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Fiscal Policy, Banks and the Financial Crisis

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Abstract:

This paper studies the effectiveness of Euro Area (EA) fiscal policy, during the recent financial crisis, using an estimated New Keynesian model with a bank. A key dimension of policy in the crisis was massive government support for banks—that dimension has so far received little attention in the macro literature. We use the estimated model to analyze the effects of bank asset losses, of government support for banks, and other fiscal stimulus measures, in the EA. Our results suggest that support for banks had a stabilizing effect on EA output, consumption and investment. Increased government purchases helped to stabilize output, but crowded out consumption. Higher transfers to households had a positive impact on private consumption, but a negligible effect on output and investment. Banking shocks and increased government spending explain half of the rise in the public debt/GDP ratio since the onset of the crisis.

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1. Introduction

The financial crisis that erupted in 2007 originated in massive bank losses on US mortgage loans. It spread rapidly to the Euro Area (EA) and other parts of the world, and led to the worst global recession since the Great Depression. These events were countered by sizable fiscal stimulus measures (increased government purchases of goods and services, transfers to households, and tax cuts) and massive government support for banks (e.g., purchases of 'toxic' assets and bank recapitalizations by the state). This paper evaluates the efficacy of these measures, using a New Keynesian model with a bank. We estimate the model with EA data (1995-2011), using Bayesian methods.

The key novelty of the study is the quantitative analysis of fiscal policy, in an economy in which the health of the banking system is a key determinant of interest rates and real activity. We assume a rich fiscal policy setup, with distorting taxes, government consumption and investment, and transfers to households and the banking system. A representative bank receives deposits from savers (patient households), and makes loans to impatient households who use their house as collateral. The bank also invests in domestic government bonds, and in foreign bonds. Importantly, the bank faces a capital requirement: she has to finance a fraction of her assets using her own funds (equity). This requirement reflects legal requirements and market pressures. In this structure, bank capital is an important state variable. A loan default lowers bank capital, which raises the spread between the mortgage lending rate and the deposit rate, and leads to a fall in investment, employment and output. Government support to the bank, modeled here as a public transfer to the bank financed by higher taxes, boosts bank capital, lowers spreads, and raises investment and output. Investment drops sharply in financial crises. Thus, government support for banking stabilizes a component of aggregate demand that is especially adversely affected by financial crises. By contrast, higher government consumption crowds out consumption and investment.

We use the estimated model to quantify the main drivers of recent business cycle fluctuations in the EA economy. Bank losses explain about a quarter of the fall in EA GDP and consumption in 2007-09, and more than three-quarters of the fall in private non-residential investment. Our empirical results suggest that government support for banks noticeably dampened the fall in EA GDP, consumption and investment during the crisis. Increased government purchases likewise helped to stabilize output, but crowded out consumption. Higher transfers to households had a positive impact on private consumption, but a negligible effect on output and investment. Banking shocks and increased government spending explain half of the 20 percentage point rise in the public debt/GDP ratio since the onset of the crisis. Our model also suggests that a default on sovereign debt held by the banking system would disrupt real activity. By contrast, a default on sovereign debt held by households is predicted to have a negligible effect on real activity.

Earlier assessments of fiscal stimulus in the crisis were based on models without banks--see, e.g., Coenen *et al.* (2012), Coenen, Straub and Trabandt (2012), Drautzburg and Uhlig (2011) and Forni and Pisani (2011). Those studies concentrated on the effects of temporary fiscal impulses in the form of increased government purchases of goods and services, transfers to households, and tax cuts. By contrast, the macro-economic effects of the government measures to support banks have, so far, received little attention in the literature. Our paper seeks to fill this gap. The paper also contributes to the literature, by *estimating* a dynamic stochastic general equilibrium (DSGE) model with a rich fiscal policy set-up—whereas the related macro literature has traditionally relied on calibrated models.[1]

Before the financial crisis, standard macro theory largely abstracted from financial intermediaries. The crisis has stimulated much research that incorporates banks into DSGE models. See, for example, Gerali et al. (2010), Curdia and Woodford (2008), in’t Veld et al. (2011), Meh and Moran (2010) and Kollmann et al. (2011). These papers use calibrated models, abstract from fiscal policy, and do not analyze government bank support measures.[2] A further contribution of the paper here is that it develops a novel specification of the banking sector. Previous DSGE models assume that banks only accumulate capital through retained earnings, and that banks take deposits from households and lend to the non-financial business sector. Yet, in reality, banks can issue equity to raise capital; also, lending to households is a key activity of banks--in the EA, bank loans to *households* exceed loans to non-financial firms. Our model thus assumes a bank that is owned by an entrepreneur who also owns the production sector--the entrepreneur can use his non-bank wealth to raise the

[1] Ratto et al. (2009), Forni et al. (2009), Leeper et al. (2010), Leeper et al. (2011), Drautzburg and Uhlig (2011) and Coenen, Straub and Trabandt (2012) likewise estimate DSGE models with fiscal policy.

[2] Gerali et al. (2010) also estimate a DSGE model with a banking sector. Roeger and in’t Veld (2012) and Kollmann et al. (2012) study the effect of government support for banks, in stylized RBC models. So do Sandri and Valencia (2012), Bianchi (2012) and Haavio et al. (2012) who focus on normative issues (we learnt about these papers after the research here was completed).

bank's capital. Also, the bank lends to households.[3] We show that, although the bank can issue equity, loan default shocks have a persistent negative effect on real activity.

Section 2 describes the model. Section 3 describes the numerical solution and the econometric approach. Section 4 discusses properties of the estimated model. Section 5 concludes.

2. The economy

We consider an open economy with a representative **entrepreneur**, **two workers** and a **government.** The entrepreneur owns a **bank**, an **intermediate good producing firm**, and a **distribution firm**. The two workers provide labor services to the intermediate good producing firm, and accumulate housing capital. The workers have different rates of time preference. In equilibrium, the more patient worker holds financial assets (bank deposits and government debt). The other (impatient) worker borrows from the bank, using her housing capital as collateral. The bank thus acts as an intermediary between the patient worker and the impatient worker. The bank also holds bonds issued by the domestic government and by the rest of the word. Importantly, the bank faces a capital constraint—a fraction of her assets has to be financed using bank capital. The distribution firm sells the intermediate output to firms that aggregate locally produced and imported intermediates into a homogeneous final good. The final good is used for private and public consumption and investment, and exported. The distribution firm has market power. Wages are set by a monopolistic labor union. Nominal prices charged by the distribution firm and nominal wages are sticky. All other markets are competitive. The government levies distorting taxes, and issues debt; a monetary authority sets the nominal interest rate on government debt. We next present the key aspects of agents' decision problems.[4]

[3] Setups with patient savers and impatient collateral-constrained borrowers have also been considered by Iacoviello (2005) and Iacoviello and Neri (2010), but those authors assumed direct lending (no bank) between these classes of households.

[4] For the sake or brevity, the following presentation abstracts from adjustment costs (for labor and capital) and variable capital utilization rates that are assumed in the estimated model. These features help to better capture the data dynamics. The detailed model is available on request.

2.1. Patient and impatient workers

Workers' welfare depends on final good consumption, hours worked and on their stock of housing capital. There is habit formation for each of these choice variables. Worker *s*=*i*,*p* (*i*: impatient; *p*: patient) maximizes

$$E_0 \sum_{t=0}^{\infty} (\beta^s)^t \left\{ \ln(C_t^s - h^C C_{t-1}^s) + \eta^s \ln(H_{t+1}^s - h^H H_t^s) - \tfrac{\omega^s}{1+\chi} \{N_t^s - h^N N_{t-1}^s\}^{1+\chi} \right\}$$

with $0<h^C, h^H, h^N<1$ and $\eta^s, \omega^s, \chi>0$. C_t^s and N_t^s are the consumption and labor hours of worker *s*=*i*,*p*, in period *t*, while H_{t+1}^s is her stock of housing capital at the end of period *t*. The subjective discount factors are β^i and β^p with $\beta^i<\beta^p$. We assume that the rate of time preference of impatient worker is sufficiently high so that, in equilibrium, only the patient worker holds financial assets (bank deposits and government bonds), while the impatient worker borrows from the bank. [5] The law of motion of the housing stock of worker *s*=*i*,*p* is: $H_{t+1}^s = H_t^s(1-\delta_H) + \iota_t^H J_t^s$, where $0<\delta_H<1$ is the depreciation rate of housing, while J_t^s is the worker's gross housing investment, in final good units. ι_t^H is an exogenous shock to the efficiency of housing investment. In period t, worker *s* has a real tax liability (net of transfers received from the government) of T_t^s (see below).

The period *t* budget constraint of the **patient worker** is

$$D_{t+1} + B_{t+1}^p + P_t T_t^p + P_t J_t^p + P_t C_t^p = D_t R_t^D + B_t^p R_t^D - P_t \Delta_t^{G,p} + w_t N_t^p,$$

where w_t is the nominal wage rate, while P_t is the final good price. D_t and B_t^p are the bank deposits and government bonds held by that worker at the end of period *t*-1. R_t^D is the gross interest rates on deposits and government bonds.[6] All domestic financial assets/liabilities are expressed in domestic currency units, and all interest rates are nominal rates. We allow for the possibility of a (partial) default on sovereign debt. This is modeled by assuming that, in period *t*, the government defaults by an exogenous real amount $\Delta_t^{G,p}$ on the amount $B_t^p R_t$ that it owes to the patient worker.

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[5]Both workers have the same habit parameters (h^C, h^H, h^H) and the same long-run Frisch labor supply elasticity, $1/\chi$. By contrast, the utility weights of housing and labor (η^s, ω^s) differ across workers—those weights are set to target the steady state consumption shares of the two workers, and the ratio of residential investment to GDP.

[6]As sovereign default is modeled in a lump-sum fashion (see below), the patient worker is indifferent between holding deposits and government bonds; thus the interest rates on these assets are equalized.

The budget constraint of the **impatient worker** is

$$L_t R_t^L - P_t \Delta_t^L + P_t T_t^i + P_t J_t^i + P_t C_t^i = L_{t+1} + w_t N_t^i,$$

where L_t is a one-period bank loan received in period t-1. R_t^L is the gross loan rate between t-1 and t. At t, the impatient worker defaults by an exogenous real amount Δ_t^L on the amount that she owes to the bank, $L_t R_t^L$. The impatient worker uses her housing stock as collateral. Maximum borrowing at t is given by the value of that housing stock, times an exogenous loan-to-value ratio χ_t imposed by the bank. The impatient worker thus faces the collateral constraint $L_{t+1}^i \leq \psi_t P_t^H H_{t+1}^i$, where $P_t^H \equiv P_t / \iota_t^H$ is the price of one unit of housing capital. We assume that β^i and ψ_t are sufficiently low so that the impatient worker always borrows the maximum amount.

2.2. The entrepreneur

The entrepreneur maximizes

$$E_0 \sum_{t=0}^{\infty} (\beta^E)^t \left\{ \ln(C_t^E - h^C C_{t-1}^E) + \eta \ln(H_{t+1}^E - h^H H_t^E) \right\},$$

where C_t^E and H_{t+1}^E are her consumption and housing stock, respectively. The entrepreneur's subjective discount factor lies between those of the two workers: $\beta^i < \beta^E < \beta^p$. This ensures that the steady state interest rate on loans exceeds the deposit rate. The law of motion of the entrepreneur's housing stock is $H_{t+1}^E = H_t^E(1-\delta_H) + \iota_t^H J_t^E$, where J_t^E is her housing investment (in final good units). The entrepreneur's period t budget constraint is $P_t C_t^E + P_t J_t^E = d_t^I + d_t^D + d_t^B - P_t T_t^E$, where T_t^E is the entrepreneur's real tax liability, while d_t^I, d_t^D and d_t^B are the dividend of the intermediate good producer, the distributor and the bank, respectively. Each of these three business entities maximizes the present values of profits, discounting future profits using the entrepreneur's intertemporal marginal rate of substitution.

2.2.1. The intermediate good producing firm

The firm has the technology $Y_t = \theta_t (K_t^G)^{\alpha_G} K_t^{\alpha} N_t^{1-\alpha}$, $\alpha_G > 0, 0 < \alpha < 1$, where Y_t, K_t and N_t are the production of a *homogenous* intermediate good, and the firm's capital and labor inputs, respectively. K_t corresponds to the private non-residential capital stock of this economy (none of the other firms uses physical capital). $\theta_t > 0$ is an exogenous random productivity parameter and K_t^G is the government capital stock (e.g., infrastructure facilities). Government capital is assumed, because the fiscal stimulus measures during the crisis included increased government investment. We assume that an increase in government capital raises *private* output, as a vast theoretical and empirical literature points to productive effects of government capital.[7]

The law of motion of the private capital stock is: $K_{t+1} = K_t(1-\delta) + \psi_t I_t$, where $0<\delta<1$ is the capital depreciation rate; I_t is real gross non-residential investment, in final good units. ψ_t is an exogenous investment efficiency parameter. $\ln(\theta_t)$ and $\ln(\psi_t)$ follow random walks with positive drift. All other exogenous variables in this model follow univariate stationary AR(1) processes. The growth of potential real output is driven by the 'total' technology trend $Z_t \equiv \Upsilon \cdot (\theta_t)^{1/(1-\alpha_G-\alpha)} (\psi_t)^{\alpha/(1-\alpha_G-\alpha)}$, where $\Upsilon > 0$ is a scale factor that we set so that the ratio of real GDP to Z equals unity, in steady state.[8]

The intermediate good producer's period *t* dividend is: $d_t^I = p_t^I Y_t - w_t N_t - P_t I_t$, where p_t^I is the price of the intermediate good. The following Euler equation characterizes optimal accumulation of non-residential capital, from the entrepreneur's viewpoint: $E_t \rho_{t,t+1} R_{t+1}^K = 1$, where $R_{t+1}^K \equiv \psi_t \cdot [(p_{t+1}^I / P_{t+1}) \cdot \partial Y_{t+1} / \partial K_{t+1} + (1-\delta)/\psi_{t+1}]$ is the real gross return on private non-residential investment, while $\rho_{t,t+1}$ is the entrepreneur's intertemporal marginal rate of substitution.[9] $E_t \rho_{t,t+1} R_{t+1}^K = 1$ and the bank's Euler equations for bank loans and deposits (see below), imply that the expected return on non-residential investment $E_t R_{t+1}^K$ is closely tied to loan and deposit rates, which implies that non-residential investment is likewise closely

[7] See, e.g., Aschauer (1989), Barro (1990), Turnovsky (1999) and Basu and Kollmann (2012). Coenen, Straub and Trabandt (2012) also analyze the effects of fiscal stimulus during the crisis, using a model with productive government investment.

[8] The trend growth of employment is zero, in the model. The long-term growth rate of government capital equals that of GDP (see below), while the trend growth of non-residential capital equals the sum of the trend growth rates of output and investment efficiency. Thus, the trend growth rate of GDP, g_{GDP}, is determined by the trend growth rates of θ_t and ψ_t: $g_{GDP} = g_\theta + \alpha_G g_{GDP} + \alpha(g_{GDP} + g_\psi)$. Thus $g_{GDP} = (g_\theta + \alpha g_\psi)/(1-\alpha_G - \alpha)$, which corresponds to the trend growth rate of Z_t.

[9] We assume that habit formation is 'external', which implies $\rho_{t,t+s} = (\beta^E)^s (C_t^E - h^C C_{t-1}^E)/(C_{t+s}^E - h^C C_{t+s-1}^E)$ for s≥0.

related to these interest rates. Empirically, non-residential investment is much less closely related to interest rates. The estimated model thus assumes that the Euler equation for non-residential capital is disturbed by a stationary exogenous random variable $1+\varphi_t$, where φ_t has an unconditional mean of zero $(E\varphi_t=0)$:

$$(1+\varphi_t)E_t\rho_{t,t+1}R^K_{t+1}=1. \tag{1}$$

φ_t can be interpreted as reflecting a bias in the entrepreneur's date t forecast of the physical investment return R^K_{t+1}.[10]

2.2.2. The distribution firm

The distribution firm costlessly 'differentiates' the homogeneous intermediate good into a continuum of 'varieties' indexed by $s\in[0,1]$. These varieties are sold to the final good sector. The final good sector bundles the varieties into a (domestically produced) composite good $Q_t=\{\int_{s=0}^{1}(q_t^s)^{(\nu-1)/\nu}ds\}^{\nu/(\nu-1)}$ where q_t^s is the amount of variety *s*, and $\nu>1$ is the substitution elasticity. Demand for variety *s* is $q_t^s=(p_t^s/P_t^D)^{-\nu}Q_t$, where p_t^s is the price of variety s, while $P_t^D=\{\int(p_t^s)^{1-\nu}ds\}^{1/(1-\nu)}$ is the price (marginal cost) of the domestic composite good. The dividend of the distributor is $d_t^D=\int p_t^s q_t^s ds-p_t^I Y_t$, with $Y_t=\int q_t^s ds$. The distributor acts as a monopolist, and sets prices for each variety subject to Calvo (1983) price adjustment schemes. This implies that the (log) inflation rate of the domestically produced composite good, $\pi_t^D\equiv\ln(P_t^D/P_{t-1}^D)$, obeys an expectational Phillips curve, up to a (log-) linear approximation (e.g., Erceg et al. (2000)):

$$\pi_t^D-\pi^D=\beta^E E_t(\pi_{t+1}^D-\pi^D)+\lambda_D(p_t^I/P_t^D-\tfrac{\nu-1}{\nu}),$$

where π^D is the steady state inflation rate of the composite good, and $\lambda_D>0$ is a coefficient that depends on the cost of changing prices.[11]

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[10] Assume that the entrepreneur's beliefs at *t* about R^K_{t+1} are given by a probability density function, f_t^s, that differs from the true pdf, f_t, by a factor $1/(1+\varphi_t)$: $f_t^s(R^K_{t+1},\Omega_t)=f_t(R^K_{t+1}/(1+\varphi_t),\Omega_t)/(1+\varphi_t)$ where Ω_t is any other random variable. The entrepreneur's Euler equation for non-residential capital is then given by (1).

[11] $(\nu-1)/\nu$ is the inverse of the steady state mark-up factor charged by the distribution firm.

2.2.3. The bank

The paper assumes a representative bank.[12] In addition to her deposit and loan activities, the bank invests in one-period government bonds and in an internationally traded bond denominated in foreign currency. The bank's holdings of government and foreign bonds at the end of period *t* are denoted by B^B_{t+1} and F_{t+1} respectively. Bank capital at the end of period *t* is hence $L_{t+1}+B^B_{t+1}+e_tF_{t+1}-D_{t+1}$, where e_t is the nominal exchange rate, defined as the domestic currency price of foreign currency. The bank faces a capital requirement: an exogenous fraction γ of her assets has to be financed using bank capital. This constraint reflects legal requirement and market pressures.[13] The bank can deviate from the required capital ratio, but this is costly. Let

$$x_t \equiv (L_{t+1}+B^B_{t+1}+e_tF_{t+1}-D_{t+1}-\gamma\cdot(L_{t+1}+B^B_{t+1}+e_tF_{t+1}))/P_t$$

denote the bank's real excess capital (gap between actual capital and the target capital). The bank bears a real cost Φ^X_t in period *t* (in final good units) if her capital differs from the target:

$$\Phi^x_t=\tfrac{1}{2}\phi^x\cdot(x_t)^2/Z_t,\ \text{with}\ \phi^x>0,$$

where Z_t is the 'total' productivity trend (see above).

To pin down the bank's bond portfolio, we assume that at date *t* the bank bears real costs $\Phi^B_t=\tfrac{1}{2}\phi^B\cdot(B^B_{t+1}/P_t-\Gamma^B Z_t)^2/Z_t$ and $\Phi^F_t=\tfrac{1}{2}\phi^F\cdot(e_tF_{t+1}/P_t-\Gamma^F Z_t)^2/Z_t$ (with $\phi^B,\phi^F,\Gamma^B,\Gamma^F>0$) when her (real) holdings of domestic and foreign bonds deviate from the targets $\Gamma^B Z_t$ and $\Gamma^F Z_t$, respectively.[14] At date *t*, the bank also bears a real operating cost $\kappa\cdot(L_{t+1}+e_tF_{t+1}+D_{t+1})/P_t$, where $\kappa>0$ is a constant.

In period *t*, the impatient household and the foreign bond issuer default by exogenous real amounts $\Delta^L_t\geq 0$ and $\Delta^F_t\geq 0$ on the sums owed to the bank $(R^L_tL_t, e_tR^F_tF_t)$. The total loan

[12] The interbank market is thus not modeled here. Frictions in that market would matter for aggregate activity if they affected the total flow of funds from savers to borrowers. The model here generates realistic empirical fluctuations in the loan rate spread and in the total volume of intermediation.

[13] Bank capital requirements are often justified as limiting moral hazard in the presence of informational frictions and deposit insurance (see Freixas and Rochet (2008)). These issues are not explicitly modelled here. Instead, we take the capital requirement as given, and focus on its macroeconomic effects.

[14] Positive bond holdings can be justified by the idea that these bonds provide liquidity services. See Woodford (1990) for a model in which public debt provides liquidity services to the private agents.

loss $(\Delta^L_t+\Delta^F_t)/Z_t$ follows an AR(1) process. Foreign losses are assumed to represent 50% of total losses, consistent with estimates of the geographic origin of the losses suffered by EA banks, during the global financial crisis (see IMF (2010)).

When a loan loss occurs, the government may provide financial assistance to the bank, in the form of a subsidy S^B_t (E.g., when the bank faces loan default, the government may purchase maturing loans from the bank, at *face* value; S^B_t then is the difference between the face value and the fair value of the loans.)

However, the government itself may become a threat to the bank's health, by defaulting on its debt. Let $\Delta^{G,b}_t \geq 0$ be the (real) amount by which the government defaults on the amount owed to the bank in period *t*, $R^B_t B^B_t$.

The bank's period *t* budget constraint is, hence:

$$D_t R_t + L_{t+1} + B^B_{t+1} + e_t F_{t+1} + \kappa\cdot(D_{t+1}+L_{t+1}+e_t F_{t+1}) + P_t\Phi^x_t + P_t\Phi^B_t + P_t\Phi^F_t + d^B_t =$$

$$D_{t+1} + L_t R^L_t - P_t\Delta^L_t + B^B_t R_t - P_t\Delta^{G,B}_t + e_t F_t R^F_t - P_t\Delta^F_t + P_t S^B_t,$$

where d^B_t is the bank's dividend, and R^F_t is the gross interest rate on the foreign bond.

The bank's Euler equations for deposits and mortgage loans are:

$$R^D_{t+1}E_t(P_t/P_{t+1})\rho_{t,t+1} = 1-\kappa+\phi^x\cdot\xi_t/Z_t, \tag{2}$$

$$R^L_{t+1}E_t(P_t/P_{t+1})\rho_{t,t+1} = 1+\kappa+(1-\gamma)\cdot\phi^x\cdot\xi_t/Z_t, \tag{3}$$

(Log-)Linear approximations of (1) and (2) imply that the spread between the expected real returns on private non-residential investment and deposits obeys:

$$E_t R^K_{t+1} - (R^D_{t+1} - E_t\pi_{t+1}) \cong \kappa - \phi^x\cdot\xi_t/Z_t - \psi_t, \tag{4}$$

with $\pi_{t+1} \equiv \ln(P_{t+1}/P_t)$. [15] To get an intuition for this expression, assume that the bank increases deposits by an amount corresponding to one unit of the final good, in order to increase the dividend, and that the entrepreneur uses the higher dividend to increase the production firm's capital stock. This raises the bank's operating cost by κ, and it lowers the bank's capital by one unit, which increases the bank's cost Φ^x_t by $-\phi^x\cdot\xi_t/Z_t$. (4) shows that, under optimizing behavior by the entrepreneur, the expected return on physical investment has to equal the entrepreneur's marginal cost of borrowing via the bank, i.e. the sum of the real interest rate

[15] The linear approximations discussed in this Section are taken around $R^K=R^D=R^L=\rho=\pi=1, \kappa=\xi=0$.

on deposits, of the marginal bank operating costs and of the marginal cost of bank leverage, $-\phi^{x}\cdot x_t/Z_t$. The spread between the real expected return on physical investment and the real deposit rate, $E_t R^K_{t+1}-(R^D_{t+1}-E_t\pi_{t+1})$, thus has to cover the bank's marginal operating cost plus the marginal cost of leverage (less the Euler equation disturbance, φ_t); see (4). In what follows, we refer to that spread as the 'non-residential investment (return) spread'.

Condition (4) is key for understanding the role of the bank capital requirement in the transmission of bank balance sheet shocks to real activity. Note that the marginal cost of leverage is a decreasing function of the bank's excess capital (as $\phi^{x}>0$). Hence a negative shock to bank capital *raises* the 'non-residential investment spread'. The simulations discussed below show that the rise in the spread is accompanied by a fall in non-residential investment, and a reduction in real activity. (In the absence of an operative capital requirement, $\phi^{x}=0$, the non-residential investment spread is constant, and shocks to bank capital have little effect on investment and real activity.)

Linear approximations of (2)-(3) show that the spread between the bank loan rate and the deposit rate obeys:

$$R^L_{t+1}-R^D_{t+1}\cong 2\kappa-\gamma\cdot\phi^{x}\cdot x_t/Z_t,$$

If the bank raises deposits *and* loans by one unit of the final good, then her operating cost increases by 2κ; excess bank capital falls by γ, which increases the penalty Φ^{x}_{t} by $-\gamma\cdot\phi^{x}\cdot x_t/Z_t$. Optimizing behavior by the entrepreneur requires that the spread between the loan rate and the deposit rate $R^L_{t+1}-R^D_{t+1}$ covers the marginal cost $2\kappa-\gamma\phi^{x}\cdot x_t/Z_t$. Hence, the loan–deposit rate spread is a decreasing function of the bank's excess capital. A negative shock to the bank's (excess) capital thus raises the lending rate spread $R^L_{t+1}-R^D_{t+1}$; as shown below, this is accompanied by a fall in residential investment.

The sensitivity of the non-residential investment spread and of the lending rate spread to (excess) bank capital hinges on the parameter ϕ^{x}. Note that $x_t/Z_t\cong(cr_t-\gamma)A$ where $cr_t\equiv(L_{t+1}+B^B_{t+1}+e_tF_{T+1}-D_{t+1})/(L_{t+1}+B^B_{t+1}+e_tF_{T+1})$ is the bank capital ratio (i.e. the ratio of bank equity to bank assets), while A denotes steady state of bank assets (normalized by the total technology trend, Z_t). Thus, a one percentage point rise in the bank capital *ratio* lowers the non-residential investment spread and the lending rate spread by $4\phi^{x}A$ and by $4\gamma\phi^{x}A$

percentage points per annum, respectively. Hence, the ‘non-residential investment spread’ is more sensitive than the lending rate spread to changes in the bank capital ratio.

2.3. Wage setting

We assume a trade union that ‘differentiates’ homogenous labor hours provided by the two workers into imperfectly substitutable labor services, and then offers these services to the intermediate good-producing firm--the labor input N_t in the producer’s production function (see above) is a CES aggregate of these differentiated labor services. The union sets nominal wage rates of the differentiated labor services to maximize the sum of the expected life-time utilities of the two workers, subject to independent Calvo (1983) wage adjustment schemes for each type of differentiated labor (Kollmann (2001, 2002)). This implies that the (log) growth rate of the nominal wage rate, $\pi_t^w \equiv \ln(w_t/w_{t-1})$, obeys the following wage Phillips curve, up to a (log-)linear approximation (e.g. Erceg et al. (2000)):

$$\pi_t^w - \pi^w = \beta^w E_t(\pi_{t+1}^w - \pi^w) + \lambda_w z_t^w,$$

where β^w is a weighted average of the two workers’ discount factors, π^w is steady state wage inflation, and $\lambda_w > 0$ is a coefficient that depends on the cost of changing nominal wages; z_t^w is the gap between a weighted average of workers’ marginal rates of substitution between consumption and leisure, and the real wage rate.

2.4. Final good sector

The final good technology is $\Upsilon_t = [\alpha^{1/\varepsilon} Q_t^{(\varepsilon-1)/\varepsilon} + (1-\alpha)^{1/\varepsilon} M_t^{(\varepsilon-1)}]^{\varepsilon/(\varepsilon-1)}$, with $\varepsilon > 0$, where Υ_t is final good output. Q_t is the CES aggregate of locally produced intermediate good varieties described above, and M_t is a homogenous imported intermediate good. $0.5 < \alpha < 1$ determines the local content of the final good. The Law of One Price holds for the imported good; the domestic and foreign currency prices of the imported good are $e_t P_t^*$ and P_t^*, respectively.[16]

[16] P_t^* equals the price level in the rest of the world (RoW). The RoW economy is described by a simplified New Keynesian model without capital. RoW and EA output has the same trend growth rate. The foreign price level equals the price of EA imports. Foreign demand for EA exports is a function of foreign absorption and of the relative price of EA exports.

Perfect competition in the final good market implies that its price, P_t, equals its marginal cost: $P_t=[\alpha_t(P_t^D)^{1-\varepsilon}+(1-\alpha_t)(e_tP_t^*)^{1-\varepsilon}]^{1/(1-\varepsilon)}$. The final good is exported, and used for domestic consumption and investment: $\Upsilon_t=C_t+G_t+I_t+I_t^G+J_t+X_t$, where $C_t\equiv C_t^i+C_t^p+C_t^E$ is private consumption, I_t^G is government investment, $J_t\equiv J_t^i+J_t^p+J_t^E$ is total residential investment, and X_t are exports.

2.5. Monetary policy

The monetary authority sets the interest rate on government bonds, $r_t=R_t-1$, as a function of the year-on-year growth rates of GDP and of the final good price:

$$r_t=(1-\rho^r)\bar{r}+\rho^r r_{t-1}+(1-\rho^r)[\tau_\pi^r(\tfrac{1}{4}\ln(P_t/P_{t-4})-\pi)+\tau_Y^r(\tfrac{1}{4}\ln(GDP_t/GDP_{t-4})-\gamma_{GDP})]+\varepsilon_t^r,$$

where π is the steady state quarterly final good inflation rate; ε_t^r is an exogenous mean zero AR(1) disturbance.

2.6. Fiscal policy

There are proportional taxes on consumption, labor income and dividend income.[17] We disaggregate government spending into bank support, government consumption, investment and transfers to workers, in order to assess the role of each of these spending items during the crisis. Coenen et al. (2012) show that, in a range of macro-models, the GDP multiplier of tax cuts is smaller than 'conventional' government spending multipliers. Thus it seems especially interesting to compare bank support measures to conventional government spending shocks. In order to focus on spending changes, and in order to keep the model manageable, we assume that tax *rates* are time-invariant.[18] Let S_t^s be the real government transfer to worker $s=i,p$ (in final good units). The real *net* tax paid by worker $s=i,p$ (T_t^s) equals thus her real consumption and labor tax liabilities, minus the transfer S_t^s. Each worker receives a time-

[17] Given the high and distortionary tax burden in the Euro Area (40% of GDP), a model with a lump sum tax or with only *one* type of tax would be unrealistic.

[18] It might be fruitful to extend our estimated model by allowing for tax based stimulus measures. This is beyond the scope of the present paper, i.a. because there are no time series on marginal tax rates for the Euro Area.

invariant share of the *total* transfer $S_t \equiv S_t^i + S_t^p$ that is set according to a policy rule discussed below.[19] The real tax paid by the entrepreneur (T_t^E) is the sum of her real consumption and dividend tax liabilities.

Real Government consumption, investment and transfers to workers track the total technology trend Z_t, and respond to deviations of the public debt and deficit from long run targets for these variables, according to these policy rules:

$$c_t^G = (1-\rho^{CG})\overline{c}^G + \rho^{CG} c_{t-1}^G - \tau_B^{CG}(B_t/(GDP_{t-1}P_{t-1}) - \overline{B}) - \tau_d^{CG}(\delta_{t-1}^B/GDP_{t-1} - \overline{\delta}^B) + \varepsilon_t^{CG}, \quad (5)$$

$$i_t^G = (1-\rho^{IG})\overline{i}^G + \rho^{IG} i_{t-1}^G - \tau_B^{IG}(B_t/(GDP_{t-1}P_{t-1}) - \overline{B}) - \tau_d^{IG}(\delta_{t-1}^B/GDP_{t-1} - \overline{\delta}^B) + \varepsilon_t^{IG}, \quad (6)$$

$$s_t = (1-\rho^{S})\overline{s} + \rho^{S} s_{t-1} - \tau_B^{S}(B_t/(GDP_{t-1}P_{t-1}) - \overline{B}) - \tau_d^{S}(\delta_{t-1}^B/GDP_{t-1} - \overline{\delta}^B) + \varepsilon_t^{S}, \quad (7)$$

where $c_t^G \equiv G_t/Z_t$, $i_t^G \equiv I_t^G/Z_t$ and $s_t \equiv S_t/Z_t$ denote expenditures types normalized by the 'total' technology trend Z_t. $\overline{c}^G, \overline{i}^G$ and $\overline{s}$ are the steady state values of the normalized spending types. B_t is (nominal) public debt at the end of period *t*-1, while δ_{t-1}^B is the real deficit in $t-1$. $\overline{B}$ and $\overline{\delta}^B$ are the steady state (target) values of the ratios of the debt and deficit to real GDP. $\varepsilon_t^{CG}, \varepsilon_t^{IG}, \varepsilon_t^{S}$ are exogenous AR(1) disturbances.

The normalized government transfer to the bank, $s_t^B \equiv S_t^B/Z_t$ is serially independent; this captures that idea that EA bank rescue measures were unanticipated, exceptional events.[20]

The law of motion of the government capital stock is $K_{t+1}^G = K_t^G(1-\delta) + \iota_t^{IG} I_t^G$, where I_t^G is government investment (in final good unit). $\iota_t^G > 0$ is an exogenous efficiency parameters that differs from private investment efficiency, ι_t. The government investment deflator and the private investment deflator are given by $P_t^{IG} \equiv P_t/\iota_t^{IG}$ and $P_t^I \equiv P_t/\iota_t^I$, respectively. The assumption that $\iota_t^{IG} \neq \iota_t$ is motivated by sizable empirical divergences

[19] The share of worker *s=i,p* in the *total* transfer equals the steady state share of the worker's consumption in total consumption of the two workers.

[20] We also experimented with a feedback rule under which the transfer to the bank is set as a function of bank losses, sovereign debt, the deficit and output. However, our dataset only includes 4 quarters with bank support (bank support was concentrated in 2009), and thus it is impossible to reliably estimate such a decision rule (the estimated response coefficients are insignificant); model fit (as measured by the marginal likelihood) deteriorates when the feedback rule is assumed.

between empirical public and private investment deflators. Capturing the dynamics of government purchases deflators in the model is important for an adequate representation of the government's budget constraint. For the same reason, we allow the government consumption deflator to differ from the private CPI (we take the private CPI as the empirical measure of the theoretical final good price)--we assume that one unit of the final good can be transformed into $\iota_t^{CG}>0$ units of government consumption, where ι_t^{CG} is an exogenous random variable. Thus, the government consumption deflator is $P_t^G \equiv P_t/\iota_t^{CG}$. The period t government budget constraint is:

$$P_t T_t + B_{t+1} = R_{t+1}^B B_t - P_t(\Delta_t^{G,p} + \Delta_t^{G,b}) + P_t^G G_t + P_t^{IG} I_t^G + P_t S_t^B,$$

where $T_t \equiv T_t^i + T_t^p + T_t^E$ is the total real tax revenue, net of transfers to workers.

3. Model solution and econometric approach

The model is transformed into a stationary system, by normalizing real activity, aggregate demand components and assets using the 'total' technology trend Z_t. We compute an approximate model solution by linearizing the transformed economy around its deterministic steady state.

3.1. Calibrated parameters

One period represents one quarter in calendar time. Following the recent literature that estimates DSGE models (e.g., Smets and Wouters (2007)), we calibrate a subset of parameters to match trend features of the EA economy during the sample period (and other long-run data properties). We thus set the trend growth rates of GDP and of investment efficiency at 1.64% and 1.33% per annum, respectively (investment efficiency is measured as the ratio of the CPI to the private investment deflator). The state steady inflation rate is set at 2% p.a. The elasticity of intermediate output w.r.t. labor is set at 0.65. We set the parameter of the public capital externality at $\alpha_G=0.1$, as that value ensures that, in steady state, the marginal product of public capital equals that of private non-residential capital (given the government's decision rule for public investment). The depreciation rates of non-residential capital and of housing capital are set at 0.1 and 0.04 p.a.. The steady state foreign trade share is calibrated at a=0.16.

The steady state real interest rates on deposits, government bonds and foreign bonds are set at 1.70% per annum. This pins down the (quarterly) subjective discount factor of the patient household: b^p=0.9994. The steady state real loan rate is set at 2.5% p.a. (average historical EA real household mortgage rate). Following Iacoviello and Neri (2010), we set the discount factor of the impatient household at the markedly lower value of 0.960, in order to ensure that the collateral constraint always binds in the stochastic equilibrium. The subjective discount factor of the entrepreneur is set at 0.971 which allows the model to match the empirical mean ratio of private non-residential capital to annual GDP of 1.05. [21] (The ratio of total capital to GDP is 2.5).

The steady state ratio of bank loans to annual GDP is set at 46.8% (which corresponds to the mean ratio of outstanding household loans to GDP in the EA). The steady state bank capital ratio is set at *cr*=0.105, consistent with EA data. Due to the short time span for which data on EA bank asset losses are available (2007q3-2010q4), we calibrate the autocorrelation of losses at 0.8, and treat losses in 2011 as a latent variable.[22]

The empirical literature on credit-constrained household frequently reports that the income share of these households is in the range of 25% or above.[23] We set the steady state income share of credit-constrained households at 25%, and assume that, in steady state, the entrepreneur holds 50% of total net worth. [24]

The steady state ratios of government debt and of household mortgage debt to annual GDP are set at 0.7 and 0.46, respectively (which corresponds to sample means of these ratios). In steady state, 20% of government debt is held by the bank. Tax rates are likewise calibrated on sample averages (the tax rates on consumption, labor income and dividends are

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[21] Equation (1) links the steady state marginal product of capital (and thus the ratio of residential capital to output) to b^E.

[22] We treat loan losses as exogenous. As pointed out by a referee, it would be interesting to allow for endogeneity of losses with respect to aggregate activity. However, the short sample on EA loan losses makes it impossible to reliably estimate such an endogenous effect. Also, about half of the losses experienced by EA banks were due to external assets (largely located in the US), as mentioned above. Hence, a substantial part of EA bank losses was not caused by a worsening of macroeconomic conditions in the EA.

[23] See Ratto et al. (2009), Campbell and Mankiw (1989, 1991) and Mankiw (2000) for estimates of that shares, based on aggregate data. Micro data also suggest a substantial fraction of credit constrained households (Souleles (2002), Johnson, Parker, and Souleles (2006)).

[24] According to the Luxembourg Wealth Study (Sierminska et al. (2006)), the top 10% of the population in the European Union owns roughly 50% of total net worth.

set at 0.20, 0.30 and 0.27, respectively). Government transfers to households amount to 17% of GDP.

3.2. Estimated parameters

The remaining parameters are estimated using a Bayesian approach (Otrok (2001), Smets and Wouters (2007)), with quarterly EA data for 1995q1-2011q4.[25] We assume that all exogenous variables are normally (or log-normally) distributed, and independent from each other. The estimation uses data on EA GDP and its components, the deflators of these aggregates, the interest rate on mortgage loans to households, the short-term government bond rate, bank asset write-downs, government support for banks, the bank capital ratio, government consumption, investment and transfers to households, public debt, and the nominal exchange rate. In addition, data on GDP and the short term interest in the rest of the world are used. Note that the estimation uses historical data on the fiscal variables, on government bank support and on loan losses.[26] The empirical measure of bank support is the sum of bank recapitalizations and of purchases of impaired bank assets by EA governments.[27] See the Appendix for further information on the data.

Posterior estimates of key structural parameters are reported in Table 1. We set the prior mean duration between price and wage changes at 2 quarters; according to the posterior estimates, the mean durations between price and wage changes are 7 quarters and 4 quarters, respectively. The posterior estimate of the long-run Frisch labor supply elasticity $1/c$ is 0.15. The estimates also suggest strong habit formation for consumption, housing and hours worked. The curvature parameter of the bank's cost of deviating from the target bank capital ratio is estimated at ϕ^x=0.61 implying that a 1 percentage point rise in the bank capital ratio lowers the spread between the mortgage loan rate and the deposit rate by 28 basis points per annum, which is in line with empirical estimates of the response of the loan rate spread reported by Kollmann (2012). We also find a stronger feedback from debt/GDP and

25 Adjemian et al (2011). Posterior estimates are obtained with Metropolis running in parallel (DYNARE Parallel Toolbox, Ratto et al, 2011) four chains of 300,000 each and dropping the first 50% of runs.

26 By contrast, much of the recent literature that estimates DSGE models treats the shocks as latent variables, i.e. no direct empirical measures of shocks are used in estimation (e.g., Smets and Wouters (2007)).

27 EA governments also supported banks by issuing guarantees on bank liabilities, thus lowering banks' funding costs. Modeling those guarantees is an interesting avenue for future research.

deficit/GDP ratios to government investment than to government consumption or transfers to households.

4. The role of bank losses and fiscal policy in the Great Recession

Table 2 summarizes the economic performance of the EA in 2008-2010. EA (real) GDP fell by 4.2% in 2009, while consumption and private non-residential investment fell by 1.7% and 20.0%, respectively; residential investment fell by 9.3%. Private non-residential investment was thus the demand component most adversely affected by the crisis. By contrast, government consumption rose by 2.5% in 2009. This Section evaluates whether bank losses, government support for banks, and increased government spending generate responses of key macro aggregates that match the behavior of those aggregates during the financial crisis. All model predictions are computed at posterior modes of the estimated model parameters.

4.1. Impulse responses

The estimated model predicts that a loan loss shock generates a sizable reduction in real activity, while government support for banks has a substantial positive effect on output and consumption and, especially, on private investment. A rise in government consumption also raises output, but crowds out consumption and (especially) investment, in the short run.

Figure 1 shows dynamic effects of mortgage loan losses, of government support for the bank, of government consumption purchases, and of sovereign debt losses. In each case, an innovation worth 1% of steady state quarterly GDP is fed into the laws of motion of the relevant forcing variable. Predicted responses of GDP, private consumption, non-residential investment and employment are expressed in percentage deviations from steady state; responses of the bank capital ratio are in percentage points, while responses of spreads are in basis points per annum.

4.1.1. Bank loan loss shock (Figure 1, Panel (a))

Due to the positive serial correlation of the loan loss process, an innovation to the bank loan loss worth 1% of *quarterly* steady state GDP produces a first-year loss of 0.98% of GDP, and a cumulative (total) loss of 1.25% of annual GDP. The loan loss leads to a persistent fall in the bank's capital; the bank capital *ratio* falls by 0.3 percentage points, on impact, and then slowly returns to the unshocked path. On impact, the loan rate spread $(R^L_{t+1} - R^D_{t+1})$ and the ‘non-residential investment spread’ $(E_t(R^K_{t+1}+\rho_{t+1})- R^D_{t+1})$ rise by about 20 and 165 basis points (bp) per annum, respectively. Non-residential (private) investment falls sharply (-2.2%, on impact). Output and employment fall too, due to the fall in investment demand (given price stickiness). The bank capital constraint makes it costly for the bank to take more deposits to smooth the stream of bank dividends—the bank thus cuts her dividend. To smooth her consumption, the entrepreneur hence reduces physical investment in the intermediate-good firm. On impact, GDP falls by 0.15%--GDP continues to fall for 2 quarters after the shock, before slowly reverting to its pre-shock path. During the first year, GDP falls by 0.24%. Consumption falls likewise, because of the reduction in real activity, and because 50% of loan loss is an external loss (i.e. a wealth transfer to the rest of the world)—but notice that consumption falls more gradually than output and investment.

The cumulated asset losses of EA banks since 2007 amounted to 8.7% of annual GDP (see below). The model predicts that a loss shock of this cumulative magnitude generates reductions of GDP, non-residential investment and consumption of 2.1%, 26% and 0.3%, respectively, during the first year after the shock. These predicted responses are consistent with key features of the financial crisis—in particular with the sharp reduction in investment and the more muted fall in consumption.

4.1.2. Government support for banking (Figure 1, Panel (b))

Qualitatively, the effects of government support for the bank are mirror-images of the responses to the loan loss shock. The bank reacts to the government subsidy by increasing her capital, and by paying a higher dividend. The entrepreneur responds to this by raising physical investment in the intermediate good-producing firm. Thus, government support for banks stabilizes a component of aggregate demand that was especially adversely affected by the crisis. The increase in bank capital is persistent, and it thus leads to a persistent reduction in the lending rate spread, and the non-residential investment spread. Thus, mortgage lending increases. However, the entrepreneur allocates the additional funds received by the government mostly to non-residential investment and less to mortgage lending. This is a consequence of the fact that the bank rescue measure is a wealth transfer from workers to the entrepreneur (mortgage loans increase only slightly, as borrowers expect to pay higher future taxes). In the first quarter, the bank subsidy raises GDP and non-residential investment by 0.13% and 0.6%, respectively. The effect of the bank rescue measure is persistent: during the first (second) year, GDP rises by 0.1% (0.03%), while non-residential investment increases by 0.58% (0.27%) over the same horizon. [28] The cumulative GDP multiplier (ratio of cumulated GDP changes to cumulated fiscal spending changes) of the bank rescue measure is 0.41 during the first year (but is greater at longer horizons).

4.1.3. Government purchases (Figure 1, Panel (c))

The estimated law of motion of government consumption is highly persistent--an innovation to the law of motion of government consumption worth 1% of steady state quarterly GDP raises government consumption by 1.37% (1.42%) of GDP in year 1 (year 2). The cumulative increase in government consumption amounts to 6.6% of annual GDP. GDP rises by 0.80% (0.64%) of GDP in year 1 (year 2), and employment too increase persistently. Consumption and investment fall by 0.04% and 1.60%, respectively in year 1. Private consumption remains depressed thereafter, while investment returns to its pre-shock value in year 2, and then rises above the unshocked paths in years 2-5 (due to the rise in employment which increases the marginal product of capital).[29] The GDP multiplier is 0.58 in year 1, a value in the lower range of multipliers predicted by estimated New Keynesian models *without* banks--see, e.g., the models discussed in Coenen et al. (2012).[30] A comparison with Panel (b) shows that government consumption has a larger impact multiplier than government support for banking, but that government consumption crowds out consumption and investment (in the short term), while bank support raises consumption and investment. [31]

[28] In comparing responses in Panels (a) and (b), one should bear in mind that bank support is i.i.d.; thus Panel (b) shows responses to a one-time bank support; by contrast, loan losses are serially correlated and thus a given loss innovation triggers a much greater cumulated loss.

[29] Private consumption rises slightly in the first two quarters, because the consumption of credit constrained households responds positively to the increase in their labor income. Consumption falls thereafter, as the rise in public debt triggers a reduction in government transfers to households.

[30] Coenen et al. consider a fiscal spending shock that only lasts 2 years. With more persistent spending shock (as in the paper here), anticipated higher future (net) tax payments lead to a stronger and more rapid fall in private consumption and, thus a weaker expansion of GDP.

[31] A model variant without an operative bank capital requirement (f^x=0) generates a slightly smaller GDP multiplier of government consumption. By contrast, the real effects of loan losses and of government support to banks are negligible when f^x=0, as then the lending spread (and the non-residential investment spread) are unaffected by shocks to the bank's capital (up to a first-order approximation).

4.1.4. Sovereign default (Figure 1, Panel (d))

No sovereign default occurred during the sample period used for estimation (1995q1-2011q4). However, partial default on the debt of an EA government (Greece) occurred in 2012. It thus seems instructive to analyze the consequences of a sovereign debt default, using the model. The model predicts that the consequences of a default hinge crucially on whether the government defaults on debt that is held by the bank or on debt held by the (patient) household. The response to a default on debt closely resemble the consequences of a loss on mortgage loans: there is a significant and persistent fall in bank capital, a rise in spreads, and a fall in GDP, employment and investment.[32] Figure 1, Panel (d), considers a loss on bank-held sovereign debt which is of the same size and time profile as the loss shock on mortgage loans discussed above (i.e. the cumulated default amounts to 1.25% of annual GDP). In the first year, the sovereign loss triggers a 0.30% (2.1%) fall in GDP (investment). By contrast, a default that only affects sovereign debt held by the (patient) household hardly affects real activity—i.e. Ricardian equivalence then holds approximately. (Obviously, this assumes that default does not trigger subsequent financing restrictions for the government)

4.2. EA banking shocks and fiscal policy in the financial crisis: historical decompositions

Figure 2 plots year-on-year (YoY) growth rates of EA GDP, private non-residential investment and private consumption, as well as the public debt/GDP ratio, in 2007-2011. (The mean 1995-2011 YoY growth rates (mean debt/GDP) have been subtracted from each of the plotted growth rate (debt/GDP) series.) The Figure also shows the contributions of banking and fiscal shocks to the historical series.

4.2.1. Bank losses, bank rescue measures and innovations to conventional fiscal instruments

Estimates of EA bank asset write-downs in the period 2007-2011 are shown in Figure 3. Write-downs were highest in 2009, amounting to 4.5% of GDP. Cumulated 2007-2011 write-downs amount to 8.7% of 2009 GDP. EA Bank rescue measures during the financial crisis were likewise concentrated in the year 2009 (and especially in the second part of 2009). Table 3 documents that government purchases of impaired ('toxic') assets by banks and bank recapitalisations amounted to 2.84% and 1.88%, respectively, of EA GDP in 2009. Total

[32]A key difference between the sovereign loss and the loan loss (discussed above), is that 50% of the latter is an external loss. By contrast, the sovereign loss shock is a wealth transfer *within* the EA economy; that redistributive nature of the shock dampens the negative aggregate consumption response.

government support for banks thus amounted to 4.7% of GDP in 2009. (As mentioned above, the estimation uses the sum of impaired asset purchases and of bank recapitalizations as a measure of bank support.)

Figure 4 plots the components of EA government consumption, government investment and transfers to households (normalized by an exponential trend fitted to GDP) that are solely accounted for by current and past *innovations* to the corresponding fiscal spending rules (see (5)-(7)). The Figure shows that these 'non-systematic' components of government consumption and transfers both rose strongly during the crisis, namely by about 1.5% of trend GDP, a clear indication of an expansionary fiscal stance. By contrast, non-systematic public investment spending rose only slightly in 2008-2011 (by less than 0.5% of GDP). The cumulative fiscal impulses in 2008-2011 amounted to 8.2% of trend GDP (of which 4.3%, 3.6% and 0.3%, respectively, were due to higher government consumption, transfers to households, and government investment). The average conventional fiscal impulse thus amounted to 2.1% of GDP, per year, in 2008-2011.[33]

4.2.2. Historical decompositions of real activity and public debt

Figure 2 shows the contributions of different types of shocks to the historical time series of GDP, private non-residential investment, consumption (YoY growth rates), and of the public debt/GDP ratio. Specifically, we decompose the historical series into components due to: (i) fiscal shocks other than transfers ('Fiscal excluding transfers'); (ii) 'Transfers to households'; (iii) 'Bank support'; (iv) 'Bank asset losses'. The remainder ('Other') captures the effect of all other shocks.

The 'Fiscal, excl. transfers' and 'Transfers' components of the historical series correspond to predicted paths that obtain when residuals of the fitted fiscal spending rules are fed into the model. The 'Bank support' and 'Bank asset losses' components correspond to predicted series that are generated when the historical bank losses and bank support payments (Figure 3, Table 3) are fed into the model.

[33] These estimates of fiscal stimulus, based on estimated non-systematic innovations, include the workings of automatic stabilisers, and are larger than the discretionary fiscal measures announced by EA governments in early 2009 (European Economic Recovery Plan): the discretionary measures for 2009 and 2010 amounted to 0.83% and 0.72% of EA GDP, respectively (Coenen et al., 2012).

Our model suggests that, between late 2007 and the end of 2009, bank losses exerted a strong negative influence on EA bank capital, bank lending and real activity. [34] The Bank losses explain roughly ¼ of the fall in EA GDP and consumption, and 3/4 of the fall in EA non-residential investment, between 2007q1 and 2009q1. Consistent with the impulse responses discussed above, we thus find that investment is especially sensitive to loan loss shocks. The bank support measures in 2009 had a noticeable stabilizing effect on GDP and, especially, on consumption and investment. Bank support essentially off-set the effect of bank losses on GDP, in 2009. As bank support was concentrated in 2009, the absence of bank support in 2010 shows up as a negative contribution to GDP, consumption and investment YoY growth in 2010. The rise in transfers to households had a noticeable stabilizing effect on consumption, but hardly affected GDP and investment. Increased government consumption and investment helped to stabilize GDP in 2008-2009, but crowded out consumption, and had a slight negligible effect on investment.

The public debt/GDP ratio increased by about 20 percentage points in 2008-2011. Bank support accounts for about 18% of that rise in the debt/GDP ratio, while fiscal shocks explain 33% of the increase. Together, the fiscal and bank-related shocks account for about half of the rise in the debt/GDP ratio.

5. Conclusion

This paper has analyzed the impact of Euro Area (EA) bank asset losses, government support for banks, and conventional fiscal stimulus measures, using an estimated New Keynesian model with a bank. Our model traces out a transmission channel of these shocks to the EA real economy which is consistent with key features of the recent financial crisis, in particular with the strong decline of non-residential investment. Bank losses explain about a quarter of the fall in EA GDP and consumption in 2007-2009, and more than three quarter of the fall in private non-residential investment. Government support for banks was an effective tool for stabilizing output and consumption and, especially, physical investment, the component of aggregate demand most adversely affected by the financial crisis. The sizable increase in

[34] The ECB's Euro Area bank lending survey (BLS) suggests a strong tightening of credit conditions that began in the second half of 2007, and culminated in late 2008 (Lehman collapse). Costs related to bank capital positions, as well as risks on collateral demanded and expectations regarding economic conditions, are reported by a significant fraction of banks as having contributed to that tightening.

government purchases during the crisis helped to stabilize GDP, but crowded out consumption and investment. Higher transfers to households raised private consumption, but hardly affected GDP and investment.

DATA APPENDIX

A1. The following variables are used as observables

Euro Area variables:

● GDP, private consumption, government consumption, private non-residential investment, residential investment, government investment, net exports, employment. The estimation uses there variables at constant prices, plus corresponding deflators (where appropriate). As empirical measures of investment efficiency shocks, we use the ratios of private non-residential investment deflators, of private residential investment deflators, and of government investment, to the CPI.

● Residential property prices (new and existing dwellings)

● Bank capital to asset ratio; mortgage loans to households; bank write-downs (see below); government support for banks (see below).

● Short term government bond rate; household mortgage interest rate (available since 2003 only).

● Nominal government transfers to households (Paredes et al. (2009) database, with updates by authors); nominal government debt; nominal government interest payments

Rest-of-world variables:

Trade weighted average of GDP of 41 EA trading partners (current and constant prices); Nominal effective exchange rate (trade weighted average of 41 bilateral EA-trading partner exchange rates). US federal funds rate (used as a proxy of the world interest rate).

Sources: DG ECFIN, ECB Monthly Bulletin, Eurostat national accounts, IMF International Financial Statistics, US Federal Reserve, Bloomberg.

A2. Estimates of bank asset losses and of government support for banks in the EA

To construct an estimate of EA bank losses, we compute the sum of the write-downs of the 36 largest EA banks, as reported by Bloomberg (see Roeger and in't Veld (2012)). That data is available for the period 2007q3-2010q4. These 36 banks account for 80% of total EA bank assets. We multiplied aggregate write-downs for these banks by a factor 1/0.8 to construct an estimate of total EA bank write-downs, and we added EA government purchases of impaired bank assets to the scaled series (see below). The estimation uses the resulting 2007q3-2010q4 series, as an empirical measure of EA bank loan losses. We treat loan losses in 2011 as a latent variable. The loan losses (with model implied estimates for 2011) are shown in Figure 3.

Government support for banks during the financial crisis were concentrated in the year 2009 (Laeven and Valencia (2011)). Data on government support for banks in 2009 are reported in Table 3. (Source: European Commission services, based on surveys of euro area member states.) The bank support measures included recapitalizations ('capital injections into financial institutions') and purchases of impaired ('toxic') assets by governments ('impaired asset relief mechanisms'). The estimation uses the sum of recapitalizations and purchases of impaired assets by EA governments (in 2009) as an empirical measure of the theoretical bank rescue measure. Bank losses are assumed to equal zero, in the rest of the sample period.

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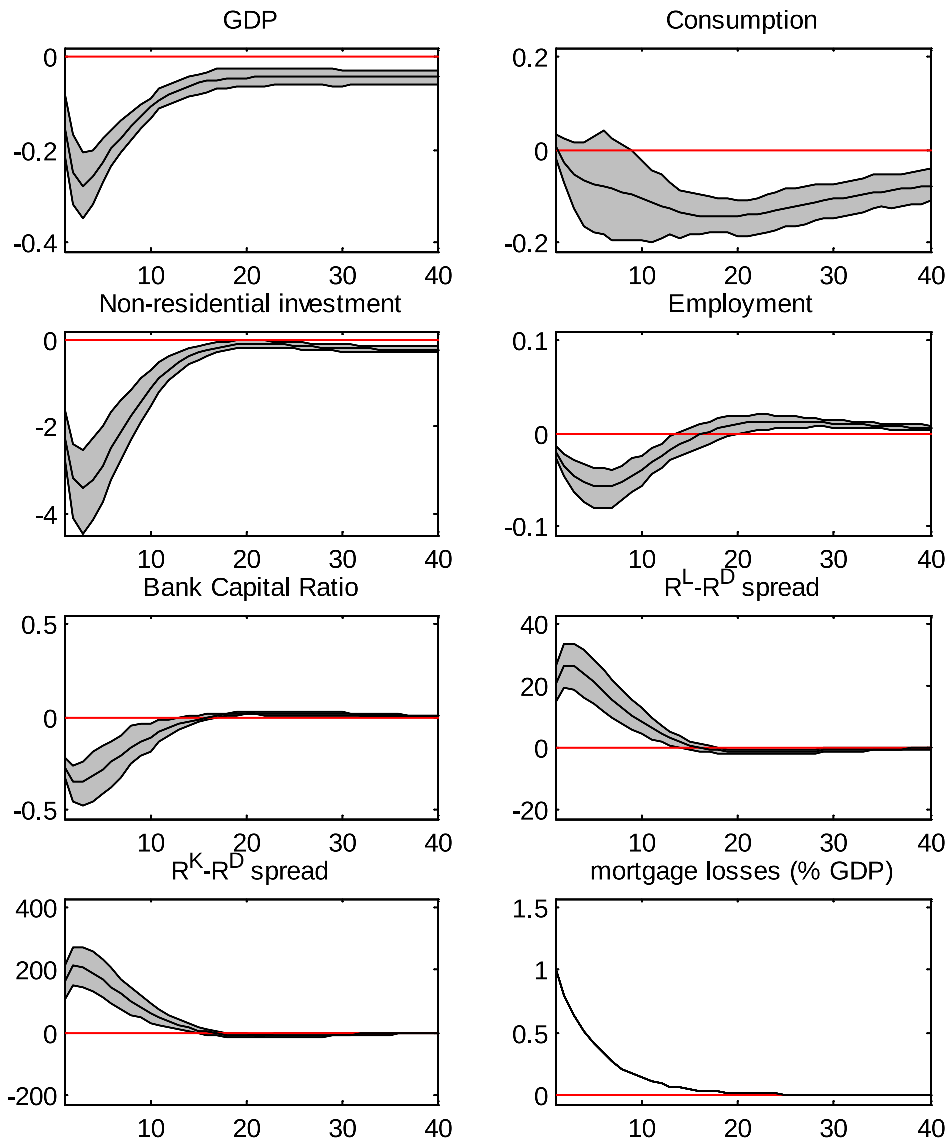
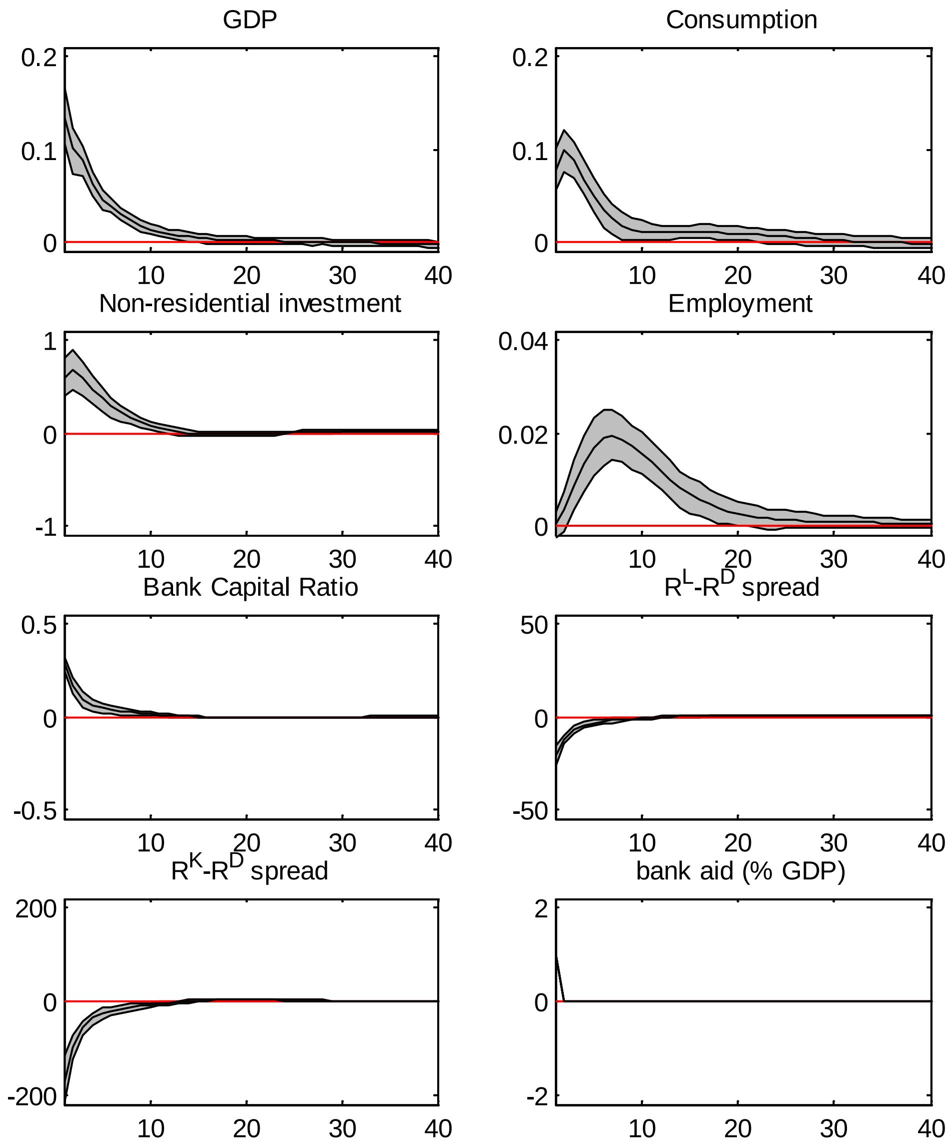
Figure 1. Dynamic effects of shocks

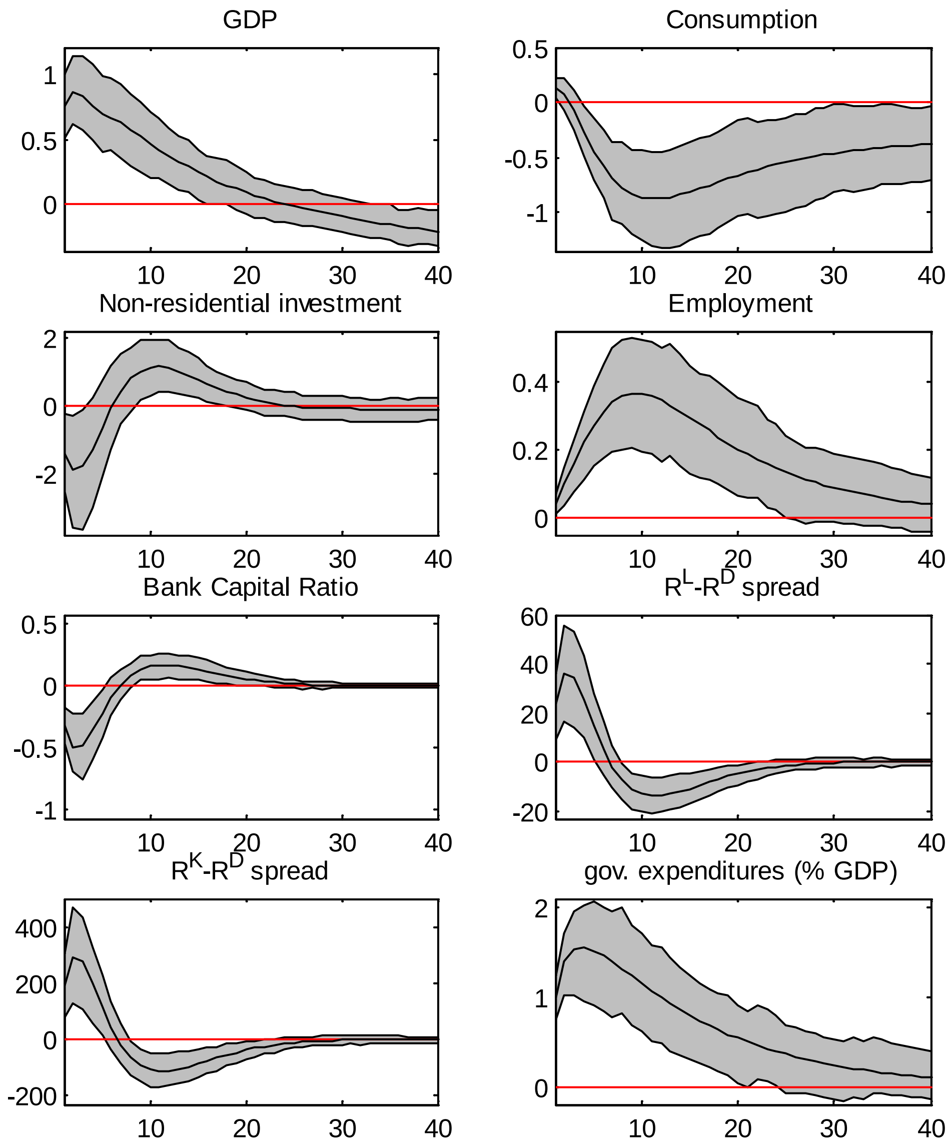
(a) Innovation to bank loan loss (1% of quarterly GDP)



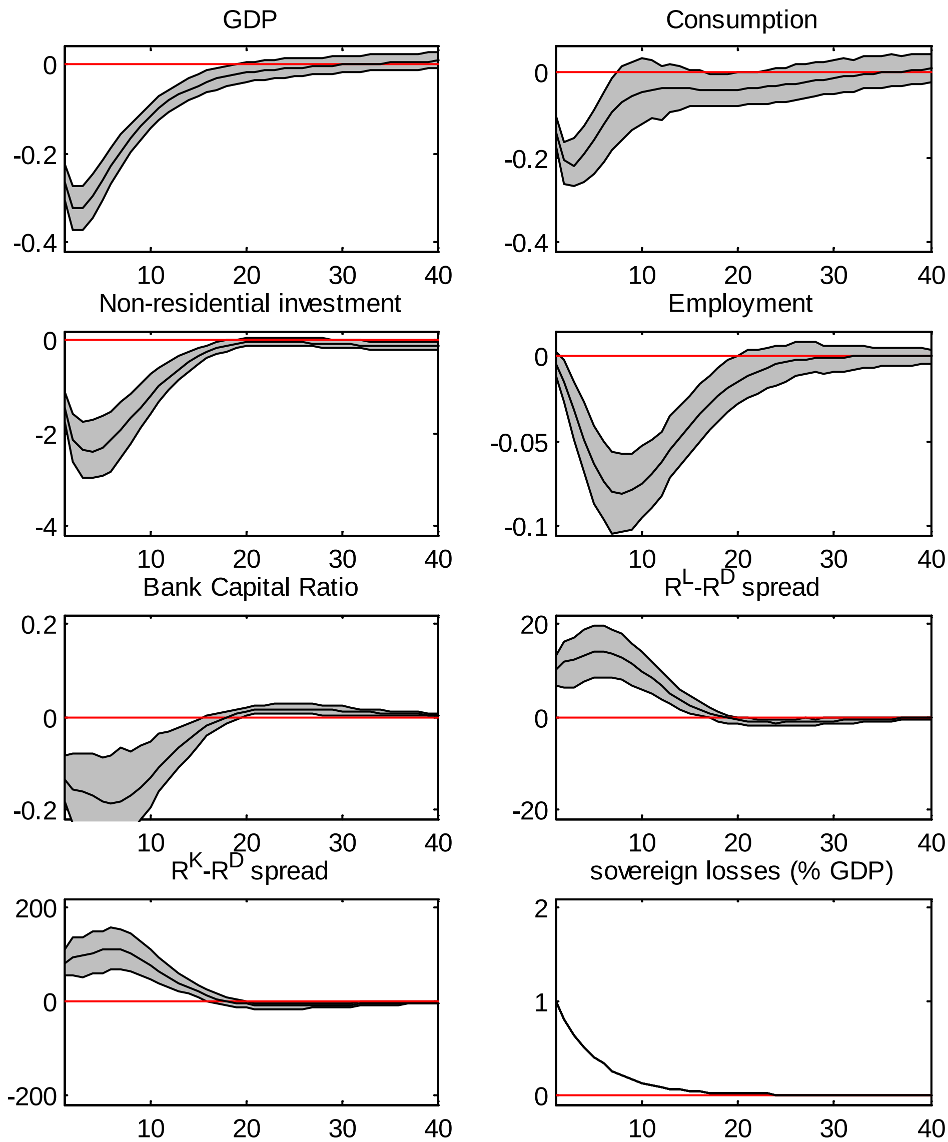
(b) One-time government support for bank (1% of quarterly GDP)



(c) Innovation to government consumption rule (1% of quarterly GDP)



(d) Innovation to default on sovereign debt held by the bank (1% of quarterly GDP)



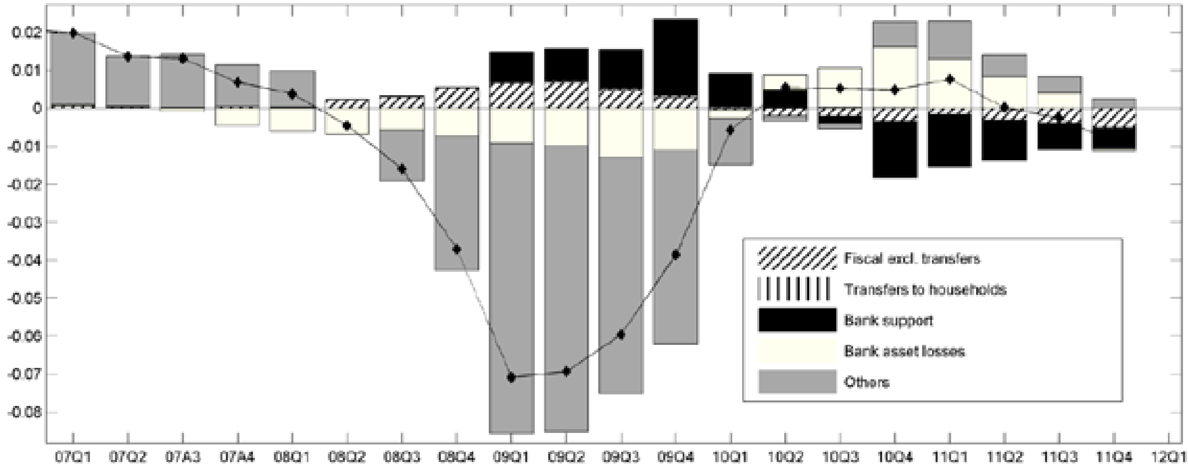
Notes: Dynamic responses to exogenous shocks are shown. Panel (a): innovation to law of motion of bank loan loss; Panel (b): one-time bank aid; Panel (c): innovation to policy rule for government purchases; Panel (c): loss to sovereign debt held by bank of same magnitude as loan loss shock. In all panels, the innovation represents 1% of GDP.

Responses of GDP, consumption (all private agents) and non-residential investment, employment are expressed as % deviation from the deterministic steady state. Responses of the bank capital ratio are expressed in percentage points. Responses of spreads are in basis points per annum.

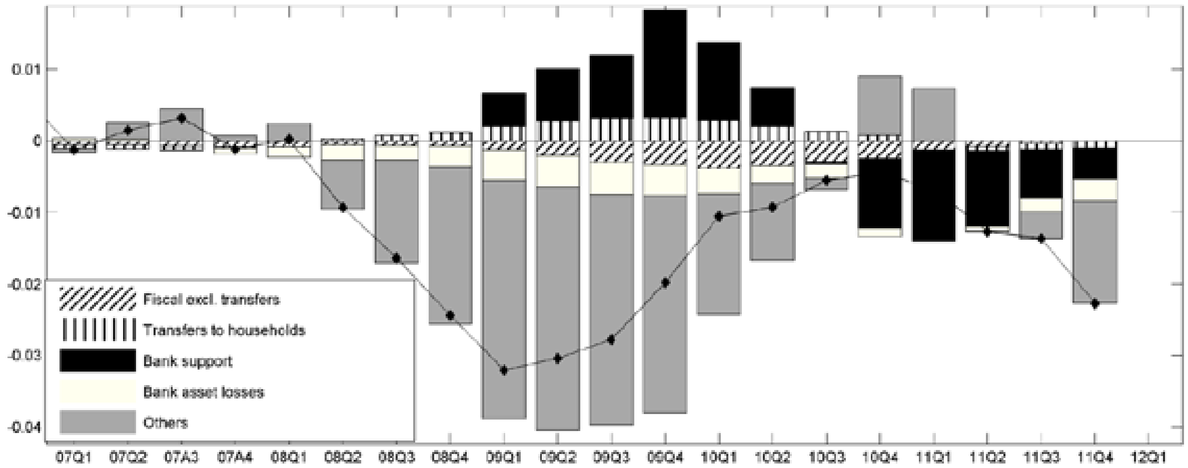
'R^L-R^D spread': loan rate spread R^L_{t+1}- R^D_{t+1}; 'R^K-R^D spread': 'non-residential investment spread' $E_t(R^K_{t+1}+\rho_{t+1})$- R^D_{t+1}.

Figure 2. Historical decompositions of Euro Area variables

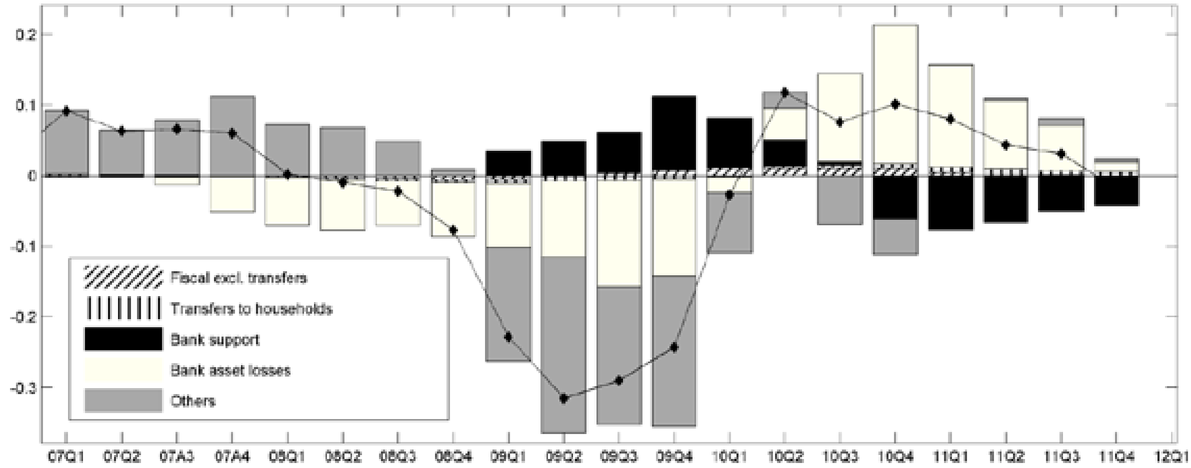
(a) YoY GDP growth (demeaned)



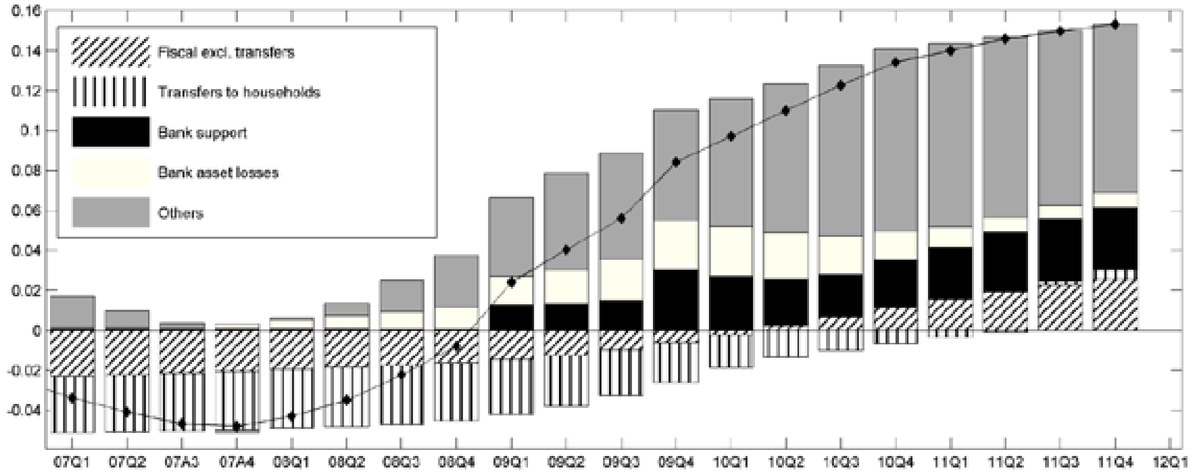
(b) YoY Consumption growth (demeaned)



(c) YoY private non-residential investment growth (demeaned)



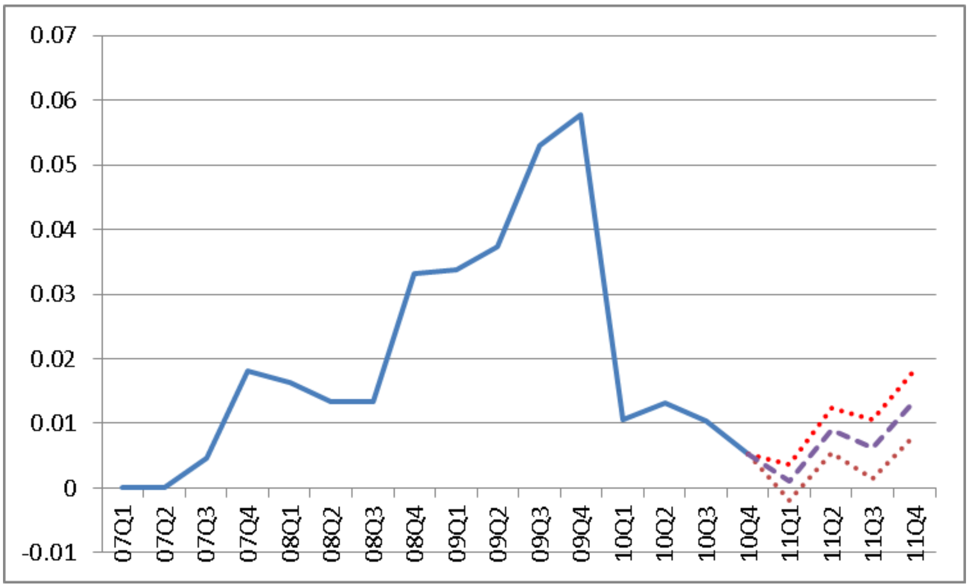
(d) Debt to GDP ratio (demeaned)



Note: Solid lines with dots show year-on-year (YoY) growth rates of EA GDP (Panel (a)), of private consumption (b) and of private non-residential investment (c), and the public debt ratio (Panel (d)), in 2007q1-2011q4. Mean YoY growth rates during the model estimation sample (1995-2011) are subtracted from plotted growth rates; the 1995-2011 mean debt/GDP ratio is subtracted from the plotted debt/GDP series.

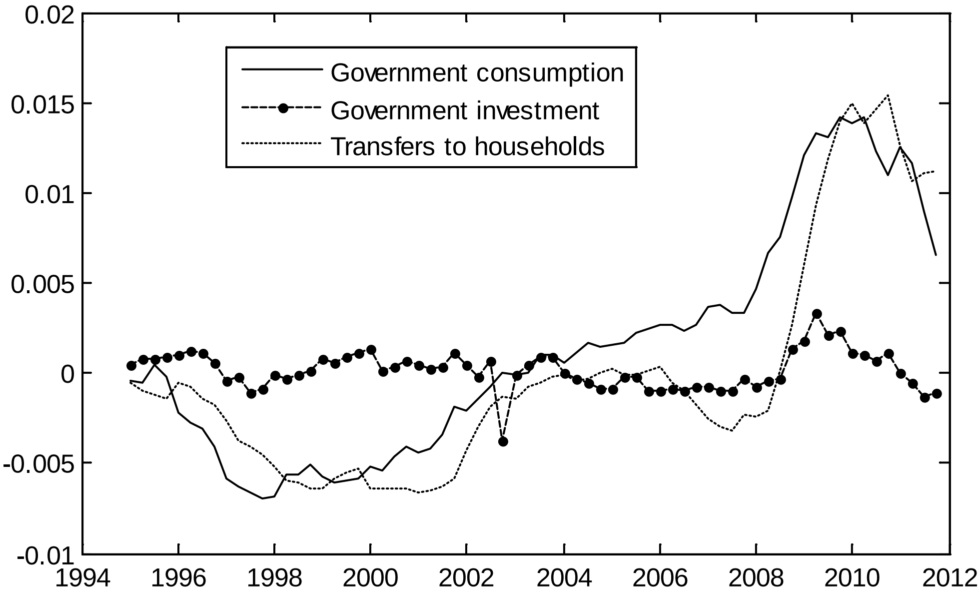
The bars show the contributions of different types of shocks to the historical series.

Figure 3--EA bank asset write-downs (as share of trend of quarterly GDP)



Note: values shown for 2011 (dashed line) are estimated through the lens of the model, included posterior 90% confidence bounds.

Figure 4—Non-systematic components of fiscal variables (as share of trend of quarterly GDP)



Note: The Figure plots the components of EA government consumption (solid line), government investment (dotted line) and transfers to households (dashed line), normalized by an exponential trend fitted to quarterly GDP, that are accounted for by current and past *innovations* to the corresponding fiscal spending rules (see (5)-(7)).

Table 1. Prior and posterior distributions of key model parameters

Parameters	Prior distributions			Posterior distributions		
	Distrib.	mean	s.d.	mean	HPD inf.	HPD sup
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Household preferences						
k	Gamma	3.50	1.40	6.728	4.092	9.266
h^{C}	Beta	0.70	0.10	0.9353	0.9173	0.9537
h^{H}	Beta	0.50	0.20	0.5984	0.2815	0.925
h^{N}	Beta	0.70	0.10	0.9031	0.8629	0.9464
Bank capital constraint						
f^{x}	Gamma	0.60	0.16	0.6093	0.3891	0.8354
Fiscal policy rules						
r^{CG}	Beta	0.50	0.20	0.4869	0.2314	0.7498
t_{B}^{CG}	Gamma	0.02	0.01	0.01252	0.00268	0.02135
t_{d}^{CG}	Gamma	0.02	0.01	0.01353	0.00341	0.02322
r^{IG}	Beta	0.50	0.20	0.2044	0.03456	0.366
t_{B}^{IG}	Gamma	0.02	0.01	0.01389	0.00754	0.02045
t_{d}^{IG}	Gamma	0.02	0.01	0.01351	0.00417	0.0224
r^{S}	Beta	0.50	0.20	0.7419	0.5276	0.9657
t_{B}^{S}	Gamma	0.02	0.01	0.00934	0.00179	0.01628
t_{d}^{S}	Gamma	0.02	0.01	0.01064	0.00174	0.01918
Monetary policy rules						
r^{r}	Beta	0.50	0.15	0.8737	0.8292	0.9175
t_{p}^{r}	Gamma	2.00	0.60	2.178	1.336	2.982
t_{Y}^{r}	Gamma	1.00	0.40	1.023	0.5564	1.491

Notes: Cols. (1) lists the parameters; Col. (2) indicates the distribution function of the prior. Cols. (3) and (4) show the means and the standard deviations (s.d.) of the prior distributions of the listed parameters, respectively. Cols. (5-7) report means and the 90% Highest Probability Density intervals of the posterior parameter distributions. Posterior distributions are computed with DYNARE (Adjemian et al., 2011) using the Random Walk Metropolis algorithm, taking four chains each of length 300,000 and dropping the first 150,000 samples. The four chains have been run in parallel exploiting the DYNARE Parallel Toolbox (Ratto et al. 2011).

Table 2: Euro Area - Financial Crisis 2008-2010:

	Annual growth rates		
	2008	2009	2010
GDP	0.5	-4.2	1.8
Government consumption	2.3	2.5	0.5
Consumption	0.7	-1.7	0.8
Non-residential investment	2.3	-20.0	4.3
Residential Investment	1.2	-9.3	-5.2
Employment	0.9	-1.9	-0.5

Table 3: EA government support for banks (cumulative, as % of GDP)

	Feb-09	May-09	Aug-09	Dec-09
Purchases of impaired bank assets	0.43	0.45	0.75	2.84
Recapitalizations	1.09	1.45	1.67	1.88
Total bank aid	1.52	1.90	2.42	4.72

APPENDIX

Table A.1: full table of posterior parameter estimates.

	Prior			Posterior			
	distrib.	mean	std	mean	std	hpdinf	hpdsup
ALPHAD	beta	0.6	0.16	0.6093	0.1315	0.3891	0.8354
ALPHABG	beta	2.5	1	0.5383	0.0999	0.03877	1.327
GAMUCAP2E	gamma	0.02	0.008	0.01041	0.004	0.004395	0.01635
GAMHOUSEE	gamma	30	20	177.2	34.5145	123.7	228.8
GAMHOUSE1E	gamma	15	10	2.062	1.2293	0.1801	3.923
GAMKE	gamma	30	20	18.46	7.6799	3.667	33.09
GAMIE	gamma	15	10	11.08	3.5838	4.796	17.28
GAMLE	gamma	30	20	138.6	22.0115	101.5	173.7
GAMPE	gamma	12	4	34.43	5.725	25.38	43.96
GAMPCONSTRE	gamma	30	20	44.65	17.1007	18.39	70.75
GAMPHOUSEE	gamma	30	20	48.82	15.9471	21.36	74.7
GAMPME	gamma	30	20	7.724	4.4802	1.447	14.33
GAMPXE	gamma	30	20	33.34	16.9499	5.605	59.88
GAMWE	gamma	12	4	2.951	0.9897	1.266	4.505
G1E	beta	-0.1	0.04	-0.02893	0.0129	-0.05018	-0.00706
GSLAGE	beta	0.5	0.2	0.4869	0.1556	0.2314	0.7498
HABE	beta	0.7	0.1	0.9353	0.0112	0.9173	0.9537
HABHE	beta	0.5	0.2	0.5984	0.2035	0.2815	0.925
HABLE	beta	0.7	0.1	0.9031	0.0256	0.8629	0.9464
HABWE	beta	0.5	0.2	0.1486	0.0951	0.01976	0.2828
IG1E	beta	-0.1	0.04	-0.03014	0.0088	-0.04542	-0.01463
IGSLAGE	beta	0.5	0.2	0.2044	0.1064	0.03456	0.366
ILAGE	beta	0.5	0.15	0.8737	0.0283	0.8292	0.9175
ILAGWE	beta	0.5	0.15	0.7866	0.0392	0.725	0.8516
KAPPAD	gamma	1.5	0.6	1.645	0.2358	1.055	2.228
KAPPAE	gamma	3.5	1.4	6.728	1.5855	4.092	9.266
RHOPCPME	beta	0.3	0.12	0.3188	0.1187	0.1158	0.5002
RHOPWPXE	beta	0.3	0.12	0.2832	0.0868	0.1367	0.4267
LAGDEBTCCE	beta	0.5	0.2	0.9002	0.0207	0.8668	0.9358
RPREME	beta	0.05	0.021	0.01138	0.0051	0.003063	0.01893
SFPE	beta	0.7	0.1	0.9284	0.0367	0.871	0.9875
SFPCONSTRE	beta	0.7	0.1	0.9109	0.0485	0.842	0.9844
SFPHOUSEE	beta	0.7	0.1	0.8893	0.0536	0.81	0.9724
SFPME	beta	0.7	0.1	0.7917	0.0826	0.6636	0.9234
SFPXE	beta	0.7	0.1	0.8645	0.0583	0.7704	0.9642
SFPWE	beta	0.7	0.1	0.7373	0.1035	0.5613	0.9094
SIGEXE	gamma	1.25	0.5	2.002	0.2866	1.551	2.444
SIGIME	gamma	1.25	0.5	0.6564	0.1952	0.3224	0.9719
SIGLANDE	beta	0.5	0.2	0.4866	0.125	0.2737	0.709
TGOVB1E	beta	0.02	0.01	0.01252	0.0062	0.002679	0.02135

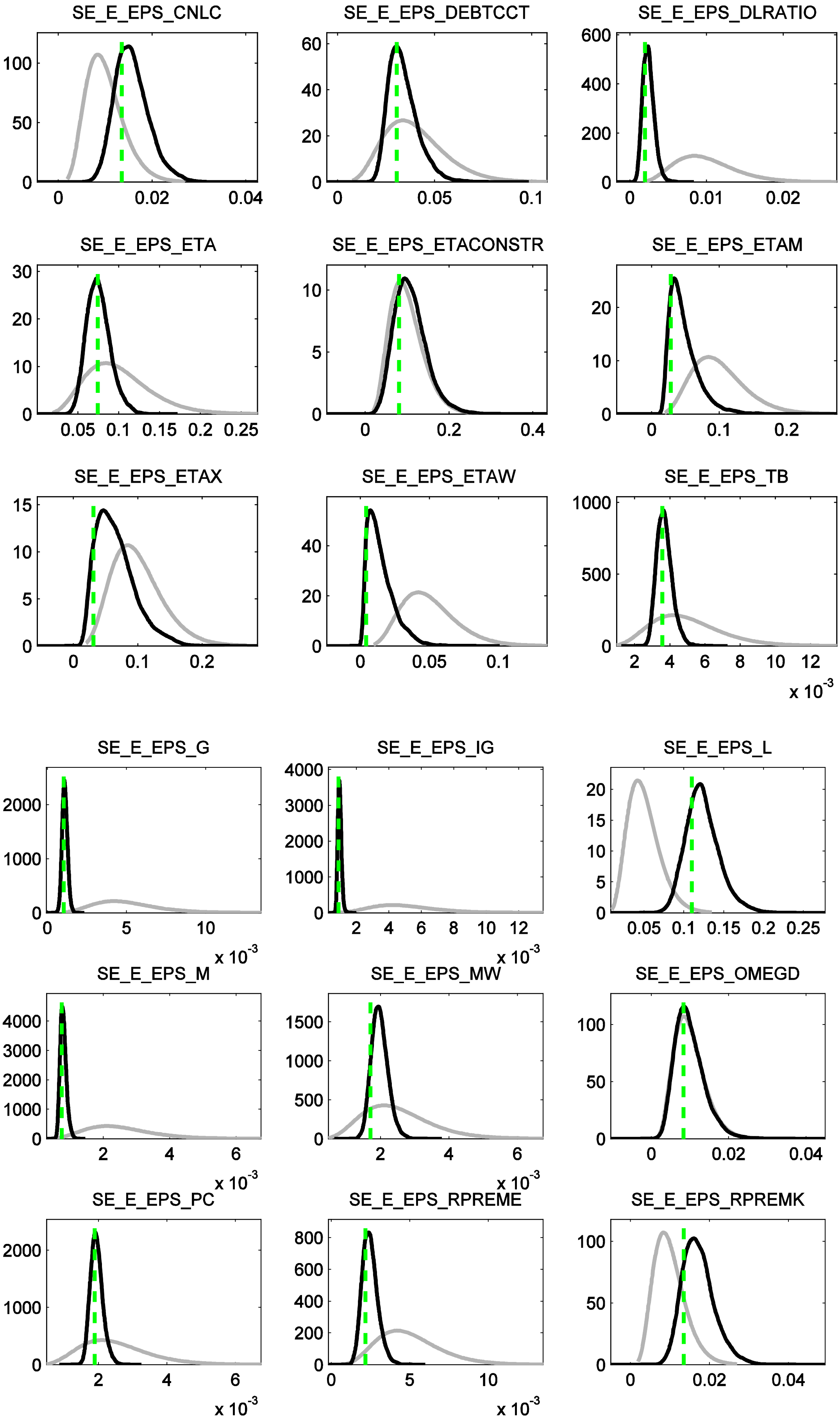
TGOVB2E	beta	0.02	0.01	0.01353	0.0064	0.003407	0.02322
TGOVB1IGE	beta	0.02	0.01	0.01389	0.0037	0.007545	0.02045
TGOVB2IGE	beta	0.02	0.01	0.01351	0.0059	0.004168	0.0224
TGOVB1TRE	beta	0.02	0.01	0.009342	0.0046	0.00179	0.01628
TGOVB2TRE	beta	0.02	0.01	0.01064	0.0062	0.001739	0.01918
TINFE	beta	2	0.6	2.178	0.5074	1.336	2.982
TINFWE	beta	2	0.6	1.551	0.1812	1.28	1.818
TAUWE	gamma	6	4	6.526	2.9529	1.359	12.23
TRSLAGE	beta	0.5	0.2	0.7419	0.1459	0.5276	0.9657
TY1E	beta	1	0.4	1.023	0.2655	0.5564	1.491
TYWE	beta	0.3	0.2	0.02346	0.0173	0.00053	0.04587
WMUPE	gamma	3.5	1	6.371	1.3429	4.07	8.573

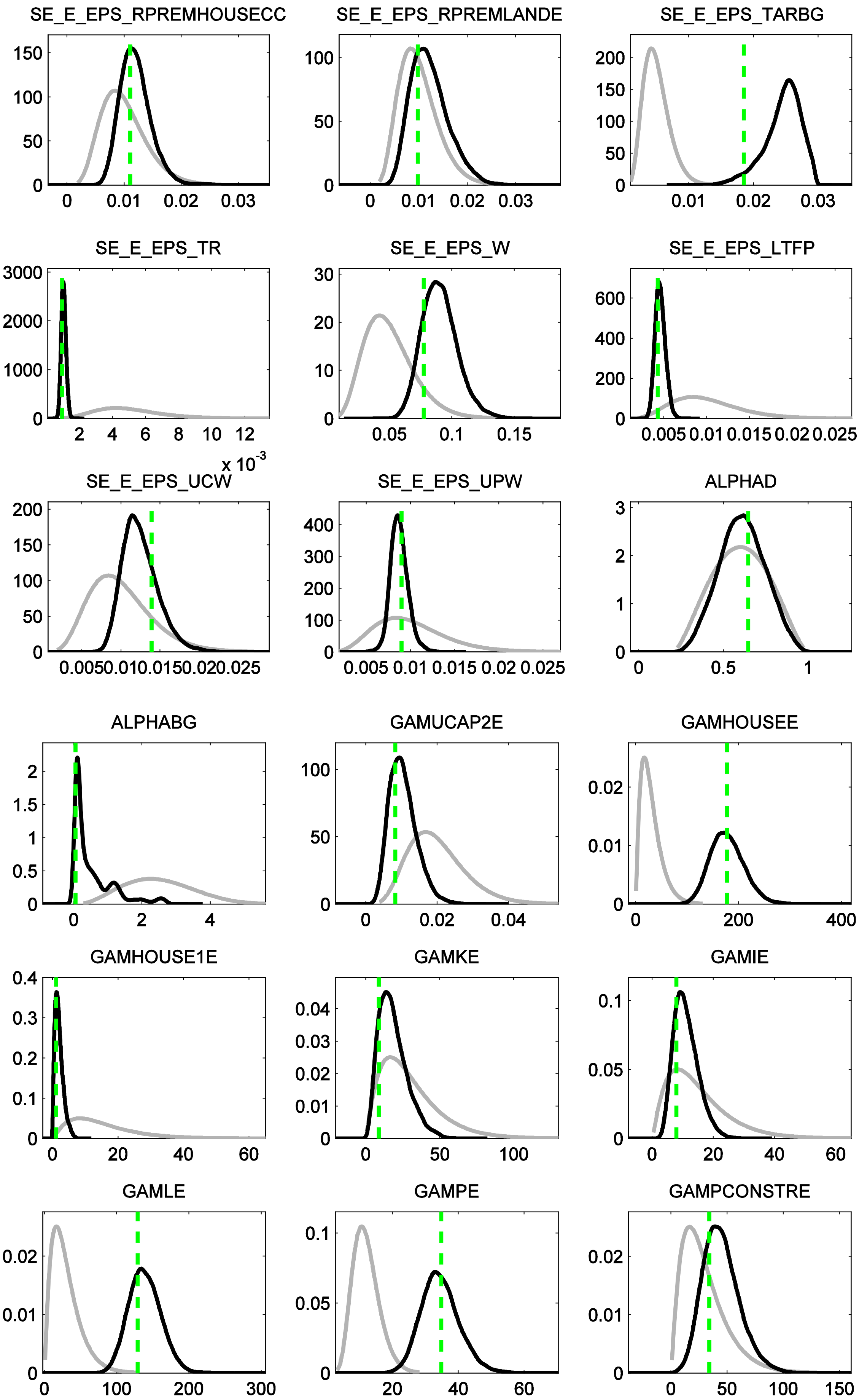
Table A.2: full table of posterior shocks estimates.

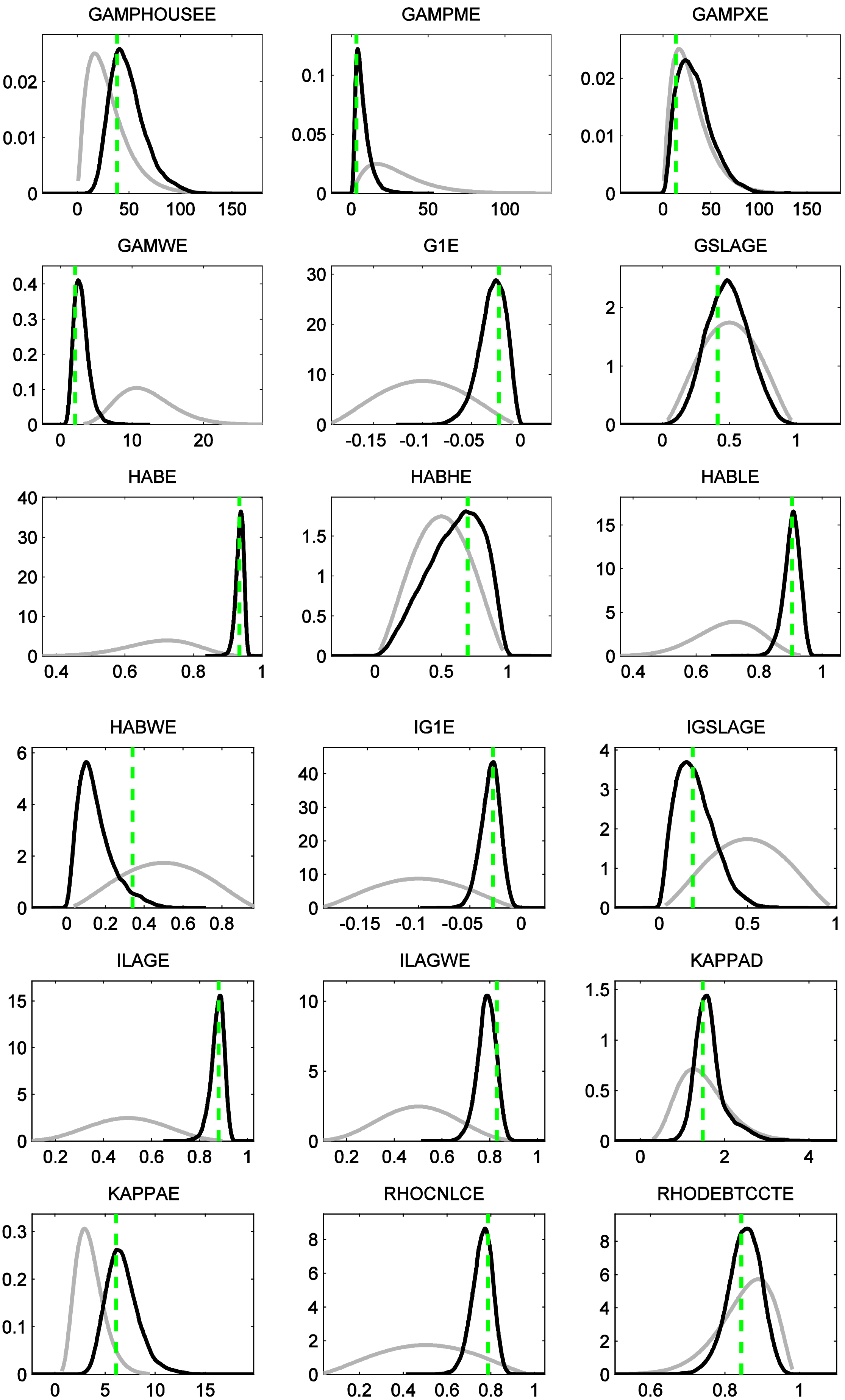
	Prior			Posterior			
	distrib.	mean	std	mean	std	hpdinf	hpdsup
RHOCNLCE	beta	0.5	0.2	0.7603	0.0463	0.6842	0.8358
RHODEBTCCTE	beta	0.85	0.075	0.8514	0.0454	0.7798	0.9248
RHODLRATIO	beta	0.85	0.075	0.9018	0.0594	0.8131	0.9833
RHOETAE	beta	0.5	0.2	0.2072	0.0975	0.0489	0.3562
RHOETACONSTRE	beta	0.5	0.2	0.8008	0.0651	0.6906	0.9161
RHOETAME	beta	0.85	0.075	0.7229	0.0779	0.5976	0.8523
RHOETAXE	beta	0.85	0.075	0.886	0.0439	0.8142	0.9666
RHOETAWE	beta	0.85	0.075	0.8872	0.0784	0.7889	0.985
RHOGE	beta	0.85	0.075	0.9339	0.0304	0.8877	0.9826
RHOIGE	beta	0.5	0.2	0.3105	0.1311	0.0783	0.5287
RHOLE	beta	0.85	0.075	0.8005	0.0493	0.7174	0.8815
RHOME	beta	0.5	0.15	0.4198	0.1039	0.2415	0.5929
RHOOMEGDE	beta	0.5	0.2	0.8386	0.0268	0.3186	0.9892
RHORPEE	beta	0.85	0.075	0.9456	0.0168	0.9197	0.9718
RHORPKE	beta	0.85	0.075	0.7747	0.0548	0.6852	0.865
RHORPHOUSECCE	beta	0.85	0.075	0.8855	0.0261	0.843	0.9302
RHORPLANDE	beta	0.85	0.075	0.9643	0.0102	0.9496	0.9798
RHOTARBG	beta	0.5	0.2	0.9111	0.0349	0.8614	0.9629
RHOTBE	beta	0.5	0.2	0.9472	0.0179	0.9188	0.9766
RHOTRE	beta	0.5	0.2	0.8336	0.1301	0.669	0.9755
RHOUCWE	beta	0.85	0.075	0.9002	0.0316	0.851	0.9515
E_EPS_CNLC	gamma	0.01	0.004	0.01564	0.0032	0.009781	0.02141
E_EPS_DEBTCCT	gamma	0.04	0.016	0.03375	0.008	0.02194	0.04541
E_EPS_DLRATIO	gamma	0.01	0.004	0.002434	5.47E-04	0.001231	0.00359
E_EPS_ETA	gamma	0.1	0.04	0.07523	0.0143	0.05096	0.09755
E_EPS_ETACONSTR	gamma	0.1	0.04	0.1076	0.042	0.04613	0.1667
E_EPS_ETAM	gamma	0.1	0.04	0.04747	0.0194	0.01832	0.07708
E_EPS_ETAX	gamma	0.1	0.04	0.06532	0.0277	0.01971	0.1088
E_EPS_ETAW	gamma	0.05	0.02	0.01473	0.0088	0.002062	0.02819
E_EPS_TB	gamma	0.005	0.002	0.00369	4.10E-04	0.002959	0.004369
E_EPS_G	gamma	0.005	0.002	0.001108	1.68E-04	0.000841	0.001384
E_EPS_IG	gamma	0.005	0.002	0.000967	1.06E-04	0.000785	0.001137
E_EPS_L	gamma	0.05	0.02	0.1232	0.0187	0.08835	0.1559
E_EPS_M	gamma	0.003	0.001	0.000799	8.36E-05	0.000643	0.000941
E_EPS_MW	gamma	0.003	0.001	0.001975	2.34E-04	0.001583	0.002357
E_EPS_OMEGD	gamma	0.01	0.004	0.009915	0.0042	0.003868	0.0157
E_EPS_PC	gamma	0.003	0.001	0.001945	1.77E-04	0.001642	0.002231
E_EPS_RPREME	gamma	0.005	0.002	0.002467	4.88E-04	0.001667	0.003245
E_EPS_RPREMK	gamma	0.01	0.004	0.01717	0.0038	0.01066	0.02354
E_EPS_RPREMHOUSECC	gamma	0.01	0.004	0.01196	0.0024	0.007621	0.01619
E_EPS_RPREMLANDE	gamma	0.01	0.004	0.01221	0.0041	0.005918	0.01815
E_EPS_TARBG	gamma	0.005	0.002	0.02452	0.0032	0.02025	0.02909

E_EPS_TR	gamma	0.005	0.002	0.001038	1.36E-04	0.000794	0.001269
E_EPS_W	gamma	0.05	0.02	0.09005	0.0143	0.06692	0.1125
E_EPS_LTFP	gamma	0.01	0.004	0.004588	5.90E-04	0.003636	0.005584
E_EPS_UCW	gamma	0.01	0.004	0.01245	0.0023	0.008923	0.01605
E_EPS_UPW	gamma	0.01	0.004	0.008722	0.001	0.007167	0.01033

Figure A.1. Prior and posterior plots




SE_E_EPS_RPREMHOUSECC
SE_E_EPS_RPREMLANDE
SE_E_EPS_TARBG
SE_E_EPS_TR
x 10^-3
SE_E_EPS_W
SE_E_EPS_LTFP
SE_E_EPS_UCW
SE_E_EPS_UPW
ALPHAD
ALPHABG
GAMUCAP2E
GAMHOUSEE
GAMHOUSE1E
GAMKE
GAMIE
GAMLE
GAMPE
GAMPCONSTRE


GAMPHOUSEE
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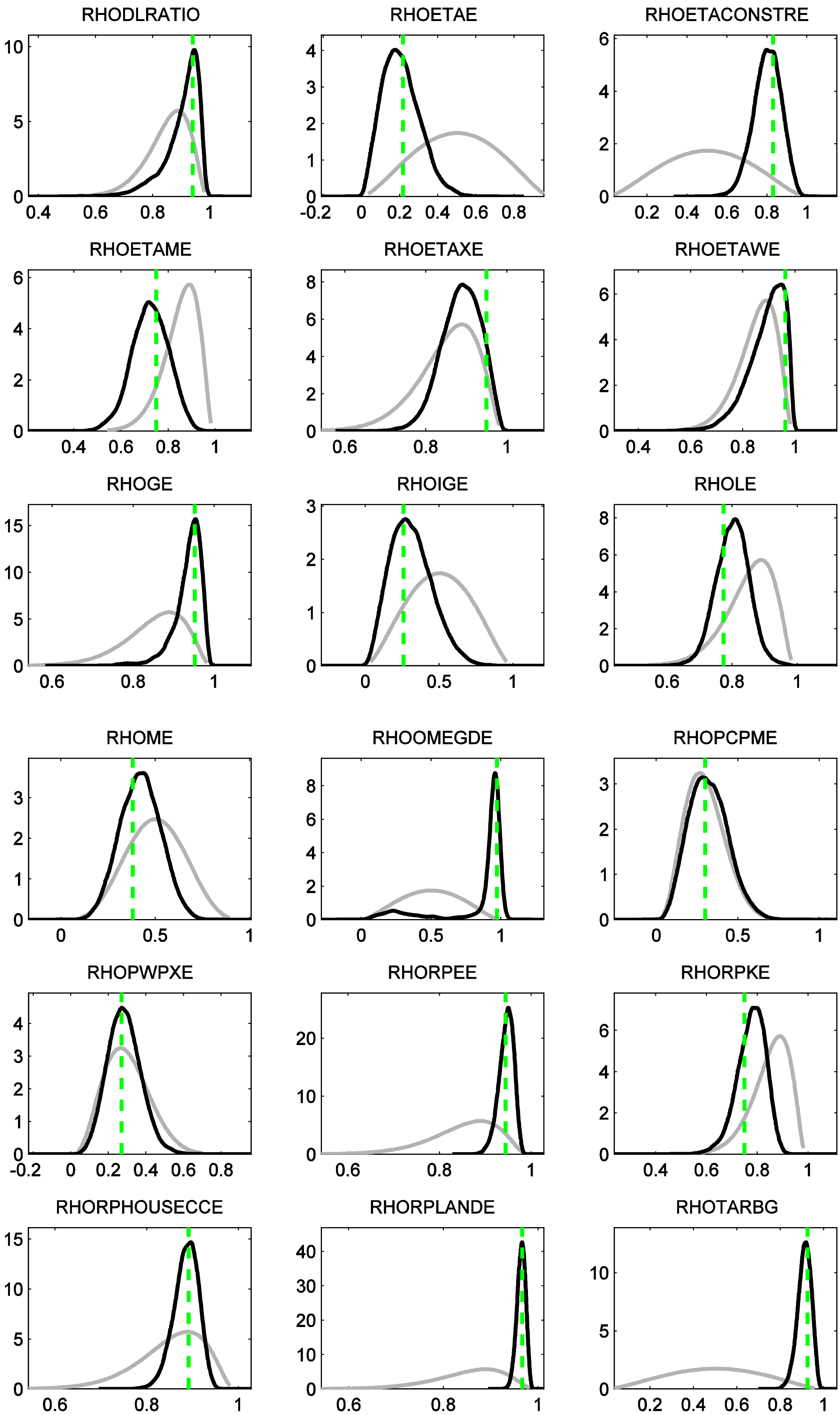
0.01
0
0 50 100 150
GAMPME
0.1
0.05
0
0 50 100
GAMPXE
0.02
0.01
0
0 50 100 150
GAMWE
0.4
0.3
0.2
0.1
0
0 10 20
G1E
30
20
10
0
-0.15 -0.1 -0.05 0
GSLAGE
2
1
0
0 0.5 1
HABE
40
30
20
10
0
0.4 0.6 0.8 1
HABHE
1.5
1
0.5
0
0 0.5 1
HABLE
15
10
5
0
0.4 0.6 0.8 1
HABWE
6
4
2
0
0 0.2 0.4 0.6 0.8
IG1E
40
30
20
10
0
-0.15 -0.1 -0.05 0
IGSLAGE
4
3
2
1
0
0 0.5 1
ILAGE
15
10
5
0
0.2 0.4 0.6 0.8 1
ILAGWE
10
5
0
0.2 0.4 0.6 0.8 1
KAPPAD
1.5
1
0.5
0
0 2 4
KAPPAE
0.3
0.2
0.1
0
0 5 10 15
RHOCNLCE
8
6
4
2
0
0.2 0.4 0.6 0.8 1
RHODEBTCCTE
8
6
4
2
0
0.6 0.8 1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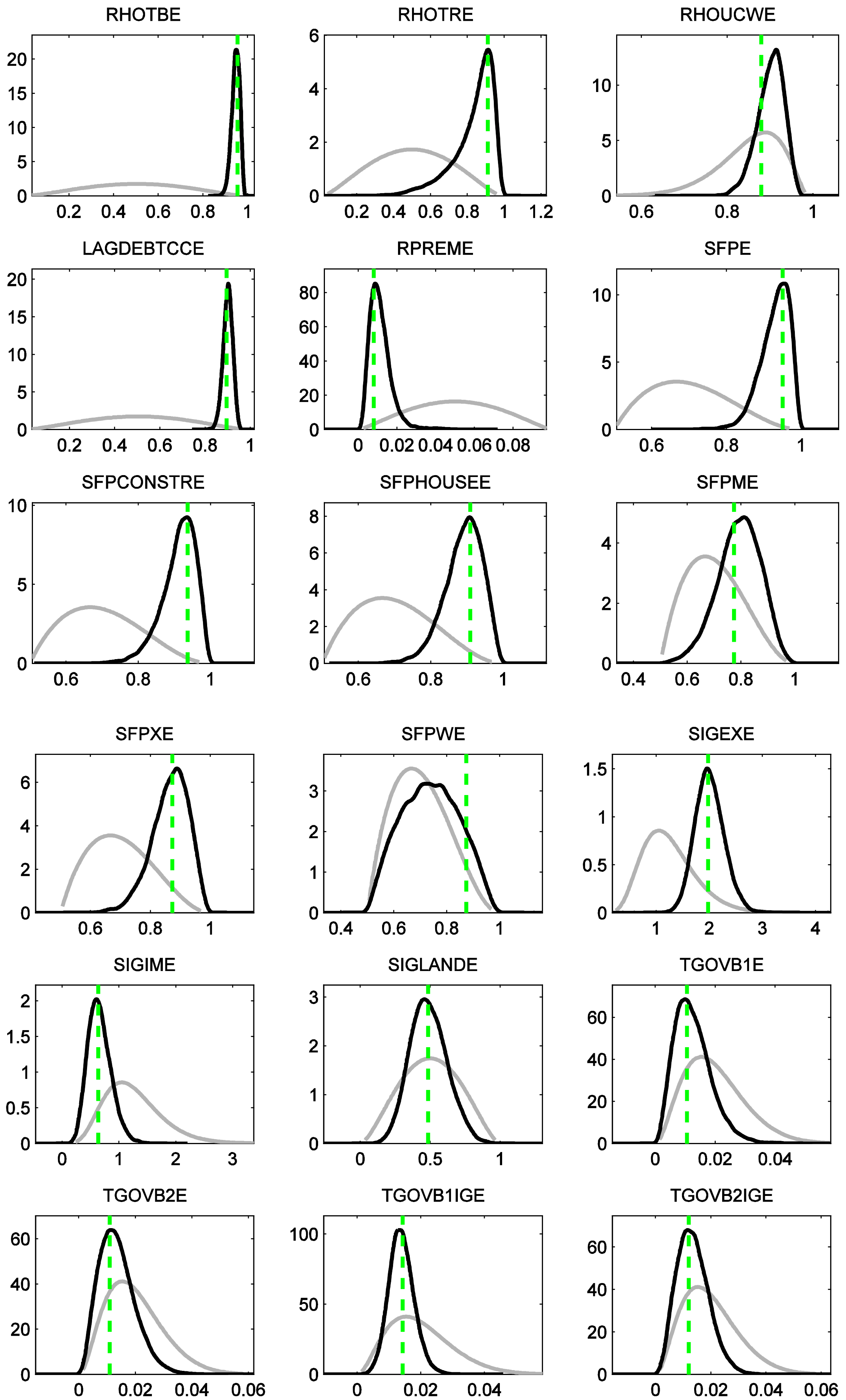
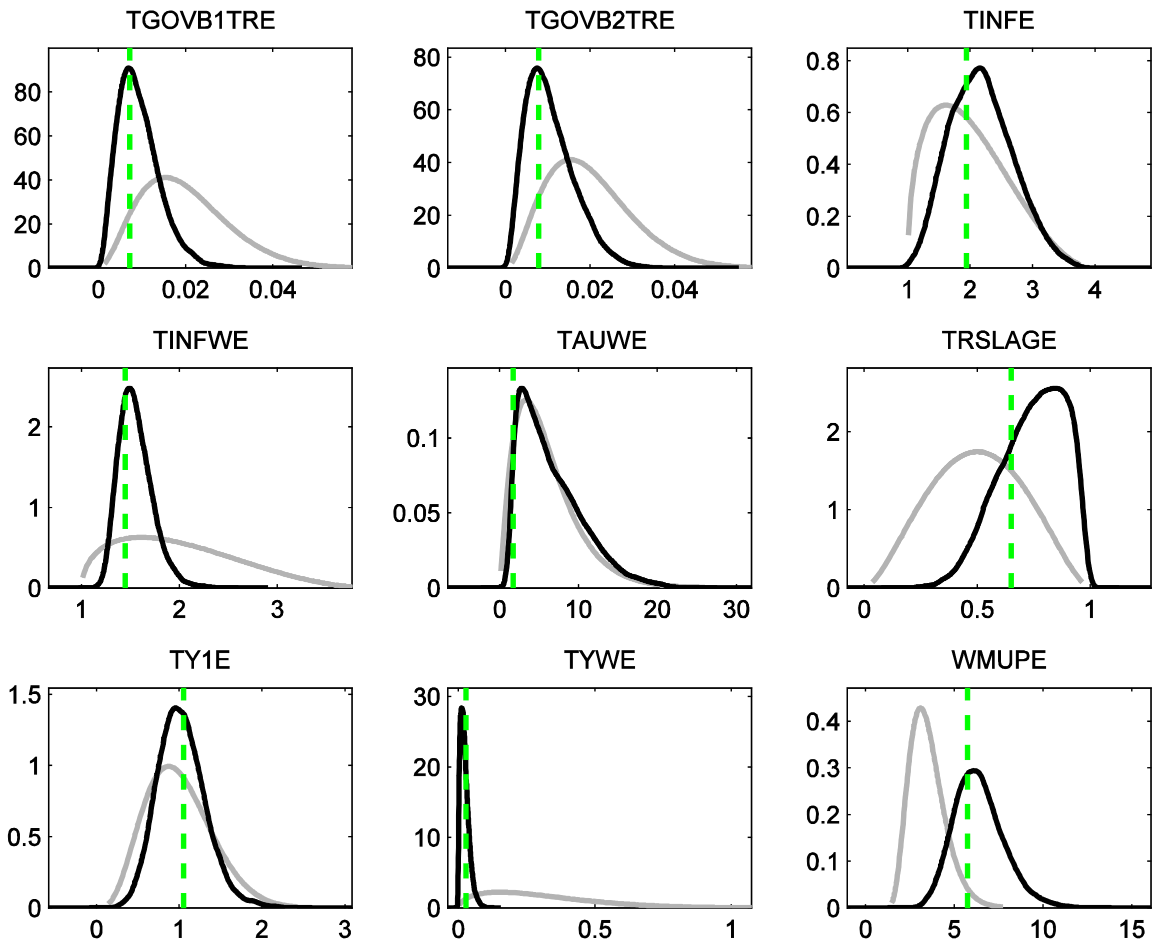
5
0
0.4 0.6 0.8 1
RHOETAE
4
3
2
1
0
-0.2 0 0.2 0.4 0.6 0.8
RHOETACONSTRE
6
4
2
0
0.2 0.4 0.6 0.8 1
RHOETAME
6
4
2
0
0.4 0.6 0.8 1
RHOETAXE
8
6
4
2
0
0.6 0.8 1
RHOETAWE
6
4
2
0
0.4 0.6 0.8 1
RHOGE
15
10
5
0
0.6 0.8 1
RHOIGE
3
2
1
0
0 0.5 1
RHOLE
8
6
4
2
0
0.6 0.8 1
RHOME
3
2
1
0
0 0.5 1
RHOOMEGDE
8
6
4
2
0
0 0.5 1
RHOPCPME
3
2
1
0
0 0.5 1
RHOPWPXE
4
3
2
1
0
-0.2 0 0.2 0.4 0.6 0.8
RHORPEE
20
10
0
0.6 0.8 1
RHORPKE
6
4
2
0
0.4 0.6 0.8 1
RHORPHOUSECCE
15
10
5
0
0.6 0.8 1
RHORPLANDE
40
30
20
10
0
0.6 0.8 1
RHOTARBG
10
5
0
0.2 0.4 0.6 0.8 1


RHOTBE
RHOTRE
RHOUCWE
LAGDEBTCCE
RPREME
SFPE
SFPCONSTRE
SFPHOUSEE
SFPME
SFPXE
SFPWE
SIGEXE
SIGIME
SIGLANDE
TGOVB1E
TGOVB2E
TGOVB1IGE
TGOVB2IGE


TGOVB1TRE
TGOVB2TRE
TINFE
TINFWE
TAUWE
TRSLAGE
TY1E
TYWE
WMUPE

KC-AI-12-464-EN-N

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