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Evaluating the Macroeconomic Effects of Government Support Measures to Financial Institutions in the EU

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Abstract

This paper analysis the macroeconomic effects of state aid to the financial sector using a microfounded structural model. We simulate a crisis scenario in which the economy is hit by a severe financial shock and is subject to financial market imperfections. We then look at three types of measures: purchases of toxic assets, bank recapitalisation measures and government loan guarantees. State support to banks are found to help propping up the value of banks and reduce the risk premium that had emerged, so supporting corporate investment which had been particularly badly affected in the crisis.

JEL classification: C54 ; E62 ; E32 ; E44 ; G21 ; H62 .
Key words: financial crisis, fiscal policy, bank state aid, government purchases.

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1. Introduction

There is currently an intense debate about the effects of fiscal measures in the recent financial crisis. This debate concentrates mostly on the consequences of increases in government purchases and transfers to households, and of tax cuts (see, e.g., Coenen *et al.* (2010), Corsetti *et al.* (2010) and Drautzburg and Uhlig (2011) for overviews of that debate).

However, a key dimension of the fiscal policy response to the crisis were sizable government interventions in the banking system, in the form of bank asset purchases, loan guarantees and bank recapitalization (government purchases of bank shares).[1] As documented below, these 'unconventional' fiscal interventions were actually larger than the changes in standard fiscal instruments enacted during the crisis. Surprisingly, the macro-economic effects of these unconventional fiscal measures directed at the financial sector have, so far, received little attention in the literature. This paper seeks to fill this gap, by analyzing the effects of government support measures to banks, using the Commission's macroeconomic model QUEST III augmented by a financial sector. This type of model has been used to empirically account for the boom and bust cycle in the US (see in ´t Veld *et al.* (2011).

In this framework, the banking sector lends predominantly to private households and it holds asset issued by the corporate sector, government bonds and foreign bonds. Banks receive funds from households in the form of deposits and a fraction of households also provide bank capital. Losses from loan defaults are eventually borne by equity owners. In a financial crisis, the recapitalisation efforts of these households require massive reallocation of consumption over time which raises the required rate of return on bank equity.

We model government purchase of toxic assets from the banking sector by assuming that the government takes possession of a fraction of mortgage loans, and writes them off completely. Government recapitalisation measures are modelled as government purchases of newly issued bank shares. Government guarantees are more difficult to model as they provide an insurance function and were introduced to restore confidence in the interbank market. We model these guarantees by comparing a scenario with large expected losses to banks to one where the government steps in and takes over these losses, redistributing them to tax payers.

In our set-up, the intertemporal government budget constraint captures contingent liabilities from expected losses, expenditure related to the purchase of bank equity, as well as expected dividends earned from holding bank shares and the possible revenue from selling

[1] For a detailed description of the effects of temporary state aid rules adopted in the crisis, see European Commission (2011).

shares at the stock market (on the revenue side) and expenditure related to the purchase of securities which must partially be written off. With the presence of this intertemporal government budget constraint, we can look at the benefits and costs of state aid measures, since these will have to be financed via the government budget (or constitute contingent liabilities, creating an expectation of future budgetary costs). Since the government has various degrees of freedom on how to adjust the budget - it can either reduce spending or increase tax revenues - an explicit modelling choice has to be made concerning the government financing strategy. We assume that governments will respond by gradually adjusting distortionary taxes, in particular labour taxes. With this choice we stress that there will be costs to society which can directly be measured in terms of GDP. Other adjustment alternatives, e. g. a cut in government spending would yield smaller long term GDP losses, but we would insufficiently account for welfare losses to households associated with reduced government spending. Because we assume rational expectations of households and firms, expectations of budgetary costs (including contingent liabilities) will have consequences for current investment, employment and consumption decisions. This framework is therefore in principle suitable to assess the costs of fiscal measures.

Our analysis also makes an attempt to account for the benefits of government intervention during financial crises by using a model which stresses financial market imperfections which leads to amplification of negative financial shocks. We consider two types of financial market distortions, related to a disaggregation of the household sector into three distinct groups, namely, on the one hand, credit constrained borrowers and on the other hand savers, where, among the latter we distinguish between (risk averse) households which only hold government bonds and deposits, and households which own equity. There are two financial frictions. First, a borrowing constraint restricts consumption smoothing of borrowers and makes their spending more strongly dependent on current income and current interest payments. Second, the segmentation of the capital market into government bonds and deposits on the one hand, and equity on the other imposes effectively a borrowing constraint on equity holders which can generate substantial fluctuations in the equity premium associated with variations in bank cash flows. This segmentation of capital markets makes it difficult for banks to recapitalise in financial markets in the case of large losses and increases risk premia in equity markets which makes investment more costly. This increase in risk premia is a typical feature of many financial crises, including the most recent one and shows up in strong increases in spreads between risky and less risky securities (e. g. corporate bond spreads). As emphasised by Hall (2011) for example, changes in equity premia can account for the stylised

facts of the transmission of financial market shocks to the real economy. It must be stressed that our modelling devise is not the only one possible, there are other models which emphasise moral hazard (Gertler and Karadi (2010)) or asymmetric information and monitoring costs (Christiano et al. (2012)). All these alternative specifications have in common that initial financial shocks get amplified because of frictions within the financial sector, which makes government intervention a feasible choice for stabilising the economy.

Krishnamurthy (2009) provides an overview of the various models. He makes a distinction between two alternative amplification channels, namely via balance sheet effect and via uncertainty. The latter channel has especially been stressed by Caballero (2010) who points to a large discrepancy between actual losses from mortgage related assets and the total loss of market value of banks (equity plus debt), with the latter being about 2.5 times the former in absolute value. Caballero argue that this could possibly be explained by some form of panic in financial markets, resulting from increased (Knightian) uncertainty of financial market participants associated with limited experience with new financial instruments, making them base their strategies on worst case scenarios. Also Bean (2010) notices that once losses from subprime mortgages turned out to be larger than initially expected, ´investors switched from believing that returns behaved according to a tight and well behaved distribution to one in which they had very little idea about the likely distribution of returns´. Amidst all this, Bean points out that the failure of Lehman Brothers aggravated the uncertainty problems, with financial markets noticing that previously believed bailout guarantees for large and interconnected institutions were not viable any longer. This led to a sharp increase of CDS spreads of major banks. As events unfolded in financial markets, loss forecasts escalated. While in 2007, the US FED estimated losses from subprime mortgages in the order of 50 Bio US dollars (Testimony of B. Bernanke to the US Senate Banking Committee, July 2007), by October the IMF (IMF 2009) estimated global write downs in financial institutions of 3.4 Trio US dollars (from 2007-2010). With hindsight we know that this number was far too large. Recent estimates of credit losses arrive at a number which is close to one trio. dollars. Krishnamurthy observes that the uncertainty model provides justification for insurance policy proposals or guarantee schemes. Uncertainty will also play an important role in our study. First, we find it necessary to introduce panic type shocks, because the model otherwise would not have been able to generate the decline in economic activity (and stock prices) as observed in the recent financial crisis. Second, uncertainty provides an important rationale for providing government guarantees.

Section 2 provides an overview of fiscal policy during the recent financial crisis. Section 3 describes our model. The calibration is discussed in Section 4, while Section 5 presents our simulation results. Section 6 concludes.

2. Fiscal measures in the global financial crisis

In response to the economic downturn in 2008/2009, governments have intervened on various fronts. The US government has enacted a fiscal stimulus programme, under the American Recovery and Reinvestment Act (ARRA), while EU member states implemented countercyclical fiscal measures under the European Economic Recovery Plan (EERP), launched by the EU Commission in Dec. 2008. The fiscal stimulus in the US amounted to almost 2% of GDP in 2009 and 2010 and included increases in purchases of goods and services, public investment and income support measures extending unemployment benefits payments over longer periods of unemployment. In the European Union, the size of stimulus packages varied considerably across countries, but the overall stimulus amounted to only 0.8% of EU GDP in 2009-10.

Table 1: Conventional fiscal stimulus measures (as % of GDP)

	US		EU	
	2009	2010	2009	2010
Total fiscal stimulus	2.0	1.8	0.8	0.7
of which				
Government expenditure	*0.7*	*0.8*	*0.3*	*0.2*
Transfers	*0.6*	*0.2*	*0.2*	*0.1*
Tax reductions	*0.7*	*0.8*	*0.3*	*0.5*

Source: Coenen et al. (2010).

At the same time, governments announced unprecedented interventions in the financial markets to improve credit conditions and regain financial stability. These stabilisation measures consisted of three broad type of interventions: (1) recapitalisation (capital injections

into financial institutions) through equity shares or hybrid instruments provided by governments, including government acquisitions of stakes in the banking sector and support of an acquisition by a third party; (2) guarantees on banks' liabilities by means of guarantess on new bond issuance with maturity ranging from three months to five years; (3) purchases of toxic or impaired assets by governments, "bad banks" (Impaired Asset Repair mechanisms). [2] Recapitalisations and asset purchases combined amounted to roughly 5% of EU GDP in total over the crisis. Liability guarantees were much larger almost 8% at its peak, and form contingent liabilities for the general government. For comparison, in the US capital injections into financial institutions and direct asset purchases amounted to more than 6% of GDP in total, but liabilities guarantees played a much smaller role. [3]

Table 2: Cumulative state aid for financial sector (as % of GDP)

	Feb-09	May-09	Aug-09	Dec-09	Oct-10	Dec-10	Apr-11
IAR	0.4	0.5	0.8	2.8	2.2	2.0	1.9
Recap	1.1	1.5	1.7	1.9	2.2	2.2	2.1
Guarantees	6.6	7.3	8.0	7.8	5.8	5.6	5.1
Total	8.1	9.2	10.4	12.5	10.1	9.8	9.1

Source: Commission services (survey based)

[2] Liquidity support provided by governments could be considered a fourth category of state intervention. This includes liquidity assistance provided by central banks in the case there is an explicit guarantee by the State, loans or high quality asset swaps. We do not consider this here but focus on the three direct forms of state aid interventions.

[3] The statistical recording of these complex public interventions in government accounts is more complicated and distinguishes capital transfers (expenditure) and acquisition of equity. Capital injections in heavily loss-making banks are considered as capital transfers and not as acquisition of equity. This was e.g. the case in Ireland in 2010.
http://epp.eurostat.ec.europa.eu/portal/page/portal/government_finance_statistics/excessive_deficit/supplementary_tables_financial_turmoil.

3. The Model [4]

We consider two regions, the EU and the Rest of the World (RoW). Both regions produce goods which are imperfect substitutes to goods produced in the other region and there is perfect international capital mobility. 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[5]. 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. Behavioural and technological relationships can be subject to shocks denoted by Z_t^k, where *k* stands for the type of shock.

3.1 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

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

where N_t is a CES aggregate of labour supplied by individual households *i*. The parameter $q > 1$ determines the degree of substitutability among different types of labour. There is an

[4] In order to keep the model description as simple as possible, we do not discuss real and nominal frictions associated with adjustment costs for labour, capital (residential, equipment and structures), capacity, prices and wages. These adjustment rigidities are important for fitting the model to time series observations and are therefore included in the estimated model.

[5] 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 nonfinancial corporations is not important for our results.

economy wide technology shock Z_t^Y and an investment specific technology shock Z_t^J affecting current investment vintages. The number of outstanding shares of the nonfinancial corporate sector is S_t^{NF}. Dividends are given by

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

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

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

The first order condition for physical capital is given by

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

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 B_t^B and foreign bonds $e_t F_t$ using deposits D_t and bank capital $L_t + B_t^B + e_t F_t - D_t$. 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 $x_t = (D_t - \Gamma^L (L_t + B_t^B + e_t F_t))$ 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 target Γ^B. This could be justified by a liquidity preference motive 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 losses from domestic borrowers $\lambda_t^{CC,B}$ and foreign bonds $\lambda_t^{F,B}$ held by banks[6]. 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.

$$
\begin{aligned}
div_t^B(S_{t-1}^{BP} + S_{t-1}^{BG}) = {} & (1+r_{t-1}^L)L_{t-1} + (1+r_{t-1})B_{t-1}^B + (1+r_{t-1}^F)e_tF_t - (1+r_{t-1}^D)D_{t-1} \\
& - L_{t+j} - e_tF_t - B_t^B + D_t + TR_t^B + guar_t(L_{t-1} + e_tF_t) \\
& - f/2(D_t - \gamma^L(L_t + B_t^B + e_tF_t))^2 - q/2(B_t^B - \gamma^B)^2 - \\
& \lambda_t^{CC,B} - \lambda_t^{F,B} + q_t(\Delta S_t^{BP} + \Delta S_t^{BG})
\end{aligned}
\tag{5}
$$

Government bailout policies can take the form of recapitalisation measures, the purchase of toxic assets and the provision of guarantees. Recapitalisation measures consist of the purchase of newly issued bank shares at the current market price ($q_t \Delta S_t^G > 0$). Government purchases of toxic assets are modelled as a transfer TR_t^B from the government to the bank, i.e. we assume that governments only take over assets which must be written off completely. Guarantees on loans and foreign assets at rate $guar_{t+j}$ provide insurance to the banking system. 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 are given by

$$
\frac{\partial V_t^B}{\partial D_t} = \frac{1+r_t^D+\gamma}{1+r_{t+1}^E} - 1 + f(D_t - \gamma^L(L_t + B_t^B + e_tF_t)) = 0 \tag{6a}
$$

[6] Expected future losses as perceived by the bank are not necessarily identical to losses as perceived by

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

(6c) $$\frac{\partial V_t^B}{\partial B_t^B} = \frac{1+r_t}{1+r_{t+1}^E} - 1 - q(B_t^B - \gamma^G) + f(D_t - \gamma^L(L_t + B_t^B + e_t F_t))\gamma^L = 0$$

(6d) $$\frac{\partial V_t^B}{\partial F_t} = \frac{1+r_t^F}{1+r_{t+1}^E}\left(\frac{e_{t+1}}{e_t}\right) - (1 + f(D_t - \gamma^L(L_t + B_t^B + e_t F_t))\gamma^L) = 0$$

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. According to equation (6c), the degree in which banks deviate from their sovereign bond target is determined by the interest differential between the bond rate and the ROE. Equation (6d) gives the interest parity condition. From these FOCs we obtain the following loan interest rate rule

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

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. 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.

3.2 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

---

households, because of panic-related inflated loss expectations of lenders.

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[7] 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

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

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

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.

3.2.1 Savers

Savers provide deposits D_t to the banking system and hold government bonds B_t^H. They also own the stock of land ($Land_t$) and they use a CES technology

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

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

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

$$
\begin{aligned}
&Max \quad V_0^s = E_0 \sum_{t=0}^{\infty} \beta^{s^t} U^s(C_t^s, s^s - N_t^s, H_t^s, D_t^s) \\
&- E_0 \sum_{t=0}^{\infty} \lambda_t^s \beta^{s^t} \begin{pmatrix} p_t^C C_t^s + p_t^H J_t^{H,s} + J_t^{Constr} + B_t^H + D_t^s - (1+r_{t-1}) B_{t-1}^H \\ - (1+r_{t-1}^D) D_{t-1}^s - w_t N_t^s - p_t^L J_t^{Land} - p_t^H J_t^{H,s} + T_t^s \end{pmatrix} \\
&- E_0 \sum_{t=0}^{\infty} \lambda_t^s z_t^s \beta^{s^t} \left(H_t^s - J_t^{H,s} - (1-\delta^H) H_{t-1}^{H,s} \right) \\
&- E_0 \sum_{t=0}^{\infty} \lambda_t^s x_t^s \beta^{s^t} \left(Land_t + J_t^{Land} - (1+g_t^{Land}) Land_{t-1} \right)
\end{aligned}
\tag{10}
$$

The budget constraint is written in real terms with all prices expressed relative to final output (P). Investment is a composite of domestic and foreign goods. The consumption and housing investment decision are determined by the following first-order conditions (FOCs)

Consumption:

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

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

Deposits:

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

Residential investment

$$
p_t^H = \frac{U_{H,t}^s}{U_{C,t}^s / p_t^C} + E_t \left(\delta_t^s P_{t+1}^H (1-\delta^H) \right) \tag{13}
$$

Land prices

$$
p_t^{Land} = E_t \left(\delta_t^s p_{t+1}^{Land} (1+g^{Land}) \right) \tag{14}
$$

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.

3.2.2 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 $\kappa_t^c = \kappa^c + z_t^c$. The Lagrangian of this maximisation problem is given by

$$
\begin{aligned}
& Max \quad V_0^c = E_0 \sum_{t=0}^{\infty} \beta^{c^t} U^c(C_t^c, 1 - N_t^c, H_t^c) \\
& - E_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{c^t} \left(p_t^C C_t^c + p_t^H J_t^{H,c} - L_t + (1 + r_{t-1}^L) L_t) - \Lambda_t^{CC} - w_t N_t^c + T_t^c \right) \\
& - E_0 \sum_{t=0}^{\infty} \lambda_t^c z_t^c \beta^{c^t} \left(H_t^c - J_t^{H,c} - (1 - \delta^H) H_{t-1}^c \right) \\
& - E_0 \sum \lambda_t^c \gamma_t \beta^{c,t} \left((1 + r_t^L) L_t - \kappa_t^c p_t^H H_t^c \right)
\end{aligned}
\tag{15}
$$

Consumption

$$
U_{C,t}^c = E_t \frac{(1 + r_t^L) \beta^c}{(1 - (1 + r_t^L) \gamma_t)} \frac{p_t^C}{p_{t+1}^C} U_{C,t+1}^c \tag{16}
$$

Define the discount factor $d_t^c = \dfrac{(1 - (1 + r_t^L) \gamma_t)}{(1 + r_t^L)} = E_t \dfrac{U_{C,t+1}^c \beta^c}{U_{C,t}^c} \dfrac{p_t^C}{p_{t+1}^C}$

Residential investment

$$(17) \qquad p_t^H = \frac{U_{H,t}^c}{U_{C,t}^c / p_t^C} \frac{1}{(1-\gamma_t(1-\delta^H)\varphi_t^c)} + E_t \delta_t^c \frac{(1-\delta^H)}{(1-\gamma_t(1-\delta^H)\varphi_t^c)} p_{t+1}^H$$

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 $\gamma_t(1-\varphi_t^c)$. 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.

3.2.3 Equity owners

Equity owners receive income (distributed profits) from dividends paid by financial and non financial corporations. They maximise an intertemporal utility function[8] subject to a budget constraint

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

$$(18) \qquad E_0 \sum_{t=0}^{\infty} \lambda_t \beta^{e,t} \left[q_t^B S_t^{BP} - (div_{t-1}^B + q_t^B) S_{t-1}^{BP} + q_t^{NF} - (div_{t-1}^{NF} + q_t^{NF}) S_{t-1}^{NF} - p_t^c C_t^e \right]$$

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

$$(19) \qquad E_t \frac{U_{C,t}^e p_t^c}{U_{C,t+1}^e p_{t+1}^c \beta^e} = (1 + r_t^E)$$

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

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

3.2.4 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

$$(20) \qquad \frac{s^c U^c_{s^c - N^c,t} + s^s U^s_{s^s - N^s,t}}{s^c U^c_{c,t} + s^s U^s_{c,t}} = \frac{w_t}{p_t^C} h_t$$

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.

3.3 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_t^F. 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

$$(21) \qquad p_t^F = bE_t p_{t+1}^F + 1/g_p MC_t^{WS}$$

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

3.4 Monetary Policy

We assume that monetary policy is partly rules based and partly discretionary. The Central Bank sets interest rates according to a Taylor rule and responds to annual consumer price inflation and the annual growth rate of output

$$(22)\qquad \begin{aligned} i_t &= \tau^M_{lag} i_{t-1} + (1-\tau^M_{lag})[r^{EQ} + \pi_t^T + \tau^M_{\pi}(\pi^C_t + \pi^C_{t-1} + \pi^C_{t-2} + \pi^C_{t-3} - 4\pi_t^T)/4 \\ &\quad + \tau^M_y(gy_t + gy_{t-1} + gy_{t-2} + gy_{t-3} - 4\overline{gy})/4] + z^M_t \end{aligned}$$

The term z^M_t indicates discretionary deviations from the Taylor rule.

3.5 Fiscal Policy

Government expenditure is the sum of government purchases of goods and services G_t transfers to households TR^H, transfers to banks TR^B (purchase of toxic assets), payments arising from government guarantees and the purchase of bank shares. Total tax revenues T are the sum of three types of taxes, a consumption tax, a wage tax and a corporate income tax. These taxes are proportional to their respective tax bases. The government uses the wage tax 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 $B_t = B^S_t + B^B_t$. The government budget constraint is given by

$$(23)\qquad B_t = (1+r_{t-1})B_{t-1} + G_t + TR^H_t + TR^B_t + guar_t(L_t + e_t F_t) + q^B_t \Delta S^G_t - T_t - div_t S^G_{t-1}$$

3.6 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

$$(24)\qquad A^i = \left[(1-\sigma^M - Z^M_t)^{\frac{1}{\sigma^M}} A^{d^i \frac{\sigma^M - 1}{\sigma^M}} + (\sigma^M + Z^M_t)^{\frac{1}{\sigma^M}} A^{f^i \frac{\sigma^M - 1}{\sigma^M}}\right]^{\frac{\sigma^M}{(\sigma^M - 1)}}$$

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 savers hold internationally tradable bonds $e_t F_t$ which are denominated in foreign currency. These assets are subject to losses $\mathcal{L}_t^W$. We assume producer pricing. The stock of net foreign assets thus evolves as

$$(25) \qquad e_t F_t = (1 + r_{t-1}^F) e_t F_{t-1} - \mathcal{L}_t^F + X_t - rer_t M_t$$

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

3.7 Equilibrium

Equilibrium in our model economy is an allocation, a price system and monetary policies in the EU and the RoW such that households maximise utility, and the following market clearing conditions hold for final EU and RoW goods:

$$(26) \qquad Y_{t_t}^{EU} = C_t^{EU,d} + J_t^{EU,d} + J_t^{Constr,EU} + X_t,$$

$$(27) \qquad Y_{t_t}^{W} = C_t^{W,d} + M_t,$$

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

4. Calibration

For the non-financial sector we use parameter estimates from Ratto et al. (2009) and In 't Veld et al. (2011) for the Euro area and the US[9] respectively. We want the model to replicate a fairly skewed wealth distribution and assume a small population share of equity owners of 10% and we further assume that savers and debtors represent 45% of the population

[9] We have no estimated model for the RoW, therefore we use structural parameters for the US.

respectively. According to the Luxembourg Wealth Study (Sierminska et al. (2006)) the top 10% of the population in the EU own roughly 50% of total net worth (financial assets + dwellings + consumer durables - liabilities) and the top 10% of the US population own about 70% of total net worth. The equity owners in the model own roughly 65% of total net worth[10] in both regions. Individual household types have different rates of time preference and risk aversion parameters. Savers and equity owners have the same discount factor of 0.99 but differ in their degree of risk aversion. Savers have a $s^h = 1$, while equity owners are slightly less risk averse ($s^h = .75$). Debtors have a higher discount factor ($b^c = 0.75$) but log utility like savers. We also set the elasticity of substitution between consumption and housing equal to one for both savers and debtor households ($s^H = 1$). Concerning the banking sector we choose parameters such that the model can match stylised pre crisis balance items (see ECB, 2009). Concerning the asset side of the banks balance sheet, we determine the loan to value ratio in the collateral constrained such that the model replicates a share of loans to private households of about 70%. We do not separately model loans to firms and holdings of shares but assume that banks provide funding to non financial firms by holding shares only. The combined value of loans and shares amounts to about 40% of GDP in the EU. Finally we impose a capital requirement such that the model replicates a stock market value of the banking sector of about 20% of GDP. All remaining bank liabilities are held by households in the form of deposits. The parameter f is set so that 1 percentage point rise in the bank capital ratio lowers the spread between the mortgage loan rate and the deposit rate by 40 basis points per annum, as suggested by empirical estimates of the response of the loan rate spread reported by Kollmann (2011).

For interest semi-elasticity of the supply of deposits of households we choose a value of five.. For the US, the semi elasticity estimates vary between 5 and 10 (see Ball (2001)), For the EA estimates range between 1 and 3 (see, for example, Beyer (2009), Bruggemann et al. (2003) and Dedola (2001)). Especially Dedola et al. point out that data and aggregation problems in Euro area countries may significantly bias downwards the interest elasticity estimates in the Euro area.

We simulate the model to set up a crisis scenario, which mimics the collapse in GDP, private consumption and corporate and residential investment as have occurred since the crisis unfolded. Table 3 shows the developments in the main economic variables for the EU.

[10] In the model, equity owners own the stock of banks and non financial firms. Savers own government bonds, bank deposits and dwellings. The net worth of debtor households consists of the value of their housing stock

Table 3 : Stylised facts:

EU27	2008	2009	2010
GDP growth	0.3	-4.2	1.8
Consumption growth	0.3	-1.7	1.0
Corp.investment growth	2.3	-20.0	4.3
Res. investment growth	1.2	-9.3	-5.2
Employment growth	0.9	-1.7	-0.5

A particular feature of the 2009 recession was the strong decline of non residential investment. This drop is accompanied by a strong increase in corporate bond spreads and a strong decline in the market value of banks. In the first half of 2009, the AAA-rated bond spread rose to more than 100 BP while the spread of BBB-rated bonds reached 400BP.

5. Simulations

We start by giving a combination of shocks, starting at the 3rd quarter of 2008 to the model in order to generate a recession scenario with a similar sharp contraction as observed in the data. This is a highly stylised scenario that captures the collapse in house prices and the financial crunch that followed, and leads to a contraction in output that is particularly severe in corporate and housing investment. [11]

First, a shock to house price risk premia is simulated to capture the collapse in house prices after the bursting of the bubble. Second, a shock is given to defaults on matured loans to household debtors. Estimates for the EU suggest total losses amounted to EUR 500bn so far, or around 4% of EU GDP. Cumulated losses in the RoW sum to about EUR 900bn, with the losses concentrated in the US (Commission Services, Bloomberg/ECFIN). As discussed in the introduction, losses of this magnitude by itself are not able to explain the large drop in economic activity that we observed in 2009, even in models which allow for balance sheet constraints in financial markets. We therefore follow Caballero and assume that increased

minus bank liabilities. Notice, the model does not distinguish between durable and non durable consumption.

[11] Our intention is not to fully match the economic downturn, since we ignore possibly important shocks which have accompanied the financial market shocks. For example we ignore all adjustments which were related to revised growth expectations (optimistic expectations before 2007). We also ignore productivity effects related to a collapse of international trade, as well as oil price related demand shocks in the automobile industry and confidence effects in corporate investment and private consumption.

uncertainty in financial markets must have exerted an additional negative effect. We therefore introduce a ´panic´ shock which essentially makes banks believe that (individual) bank losses would be about 2.5 times the actually realised losses. This magnitude is necessary in order to approximately match the decline in stock prices of banks. Modelling a panic is conceptually more difficult than modelling loan losses, since it means to look at the impacts of negative shocks (expected loan losses) which might not materialise. To make this computationally tractable we assume that financial markets expect much large losses in the medium term. Finally, to capture the tightening in lending conditions, a further shock is given to the loan-to-value ratio for household debt χ^c.

The combination of these shocks, without any government intervention, leads to a sharp contraction in output in the model, of around 8% in level terms (Table 4). This crisis scenario is characterised by a sharp decline in corporate investment and residential investment. Note that there is also a strong increase in the corporate borrowing rate and a decline of the policy rate, i e. a strong increase in the spread and a collapse in the valuation of banks.

Table 4: Crisis scenario : no government intervention

	2008	2009	2010	2011	2012	2020
GDP	-2.3	-8.2	-6.9	-3.9	-3.0	-4.9
Consumption	-1.9	-4.9	-4.4	-3.2	-3.3	-6.2
Corp. Investment	-13.0	-48.8	-38.2	-15.4	-4.9	-2.6
Res. Investment	-3.2	-9.1	-9.5	-10.0	-10.5	-9.5
Real wages	-0.8	-4.2	-5.1	-3.7	-2.3	-0.2
Employment	-1.9	-6.8	-5.2	-2.2	-1.4	-3.7
Stock market value of banks	-34.9	-61.6	-39.3	-21.3	-14.5	-12.1
Nominal interest rate (bps)	-66.8	-287.3	-295.0	-191.7	-102.7	-12.2
Nom. corporate borrowing rate-5y (bps)	191.9	318.3	297.2	83.4	22.9	8.2
Real corporate borrowing rate-5y (bps)	286.3	378.9	312.9	77.6	7.1	-17.8
Labour income tax (pp)	0.2	1.6	2.7	3.2	3.5	7.3
Gov. debt (% of GDP)	2.1	10.8	13.4	12.3	12.3	22.2

Note: % deviations from baseline values, or basispoints (bps).

The shock to house prices reduces the value of the collateral of borrower households and forces them to delever and reduce both consumption and residential investment. A similar effect results from an increase in the loan-to-value ratio required by banks. Mortgage losses in contrast relax the borrower's budget constraint which attenuates the reduction in spending of

borrower households. However mortgage losses adversely affect the banking system. Banks can respond to loan losses by either increasing debt, reducing loans or by recapitalization (lower dividends). The banks leverage constraint ($f > 0$) imposes a cost of increasing debt. Therefore the bank tries to recapitalize via the stock market. However this raises the discount rate of shareholders and capital costs for banks. The bank achieves an optimal refinancing mix when the discount rate on equity capital is equal to the rate of bank debt plus the marginal cost of increased leverage. Notice because the stock market for banks and non-financial firms is fully integrated, increasing the demand for bank equity also increases capital costs for non-financial firms and lowers physical investment of the good-producing firm. Since the bank loss shock leads to a fall in output, inflation falls. The central bank responds to this by reducing the policy rate.

Limited risk sharing among saver households as implied by the leverage constraint is an important departure from financial market efficiency and greatly amplifies the macroeconomic impact of bank loss shocks as shown in Kollmann *et al.* (2012). These financial market frictions provide justification for government intervention.

5.1 Conventional fiscal stimulus measures

To assess the effectiveness of bank support measures we want to compare these with conventional fiscal stimulus measures as they were implemented during the crisis. On average in the EU, the fiscal stimulus in 2009 amounted to slightly more than 1% of GDP and slightly less than 1% in 2010 and the measures consisted mainly of increases in direct government spending, and income support in the form of transfers to households and temporary tax reductions (see table 1).

Table 5 shows the multipliers of standardised shocks to government consumption, transfers and labour taxes, each of 1% of GDP. In the economic literature, government consumption shocks receive by far the most attention, but GDP effects are typically much smaller for shocks to transfers to households and direct taxes. [12] The increase in government consumption boosts GDP, as it enters directly the GDP definition. Government transfers to households and tax reductions support consumer spending indirectly. Permanent income households respond to the temporary nature of the stimulus largely by adjusting their saving behaviour, as they base their consumption decisions on lifetime wealth. Only the credit

[12] This is a finding in common with other structural macro models (see Coenen et al., 2012).

constrained households respond more strongly to the temporary increase in disposable incomes. Hence, temporary increases in transfers and reductions in labour taxes show overall smaller multipliers, but in these two cases it is nearly entirely generated by higher spending of the private sector. [13]

Table 5 Fiscal multipliers of conventional stimulus measures

EU27	Without collateral constraints	With collateral constraints	With collateral constraints and monetary accommodation
government purchases	0.8	0.8	1.0
general transfers	0.2	0.4	0.5
transfers targetted to collateral-constrained hh.	-	0.7	0.9
labour tax	0.2	0.4	0.6

Source: Roeger and in 't Veld (2010)

5.2 Asset purchases

Table 6 shows the effects of Impaired Assets Relief measures on GDP and other main macroeconomic aggregates. Governments buy assets from banks and as a consequence take over a share of losses associated with these loans. The macroeconomic impact of these purchases depends crucially on the toxicity of the loans taken over. These measures are financed by a gradual increase in distortionary taxes (in particular labour taxes). As discussed above, because of current and expected loan losses of the corporate banking sector, an equilibrium in a segmented capital market requires a strong increase in the equity premium. By partially taking over bank losses, the government can effectively smoothen the dividend stream of corporate banks and therefore alleviate the conflict between shareholders and corporations and provide more consumption smoothing and consequently a smaller increase in the equity premium. As can be seen from Table 6, partialy taking over impaired assets reduces the equity premium and increases corporate investment substantially, thus it targets a demand component which responds strongly to the increase in the equity premium in a segmented capital market. In contrast to standard fiscal measures, which tend to crowd out private investment, these state aid measures support corporate investment and thereby target a

[13] However, transfers targeted to constrained consumers provide a more powerful stimulus, as these consumers have a larger marginal propensity to consume out of current net income, and the multiplier can increase to 0.6-

macroeconomic aggregate most severely affected by the finnacial crisis. Notice also, the state aid do only marginally support residential investment. The reasons are twofold. First, banks only marginally pass on state aid measures to lower loan interest rates (measures are mostly used to stabilise dividends) and second the reduction in residential investment is to a large extent the response of a bubble induced correction of an overaccumulation of housing stock due to the housing bubble. In terms of effectiveness, the fiscal multiplier of state support in the form of asset purchases is positive but well below one. Total asset purchases amounting to roughly 2.8% of GDP boost GDP by around 1%. [14]

Table 6: Government intervention: asset purchases

	2008	2009	2010	2011	2012	2020
GDP	0.3	1.0	0.4	-0.4	-0.3	0.0
Consumption	0.3	0.6	0.3	-0.2	-0.1	0.2
Corp. Investment	2.4	12.3	5.8	-1.2	-1.3	-0.2
Res. Investment	0.1	0.1	0.1	-0.0	-0.1	0.0
Real wages	0.1	0.7	0.8	0.5	0.2	0.0
Employment	0.2	0.7	0.2	-0.5	-0.5	-0.0
Stock market value of banks	8.9	11.5	2.4	-1.2	-0.5	0.2
Corporate borrowing rate-5y (real) (bps)	-38.3	-63.1	-36.6	12.1	9.7	1.3
Labour income tax (pp)	-0.0	0.6	0.9	0.7	0.6	0.0
Gov. debt (% of GDP)	-0.2	1.4	2.7	2.6	1.9	-0.4

Note: % difference from no-intervention

5.3 Recapitalisations

Government recapitalisation measures have similar effects compared to asset purchases (Table 7). By purchasing newly-issued bank shares the government contributes to stabilising the income of shareholders, which dampens the increase in the equity premium. We assume government holdings of bank equity peak in 2011 (2.2% of GDP) and is then gradually

0.8. When fiscal stimulus is accommodated by monetary policy, as is the case at the zero lower bound, multipliers can also be higher. (Roeger and in 't Veld (2010), Coenen et al. (2012))

[14] This scenario assumes the assets bought by the governmnet are worthless and all loans are subject to default. This is an extreme assumption and in reality not all loans will be subject to default, which would lower the multiplier effect of the support. If none of the purchased loans were defaulting, the GDP effect would be even become negative, as the purchase of the bank assets is financed by an increase in distortionary taxes. In that hypothetical scenario where governments would have taken on only the good loans and left all toxic assets with the banks, expenditure would be recuperated in the long term.

reduced so that by the end of 2014 governments have sold about 50% of their holdings. As with purchases of impaired assets, this policy mostly affects investment and has therefore similar properties: the measures lead to a sharp drop in the equity premium and give a sizeable stimulus to investment. In terms of effectiveness, a "stimulus" in the form of recapitalisations of around 2.2 % of GDP at its peak, give a positive GDP effect of 1.7%.

The two state-aid measures differ in various respects. With the purchase of toxic assets, the government shifts losses from banks/equity owners onto other households. With recapitalisation the loss transfer depends on the extent in which losses are foreseen at the date of the asset purchase by the government. In the scenario presented here future losses are overestimated because of uncertainty aversion/panic in financial markets. This leads to a fall of the stock market value of banks below their fundamental value. The recapitalisation provides a service to capital markets in times of stress and the government is rewarded for this service in the form of a capital gain. Recapitalisation seems a socially more optimal measure since it directly targets a financial market inefficiencies and avoids a loss transfer to the general tax payer. Also the fiscal cost of this bank rescue measure are far lower.

Table 7: Government intervention: recapitalisations

	2008	2009	2010	2011	2012	2020
GDP	0.5	1.7	0.5	-0.1	-0.1	0.2
Consumption	0.3	1.0	0.4	0.1	0.1	0.3
Corp. Investment	3.3	14.2	3.0	-1.8	-2.0	-0.0
Res. Investment	0.2	0.9	1.0	0.8	0.7	0.1
Real wages	0.1	0.7	0.6	0.3	0.0	-0.1
Employment	0.4	1.4	0.3	-0.3	-0.2	0.2
Stock market value of banks	1.6	3.5	0.6	-0.5	-0.4	0.1
Corporate borrowing rate-5y (real) (bps)	-60.8	-89.6	-20.0	12.3	11.5	2.4
Labour income tax (pp)	-0.0	0.1	0.2	0.1	0.0	-0.4
Gov. debt (% of GDP)	-0.4	-0.8	0.3	0.6	0.2	-1.3

Note: % difference from no-intervention

5.4 Government guarantees:

Guarantees differ from recapitalisations and purchases of toxic assets in two important dimensions:

1. In contrast to recapitalisations and asset purchases, which are associated with actual government spending, guarantees only constitute contingent liabilities for the government which arise in case banks default on bonds issued.

2. While recapitalisations and asset purchases helped the financial sector in dealing with losses from loans given in the past, guarantees have largely been given on newly issued bonds, thus the government insures the lender to take over losses from new investments.

Apart from the insurance function provided by guarantees, the fact that governments are signalling to cover possible future losses may by itself have important implications in terms of stabilising financial markets. For example, reducing uncertainty about future losses could change behaviour of potential lenders in financial markets, i. e. making them less risk averse. However, these confidence effects are difficult to model and results will largely depend on assumptions about risk attitudes of financial market participants. We restrict ourselves to analysing the effect of government guarantees in a segmented financial market. Essentially the value added of government guarantees in such an environment consists of redistributing losses from a fraction of households (shareholders, households owning risky assets) to all households (and thereby effectively removing the market segmentation). This has a macroeconomic benefit in terms of reducing the increase of the bond rate, but it has also costs because the government support has to be financed by distortionary taxes.

In order to illustrate the costs and benefits we look at the following scenario. Given that EU governments have guaranteed bonds in the order of magnitude of 8% of GDP, we create a default scenario where the financial sector expects loan losses to accumulate to 8% of GDP and we compare two extreme cases. In the first case, no government guarantees are given, while in the second case, the government guarantees to take over all future losses.

Table 8 presents the results from the first scenario as a deviation from a no-default shock baseline. Table 9 shows the second case with government guarantees. As can be seen from these tables, the government guarantees can prevent economic activity from collapsing in the first two years. While the default scenario shows strong falls in consumption and investment due to a sharp increase in borrowing costs, with government guarantees the increase in rates can be avoided and domestic demand stabilised. However, these guarantees

also have negative effects as higher labour taxes have a negative impact on employment and corporate investment in the medium term.

Table 8: Default scenario

	2009	2010	2011	2012	2020
GDP	-6.9	-3.5	-0.7	-0.8	-1.2
Consumption	-6.3	-2.9	-0.7	-1.1	-1.5
Corp. Investment	-31.6	-16.0	-1.8	-0.6	-1.3
Res. Investment	-2.2	-2.3	-1.2	-1.0	-0.8
Real wages	-1.8	-2.6	-1.3	-0.6	-0.3
Employment	-5.6	-2.7	-0.0	-0.1	-0.6
Stock market value of banks	-31.3	-8.3	-1.2	-1.4	-1.6
Corporate borrowing rate-5y (real) (bps)	503.6	144.2	-22.7	-5.7	2.4
Labour income tax (pp)	0.7	1.4	1.3	1.2	1.5
Gov. debt (% of GDP)	7.0	6.6	4.3	4.0	4.1

Note: % difference from no-defaults baseline

Table 9.: Defaults with government guarantees

	2009	2010	2011	2012	2020
GDP	-0.4	-0.7	-0.8	-0.8	-0.7
Consumption	-0.5	-0.9	-0.9	-1.0	-0.9
Corp. Investment	-0.5	-1.1	-1.3	-1.4	-1.0
Res. Investment	-0.2	-0.5	-0.6	-0.6	-0.4
Real wages	0.1	0.3	0.3	0.3	0.0
Employment	-0.4	-0.7	-0.8	-0.8	-0.6
Stock market value of banks	-0.8	-1.0	-1.0	-1.0	-0.9
Real corporate borrowing rate-5y (bps)	-4.1	0.3	2.1	2.3	2.0
Labour income tax (pp)	1.0	2.0	2.1	2.0	1.4
Gov. debt (% of GDP)	3.6	6.8	7.0	6.5	3.0

Note: % deviation from no-default baseline

6. Conclusions

This paper has assessed the cost and benefits of state aid to the financial system in an economy which is hit by a severe financial shock and is subject to financial market imperfections (balance sheet constraints, segmentation and panic). Our analysis has shown that state interventions to support banks are an efficient means of stabilising the real economy. Multipliers are lower than those for government consumption, but generally larger than those for transfers to households. State support to the banking sector has helped to stabilise corporate investment, which is the component of aggregate demand most severely affected from the financial shock when there are financial frictions (bearing in mind that the decline in residential investment has been largely due to the bursting of a housing bubble). This feature also distinguishes state aid from conventional fiscal interventions (like an increase in government spending or transfers), which primarily target non-investment demand categories and rather crowd out private capital formation.

Financial crises are likely to be driven by many shocks and many distortions. We have tried in this paper to account for this by introducing various frictions which are discussed in the literature. While asset purchases and recapitalisations are effective in the case of actual losses, government guarantees play an important role in stabilising pessimistic financial markets driven by excessively strong loss expectations.

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Technical Appendix: Providing guarantees on bank debt.

In the QUEST model there is only an aggregate banking sector; interbank lending and borrowing is not modelled. This appendix tries to show that as long as the total banking sector is owned by a single shareholder, government guarantees on bank debt (interbank borrowing) are implicitly a guarantee from the government to bank shareholders to take over a fraction of total loan losses.

Balance sheets of a disaggregated banking sector

In order to simplify the interbank market we assume that there are investment banks which lend to the non-financial sector and they borrow from savings banks which borrow from households (i.e. interbank relationships are unidirectional).

Investment bank: $div_t^I = r_{t-1}^L L_{t-1} - r_{t-1}^D D_{t-1}^I - r_{t-1}^L L_{t-1}^{IB} - \Delta L_t + \Delta D_t^I + \Delta L_t^{IB} - (def_t^{HH} - def_t^{IB})$

The investment bank gives loans (L) to the non-financial sector and borrows in the form of deposits (D^I) and interbank loans (L^{IB}). It faces a loan risk def^{HH} and passes on some of this risk to the interbank lenders (def^{IB}).

Savings bank: $div_t^S = r_{t-1}^L L_{t-1}^{IB} - r_{t-1}^D D_{t-1}^S - \Delta L_t^{IB} + \Delta D_t^S - def_t^{IB} + guar$

The savings bank gives loans (L^{IB}) to investment banks and finances these loans from deposits (D^S) provided by households. It faces a loan risk def^{IB}.

Fiscal policy intervenes in the market for interbank loans by guaranteeing to take over a fraction of def^{IB}. We assume in our simulations that if the government takes over def^{IB} it will not charge the investment bank for this but effectively takes over a fraction of the losses to the whole banking system. This is equivalent to saying that the government takes over a fraction of total losses (def^{HH}) to the consolidated banking sector.

Consolidated banking sector:

$$div_t = div_t^I + div_t^S = r_{t-1}^L L_{t-1} - r_{t-1}^D (D_{t-1}^I + D_{t-1}^S) - \Delta L_t + \Delta(D_t^I + D_t^S) - (def_t^{HH} - guar)$$

Implicitly, what government guarantees are doing in this model is for the government to guarantee a fraction of all losses to the banking system.