tag{22}$$

In order to reduce the number of tax instruments to one, we impose that τ_t^C, τ_t^W and τ_t^L deviate from their respective steady state by the same proportion (i.e. $\tau_t^C = \tau_t \bar{\tau}^C$, $\tau_t^W = \tau_t \bar{\tau}^W$, $\tau_t^L = \tau_t \bar{\tau}^L$), and that the proportional uniform tax change, τ_t, becomes one of our fiscal policy instruments. As common in the literature, the steady-state value of the lump-sum tax is treated as a residual to calibrate the government debt at a desired steady-state level.

We allow the tax and government spending instruments to be adjusted according to the following feedback rules:

$$\log\left(\frac{\tau_t}{\tau}\right) = \rho \log\left(\frac{\tau_{t-1}}{\tau}\right) + (1-\rho)\left[e^{\phi \frac{B^G}{Y}} \rho_B \log\left(\frac{B_{t-1}^G}{B^G}\right)\right], \tag{23}$$

$$\log\left(\frac{G_t}{G}\right) = \rho \log\left(\frac{G_{t-1}}{G}\right) - (1-\rho)\left[e^{\phi \frac{B^G}{Y}} \rho_B \log\left(\frac{B_{t-1}^G}{B^G}\right)\right], \tag{24}$$

where ρ implies persistence in the fiscal policy instruments; ρ_B is the responsiveness of the instruments to the percent deviation of government debt from its steady state; and $e^{\phi \frac{B^G}{Y}}$ is an exponential factor tightening the fiscal policy stance for increasing steady-state levels of the government debt-to-GDP ratio.

Some remarks on the above fiscal rules are in order. First, these rules imply that fiscal instruments are set to keep public debt under control, as generally observed in advanced economies (see Mendoza and Ostry, 2008, among others). Second, the introduction of persistence captures policy inertia, which is justified on empirical grounds. For instance, Forni et al. (2009) impose very similar fiscal rules and find evidence of substantial policy inertia in a model estimated using euro area data. Third, one feature of our model is that higher levels of public debt, via an increase in the sovereign default probability and the associated risk premium, imply higher debt servicing costs and make debt dynamics more prone to instability. It follows that higher public indebtedness requires a stronger responsiveness of the fiscal instruments to public debt. This mechanism is line with the empirical findings of Bohn (1998, 2005) who identifies a stronger response of the primary balance to debt at high debt ratios. We capture this channel via the exponential term $e^{\phi \frac{B^G}{Y}}$, which is useful also for conducting our numerical exercises because, once parameters ρ_B and

ϕ have been set, it automatically implies a tighter fiscal stance at higher steady-state levels of government debt.

Although in practice the government may exhibit different degrees of inertia and elasticities for different instruments, assuming the same parameters for all fiscal instruments greatly simplifies the exercises presented in the following sections without loss of generality.[14]

3.5 Central bank

Monetary policy is set according to a Taylor-type interest-rate rule,

$$\log\left(\frac{R_t}{R}\right) = \rho_\pi \log\left(\frac{\Pi_t}{\Pi}\right) + \rho_y \log\left(\frac{Y_t}{Y}\right), \tag{25}$$

where ρ_π and ρ_y are the monetary policy parameters that dictate the responsiveness of the interest rate to deviations of inflation and output from their respective steady-state values.[15]

3.6 Equilibrium

Equilibrium in the goods market, the loans market, and the housing market implies that $Y_t = C_t + C'_t + C''_t + I_t + G_t + \Upsilon_t + \xi_{P,t} + \xi_{K,t}$; $B_t + B'_t + B''_t = 0$, where $B_t = \int_0^1 B_{e,t} de$; and $h + h' + h'' = 1$. This last equilibrium condition in turn implies that housing is in fixed supply, which we normalize to one. The model is completed by autoregressive processes for the shocks, $\log\left(\frac{e_t^{\varkappa}}{\bar{e}^{\varkappa}}\right) = \rho_{\varkappa} \log\left(\frac{e_{t-1}^{\varkappa}}{\bar{e}^{\varkappa}}\right) + \epsilon_t^{\varkappa}$, where $\varkappa = \{A, H, P\}$, $\rho_{\varkappa}$ are autoregressive parameters and $\epsilon_t^{\varkappa}$ are mean zero, i.i.d. random shocks with standard deviation $\sigma^{\varkappa}$.

4 Model calibration and validation

Table 3 reports the parameter values used to simulate the model. To the extent possible, we set our baseline calibration in line with previous empirical estimates or stylized facts on the Euro Area. Where this is not possible, for example agents' relative discount factors, we take parameter values from studies on the United States.

[14] For papers assessing the effects of fiscal policy in a multi-country dynamic general equilibrium model of the euro area see Gomes et al. (2012, 2016), among others.

[15] Modeling the zero lower bound is beyond the scope of the paper.

Parameter		Value
Patient households' discount factor	β	0.99
Impatient households' discount factor	β''	0.95
Entrepreneurs' discount factor	γ	0.98
Labor supply elasticity	η	1.01
Habits in consumption	θ	0.592
Capital depreciation rate	δ	0.03
Capital share	ω	0.30
Patient households' wage share	α	0.64
Capital adjustment costs	ψ_K	2.00
Elasticity of substitution in goods	χ	6.00
Price stickiness	ψ_P	41.667
Inflation -Taylor rule	ρ_π	1.50
Output -Taylor rule	ρ_y	0.10
SS stock of residential housing over annual output	$\bar{q}\left(\bar{h}' + \bar{h}''\right) / \left(4\bar{Y}\right)$	1.34
SS commercial real estate over annual output	$\bar{q}\bar{h}/\left(4\bar{Y}\right)$	0.65
SS share of government spending in GDP	$\bar{G}/\bar{Y}$	0.23
SS consumption tax rate	$\bar{\tau}^C$	0.20
SS labor income tax rate	$\bar{\tau}^W$	0.45
Persistence of fiscal instruments	ρ	0.90
Fiscal responsiveness to government debt	ρ_B	0.01
Responsiveness of the fiscal stance to government debt	ϕ	1.35
Scaling factor in default probability	η_1	-8.5527
Slope parameter in default probability	η_2	1.8261
Degree of targeted intervention	ϵ	0
Inefficiency costs	κ	0
SS impatient households loan-to-value ratio	m''	0.80
SS entrepreneurs loan-to-value ratio	m	0.375
SS public debt-to-GDP ratio	$\bar{\Gamma}/4$	0.71
Persistence of housing shock	ρ_H	0.9887
Persistence of inflation shock	ρ_P	0.8487
Persistence of technology shock	ρ_A	0.0335
Standard deviation of housing shock	σ^H	0.0105
Standard deviation of inflation shock	σ^P	0.0026
Standard deviation of technology shock	σ^A	0.0236

Table 3: Baseline Parameter Values

Shocks are calibrated to match key moments in Euro Area data. The time period in our model corresponds to one quarter in the data.

The following parameter values are rather common in the literature (see Iacoviello, 2005, among others): agents' discount factors, $\beta = 0.99$, $\beta'' = 0.95$, and

$\gamma = 0.98$; capital share, $\omega = 0.30$; patient households' wage share, $\alpha = 0.64$; and capital adjustment costs, $\psi_K = 2$. The value of the Frisch elasticity of labor supply, $1/(\eta - 1)$, is a source of controversy. While most microeconomic studies suggest an estimate of the elasticity ranging from 0 to 0.5, the estimates used by the business cycle literature are much higher (for an early survey of the literature see Card, 1991). More recently Keane and Rogerson (2012), however, concluded that estimates of small labor supply elasticities based on micro data are fully consistent with large aggregate labor supply elasticities. As regards capital depreciation, the business cycle literature generally agrees on an annual rate around 10 percent. In our baseline calibration, we follow Iacoviello (2005) who assumes a very elastic labor supply ($1/(\eta - 1) = 100 \Leftrightarrow \eta = 1.01$) and an annual capital depreciation rate of 12 percent ($\delta = 0.03$), as our model builds on his framework. However, in Appendix D we show that results are robust to different choices of both the Frisch elasticity and the capital depreciation rate.

The value of habit persistence, $\theta = 0.592$, is taken from the estimated Euro-Area model of Smets and Wouters (2003). For the interest rate response to inflation we choose a value that satisfies the Taylor principle, $\rho_\pi = 1.5$ (e.g. Taylor, 1993). In line with the empirical literature on the euro area (see, e.g., the influential paper by Smets and Wouters, 2003; Adolfson et al., 2007; Forni et al., 2009; Villa, 2016) we set the interest rate response to output, ρ_y, to 0.1. In Appendix D we check if results are robust to a higher value of ρ_y. For the steady-state values of the share of government spending in GDP, $\bar{G}/\bar{Y} = 0.23$, and the two distortionary tax rates, $\bar{\tau}^C = 0.20$ and $\bar{\tau}^W = 0.45$, as well as the degree of price stickiness, $\psi_P = 41.667$, we rely on the values used by Christiano et al. (2010) for the Euro Area.[16] Then, in line with the data, we make fiscal instruments persistent ($\rho = 0.90$). We set the degree of fiscal stance, $\rho_B = 0.01$, and its responsiveness to government debt, $\phi = 1.35$, to approximately the minimal value needed to stabilize public debt in the range of government debt-to-GDP ratios explored. The elasticity of substitution across different varieties, χ, is equal to 6 in order to target a steady state gross mark-up equal to 1.20 as common in the literature.

The steady-state stock of residential housing over annual output, $\bar{q}\left(\bar{h}' + \bar{h}''\right) / \left(4\bar{Y}\right) = 1.34$, is taken from the the OECD database on balance sheet for non-financial assets on households dwellings in France and Germany between 2000 and

[16] The value of ψ_P is chosen to match the same slope of the linearized New-Keynesian Phillips curve of Christiano et al. (2010) where prices are set as in Calvo (1983).

2013.[17] Such a value is matched through an appropriate choice of ζ. The steady-state commercial real estate over annual output, $\bar{q}\bar{h}/\left(4\bar{Y}\right) = 0.65$, is taken from the OECD database on balance sheet for non-financial assets on dwellings of non-financial corporations in France and Germany between 2000 and 2013. Such a value is matched through an appropriate choice of ν. In the baseline case, the households' LTV ratio, m, is equal to 0.80, the typical LTV ratio for a new mortgage in the majority of the Euro Area countries in 2007 (ECB, 2009). The entrepreneurial LTV, $m = 0.375$, is taken from data on corporate indebtedness in the Euro Area (ECB, 2012). Last, the debt-to-GDP ratio $\bar{\Gamma}/4 = 0.71$ corresponds to the average debt-to-GDP ratio for countries in our panel dataset. Given that the parameters related to government and private indebtedness are crucial for the results, we explore sensitivity to a wide range of values in Section 5.

Moreover, we assume no targeted intervention and zero inefficiency costs, i.e. $\epsilon = \kappa = 0$. We nonetheless show how alternative values of these two parameters affect the results in Subsection 5.3.

To calibrate the CDF of the fiscal limit, we fix two points on the function in a way consistent with empirical evidence. Given two points (Γ_1, p_1^*) and (Γ_2, p_2^*), with $\Gamma_2 > \Gamma_1$, parameters η_1 and η_2 are uniquely determined by

$$\eta_2 = \frac{1}{\Gamma_1 - \Gamma_2} \log\left(\frac{p_1^*}{p_2^*}\frac{1-p_2^*}{1-p_1^*}\right), \tag{26}$$

$$\eta_1 = \log\left(\frac{p_1^*}{1-p_1^*}\right) - \eta_2\Gamma_1. \tag{27}$$

Let us assume that when the ratio of government debt to annual GDP is Γ_2, the probability of exceeding the fiscal limit is almost unity, i.e. $p_2^* = 0.99$. We set the fiscal limit at $\Gamma_2 = 4 \times 1.8$, broadly in line with Greece's recent experience during the sovereign debt crisis. Let us fix $\Gamma_1 = 4 \times 0.6$, the average general government consolidated gross debt in the United States over the period 1980-2007. Before the financial crisis, the U.S. sovereign risk premium was very small – around 15 annual basis points (ABP) for sovereign default swap spreads (see e.g. Austin and Miller, 2011). Hence we assume that for $\Gamma_1 = 4 \times 0.6$, $ABP_1 = 15$. At the onset of the Greek sovereign debt crisis, the sovereign risk premium skyrocketed to an order of

[17] The steady-state stock of residential housing over annual output has a similar value when considering the average of euro area countries.

magnitude of around 1,000 annual basis points, hence we fix $ABP_2 = 1,000$. The haircut rate, $\bar{\Delta}$, consistent with ABP_2 and p_2^* is obtained as $\bar{\Delta} = \left[1 - \frac{1}{\frac{ABP_2}{40000}+1}\right]/p_2^*$.[18] At this point, we can recover the probability of default when $\Gamma = \Gamma_1$,

$$p_1^* = \frac{1 - \frac{1}{\frac{ABP_1}{40000}+1}}{\bar{\Delta}},$$

which is $p_1^* = 0.0152$, and the parameters η_1 and η_2 of the fiscal limit CDF can be recovered by using equations (26) and (27), i.e. $\eta_1 = -8.5527$ and $\eta_2 = 1.8261$. This parametrization implies that the probability of default remains moderate (below 20%) until the government debt-to-annual-GDP is below 100%, and then it increases at an expedited rate. This captures the fact that the pricing of risk of sovereign bonds for a country with weak fiscal fundamentals, can deteriorate rapidly and non-linearly as public debt accumulates. Analogous modeling of the risk premium can be found in Bi (2012), and is consistent with the empirical relationship observed in a a large set of advanced countries between government gross debt and sovereign spreads as reported by Corsetti et al. (2013).

Last, we set the standard deviations and the persistence of the shocks via moment-matching of the empirical standard deviations and the persistence of real output, inflation and the real house price.

Given the difficulty in matching all moments precisely, we construct a quadratic loss function $L = \sum_{j=1}^{6} \left(x_j^m - x_j^d\right)^2$, where x_j^m is the j-th moment in the model and x_j^d is its analogue in the data, and we numerically search for those parameters that minimize L. This procedure leads to persistent housing and inflation shocks, $\rho_H = 0.9887$ and $\rho_P = 0.8487$; while, as in Iacoviello (2005), the estimated technology shock exhibits a small persistence $\rho_A = 0.0347$, as the model produces significant endogenous persistence. The standard deviations of the shocks are around 1% and 2% in magnitude.

Table 4 shows the volatilities, persistences and correlations of variables in the data and in the model that we directly target, as well as two other important

[18] To see this, note that equations (C.3) and (C.4) imply the following steady-state sovereign risk premium:

$$\frac{R^G}{R} = \frac{1}{(1-\Delta^G)} = 1 + \frac{ABP}{40000},$$

using which Δ^g can be written as a function of a chosen premium expressed in annual basis points, $\Delta^g = 1 - \frac{1}{1+\frac{ABP}{40000}}$. Finally, from equation (18) $\bar{\Delta}^G = \Delta^G/p^*$.

Table 4: Moments of Key Macroeconomic Variables

Moment	Data	Model
Standard deviations		
Real output	0.0138	0.0088
Inflation	0.0061	0.0047
Real house prices	0.0158	0.0193
Autocorrelations		
Real output	0.8779	0.9435
Inflation	0.2386	0.2616
Real house prices	0.8614	0.8658
Cross-correlations with output		
Investment	0.8221	0.9728
Private consumption	0.9218	0.9955

moments.[19] As the table indicates, with this calibration the model replicates reasonably well the moments in the data, and also manages to approximate closely to the cross-correlations of investment and private consumption with output.

To check the extent to which our model is able to replicate observed historical patterns, we simulate time series of output, private and public debt-to-GDP ratios. We then estimate on these simulated data the same regressions run on actual data (Table 1).[20] To facilitate the comparison between the two sets of estimates, we simulate the model under calibrations of public debt-to-GDP using the same values for average, "low" and "high" ratios reported in Section 2. Therefore, we set $\bar{\Gamma}/4 = 0.71$, $\bar{\Gamma}/4 = 0.54$ and $\bar{\Gamma}/4 = 0.92$, to capture average, "low" and "high" public debt cases, respectively.

Table 5 shows that the model-generated data displays correlations with the same signs as those associated with actual Euro Area data. Simulated times series also capture the nonlinearities identified in the empirical relationship between public debt and output for "low" versus "high"-public-debt countries.[21]

[19]Data on euro area countries are taken from the Statistical Data Warehouse of the ECB and the International Financial Statistics database of the IMF. They refer to the period 1999Q1-2015Q1 (or shorter where observations are not available). Time series of GDP components and real house prices are detrended using the HP filter.

[20]To take advantage of the illustrative simulation exercise, we consider a large sample of simulated observations equal to 5,000 quarters for each regression.

[21]The estimated coefficients are always significant at a 1 percent level due to the large size of the simulated sample. Hence significance stars and standard errors are not reported.

Table 5: Cyclical Fluctuations of Private and Public Debt and Subsequent Cyclical Fluctuations of Real GDP in Simulated Data

	Dependent variable: $\hat{y}_{it+12}$			
	(1)	(2)	(3)	(4)
$\left(\frac{\hat{PRD}}{Y}\right)_t$	-0.180	-0.191	-0.216	-0.070
$\left(\frac{\hat{PUD}}{Y}\right)_t$		0.040	0.049	-0.022
"Low" public debt	✓	✓	✓	
"High" public debt	✓	✓		✓
R^2	0.029	0.031	0.036	0.025
Observations	5000	5000	5000	5000

Notes: Estimates are obtained via regressions of simulated series of real GDP in $t+3$ on simulated series of private and public debt to GDP ratios in t.

5 A deleveraging episode

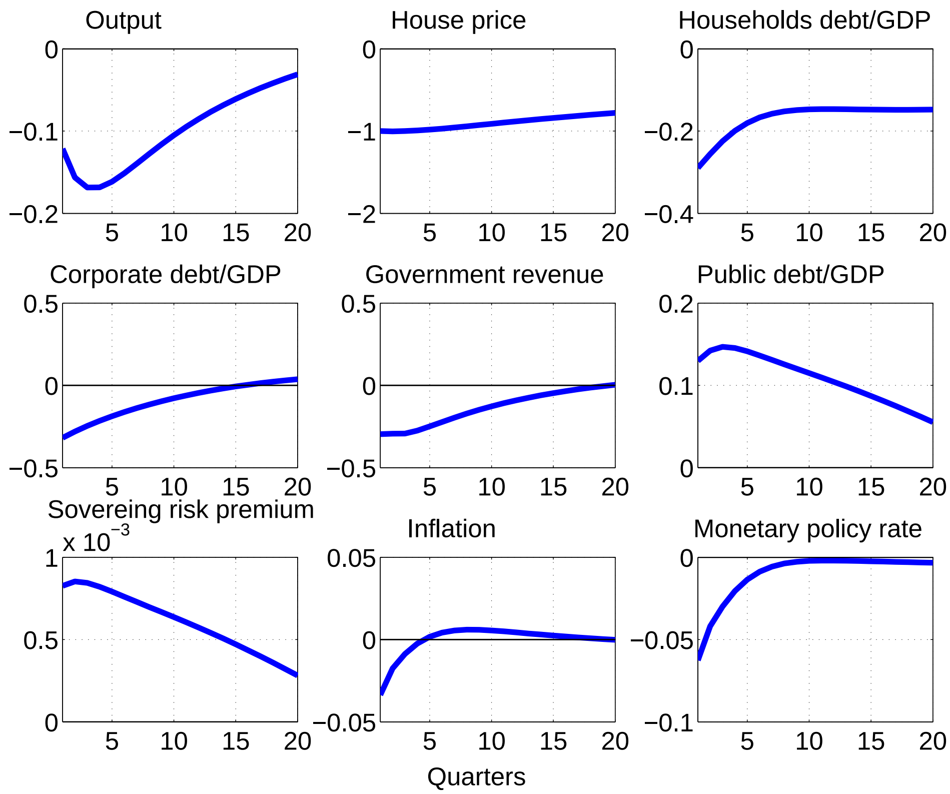
The results presented in the previous sections are obtained assuming that all shocks (both in actual and simulated data) are at play simultaneously. In this section we focus on the effects of a single shock, namely a negative house price disturbance that triggers a deleveraging episode. Specifically, we explore the macroeconomic consequences of deleveraging (Subsection 5.1), the role that private and public debt have in affecting economic activity during a deleveraging phase (Subsection 5.2), and the mitigating effects of government targeted intervention, as well as how these depend also on the size of fiscal buffers (Subsection 5.3).

5.1 The macroeconomic consequences of deleveraging

We trigger a downward phase of a leverage cycle via a temporary negative shock to households' housing preferences. The shock generates a decline in house prices, which in turn depresses the value of the housing collateral. In the experiments discussed throughout, the shock is set to induce a fall in house prices equivalent to one percent. Although the shock originates in the households' side of the model, the induced decrease in house prices affects also firms' borrowing constraints. As a result, both households' and corporate debt react to the shock.

Figure 1 shows that the protracted decline in house prices, and the consequent fall in the value of constrained agents' collateral make borrowing constraints tighter. This forces private agents to deleverage by cutting consumption and investment. The

Figure 1: Impulse Responses to a Negative One-Per-Cent House Price Shock



Notes: X-axes in quarters; Y-axes are in percent deviations from steady state, except for private and public debt to GDP ratios where deviations are absolute.

fall in private demand implies a protracted output contraction and a deflation. The size of the output response matches well the observed relationship between changes in house prices and the output gap in the Euro Area, e.g. during the sovereign debt crisis of 2010-2013.[22] The fall in households' debt is also more persistent than the decline in corporate debt, in line with observed developments based on BIS data of credit to households and non-financial corporations in the Euro Area in the aftermath of the past recession (this stylized fact is documented by Smets and Villa, 2016, also for the U.S.). The worsened economic outlook spills over to public finances: the fall in output induces a reduction of government revenues and the public debt-to-GDP ratio rises unambiguously. This mechanism is enhanced by

[22]The deviation of the Eurostat House Price Index reached a maximum of 4% below its trend and the euro area output gap reached a trough of about 1% (2013q1), a level close to what the model would suggest, $\approx (0.17 \times 4)\,\% = 0.7\%$.

debt deflation, and by the fact that higher public indebtedness boosts the sovereign risk premium, propping up government's financing costs.[23]

5.2 The role of private and public debt during deleveraging

To understand the extent to which public and private indebtedness matters, in Figure 2 we simulate the model under varying assumptions about the steady-state level of the private and public debt/GDP ratios. Namely, we vary private debt at the steady state by modifying the loan-to-value (LTV) ratio parameters. To shift the steady-state value of public debt, we change the long-run target of the public debt-to-GDP ratio.[24] We plot the three-year cumulative responses of output, private and public debt-to-GDP ratios to an identical negative house price shock.

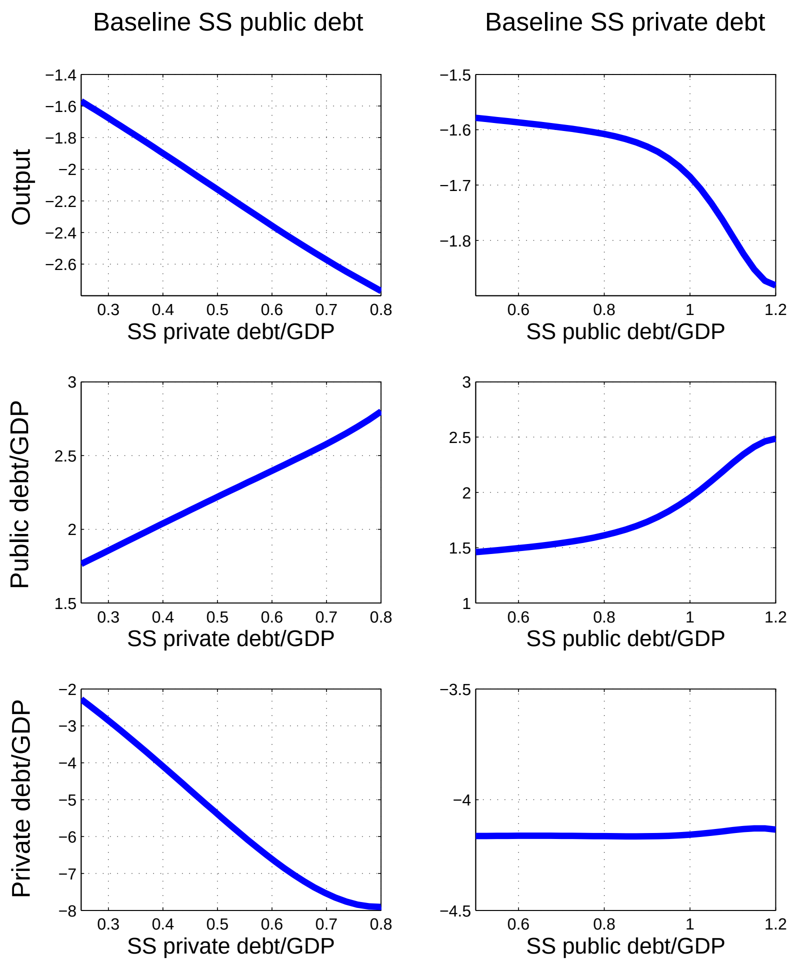
There are three main results. First, the economic contraction is increasingly worse the higher private debt is relative to GDP. In other words, countries in which households and firms have borrowed more to finance expenditure will experience a larger drop in demand when credit constraints become tighter. This result is in line with the standard behavior of the financial accelerator effect embedded in these models featuring collateral constraints (e.g. Iacoviello and Neri, 2010; Liu et al., 2013; Christensen et al., 2016, among many others).

Second, due to the decline in output, government fiscal revenues in countries with higher initial private debt decline by more and more rapidly when private credit dries up. Together with the greater severity of the drop in GDP, this leads

[23]Note that Figure 1 shows impulse response functions to the house price shock for 20 quarters. Table 5, instead, shows the correlations between cyclical fluctuations of private and public debt and cyclical fluctuations of real GDP 12 quarters-ahead, using a large sample of 5,000 observations. In response to the house price shock the correlation between cyclical fluctuations of public debt and cyclical fluctuations of real GDP 12 quarters-ahead is negative even at an horizon longer than the one reported in the figure. The positive (and low) correlation between these two variables shown in Table 5 is driven mainly by the technology shock, which plays an important role in accounting for fluctuations in public debt.

[24]Specifically, to produce the charts in the left column of the figure, we keep the steady-state level of public debt/GDP at the baseline value of $\Gamma = 4 \times 0.71$. This is equivalent to the average level of public debt in our Euro Area dataset, i.e. 71 percent of annual GDP. Then, we set the two LTV ratios (for impatient households and firms) to the same value, let them vary over the same parameter range ($m = m'' \in [0.375, 0.80]$), and we plot the corresponding three-year cumulative responses of output, public debt/GDP and private debt/GDP. For ease of comparison with public debt, on the x-axis we report the resulting private debt/GDP ratio. Instead, to produce the charts in the right column of the figure, we keep the steady state of private debt at the baseline level ($m = 0.375$ and $m'' = 0.80$), let the steady-state level of public debt/GDP vary in the interval $\bar{\Gamma} \in [4 \times 0.5, 4 \times 1.2]$, so that public debt ranges between 50 and 120 percent of annual GDP, and plot the same variables.

Figure 2: Three-Year Cumulative Responses to a Negative One-Per-Cent House Price Shock for Different Loan-to-Value (LTV) Ratios and Different Steady-State (SS) Public Debt/GDP Ratios



Notes: In the left column the LTV ratios, m and m'', vary between 0.375 and 0.80; for ease of comparison with public debt, on the x-axis we report the resulting private debt/GDP ratio. In the right column, the steady-state government debt-to-GDP ratio, Γ, varies between 4×0.5 and 4×1.2; Y-axes for output are in percent deviations from steady state, while for private and public debt to GDP ratios they are in absolute deviations.

to a more pronounced increase in public debt as a fraction of GDP.

The third main result is that the higher public debt relative to GDP before the financial shock, the worse the recession, but this relationship becomes material only when public debt is above a certain threshold (about 90 percent of GDP). The behavior of these impulse responses highlights the non-linear relationship between the average level of public debt and the severity of the contraction. This can be explained by the fact that any change in public debt implies a different elasticity of the return on government bond holding, R^G, to public debt given the assumed CDF of the fiscal limit.[25]

The relationship between steady-state public debt levels in terms of GDP and its cumulative response is positive but also non-linear: once again, for levels of the steady-state public debt-to-GDP ratio below 0.90 the cumulative response of public indebtedness is marginally affected. The effects become stronger at higher levels of steady-state public debt that, in line with the calibration of the CDF of the fiscal limit, imply a boost in sovereign risk premia and the government's financing costs.

Interestingly, differences in levels of private debt exert proportionally stronger impacts on output than differences in public debt. For example, an increase in the steady-state level of private debt-to-GDP ratio by 10 percentage points leads to a deepening three-year GDP contraction of 11 percent on average. The worsening of the recession is approximately proportional to the increase in the private debt-to-GDP ratio. Instead, nonlinearities are more evident for the case of public debt. When the level of steady-state public debt is lower than 90 percent of GDP, an increase of the ratio by 10 percentage points leads to a deepening of the three-year GDP contraction of less than 1 percent. The worsening in the GDP contraction reaches a maximum value of 6 percent when steady-state public debt increases from 100 to 110 percent of GDP. The rationale for this result is that the more impatient agents have resorted to borrowing to finance their expenditure, the larger the required spending cut to satisfy their borrowing constraints when the shock hits. In contrast, if the government is sufficiently far from its fiscal limit, it can borrow more and partially offset the financial shock, even in the face of higher financing costs.[26]

[25] Linearizing the relevant equilibrium conditions, it is possible to derive the elasticity of the return on government bond holding to public debt, Θ_t. Note that $\hat{R}^G_{t-1} = \frac{\Delta^G}{(1-\Delta^G)} \frac{\eta_2}{1+A(\Gamma)} \Gamma \hat{\Gamma}_t + \hat{R}_{t-1}$, hence the elasticity $\Theta_t = \frac{\Delta^G}{(1-\Delta^G)} \frac{\eta_2}{1+A(\Gamma)} \Gamma$, where $A(\Gamma) = exp(\eta_1 + \eta_2 \Gamma)$. This elasticity inherits the property of the first derivative of the CDF, which is a convex function of Γ.

[26] This case is reminiscent of the point made by Ostry et al. (2015), whereby if public debt is sufficiently below that implied by the fiscal limit,the government is still better off increasing its debt further to absorb a negative shock.

5.3 The effects of targeted intervention and the merits of fiscal buffers

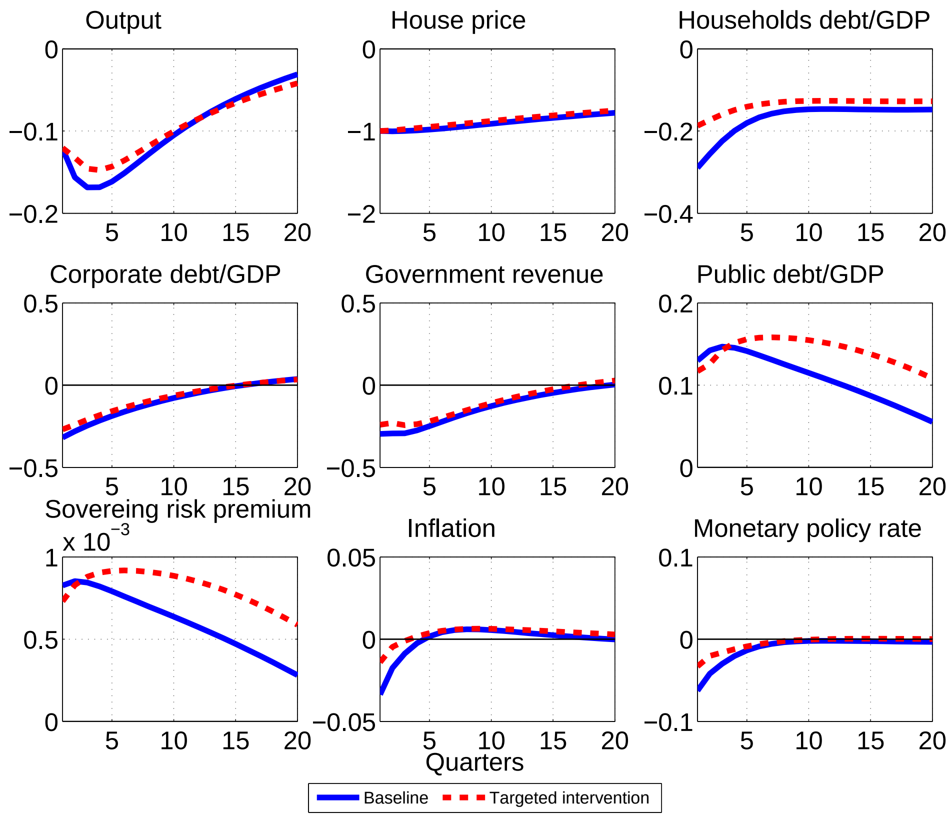
In our model, the government can lend money to the private sector (i.e. impatient households and entrepreneurs) at times when swings in the value of their collateral impose sharp and abrupt cuts to the credit they have access to. We refer to this policy as "targeted intervention". We interpret the intervention in a general sense, to capture a set of real-world policy measures adopted by various governments in the Euro Area and elsewhere during the global financial crisis to alleviate households' and firms' borrowing constraints. These initiatives included, among others, government credit to facilitate mortgage payments by agents in distress (for example in Spain), unsecured government lending to households to finance home renovation projects, credit support to firms (for example in Germany and France) at a time when other forms of financial intermediation had dried up.[27]

For the government there is an obvious merit in relaxing the private sector's borrowing constraints at times of stress: similarly to unconventional monetary easing, by lending directly to the larger economy, the government can effectively remove a financial friction that would otherwise impede credit-constrained agents to smooth spending during a deleveraging phase. In so doing, the government *de facto* supports economic activity while, at the same time, it mitigates the drop in government revenues. We show below that, if the policy is appropriately set, it has dual beneficial macroeconomic consequences because it averts a deterioration of the recession as well as a deterioration of public finances, including public debt.

Our set up is well suited to clarify how these mechanisms work because it embeds explicitly the links between private and public debt, and output. To be worthwhile, the output/fiscal revenue gains from targeted interventions must thus be large

[27]The fiscal stimulus implemented by Euro Area governments in response to the financial crisis is known as the European Economic Recovery Plan (EERP). These fiscal measures have been implemented in addition to the stimulus provided via automatic fiscal stabilizers. One of the key principles of the EERP is that the budgetary stimulus should be *targeted* towards the source of the economic challenge (increasing unemployment, credit constrained firms/households, etc. and supporting structural reforms) (Commission, 2008, page 8), within the Stability and Growth Pact. Among the measures listed in the EERP, "guarantees and loan subsidies to compensate for the unusually high current risk premium can be particularly effective in an environment where credit is generally constrained". The enhanced access to financing for business is implemented also via the intervention of the European Investment Bank, which has put together a package of 30 billion euro for loans to small and medium enterprises, an increase by 10 billion euro over its usual lending in this sector.

Figure 3: Impulse Responses to a Negative One-Per-Cent House Price Shock: Effects of Targeted Intervention



Notes: Targeted intervention is obtained by setting $\epsilon = 0.1$ and $\kappa = 0.1$; X-axes in quarters; Y-axes are in percent deviations from steady state, except for private and public debt to GDP ratios where deviations are absolute.

enough to outweigh the adverse impact on output of subsequent necessary fiscal consolidations aimed at keeping public debt sustainable. This trade-off depends on the amount of fiscal space (namely the distance between the initial stock of outstanding government debt and the fiscal limit) available when the shock hits. The smaller the fiscal space (i.e. the larger public debt) before the financial crisis, the larger the debt servicing costs, the narrower the room for maneuver for targeted intervention, the tighter the fiscal policy stance needs to be.[28]

[28]By contrast, the model abstracts from the potential implications of moral hazard, that is the possibility that impatient agents may borrow excessively, factoring in the likelihood of a future government targeted intervention in their favor. Below we partially compensate for this by introducing inefficiency costs to government targeted intervention. While this does not address the simplification of ruling out moral hazard behavior, they do approximate the economic losses that may potentially arise from such behavior.

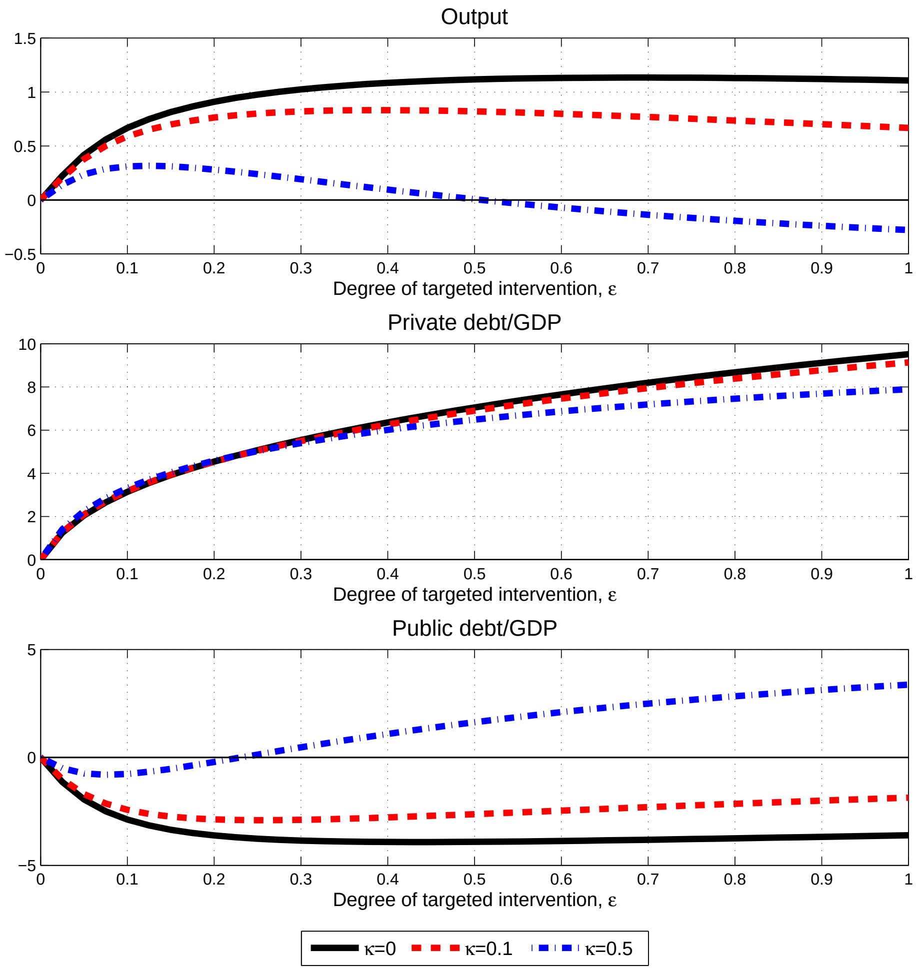
In Figure 3 we examine the role of targeted intervention in the simulated deleveraging episode. To activate this policy channel in the model we set the relevant parameters ϵ and κ equal to 0.1. This parametrization captures a moderate degree of targeted intervention and inefficiency costs in the range considered by Gertler and Karadi (2011). While in this exercise the degree of targeted intervention is set arbitrarily, in the remainder of this subsection we compute the level of intervention that maximizes gains and explore the interactive effects of ϵ and κ on the effectiveness of the policy.

The illustrative simulation shows that government lending is effective at containing the contractionary consequences of private sector deleveraging. This, in turn, helps contain the decline in government revenues and the extent of the deflation. However, the intervention raises public spending temporarily, because of the increase in the risk premium, and thus in debt servicing costs, and the cost of inefficiencies arising from public intermediation. Reflecting these additional costs, public debt is not only higher but also more persistent compared to the baseline scenario.

By choosing the level of targeted intervention (ϵ) appropriately, however, the government can simultaneously support economic activity and reduce the debt-to-GDP ratio. To see how, let us suppose that the private sector is highly indebted, which we capture by setting the LTV ratios at levels located in the highest range of the historical Euro Area statistical distribution (ECB, 2012) – $m'' = 0.99$ and $m = 0.44$. Let us also suppose that the government has fiscal space, so that the targeted intervention does not need to be compensated off through an aggressive exacerbation of the fiscal stance (to this end we set the steady-state level of public debt/GDP at the average Euro Area value of 71 percent, i.e. $\bar{\Gamma} = 4 \times 0.71$). To check whether and to what extent it is desirable for the government to intervene, we compute the gains from targeted intervention, i.e. the differences between three-year cumulative impulse responses to a negative one-per-cent house price shock for different degrees of targeted intervention ($\epsilon \in [0, 1]$) and their analogues in a no-policy-action scenario ($\epsilon = 0$). We conduct the same exercise for three levels of inefficiency costs ($\kappa = \{0, 0.1, 0.5\}$) and report the results in Figure 4. This parameter range for κ is very wide: $\kappa = 0.1$ is already in the high range of values that Gertler and Karadi (2011) consider plausible; $\kappa = 0.5$ captures the case of extreme inefficiencies in public intermediation of funds.[29]

[29] Throughout this subsection, in analogy to Clerc et al. (2015), we consider a measure of output directly comparable with the data, which is net of adjustment costs and dead weight losses, i.e.

Figure 4: Three-Year Cumulative Gains from Targeted Intervention Relative to a No-Policy-Action Scenario.



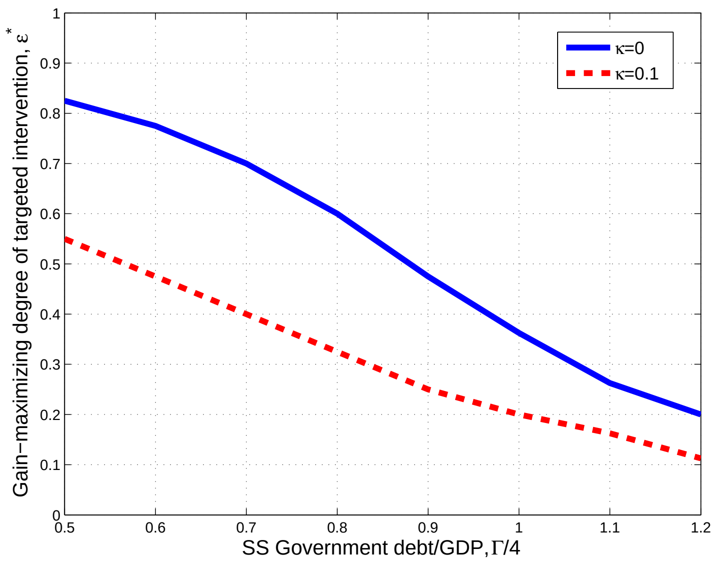
Notes: The charts report differences between three-year cumulative impulse responses to a negative one-per-cent house price shock for different degrees of targeted intervention (ϵ) and their analogues in the no-policy-action scenario ($\epsilon = 0$). The same exercise is conducted for three levels of inefficiency costs (κ). This difference is defined as the three-year cumulative gains. Private debt is calibrated by setting $m'' = 0.99$ and $m = 0.44$. Y-axes for output are in percent deviations from steady state, while for private and public debt to GDP ratios they are in absolute deviations.

Two main results emerge from this exercise: (i) there is a non-zero level of targeted intervention, ϵ^*, that minimizes output losses and the increase in public debt to GDP following the shock;[30] (ii) the more efficient the intervention (the

$\tilde{Y}_t = C_t + C'_t + C''_t + I_t + G_t$.

[30] In the charts, these reduced losses are shown in terms of macroeconomic gains of intervening relative to not intervening.

Figure 5: Fiscal Space and Gain-Maximizing Degree of Targeted Intervention



Notes: The gain-maximizing degree of targeted intervention, ϵ^*, is computed as the level of ϵ that maximizes the difference between the three-year cumulative impulse response of output to a negative one-per-cent house price shock and its analogue in the no-policy-action scenario ($\epsilon = 0$). Private debt is calibrated by setting $m'' = 0.99$ and $m = 0.44$. The same exercise is conducted for two levels of inefficiency costs ($\kappa = 0$ and $\kappa = 0.1$).

lower the value of κ) the larger the benefits for output and public debt ratio of any level of targeted intervention and, accordingly, the higher the gain-maximizing level of targeted intervention (higher ϵ^*).

It is noteworthy that, when the level of targeted intervention is set equal to ϵ^*, the increase in the public debt-to-GDP ratio over three years is less than in the case of no government intervention. In fact, in the former case, the beneficial effect of targeted intervention on output exceeds the adverse impact of the subsequent fiscal consolidation required to neutralize the effect of additional public spending.[31]

In a further policy experiment we ask what the impact of targeted interventions

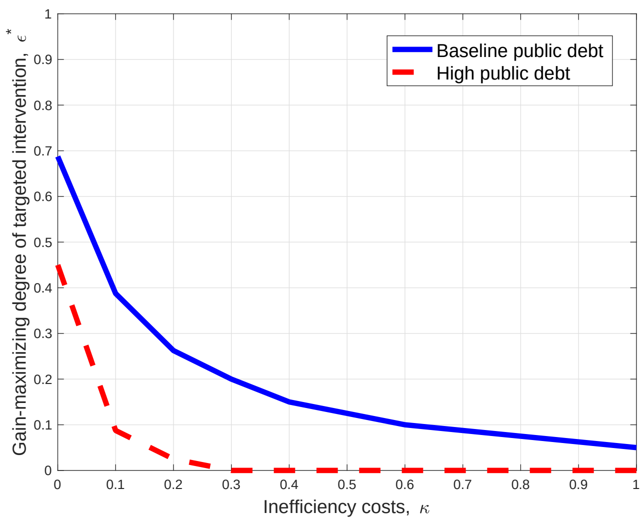
[31] In an exercise reported in the Fiscal Monitor (IMF, 2016), our DSGE model is used to assess the benefits of three alternative fiscal policy measures: targeted intervention, government consumption, and public investment. Results unveil that the output benefits of targeted intervention are four times larger than those of more standard stimulus measures. The rationale behind this result is that, by lending to credit-constrained households and firms, the government can leverage a much larger amount of spending than through other policy stimuli of equal cost. In fact, the fiscal cost of targeted intervention is only a fraction of the total government loan.

is when the government has modest fiscal space. To this end we simulate the model setting the value of the public debt-to-GDP ratio at higher steady-state levels, Γ. Figure 5 shows that, even when fiscal space is modest, targeted intervention remains beneficial for output in net terms, although the degree of intervention that minimizes output losses diminishes monotonically as fiscal space shrinks. This happens because higher government debt implies a dearer debt service, which demands a larger consolidation *ex post*. Inefficiency costs (the effect of which can be appreciated by setting κ to 0.1 from 0) worsen the picture because, other things equal, they augment the cost of the intervention, shifting the relationship between ϵ^* and Γ downward. This warrants an even lower degree of intervention. In fact, as shown in Figure E.1 (Appendix E), keeping the degree of targeted intervention fixed (ϵ =0.1), tax rates on consumption and labor income increase by more with higher steady-state levels of public debt-to-GDP to ensure fiscal solvency. The negative effects generated by the higher levels of (current and future) taxes depress consumption, labor, and hence output. The policy implication from this experiment is that, while more limited fiscal spaces harshen the policymaker's trade-offs, to a lesser extent, targeted intervention minimizes output losses also when fiscal buffers are smaller and public intermediation of funds is not completely efficient.

As a last exercise, we compute the threshold value of inefficiency costs, κ, above which intervention would become detrimental, i.e. it would produce a loss of output relative to the no-policy-action scenario. Figure 6 reports the gain-maximizing degree of targeted intervention, ϵ^*, as a function of κ for two levels of steady-state government debt ratios: $\bar{\Gamma}/4 = 0.71$, and $\bar{\Gamma}/4 = 0.92$, which capture baseline and "high" public debt cases as in the rest of the paper. As expected, in all cases, ϵ^* is a negative function of κ. The higher the inefficiency costs, the higher the costs of government intermediation of funds, the lower the gain maximizing degree of targeted intervention. In addition, the figure shows that higher levels of public debt cause a downward shift of the relationship, due to the larger sovereign risk premium and, hence, higher costs of intervention for any given level of κ. For a baseline level of the steady-state government debt ratio, ϵ^* is very small but positive even if the government is not able to recover any of the loans extended to the private sector, i.e. κ =1. In contrast, with high public debt, ϵ^* turns zero if $\kappa \geq 0.3$.[32]

[32] In the absence of inefficiency costs ($\kappa = 0$) and sovereign risk premium, ϵ^* would be unbounded and the government could neutralize completely the deleveraging phase.

Figure 6: Inefficiency Costs and Gain-Maximizing Degree of Targeted Intervention



Notes: The gain-maximizing degree of targeted intervention, ϵ^*, is computed as the level of ϵ that maximizes the difference between the three-year cumulative impulse response of output to a negative one-per-cent house price shock and its analogue in the no-policy-action scenario ($\epsilon = 0$). Private debt is calibrated by setting $m'' = 0.99$ and $m = 0.44$. The same exercise is conducted for two levels of steady-state government debt ratios: $\bar{\Gamma}/4 = 0.71$ and $\bar{\Gamma}/4 = 0.92$, to capture baseline and high public debt cases.

6 Conclusion

Do the outstanding levels of private and public debt amplify swings in economic activity over the leverage cycle? Is government lending toward credit-constrained agents, i.e. targeted intervention, desirable at times of financial stress?

This paper attempts to answer these fundamental, and yet largely unanswered policy questions in the context of a general equilibrium model that stylizes private debt/public debt dynamics and can thus reproduce well the observed correlations between debt and future economic activity in the Euro Area. These imply that higher private debt leads deeper recessions, while higher public debt does not, unless the average level of public debt is especially high.

Our answer to the first question is yes, with some caveats. Our model predicts that economies with a larger stock of private debt tend to face more severe recessions following financial shocks. By contrast, the level of public debt has virtually no bearing on the severity of financial recessions, unless public debt is high to begin with. From this we arrive at the less obvious conclusion that hefty levels of private debt are as, or even more worrisome than hefty stocks of public debt for macroeconomic stability at times of heightened financial volatility.

Our answer to the second question is also yes. By alleviating the private sector's borrowing constraints, the government mitigates the recession and thus limits the drop in fiscal revenues associated with less favorable output realizations. However, two qualifications are in order. First, financial assistance during phases of financial deleveraging should not be confused with blanket fiscal stimuli: here we explore a specific targeted policy, i.e. lending to financially-constrained agents during phases of credit deleveraging, and not standard spending stimuli. Second, there is a clear trade-off between costs and benefits of intervention. This is because the economic costs of targeted intervention rise (i) with the level of public debt – as endogenous sovereign risk premia aggravate debt servicing and taxes need to increase by more, causing greater output losses; and (ii) with the inefficiency of public intervention in aid of financially-constrained agents. In line with these findings, simulations demonstrate the important role played by fiscal buffers, precisely because these allow greater degrees of targeted intervention.

Our findings also have implications for macro-financial surveillance, in suggesting that equal attention should be warranted towards risks posed by the evolution and levels of private indebtedness, relative to those traditionally believed to be associated with public indebtedness in isolation. In addition, limiting LTV ratios both in advanced and emerging market economies greatly reduces macro financial vulnerabilities associated with excessive credit booms and would limit the realizations of deeper and more prolonged recessions following episodes of financial instability.

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Appendix

A Countries in Panel Regressions and Descriptive Statistics

Table A.1: Countries in Panel Regressions and Descriptive Statistics

	Private debt (% of GDP)			Public debt (% of GDP)		
	Years	Average	Std. dev.	Years	Average	Std. dev.
Austria	1960-2014	92.29	38.36	1988-2014	68.27	9.28
Belgium	1970-2014	120.52	45.38	1980-2014	111.33	16.01
Finland	1970-2014	120.34	31.20	1980-2014	36.61	16.67
France	1969-2014	125.86	25.73	1980-2014	54.93	22.21
Germany	1960-2014	100.24	19.14	1991-2014	62.37	11.61
Greece	1970-2014	62.28	33.17	1980-2014	91.52	45.06
Ireland	1971-2014	135.17	85.22	1995-2014	61.43	33.97
Italy	1960-2014	79.55	21.70	1988-2014	109.02	11.61
Netherlands	1961-2014	141.13	70.35	1980-2014	63.21	10.56
Portugal	1960-2014	124.69	49.46	1990-2014	72.27	28.40
Spain	1970-2014	123.53	44.86	1980-2014	52.09	19.57

B Private Debt and GDP Growth at Different Frequencies

The growth literature has looked extensively at the effects of private debt on the macroeconomy. It is beyond the scope of the present work to provide an exhaustive review of these studies. As a background to our analysis, here we briefly summarize the three main relevant strands of the literature. The first finds that in the long term, higher private sector credit supports economic growth (e.g. Levine, 1997; Levine et al., 2000; Arestis et al., 2015, among many others). A second strand of the literature finds that not just the size but also the structure of the financial system matters for growth (Ergungor, 2008; Fecht et al., 2008; Luintel et al., 2008; Demirgüç-Kunt et al., 2013; Peia and Roszbach, 2015). The third strand of the literature examines the non-linear effect of financial development on growth. For example, Aghion et al. (2005) find that financial development – measured using private credit divided by GDP – has a positive but eventually vanishing effect

Table B.1: Correlations Between Changes in Private Debt and Subsequent Real GDP Growth at Various Horizons

	Full Sample	"Low" private debt	"High" private debt
$Corr\left(\Delta_3\left(\frac{PRD}{Y}\right)_{t-1}, \Delta_3 y_{t+3}\right)$	-0.321***	-0.436***	-0.338***
$Corr\left(\Delta_5\left(\frac{PRD}{Y}\right)_{t-1}, \Delta_5 y_{t+5}\right)$	-0.318***	-0.389***	-0.383***
$Corr\left(\Delta_{10}\left(\frac{PRD}{Y}\right)_{t-1}, \Delta_{10} y_{t+10}\right)$	-0.077	0.010	-0.321***
$Corr\left(\Delta_{15}\left(\frac{PRD}{Y}\right)_{t-1}, \Delta_{15} y_{t+15}\right)$	0.525***	0.498***	0.478***

Notes: $\frac{PRD}{Y}$ denotes the ratio of private debt to GDP, y denotes the log of real GDP, while $\Delta_k x_t = x_t - x_{t-k}$. The threshold value to distinguish low- and high-private-debt countries is the median of average the private-debt to-GDP ratio (120.52 percent of GDP). *, ** and *** denote significance at a 10, 5 and 1 percent level, respectively.

on steady-state GDP. Along this line, Arcand et al. (2015) show that there is a threshold above which finance (measured as private credit to GDP) starts having a negative effect on economic growth. The growth literature, however, is far from having reached a consensus. Differences among different studies include the choice of financial variable proxies, the kind of data used, as well as whether studies take the issue of endogeneity into account.

As already mentioned in the paper, at shorter frequencies – mostly 3 to 5 years – new empirical studies have shown that increases in private sector credit, especially household debt, may raise the likelihood of a financial crisis and can lead to lower future growth (e.g. Jordà et al., 2014; Mian et al., 2017, among others). This is because high indebtedness can cause significant debt overhang problems when a country faces negative shocks.

In Table B.1, we distinguish between high-frequency (3 to 5 years) and low-frequency (10-15 years) correlations of changes in private debt with GDP growth. The table shows that the euro area data are consistent not only with the recent findings on the relationship between debt and growth at high frequencies that we examine in the paper, but also with those pointing to the existence of a positive finance-growth nexus in the long run. In particular, the negative association between changes of private debt and future growth at business cycle frequencies (3 to 5 years) is confirmed for both the full sample of euro area countries considered and for subsamples with "low" and "high" average private debt.[33] At a 10-year horizon,

[33]The threshold value to distinguish "low"- and "high"-private-debt countries is the median of the average private-debt to-GDP ratio (120.52 percent of GDP). This criterion places Greece, Italy,

the picture is more heterogeneous as the correlation becomes approximately zero for the full sample and for countries with “low” private debt, while it remains negative for the “high”-debt countries, echoing to some extent the findings of the growth literature on nonlinear effects. At a 15-year horizon, the positive nexus between private debt and growth can be detected for all samples.

C Equilibrium conditions

C.1 Optimality conditions of households and entrepreneurs

Patient households

Intertemporal maximization yields the following first-order conditions with respect to C'_t, L'_t, B'_t, B^G_t and h'_t:

$$\mu'_t = \frac{1}{\left(1+\tau^C_t\right) X'_t}, \tag{C.1}$$

$$\left(1-\tau^W_t\right) \frac{W'_t}{P_t} = \left(L'_t\right)^{\eta-1} \left(1+\tau^C_t\right) X'_t, \tag{C.2}$$

$$\frac{1}{\left(1+\tau^C_t\right) X'_t} = \beta E_t \left[\frac{R_t}{\left(1+\tau^C_{t+1}\right) X'_{t+1} \Pi_{t+1}} \right], \tag{C.3}$$

$$\frac{1}{\left(1+\tau^C_t\right) X'_t} = \beta E_t \left[\frac{\left(1-\Delta^G_{t+1}\right) R^G_t}{\left(1+\tau^C_{t+1}\right) X'_{t+1} \Pi_{t+1}} \right], \tag{C.4}$$

$$\frac{q_t}{\left(1+\tau^C_t\right) X'_t} = \frac{\zeta e^H_t}{h'_t} + \beta E_t \left[\frac{q_{t+1}}{\left(1+\tau^C_{t+1}\right) X'_{t+1}} \right], \tag{C.5}$$

where μ'_t is the Lagrange multiplier associated to the budget constraint and $\Pi_{t+1} \equiv P_{t+1}/P_t$ represents the gross inflation rate. Equations (C.3) and (C.4) imply a non-arbitrage condition between the riskless interest rate and that on government bonds, whereby a sovereign risk spread arises, i.e. $R^G_t = E_t \left[\left(1-\Delta^G_{t+1}\right)^{-1} \right] R_t$.

Austria, Germany, Finland and Belgium in the “low” private debt subsample; and Spain, Portugal, France, Netherlands and Ireland in the “high” private debt subsample.

Impatient households

Intertemporal maximization yields the following first-order conditions with respect to C_t'', L_t'', B_t'' and h_t'':

$$\mu_t'' = \frac{1}{\left(1+\tau_t^C\right) X_t''}, \tag{C.6}$$

$$\left(1-\tau_t^W\right) \frac{W_t''}{P_t} = \left(L_t''\right)^{\eta-1} \left(1+\tau_t^C\right) X_t'', \tag{C.7}$$

$$\frac{1}{\left(1+\tau_t^C\right) X_t''} = \beta'' E_t \left[\frac{R_t}{\left(1+\tau_{t+1}^C\right) X_{t+1}'' \Pi_{t+1}} \right] + \lambda_t'' R_t, \tag{C.8}$$

$$\frac{q_t}{\left(1+\tau_t^C\right) X_t''} = \frac{\zeta e_t^H}{h_t''} + E_t \left[\frac{\beta'' q_{t+1}}{\left(1+\tau_{t+1}^C\right) X_t''} + \lambda_t'' m'' q_{t+1} \Pi_{t+1} \right], \tag{C.9}$$

where μ_t'' is the Lagrange multiplier associated to the flow of funds and λ_t'' is the Lagrange multiplier associated with the borrowing constraint.

Entrepreneurs

Maximization of function (11) subject to (9), (10), (12), (13), (14), (15) and the two quadratic adjustment costs yields the following first-order conditions with respect to $C_{e,t}$, $B_{e,t}$, $I_{e,t}$, $K_{e,t}$, $h_{e,t}$, $L'_{e,t}$, $L''_{e,t}$, and $P_{e,t}$ which, evaluated at the symmetric equilibrium, read as:

$$\mu_t = \frac{1}{\left(1+\tau_t^C\right) X_t}, \tag{C.10}$$

$$\mu_t = \lambda_t R_t + \gamma E_t \left[\mu_{t+1} \frac{R_t}{\Pi_{t+1}} \right], \tag{C.11}$$

$$\mu_t = \lambda_t R_t + \gamma E_t \left[\mu_{t+1} \frac{R_t}{\Pi_{t+1}} \right], \tag{C.12}$$

$$u_t = \mu_t \left[1 + \frac{\psi_K}{\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right) \right], \tag{C.13}$$

$$u_t = \gamma E_t \left\{ \begin{array}{c} \mu_{t+1} \left[\frac{\psi_K}{\delta} \left(\frac{I_{t+1}}{K_t} - \delta \right) \frac{I_{t+1}}{K_t} - \frac{\psi_K}{2\delta} \left(\frac{I_{t+1}}{K_t} - \delta \right)^2 \right] \\ + \left[\mu_{t+1} MC_{t+1} \frac{\omega Y_{t+1}}{K_t} + (1-\delta) u_{t+1} \right] \end{array} \right\}, \tag{C.14}$$

$$\mu_t q_t = E_t \left\{ \gamma \mu_{t+1} \left[q_{t+1} + MC_{t+1} \frac{\nu Y_{t+1}}{h_t} \right] + m \lambda_t q_{t+1} \Pi_{t+1} \right\}, \tag{C.15}$$

$$w_t' = MC_t \frac{\alpha (1 - \omega - \nu) Y_t}{L_t'}, \tag{C.16}$$

$$w_t'' = MC_t \frac{(1 - \alpha)(1 - \omega - \nu) Y_t}{L_t''}, \tag{C.17}$$

$$\begin{aligned} 0 &= 1 + e_t^P \chi (MC_t - 1) - \psi_P (\Pi_t - 1) \Pi_t \\ &+ \psi_P E_t \left[\gamma \frac{\mu_{t+1}}{\mu_t} (\Pi_{t+1} - 1) \Pi_{t+1} \frac{Y_{t+1}}{Y_t} \right], \end{aligned} \tag{C.18}$$

respectively, where λ_t is the Lagrange multiplier associated with the borrowing constraint, MC_t is the the firm's marginal cost and u_t is Tobin's q.

C.2 Remaining equilibrium conditions

$$X_t{}' = C_t' - \theta C_{t-1}' \tag{C.19}$$

$$\left(1 + \tau_t^C\right) C_t'' + q_t \Delta h_t'' + \frac{R_{t-1} B_{t-1}''}{\Pi_t} + \frac{R_{t-1} B_{g,t-1}''}{\Pi_t} = \left(1 - \tau_t^W\right) w_t'' L_t'' + B_t'' + B_{g,t}'' \tag{C.20}$$

$$B_t'' = m'' E_t \left[\frac{q_{t+1} h_t'' \Pi_{t+1}}{R_t} \right] \tag{C.21}$$

$$X_t{}'' = C_t'' - \theta C_{t-1}'' \tag{C.22}$$

$$\begin{aligned} Y_t + B_t + B_{g,t} &= \left(1 + \tau_t^C\right) C_t + q_t \Delta h_t + \frac{R_{t-1} B_{t-1}}{\Pi_t} + \frac{R_{t-1} B_{g,t-1}}{\Pi_t} \\ &+ w_t' L_t' + w_t'' L_t'' + I_t + \xi_{K,t} + \xi_{P,t} \end{aligned} \tag{C.23}$$

$$R_t B_t = m E_t \left[q_{t+1} h_t \Pi_{t+1} \right] \tag{C.24}$$

$$Y_t = e_t^A K_{t-1}^{\omega} h_{t-1}^{\nu} (L_t')^{\alpha(1-\omega-\nu)} (L_t'')^{(1-\alpha)(1-\omega-\nu)} \tag{C.25}$$

$$I_t = K_t - (1 - \delta) K_{t-1} \tag{C.26}$$

$$\xi_{K,t} = \frac{\psi_K}{2\delta} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 K_{t-1} \tag{C.27}$$

$$\xi_{P,t} \equiv \frac{\psi_P}{2} \left(\frac{P_t}{P_{t-1}} - 1 \right)^2 Y_t \tag{C.28}$$

$$X_t = C_t - \theta C_{t-1} \tag{C.29}$$

$$Y_t = C_t + C_t' + C_t'' + I_t + G_t \tag{C.30}$$

$$h + h' + h'' = 1 \tag{C.31}$$

$$\log\left(\frac{R_t}{R}\right) = \rho_r \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_r)\left[\rho_\pi \log\left(\frac{\Pi_t}{\Pi}\right) + \rho_y \log\left(\frac{Y_t}{Y}\right)\right] \tag{C.32}$$

$$p_t^* = \frac{\exp\left(\eta_1 + \eta_2 \Gamma_t\right)}{1 + \exp\left(\eta_1 + \eta_2 \Gamma_t\right)} \tag{C.33}$$

$$\Gamma_t = \frac{B_t^G}{Y_t} \tag{C.34}$$

$$\Delta_t^G = p_t^* \bar{\Delta}^G \tag{C.35}$$

$$B_t^G = \left(1 - \Delta_t^G\right) \frac{R_{t-1}^G B_{t-1}^G}{\Pi_t} + G_t + \frac{\left(R_{t-1}^G - R_{t-1}\right) B_{t-1}^{int}}{\Pi_t} + \kappa B_t^{int} - T_t + \Xi_t \tag{C.36}$$

$$\Xi_t = \Delta_t^G \frac{R_{t-1}^G B_{t-1}^G}{\Pi_t} \tag{C.37}$$

$$T_t = \tau_t^C \left(C_t' + C_t'' + C_t\right) + \tau_t^W \left(w_t' L_t' + w_t'' L_t''\right) + \tau_t^L \tag{C.38}$$

$$B_t^{int} \equiv B_{g,t}'' + B_{g,t} \tag{C.39}$$

$$b_{g,t}'' = -\epsilon b_t'' \tag{C.40}$$

$$b_{g,t} = -\epsilon b_t \tag{C.41}$$

$$b_{g,t}'' = \frac{B_{g,t}'' - B_g''}{Y} \tag{C.42}$$

$$b_{g,t} = \frac{B_{g,t} - B_g}{Y} \tag{C.43}$$

$$b_t'' = \frac{B_t'' - B''}{Y} \tag{C.44}$$

$$b_t = \frac{B_t - B}{Y} \tag{C.45}$$

$$\log\left(\frac{\tau_t}{\tau}\right) = \rho \log\left(\frac{\tau_{t-1}}{\tau}\right) + (1-\rho)\left[e^{\phi \frac{B^G}{Y}} \rho_B \log\left(\frac{B_{t-1}^G}{B^G}\right)\right], \tag{C.46}$$

Table D.1: Gain-Maximizing Degree of Targeted Intervention–Robustness Checks

	Gain-maximizing degree of targeted intervention, ϵ^*		
	$\bar{\Gamma}/4 = 0.54$	$\bar{\Gamma}/4 = 0.71$	$\bar{\Gamma}/4 = 0.92$
Baseline	0.81	0.69	0.45
$\eta = 2$	0.71	0.62	0.40
$\delta = 0.035$	0.82	0.70	0.45
$\rho_y = 0.2$	0.79	0.65	0.40

Notes: The gain-maximizing degree of targeted intervention, ϵ^*, is computed as the level of ϵ that maximizes the difference between the three-year cumulative impulse response of output to a negative one-per-cent house price shock and its analogue in the no-policy-action scenario ($\epsilon = 0$). Private debt is calibrated by setting $m'' = 0.99$ and $m = 0.44$. we set $\bar{\Gamma}/4 = 0.54$, $\bar{\Gamma}/4 = 0.71$, $\bar{\Gamma}/4 = 0.92$ to capture low, average and high public debt cases, respectively as in the rest of the paper.

$$\log\left(\frac{G_t}{G}\right) = \rho \log\left(\frac{G_{t-1}}{G}\right) - (1-\rho)\left[e^{\phi \frac{B^G}{Y}} \rho_B \log\left(\frac{B^G_{t-1}}{B^G}\right)\right], \tag{C.47}$$

$$\tau^C_t = \tau_t \bar{\tau}^C \tag{C.48}$$

$$\tau^W_t = \tau_t \bar{\tau}^W \tag{C.49}$$

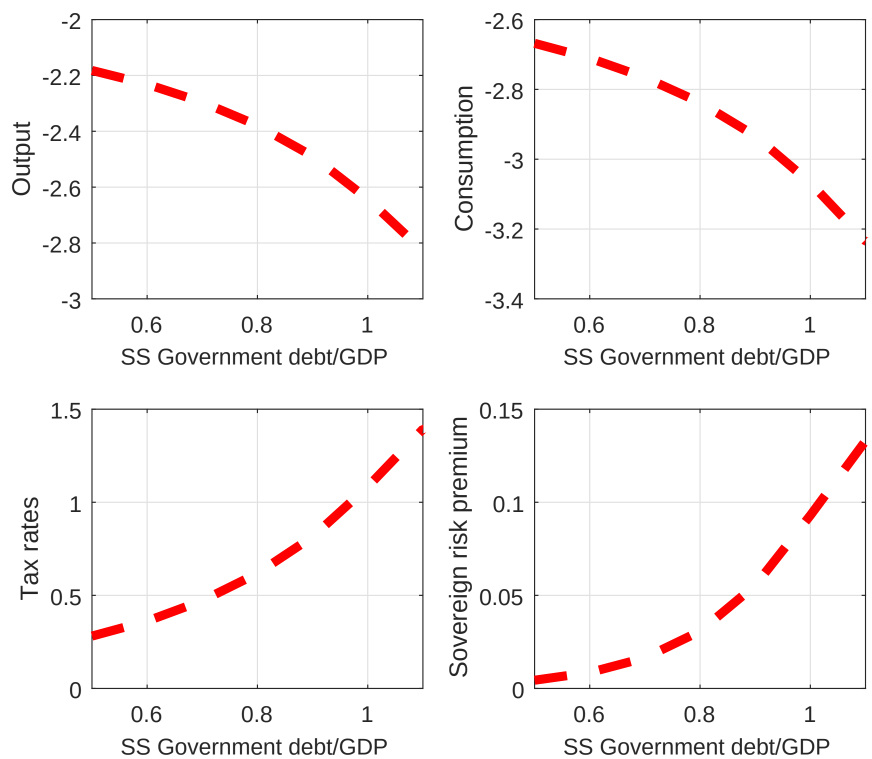
$$\tau^L_t = \tau_t \bar{\tau}^L \tag{C.50}$$

$$\log\left(\frac{e^{\varkappa}_t}{\bar{e}^{\varkappa}}\right) = \rho_{\varkappa} \log\left(\frac{e^{\varkappa}_{t-1}}{\bar{e}^{\varkappa}}\right) + \epsilon^{\varkappa}_t, \qquad \varkappa = \{A, H, P\} \tag{C.51}$$

D Robustness Checks to Selected Parameter Values

In Table D.1 we check if the gain-maximizing degree of targeted intervention, ϵ^*, is robust to a very different choice of the Frisch elasticity. We follow Adolfson et al. (2007) who, in an influential empirical paper on the euro area, use a value of the Frisch equal to 1, i.e. $1/(\eta - 1) = 1 \iff \eta = 2$. Under the alternative parametrization, the values of ϵ^* are fairly close to those obtained under the baseline, especially for a high level of public debt at the steady state. In a recent paper, Iacoviello (2015) sets a higher value of the capital depreciation rate: $\delta = 0.035$. Table D.1 shows that ϵ^* is virtually unaffected by this different choice of δ. Our final robustness check concerns the output response in the Taylor rule. In Table D.1 we examine how ϵ^* changes when using a double value for ρ_y, i.e. 0.2. It turns out that this different choice has only a very minor impact on the gain-maximizing degree of targeted intervention.

Figure E.1: Three-Year Cumulative Responses to a Negative One-Per-Cent House Price Shock for Different Steady-State (SS) Public Debt/GDP Ratio in the Case of Targeted Intervention



Notes: Y-axes are in percent deviations from steady state. The degree of targeted intervention ϵ is equal to 0.1 and inefficiency costs κ are equal to 0.1.

E The Role of Fiscal Buffers in the Case of Targeted Intervention

This section highlights the transmission mechanism of the negative house price shock in the case of targeted intervention for different steady-state levels of the public debt-to-GDP ratio. In this exercise we assume a moderate degree of targeted intervention and inefficiency costs, $\epsilon = 0.1$ and $\kappa = 0.1$ respectively, as in Subsection 5.3. Figure E.1 shows the three-year cumulative responses of output, consumption, tax rates and the sovereign risk premium to a negative house price shock for different steady-state public debt/GDP ratio.[34] When fiscal space is limited (i.e. for a high level of the public debt-to-GDP ratio), debt servicing costs increase due to the higher sovereign risk premium. As evident from equation (21) describing public debt dynamics, public debt increases by more, and this requires bolder fiscal consolidation as foreseen by the fiscal rules (equations 23 and 24). The resulting increase in the tax rates and the contraction of government spending depress consumption, labor, and hence output. This figure confirms the merits of having fiscal buffers for any given level of targeted intervention.

[34]Given our calibration of fiscal rules the two tax rates move symmetrically from their respective steady states.

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