# Interlinkages between Private and Public Debt Overhangs*

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November 9, 2015

**Abstract**

The debate about a country's appropriate level of public debt in the medium run continues to rage, and it remains unclear whether high debt is a cause or a consequence of low economic growth. By combining the financial accelerator literature with that on sovereign risk premia and fiscal limits, we build a model with borrowing constraints that produces leverage cycles, and embeds links between private and public debt dynamics. The model is calibrated on average euro area data and tracks well recent leverage dynamics. Four key results emerge. First, high private debt—rather than high public debt—is a more serious source of macro-fiscal vulnerability, because it leads to bigger contractions and deflations in response to adverse shocks. Second, when fiscal buffers are available, the government should always intervene to relax borrowing constraints of the private sector, and mitigate the consequences of deleveraging. Third, during deleveraging, first best monetary and fiscal stances should not exceed the minimum necessary to anchor inflation expectations and stabilize government debt. Too much fiscal austerity delays the return to macro-fiscal stability, and raises the likelihood of new fallouts, especially if monetary policy is at the zero lower bound. Fourth, the optimal macro-prudential policy is given by the loan-to-value ratio that delivers the most output-friendly leverage cycle.

*Keywords*: Public debt, private debt, loan-to-value ratio, borrowing constraints, sovereign risk premium, deleveraging, fiscal limits, DSGE

*JEL Codes*: E44, E62, H63

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*The views expressed in this paper are those of the authors and do not necessarily represent those of the International Monetary Fund or IMF policy. All remaining errors are ours.

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# 1 Introduction

Seven years on the effects of the financial crisis are still being felt: global growth remains fragile and unbalanced, while signs of asset price overvaluation have started to re-emerge.

The financial crisis is predominantly a story of excessive leverage fostered by multiple causes. The most evident is the adoption of wide-spread practices in financial markets that supposedly were meant to get rid of risk when in fact they implied losing track of it. Many argue that central bankers and other regulators also bear blame, for they *de facto* ratified this irrational exuberance. The macroeconomic backdrop was important too. The "Great Moderation"—years of low inflation, low interest rates and stable growth—fostered complacency and risk-taking. A "savings glut" in Asia pushed down global interest rates. Some also implicate European banks, which borrowed greedily in American money markets before the crisis, and used the funds to buy questionable securities.

All these factors came together to promote a surge of private debt—an extraordinary upward swing in the leverage cycle (Geanakoplos, 2010; Geanakoplos et al., 2012)—in what seemed to have become a less risky world. In practice, as it later became self-evident, not only risk had not gone away, but economies had become more vulnerable to it, given the extraordinary concentration of large stocks of liabilities in the hands of few investors.

When the bubble burst, the massive debt accumulation in the private sector sparked a typical debt deflation dynamics (Fisher, 1933; Minsky, 1982) that propelled the ratio of public debt to GDP very rapidly. This occurred through two channels. The first worked through the automatic stabilizers, the recession-induced decline in government revenues, and a fall in the level of prices–including those of assets. The second consisted in governments actually taking over private debt gone sour as the crisis erupted (mostly bank debt). In several countries debt has continued to grow since the crisis, taking the ratio of the global stock of debt outstanding as a share of GDP to 286 from 269 percent, between end-2007 and mid-2014 (Figure 1). The hoped-for financial healing has happened only in a few scattered parts of the global economy.

More specifically, in advanced countries, private sector debt–especially that held by financial companies such as banks–has come down. However, in some emerging market countries, debt continues to grow either in the private or public sectors, pushed also by global factors (Batsaikhan and Huttl, 2015; IMF, 2015; McKinsey, 2015) and posing

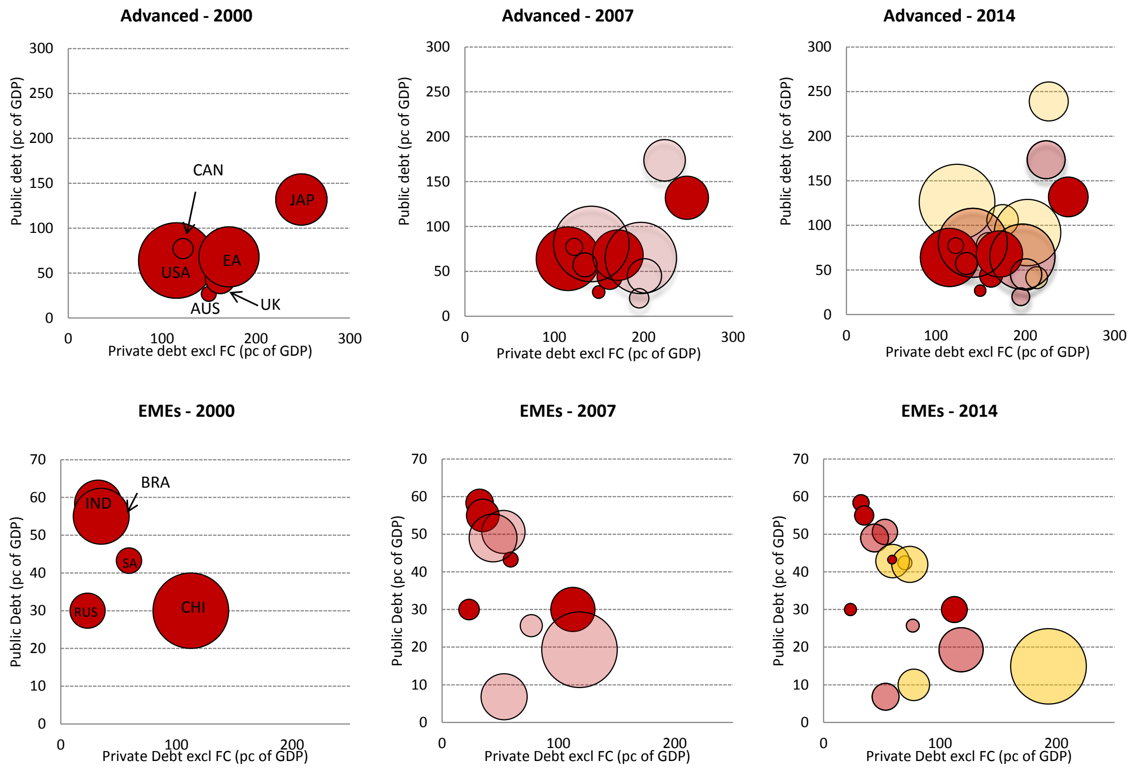



Figure 1: Ratios of public and private (households and nonfinancial corporations) debt to GDP in selected advanced and emerging market economies in 2000 (red balls), 2007 (pink balls) and 2014 (yellow balls). Area of balls proportional to GDP. Source: Haver analytics.

new risks to financial stability and the recovery. Although the level of leverage is higher in developed markets, the speed of the recent leverage process in emerging economies, and especially in Asia, is indeed an increasing concern as these countries might be the epicentre of the next crisis.

As a result of these dynamics, we are now left with simultaneously large private and public overhangs at a global level. In advanced countries, albeit heterogenous, a slow process of deleveraging amidst economic weakness, has begun. By contrast, emerging market economies continue to face a poisonous combination of rising leverage and slowing growth. In this environment, growth is severely limited by borrowing constraints and/or deleveraging of both household, non-financial as well as financial corporations and government, which mutually reinforce their negative impact on activity in the near run. Traditionally post-financial-crisis deleveraging is lengthy, and it is thus reasonable to expect that the restraint on near-term growth will spill over to potential growth, with adverse consequences for both private and public finances sustainability. The fall in inflation rates in many countries is complicating debt repayment. It is no surprise, then, that the world economy is still struggling to generate a convincing recovery.

This paper derives a model of the economy that stylizes the development of leverage cycles and embeds links between private and public debt dynamics. The basic structure follows Kiyotaki and Moore (1997)'s model of credit cycles that shows how small shocks to the economy might be amplified by credit restrictions, giving rise to large output fluctuations; and it embeds Iacoviello (2005)'s modifications to replicate features of borrowing constraints in the housing market within a New-Keynesian setting. It is then enriched with elements of the literature on government debt and sovereign risk premium (Corsetti et al., 2013; Bi and Traum, 2014), on one side, and on government intervention in the intermediation of funds (Gertler and Karadi, 2011), on the other side. Thus, our model accounts explicitly for the two key links between private and public indebtedness that characterize debt deflation dynamics: first, through the financial accelerator, private deleveraging affects output and prices, which in turn depresses government revenues; and second, public debt is affected by government interventions to alleviate private borrowing constraints, and mitigate the consequences of private deleveraging on output and prices. This way we capture how excessive private leverage can infect public finances, and weigh on growth; and we can also track the way in which, in turn, increases in public debt associated with financial assistance to the private sector require fiscal consolidation, depressing income and thus aggravating private deleveraging, conditional on the mix of demand and macroprudential policies. The model's shocks and great ratios are calibrated on average euro area data. Under this calibration, the model can reproduce the classical pattern of leverage cycles, and captures well the dynamic correlation between private and public debt observed in the data of key European countries.

We simulate the model to identify policies that can contain leverage cycles, and reduce their adverse effects on economic growth while preserving fiscal sustainability.

Specifically, we focus on four main macro-fiscal and macro-prudential policy questions:

1. **How does the relative weight of private versus public debt in total debt affect the downward phase of a leverage cycle?** We find that, contrary to popular belief, high private debt—rather than high public debt—is a more serious source of macro-fiscal vulnerability: the higher the level of private

leverage–regardless of the level of public debt up to very high levels–the greater the contraction and deflation following adverse shocks. Potentially, this calls for a re-evaluation of the widely-assumed macrofinancial resilience of a number of advanced countries, including those currently seen as safe havens by financial markets, and it clearly draws the attention to the dangers posed by exposure of some large emerging market economies to further economic and financial stress.

2. **Can (and should) the public sector intervene to mitigate financial stress during a deleveraging phase?** We find that when fiscal buffers are available, and abstracting from moral hazard considerations, the government should always intervene to relax borrowing constraints and mitigate the consequences of private deleveraging, even if this pushes up public debt. In fact, there is merit in financial intervention even when buffers are small, but then the trade-off between the benefits of a more gradual deleveraging and the costs of a larger subsequent fiscal consolidation become less favorable. While this finding fundamentally entrenches the public backing of the private market that took place during the financial crisis, we find that government intervention should not be large. So, indirectly, our result also validates a parametrization of resolution regimes privileging bail-in, like the one that has been adopted in Europe in 2014.[1]

3. **What is the preferable policy mix during the deleveraging phase?** We find that during deleveraging, first best monetary and fiscal stances should not exceed the minimum necessary to anchor inflation expectations and stabilize government debt. This means that praise is indeed due to most central banks and fiscal policymakers around the world for the righteousness and timeliness of their demand policy actions in the first years of the crisis. Accordingly, however, we also find that too much fiscal austerity delays the return to macro-fiscal stability, especially if monetary policy is at the zero lower bound, something that may explain the more sluggish recovery of the euro area relative to the United States since 2011.

4. **What is the optimal level of the loan-to-value (LTV) ratio?** Our model suggests 75 percent, which in our set up corresponds to the LTV ratio that delivers the most output-friendly leverage cycle, obtained by maximizing social welfare. This is reassuring from the point of view of macrofinancial surveillance,

[1] Directive 2014/59/EU on Bank Recovery and Resolution Regimes.

since while in the run-up to the crisis mortgages with an LTV of up to 125 percent were quite common; today national regulations seem to have restrained the availability of mortgages with an LTV of over 90 percent.

The paper is organized as follows. Section 2 sets the context in relation to the data and the literature. Section 3 describes the model. Section 4 presents the results. Section 5 concludes and draws policy implications.

# 2 Stylized facts and related literature

The Roaring Twenties, Japan's rapid expansion of the '80s, the Asian boom of the '90s, and the global financial crisis of 2008-9 all share one thing: they were spending sprees spurred by debt that caused sustained long-term downturns in economic activity.

In almost all instances, rampages in the pace of accumulation of private debt coupled with initially high levels of debt have led to crises. Although often eyed as "the" ultimate root of crises, public debt seems, by contrast, to have played little role in igniting them. The ratio of government debt-to-GDP was relatively low, and its rate of growth flat, before the crash of 1929, the Asian crisis of 1997, and the Japanese crisis of 1991. In the United States, even with its Middle Eastern wars and a major increase in social program expenditures, the ratio of federal debt to GDP was no higher in 2007 than it had been a decade before. The five-year increases in government debt-to-GDP in Japan as of 1991 and in South Korea as of 1997 were both near zero. In Spain, before its recent crisis, government debt-to-GDP declined by 16 percentage points.

Figure 2 shows the evolution of private debt relative to public debt and GDP in a number of countries for different crisis episodes. Starting with the United States in 2007-8, it is evident that, in the years prior to the crisis, federal government debt roughly paralleled gross domestic product; federal debt was not growing dramatically as a fraction of GDP. On the contrary private debt clearly did not parallel GDP: it grew rapidly relative to GDP. The chart plotting Japanese debt shows a similar pattern ahead of the 1991 crisis. Same thing applies to several European countries around the time of the global financial crisis. The data for China is quite alarming. Between 2008-2014, private credit to GDP measured by Total Social Financing (TFS) grew by about 73 percentage points. While since 2014 credit growth, especially in shadow banking, has declined considerably, China's private debt to GDP ratio in 2014 stood at above

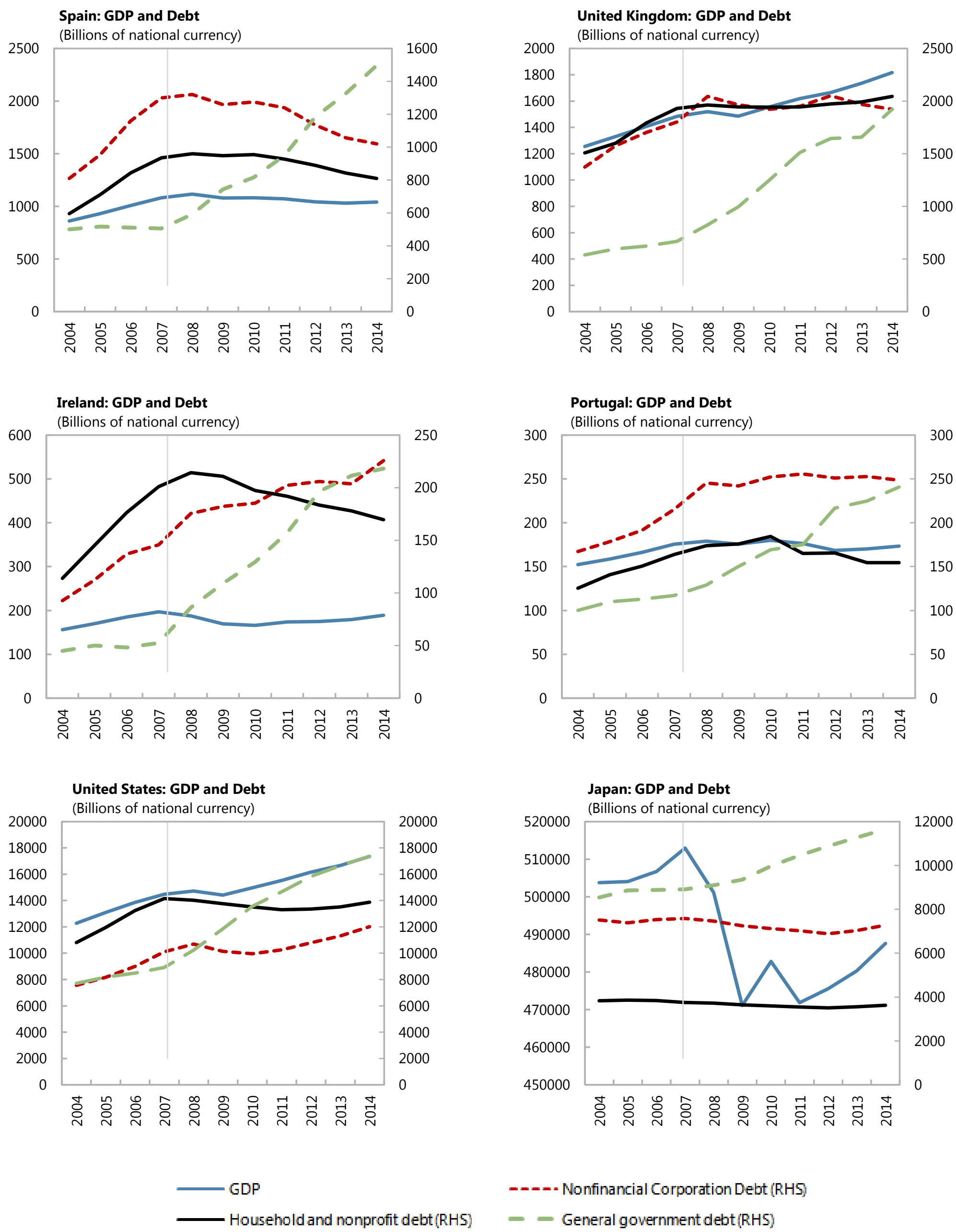



Figure 2: Public, private (households and nonfinancial corporations) debt and GDP in selected advanced economies. Source: Haver analytics.

190 percent.[2]

Protracted periods of high private and public debt accumulation inevitably lead to

[2]Data on China's shadow banking sector are somewhat difficult to pin down, and recent estimates of its size range from around 10 to over 80 percent of China's 2013 GDP/

periods of subpar growth when an upward phase of the leverage cycle ends, as agents (including the government) restructure their balance sheets by cutting down consumption and investment, and by postponing employment. If these deleveraging periods are long enough, the effects of debt restructuring can spill over onto long-run economic trends, notably the rate at which economies's productive potential evolves, structural labor force participation, and the natural rate of unemployment–a phenomenon called "hysteresis".

The aim of this paper is to use model analysis to identify economic policies that can contain leverage cycles, and reduce their adverse effects on economic growth while preserving fiscal sustainability. To our knowledge, this is the first paper in the economic literature attempting to build a model capable of addressing simultaneously demand and macroprudential policy analysis in the context of an economy where private leveraging feeds onto public liabilities and vice versa.

The bulk of the literature on debt, financial crises and growth predates the crisis, and is largely empirical, concentrating on the relationship between public debt and growth, exploring the influences that public debt has over the economy both in the short- and the long run. As debt deflation in many countries quickly transmitted private debt problems onto public finances, many eventually (and mistakenly) identified government profligacy with the source of the debt crisis. This literature has hence tended to dominate the narrative of policy discussions during the recent financial crisis, especially in Europe. The conventional wisdom is that debt can stimulate aggregate demand and output in the short run, but crowds out capital and reduces output in the long run (see Elmendorf and Mankiw, 1998 for a literature survey on public debt). Perhaps the most famous work on the topic belongs to Reinhart and Rogoff (2010), who studied the striking similarities of the recurring booms and busts that have characterized financial history, arguing that there are limits beyond which, however, debt depresses growth–a claim though partially rebutted by Herndon et al. (2014) in subsequent work.

Research on the relationship between private debt and growth was scant pre-crisis. For the great part, it concentrated on the empirical role of credit constraints in explaining the sensitivity of aggregate consumption to aggregate income (e.g. Ludvigson, 1999) or on the role of higher house prices for households' borrowing constraints, particularly as home prices began to rise rapidly early in the 2000s (see e.g. Iacoviello, 2005; Disney et al., 2010). However, some earlier research examined the role played by private debt in economic downturns. Mishkin (1977), for example, maintained that private deleveraging exacerbated the 1973–75 U.S. recession.

Considerably more analysis has been produced on private debt, particularly mortgages, since the crisis. This more recent literature focuses on issues such as the empirical relationship between defaults and securitization (Keys et al., 2010), the interaction between the borrower's and lender's choices (Foote et al., 2009), strategic defaults by underwater borrowers (Bhutta et al., 2010), and the timing of the rise in defaults among among borrowers whose mortgages were classified as "subprime" or "near-prime" (Mayer et al., 2009). Mian et al. (2013) and Mian and Sufi (2014) investigate the consumption consequences of the 2006 to 2009 housing collapse in the United States. Findings in Dynan (2012) lend support to the view that excessive leverage has contributed to the weakness in consumption and that the effects of deleveraging may persist for some time to come since U.S. households, on the whole, have made limited progress in reducing leverage over the past few years.

Modern model-based studies of collateral and leverage cycles go back to the mid-1990s, and have focused primarily on the role played by collateral into generating leverage and exploring the mechanisms via which things can go wrong after a shock. Pioneering work on this dates back to Bernanke and Gertler (1995) and Bernanke et al. (1999), Kiyotaki and Moore (1997), Holmstrom and Tirole (1997), Aoki et al. (2004) and Iacoviello (2005). Bernanke and Gertler (1995) and Bernanke et al. (1999) concentrated on how adverse shocks may be amplified by worsening credit conditions – the "financial accelerator" – while Kiyotaki and Moore (1997) showed how small shocks to the economy might be amplified by credit restrictions, notably the conditionality of lending to the provision of collateral in the form of capital, giving rise to large output fluctuations.

A few, but influential other empirical studies, have demonstrated that an overgrown private debt is more likely to induce financial crises than an overgrown public debt. Through a series of tests run on a sample of 14 advanced economies between 1870 and 2008, Schularick and Taylor (2012) establish that the link between the growth of private sector debt and the likelihood of financial crisis is stronger than between crises and growth in the broad money supply, the current account deficit, or an increase in public debt. The study shows that excessive private debt is a much more accurate and consistent predictor of financial crisis than the amount of public debt. However, high levels of public debt exacerbate the problems caused by massive private debt, since governments which are already “in the red” have little ammunition left with which to help out the economy, an assertion clearly verified in our model (see Subsection 5.2). More recent work by Jordà et al. (2014), using historical evidence from 17 advanced economies explores the interdependency between private and public debt levels in determining the shape of the economic recovery following a financial crisis. They reaffirm the finding that a deteriorating fiscal position is not usually predictive of financial crises in advanced economies (see also Jordà et al., 2013); and that a recession is made worse and a recovery slower when a credit boom is large in an expansion, regardless of the behavior of public-sector debt.

# 3 Model

The backbone of the model is the structure of Iacoviello (2005), hence presenting financial frictions in the Kiyotaki and Moore (1997) tradition. The basic structure has been extended to account for fiscal policy, government indebtedness, the sovereign risk premium, and private-public debt interlinkages. The economy is populated by patient households, impatient households, entrepreneurs and the government. 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 raising a mix of lump-sum and distortionary taxes and by issuing government bonds. Holding government debt is subject to sovereign default risk.

It is important to note a few but important definitional conventions in the paper. By “leverage cycle” we mean an increase (decrease) in private indebtedness caused by a loosening (tightening) of borrowing constraints when the debt collateral–of either or both impatient households and entrepreneurs–appreciate (depreciate) in value. By “deleveraging” we refer to a reduction in liabilities achieved through cuts to spending. By a “crisis”, we indicate a phase of intensified financial stress, which occurs when a drop in the value of the collateral reduces the availability of credit to borrow out of future income. In the paper, “public intervention” refers to credit extended to the private sector to alleviate borrowing constraints that originate in swings in the value of private debt collateral.

In line with the great part of the dynamic stochastic general equilibrium literature, we focus on deviations from steady state, and look at welfare as a benchmark of government targets: in this model there is no growth nor unemployment. Finally, to keep the model simple, but without loss of generality, we do not include banks: 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. As a result of this, in the model we do not contemplate traditional "doom loops"—namely those vicious cycles by virtue of which weak banks drag down governments by relying on public financial assistance, while weak governments drag down their nations' banks who have bought government bonds. This means that, if anything, our policy implications are starker in that we underestimate the financial accelerator effect.

We model both demand and macro prudential policies. Monetary policy follows a Taylor-type rule according to which the official interest rate is set to close inflation deviations from a pre-specified target and the output gap. The fiscal rule implies that government expenditures and taxes react to stabilize public debt compatibly with the government's fiscal limits, modeled as in Corsetti et al. (2013) and Bi and Traum (2014). The government has at its disposal macro prudential tools, notably by setting a cap to the amount of money households and firms can borrow as a percent of the value of their collateral, which in this model is represented by housing assets. Below we experiment with various calibrations and combinations of the policy mix. Social welfare is a function of aggregate consumption and leisure of the three private agents in the model: patient and impatient households, and firms. The sub-sections below provide more details about the model equations.

## 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:

$$U_t = E_t \sum_{s=0}^{\infty} \beta^{t+s} \left( \ln X'_{t+s} + e_t^H \zeta \ln h'_{t+s} - \frac{\left(L'_{t+s}\right)^{\eta}}{\eta} \right), \tag{1}$$

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

$$X_t{}' = C_t' - \theta C_{t-1}', \tag{2}$$

where $C_t'$ is the level of consumption and $\theta \in (0,1)$ is the degree of habit formation.

Households buy consumption goods, $C_t'$ and housing, $h_t'$. The relative price of housing is $q_t$. In addition, they invest in riskless private bonds, $B_t$, and in nominal government bond holdings, $B_t^G$; pay a mixture of net lump-sum, $\tau_t^L$, and distortionary taxes, $\tau_t^C$ and $\tau_t^W$, 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, $R_t^G$, discounted at the *ex-ante* expected haircut rate, $\Delta_t^G$; (iv) a rebate made by the government in case of default, $\Xi_t$; and (vi) a rebate for losses created by the government when it directly intermediates funds to constrained agents, $\Upsilon_t$.[3] Therefore, households' budget constraint reads as:

$$\begin{aligned} &\left(1+\tau_t^C\right) C_t' + q_t \Delta h_t' + \frac{B_t'}{P_t} + \frac{B_t^G}{P_t} + \tau_t^L \\ \leq &\left(1-\tau_t^W\right) \frac{W_t'}{P_t} L_t' + \frac{R_{t-1} B_{t-1}'}{P_t} + \left(1-\Delta_t^G\right) \frac{R_{t-1}^G B_{t-1}^G}{P_t} + \Xi_t + \Upsilon_t. \end{aligned} \tag{3}$$

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

$$\mu_t' = \frac{1}{\left(1+\tau_t^C\right) X_t'}, \tag{4}$$

$$\left(1-\tau_t^W\right) \frac{W_t'}{P_t} = \left(L_t'\right)^{\eta-1} \left(1+\tau_t^C\right) X_t', \tag{5}$$

$$\frac{1}{\left(1+\tau_t^C\right) X_t'} = \beta E_t \left[\frac{R_t}{\left(1+\tau_{t+1}^C\right) X_{t+1}' \Pi_{t+1}}\right], \tag{6}$$

$$\frac{1}{\left(1+\tau_t^C\right) X_t'} = \beta E_t \left[\frac{\left(1-\Delta_{t+1}^G\right) R_t^G}{\left(1+\tau_{t+1}^C\right) X_{t+1}' \Pi_{t+1}}\right], \tag{7}$$

$$\frac{q_t}{\left(1+\tau_t^C\right) X_t'} = \frac{\zeta e_t^H}{h_t'} + \beta E_t \left[\frac{q_{t+1}}{\left(1+\tau_{t+1}^C\right) X_{t+1}'}\right], \tag{8}$$

where $\mu_t'$ 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 (6) and (7) imply a non-arbitrage

[3] Government's default risk and intervention are explained in Subsection 3.4.

condition between the riskless interest rate and that on government bonds, whereby a sovereign risk spread arises, i.e. $R_t^G = E_t\left[\left(1-\Delta_{t+1}^G\right)^{-1}\right]R_t$.

## 3.2 Impatient households

Impatient households have a discount factor, $\beta''$, lower than that of patient households. They choose consumption, $C_t''$, housing, $h_t''$, and labor, $L_t''$, to maximize the following inter-temporal utility function:

$$E_t \sum_{s=0}^{\infty} (\beta'')^{t+s} \left( \ln X_{t+s}'' + e_t^H \zeta \ln h_{t+s}'' - \frac{\left(L_{t+s}''\right)^{\eta}}{\eta} \right), \tag{9}$$

where the habit-adjusted consumption, $X_t''$, is given by:

$$X_t{}'' = C_t'' - \theta C_{t-1}''. \tag{10}$$

Impatient households face two constraints in their optimization problem. First, the following flow of funds:

$$\left(1+\tau_t^C\right) C_t'' + q_t \Delta h_t'' + \frac{R_{t-1}B_{t-1}''}{\Pi_t} + \frac{R_{t-1}B_{g,t-1}''}{\Pi_t} \leq \left(1-\tau_t^W\right) \frac{W_t''}{P_t} L_t'' + B_t'' + B_{g,t}'', \tag{11}$$

where $B_t''$ is what they borrow from patient households, $B_{g,t}''$ denotes the amount of credit received in case the government decides to mitigate deleveraging in the private sector, and $W_t''$ is their wage rate. The interest rate paid to the government is the market rate, $R_{t-1}$, as described in Subsection 3.4.

As in Kiyotaki and Moore (1997) and Iacoviello (2005), impatient households face a limit on their obligation towards patient households arising from the fact that, if borrowers repudiate their debt obligations, lenders repossess their assets minus a proportional transaction cost. Therefore, they face a borrowing constraint, which limits what they can lend to a fraction of the present discounted value of housing holdings:

$$B_t'' \leq m'' E_t \left[ \frac{q_{t+1} h_t'' \Pi_{t+1}}{R_t} \right]. \tag{12}$$

The interesting case is a steady state in which the return to savings is above the interest rate. In such a case, borrowing constraint (12) 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 ratio. Moreover, $\beta'' < \beta$ ensures that impatient households will not postpone consumption and accumulate enough wealth to make the borrowing constraint not binding.

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

$$\mu''_t = \frac{1}{\left(1+\tau^C_t\right) X''_t}, \tag{13}$$

$$\left(1-\tau^W_t\right) \frac{W''_t}{P_t} = \left(L''_t\right)^{\eta-1} \left(1+\tau^C_t\right) X''_t, \tag{14}$$

$$\frac{1}{\left(1+\tau^C_t\right) X''_t} = \beta'' E_t \left[ \frac{R_t}{\left(1+\tau^C_{t+1}\right) X''_{t+1} \Pi_{t+1}} \right] + \lambda''_t R_t, \tag{15}$$

$$\frac{q_t}{\left(1+\tau^C_t\right) X''_t} = \frac{\zeta e^H_t}{h''_t} + E_t \left[ \frac{\beta'' q_{t+1}}{\left(1+\tau^C_{t+1}\right) X''_t} + \lambda''_t m'' q_{t+1} \Pi_{t+1} \right], \tag{16}$$

where $\mu''_t$ is the Lagrange multiplier associated to the flow of funds and $\lambda''_t$ is the Lagrange multiplier associated with the borrowing constraint.

## 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 and operate under monopolistic competition, facing a Dixit-Stiglitz firm-specific demand:

$$Y_{e,t} = \left( \frac{P_{e,t}}{P_t} \right)^{-e^P_t \chi} Y_t, \tag{17}$$

where $\chi$ is the intertemporal elasticity of substitution across varieties of goods, and $e^P_t$ is an inflation shock.

Their production function specializes as:

$$Y_{e,t} = e^A_t K^{\omega}_{e,t-1} h^{\nu}_{e,t-1} \left(L'_{e,t}\right)^{\alpha(1-\omega-\nu)} \left(L''_{e,t}\right)^{(1-\alpha)(1-\omega-\nu)}, \tag{18}$$

where $K_{e,t}$ is capital, $h_{e,t}$ is the real estate input, and $L'_{e,t}$ and $L''_{e,t}$ is the labor input provided by patient and impatient households, respectively, and $e^A_t$ is a technology shock. While parameters $\omega$ and $\nu$ are the elasticities of output to capital and real estate, respectively, $\alpha$ represents the contribution of patient households to the labor share.

Like impatient households, also 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 leads to entrepreneurs being borrowers as well. They only care about their own consumption, $C_{e,t}$, and maximize the following inter-temporal utility function:

$$U_t = E_t \sum_{s=0}^{\infty} \gamma^{t+s} \ln \left( X_{e,t+s} \right), \tag{19}$$

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

$$X_{e,t} = C_{e,t} - \theta C_{e,t-1}, \tag{20}$$

subject to the entrepreneurial flow of funds:

$$\begin{aligned} \frac{P_{e,t}}{P_t} Y_{e,t} + B_{e,t} + B_{ge,t} = \left(1 + \tau_t^C\right) C_{e,t} + q_t \Delta h_{e,t} + \frac{R_{t-1} B_{e,t-1}}{\Pi_t} \\ + \frac{R_{t-1} B_{ge,t-1}}{\Pi_t} + w_t' L_{e,t}' + w_t'' L_{e,t}'' + I_{e,t} + \xi_{K,t} + \xi_{P,t}, \end{aligned} \tag{21}$$

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, and $B_{ge,t}$ is the credit directly intermediated by the government in case of intervention (analogously to the case of impatient households), $I_{e,t}$ is investment in capital goods following law of motion:

$$I_{e,t} = K_{e,t} - (1 - \delta) K_{e,t-1}, \tag{22}$$

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.

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

$$B_{e,t} \leq m E_t \left[ \frac{q_{t+1} h_{e,t} \Pi_{t+1}}{R_t} \right]. \tag{23}$$

The considerations made for impatient households' borrowing constraint apply also to the case of entrepreneurs.

Maximization of function (19) subject to (17), (18), 20, (21), (22), (23) and the two quadratic adjustment costs yields the following first-order conditions with respect to $X_{e,t}$, $B_{e,t}$, $I_{e,t}$, $K_{e,t}$, $h_{e,t}$, $L'_{e,t}$, $L''_{e,t}$, and $P_{e,t}$ which, evaluated at the symmetric equilibrium, read as:

$$\mu_t = \frac{1}{\left(1+\tau_t^C\right) X_t}, \tag{24}$$

$$\mu_t = \lambda_t R_t + \gamma E_t \left[ \mu_{t+1} \frac{R_t}{\Pi_{t+1}} \right], \tag{25}$$

$$u_t = \mu_t \left[ 1 + \frac{\psi_K}{\delta} \left( \frac{I_t}{K_{t-1}} - \delta \right) \right], \tag{26}$$

$$u_t = \gamma E_t \left\{ \begin{array}{c} \mu_{t+1} \left[ \frac{\psi_K}{\delta} \left( \frac{I_{t+1}}{K_t} - \delta \right) \frac{I_{t+1}}{K_t} - \frac{\psi_K}{2\delta} \left( \frac{I_{t+1}}{K_t} - \delta \right)^2 \right] \\ + \left[ \mu_{t+1} MC_{t+1} \frac{\omega Y_{t+1}}{K_t} + (1-\delta) u_{t+1} \right] \end{array} \right\}, \tag{27}$$

$$\mu_t q_t = E_t \left\{ \gamma \mu_{t+1} \left[ q_{t+1} + MC_{t+1} \frac{\nu Y_{t+1}}{h_t} \right] + m \lambda_t q_{t+1} \Pi_{t+1} \right\}, \tag{28}$$

$$w'_t = MC_t \frac{\alpha \left(1-\omega-\nu\right) Y_t}{L'_t}, \tag{29}$$

$$w''_t = MC_t \frac{\left(1-\alpha\right)\left(1-\omega-\nu\right) Y_t}{L''_t}, \tag{30}$$

$$0 = 1 + e_t^P \chi \left( MC_t - 1 \right) - \psi_P \left( \Pi_t - 1 \right) \Pi_t + \psi_P E_t \left[ \gamma \frac{\mu_{t+1}}{\mu_t} \left( \Pi_{t+1} - 1 \right) \Pi_{t+1} \frac{Y_{t+1}}{Y_t} \right], \tag{31}$$

respectively, where $\lambda_t$ 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.

## 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. As in Bi and Traum (2014), each period a stochastic fiscal limit expressed in terms of government debt-to-GDP ratio and denoted by $\Gamma_t^*$, is drawn from a distribution, the cumulative density function (CDF) of which is represented by a logistical function, $p_t^*$, with parameters $\eta_1$ and $\eta_2$:

$$p_t^* = P\left(\Gamma_t^* \leq \Gamma_t\right) = \frac{\exp\left(\eta_1 + \eta_2 \Gamma_t\right)}{1 + \exp\left(\eta_1 + \eta_2 \Gamma_t\right)}, \tag{32}$$

where $\Gamma_t \equiv B_t^G/Y_t$. 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. In order to be able to solve the model with perturbation methods, we follow Corsetti et al. (2013) and Cantore et al. (2015) in assuming that agents consider the *ex-ante* expected haircut rate,

$$\Delta_t^G = \begin{cases} 0 & \text{with probability } 1 - p_t^* \\ \bar{\Delta}^G & \text{with probability } p_t^* \end{cases}, \tag{33}$$

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

$$\Delta_t^G = p_t^* \bar{\Delta}^G. \tag{34}$$

The government has the option of direct intervention in the intermediation of funds towards financially constrained agents as a way to mitigate deleveraging in the face of negative shocks, using a mechanism similar to that proposed by Gertler and Karadi (2011). If government intermediation occurs, the government issues additional bonds $B_t^{int} \equiv B''_{g,t} + B_{g,t}$, that pay the gross nominal interest rate $R_t^G$, and lends the raised funds to the private sector at the market rate $R_t$. This operation comes at the cost of an efficiency loss equal to $\kappa$ per unit supplied due to costs of raising funds through government debt. The total loss affecting the government budget constraint is then $\Upsilon_t \equiv \kappa B_t^{int}$, which is rebated as a lump-sum transfer to patient households.

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

$$b''_{g,t} = -\epsilon b''_t, \tag{35}$$

$$b_{g,t} = -\epsilon b_t, \tag{36}$$

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 ($B''_g = B_g = 0$), hence when $\epsilon = 0$ the model collapses to the standard case in which funds are entirely exchanged in the private sector.

A significant departure from the mechanism of Gertler and Karadi (2011)–where the government is not balance-sheet constrained and borrows at the risk-free rate–is that here it is subject to fiscal limits giving rise to a sovereign risk premium. Therefore an additional cost, given by the spread $\left(R_t^G - R_t\right)$ times the units of funds intermediated $B_t^{int}$, enters the government flow of funds, which reads as:

$$B_t^G = \left(1 - \Delta_t^G\right) \frac{R_{t-1}^G B_{t-1}^G}{\Pi_t} + G_t + \frac{\left(R_{t-1}^G - R_{t-1}\right) B_{t-1}^{int}}{\Pi_t} + \kappa B_t^{int} - T_t + \Xi_t, \tag{37}$$

where $\Xi_t \equiv \Delta_t^G \frac{R_{t-1}^G B_{t-1}^G}{\Pi_t}$ represents a transfer made by the government in a way that sovereign default does not alter the actual debt level.[4]

Total government revenue $T_t$ is given by:

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

In order to reduce the number of tax instruments to one, we impose that $\tau_t^C$, $\tau_t^W$ and $\tau_t^L$ 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, $\tau_t$, 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 rate and government spending to be adjusted according to the following feedback rules:

$$\log\left(\frac{\tau_t}{\tau}\right) = \rho \log\left(\frac{\tau_{t-1}}{\tau}\right) + (1-\rho)\rho_B \log\left(\frac{B_{t-1}^G}{B^G}\right), \tag{39}$$

$$\log\left(\frac{G_t}{G}\right) = \rho \log\left(\frac{G_{t-1}}{G}\right) - (1-\rho)\rho_B \log\left(\frac{B_{t-1}^G}{B^G}\right), \tag{40}$$

where $\rho$ implies persistence in the fiscal policy instruments and $\rho_B$ is the responsiveness of the instruments to the percent deviation of government debt from its steady state. 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

[4]As Corsetti et al. (2013) point out, in the real world, sovereign default causes some redistribution among households, however in DSGE models risk sharing allows them to perfectly insure themselves against the distributional consequences of sovereign default. Therefore, 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. This assumption in essence eliminates this counterintuitive effect.

loss of generality.

### 3.5 Central bank

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

$$\log\left(\frac{R_t}{R}\right) = \rho_\pi \log\left(\frac{\Pi_t}{\Pi}\right) + \rho_y \log\left(\frac{Y_t}{Y}\right), \tag{41}$$

where $\rho_\pi$ and $\rho_y$ are the monetary responses to inflation and output relative to its steady state.

### 3.6 Equilibrium

Equilibrium in the goods market, the loans market, and the housing market implies that $Y_t = C_t + C_t' + C_t'' + I_t + G_t$, $B_t + B_t' + B_t'' = 0$ 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 Parameter values

Table 1 reports the parameter values used to simulate the model. For the baseline calibration, to the extent possible, we choose parameters to match stylized facts in line with the average euro area experience. For the parameters related to government and private indebtedness we explore several alternative scenarios. For a few parameters, the estimates of which are not available for the euro area, we borrow estimates for the United States. Shocks are calibrated to match key moments in euro area data. The time period in our model corresponds to one quarter in the data.

We borrow the following parameter values from Iacoviello (2005): agents' discount factors, $\beta = 0.99$, $\beta'' = 0.95$, and $\gamma = 0.98$; the labor supply elasticity, $\eta = 1.01$; capital depreciation rate, $\delta = 0.03$; capital share, $\omega = 0.30$; patient households' wage share, $\alpha = 0.64$; and capital adjustment costs, $\psi_K = 2$.

The value of habit persistence, $\theta = 0.592$, is taken from Smets and Wouters (2003), while for the Taylor rule parameters we choose values that satisfy the Taylor principle

| Parameter | | Value |
|---|---|---|
| Patient households' discount factor | $\beta$ | 0.99 |
| Impatient households' discount factor | $\beta''$ | 0.95 |
| Entrepreneurs' discount factor | $\gamma$ | 0.98 |
| Labor supply elasticity | $\eta$ | 1.01 |
| Habits in consumption | $\theta$ | 0.592 |
| Capital depreciation rate | $\delta$ | 0.03 |
| Capital share | $\omega$ | 0.30 |
| Patient households' wage share | $\alpha$ | 0.64 |
| Capital adjustment costs | $\psi_K$ | 2.00 |
| Elasticity of substitution in goods | $\chi$ | 6.00 |
| Price stickiness | $\psi_P$ | 41.667 |
| Inflation -Taylor rule | $\rho_\pi$ | 1.5 |
| Output -Taylor rule | $\rho_y$ | 0.1 |
| 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 | $\rho$ | 0.90 |
| Haircut rate | $\bar{\Delta}$ | 0.0246 |
| Scaling factor in default probability | $\eta_1$ | -8.5527 |
| Slope parameter in default probability | $\eta_2$ | 1.8261 |
| Government intervention | $\epsilon$ | 0.10 |
| Efficiency costs | $\kappa$ | 0.10 |
| SS impatient households loan-to-value ratio | $m''$ | 0.80 |
| SS entrepreneurs loan-to-value ratio | $m$ | 0.375 |
| SS debt-to-GDP ratio | $\bar{\Gamma}$ | 0.68 |
| Persistence of housing shock | $\rho_H$ | 0.9843 |
| Persistence of inflation shock | $\rho_P$ | 0.8431 |
| Persistence of technology shock | $\rho_A$ | 0.0301 |
| Standard deviation of housing shock | $\sigma^H$ | 0.0102 |
| Standard deviationof inflation shock | $\sigma^P$ | 0.0014 |
| Standard deviation of technology shock | $\sigma^A$ | 0.0257 |

Table 1: Baseline parameter values

$\rho_\pi = 1.5$ (Taylor, 1993), and assign a small reaction to output $\rho_y = 0.1$, in line with Smets and Wouters (2003). 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.[5] Then, we make fiscal instruments rather persistent ($\rho = 0.90$). Similarly to Corsetti et al. (2013), we set the degree of fiscal stance, $\rho_B$, to the minimal value needed to stabilize public debt (which varies from case to case). The elasticity of substitution across different varieties, $\epsilon$, is equal to 6 in order to target a steady state gross mark-up equal to 1.20.

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 2013.[6] Such a value is matched through an appropriate choice of $\zeta$. 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 $\nu$. 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); and the debt-to-GDP ratio $\bar{\Gamma} = 0.68$ corresponds the average of euro area countries between 1999 and 2007. However, we explore several combinations of high/low private/public indebtedness.

Moreover, the baseline scenario exhibits a small degree of government intervention, $\epsilon$, equal to 0.10 and an efficiency cost, $\kappa$, set at 0.1 in line with Gertler and Karadi (2011). We nonetheless show how alternative values of these two parameters affect the results.

To calibrate the CDF of the fiscal limit, depicted in Figure 3, we fix two points on the function in a way consistent with empirical evidence. Given two points $(\Gamma_1, p_1^*)$ and $(\Gamma_2, p_2^*)$, with $\Gamma_2 > \Gamma_1$, parameters $\eta_1$ and $\eta_2$ are uniquely determined by

$$\eta_2 = \frac{1}{\Gamma_1 - \Gamma_2} \log\left(\frac{p_1^*}{p_2^*}\frac{1-p_2^*}{1-p_1^*}\right), \tag{42}$$

$$\eta_1 = \log\left(\frac{p_1^*}{1-p_1^*}\right) - \eta_2\Gamma_1. \tag{43}$$

Let us assume that when the ratio of government debt to annual GDP is $\Gamma_2$, the

[5] The value of $\psi_P$ 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).

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

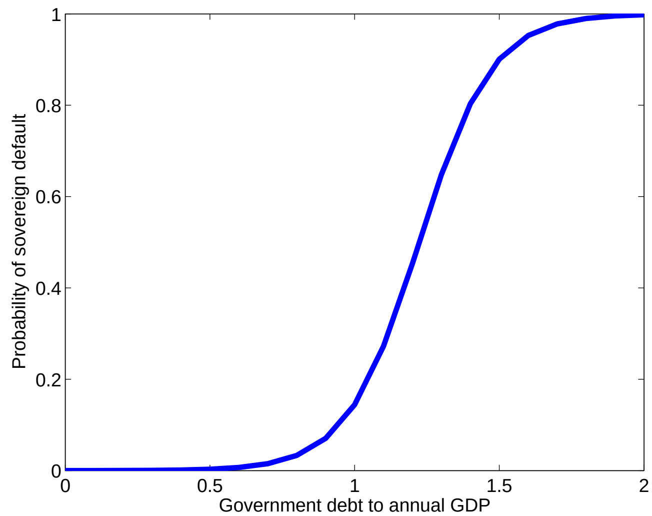



Figure 3: Cumulative density function of the fiscal limit

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 the Greek experience. 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. Given that, for most of this period, the U.S. sovereign risk premium (measured by one-year credit default swaps) was very low (around 15 annual basis points), we assume that for $\Gamma_1 = 4 \times 0.6$, $ABP_1 = 15$, where $ABP$ is the sovereign risk premium expressed in annual basis points. At the onset of the Greek sovereign debt crisis, the sovereign risk premium skyrocketed to an order of 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

$$\bar{\Delta} = \frac{1 - \frac{1}{\frac{ABP_2}{40000}+1}}{p_2^*},$$

which implies $\bar{\Delta} = 0.0246$.[7] At this point, we can recover the probability of default

[7]To see this, note that in the absence of long-term government bonds, equations (6) and (7) imply the following steady-state sovereign risk premium:

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

using which $\Delta^g$ 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 (34) $\bar{\Delta}^G = \Delta_t^G / p_t^*$.

| Moment | Data | Model |
|---|---|---|
| *Standard deviations* | | |
| Real output | 0.0138 | 0.0162 |
| Inflation | 0.0061 | 0.0057 |
| Real house prices | 0.0158 | 0.0186 |
| | | |
| *Autocorrelations* | | |
| Real output | 0.8779 | 0.9804 |
| Inflation | 0.2386 | 0.4030 |
| Real house prices | 0.8614 | 0.8343 |
| | | |
| *Cross-correlations with output* | | |
| Real house prices | 0.8630 | 0.7079 |
| Investment | 0.8221 | 0.9789 |
| Private consumption | 0.9218 | 0.9939 |

Table 2: Moments of key macroeconomic variables

when $\Gamma = \Gamma_1$,

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

which is $p_1^* = 0.0152$, and parameters $\eta_1$ and $\eta_2$ of the fiscal limit CDF can be recovered by using equations (42) and (43), i.e. $\eta_1 = -8.5527$ and $\eta_2 = 1.8261$. As shown in Figure 3, this parametrization implies that the probability of default remains moderate (below 20%) until the government debt-to-annual-GDP is below 100% and then increases at an expedited rate. This captures the fact that problems related to sovereign default may mount at a very fast pace as public debt accumulates.

Last, we set (i) the standard deviations, and (ii) the persistence of the shocks via moment-matching of (a) the empirical standard deviations and (b) the persistence of real output, inflation and the real house price.

Given the difficulty in matching exactly all moments, 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 $x_j^m$ 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, $\rho_H = 0.9843$ and $\rho_P = 0.8431$; while, as in Iacoviello (2005), the technology shock exhibits a small persistence $\rho_A = 0.0301$, as the model produces significant endogenous persistence. The standard deviations of the shocks are of magnitudes of around 1% and 2%.

Table 2 shows both the volatilities, persistences and correlations of variables in the data and in the model that we directly target and a few other moments of key macroeconomic variables.[8] Overall, the model replicates reasonably well the moments in the data and gets close to the cross-correlation of real house prices, investment, and private consumption with output on average in the euro area. In addition, the comovement structure of output, private and public debt of the model's simulated variables is in line with recent developments in the real world. In Figure (4), we report the historically observed cyclical deviations of these three variables for the case of Spain (upper-left graph). While private debt and output positively comove; government debt and output move in opposite directions. Furthermore, private debt leads public debt by approximately three years (lower-left graph). The model's simulated variables reproduce these patterns rather well (upper and lower-right graphs).

# 5 Results

## 5.1 How does the relative weight of private versus public debt to total debt affect the economic consequences of deleveraging?

The are essentially four possible stylized combinations of the relative levels of private and public debt vis-á-vis total debt: (i) both debt stocks are low relative to nominal GDP; (ii) private debt is low and public debt is high; (iii) private debt is high and public debt is low; (iv) both debt stocks are high. Below we show that these four possible initial combinations have important consequences in the transmission of a shock triggering a downward phase of a leverage cycle.

In our simulations we consider *low* the baseline steady-state values for the private LTV ratios ($m = 0.375$ and $m'' = 0.80$) and for the debt-to-GDP ratio ($\bar{\Gamma} = 0.68$) consistent with euro area average data, and discussed in Section 4. On the contrary *high* indebtedness is obtained using pre-crisis high-end values of the LTV ratios and the debt-to-GDP ratio in the euro area experience, that is, $m'' = 0.99$ for households (ECB, 2009), $m = 0.44$ for entrepreneurs (ECB, 2012), and $\bar{\Gamma} = 1.20$ for the government (close to the pre-crisis Italian experience). The degree of fiscal stance, $\rho_B$, is set to the

[8]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.

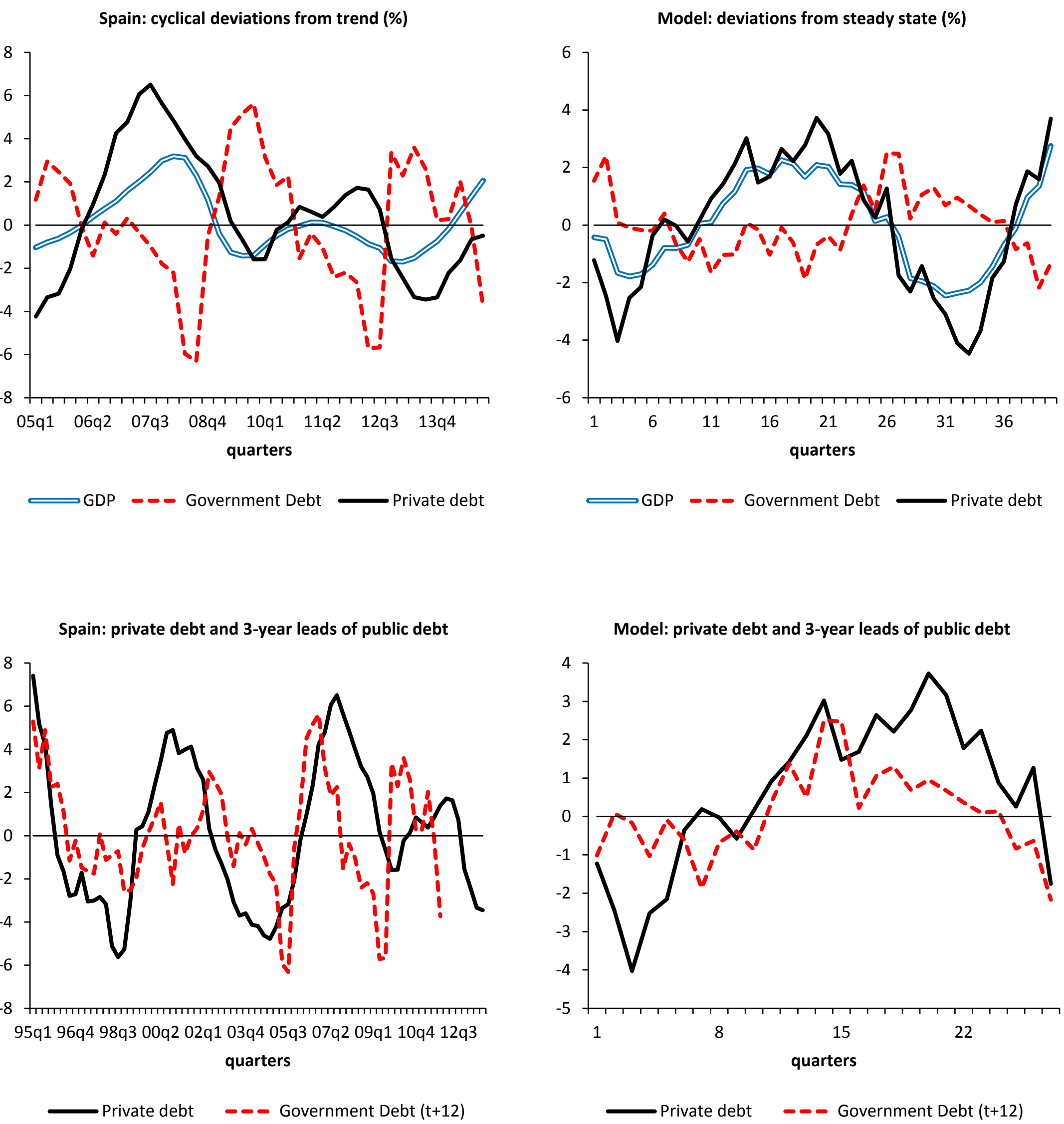



Figure 4: Upper-left: Cyclical deviations of Spanish real GDP, real government debt and real private (households and nonfinancial corporation) debt (2005q1-2014q4). Upper-right: one realization of simulations of cyclical deviations of the same variables in the model for 40 quarters. Lower-left: Cyclical deviations of Spanish real private (households and nonfinancial corporation) debt and 3-year leads of real government debt (1995q1-2014q4). Lower-right: one realization of simulations of the same variables in the model. Detrending method: HP filter (1600). Source: Haver analytics and authors' calculations.

minimal value that guarantees public debt stability for every scenario. The trigger of a downward phase of a leverage cycle is a temporary negative house price shock, which

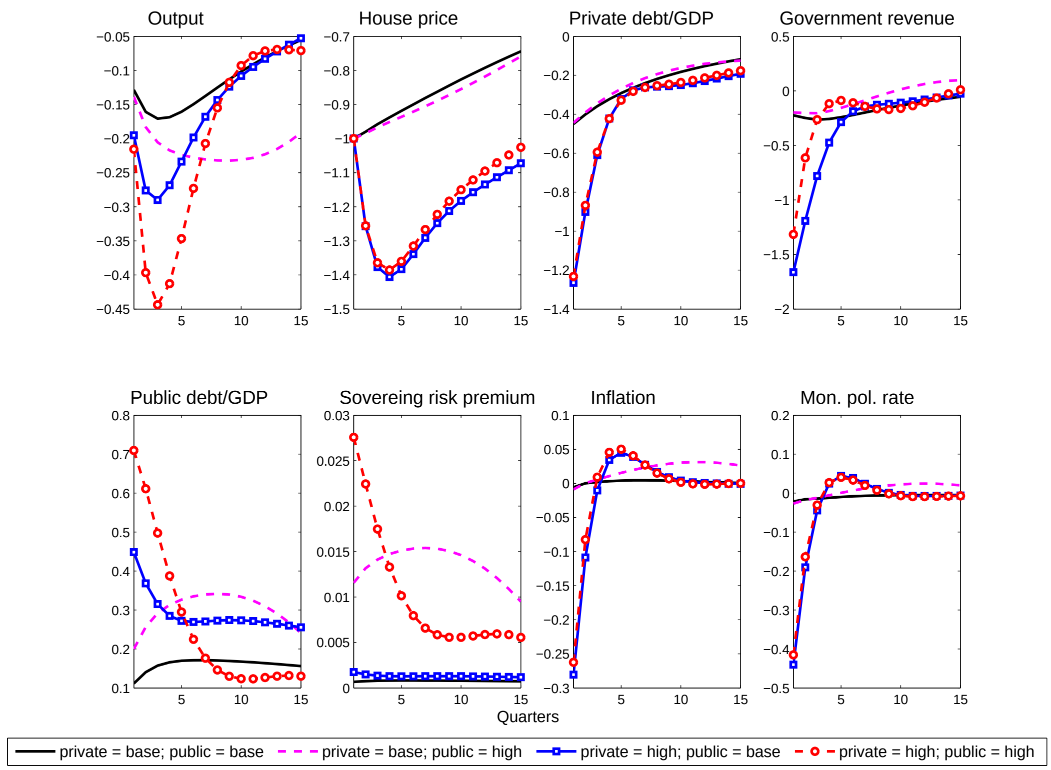



Figure 5: Impulse responses to a negative one-per-cent house price shock. Base private indebtedness refers to $m = 0.375$ and $m'' = 0.80$; high private indebtedness refers to $m'' = 0.99$ and $m = 0.44$. Base government indebtedness refers to $\bar{\Gamma} = 0.68$; high government indebtedness refers to $\bar{\Gamma} = 1.20$. X-axis in quarters; Y-axis are in percent deviations from steady state, except for private and public debt to GDP ratios where deviations are absolute.

depresses the value of the housing collateral. The shock is such that house prices fall by one percent, under each scenario. Greater shocks magnify the results, proportionally.

Figure 5 shows the responses of key macroeconomic variables to the negative house price shock. In all scenarios, the decline in house prices and consequent fall in the value of constrained agents' collateral, makes borrowing constraints tighter. This forces private agents to deleverage by cutting consumption and investment. In turn, this implies a protracted output contraction and a deflation. The worsened economic outlook spills over to public finances: the fall in output induces a reduction in government revenues and the public debt-to-GDP ratio unambiguously rises (while the numerator increases, the denominator is reduced). This mechanism is enhanced (i) by debt deflation, which is particularly strong when private debt is high; (ii) by the fact that higher public indebtedness boosts the sovereign risk premium, causing higher government's financing costs; and (iii) response of the government–which, we assume, responds endogenously via equations (35) and (36)–to partially mitigate the private sector deleveraging itself, entailing the payment of premium $R_t^G - R_t$ in the financial market and efficiency losses (small in the baseline calibration, and disentangled in Subsection 5.2). The higher the steady-state public debt-to-GDP ratio, the more pronounced the sovereign risk premium mechanism. In addition, the higher the steady-state private indebtedness, the stronger is the process of deleveraging.

Let us look in more detail at the four debt combinations. Corner cases (i) and (iv) are trivial: a highly-leveraged economy, in which both stocks of public and private debt are elevated (red line with round markers) experiences by far the worst contraction, the most pronounced increase in the public debt-to-GDP ratio, and the sharpest surge in the sovereign risk premium. At the other extreme, an economy characterized by simultaneously low private and low public debt stocks in relation to GDP (black line) withstands the negative shock avoiding a sharp deleveraging, since private agents can continue to finance spending through borrowing. This hence implies a very mild recession followed by a very limited increase in government debt.

The intermediate cases (ii) and (iii) are considerably more interesting. A low private, but high public debt (dashed magenta line) generates a milder, yet more persistent recession (reminiscent of Italy's experience in the aftermath of the global financial crisis); while an economy with high private, but low public debt (blue line with squared markers) tends to experience a deep contraction (in a way similar to that lived post-crisis by Denmark, Spain, Sweden and the United Kingdom).

This last result is not confined to the specific parameter choice adopted in Figure 5, but it holds true across all plausible ranges of the LTV ratio and debt/GDP ratios. We show this in Figure 6 where we plot how, following a shock, both the severity of the contraction in output and private and public debt-to-GDP ratios vary with (i) different caps on the LTV ratio; and (ii) different long-run targets of the public debt-to-GDP ratio.[9] Three important results emerge. First, the economic contraction is increasingly worse the higher the LTV ratio. On the contrary, the initial level of public

[9] Specifically, first we keep the steady-state level of public debt/GDP at a low value of $\Gamma = 0.6$ (left column), let the LTV ratios vary by the same amount ($\Delta m = \Delta m''$) in their respective empirically plausible ranges ($m \in [0.30, 0.55]$; $m'' \in [0.75, 1]$) and we plot the corresponding peak responses of output, public debt/GDP and private debt/GDP. Second (right column), we keep the steady state of private debt a low level ($m = 0.30$ and $m'' = 0.75$), let the steady-state level of GDP vary in the interval $\bar{\Gamma} \in [0.6, 1.3]$, and plot the same variables.

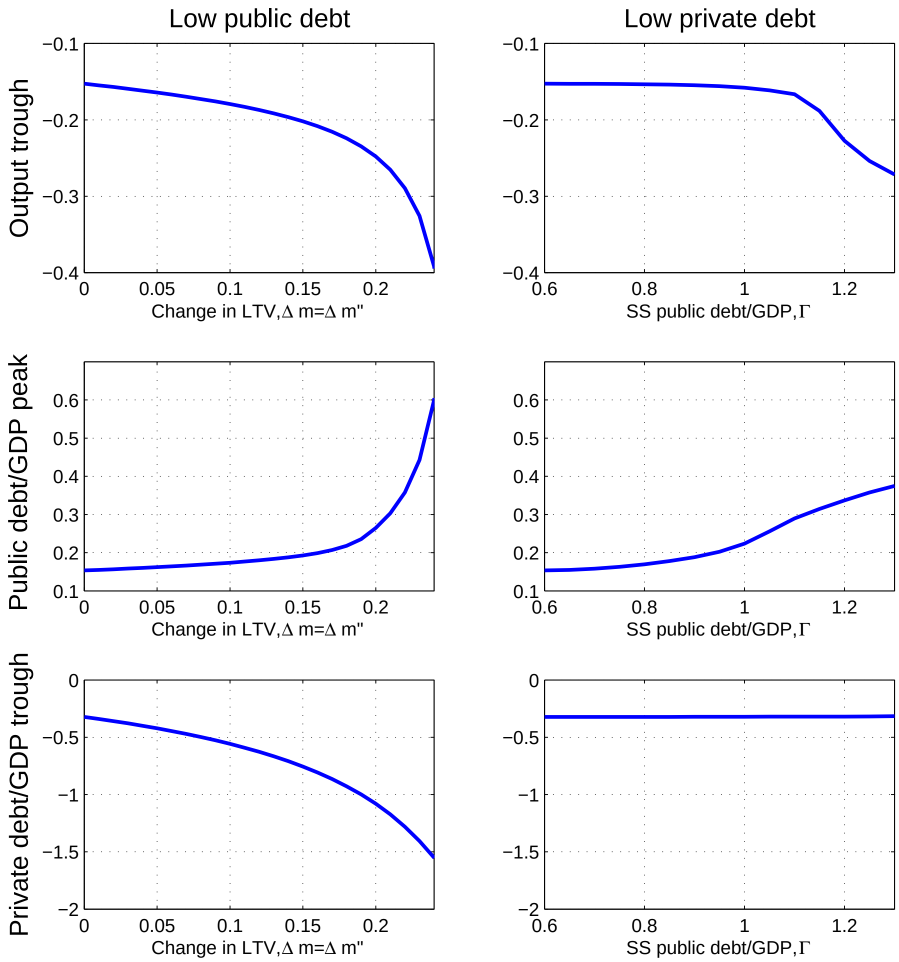



Figure 6: Peak responses to a negative one-per-cent house price shock for different loan-to-value (LTV) ratios, $m$ and $m''$ (keeping the steady state of the public debt/GDP ratio at a low level of $\Gamma = 0.6$), and different steady-state (SS) public debt/GDP ratios, $\Gamma$ (keeping the LTV ratios at low levels of $m = 0.30$ and $m'' = 0.75$). Note that in the figures the corporate LTV ratio $m$ varies between 0.30 and 0.55, while the households LTV ratio $m''$varies between 0.75 and 1. These change by the same amount ($\Delta m = \Delta m''$). Y-axis are in percent deviations from steady state for output and absolute deviations for public debt to GDP.

debt has no bearing on the severity of the contraction if below a certain threshold (in our model equivalent to debt around 110% of annual GDP, i.e.$\bar{\Gamma} \lesssim 1.1$). Second, the level of public debt resulting after a shock is positively correlated with the initial level of private debt. The larger private liabilities before the shock hits, the worse the public debt legacy afterwards, because the private sector will be facing a faster deleveraging from a more adverse starting point and demand greater government support, other things equal. Last, higher caps on the LTV ratio cause more deleveraging, while the amount of deleveraging that takes place after the shock does not depend on the level of public debt.

## 5.2 Can the public sector intervene to mitigate financial stress during private sector deleveraging?

In our model, the government can lend money to private sector borrowers (i.e. impatient hosueholds and entrepreneurs) at times when swings in the value of their debt collateral make their borrowing constrains binding. This captures real world policy measures taken during the crisis to facilitate mortgage payments by agents in distress (e.g. in the United States), government credit (either in cash or tax credit form) for home renovation, or other initiatives to spur spending on consumer durables (e.g. the program "Cash-for-Clunkers' launched in the United States in 2009-10), in addition to more widespread practices of financial assistance to private borrowers vehicled indirectly via direct support to financial intermediaries.

For the government there is an obvious merit in relaxing the private sector's borrowing contraints at times of stress: by allowing them to smooth spending through a deleveraging phase, the government is *de facto* indirectly supporting economic activity, which in turn prevents a drop in government revenues. There are two obvious trade-offs. The first has to do with intervention itself. To be worthwhile, the output/fiscal revenue support of the intervention must be large enough to outweigh the adverse impact on output (and hence fiscal revenues) of subsequent fiscal consolidations to rein in spending on intervention (the government financial assistance pushes up public debt permanently). Second, to intervene the government must have sufficient fiscal space. Like in the real world, in our model this is given by the distance between the initial stock of government debt outstanding and the fiscal limit. The larger public debt before the shock hits, the narrower the room of manouver for public intervention as well as the harsher the first type of trade-off mentioned above.

The second of these trade-offs, i.e. the relationship between the fiscal space and the magnitude of the government's financial intervention, is characterized by the model's regions of instability. These are a function of policy parameters and initial conditions– in particular, the fiscal policy responsiveness to increases in government debt, $\rho_B$, the degree of government intervention against private deleveraging, $\epsilon$, the LTV ratios $m$ and $m''$, and the steady-state level of government debt, $\bar{\Gamma}$. The last parameter is crucial because, as shown in Section 4, a higher $\bar{\Gamma}$ is associated with a higher sovereign default probability, and hence a higher sovereign risk premium.[10]

To highlight these issues, Figure 7 plots the model's regions of (in)stability as a function of the policy parameters and initial debt levels.

In Subfigure 7a we assume a low ($\kappa = 0.1$) unit efficiency cost for the government intervention in the financial market (as in Gertler and Karadi, 2011). With the base steady-state level of public debt–68% of annual GDP–the default probability and consequent sovereign risk premium are low. Therefore, the government has sufficient fiscal buffers to afford substantial intervention in the private financial market, with a small fiscal responsiveness ($\rho_B$) guaranteeing government debt stability. In fact the regions of instability are very small.

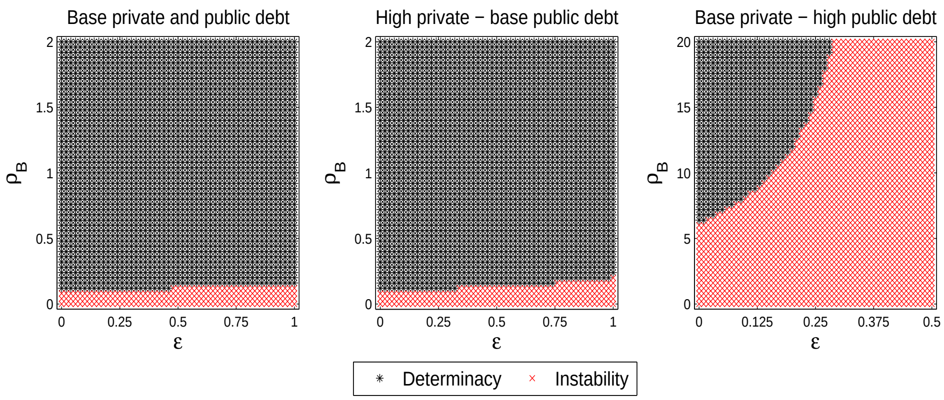
With high private debt ($m'' = 0.99$ and $m = 0.44$), but still low public debt and low efficiency costs, the government has still a lot of room for maneuver to curb the private sector deleveraging without having to change the fiscal stance to a large extent.

When the steady-state level of public debt is high–e.g. 120% of annual GDP–the picture dramatically changes, as the government has much less room for maneuver. In fact, even without government intervention in the financial market ($\epsilon = 0$), the minimal fiscal responsiveness guaranteeing government debt stability is much higher ($\rho_B > 5$) as the sovereign risk premium is high. In addition, higher and higher degrees of intervention require an even stronger fiscal responsiveness in terms of tax hikes and spending cuts, to guarantee government debt stability. Even if efficiency losses are small, the premium ($R_t^G - R_t$) paid to directly intermediate funds towards the private sector is large because of the high sovereign risk.

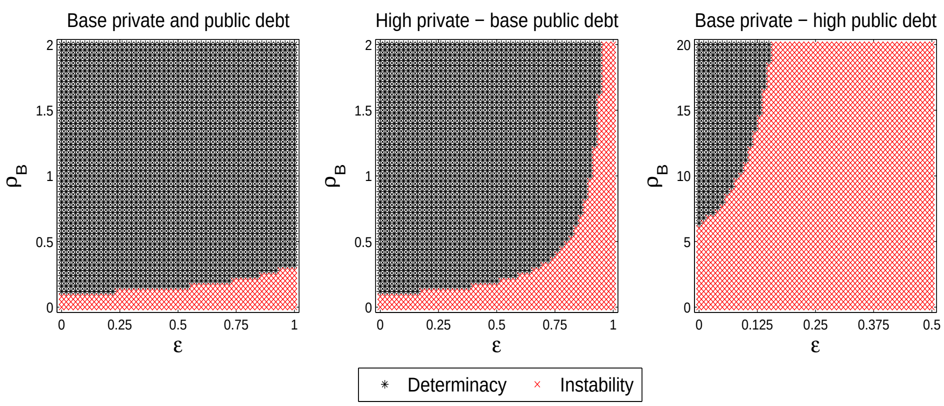
In Subfigure 7b the unit efficiency cost is double ($\kappa = 0.2$). Unsurprisingly, the stability (and determinacy) region of the model shrinks even further with high efficiency losses and the fiscal stance needs to be bolder if the degree of intervention is high.

The bottom line of this analysis is that intervening mitigates deleveraging and the

[10] In practice, the two main mechanisms via which government debt may become unstable are: (i) increasingly higher sovereign risk premia associated with higher public debt stocks and; (ii) the government's direct intermediation of funds towards the private sector to mitigate deleveraging, which bear fiscal costs. Both features cause additional expenditures for the public sector: the former via greater borrowing costs per unit of funds borrowed ($R_t^G$), as also demonstrated by Corsetti et al. (2013); the latter via the cost the government bears from borrowing funds (at rate $R_t^G$) to lend it to the private sector (at rate $R_t < R_t^G$), and the efficiency loss ($\kappa$) this operation entails.




(a) Low level of inefficiency created by direct government intermediation of funds, $\kappa = 0.1$




(b) High level of inefficiency created by direct government intermediation of funds, $\kappa = 0.2$

Figure 7: Model's determinacy (and instability) regions as a function of the fiscal responsiveness parameter to public debt, $\rho_B$, and the degree of government intervention against private deleveraging, $\epsilon$, (x represents a point of instability; * represents a point of stability and determinacy). Base private indebtedness refers to $m = 0.375$ and $m'' = 0.80$; high private indebtedness refers to $m'' = 0.99$ and $m = 0.44$. Base government indebtedness refers to $\bar{\Gamma} = 0.68$; high government indebtedness refers to $\bar{\Gamma} = 1.20$.

contraction, but eats up fiscal space. If the government has low fiscal buffers, the intervention requires subsequent strong consolidation, impairing mitigation effects. All this is made worse if interventions are inefficient. Having fiscal buffers is desirable, and it is thus important to rebuild them when they have dropped to too low levels.

## 5.3 Is there a desirable non-zero level of intervention?

Let us suppose that the private sector is highly indebted ($m'' = 0.99$ and $m = 0.44$) but the government has indeed fiscal space to intervene with direct intermediation of funds, without having to resort to an aggressive fiscal stance ($\bar{\Gamma} = 0.68$). To check whether and to what extent it is desirable for the government to intervene, we compare the peak responses to a contractionary one-per-cent house price shock for different degrees of government reaction to private deleveraging, $\epsilon \in [0, 1]$, and for alternative levels of inefficiency losses created by direct government intermediation of funds, $\kappa$ (Figure 8).[11] A number of results emerge from this exercise: (i) there is a non-zero level of government intervention that minimizes output losses; (ii) the more efficient is government intervention (the lower the value of $\kappa$) the bolder is the output-loss-minimizing degree of intervention (higher $\epsilon$); (iii) private sector's deleveraging and deflation are monotonically mitigated by a stronger intervention (virtually irrespective of the value of $\kappa$); (iv) there is a non-zero level of intervention that minimizes the surge in government debt/GDP and this is a positive function of its efficiency.

The ability of the direct government intermediation of funds to mitigate deflation is particularly relevant in a context of binding zero-lower-bound (ZLB) on the monetary policy rate. In fact, if the central bank has already exhausted its margins for maneuver through conventional monetary policy, the deflation following a negative house price shock can be very large, as we show in Figure 9. Here we use the algorithm proposed by Guerrieri and Iacoviello (2015) to impose the ZLB and produce impulse responses to a sufficiently large shock to house prices that lasts for five quarters and make house prices fall by up to 25%. In this circumstance the ZLB is binding, and the deflation is double relative to the case in which the monetary policy rate may fall below zero. The ZLB magnifies deleveraging, the recession and, most notably, the fall in government revenue, as well as the increase in public debt and the sovereign risk premium. As a result, government intervention–as an unconventional tool to fight deflation–becomes even more appealing under these conditions.

In sum, if there is fiscal space–and abstracting from moral hazard considerations–the trade-off between the additional fiscal costs created by government intervention and its ability to mitigate the private sector's deleveraging, the deflation and, ultimately, the recession suggests intervening. A moderate intervention has also beneficial effects on

[11] We use the minimal value for the fiscal stance, $\rho_B$, that guarantees public debt stability in all cases.

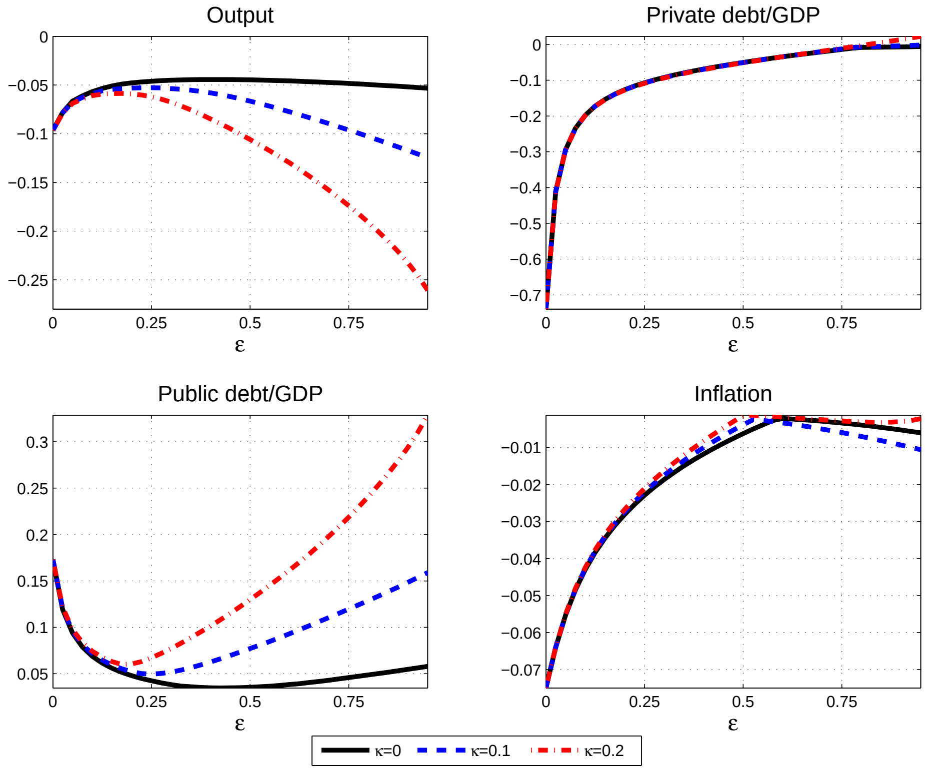



Figure 8: Peak responses to a negative one-per-cent house price shock for different degrees of government intervention to private deleveraging, $\epsilon$, and alternative levels of inefficiency created by direct government intermediation of funds, $\kappa$. Private indebtedness is high ($m'' = 0.99$ and $m = 0.44$). Government indebtedness is base ($\bar{\Gamma} = 0.68$); Y-axes are in percent deviations from steady state for output and inflation and absolute deviations for private and public debt to GDP ratios.

government debt through its boost on output, government revenues and inflation. This becomes even more topical in the context of binding ZLB. On the contrary, excessive intervention (especially if inefficient) is detrimental and self-defeating because it creates a fiscal burden requiring pronounced consolidations.

## 5.4 What is the preferable policy mix during the deleveraging phase?

Another important issue in the context of a deleveraging phase is which fiscal-monetary policy mix is best to mitigate the recession while fostering government debt sustainability. To investigate this issue, we show how the the model responds–measured as

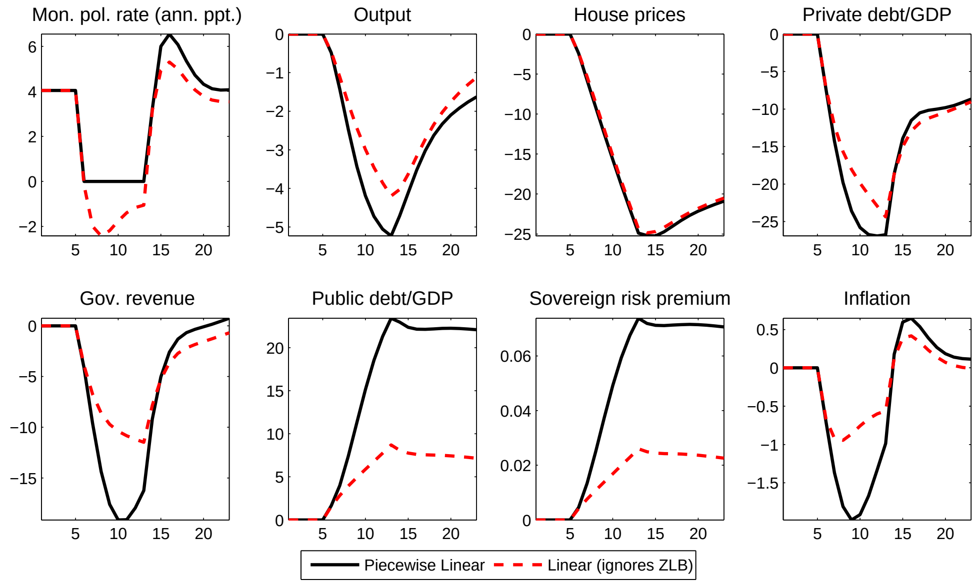



Figure 9: The effect of the zero lower bound (ZLB) on the monetary policy rate. Impulse responses to a negative one-per-cent house price shock. Private indebtedness is high ($m'' = 0.99$ and $m = 0.44$). Government indebtedness is base ($\bar{\Gamma} = 0.68$). X-axis in quarters; Y-axis in percent deviations from steady state, except for private and public debt to GDP ratios where deviations are absolute, and for the monetary policy rate, which is in annual percent points.

the trough response of output ($y_{trough}$) and private debt/GDP ($b_{trough}$) as well as the peak response of public debt/GDP ($b^G_{peak}$)–to a 1% house price shock, depending on different monetary ($\rho_\pi$) and fiscal policy ($\rho_B$) combinations. For this purpose we build loci of pairs ($\rho_B$,$y_{trough}$), ($\rho_B$,$b_{trough}$), ($\rho_B$,$b^G_{peak}$) for three given levels of monetary policy stance: tight ($\rho_\pi = 1.1$, black line), medium ($\rho_\pi = 1.5$, red line, the original value in Taylor (1993)), and loose ($\rho_\pi = 1.7$, blue line).[12] The fiscal stance parameter $\rho_B$ ranges from a value sufficient to make government debt stable to higher values. Throughout we focus on the most troublesome scenario of all, i.e. one in which both private and public indebtedness are high ($m'' = 0.99$, $m = 0.44$ and $\bar{\Gamma} = 1.2$).

The analysis of the loci reported in Figure 10 yields a number a interesting results. Keeping both monetary and fiscal policy at the minimum control delivers the lowest possible contraction in output. This combination is the one that also delivers low deleveraging and the least increase in public debt/GDP. However, when public debt

[12]In the context of a deflationary shock, a higher $\rho_\pi$ represents a looser monetary policy stance, because it induces a stronger fall in the nominal interest rate in response to the fall in prices.

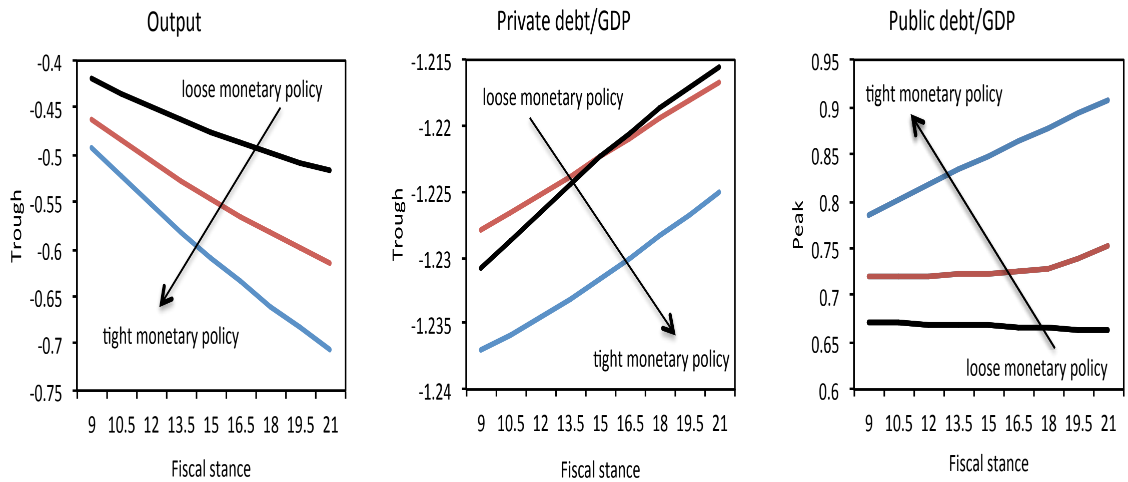



Figure 10: Loci of troughs of output and private debt/GPD as well as peaks of public debt/GDP in response to a negative one-per-cent house price shock for given degrees of fiscal stance ($\rho_B$), given three degrees of monetary policy stance ($\rho_\pi = \{1.1; 1.5; 1.7\}$). Private and public indebtedness are high ($m'' = 0.99$, $m = 0.44$ and $\bar{\Gamma} = 0.68$). Y-axis in percent deviations from steady state (output) and absolute deviations from steady state (private and public debt to GDP ratios).

is high like here, adverse market sentiment towards the sovereign may compel the adoption of a tighter fiscal stance than the one implied by mechanical stabilization of the debt. In this case, keeping monetary policy loose helps contain the fall in output and prices, while low interest rates keep the debt service low. Finally, when the ZLB binds, it may not be feasible to keep monetary policy in the "loose" stance because, under this parameterization, the nominal interest rate may have to fall below zero. In this case, the true characterization of monetary policy will be somewhere inbetween the black and the red lines. Under this scenario, a fiscal policy that is tighter than minum control is particularly recessionary and self-defeating, in that it pushes up rather than reduce the public debt/GDP ratio–the more so the tighter it becomes– also in line with findings that, at the ZLB, fiscal multipliers are larger than normal (see Christiano et al., 2009, among others).

In sum, during a deleveraging phase, both monetary and fiscal policy should be as loose as possible to support economic activity and mitigate deflation; keeping monetary policy loose is particularly important when the government is obliged to follow a stringent consolidation path, validating the adequacy of extraordinary monetary policy accommodation after the crisis around the world. When the nominal rates are at their effective lower bound, the pace of public deleveraging needs to be very gradual because the fiscal multipliers tend to be large. Therefore, too much austerity may end up delaying both the repair of private balance sheets and, more generally, the return to macro-fiscal stability.

## 5.5 What is the optimal level of the loan-to-value ratio?

The analysis so far has highlighted that the level of private indebtedness has strong implications for the dynamics of the leverage cycle and policy recommendations. Hence, a natural question is whether there is an optimal level for the loan-to-value ratio in the medium to long run. To address this issue we construct a measure of intertemporal social welfare and study how this varies across different levels of the loan-to-value ratio.

In particular, the social welfare measure is

$$W_t^G = U_t^G + \beta^G W_{t+1}^G, \tag{44}$$

where $\beta^G$ is the discount factor of the social planner and $U_t^G \equiv \ln\left(\tilde{X}_t\right) - \frac{\left(\tilde{L}_t\right)^\eta}{\eta}$ is its per-period utility function, in turn depending on aggregate habit-adjusted consumption, $\tilde{X}_t$, and aggregate labor, $\tilde{L}$. The reason why housing does not enter $U_t^G$ is that it is constant in the aggregate, being in fixed supply. We perform a second-order approximation both to the model's equilibrium conditions and to welfare, set $\beta^G = 0.99$, and simulate the model subject to the stochastic shocks, and report the mean of welfare.

The outcome of this exercise is reported in Figure 11. We report welfare as a function of the LTV ratio ranging in the interval [0.05,0.95], assuming that public debt is at its baseline level and, for simplicity, that the LTV ratio is the same for credit-constrained households and entrepreneurs ($m = m''$). Welfare is maximized at an interior point of the range, around 0.75. This is the outcome of two opposite forces: on one hand, if the LTV ratio is too low, the economy foregoes consumption and investment opportunities in the upward phase of the leverage cycle; on the other hand, if the LTV ratio is too high, macroeconomic volatility is higher and deleveraging, in response to adverse shocks, is more painful in terms of output losses.

These results are reassuring from the point of view of macrofinancial surveillance, since while in the run-up to the crisis mortgages with an LTV of up to 125 percent were quite common, today national regulations seem to have restrained the availability

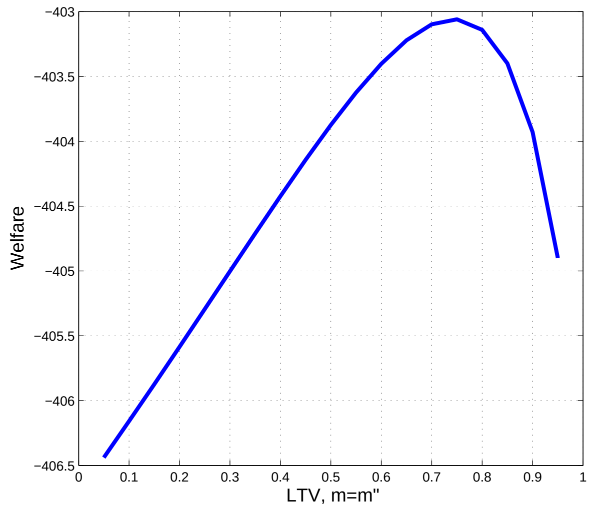



Figure 11: Social welfare for different values of LTV ratios ($m = m''$).

of mortgages with an LTV of over 90 percent.

The bottom line of this stylized experiment is that macroprudential policy should find the right balance between compressing and overheating the loan market in the quest for the loan-to-value ratio that delivers the most output-friendly leverage cycle.

# 6 Conclusion

Should we worry more about the level of public or private debt? Should governments extend financial assistance to private agents at times of financial stress? Should central banks counteract the output and deflationary consequences of private sector deleveraging? What should fiscal policy do during protracted phases of balance sheet unwinding? What is the optimal level of the loan-to-value ratio allowed in macro prudential regulation? This paper attempts to answer these fundamental, and yet largely unanswered, policy questions in the context of a general equilibrium model that can reproduce well the observed leverage dynamics in Europe. Results support policy actions taken since the crisis in a number of directions: it was right to loosen fiscal and monetary policy when the crisis hit, and to keep monetary policy very loose thereafter; and current regulation on LTV ratios brings these to more appropriate levels internationally–levels that greatly reduce macro financial vulnerabilities associated with excessive credit booms. On the other hand, results also ring some alarming bells. First, several countries considered "safe" by financial markets, may in fact be more vulnerable to shocks than countries which are seen as less safe from a macro-fiscal sustainability point of view. This calls for modifications to implicit practices entrenched in macro-fiscal and macro-financial surveillance in order to give, not just equal attention, but unequivocally more prominence to the risks posed by the evolution and levels of private indebtedness relative to those traditionally believed to be associated with public indebtedness in isolation. The evolution of private debt in emerging markets is particularly concerning, and suggests that these could be the epicenter of the next financial crisis. Second, fiscal consolidation in some parts of the world has become more neutral, but before doing so, may have been set in a way that prolonged deleveraging and magnified its costs. Inasmuch as this is still ongoing, and thinking of future shocks, fiscal rules should be modified to account explicitly for the quintessential mitigating role of government both as a fiscal actor and as a lender of last resort during protracted phases of financial stress. Last but not least, while LTVs have been internationally capped down at safer levels, above-safe-levels LTV loan options exist and remain common around advanced and emerging market economies alike. Ruling out these options would likely greatly limit outstanding systemic financial risks.

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