Fiscal policy and the Great Recession in the euro area

Coenen, Gunter and Straub, Roland and Trabandt, Mathias

European Central Bank

December 2011

Fiscal Policy and the Great Recession in the Euro Area[⋆]

Günter Coenen, Roland Straub, Mathias Trabandt[†]

December 31, 2011

Abstract

How much did fiscal policy contribute to euro area real GDP growth during the Great Recession? We estimate that *discretionary* fiscal measures have increased annualized quarterly real GDP growth during the crisis by up to 1.6 percentage points. We obtain our result by using an extended version of the European Central Bank's New Area-Wide Model with a rich specification of the fiscal sector. A detailed modeling of the fiscal sector and the incorporation of as many as eight fiscal time series appear pivotal for our result.

JEL Classification System: C11, E32, E62

Keywords: Fiscal policy, DSGE modelling, Bayesian inference, euro area

⋆ Correspondence: Coenen: Directorate General Research, European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany, e-mail: gunter.coenen@ecb.int; Straub: Directorate General International and European Relations, European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany, e-mail: roland.straub@ecb.int; Trabandt: Division of International Finance, Board of Governors of the Federal Reserve System, 20th Street and Constitution Avenue N.W, Washington, DC 20551, USA, e-mail: mathias.trabandt@googlemail.com.

† We have benefited from presentations of earlier drafts at the ECB Conference on "Monetary and Fiscal Policy Challenges in Times of Financial Stress", at the Banque de France-Deutsche Bundesbank-University of Hamburg Workshop on "Current Macroeconomic Challenges", at the Annual Congress 2011 of the German Economic Association, and at Norges Bank. Without implicating, we are particularly grateful for comments from and helpful discussions with Kai Christoffel, Thorsten Drautzburg, Jordi Galí, Robert Kollmann, Thomas Laubach, Eric Leeper, Marco Del Negro, Werner Roeger, Chris Sims, Frank Smets, Nikolai Staehler, Leopold von Thadden, Harald Uhlig and Anders Warne. We also thank Markus Kirchner for valuable support at an earlier stage in the preparation of this paper. The opinions expressed in the paper are those of the authors and do not necessarily reflect views of the institutions with which the authors are affiliated.

1 Introduction

The financial crisis triggered a large-scale fiscal policy response in the euro area, leading to a sizeable increase in government deficits and debt levels. In the policy debate, it is often argued that expansionary fiscal policies had a substantial impact on economic activity. So a natural question that arises is how much did fiscal policy actually contribute to euro area real GDP growth during the so-called Great Recession?

Most of the theoretical and empirical literature that analyses the impact of fiscal policy on economic activity has focused on the size and sensitivity of fiscal multipliers or on the effectiveness of fiscal stimulus packages.[1] Prominent examples are the recent model-based studies by Cogan et al. (2010), Christiano et al. (2011) and Coenen et al. (2012).[2] However, the full fiscal policy response to the financial crisis did not rely on discretionary fiscal stimulus alone. For instance, automatic stabilisers, as well as financial sector support measures, did provide further support to the economy. Therefore, it is deemed essential to account for the effects of automatic stabilisers when assessing the quantitative impact of discretionary fiscal policies on real GDP during the crisis.

In this paper, and in contrast to previous model-based studies, we provide an ex-post evaluation of the overall effectiveness of discretionary fiscal policies in the euro area during the crisis on the basis of a growth accounting exercise. To this end, we utilise an extended version of the ECB's New Area-Wide Model (NAWM) with a detailed specification of the fiscal sector to decompose the dynamics of real GDP growth in the euro area into the contributions of fiscal and non-fiscal shocks over the period of 2007-10. Our specification of the fiscal sector aims at balancing the need for a high degree of detail, which is deemed important for conducting a meaningful quantitative analysis of the impact of fiscal policy on real GDP, and tractability, which permits identifying the relevant economic mechanisms. Specifically, the extended NAWM features: (i) non-Ricardian households, so that government transfers have real effects; (ii) government consumption, which is valued by households in a non-separable way; (iii) public capital subject to a time-to-build technology, which can be either a complement or a substitute of private capital; (iv) time-varying distortionary tax rates; and (v) fiscal rules, capturing the operation of automatic stabilisers.

Our model-based estimates suggest that discretionary fiscal policies led to an increase in annualized quarterly real GDP growth by up to 1.6 percentage points during the crisis.

[1] Two such large-scale fiscal packages were the American Recovery and Reinvestment Act (ARRA) in the United States and the European Economic Recovery Plan (EERP) in the European Union.

[2] See also Corsetti et al. (2011), Drautzburg and Uhlig (2011), Eggertsson (2011), Erceg and Lindé (2010), Uhlig (2010) and Woodford (2011). A review of the literature can be found in Coenen et al. (2012).

The incorporation of as many as 8 time series that characterise fiscal policy and a detailed modelling of the fiscal sector appear to be pivotal for our result. That is, a baseline version of the model that only measures one fiscal time series, namely government consumption, and that has a rather stylised fiscal sector, predicts a negligible role of fiscal policies for real GDP growth during the crisis. We cross-check our central result by inspecting the model's multipliers and by conducting an assessment of the European Economic Recovery Plan (EERP) similar to Cwik and Wieland (2010), European Commission (2009) and ECB (2010).[3] We show that our results are comparable to the findings in these studies, i.e. we find that the effects of fiscal stimulus packages can be sizeable but are rather short lived.

The remainder of the paper is structured as follows. Section 2 provides an overview of the model, while Section 3 reports on the data and the main estimation results. Section 4 presents our central result regarding the contribution of discretionary fiscal policies to euro area real GDP growth during the crisis. Section 5 presents the multipliers and the assessment of the EERP, and Section 6 concludes.

2 The Model

In this section we give a brief overview of the extended version of the ECB's New Area-Wide Model (NAWM) with a detailed specification of the fiscal sector. As the main elements of the model's baseline version are relatively standard, we just provide a non-technical sketch of its basic structure and highlight subsequently those features that are most relevant for understanding the enhanced role of fiscal policy in the extended model.

2.1 The Baseline Model: A Bird's Eye View

The baseline version of the NAWM is a micro-founded open-economy model of the euro area designed for use in the (Broad) Macroeconomic Projection Exercises regularly undertaken by ECB/Eurosystem staff and for analysis of topical policy issues; see Coenen et al. (2008) for a detailed description of the model's structure. Its development has been guided by the principal consideration of covering a comprehensive set of core projection variables, including a small number of foreign variables, which, in the form of exogenous assumptions, play an important role in the projections.

The NAWM features four types of economic agents: households, firms, a fiscal authority and a monetary authority. Households make optimal choices regarding their purchases of

[3] See Cogan et al. (2010), Coenen et al. (2012) and Drautzburg and Uhlig (2011) for an analysis of the ARRA package in the United States.

consumption and investment goods, the latter determining the economy-wide capital stock. They supply differentiated labour services in monopolistically competitive markets, they set wages as a mark-up over the marginal rate of substitution between consumption and leisure, and they trade in domestic and foreign bonds.

As regards firms, the NAWM distinguishes between domestic producers of tradable intermediate goods and domestic producers of three types of non-tradable final goods: a private consumption good, a private investment good, and a public consumption good. The intermediate-good firms use labour and capital services as inputs to produce differentiated goods, which are sold in monopolistically competitive markets domestically and abroad. Accordingly, they set different prices for domestic and foreign markets as a mark-up over their marginal costs. The final-good firms combine domestic and foreign intermediate goods in different proportions, acting as price takers in fully competitive markets. The foreign intermediate goods are imported from producers abroad, who set their prices in euro in monopolistically competitive markets, allowing for an incomplete exchange-rate pass-through. A foreign retail firm in turn combines the exported domestic intermediate goods, where aggregate export demand depends on total foreign demand.

Both households and firms face nominal and real frictions, which have been identified as important in generating empirically plausible dynamics. Real frictions are introduced via external habit formation in consumption, through generalised adjustment costs in investment, imports and exports, and through fixed cost in intermediate goods production. Nominal frictions arise from staggered price and wage-setting à la Calvo (1983), along with (partial) dynamic indexation of price and wage contracts. In addition, there exist financial frictions in the form of domestic and external risk premia.

The fiscal authority purchases the public consumption good, issues domestic bonds, and levies different types of distortionary taxes, albeit at constant rates. Nevertheless, Ricardian equivalence holds because of the simplifying assumption that the fiscal authority's budget is balanced each period by means of lump-sum taxes. The monetary authority sets the short-term nominal interest rate according to a Taylor (1993)-type interest-rate rule, stabilising inflation in line with the ECB's definition of price stability.

The NAWM is closed by a rest-of-the-world block, which is represented by a structural VAR (SVAR) model determining five foreign variables: foreign demand, foreign prices, the foreign interest rate, foreign competitors' export prices and the price of oil. The SVAR model does not feature spill-overs from the euro area, in line with the treatment of the foreign variables as exogenous assumptions in the projections.

2.2 The Model with an Enhanced Role for Fiscal Policy

In the extended version of the NAWM, we allow fiscal policy to influence the economy through several additional channels. Specifically, the extended model features: (i) non-Ricardian households, so that, inter alia, government transfers have real effects; (ii) government consumption, which is valued by households in a non-separable way; (iii) public capital subject to a time-to-build technology, which can be a complement or a substitute of private capital; (iv) time-varying distortionary tax rates; and (v) fiscal rules that determine the endogenous adjustment of the different fiscal instruments.

2.2.1 Households and Government Consumption

We adapt the baseline model by introducing non-Ricardian households in the form of rule-of-thumb consumers, following Galí, López-Salido and Vallés (2007) and Coenen and Straub (2005).[4] To this end, we assume that there is a continuum of households, indexed by $h \in [0,1]$, which is split into two groups: (i) Ricardian households, indexed by $i \in (\omega, 1]$, who accumulate physical capital and have access to financial markets, and (ii) non-Ricardian households, indexed by $j \in [0, \omega]$, who do not. As a result, the former group of households can smooth consumption intertemporally in response to shocks, whereas the latter simply consume their after-tax disposable income.[5]

Furthermore, we adapt the model by allowing for non-separable valuable government consumption similar to Leeper, Walker, and Yang (2009b). This feature has several interesting implications. First, changes in government consumption affect optimal private consumption decisions directly, as opposed to the indirect wealth effect in case of separable government consumption. Second, conditional on the estimated degree of complementarity a co-movement of private and government consumption may be obtained. Formally, aggregate consumption $\tilde{C}_{h,t}$ of household h is defined as a constant elasticity of substitution (CES) aggregate:

$$\tilde{C}_{h,t} = \left(\alpha_G^{\frac{1}{\upsilon_G}} \, C_{h,t}^{\frac{\upsilon_G - 1}{\upsilon_G}} + (1 - \alpha_G)^{\frac{1}{\upsilon_G}} \, G_t^{\frac{\upsilon_G - 1}{\upsilon_G}} \right)^{\frac{\upsilon_G}{\upsilon_G - 1}}, \tag{1}$$

where $C_{h,t}$ denotes the household's consumption of private goods, and G_t measures government consumption. Note that α_G is a share parameter and $\upsilon_G > 0$, where υ_G measures

[4] There is a large literature on rule-of-thumb consumers, with early contributions by Campbell and Mankiw (1989) and Mankiw (2000).

[5] Coenen, McAdam and Straub (2008) consider a generalised framework in which non-Ricardian households can adjust their holdings of money subject to a transaction cost technology, which gives rise to limited consumption smoothing on the part of non-Ricardian households.

the elasticity of substitution between private consumption and government consumption. $\upsilon_G \to 0$ implies perfect complementarity, $\upsilon_G \to \infty$ gives perfect substitutability, and $\upsilon_G \to 1$ yields the Cobb-Douglas (CD) case.

Ricardian Households

Each Ricardian household i maximises its lifetime utility in a given period t by choosing purchases of the private consumption good, $C_{i,t}$, purchases of a private investment good, $I_{i,t}$, which determines next period's private capital stock, $K_{i,t+1}$, and next period's (net) holdings of domestic government bonds and internationally traded foreign bonds, $B_{i,t+1}$ and $B^*_{i,t+1}$, respectively. The household's lifetime utility function is given by:

$$\mathrm{E}_t \left[\sum_{k=0}^{\infty} \beta^k \left(\ln \left(\tilde{C}_{i,t+k} - \kappa \, \tilde{C}_{t+k-1} \right) - \frac{1}{1+\zeta} \, (N_{i,t+k})^{1+\zeta} \right) \right], \tag{2}$$

where β denotes the discount factor and ζ is the inverse of the Frisch elasticity of labour supply. The parameter κ measures the degree of external habit formation in consumption. Thus, the utility of household i depends positively on the difference between the current household-specific aggregate consumption bundle, $\widetilde{C}_{i,t}$, and the lagged economy-wide aggregate consumption bundle, $\widetilde{C}_{t-1}$, and negatively on labour supply, $N_{i,t}$.

The household faces the following period-by-period budget constraint:

$$\begin{aligned} &(1+\tau_t^C)\, P_{C,t}\, C_{i,t} + P_{I,t}\, I_{i,t} + \frac{B_{i,t+1}}{\epsilon_t^{RP} R_t} + \frac{S_t\, B^*_{i,t+1}}{[1-\Gamma_{B^*}(B^*_{t+1};\epsilon_t^{RP^*})]\; R^*_t} + T_{i,t} \qquad (3)\\ &\quad = (1-\tau_t^N - \tau_t^{W_h})\, W_{i,t}\, N_{i,t} + \left[(1-\tau_t^K)\, R_{K,t} + \tau_t^K\, \delta\, P_{I,t}\right] K_{i,t} + (1-\tau_t^D)\, D_{i,t} \\ &\qquad + TR_{i,t} + B_{i,t} + S_t\, B^*_{i,t} + \Xi^B_{i,t} + \Xi^{B^*}_{i,t}, \end{aligned}$$

where $P_{C,t}$ and $P_{I,t}$ are the prices of a unit of the private consumption good $C_{i,t}$ and the investment good $I_{i,t}$, respectively. $W_{i,t}$ denotes the wage rate for the labour services provided to firms, $N_{i,t}$; $R_{K,t}$ indicates the rental rate for the capital services rented to firms, $K_{i,t}$; and $D_{i,t}$ are the dividends paid by the household-owned firms. R_t and R^*_t denote the respective risk-less returns on domestic government bonds and internationally traded foreign bonds. The latter are denominated in foreign currency and, thus, their domestic value depends on the nominal exchange rate S_t.

The fiscal authority absorbs part of the household's gross income to finance its expenditure. τ_t^C denotes the consumption tax rate that is levied on the household's consumption purchases; and τ_t^N, τ_t^K and τ_t^D are the tax rates levied on the different sources of the household's income: wage income, capital income and dividend income. Here, for simplicity, we assume that the physical capital depreciation, $\delta\, P_{I,t}\, K_{i,t}$, is exempted from taxation. $\tau_t^{W_h}$ is the additional payroll tax rate levied on wage income (representing the household's contribution to social security). The terms $T_{i,t}$ and $TR_{i,t}$ denote lump-sum taxes and lump-sum transfers, respectively.

The effective return on the risk-less domestic bonds depends on a financial intermediation premium, represented by an exogenous domestic risk premium shock ϵ_t^{RP}, which drives a wedge between the interest rate controlled by the monetary authority and the return required by households. Similarly, when taking a position in the international bond market, the household encounters an external financial intermediation premium $\Gamma_{B^*}(B_{t+1}^*; \epsilon_t^{RP^*})$, where $\epsilon_t^{RP^*}$ represents an external risk premium shock. This specification implies that, in the non-stochastic steady state, households have no incentive to hold foreign bonds and the economy's net foreign asset position is zero. The incurred intermediation premia are rebated in the form of lump-sum payments, $\Xi_{i,t}^{B}$ and $\Xi_{i,t}^{B^*}$.

Finally, the physical capital stock owned by household i evolves according to the following capital accumulation equation:

$$K_{i,t+1} \quad = \quad (1-\delta)\, K_{i,t} + \epsilon_t^I\, (1 - \Gamma_I(I_{i,t}/I_{i,t-1}))\, I_{i,t}, \tag{4}$$

where δ denotes the depreciation rate of the private capital stock. $\Gamma_I(I_{i,t}/I_{i,t-1})$ represents a generalised adjustment cost function in investment and ϵ_t^I is an investment-specific technology shock.

Non-Ricardian Households

The preferences of non-Ricardian and Ricardian households are identical. However, Non-Ricardian households do not invest in physical capital and have no access to financial markets. Therefore, each non-Ricardian household j sets nominal consumption expenditure equal to after-tax disposable wage income plus government transfers. This results in the following period-by-period budget constraint:

$$(1+\tau_t^C)\, P_{C,t}\, C_{j,t} \quad = \quad (1 - \tau_t^N - \tau_t^{W_h})\, W_{j,t}\, N_{j,t} + TR_{j,t}. \tag{5}$$

Note that the approach to introducing non-Ricardian households adopted here implies that lump-sum taxes are only paid by Ricardian households. Moreover, in response to stochastic shocks, we allow for a possibly uneven distribution of transfers amongst Ricardian and non-Ricardian households according to the following rule: $\varpi\,(TR_{i,t}/TR_i - 1) = (1 - \varpi)\,(TR_{j,t}/TR_j - 1)$.[6]

Wage Setting and Labour Supply

As in Coenen and Straub (2005), we assume that both the Ricardian and the non-Ricardian households supply their labour services to firms via unions which act as wage setters in monopolistically competitive markets, taking firms' aggregate demand for labour as given. Furthermore, we assume that the individual union's choice variable is a common nominal wage rate for both types of households. These assumptions imply that the model's aggregate wage Phillips curve is unaffected by the introduction of non-Ricardian households.

Finally, we assume that the unions pool the wage income of all households and then distribute the aggregate wage income in equal proportions.[7] The common wage rate, $W_{i,t} = W_{j,t} = W_t$, and identical separable preferences imply that Ricardian and non-Ricardian households supply the same amount of labour, i.e. $N_{i,t} = N_{j,t} = N_t$.[8]

2.2.2 Intermediate-Good Firms and Public Capital

Public capital is added as an input for domestic intermediate goods production. In particular, each intermediate-good firm $f \in [\,0,1\,]$ producing a differentiated intermediate good $Y_{f,t}$ has access to a Cobb-Douglas technology which takes as inputs labour services $N_{f,t}$ and physical capital $\tilde{K}_{f,t}$:

$$Y_{f,t} \;=\; \varepsilon_t \left(\tilde{K}_{f,t}\right)^{\alpha} (z_t\, N_{f,t})^{1-\alpha} - z_t\,\psi. \tag{6}$$

The variable ε_t represents a serially correlated, but transitory technology shock that affects total factor productivity, while the variable z_t denotes a permanent technology shock that introduces a unit root in the firm's output by augmenting the productivity of labour lastingly. The (gross) rate of labour-augmenting productivity $g_{z,t} = z_t/z_{t-1}$ follows a serially correlated process and determines the model's balanced growth path. The term $z_t\,\psi$ represents the firm's fixed costs of production.

Physical capital is a CES aggregate of private capital services $K_{f,t}$ and the public capital

[6] In steady state, we compute TR_i and TR_j such that $C_j/C_i = \iota$, where ι is an estimated parameter which equals roughly 0.8 at the posterior mode.

[7] Formally, this can be justified by the existence of state-contingent securities that are traded amongst unions in order to insure households against variations in household-specific wage income associated with Calvo-type wage rigidities.

[8] The alternative assumption that non-Ricardian households set their wage rate equal to the average wage rate of Ricardian households and face identical labour demand would yield the same result that wages and labour supply are identical across both groups.

stock $K_{G,t}$:

$$\tilde{K}_{f,t} = \left(\alpha_K^{\frac{1}{\upsilon_K}} \left(K_{f,t}\right)^{\frac{\upsilon_K - 1}{\upsilon_K}} + \left(1 - \alpha_K\right)^{\frac{1}{\upsilon_K}} \left(K_{G,t}\right)^{\frac{\upsilon_K - 1}{\upsilon_K}}\right)^{\frac{\upsilon_K}{\upsilon_K - 1}}, \tag{7}$$

where α_K is a share parameter, and the parameter $\upsilon_K > 0$ denotes the elasticity of substitution between private capital services and the public capital stock. $\upsilon_K \to 0$ implies perfect complements, $\upsilon_K \to \infty$ gives perfect substitutes, and $\upsilon_K \to 1$ yields the CD case. Note that each intermediate-good firm f has access to the same public capital stock and that the latter grows at the same speed as private capital services along the balanced growth path of the model.

Recently, Leeper, Walker and Yang (2009b) have argued that time-to-build for public capital is important for analysing the American Recovery and Reinvestment Act (ARRA). In fact, government investment is typically subject to longer implementation delays than, for example, government goods purchases. In particular, it takes time until a budgeted government investment project (e.g. infrastructure) is implemented and contributes to the public capital stock. Leeper, Walker and Yang (2009b) model the delays between the authorisation of a government spending plan and completion of an investment project by a time-to-build technology for public capital projects, as in Kydland and Prescott (1982).[9]

We allow for the possibility of several periods of time-to-build in public capital, adopting a similar specification. We thus assume that the government initiates investment projects that take L periods until they become productive and augment the public capital stock. The law of motion for public capital is then given by:

$$K_{G,t+1} = \left(1 - \delta_G\right) K_{G,t} + A_{I_G,t-L+1}, \tag{8}$$

where δ_G, denotes the depreciation rate of the public capital stock. $A_{I_G,t-L+1}$ is the authorised budget for government investment in period $t - L + 1$. Government investment that is actually implemented (outlayed) is defined by:

$$I_{G,t} = \sum_{n=0}^{L-1} b_n \, A_{I_G,t-n} \tag{9}$$

with $\sum_{n=0}^{L-1} b_n = 1$, and enters the government budget constraint as well as the economy's aggregate resource constraint.

[9] For an approach in which the government chooses government investment to maximise output net of government investment, see e.g. Drautzburg and Uhlig (2011).

In the case of a one-period time-to-build technology (as assumed for private investment), public investment outlayed in period t becomes productive in period $t+1$, i.e. $L = 1$ and $I_{G,t} = A_{I_G,t}$.

2.2.3 Government Budget Constraint and Fiscal Rules

The fiscal authority purchases the public consumption good, G_t, and the public investment good, $I_{G,t}$, issues bonds to refinance its debt, B_t, makes transfer payments, TR_t, and raises different types of taxes with details on the latter given above. The fiscal authority's period-by-period budget constraint has the following form:[10]

$$\begin{aligned} & P_{G,t}\, G_t + P_{I_G,t}\, I_{G,t} + B_t + TR_t \\ & \quad = \tau_t^C\, P_{C,t}\, C_t + \left(\tau_t^N + \tau_t^{W_h} + \tau_t^{W_f}\right) W_t\, N_t \\ & \qquad + \tau_t^K\, (R_{K,t} - \delta\, P_{I,t})\, K_t + \tau_t^D\, D_t + \frac{B_{t+1}}{R_t} + T_t, \end{aligned} \tag{10}$$

where $P_{G,t}$ and $P_{I_G,t}$ are the prices of a unit of the public consumption good and the public investment good, respectively. $\tau_t^{W_f}$ denotes the rate of firms' contributions to social security. Note that all quantities are expressed in per-capita terms.[11]

The fiscal instruments on both the expenditure and revenue side are assumed to follow the prescriptions of simple feedback rules with a uniform specification. Specifically, we assume that all fiscal instruments react to their own lagged values, to real government debt, B_t/P_t, and to output, Y_t, where the latter feedback is thought to reflect the notion of automatic stabilisers.

On the expenditure side, taking government consumption as an example, the log-linear specification of the rule is given by:

$$\hat{g}_t = \theta_G\, \hat{g}_{t-1} + \theta_{G,B}\, \hat{b}_t + \theta_{G,Y}\, \hat{y}_t + (1-\psi_G)\, \hat{\eta}_t^G + \psi_G\, \hat{\eta}_{t-1}^G, \tag{11}$$

where a '^' denotes log-deviations from the values implied by the model's balanced growth path, or steady state. η_t^G is an unanticipated shock to government consumption, representing a discretionary fiscal impulse. Following Leeper, Walker and Yang (2009a) we allow for

[10] In deriving the budget constraint, we have used the fact that the total wage sum paid by firms to the households equals $\int_0^1 W_{h,t}\, N_{h,t}\, dh = N_t \int_0^1 W_{h,t}\, (W_{h,t}/W_t)^{-\varphi^W/(\varphi^W-1)}\, dh = W_t\, N_t$, where φ^W denotes the steady-state wage markup in the model.

[11] The aggregate quantity of a household-specific variable $X_{h,t}$, expressed in per-capita terms, is given by $X_t = \int_0^1 X_{h,t}\, dh = (1-\omega)\, X_{i,t} + \omega\, X_{j,t}$.

pre-announcement effects, with a weight of ψ_G. In terms of fiscal feedback rules, we allow for the same structure for government investment and government transfers.

Similarly, as an illustration of the fiscal rules on the revenue side, the labour tax rule is given by:

$$\breve{\tau}_t^N = \theta_N \, \breve{\tau}_{t-1}^N + \theta_{N,B} \, \hat{b}_t + \theta_{N,Y} \, \hat{y}_t + (1 - \psi_N) \, \hat{\eta}_t^N + \psi_N \, \hat{\eta}_{t-1}^N, \tag{12}$$

where a '$\breve{}$' denotes percentage-point deviations from the steady-state tax rate. In terms of rules, we allow for the same structure for employer and employee social security contributions as well as for lump-sum taxes. Note that for consumption taxes, we only allow for pre-announcement but not for feedback on debt or output. All other fiscal instruments are kept constant at their steady-state values.

3 Bayesian Estimation

We adopt the approach outlined in An and Schorfheide (2007) and Schorfheide (2000) and estimate the extended version of the NAWM employing Bayesian inference methods over the sample period from 1985Q1 to 2010Q2 (using the period 1980Q2 to 1984Q4 as training sample). This involves obtaining the posterior distribution of the model's parameters based on its log-linear state-space representation using the Kalman filter.[12]

An extensive discussion of the estimation results for the extended NAWM is beyond the scope of this paper. Here we report selectively on the data used in the estimation, on the model's shock processes, on the calibration of important steady-state ratios and on the prior and posterior distributions of key parameters, to the extent that this helps to understand the enhanced role of fiscal policy in our model. For details concerning the estimation of the baseline model structure the reader is referred to Christoffel et al. (2008, Section 3).

[12]Although we employ linear methods to solve and estimate the model, recent data for euro area nominal interest rates may be subject to a potentially important non-linearity—the zero lower bound (ZLB). In order to check the importance of the ZLB we pursue the following analysis. From the data set used in the model estimation we select the following three quarterly time series: consumer price inflation, log real GDP and the 3-month Euribor interest rate. We use these data to simulate the nominal interest rate that is implied by the Taylor-type feedback rule (see Coenen et al., 2008) in the model. The feedback rule has the following arguments: previous quarter nominal interest rate (interest rate smoothing), deviations of previous quarter inflation rate from inflation rate target, deviations of log real GDP from trend and quarter-on-quarter changes of the inflation rate and log real GDP. Using the feedback coefficients at the estimated posterior mode, it turns out that the actual nominal interest rate and the simulated one are very close. More importantly, the simulated nominal interest rate in the years 2009-10 is positive albeit not very far from zero. A high degree of interest rate smoothing is important for this result. That is, with no interest rate smoothing the simulated nominal interest rate would be negative indeed. However, for moderate degrees of interest rate smoothing, the ZLB does not appear to be of pivotal importance in our sample of interest so that we shall proceed with the analysis.

3.1 Data and Shock Processes

In estimating the extended version of the NAWM, we use quarterly time series for 17 out of the 18 macroeconomic variables used in the estimation of the baseline model: real GDP, private consumption, government consumption, extra-euro area exports and imports, the GDP deflator, the consumption deflator, the extra-euro area import deflator, total employment, nominal wages per head, the short-term nominal interest rate, the nominal effective exchange rate, foreign demand, foreign prices, the foreign interest rate, competitors' export prices, and the price of oil. The time series for total investment is replaced by the time series for private investment. All time series are taken from an updated version of the AWM database (see Fagan, Henry and Mestre, 2001), except for the extra-euro area trade data, the construction of which is detailed in Dieppe and Warmedinger (2007), and the government consumption data. For further details on the data and their transformation prior to estimation see Christoffel et al. (2008, Section 3.2).

For government consumption and 7 additional fiscal variables, namely government investment, government transfers, indirect taxes, direct taxes, employees' and employers' social security contributions, as well as government debt, we use quarterly time series from a new fiscal database by Paredes et al. (2009). This database exploits intra-annual fiscal information for interpolation purposes which allows to capture genuine intra-annual "fiscal" dynamics in the data. This helps to circumvent two important problems that are present in fiscal time series interpolated on the basis of general macroeconomic indicators: (i) the endogenous bias that arises if such interpolated fiscal series were used with macroeconomic variables to assess the impact of fiscal policies; and (ii) the well-known decoupling of tax collection from the evolution of macroeconomic tax bases (revenue windfalls/shortfalls). For further details on the fiscal data see the Appendix.

Data on government consumption are available in real terms, while existing nominal data on government investment and on government transfers and government debt are deflated using, respectively, the private investment deflator and the private consumption deflator from the AWM database. Revenue data are constructed as a ratio to consumption expenditure (indirect taxes) or to wage and salary income (direct taxes as well as social security contributions). We remove a linear trend from all fiscal data, except for social security contributions and government debt from which we subtract HP-trends and a broken linear trend, respectively.[13] Figure 1 shows the time series of the transformed fiscal variables

[13]Compared to the earlier sample, government debt grew at a much slower rate after the year 1993, i.e. after the Maastricht treaty became effective. Since political economy considerations are beyond the scope of the model, we choose a breakpoint for the linear trend of government debt in 1993Q4. Further, due to

for our sample period from 1985Q1 to 2010Q2.

Commensurate with the number of time series used in the estimation, the extended NAWM features 20 distinct structural shocks, several of which have been discussed in Section 2, plus the 5 shocks in the SVAR model for the foreign variables. In particular, we distinguish 7 shocks entering the fiscal feedback rules for government consumption, investment and transfers, for indirect and direct taxes, and for employees' and employers' social security contributions, plus a shock to the lump-sum tax rule which closes the government budget constraint in the model. All shocks are assumed to follow first-order autoregressive processes, except for the shocks to the interest-rate and fiscal feedback rules and the shocks in the SVAR model, which are assumed to be serially uncorrelated.[14]

3.2 Calibration and Prior Selection

Regarding the NAWM's steady state, all real variables are assumed to evolve along a balanced-growth path with a steady-state growth rate of 2% per annum, which roughly matches average real GDP growth in our estimation sample. Consistent with the balanced-growth assumption, we then calibrate key steady-state ratios of the model by matching their empirical counterparts over the sample period. For example, the expenditure shares of private consumption, private investment, government consumption and government investment are set to, respectively, 57.5%, 18.3%, 21.5% and 2.8% of nominal GDP, while the export and import shares are set to 16%, ensuring balanced trade in steady state; see Table 1. Conditional on the model's steady-state growth rate, the discount factor β is chosen to imply an annualised equilibrium real interest rate of 2.5%, while, on the nominal side, the steady-state inflation rate is set equal to 1.9% per annum, consistent with the ECB's quantitative definition of price stability.

On the demand side of our model, we set the share of private consumption in the aggregate consumption bundle, α_G, equal to 0.75. At the prior and posterior modes, this parameter value implies roughly equal marginal utilities of private (Ricardian) consumption and government consumption. Turning to the model's supply side, we set the capital share

institutional reforms in e.g. Italy data on social security contributions (SSC) show a quantitatively large increase in the mid-1990s for several years before reverting back. A simple linear trend would imply negative deviations of detrended SSC before and after the mid-1990s throughout. As a step forward, we remove HP-trends from these data.

[14] In addition, see Christoffel et al. (2008), we account for measurement error in extra-euro area trade data as they are prone to sizeable revisions. We also allow for small errors in the measurement of real GDP and the GDP deflator to alleviate discrepancies between the national accounts framework underlying the construction of official GDP data and the models's aggregate resource constraint. All measurement errors are assumed to be serially uncorrelated.

of output, α, to 30% and the depreciation rate of both private capital, δ, and public capital, δ_G, to 6% at an annualised rate. Furthermore, we assume $b_0 = 1$ with one period time-to-build for public capital and set $\alpha_K = 0.9$. The latter parameter value implies that the marginal products of private and public capital are roughly equal at the prior and posterior modes. As concerns capital formation, we fix $\tau^K = 0.35$ in line with Trabandt and Uhlig (2011). Finally, similar to e.g. Drautzburg and Uhlig (2011), we allow for a wedge between the return on capital and government bonds. We assume this wedge to be constant over time and set it to roughly 0.8 percentage points per annum in steady state.[15]

As regards the fiscal sector, the steady-state tax rates are calibrated so that average tax rates match the corresponding average revenue-to-output ratios in the data. This approach is consistent with our treatment of distortionary taxes as latent variables by measuring tax revenues in the data. Specifically, we set the steady-state values of the indirect and direct tax rates, τ^C and τ^N, to 22.3% and 11.6%, respectively. Similarly, employees' and employers' social security contributions, τ^{W_h} and τ^{W_f}, are set to 12.7% and 13.2%, respectively. We set the tax rate τ^D to zero throughout. Regarding government debt, we assume a steady state debt-to-GDP ratio of 60% per annum consistent with the Stability and Growth Pact, which provides an anchor for debt developments in the euro area over the medium to long term. This value is close to the average share of government debt to GDP of approximately 65% at the onset of the crisis, but significantly below the levels of debt reached in the aftermath of the crisis.

Finally, we calibrate a small number of additional parameters that are inherently difficult to identify. This concerns, for example, the inverse of the labour supply elasticity ζ, which we set equal to 2 in line with the range of available estimates in the literature, and the parameter ψ determining the fixed costs of production of intermediate-good firms, which we calibrate such that firms' profits are zero in steady state.

We select our model priors endogenously, using a strategy similar to Christiano, Trabandt and Walentin (2011). Concerning the choice of the initial prior distributions, we use broadly the same priors as Christoffel et al. (2008) for those parameters that are common to the baseline and the extended version of the NAWM. So our discussion here focuses on the prior distributions of the parameters characterising the fiscal sector in the extended model, as detailed in Table 2. To start with, for the share of non-Ricardian households ω we choose a beta distribution with a mean of 0.5 and a standard deviation of 0.1. Similarly, for the distribution parameter ϖ we assume a beta distribution with mean 0.5 and standard

[15] We have also experimented with allowing for time variation in this wedge. However, none of our fundamental results changed substantially.

deviation 0.2. Noting that the elasticities υ_G and υ_K of the CES aggregates determining aggregate consumption and the aggregate capital stock are restricted to be positive by theory, we specify a truncated normal distribution with mean 1 (corresponding to the CD case) and standard deviation 0.1 for these parameters.

Turning to the feedback coefficients on output and debt in the fiscal rules, $\theta_{\cdot,Y}$ and $\theta_{\cdot,B}$, we adopt normal distributions with mean 0 and standard deviation 2. For the coefficient on the own lagged value of the fiscal instrument, $\theta_{\cdot}$, we use a beta distribution with mean 0.5 and standard deviation 0.2, and for the weights concerning the importance of pre-announcement effects, $\psi_{\cdot}$, we employ a beta distribution with mean 0.5 and standard deviation 0.2. Finally, for the standard deviations of the fiscal shocks we use inverse gamma distributions with mode 0.10 and 2 degrees of freedom, reflecting the fact that there is little a priori information on these parameters.

3.3 Posterior Distributions

In Table 2, we present estimation results for selected parameters characterising the fiscal sector in the extended version of the NAWM. The entries in the posterior-mode column refer to the values of the structural parameters that are obtained by maximising the model's posterior distribution. The remaining three columns report the mean as well as the 5% and 95% percentiles of the (marginal) posterior distributions which are computed using a posterior sampling algorithm.

The posterior mode of the share of non-Ricardian households equals $\omega = 0.18$ which is similar, if anything somewhat smaller, compared to e.g. Coenen and Straub. Based on the findings in the literature (see e.g. Coenen and Straub, 2005, and Galí et al., 2007), the estimated share would, in general, be too low for generating a positive output multiplier of government consumption shocks in a standard New-Keynesian DSGE model. Yet in our model it will nevertheless allow transfer shocks to play a material role via distributional effects. The strength of these effects is determined by the distribution parameter with a posterior mode estimate of $\varpi = 0.30$. The posterior mode estimate of the elasticity of substitution between public and private consumption goods is $\upsilon_G = 0.29$, so that the two goods enter the households' utility function as rather strong complements. Similarly, the posterior mode estimate of the elasticity of substitution between private and public capital is $\upsilon_K = 0.84$, giving rise to moderate complementarities in the composite capital stock.

Turning to the parameters of the fiscal rules, the feedback coefficients in both the expenditure and tax rules seem in general well-identified by the data. For government investment and transfers, we estimate relatively sizeable feedback coefficients on government debt with $\theta_{I_G,B} = -0.18$ and $\theta_{TR,B} = -0.14$, while the reaction of government consumption to debt is estimated to be weaker with $\theta_{G,B} = -0.02$. With the exception of government investment, the expenditure items are estimated to react less strongly to movements in output, but positively: the posterior mode estimates are $\theta_{I_G,Y} = 0.55$, $\theta_{G,Y} = 0.06$, and $\theta_{TR,Y} = 0.10$, respectively. On the revenue side, the feedback of lump-sum taxes to government debt and output is estimated at $\theta_{T,B} = 0.07$ and $\theta_{T,Y} = 0.21$, respectively. Smaller feedback coefficients are obtained for labour income taxes plus employees' social security contributions ($\theta_{W_h,B} = -0.01$ and $\theta_{W_h,Y} = -0.05$) and for employers' social security contributions ($\theta_{W_f,B} = 0.01$ and $\theta_{W_f,Y} = -0.03$). Overall, these results indicate that feedbacks from government debt and output to expenditure items are stronger than to revenue items. Pre-announcement effects seem to play a role, in particular for government investment ($\psi_{I_G} = 0.93$), transfers ($\psi_{TR} = 0.81$), and lump-sum taxes ($\psi_T = 0.90$).

In Table 3, we compare the posterior mode estimates of selected parameters that are common to the extended and the baseline version of the NAWM. Overall, the posterior mode estimates of the parameters characterising households' preferences, wage and price-setting behaviour, final-good production, adjustment costs and monetary policy are found to be broadly similar across the two model versions. That is, the estimation of the common parameters appears rather robust to the extension of the NAWM's fiscal sector and to the inclusion of the additional 7 fiscal variables in the set of observables.

4 Discretionary Fiscal Policies during the Crisis

4.1 Comparing Historical Decompositions

In order to assess the predictions of our enhanced version of the NAWM for the role of discretionary fiscal policies during the crisis, we compare the implied historical decomposition of euro area real GDP growth over the period 2007-10 with the decomposition implied by the baseline NAWM with a stylised specification of the fiscal sector and with government consumption being the only observed fiscal variable. As the baseline model assumes a balanced budget, there is no role for fiscal rules in determining macroeconomic outcomes and all distortionary tax rates are constant.

We first consider the historical decomposition obtained with the baseline model. To this end, we decompose annualised quarter-on-quarter real GDP growth (in deviation from the mean GDP growth rate) into the contributions of fiscal and non-fiscal shocks. With government consumption being the only observed fiscal variable, the baseline model features a single fiscal shock associated with discretionary government spending. The historical decomposition depicted in Figure 2 suggests that discretionary fiscal spending played a negligible role in stabilising real GDP growth in the years 2009-10. This could lead to the conclusion that in a counterfactual world without discretionary fiscal policy measures, real GDP outcomes would have not been significantly different from the ones observed.

In contrast, in our model with an enhanced fiscal sector and using as many as 8 different fiscal variables as observables, the role of discretionary fiscal policies is much more prominent. The decomposition of real GDP growth in Figure 3 suggests that discretionary fiscal shocks pushed up annualised quarter-on-quarter growth rates by up to 1.6 percentage points (in 2009Q2). Naturally, the question arises which fiscal shocks had the strongest positive impact on euro area real GDP growth during the crisis. To shed some light on that question, we present the contributions of the individual fiscal shocks in Figure 4. According to the figure, shocks to government investment, government consumption, transfers, as well as consumption and labour income taxes have all been important in supporting euro area GDP growth.[16] As we demonstrate later, these findings on the relative importance of the fiscal shocks are broadly in line with the fiscal measures that were actually enacted under the EERP.

4.2 Inspecting the Economic Mechanisms

What drives the important role of fiscal variables in our enhanced model? We aim to answer this question by highlighting the role of three particular features of our model (i) the inclusion of non-Ricardian households, (ii) non-separable government consumption, and (iii) public capital. Note that for the sake of simplifying the analysis, we exclude all feedback and pre-announcement effects from the fiscal rules. We only allow lump-sum taxes to react to government debt.

In Figure 5, we show the impact of transfer shocks on private consumption under three different parameterisations. For $\omega = 0$, all households in our model are Ricardians and, thus, there are also no distributional effects. Accordingly, transfer shocks have no impact on consumption. We would consider this as the benchmark parameterisation, as most DSGE models assume neither a role for non-Ricardian households nor for income redistribution.[17]

[16] The slightly negative contribution of government investment in 2009Q1 is consistent with a sharp fall in public construction activity because of the adverse weather conditions around the turn of the year.

[17] If the feedback effects in the fiscal rules were active, the impact on private consumption would be negative since any increase in transfers needs to be partly financed by an increase in distortionary taxes.

In contrast, when $\omega = 0.35$, we observe a rather strong impact of transfer shocks on private consumption as the non-Ricardian households consume the additional income induced by the rise in transfers. Note that this impact is not only driven by the hand-to-mouth consumption behaviour of the non-Ricardian households, but also by the implied re-distribution of income from Ricardian to non-Ricardain households. As an intermediate case, we consider the estimated share of non-Ricardian households with $\omega = 0.18$. Not surprisingly, under this parametrisation the reaction of private consumption is less pronounced.

Another feature that is crucial for understanding the transmission of fiscal shocks in our model, is the assumption that government consumption is valued and non-separable. Starting with the benchmark case of modelling government consumption as pure waste, i.e. with $\alpha_G = 1$, Figure 6 depicts a persistent negative response of private consumption to an exogenous increase in government spending. The "crowding-out" of private consumption is caused by the negative wealth effect implied by an increase in government debt and the anticipation of a higher tax burden in the future. Our estimated share of non-Ricardians is not large enough to overturn this effect. This result holds under more general parameterisations, as discussed in Coenen and Straub (2005). Assuming that public and private consumption are highly substitutable, e.g. with $\upsilon_G = 3$, induces a strong negative reaction of private consumption to a government consumption shock. However our posterior mode estimate of $\upsilon_G = 0.29$ suggests that the data favour a specification with a strong complementarity of public and private consumption. In this case, we observe a positive and hump-shaped response of private consumption to an exogenous increase in public consumption.

Finally, in Figure 7, we evaluate the impact of a government investment shock on private investment by varying the degree of substitutability of private and public capital. We choose as the benchmark the Cobb-Douglas case with $\upsilon_K = 1$. In this case, the reaction of private investment to a government investment shock is as expected substantially negative. When setting $\upsilon_K = 0.25$, the decline in private investment following a government investment shock is muted as private and public capital are strong complements. Using our posterior mode estimate of $\upsilon_K = 0.84$ for simulating the response of private investment represents an intermediate case. Naturally, the question arises under which parameterisation does a government investment shock crowd in private investment? It turns out, that we would need to set $\upsilon_K = 0.25$ and $\alpha_K = 0.85$ to trigger a positive reaction of private investment after a government investment shock. Thus, a relatively strong complementarity together with a larger share of public capital in composite capital leads to "crowding-in".

5 Fiscal Multipliers and the Impact of the EERP

Governments in the euro area have responded to the economic crisis with a range of fiscal stimulus measures within the framework of the EERP. Table 4 provides a breakdown of the different fiscal measures implemented at the euro area level, as estimated by the European Commission (2009). In total, the fiscal stimulus measures amount to 1.1% and 0.8% of GDP in the years 2009 and 2010, respectively. These fiscal measures have been implemented in addition to the stimulus provided through the operation of automatic fiscal stabilisers and do not include other extra budgetary actions such as capital injections, loans and guarantees to the financial sector, as well as investment by public corporations.

Table 4 reveals that under the EERP support for households' purchasing power accounts for about 40% of the total stimulus in the euro area countries in 2009-10. These fiscal measures have taken the form of a reduction in VAT, direct taxes, social security contributions, as well as direct aid, such as income support for households and support for housing or property markets. Notable stimulus measures have also been adopted to support investment and businesses directly. These categories account for roughly 30% and 20% of the total stimulus, respectively. Support for investment has primarily taken the form of public (infrastructure) investment, while the measures directly targeted at supporting business activity have mainly been targeted at reducing business costs (reduction of taxes and social security contributions, direct aid in the form of earlier payment of VAT returns, subsidies and the stepping up of export promotion). Labour-market measures (wage subsidies and active labour-market policies) account for about 10% of the total stimulus and thus represent the smallest fraction of the total stimulus measures.

We use our model to illustrate, by means of simulations, the likely economic effects of the EERP and compare them with the standardised fiscal multipliers of the estimated model. To this end, Table 4 also provides information on how the different fiscal measures implemented under the EERP were allocated to the model's fiscal variables in the simulation exercise. Because of the unavoidably imperfect match between the exact fiscal stimulus measures adopted by the euro area member states and the model's fiscal variables, a certain amount of judgement is needed. For instance, labour-market measures are allocated to government consumption since they represent primarily active labour-market policies, the costs of which are paid for by the government. Nevertheless, keeping the above-mentioned caveat in mind, the simulations broadly reflect the actual EERP measures.

In order to put the economic effects of the EERP into perspective, we first examine the size of the fiscal multipliers implied by our estimated model. To this end, we simulate the effects of anticipated shocks to individual fiscal instruments that are assumed to last for 2 years and that are calibrated so as to shift the fiscal instrument by 1% of GDP. The stimulus is fully debt-financed in the first two years, with all fiscal rules being switched off. Thereafter, lump-sum taxes adjust to balance the budget. Within the first two years, the nominal interest rate is kept constant. Thereafter, the nominal interest rate adjusts according to a static Taylor-type rule, which for the sake of comparability with other studies (see Cogan et al., 2010, and Cwik and Wieland, 2010) reacts only to contemporaneous inflation and real GDP growth, with response coefficients of 1.5 and 0.125, respectively.

The results in the upper panel of Table 5 show that the fiscal instrument with the largest multiplier is government consumption. The impact multiplier equals 1.26, while the long-run present-value multiplier is 1.63.[18] The long-run multiplier is also above one for exogenous increases in government investment. These results are of course driven by the estimated degrees of complementarity between private and government consumption as well as private and public capital. At the same time, transfers have rather modest effects on GDP, despite the presence of non-Ricardian households and their distributional impact in our model. Concerning the fiscal instruments on the revenue side, consumption tax reductions have the largest multiplier, with 0.36 on impact and 0.48 in the long run. Overall, the estimated multipliers on the revenue side are found to be low when compared to the expenditure multipliers. Not surprisingly, a reduction in labour income taxes and in social security contributions (SSC) of employees have a very similar impact on real GDP, as they affect the same margin in the model.

The lower panel in Table 5 reports the simulation results for the EERP on the basis of the information provided in Table 4. Note that we first re-calibrated the EERP shock such that it is comparable to the model's standardised multipliers, i.e. also representing a two-year fiscal stimulus of one percent. In addition to the multipliers, we also include below the GDP effects of the EERP. The multiplier in the first two years is positive, amounting to about 0.68 and 0.72, respectively. Assuming that the fiscal stimulus measures are lifted in the third year, the effects on real GDP fade away however rather quickly, as can be clearly seen from the corresponding output effects, converging finally to a long-run multiplier of around 0.89. These results are comparable to those from other studies such as Cwik and Wieland (2010), European Commission (2009) and ECB (2010).

[18] We compute the present-value multiplier following Uhlig (2010).

6 Conclusions

In this paper, we have conducted a quantitative evaluation of the effects of discretionary fiscal policies on euro area economic activity during the Great Recession. To this end, we have employed a DSGE model that is characterised by a rich specification of the fiscal sector. We have estimated the model using Bayesian methods and utilising a large set of euro area fiscal time series. Our results suggest that discretionary fiscal policies led to an increase in annualized quarterly real GDP growth of up to 1.6 percentage points during the crisis. We have argued that a detailed modelling of the fiscal sector and the incorporation of many time series that characterise fiscal policy turn out to be pivotal for our result. Finally, we have shown that discretionary fiscal spending, associated with the EERP, can generate sizeable, albeit short-lived fiscal multipliers.

While our analysis has focused on the quantitative evaluation of the expansionary effects of discretionary fiscal measures during the crisis, the latter has ledpartly as a consequence of the enacted measuresto a sizeable increase in government deficits and debt levels. Hence, future research ought to be extended towards examining the effects of fiscal consolidation strategies aimed at curtailing deficits and debt levels over the medium term. In pursuing this research, accounting for the endogenous nature of government bond premia, which have been rising sharply in some countries, will be a fundamental challenge.

References

An, S. and F. Schorfheide, 2007, "Bayesian Analysis of DSGE Models", *Econometric Reviews*, 26, 113–172.

Calvo, G. A., 1983, "Staggered Prices in a Utility-Maximizing Framework", *Journal of Monetary Economics*, 12, 383–398.

Campbell. J. Y. and N. G. Mankiw, 1989, "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence", in O. J. Blanchard and S. Fischer (eds), NBER Macroeconomics Annual, 1989, Vol. 4, MIT Press, Cambridge, 185–216.

Christiano, L. J., M. Eichenbaum and S. Rebelo, 2011, "When Is the Government Spending Multiplier Large?", *Journal of Political Economy*, 119, 78–121.

Christiano, L. J., M. Eichenbaum and C. L. Evans, 2005, "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy", *Journal of Political Economy*, 113, 1–45.

Christiano, L. J., M. Trabandt and K. Walentin, 2011, "Introducing Financial Frictions and Unemployment into a Small Open Economy Model", *Journal of Economic Dynamics and Control*, forthcoming.

Christoffel, K., G. Coenen, and A. Warne, 2008, "The New Area-Wide Model of the Euro Area: A Micro-Founded Open-Economy Model for Forecasting and Policy Analysis", ECB Working Paper No. 944, European Central Bank, October.

Coenen, G., C. J. Erceg, C. Freedman, D. Furceri, M. Kumhof, R. Lalonde, D. Laxton, J. Lindé, A. Mourougane, D. Muir, S. Mursula, C. de Resende, J. Roberts, W. Roeger, S. Snudden, M. Trabandt and J. in't Veld, 2012,"Effects of Fiscal Stimulus in Structural Models", *American Economic Journal: Macroeconomics*, 4, 1–47.

Coenen, G., P. McAdam and R. Straub, 2008, "Tax Reform and Labour-Market Performance in the Euro Area: A Simulation-Based Analysis Using the New Area-Wide Model", *Journal of Economic Dynamics and Control*, 32, 2543–2583.

Coenen, G. and R. Straub, 2005, "Does Government Spending Crowd in Private Consumption? Theory and Empirical Evidence for the Euro Area", *International Finance*, 8, 435–470.

Cogan, J. F., T. Cwik, J. B. Taylor and V. Wieland, 2010, "New Keynesian versus Old Keynesian Government Spending Multipliers", *Journal of Economic Dynamics and Control*, 34, 281–295.

Corsetti, G., A. Meier and G. Müller, 2009, "Fiscal Stimulus with Spending Reversals", IMF Working Paper 09/106, International Monetary Fund.

Cwik, T. and V. Wieland, 2010, "Keynesian Government Spending Multipliers and Spillovers in the Euro Area", ECB Working Paper No. 1276, European Central Bank, November.

Drautzburg, T. and H. Uhlig, 2011, "Fiscal Stimulus and Distortionary Taxation", NBER Working Paper No. 17111.

ECB, 2007, *Government Finance Statistics Guide*, European Central Bank, January.

ECB, 2010, "The Effectiveness of Euro Area Fiscal Policies", *Monthly Bulletin*, European Central Bank, July.

Eggertsson, G. B., 2011, "What Fiscal Policy is Effective at Zero Interest Rates?", in D. Acemoglu and M. Woodford (eds), NBER Macroeconomics Annual 2010, Vol. 25, University of Chicago Press, Chicago, 59–112.

Erceg C. J. and J. Lindé, 2010, "Is There a Fiscal Free Lunch in a Liquidity Trap?", International Finance Discussion Paper No. 1003, Board of Governors of the Federal Reserve System.

European Commission, 2009, "Public Finances in EMU", *European Economy*, 5/2009, European Commission.

Fagan, G., J. Henry, and R. Mestre, 2001, "An Area-Wide Model (AWM) for the Euro Area", ECB Working Paper No. 42, European Central Bank, January.

Galí, J., J. D. López-Salido and J. Vallés, 2007, "Understanding the Effects of Government Spending on Consumption", *Journal of the European Economic Association*, 5, 227–270.

Kydland, F. E. and E. C. Prescott, 1982, "Time to Build and Aggregate Fluctuations", *Econometrica*, 50, 1345–1370.

Leeper, E., T. B. Walker and S. C. S. Yang, 2009a, "Fiscal Foresight and Information Flows", NBER Working Paper No. 14630.

Leeper, E., T. B. Walker and S. C. S. Yang, 2009b, "Government Investment and Fiscal Stimulus in the Short and Long Runs", NBER Working Paper No. 15153.

Mankiw, N. G., 2000, "The Savers-Spenders Theory of Fiscal Policy", *American Economic Review*, 90, 120–125.

Paredes, J., D. J. Pedregal and J. Pérez, 2009, "A Quarterly Fiscal Database for the Euro Area Based on Intra-Annual Fiscal Information", ECB Working Paper No. 1132, European Central Bank, September.

Schorfheide, F., 2000, "Loss-Function-Based Evaluation of DSGE Models", *Journal of Applied Econometrics*, 15, 645–670.

Taylor, J. B., 1993, "Discretion Versus Policy Rules in Practice", *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.

Trabandt and Uhlig, 2011, "The Laffer Curve Revisited", *Journal of Monetary Economics, forthcoming.*

Uhlig, H., 2010, "Some Fiscal Calculus", *American Economic Review*, 100, 30–34.

Woodford, M., 2011, "Simple Analytics of the Government Expenditure Multiplier", *American Economic Journal: Macroeconomics*, 3, 1–35.

Appendix: The Fiscal Data

In the estimation of our model, we use quarterly euro area data on general government expenditures and revenues as well as general government debt from the new fiscal database by Paredes et al. (2009):

- real general government final consumption expenditure (GCR)
- nominal general government gross fixed capital formation (GIN)
- nominal general government transfers to households (THN)
- nominal general government revenues from indirect taxes, total (TIN)
- nominal general government revenues from direct taxes, total (DTX)
- nominal general government revenues from employer social security contributions (SCR)
- nominal general government revenues from employee (and other, self-employed) social security contributions (SCE)
- nominal general government debt (GDN)

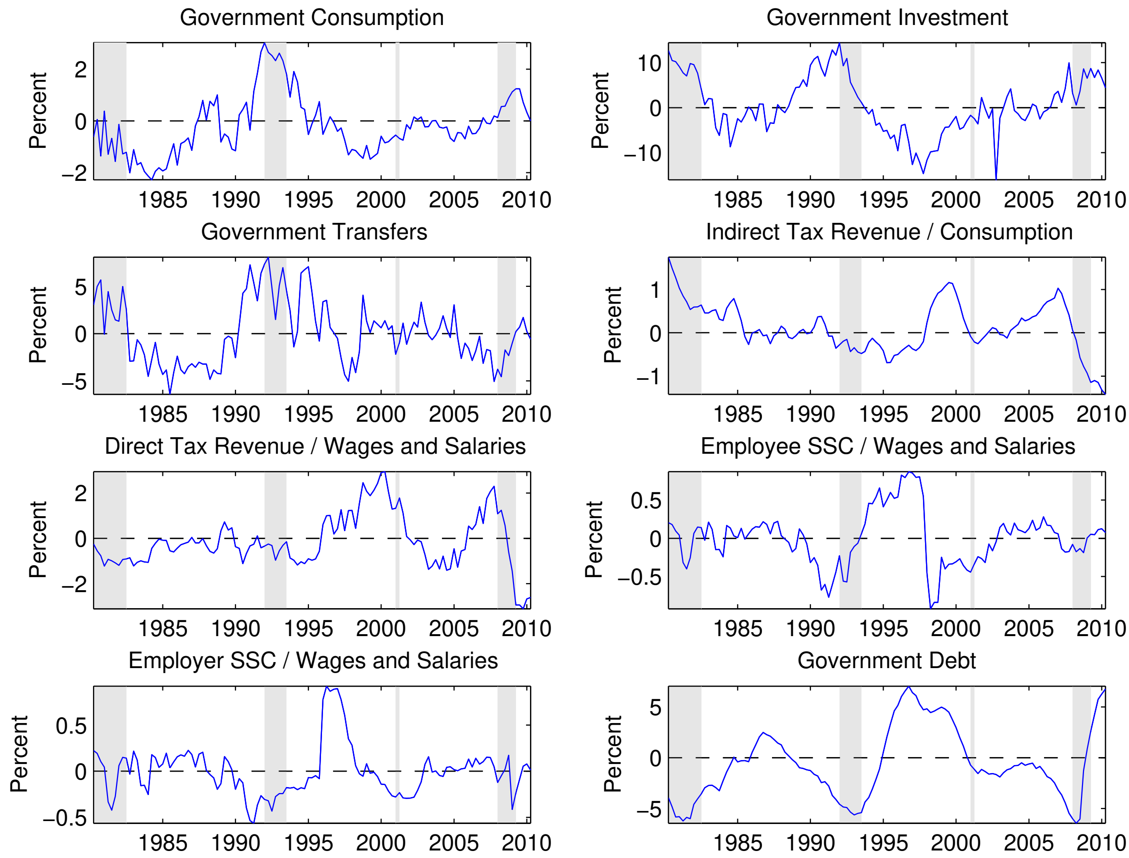
with the data abbreviations following the conventions in the Government Finance Statistics Guide (ECB, 2007).

In the Paredes et al. (2009) database social security contributions for employers and employees are only available after 1991Q1. Before that date only total social security contributions are available. We compute the shares of employer and employee social security contributions on total social security contributions from 1991Q1 to 2007Q1. These shares are relatively stable. Therefore we impose the average 1991Q1-2007Q1 shares to total social security contributions prior to 1991Q1 in order to obtain data on employer and employee social security contributions.

The database provides nominal unadjusted data for all fiscal variables, plus real seasonally adjusted data for government consumption. The methodology developed by Paredes et al. (2009) to interpolate annual fiscal data to quarterly frequencies using cash data explicitly models a seasonal component. Hence, the quarterly fiscal database also delivers nominal seasonally adjusted data.[19]

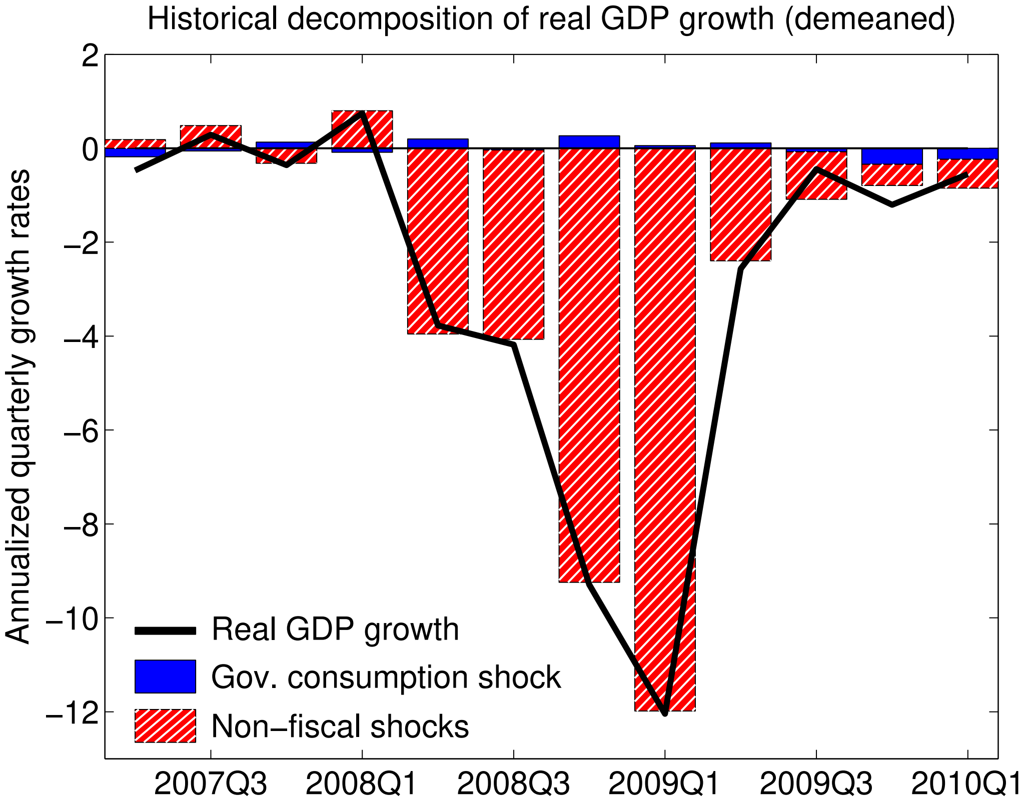
[19] Both series are identical to the corresponding ESA95 quarterly national accounts data, where government consumption is the only item available in real, seasonally adjusted terms. However, Eurostat only provides data from 1991Q1 onwards for real government consumption, and data from 1995Q1 onwards for nominal government consumption. By construction, the government consumption data provided by Paredes et al. (2009) therefore pins down the ESA95 data from 1991Q1 and 1995Q1 onwards. The same holds for the remaining data in nominal unadjusted terms which are available from Eurostat from 1999Q1 onwards. The ESA95 quarterly national accounts series which are available from 1999Q1 onwards only are total direct taxes, total indirect taxes, total social security contributions, government investment, and transfers to households. For the period for which no quarterly national accounts data is available, the annual sums of the fiscal data match annual national accounts data from the European Commission's AMECO database.

Figure 1: The Fiscal Data, 1985Q1–2010Q2



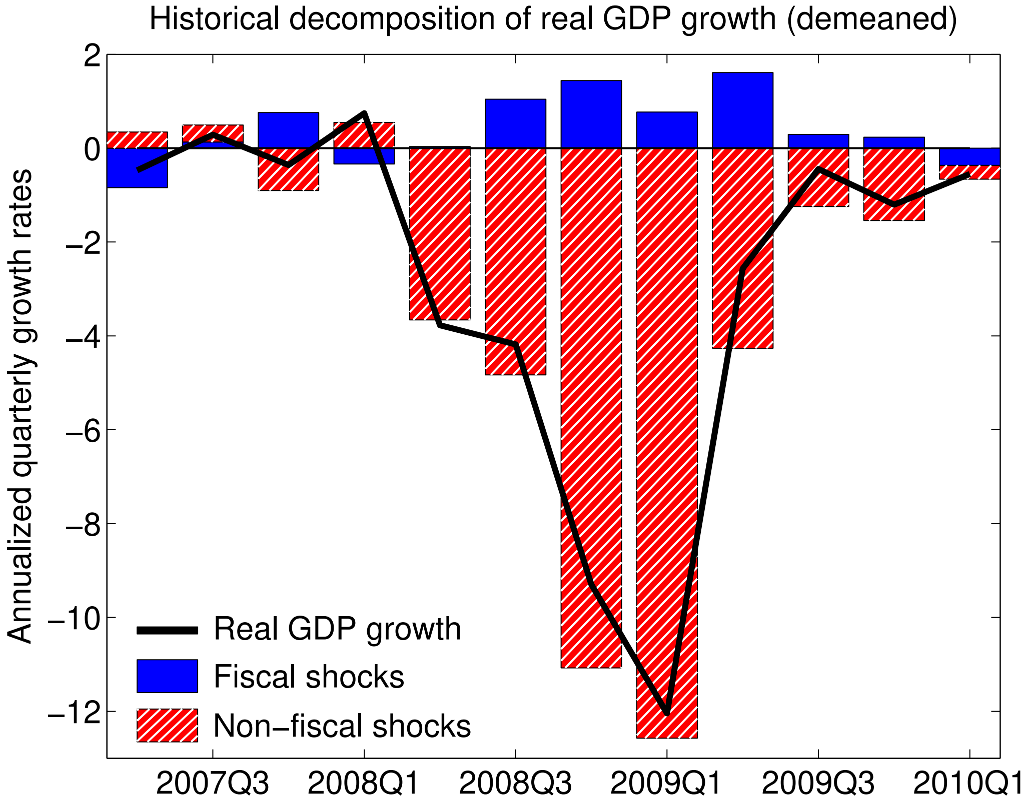
Notes: This figure shows the time series of the fiscal variables used in the estimation of the extended version of the NAWM. Details on the variable transformations are provided in Section 3.1. "SSC" are social security contributions. Shaded areas are CEPR recession dates and periods of significant growth slowdowns.

Figure 2: A Historical Decomposition of Euro Area Real GDP Growth with the Baseline NAWM, 2007–2010



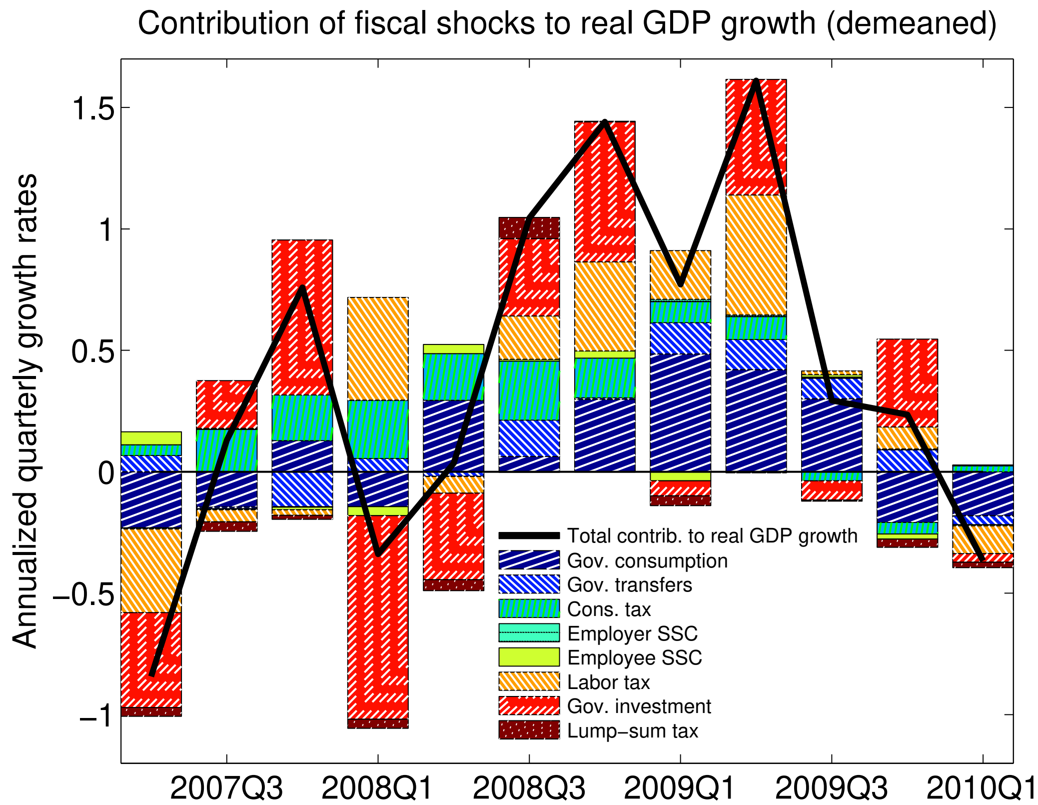
Notes: This figure provides a historical decomposition of euro area real GDP growth into contributions of government consumption shocks and non-fiscal shocks using the baseline NAWM at the estimated posterior mode. Note that in the baseline NAWM government consumption shocks are the only fiscal shocks. The contributions of measurement errors and the initial state to this decomposition are small and not plotted. A breakdown of all non-fiscal shocks is available upon request. Non-fiscal shocks comprise shocks to: domestic risk premium, foreign risk premium, unit-root neutral technology, transitory neutral technology, transitory investment-specific technology, wage markup, domestic price markup, export price markup, import price markup, import demand, export preferences, nominal interest rate, foreign inflation, foreign output, foreign interest rate, competitors's export prices and oil prices.

Figure 3: A Historical Decomposition of Euro Area Real GDP Growth with the Extended NAWM, 2007–2010



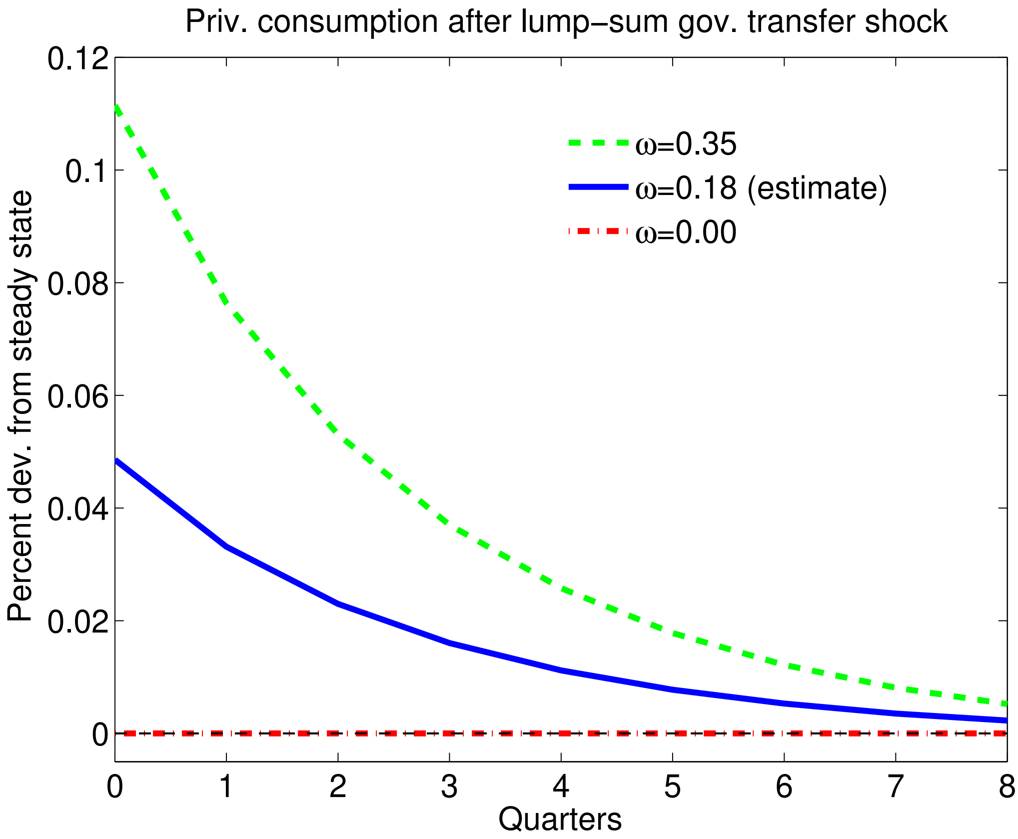
Notes: This figure provides a historical decomposition of euro area real GDP growth into contributions of fiscal and non-fiscal shocks using the extended NAWM at the estimated posterior mode. Contributions of measurement errors and the initial state to this decomposition are small and not plotted. A breakdown of the contributions of individual fiscal shocks is provided in Figure 4. A breakdown of all non-fiscal shocks is available upon request. Non-fiscal shocks comprise shocks to: domestic risk premium, foreign risk premium, unit-root neutral technology, transitory neutral technology, transitory investment-specific technology, wage markup, domestic price markup, export price markup, import price markup, import demand, export preferences, nominal interest rate, foreign inflation, foreign output, foreign interest rate, competitors's export prices and oil prices.

Figure 4: A Historical Decomposition of Euro Area Real GDP Growth with the Extended NAWM, 2007–2010: The Contribution of Individual Fiscal Shocks



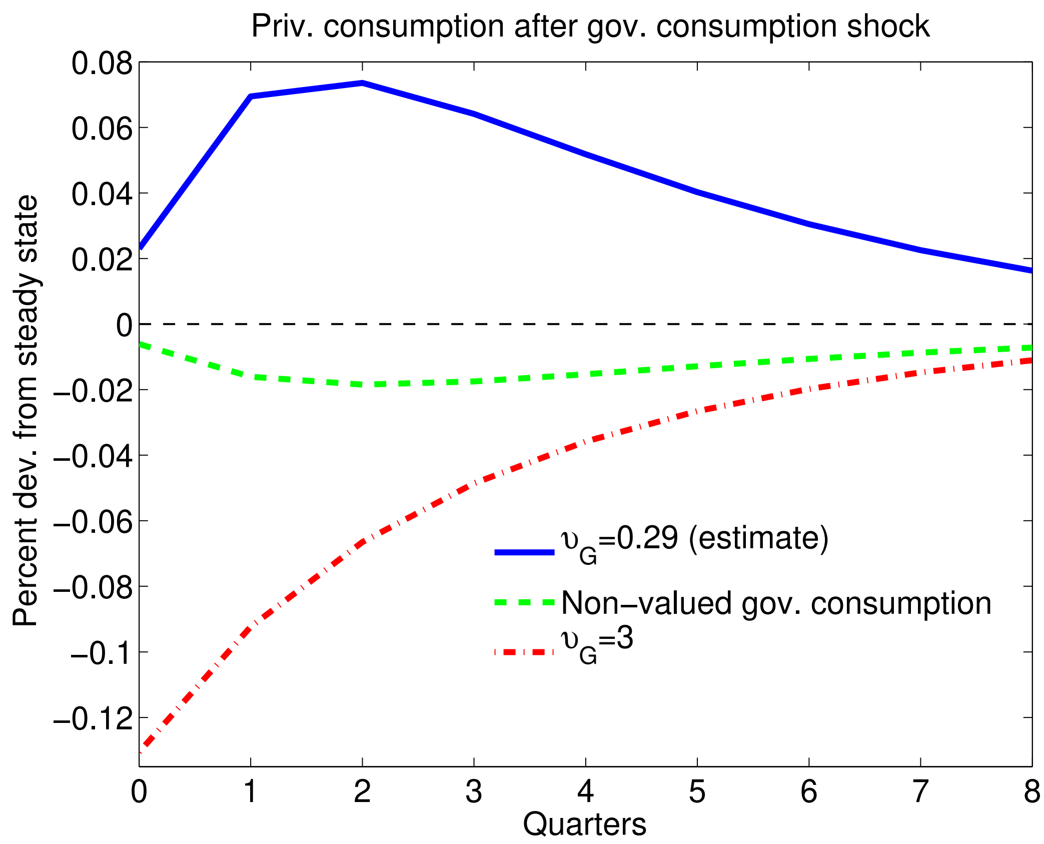
Notes: This figure provides a breakdown of the contributions of fiscal shocks to euro area real GDP growth using the extended NAWM at the estimated posterior mode.

Figure 5: Inspecting the Economic Mechanisms: Non-Ricardian Households



Notes: This figure shows private consumption after a lump-sum government transfer shock (one standard deviation). The effects of various shares of non-Ricardian agents, ω, are shown. Note that, to ease understanding of the economic mechanism, fiscal feedback rules and pre-announcement features of the fiscal shock are de-activated in the simulations shown in this figure. All other parameters are kept at the estimated posterior mode.

Figure 6: Inspecting the Economic Mechanisms: Valued Government Consumption

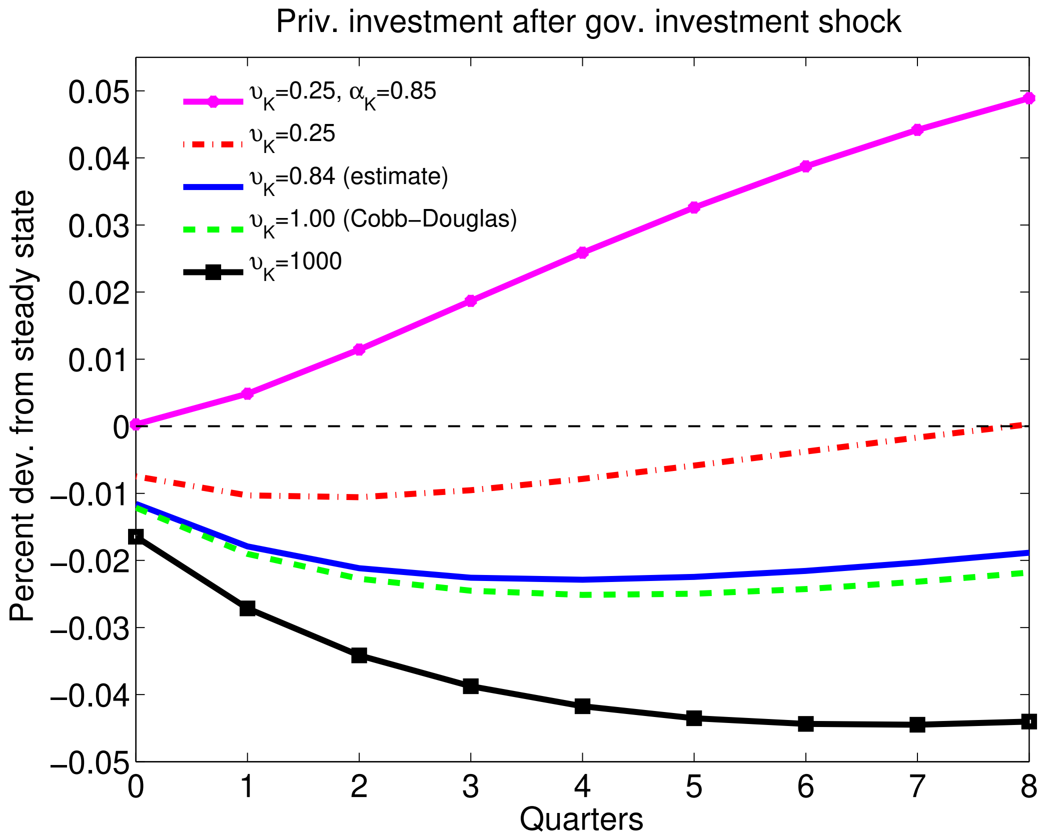


Notes: This figure show private consumption after a government consumption shock (one standard deviation) for various degrees of valuation of government consumption by households. Composite consumption that affects household utility is given by:

$$\tilde{C}_{h,t} = \left(\alpha_G^{\frac{1}{\upsilon_G}} C_{h,t}^{\frac{\upsilon_G - 1}{\upsilon_G}} + (1-\alpha_G)^{\frac{1}{\upsilon_G}} G_t^{\frac{\upsilon_G - 1}{\upsilon_G}} \right)^{\frac{\upsilon_G}{\upsilon_G - 1}}.$$

The parameter υ_G determines the degree of complementarity resp. substitutability of private and government consumption. $\upsilon_G \to 0$ is the case of perfect complements. $\upsilon_G \to 1$ is the Cobb-Douglas case while $\upsilon_G \to \infty$ is the case of perfect substitutes. α_G determines the share of private consumption in composite consumption. "Non-Valued Gov. Consumption" refers to the case when $\alpha_G = 1$, keeping all other parameters at their estimated posterior modes. Note that, to ease understanding of the economic mechanism, fiscal feedback rules and pre-announcement features of the fiscal shock are de-activated in the simulations shown in this figure. All other parameters are kept at the estimated posterior mode.

Figure 7: Inspecting the Economic Mechanisms: Public Capital



Notes: This figure shows private investment after a government investment shock (one standard deviation) for various degrees of complementarity/substitutability between private and public capital. Composite capital used in production is given by:

$$\tilde{K}_{f,t} = \left(\alpha_K^{\frac{1}{\upsilon_K}} \left(K_{f,t}\right)^{\frac{\upsilon_K - 1}{\upsilon_K}} + (1-\alpha_K)^{\frac{1}{\upsilon_K}} \left(K_{G,t}\right)^{\frac{\upsilon_K-1}{\upsilon_K}} \right)^{\frac{\upsilon_K}{\upsilon_K - 1}} .$$

The parameter υ_K determines the degree of complementarity resp. substitutability of private and public capital. $\upsilon_K \to 0$ is the case of perfect complements. $\upsilon_K \to 1$ is the Cobb-Douglas case while $\upsilon_K \to \infty$ is the case of perfect substitutes. α_K determines the share of private capital in composite capital. Note that, to ease understanding of the economic mechanism, fiscal feedback rules and pre-announcement features of the fiscal shock are de-activated in the simulations shown in this figure. All other parameters are kept at the estimated posterior mode.

Table 1: Calibration of Key Steady-State Ratios and Selected Parameters of the Extended Version of the NAWM

Share/Parameter	Description	Value
A. Expenditure shares		
s_C	Private consumption	57.5
s_I	Private investment	18.3
s_G	Government consumption	21.5
s_{I_G}	Government investment	2.8
s_X	Exports	16.0
s_{IM}	Imports	16.0
B. Preferences		
β	Discount factor	0.997
ζ	Inverse Frisch elasticity	2.0
α_G	Private consumption share in CES	0.75
C. Technology		
δ	Depreciation rate: private capital	0.015
δ_K	Depreciation rate: public capital	0.015
α_K	Private capital share in CES	0.9
b_0	Time-to-build parameter	1
D. Tax rates		
τ^C	Consumption tax	22.3
τ^N	Labour income tax	11.6
τ^{W_h}	Employees' social security contribution	12.7
τ^{W_f}	Employer social security contribution	13.2
τ^K	Capital income tax	35.0
τ^D	Profit income tax	0.0
E. Monetary policy		
$\bar{\pi}$	Inflation objective	1.90
F. Fiscal policy		
B_Y	Government debt-to-output ratio	2.40

Table 2: Selected Estimates of the Fiscal Parameters in the Extended Version of the NAWM

Parameter	Prior distribution	Posterior distribution			
		mode	mean	5%	95%
A. Share of non-Ricardian households					
ω	B(0.5,0.1)	0.18	0.18	0.12	0.24
ϖ	B(0.5,0.2)	0.30	0.32	0.11	0.52
B. Elasticity of substitution in CES aggregates					
υ_G	N^{tr}(1,0.5;0)	0.29	0.37	0.00	0.61
υ_K	N^{tr}(1,0.5;0)	0.84	0.98	0.17	1.69
C. Output feedback coefficients in fiscal rules					
$\theta_{G,Y}$	N(0,2)	0.06	0.08	0.00	0.15
$\theta_{I_G,Y}$	N(0,2)	0.55	0.52	-0.04	1.10
$\theta_{TR,Y}$	N(0,2)	0.10	0.11	-0.27	0.50
$\theta_{T,Y}$	N(0,2)	0.21	0.43	0.08	0.80
$\theta_{N,Y}$	N(0,2)	0.04	0.04	-0.03	0.11
$\theta_{W_h,Y}$	N(0,2)	-0.05	-0.05	-0.08	-0.02
$\theta_{W_f,Y}$	N(0,2)	-0.03	-0.03	-0.06	0.00
D. Debt feedback coefficients in fiscal rules					
$\theta_{G,B}$	N(0,2)	-0.02	-0.02	-0.06	0.02
$\theta_{I_G,B}$	N(0,2)	-0.18	-0.20	-0.45	0.06
$\theta_{TR,B}$	N(0,2)	-0.14	-0.13	-0.30	0.05
$\theta_{T,B}$	N(0,2)	0.07	0.15	0.04	0.27
$\theta_{N,B}$	N(0,2)	0.05	0.05	0.02	0.09
$\theta_{W_h,B}$	N(0,2)	-0.01	-0.01	-0.03	0.00
$\theta_{W_f,B}$	N(0,2)	0.01	0.01	-0.01	0.02
E. Pre-announcement coefficients in fiscal rules					
ψ_G	B(0.5,0.2)	0.06	0.08	0.02	0.15
ψ_{I_G}	B(0.5,0.2)	0.93	0.90	0.83	0.98
ψ_{TR}	B(0.5,0.2)	0.81	0.77	0.65	0.90
ψ_C	B(0.5,0.2)	0.31	0.30	0.25	0.36
ψ_T	B(0.5,0.2)	0.90	0.62	0.09	0.96
ψ_N	B(0.5,0.2)	0.11	0.13	0.05	0.22
ψ_{W_h}	B(0.5,0.2)	0.26	0.27	0.19	0.35
ψ_{W_f}	B(0.5,0.2)	0.77	0.76	0.68	0.84

Note: This table provides information on the (marginal) prior and posterior distributions of selected parameters concerning the fiscal sector of the extended version of the NAWM. The posterior distributions are based on two Markov chains with 1000,000 draws, with 300,000 draws being discarded as burn-in draws. The average acceptance rate is rougly 24 percent.

Table 3: Selected Estimates of the Parameters Common to the Baseline and the Extended Version of the NAWM

Parameter	Description	Posterior mode of baseline NAWM	Posterior distribution of extended NAWM		
			mode	5%	95%
A. Preferences					
κ	Habit formation	0.59	0.57	0.53	0.66
B. Wage and price setting					
ξ_W	Calvo: wages	0.78	0.85	0.81	0.90
χ_W	Indexation: wages	0.54	0.53	0.36	0.69
ξ_H	Calvo: domestic prices	0.93	0.92	0.88	0.93
χ_H	Indexation: domestic prices	0.38	0.82	0.63	0.89
ξ_X	Calvo: export prices	0.80	0.55	0.34	0.64
χ_X	Indexation: export prices	0.50	0.81	0.62	0.92
ξ^*	Calvo: import prices	0.50	0.07	0.05	0.10
χ^*	Indexation: import prices	0.35	0.44	0.27	0.64
C. Final-good production					
μ_C	Subst. elast.: consumption	2.28	1.98	1.66	2.55
μ_I	Subst. elast.: investment	1.69	1.75	1.39	2.31
D. Adjustment costs					
γ_I	Investment	5.56	6.10	5.05	7.20
$\gamma_{IM,C}$	Import content: consumption	5.62	4.16	2.20	5.71
$\gamma_{IM,I}$	Import content: investment	0.83	0.80	0.35	5.17
γ^*	Export market share	2.68	2.69	1.69	5.07
E. Interest-rate rule					
ϕ_R	Interest-rate smoothing	0.88	0.86	0.81	0.90
ϕ_Π	Resp. to inflation	1.89	1.73	1.54	1.84
$\phi_{\Delta\Pi}$	Resp. to change in inflation	0.14	0.20	0.13	0.30
$\phi_{\Delta Y}$	Resp. to output growth	0.16	0.11	0.07	0.17

Note: This table provides information on the (marginal) posterior distributions of selected parameters common to the baseline and the extended version of the NAWM. The posterior distributions for the extended NAWM are based on two Markov chains, each with 1000,000 draws, with 300,000 draws being discarded as burn-in draws. The average acceptance rate is rougly 24 percent. Note that the baseline NAWM has been re-estimated using data until 2010.

Table 4: Composition of the European Economic Recovery Plan (EERP)

Stimulus measures	2009	2010	Fiscal instruments
Measures aimed at households	0.4	0.3	τ^C, τ^N, τ^{W_h}, TR
Measures aimed at businesses	0.2	0.2	τ^{W_f}
Increased public investment	0.3	0.2	I_G
Increased spending on labour market	0.1	0.1	G
Total	1.1	0.8	

Note: Stimulus measures are expressed as a percentage of GDP. The measures aimed at households are evenly distributed across the model's fiscal instruments.

Table 5: Standardised Fiscal Multipliers and EERP Impact

	Quarters				Long run	Maximum
	1	4	8	16		
A. Fiscal instrument						
Gov. consumption, G	1.26	1.55	1.62	1.67	1.63	1.69
Gov. investment, I_G	1.08	1.08	1.08	1.13	1.55	1.55
Gov. transfers, TR	0.06	0.07	0.06	0.06	0.06	0.07
Consumption taxes, τ^C	0.36	0.46	0.48	0.48	0.48	0.50
Labour income taxes, τ^N	0.13	0.12	0.12	0.15	0.15	0.15
SSC: employees, τ^{W_h}	0.13	0.12	0.13	0.04	0.15	0.15
SSC: employers, τ^{W_f}	-0.04	-0.04	-0.00	0.05	0.04	0.05
B. Fiscal package						
EERP: fiscal multipliers	0.64	0.68	0.72	0.76	0.89	0.89
EERP: output effects	0.68	0.72	0.62	0.03	0.00	0.72

Note: Present-value fiscal multipliers of a 2-year stimulus of 1% of GDP accompanied by 2 years of monetary accommodation. The fiscal multipliers and the European Economic Recovery Plan (EERP) effects are computed at the posterior mode estimates of the model parameters. In the simulations, the intra-annual profile of the EERP stimulus measures in 2009 and 2010 is assumed to be flat. The output effects of the EERP are average percentage deviations from the steady state after a 2-year standardised fiscal stimulus (1.1 percent in the first year, and 0.8 percent in the second year in terms of baseline GDP) accompanied by 2 years of monetary accommodation.