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Abstract

This paper uses a two region DSGE model for the Euro area (periphery vs. core), to analyse the costs of higher sovereign risk premia, the so called 'sovereign risk channel'. We highlight the importance of valuation effects of sovereign bonds in bank balance sheets for the transmission of sovereign default expectations to the private sector. While at the current juncture the fiscal multiplier is larger in the EA periphery, we show that for highly indebted countries in the EA no fiscal consolidation could have more detrimental effects if it leads to expectations of sovereign default. In our view these results provide useful additional information for the debate on fiscal austerity which focusses mainly on the size of the multiplier.

JEL classification: E62; E32; E62; G21; H63; F41

Keywords: Fiscal Policy; sovereign risk; banking systems, fiscal multipliers.

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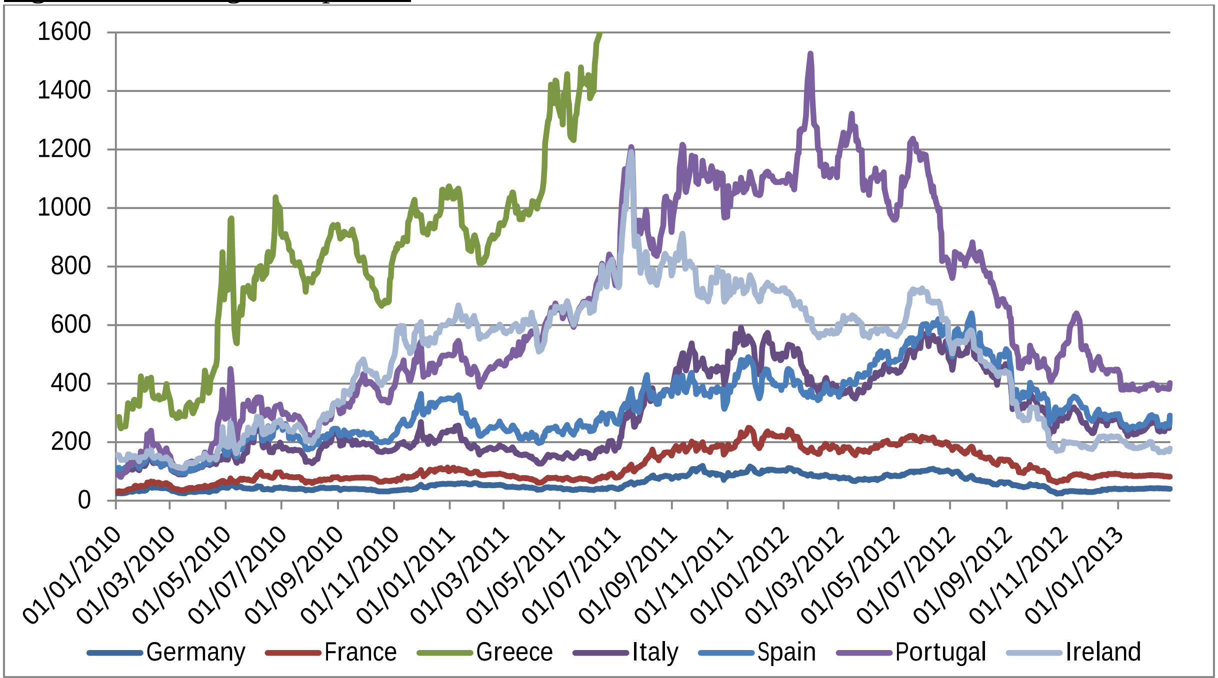
The most vulnerable euro area countries have seen sharp increases in sovereign risk premia in recent years. These countries have been hit by various adverse shocks, forcing private household and bank deleveraging, and are in addition confronted with rising NAWRUs, since rigid labor and goods markets are slow to adjust to deleveraging shocks. Declining GDP and automatic stabilizers have led to a secular increase of the debt-to-GDP ratio and raised doubts about the ability and willingness of governments to fully honor their debt obligations. While sovereign CDS spreads have come down significantly since mid-2012, they remain above pre-crisis levels (see Figure 1).

Against this background there has been an intensive debate about the best fiscal policy response. Proponents of fiscal consolidation argue that countries facing higher risk premia should engage in consolidation measures, i.e. complementing private deleveraging with public deleveraging. Their argument is based on the fear that an expectation of sovereign debt restructuring not only increases sovereign borrowing costs but also has detrimental effects on the domestic banking system which typically holds a sizeable amount of bonds issued by domestic governments. Critics of fiscal consolidation on the other hand stress that fiscal austerity worsens the demand shortfall in an economy which is already hit by negative demand shocks. In addition, they argue that currently monetary policy can do little to accommodate consolidation efforts and that a credit constrained private sector will also be unable to offset negative public demand shocks via an increase in private borrowing.

Figure 1: Sovereign risk premia



Note: 5-yr sovereign CDS spreads (no CDS spreads quoted for Greece after 09/2011). Source: Bloomberg

A similar debate rages about the size of the fiscal multiplier. Those believing in a small multiplier (e.g. Cogan et al. (2010)) are favouring consolidation while those pointing to estimates of larger multiplier (as found in e.g. Auerbach and Gorodnichenko (2012)) argue for postponing consolidations. While the discussion on multipliers is important because it provides information about the short term income losses of consolidation measures, it is not the only criterion on which one should base fiscal policy decisions, because multiplier calculations usually assume that under the alternative – no-consolidation scenario – the perceived risk of a government restructuring would remain unchanged. However, many governments in countries with high and strongly rising sovereign debt are facing higher financing costs (and in some cases even a loss of financial market access). This in turn has repercussions for the private sector. Recent developments in some of the highly indebted euro area countries show a strong comovement between credit default swap (CDS) spreads on sovereign debt and nonfinancial corporate debt. An important transmission channel to the private sector, which has been emphasized in recent discussions, is the vulnerability of the domestic banking sector, which suffers already under recapitalization pressures from loan losses, and faces additional pressure from declining government bond prices. Following Corsetti et al. (2012) we name this the ´sovereign risk channel´. These authors use a DSGE model augmented by a simple banking sector and analyse the effects of fiscal retrenchment under alternative debt levels. Given their model and calibration assumptions they find that for sovereign debt-to-GDP ratios of around 115%, retrenchment packages could actually avoid an initial decline in output as the sovereign risk channel turns out to dominate the direct effects of spending cuts. In this paper we use a two country DSGE model with a banking sector (see Kollmann et al. (2012)) to study the sovereign risk channel for an economy within a monetary union.

The paper is structured as follows. In section 1 we provide some empirical evidence of the relationship between sovereign default risk and government debt. Since typically a convex relationship between the two is found we will explore the impacts within plausible ranges of this relationship. In section 2 we describe the model used for this analysis. Since the sovereign risk channel depends crucially on the vulnerability of the banking sector to variations in government bond prices we will concentrate on a description of the banking sector. This section will also discuss some other crucial calibration assumptions. Section 3 discusses the policy experiment and presents the results.

1. Sovereign default risk and government debt, some empirical evidence

The quantitative results presented in this paper depend crucially on the sensitivity of the sovereign default probability on the level of government debt. Theoretical models of government default (see for example Arellano (2008)) typically predict a non-linear and convex relationship. Such a relationship is often found in the empirical literature. Bi (2012) models the interaction between sovereign default risk and fiscal policy using a dynamic stochastic general equilibrium (DSGE) in which, due to the existence of fiscal limits, which measure the government's ability to service its debt, the model produces a nonlinear relationship between the default risk premia and the level of government debt. Default risk premia start to emerge when the debt level reaches to a point that sovereign default becomes possible and once risk premia begin to rise, they do so rapidly. Corsetti et al. also find such a relationship between CDS spreads for governments bonds (5 year maturity) and the level of government debt (as a share of GDP) for OECD countries. Figures 2 and 3 below show the highly convex relationship between CDS spreads for governments bonds (5 year maturity) and the level of government debt (as a share of GDP) for EU countries in 2011, 2012 and 2013. Between 2011 and 2012 the relationship between debt levels and sovereign spreads has not changed much,[1] but since the announcement of OMT spreads have come down in the second half of 2012 and the convexity of the relationship is lower in February 2013.

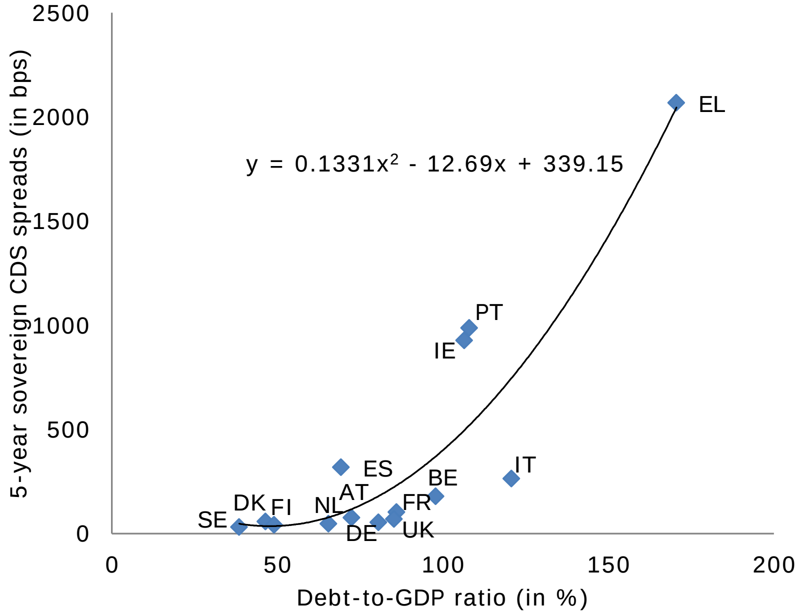
As can be seen from these figures, for low levels of government debt (below 60% of GDP), CDS spreads are not sensitive to variations in debt levels. Between 60 and 90% spreads increase more strongly with an increase in government debt. Roughly speaking, a 10 pps. increase of government debt increases the CDS spread by around 25 bps., a number often found in pre-financial crises empirical estimates (e.g. Ardagna et al., 2007, Laubach, 2009, Poghosyan, 2012). Non-linearities become more severe for debt levels beyond 90%. There is not only significant time variation, there remains also a sizeable dispersion; some countries like Belgium manage to retain low CDS spreads despite relatively high levels of government debt, while other countries such as Spain or Portugal face much higher CDS spreads for similar levels of government debt. [2] This suggests that the slope between default risk and government debt is likely to be country specific. Nevertheless, the empirical relationships

[1] Note Greece is excluded in Figure 3 as no 5-yr CDS spread is available since the Greek debt restructuring.

[2] Other factors that could explain this dispersion are differences in primary balances, potential growth projections, contingent liabilities of the public sector, independence of monetary policy and perceived redenomination risks. A large and burgeoning literature tries to explain sovereign CDS spreads. See also European Commission, QREA Dec. 2012.

shown here suggest that at debt levels of 120% a 10 pps. increase of government debt can be associated with an increase in the CDS spread of around 200 bps. In February 2013 the relationship has become much weaker, around a third of what it was at its peak, but still highly convex. In this paper we will show results for both high and low levels of CDS spreads (200 bps and 20bps respectively) to illustrate the importance of the sovereign risk channel.

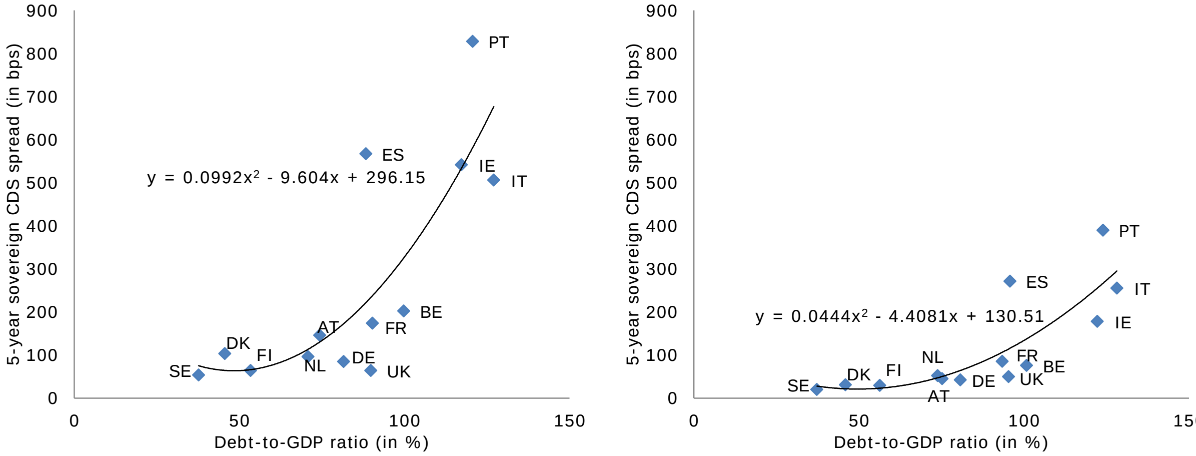
Figure 2: 5-year sovereign CDS spreads vs debt-to-GDP ratios (July 2011)



Note: The figure shows average 5-year sovereign CDS spreads (bps.) for July 2011, against end-2011 general government debt (as % of GDP) with fitted 2nd-order polynomial. The countries shown are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden and the United Kingdom. Source: Bloomberg.

Figure 3: 5-year sovereign CDS spreads vs debt-to-GDP ratios

a. July 2012 b. February 2013



Note: The figures show average 5-year soverign CDS spreads for July 2012 and February 2013, against end-2012 and (forecast for) end-2013 general government debt-to-GDP ratios with fitted 2nd-order polynomials. The countries shown are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain, Sweden and the United Kingdom. (Greece excluded)
Source: Bloomberg and European Commission, Winter forecast 2013.

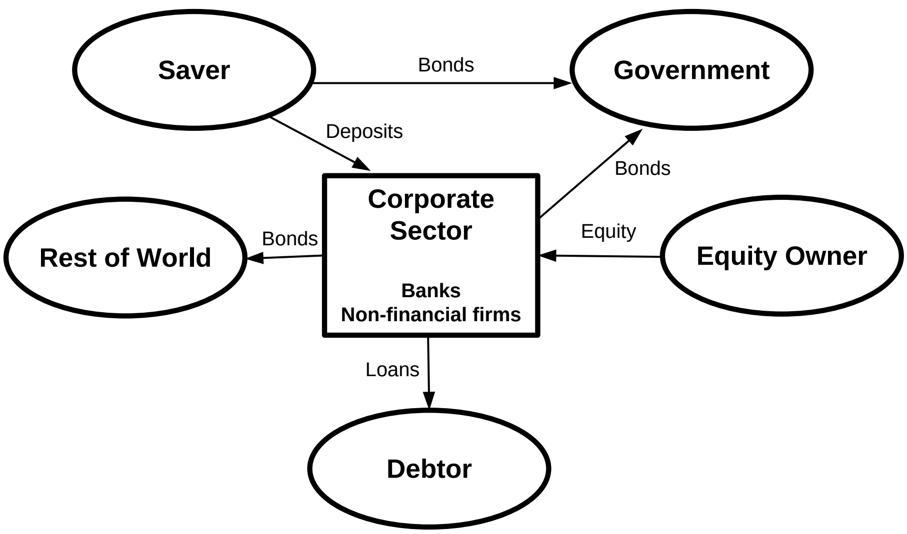
2. Model Description and Calibration

2.1 Model Overview

We use a two country DSGE model, where we divide up the EA into vulnerable (Greece, Ireland, Portugal, Italy and Spain) and non- vulnerable countries. We use the model presented by Kollmann et al. (2013). This model differs from a standard DSGE model in two respects. First, there is a banking sector and second private households are divided up into (risk averse) savers, (less risk averse) equity owners and into debtor households. The distinction between savers with different risk attitudes allows introducing a distinction between deposits (of risk averse households) and bank capital (of equity owners). This distinction introduces limited risk sharing across the aggregate household sector and allows generating larger fluctuations in borrowing costs. Figure 4 shows the structure of financial relationships between different types of households and the corporate sector.

In our analysis, the sovereign risk channel becomes important because of the vulnerability of the banking sector which is exposed to sovereign wealth effects from variations in government bond prices. In the following we briefly describe the banking sector in order to better understand the transmission mechanism from expected sovereign losses to the real economy.

Figure 4: The structure of the model



Banks issue shares to equity owners, which receive dividends from bank lending activities. Banks engage in mortgage lending and they hold government bonds. While government bonds are probably important for banks as collateral in refinancing operations, we do not explicitly model a demand for government bonds but take them as exogenous. This is sufficient for our purpose since we are only interested in the effects of bond price declines on the banks' balance sheet. For this purpose we assume that banks hold government perpetuities which pay a coupon each period. Expected sovereign restructuring is modeled as a change of expectation about future coupon payments, which results in variations of current sovereign bond prices. Given the limited types of activities of banks, the aggregate banking sector has a simple balance sheet. On the asset side it consists of loans and government bonds. Deposits and bank capital constitute the liability side. Bank activities are restricted by a capital requirement constraint which penalizes the bank if bank capital declines below a certain threshold. The bank has various options to respond to loan losses or the loss of value of sovereign bonds which both erode the current value of bank capital.[3] It can reduce lending or recapitalize in order to reestablish an optimal bank capital to asset ratio. In general banks will act in all three directions. How strongly they will increase the demand for deposits depends on how tightly the capital requirement constraint binds, since this determines the increase in funding costs associated with higher leverage. In a first step the penalty on excess leverage determines how the bank finances loan supply in order to minimize financing costs. Thus with a high penalty banks are forced to recapitalize (reduce dividends, issue new shares) via the equity market and compete for investment funding with non financial firms. This increases the rate of return on equity and thereby spreads the loss of the banking sector to corporate investment. Bank holdings of sovereign bonds is crucial for this effect. In a standard macro model without a banking sector higher sovereign default expectations would not have significant macroeconomic effects since households would weigh sovereign asset losses against lower future tax payments, i.e. in present value terms households would not be strongly affected.

[3] Notice, in this analysis we assume that banks are carrying the securities on their balance sheet at market value, i. e. in the 'trading book' and not in the 'held-to-maturity' banking book. In the latter case accounting rules would imply that sovereign bond price losses would only be recorded when a sovereign default becomes imminent. However it has been pointed out in a recent BIS working paper (BIS 2012) that this distinction may be less strong in practice, arguing that … "creditors will look through the accounting conventions, assessing the solidity of the bank based on its assets at market value, even if they are in the banking book."

2.2 Detailed Model Description

We consider two regions within the Euro area, namely the EA 'periphery' (Spain, Italy, Portugal, Ireland and Greece) and the remaining 'core' countries. If necessary we use the superscript *P* and *C* for these two regions and the superscript *EA* for the EA aggregate. Both regions produce goods which are imperfect substitutes to goods produced in the other region. Households and banks can borrow internationally. We use a New Keynesian model which is an extension of the model presented by Iacoviello (2005), which splits the household sector into borrowers and savers. We build on Iacoviello by further disaggregating saver households into risk-averse savers, who save in the form of deposits and government bonds, and equity-owners who own all shares of banks and non-financial corporations. This disaggregation allows us to distinguish between risky bank capital and insured debt on the liability side of the bank balance sheet. Banks provide loans to households to finance residential investment, while corporate investment is financed via stock and bond markets[4]. In order to distinguish between borrowers and savers in the household sector, we distinguish households by the rate of time preference. Savers with a low rate of time preference supply funds to investors, while households with a high rate of time preference receive loans from banks subject to a collateral constraint. There is a monetary authority, following rules based stabilisation policies.

2.2.1 Corporate Sector

The non-financial corporate sector produces wholesale output with a Cobb Douglas production function which uses capital K_t and labour N_t as inputs

$$(1) \qquad Y_t = K_t^{1-\alpha} N_t^{\alpha} Z_t^{Y\alpha}, \qquad \text{with } N_t = \left[\int_0^1 N_t^{i\,\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}.$$

where N_t is a CES aggregate of labour supplied by individual households *i*. The parameter $\theta > 1$ determines the degree of substitutability among different types of labour. There is an economy wide technology shock Z_t^Y and an investment specific technology shock Z_t^J

[4] We do not model loan supply to the corporate sector but assume that banks hold a fixed share of corporate shares. Since both non- financial corporations and banks are owned by equity owners the cross ownership of assets between banks and non-financial corporations is not important for our results.

affecting current investment vintages which are priced at p_t^I.[5] The number of outstanding shares of the nonfinancial corporate sector is S_t^{NF}. Dividends are given by

(2) $$div_t^{NF} = (Y_t - w_t N_t) - p_t^I J_t + q_t^{NF} \Delta S_t^{NF}$$

The nonfinancial corporate sector makes decisions which maximise the present discounted value of dividends and it applies the stochastic discount factor of equity owners $(1+r_t^E)$

(3) $$\begin{aligned} Max\, V_0^{NF} &= E_0 \sum_{t=0}^{\infty} \prod_{j=0}^{t} (1+r_{t+j}^E)^{-1} \left[div_{t+j}^{NF} \right] \\ &- E_0 \sum \lambda_t \beta^t \left[K_t - J_t Z_t^J - (1-\delta) K_{t-1} \right] \end{aligned}$$

The first order condition for physical capital is given by

(4) $$\frac{p_t^I}{Z_t^J} = Y_{K,t} + E_t \frac{(1-\delta)}{(1+r_t^E)} \frac{p_{t+1}^I}{Z_{t+1}^J},$$

which equates the marginal product of physical capital and the expected capital gain to the required rate of return of investors.

The banking sector provides mortgage loans L_t and invests in government bonds $p_t^G B_t^B$ and bonds $e_t F_t^B$ issued by foreign banks. Since bonds are issued in euro the exchange rate e_t is equal to one. Banks use deposits D_t and bank capital $L_t + P_t^G B_t^B + e_t F_t^B - D_t$. Government bonds held by the bank are perpetuities which pay a coupon τ_t each period and have a price P_t^G. The expected gross rate of return is given by $1 + r_t^G = (\tau_t + E_t p_{t+1}^G)/p_t^G$. There is an international interbank market between domestic and foreign bonds. If F_t^B is positive, then the doestic banks are net lenders to foreign banks and vice versa. The bank respects a regulatory constraint which makes it costly for the bank if deposits exceed a fraction Γ^L of total loans. This constraint may reflect a legal requirement, or market pressures. The bank can hold less capital than the required level, but this is costly. Let $x_t = (D_t - \Gamma^L (L_t + p_t^G B_t^B + e_t F_t^B))$ denote the bank's 'capital shortfall' or excess leverage. The bank bears a quadratic cost from a capital shortfall. The bank also tries to stay close to its government bond and foreign net asset target Γ^B and Γ^F respectively. This could be justified by a liquidity preference motive

[5] All prices are expressed relative to the final goods deflator.

of the bank. Bank shares are held by equity owners. Banks pay dividends div_t^B to share holders. Dividends are equal to the cash flow of banks which is made up of revenues from mortgage loans, holdings of government and foreign bonds and increases of the stock of deposits. Interest payments for deposits, increases of the stock of loans, government and foreign bonds reduce the cash flow. The bank also bears a real operating cost for managing deposits and loans, $\Gamma(D_t + L_t)$, where $\Gamma > 0$ is a constant. The cash flow of banks is also negatively affected by loan losses from domestic borrowers $\Lambda_t^{CC,B}$. The corporate banking sector issues shares at price q_t^B, and the number of outstanding shares is denoted by $S_{t-1}^B = S_{t-1}^{BP} + S_{t-1}^{BG}$. Shares are held by private equity owners and by the government.

$$
\begin{aligned}
div_t^B(S_{t-1}^{BP} + S_{t-1}^{BG}) = {} & (1+r_{t-1}^L)L_{t-1} + \tau_{t-1}B_{t-1}^B + p_t^G B_{t-1}^B + (1+r_{t-1}^{F,B})e_t F_t^B - (1+r_{t-1}^D)D_{t-1} \\
& - L_{t+j} - e_t F_t^B - p_t^G B_t^B + D_t \\
& - \varphi/2(D_t - \Gamma^L(L_t + p_t^G B_t^B + e_t F_t^B))^2 - \theta/2(p_t^G B_t^B - \Gamma^B)^2 - \\
& \psi/2(e_t F_t^B - \Gamma^F)^2 - \Lambda_t^{CC,B} + q_t(\Delta S_t^{BP} + \Delta S_t^{BG})
\end{aligned}
\tag{5}
$$

The banking sector makes decisions which maximises the present discounted value of dividends and it applies the stochastic discount factor of equity owners $1/(1+r_t^E)$

$$
\underset{\{L,B^B,F,D\}}{Max} V_0^B = E_0 \sum_{t=0}^{\infty} \prod_{j=0}^{t} (1+r_{t+j}^E)^{-1} \left[div_{t+j}^B \right]. \tag{6}
$$

The FOCs w. r. t. D_t, L_t, B_t^B and F_t^{IB} are given by

$$
\frac{\partial V_t^B}{\partial D_t} = \frac{1+r_t^D + \Gamma}{1+r_{t+1}^E} - 1 + \varphi(D_t - \Gamma^L(L_t + p_t^G B_t^B + e_t F_t^B)) = 0 \tag{6a}
$$

$$
\frac{\partial V_t^B}{\partial L_t} = \frac{1+r_t^L - \Gamma}{1+r_{t+1}^E} - 1 + \varphi(D_t - \Gamma^L(L_t + p_t^G B_t^B + e_t F_t^B))\Gamma^L = 0 \tag{6b}
$$

$$
\frac{\partial V_t^B}{\partial F_t^B} = \frac{1+r_t^{F,B}}{1+r_{t+1}^E}\left(\frac{e_{t+1}}{e_t}\right) - 1 - \psi(e_t F_t^B - \Gamma^F)^2 + \varphi(D_t - \Gamma^L(L_t + p_t^G B_t^B + e_t F_t^B))\Gamma^L e_t) = 0 \tag{6c}
$$

According to (6a) the bank sets an optimal capital shortfall (excess leverage) such that the marginal cost of excess leverage is equal to the interest differential between deposits and equity. For ROE exceeding the deposit rate the bank wants to undershoot the bank capital target. Eq (6b) states that loan supply of banks is restricted by excess leverage. Equation (6c) gives the interest parity condition. We do not model the risk and liquidity considerations of banks determining the holding of government bonds and take the stock of government bonds as given. We only consider how bond valuation effects affect loan supply and refinancing decisions of banks. From these FOCs we obtain the following loan interest rate rule

$$(7) \qquad r_t^L = (1-\Gamma^L) r_{t+1}^E + \Gamma^L r_t^D + (1+\Gamma^L)\Gamma$$

The loan interest rate is set equal to marginal cost, which is a weighted average of the deposit rate and the return on bank equity. The weights are determined by the constraints on the bank balance sheet imposed by capital requirement and the marginal operating cost of the bank. Notice also, actual and expected losses as well as government relief measures do not appear in the loan interest rate rule since it is assumed that these losses relate to past loan supply decisions of banks. Since the real expected loan rate is below the rate of time preference of borrowing households, the bank needs to impose a collateral constraint (see eq. 16) in order to prevent over-borrowing. The stock market equalises rates of return on bank and physical capital by applying the same stochastic discount factor to financial and non-financial sector capital.

2.2.2 Households

The household sector consists of a continuum of households $h \in [0,1]$. A fraction s^s of all households are savers and indexed by *s*. s^c households are credit constrained (debtors) and indexed by *c* and there is a fraction s^e of equity owners. The period utility functions have identical functional forms for all household types[6] and are specified as a nested constant elasticity of substitution (CES) aggregate of consumption (C_t^h) and housing services (H_t^h) and separable in deposits D_t^h and leisure ($s^h - N_t^h$). We follow Van den Heuvel (2008) in adding deposits to the utility function, this simplifies modelling of portfolio decisions of households. We also allow for habit persistence in consumption. For each household type $h \in \{s, c, e\}$ the temporal utility is given by

[6] Preference parameters can be different across household types.

(8a) $$U^h(C_t^h, H_t^h, D_t^h, 1-N_t^h) = \frac{\left\{CES^h(C_t^h, H_t^h)\right\}^{1-\sigma^h}}{1-\sigma^h} + J^{D,h} D_t^{h,1-\nu} + J^{N,h}\left(s^h - N_t^h\right)^{1-\kappa}$$

(8b) $$CES^h(C_t^h, H_t^h) = \left[s_{h,C}^{\frac{1}{\sigma^H}} \left(C_t^h - h^h C_{t-1}^h\right)^{\frac{\sigma^H-1}{\sigma^H}} + s_{h,H}^{\frac{1}{\sigma^H}} H_t^{h\,\frac{\sigma^H-1}{\sigma^H}} \right]^{\frac{\sigma^H}{\sigma^H-1}}$$

Only savers and debtors supply differentiated labour services to unions which maximise a joint utility function for each type of labour *i*. It is assumed that types of labour are distributed equally over the two household types. Nominal rigidity in wage setting is introduced by assuming that the household faces adjustment costs for changing wages. These adjustment costs are borne by the household.

Savers

Savers provide deposits D_t to the banking system and hold government bonds B_t^H and foreign assets F_t^H which they trade with foreign households. They also own the stock of land $Land_t$ and they use a CES technology

(9) $$J_t^H = \left(s_L^{\frac{1}{\sigma_L}} J_t^{Land\,\frac{(\sigma_L-1)}{\sigma_L}} + (1-s_L)^{\frac{1}{\sigma_L}} J_t^{Constr\,\frac{(\sigma_L-1)}{\sigma_L}} \right)^{\frac{\sigma_L}{\sigma_L-1}}$$

to combine land and final goods for the production of new houses J_t^H. Producers of new houses charge a price p_t^H which is equal to marginal cost which can be represented as a CES aggregate of land p_t^{Land} and construction prices p_t^{Constr}. In order to capture deviations of construction prices from the GDP deflator we assume that producers in the construction sector transform wholesale goods into residential investment using a linear technology subject to an auto-correlated technology shock. The Lagrangian of this maximisation problem is

(10)

$$
\begin{aligned}
Max \quad V_0^s = & \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{s t} U^s (C_t^s, \sigma^s - N_t^s, H_t^s, D_t^s) \\
& - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^s \beta^{s t} \left(\begin{array}{l} p_t^C C_t^s + p_t^H J_t^{H,s} + J_t^{Constr} + p_t^G B_t^H + e_t F_t^H + D_t^s - p_t^G B_{t-1}^H - \tau_{t-1} B_{t-1}^H \\ - (1+r_{t-1}^D) D_{t-1}^s - (1+r_{t-1}^{F,H}) e_t F_{t-1}^H - w_t N_t^s - p_t^L J_t^{Land} - p_t^H J_t^{H,s} + T_t^s - TR_t^s \end{array} \right) \\
& - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^s \zeta_t^s \beta^{s t} \left(H_t^s - J_t^{H,s} - (1-\delta^H) H_{t-1}^{H,s} \right) \\
& - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^s \xi_t^s \beta^{s t} \left(Land_t + J_t^{Land} - (1+\gamma_t^{Land}) Land_{t-1} \right)
\end{aligned}
$$

where T_t^s and TR_t^s are lump sum taxes and government transfers to saver households. The consumption and housing investment decision are determined by the following first-order conditions (FOCs)

Consumption:

(11) $$U_{C,t}^s = E_t (1+r_t) \frac{p_t^C}{p_{t+1}^C} \beta^s U_{C,t+1}^s$$

Define the discount factor $d_t^s = \frac{1}{(1+r_t)} = E_t \left(\frac{U_{C,t+1}^s \beta^s}{U_{C,t}^s} \frac{p_t^C}{p_{t+1}^C} \right)$

Deposits:

(12) $$\frac{U_{D,t}^s}{U_{C,t}^s / p_t^c} = d_t^s (1+r_t^D)$$

Residential investment

(13) $$p_t^H = \frac{U_{H,t}^s}{U_{C,t}^s / p_t^C} + \mathrm{E}_t \left(d_t^s P_{t+1}^H (1-\delta^H) \right)$$

Land price

(14) $$p_t^{Land} = \mathrm{E}_t \left(d_t^s p_{t+1}^{Land} (1+\gamma^{Land}) \right)$$

Government bond price

(15) $$p_t^G = \mathrm{E}_t\left(d_t^s(\tau_t + p_{t+1}^G)\right) \quad \text{where } \tau_t = \tau(1-\mu_t)$$

The first order conditions determine a savings schedule where the ratio between current and future expected consumption is as negative function of the real interest rate. With deposits in the utility function we capture the fact that deposits, apart from providing interest income, also provide liquidity services to the household. For constant prices and interest rates residential capital and consumption grow at equal rates. The elasticity of substitution between *C* and *H* determines how strongly the demand for consumption and housing reacts to relative price changes. Finally residential investment is a negative function of opportunity costs which consist of the nominal interest rate minus capital gains from expected increases in house prices. Land constitutes an asset for the household and arbitrage requires a return equal to the risk free rate. Only saver households engage actively in the market for government bonds, thus the price of government bonds is determined applying the save discount rate. We assume that governments issue perpetuities which pay a fixed coupon τ each period. However, we assume that saver households expect governments to reduce (future) coupon payments at rate μ_t which itself depends on government indebtedness.

Debtors

Debtor households differ from saver households in two respects. First they have a higher rate of time preference ($\beta^c < \beta^s$) and they face a collateral constraint on their borrowing L_t. Banks impose a loan to value ratio χ^c. The Lagrangian of this maximisation problem is given by

(16)
$$\begin{aligned}
&Max \quad V_0^c = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{c^t} U^c(C_t^c, 1-N_t^c, H_t^c) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{c^t}\left(p_t^C C_t^c + p_t^H J_t^{H,c} - L_t + (1+r_{t-1}^L)L_t) - \Lambda_t^{CC} - w_t N_t^c + T_t^c - TR_t^c\right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \zeta_t^c \beta^{c^t}\left(H_t^c - J_t^{H,c} - (1-\delta^H)H_{t-1}^c\right) \\
&- E_0 \sum \lambda_t^c \psi_t \beta^{c,t}\left((1+r_t^L)L_t - \chi^c p_t^H H_t^c\right)
\end{aligned}$$

Consumption

(17) $$U^c_{C,t} = E_t \frac{(1+r_t^L)\beta^c}{(1-(1+r_t^L)\psi_t)} \frac{p_t^C}{p_{t+1}^C} U^c_{C,t+1}$$

Define the discount factor $d_t^c = \frac{(1-(1+r_t^L)\psi_t)}{(1+r_t^L)} = E_t \frac{U^c_{C,t+1}\beta^c}{U^c_{C,t}} \frac{p_t^C}{p_{t+1}^C}$

Residential investment

(18) $$p_t^H = \frac{U^c_{H,t}}{U^c_{C,t}/p_t^C} \frac{1}{(1-\psi_t(1-\delta^H)\chi^c)} + E_t d_t^c \frac{(1-\delta^H)}{(1-\psi_t(1-\delta^H)\chi^c)} p^H_{t+1}$$

Both consumption and residential investment are affected by the collateral constraint. A tightening of the constraint induces debtors to shift consumption from current to future periods and to reduce residential investment by increasing shadow capital costs by $\psi_t(1-\chi_t^c)$. A high loan to value ratio reduces the impact of credit tightening on residential investment, since in this case an increase in the capital stock makes investment valuable for the household by increasing its borrowing capacity.

Equity owners

Equity owners receive income (distributed profits) from dividends paid by financial and non financial corporations. They maximise an intertemporal utility function[7] subject to a budget constraint

$$Max\, V_0^E = E_0 \sum_{t=0}^{\infty} \beta^{e,t} U^e(C_t^e) -$$

(19) $$E_0 \sum_{t=0}^{\infty} \lambda_t \beta^{e,t} \left[q_t^B S_t^{BP} - (div_{t-1}^B + q_t^B) S_{t-1}^{BP} + q_t^{NF} - (div_{t-1}^{NF} + q_t^{NF}) S_{t-1}^{NF} - p_t^c C_t^e + T_t^e \right]$$

Optimisation yields the following (inverse of the) stochastic discount factor for corporate investment

(20) $$E_t \frac{U^e_{C,t} p_t^c}{U^e_{C,t+1} p^c_{t+1} \beta^e} = (1 + r_t^E)$$

[7] We assume that equity owners do not engage in housing investment, deposit demand and labour supply.

Notice that by using the same stochastic discount factor r^E managers are implicitly determining the dividend stream to maximise consumption of equity owners.

Wage setting

A trade union is maximising a joint utility function for each type of labour *i* where it is assumed that types of labour are distributed equally over constrained and unconstrained households with their respective population weights. The trade union sets wages by maximising a weighted average of the utility functions of these households. The wage rule is obtained by equating a weighted average of the marginal utility of leisure to a weighted average of the marginal utility of consumption times the real wage of these two household types, adjusted for a wage mark up

(21) $$\frac{s^c U^c_{s^c - N^c,t} + s^s U^s_{s^s - N^s,t}}{s^c U^c_{c,t} + s^s U^s_{c,t}} = \frac{w_t}{p^C_t} h_t$$

where h_t is the wage mark up factor, with wage mark ups fluctuating around $1/q$ which is the inverse of the elasticity of substitution between different varieties of labour services. The trade union sets the consumption wage as a mark up over the reservation wage. The reservation wage is the ratio of the marginal utility of leisure to the marginal utility of consumption. This is a natural measure of the reservation wage. If this ratio is equal to the consumption wage, the household is indifferent between supplying an additional unit of labour and spending the additional income on consumption and not increasing labour supply.

2.2.3 The retail sector

There is a retail sector which buys wholesale goods and diversifies them. Retailers sell these differentiated goods in a monopolistically competitive market at price p^F_t. Retailers only face quadratic price adjustment costs (see appendix). This introduces nominal rigidities in this economy and in a symmetric equilibrium, inflation dynamics is given by a standard New Keynesian Phillips curve

(22) $$p^F_t = b E_t p^F_{t+1} + 1/g_p MC^{WS}_t$$

where MC_t^{WS} is real marginal cost in the wholesale sector.

2.2.4 Monetary Policy

We assume that monetary policy in the monetary union follows a Taylor rule which is targeting EA aggregate inflation and output growth

$$
\begin{aligned}
(23)\qquad i_t = {} & \tau^M_{lag} i_{t-1} + (1-\tau^M_{lag})[r^{EQ} + \pi_t^T + \tau^M_\pi(\pi_t^{C,EA} + \pi_{t-1}^{C,EA} + \pi_{t-2}^{C,EA} + \pi_{t-3}^{C,EA} - 4\pi_t^T)/4 \\
& + \tau^M_y(gy_t^{EA} + gy_{t-1}^{EA} + gy_{t-2}^{EA} + gy_{t-3}^{EA} - 4\overline{gy})/4] + z_t^M
\end{aligned}
$$

The term z_t^M indicates discretionary deviations from the Taylor rule.

2.2.5 Fiscal Policy

Government expenditure is government purchases of goods and services G_t and transfers to saver and debtor households TR_t^H. Total tax revenues T_t are the sum of tax revenues from the three households. The government uses taxes to balance the budget and meeting a long run debt target. In addition governments receive income from bank shares. Government bonds are held by saver households and banks $B_t = B_t^S + B_t^B$. The government budget constraint is given by

$$(24)\qquad p_t^G B_t = p_t^G B_{t-1} + \tau_{t-1} B_{t-1} + G_t + TR_t^H - T_t$$

2.2.6 The rest of the world, foreign trade and the current account

We assume that households, firms and the government have CES preferences over domestic and foreign goods

$$(25)\qquad A^i = \left[(1-\sigma^M - Z_t^M)^{\frac{1}{\sigma^M}} A^{d\,i\,\frac{\sigma^M-1}{\sigma^M}} + (\sigma^M + Z_t^M)^{\frac{1}{\sigma^M}} A^{f\,i\,\frac{\sigma^M-1}{\sigma^M}}\right]^{\frac{\sigma^M}{(\sigma^M-1)}}$$

across goods used for consumption, and investment $A^i \in \{C^i, I^i, G^i\}$. The share parameter s^M can be subject to a shock Z_t^M and $A^{d\,i}$ and $A^{f\,i}$ are indexes of demand across the continuum of differentiated goods produced respectively in the two economies. We assume producer pricing. Domestic households and banks hold internationally tradable bonds $e_t F_t^H$ and $e_t F_t^B$ which are denominated in foreign currency. These assets are subject to losses Λ_t^F. We assume producer pricing. The stock of net foreign assets thus evolves as

$$(26) \qquad e_t (F_t^H + F_t^B) = (1 + r_{t-1}^{F,H}) e_t F_{t-1}^H + (1 + r_{t-1}^{F,B}) e_t F_{t-1}^B - \Lambda_t^F + X_t - e_t M_t$$

Where imports and exports are defined as $M_t = C_t^{P,f} + J_t^{P,f}$, and $X_t = C_t^{C,f} + J_t^{C,f}$.

2.2.7 Equilibrium

Equilibrium in our model economy is an allocation, a price system and monetary policy in the Euro area periphery and core countries such that households maximise utility, and the following market clearing conditions hold for the two regions:

$$(27) \qquad Y_{t_t}^i = C_t^{i,d} + J_t^{i,d} + J_t^{Constr,i} + X_t^i, \qquad i=P,C$$

In addition markets for residential investment, labour, loans, deposits, equity and internationally traded bonds clear.

2.3 Calibration:

For this exercise it is important to have a good estimate of domestic sovereign debt holdings of domestic banks. Recently, Merler and Pisani-Ferry (2012) have calculated sovereign bond holdings of domestic banks for EA countries. They find that these asset holding have increased between 2007 and 2011. Especially domestic banks in countries in Southern Europe tend to hold relatively large shares of domestic sovereign debt as a % of GDP (GR: 16.1%, IR: 9.6%, PO: 20.8%, IT: 16.9%, ES: 15.9%). In 2007 these holdings were below 10% of GDP. For the simulations we assume that domestic banks holdings of sovereign debt amount to 12% of GDP. The curvature parameter of the bank´s cost of deviating from target bank capital implies that a 1 percentage point rise of the bank capital ratio lowers the spread between the loan rate and the deposit rate by 40 basis points. This is a critical parameter in the model, and depends crucially on the degree of risk aversion of depositors. This parameter as well as all other behavioral and technological parameters are taken from the estimated model for the Euro area in Kollmann *et al.* (2013).

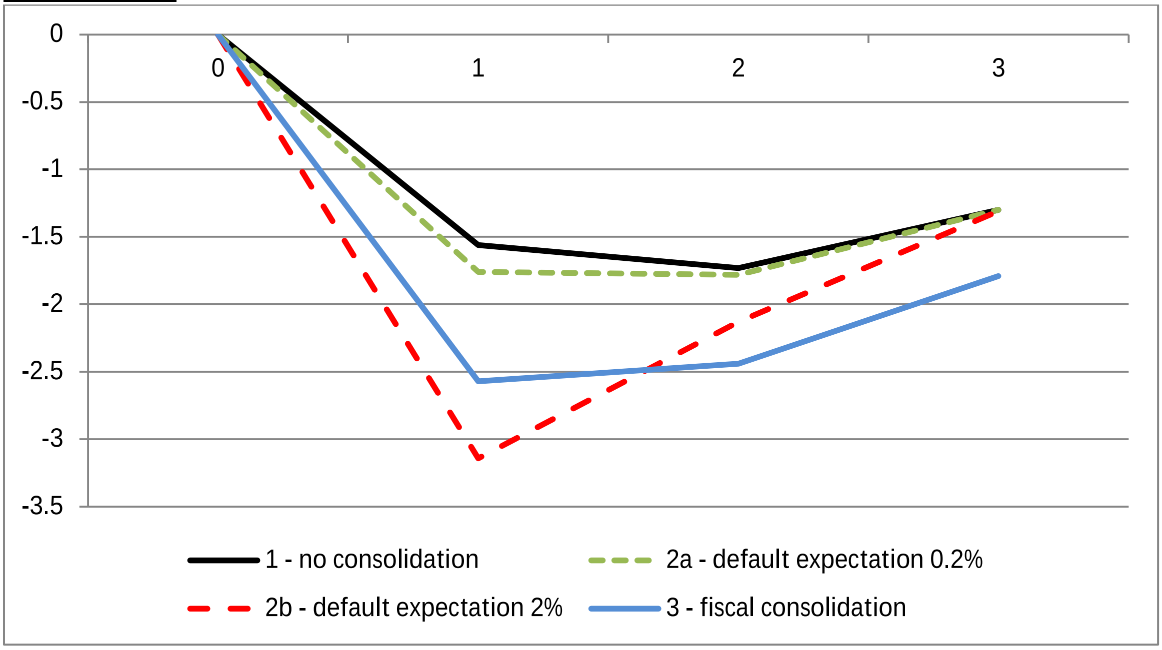
3. The Policy Experiment

Our goal is to assess the effects of fiscal consolidations in an environment with rising sovereign debt. Therefore we deviate from the standard practice of calculating multipliers, where it is commonly assumed that without consolidation the economy would move along a pre-existing steady state path. We make an intermediate step, by creating various 'no fiscal consolidation' scenarios. These are generated by adverse shocks to the EA periphery, and their size is calibrated such that the debt to GDP ratio rises by 10 pps permanently. We choose this 10 pps increase because a persistent reduction of government spending of 1% of GDP (over 10 years) roughly stabilizes the initial debt to GDP ratio. This is generated by two adverse shocks. We assume mortgage losses which build up to 2.5% of (one year's GDP) after 5 years and a permanent decline of house prices of 6%. We find these shocks to be roughly representative for the types of shocks that have been hitting EA periphery countries and which have led through the workings of automatic stabilizers to an increase in debt-to-GDP ratios. However we restrict the size of the adverse financial shocks since we only want to generate a 10% increase in public debt.

The alternative no-fiscal consolidation scenarios differ by the imposed elasticity of the sovereign risk premium to the increase in the debt to GDP ratio. Scenario 1 is the (standard) no fiscal consolidation scenario and shows the evolution of the economy under the adverse shock and the assumption that financial markets do not expect the resulting increase of government debt to have an impact on the probability of government default. Scenarios 2a and 2b are no fiscal consolidation scenarios under alternative assumptions about default expectations of financial markets. Scenario 2a shows the response of the economy under benign revisions of sovereign default expectations (in normal times and for low levels of government debt (below 60%)). In this case an increase in the debt-to-GDP ratio of 10 pps. raises 5-yr CDS spreads by 20 bps, implying a cumulative probability of sovereign default over 5 years of 1%. Scenario S2b shows the response of the economy without fiscal consolidation for a more severe revision of default expectations. This scenario corresponds to what can be inferred from sovereign CDS spreads for EA countries with a debt level above

120% in the EA in 2011, i.e. in a situation of significant financial market uncertainty (see Figure 5 below). In this case a 10 pps increase in the debt ratio raises CDS spreads by 200 bps., implying a cumulative probability of sovereign default over 5 years of 10%. Scenario 3 shows a fully credible consolidation scenario that reduces the debt-to-GDP ratio by 10 pps.. It is a permanent reduction in government consumption of 1% of GDP, which offsets the increase in public debt due to bank losses and deleveraging

Figure 5: GDP impact bank losses and deleveraging shock, expected sovereign default and consolidation



Note: GDP percent difference from baseline

The difference between Scenario 3 and 1 shows the impact of fiscal consolidation, everything else equal. GDP falls by 1.0 % following the spending cuts, i.e. the first year fiscal multiplier is equal to one (see Figure 5). The consolidation also has a negative impact on private consumption and investment, as in a monetary union, nominal interest rates are unchanged and the real interest rate increases. The contractionary effects of the consolidation lead to a larger increase in the debt-to-GDP ratio than in the baseline shock scenario in the first year (see Table 3). Only in later years does the debt-to-GDP ratio decline.

In the benign no-consolidation scenario 2a, the 10 pps expected increase of the debt-to-GDP ratio would only affect default probability by 0.2% p. a. and GDP would be 0.2% lower. The higher default probability raises financing costs for firms and households and private demand declines further (see Table 2a).

If instead the situation is such that financial investors revise their default expectations more strongly – in line with assumptions underlying scenario S2b – the short run costs of allowing for a permanent increase of government debt is 1.6%. When comparing scenario 1 to scenario 2b, it is also interesting to notice what happens to the economy in cause of increased sovereign risk. The risk premium on 5-year government bonds increases by about 200 bps, while the risk premium on 5-year corporate bonds increases by a similar amount in the first year, but falls back in following years. The increase of capital costs lowers corporate investment in the first two years. Residential investment also declines further than in the benchmark scenario 1, however by less than corporate investment since the loan rate increases by less than the rate of return on equity (the loan rate is a weighted average of the return on equity and the deposit rate, with weights equal to the capital and deposit share).

In these sovereign risk channel scenarios the increase of capital costs for firms is short-lived. This is due to the fact that the financing needs for banks arise mainly in the first year in case a sovereign default is only expected and does not materialize (as assumed here). This happens because sovereign bond prices drop immediately once the probability of a debt restructuring increases. This only requires temporary recapitalization efforts (e. g. lower bank dividends), therefore funding costs are only rising temporarily.

The sovereign risk scenarios are not directly comparable to the consolidation scenario. In the latter, there is actually a reduction in sovereign debt of 10 pps., while in the case of scenario 2b, there is only an *expectation* of a sovereign default over the next 5 years. Either no default materializes, in which case future consolidation would have to reduce sovereign debt to comparable levels as in our frontloaded consolidation scenario 3, or, if a default would actually occur in the 5 year period, it is likely that this would lead to heightened expectations of further defaults in the future. In both cases the results for no-consolidation could be considerably worse than depicted here.

Table 1: Bank losses and deleveraging

year	1	2	3
GDP	-1.56	-1.73	-1.3
Consumption	-1.2	-1.19	-0.74
Corporate investment	-4.77	-3.26	-0.28
Residential investment	-8.85	-13.91	-14.24
Rate of return equity (5yr)	60.78	20.93	-7.66
Debt-to-GDP ratio	1.73	2.85	3.30
Price sov. bond (5yr)	2.31	2.23	2.05

Note: percent difference from baseline

Table 2.a: Bank losses and deleveraging + default expectation 0.2%

year	1	2	3
GDP	-1.76	-1.78	-1.3
Consumption	-1.47	-1.24	-0.74
Corporate investment	-5.5	-3.5	-0.28
Residential investment	-8.93	-13.86	-14.23
Rate of return equity (5yr)	79.66	22.29	-8.09
Debt-to-GDP ratio	1.74	2.83	3.24
Price sov. bond (5yr)	-0.83	-0.95	-1.13

Note: percent difference from baseline

Table 2.b: Bank losses and deleveraging + default expectation 2%

year	1	2	3
GDP	-3.14	-2.13	-1.31
Consumption	-3.28	-1.63	-0.75
Corporate investment	-10.62	-5.29	-0.35
Residential investment	-9.53	-13.54	-14.12
Rate of return equity (5yr)	213.73	32.59	-10.82
Debt-to-GDP ratio	1.78	2.62	2.82
Price sov. bond (5yr)	-10.26	-10.5	-10.68

Note: percent difference from baseline

Table 3: Bank losses and deleveraging + reduction government expenditure

year	1	2	3
GDP	-2.57	-2.44	-1.79
Consumption	-1.35	-0.85	-0.09
Corporate investment	-6.55	-5.14	-1.74
Residential investment	-7.59	-11.57	-12.04
Rate of return equity (5yr)	78.89	28.49	-5.63
Debt-to-GDP ratio	2.12	2.49	2.03
Price sov. bond (5yr)	2.92	2.94	2.78

Note: percent difference from baseline

4. Concluding remarks

These scenarios show the potential costs of higher sovereign risk premia and expectations of sovereign default. This has important implications for assessing the appropriateness of the fiscal stance in highly indebted countries. While at the current juncture the costs of fiscal consolidations are larger due to higher than normal fiscal multipliers, a counterfactual of no fiscal consolidation could for those countries have more detrimental effects if it leads to expectations of sovereign default which put further pressure on the banking system when banks face capital requirement constraints. Based on a highly non-linear convex relationship between debt levels and CDS spreads we find a further increase in debt-to-GDP ratios in highly indebted countries can have large negative demand effects as the sovereign spreads spillover into higher private sector borrowing costs. While this does not change the fact that multipliers - as defined relative to the initial state – are larger now, it indicates that in some cases the no-consolidation alternative may have equal or worse consequences.

This also has possible implications for a more gradual consolidation path for highly indebted countries. The arguments in favor of back loading fiscal consolidations are, first, that multipliers will be smaller when conditions have returned to normal and hence the costs of consolidating will be lower, and, second, nominal rigidities in wages and prices generally favor slower, more gradual adjustment to fast frontloaded ones. But if a slower consolidation path risks raising fears in financial markets, the benefits of back loading consolidations may be outweighed by the costs of raising expectations of sovereign default. This highlights the need for credible long-term consolidation strategies and maintaining fiscal credibility. This could reduce the perceived probability of debt restructuring by financial markets and a flattening of the relationship between sovereign debt and risk premia on government bonds.

It should also be acknowledged that there is a large dispersion in CDS spreads across countries, with some being able to attain low CDS spreads despite large debt ratios. Moreover, since the announcement of Outright Monetary Transactions (OMT) by the ECB in the second half of 2012, sovereign risk premia have fallen significantly and the relationship between debt levels and CDS spreads has weakened. But while the announcement of OMT has helped to lower default risks, it is not unconditional support but subject to clear conditionality. Therefore sovereign risk spreads are likely to remain for countries with high debt levels and the consequences of no-consolidation remain an important consideration when judging the appropriate stance of fiscal policy. In the scenarios shown here the costs of expected defaults are heavily frontloaded to the first year, while they could be more spread out over a longer horizon for more realistic scenarios. If default would actually materialize, this is likely to lead to higher borrowing costs for governments, raising spreads further as expectations of future defaults have risen or in extreme cases block a government's access to the market completely. Either way the costs of no-consolidation would be higher than shown here. Further analysis is required to quantify these effects in a more general context.

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