Fiscal Policy and the Great Recession in the Euro Area*

Günter Coenen[†] Roland Straub[‡] Mathias Trabandt[§]

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February 25, 2011

Abstract

How much did fiscal policy contribute to euro area real GDP growth during the Great Recession? We show that fiscal policy has increased quarterly real GDP growth during the crisis by up to 0.5 percentage points. We obtain our result by using an estimated DSGE model for the euro area with a rich theoretical and empirical specification. A detailed modelling of the fiscal sector and the incorporation of as many as 8 fiscal time series appears to be pivotal for our result.

Keywords: DSGE modeling; Open-economy macroeconomics; Fiscal policy; Feedback rules; Public capital; Bayesian inference; Forecasting; Policy analysis; Euro area
JEL codes: C11; C32; E32; E37

*The opinions expressed are those of the authors and do not necessarily reflect views of the ECB, the Deutsche Bundesbank, Sveriges Riksbank or the Eurosystem.

[†]European Central Bank. Address: Directorate General Research, Econometric Modelling Division, European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany, phone: +49-69-1344-7887, e-mail: gunter.coenen@ecb.int.

[‡]European Central Bank. Address: Directorate General Research, Econometric Modelling Division, European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany, phone: +49-69-1344-8926, e-mail: roland.straub@ecb.int.

[§]Sveriges Riksbank and Deutsche Bundesbank. e-mail: mathias.trabandt@googlemail.com.

1 Introduction

The financial crisis triggered a large scale fiscal policy response in the euro area. It led to a sizable increase of government deficits and debt (see figure 1). Often it is argued that expansionary fiscal policies have a substantial impact on economic activity. The question that arises is how much did fiscal policy actually contribute to euro area real GDP growth during the so called Great Recession? We show that fiscal policy has increased quarterly real GDP growth during the crisis by up to 0.5 percentage points.

This paper contributes to a growing theoretical and empirical literature that analyses the impact of fiscal policy on economic activity. Indeed, in the wake of the financial crisis of 2008-09, fiscal multipliers have become once again the center of attention in both academic and policy debates. Most of these discussions aimed at quantifying the size and the sensitivity of fiscal multipliers associated with the launch of large-scale fiscal stimulus packages.[1] However, the full fiscal policy response to the crisis did not rely on fiscal stimulus measures only. For instance, automatic stabilizers as well as financial sector support measures have provided further support to the economy. Therefore, it is essential to account for both the effects of automatic stabilizers as well as for discretionary fiscal policies to provide a fully fledged assessment of the fiscal impact on real GDP. This paper makes a step forward on exactly that dimension.

Several existing studies focus on the effectiveness of fiscal stimulus or fiscal stimulus packages. In these papers, multipliers of (individual) fiscal instruments are evaluated in state-of-the-art DSGE models. Prominent examples are Christiano et al. (2010), Coenen et al. (2010), Cogan et al. (2010), Uhlig (2010), Uhlig and Drautzburg (2010), Eggertsson (2010), Cwik and Wieland (2010), Corsetti, Meier and Müller (2009) and Erceg and Linde (2010) among many others.

In this paper, and in contrast to previous studies, we evaluate the effectiveness of fiscal policy from a different angle. We provide an ex-post quantitative evaluation of the effectiveness of fiscal policy in influencing the euro area business cycle during the crisis. That is, we decompose the dynamics of real GDP growth in the euro area into fiscal and non-fiscal shocks during the period of 2007-10. Thereby, we evaluate the role of discretionary fiscal policy for stabilizing the real economy. To this end, we utilize an estimated DSGE model for the euro area, with a rich specification of the fiscal sector. The model specification aims at balancing complexity, which is necessary for conducting business cycle analysis, and tractability, which allows us to identify the relevant economic mechanisms.

We show that discretionary fiscal policies lead to an increase of quarterly real GDP growth by up to 0.5 percentage points during the crisis. The incorporation of as many as 8 time series that characterize fiscal policy turns out to be crucial. In addition, a detailed modelling of the fiscal sector appears to be pivotal for our result. That is, a version of the model that only measures one fiscal time series, namely government consumption, and that has a rather stylized fiscal sector, predicts a negligible impact of discretionary fiscal policies for real GDP growth during the crisis.

Furthermore, based on the estimated model, we also conduct an assessment of the Eu-

[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.

ropean Economic Recovery Package similar to Cwik and Wieland (2010) and others. We show that our results are comparable to previous studies, i.e. we find that the fiscal stimulus package multipliers can be sizable but are rather short lived.

The paper is structured as follows. Section 2 provides an overview of the model. Section 3 describes the data and the estimation. Then section 4 presents our core results on the contribution of fiscal policies to euro area real GDP growth. In addition, section 5 explores the impact of the European Economic Recovery Package in our estimated model. Finally, section 6 concludes.

2 The Model

The model is basically a small-open economy extension of the euro are model by Smets and Wouters (2005) , the so called New Area Wide Model (NAWM) described in Christoffel et al. (2008). The main changes compared to Christoffel et al. (2008) are related to a detailed specification of the fiscal sector.

The main features of the model are as follows. Within the euro area—henceforth, domestic—economy, there are four types of economic agents: households, firms, a fiscal authority, and a monetary authority. As regards households, we distinguish between Ricardian households, which have access to asset markets and rule-of-thumb agents that follow a simple rule when deciding upon current consumption. As regards firms, we distinguish between producers of tradable differentiated intermediate goods and producers of four non-tradable final goods: a private consumption good, a private investment good, a public consumption good and a public investment good. In addition, there are foreign intermediate-good producers that sell their differentiated goods in domestic markets, and a foreign retail firm that combines the exported domestic intermediate goods. We assume that public consumption and public investment goods are entirely made of domestic intermediate goods. International linkages arise from the trade of intermediate goods and international assets, allowing for limited exchange-rate pass-through on the import side and imperfect risk sharing. The model incorporates several nominal and real rigidities. For example, prices and wages are subject to indexation to past inflation and to nominal rigidities a la Calvo, while capital accumulation is subject to adjustment costs in investment. The rest of the world is modelled using a structural vector-autoregressive (SVAR) model, where the estimated parameters are kept fixed throughout the structural model estimation.

With regards to the fiscal sector, we allow fiscal policy to impact the economy through several channels:(i) depending on a parameter government consumption is valued by households in a potentially non-separable way (ii) the inclusion of non-Ricardian agents in the model, which allows transfers to have an impact on income distribution (iii) the accumulation of public capital that is subject to time-to-build, (iv) depending on a parameter, public and private capital may be complements or substitutes (v) time-varying distortionary taxation (vi) and fiscal rules that determine the dynamic path of the fiscal instruments. As the main features of the model are relatively standard, we highlight, in what follows, only those parts that are most relevant for understanding the role of fiscal policy. A more detailed description of the model can be found in the Appendix.

2.1 Households

There is a continuum of households indexed by $i \in [0, 1]$. We assume that households can be separated into two groups. Those who have access to financial markets (Ricardian households) and those who do not (non-Ricardian households). In what follows, we assume that the mass of non-Ricardian households is denoted by $j \in [0, \omega]$ and the mass of Ricardian households is $h \in (\omega, 1]$.

2.1.1 Ricardian Households

Ricardian households accumulate physical capital, the services of which they rents out to firms, and buy and sell domestic government bonds as well as internationally traded foreign bonds. This enables Ricardian households to smooth their consumption profile in response to shocks. The households supply differentiated labour services to firms and act as wage setters in monopolistically competitive markets. As a consequence, each household is committed to supply sufficient labour services to satisfy firms' labour demand. The utility function of the representative Ricardian household is adapted as follows: each Ricardian household maximises its lifetime utility in a given period t by choosing purchases of an aggregate consumption good, $\widetilde{C}_{h,t}$, defined below, purchases of a private investment good, $I_{h,t}$, which determines next period's private capital stock, $K_{h,t+1}$, the intensity with which the existing capital stock is utilised in production, $u_{h,t}$, and next period's (net) holdings of domestic government bonds and internationally traded foreign bonds, $B_{h,t+1}$ and $B^*_{h,t+1,}$ respectively, given the following lifetime utility function::

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

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 h depends positively on the difference between the current level of aggregate consumption, $\widetilde{C}_{h,t}$ and the lagged economy-wide aggregate consumption level subject to:

$$\begin{aligned}(1+\tau_t^C)\, P_{C,t}\, C_{h,t} + P_{I,t}\, I_{h,t} + \frac{B_{h,t+1}}{R_t^{gov}} + \frac{S_t\, B^*_{h,t+1}}{\left[1-\Gamma_{B^*}(s_{B^*_t+1};\epsilon_t^{RP^*})\right]\, R_t^*} + \Upsilon_{h,t} + T_t + \Xi_t^{B^*} \\ = (1-\tau_t^N - \tau_t^{W_h})\, W_{h,t}\, N_{h,t} + \left[(1-\tau_t^K)\, R_{K,t} + \tau_t^K \delta\, P_{I,t}\right] K_{h,t} + TR_t + B_{h,t} + S_t\, B^*_{h,t},\end{aligned}$$

where $P_{C,t}$ and $P_{I,t}$ are the prices of a unit of the private consumption good $C_{h,t}$ and the investment good $I_{h,t}$, respectively. $N_{h,t}$ denotes the labour services provided to firms at wage rate $W_{h,t}$; $R_{K,t}$ indicates the rental rate for the effective capital services rented to firms defined by $u_{h,t} K_{h,t}$, and $D_{h,t}$ 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 (expressed in terms of units of the domestic currency per unit of the foreign currency). The fiscal authority absorbs part of the household's gross income to finance its expenditure. In this context, τ_t^C denotes the consumption tax rate 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 utilisation cost of physical capital as well as physical capital depreciation, $\delta\, P_{I,t} K_{h,t}$, are 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 term T_t denotes lump-sum taxes. The effective return on the risk-less domestic bonds depends on a financial intermediation premium, represented by the exogenous "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 $\Gamma_{B^*}(s_{B^*,t+1}; \epsilon_t^{RP^*})$, where $\epsilon_t^{RP^*}$ is an external risk premium shock. This specification implies that, in the nonstochastic steady state, households have no incentive to hold foreign bonds and the economy's net foreign asset position is zero. The incurred intermediation premium is rebated in a lump-sum manner, being indicated by $\Xi_t^{B^*}$.For analytical convenience, each household h is assumed to hold a state-contingent securities which returns are distributed by $\Upsilon_{h,t}$ in a lump-sum manner. These securities are traded amongst Ricardian households and provide insurance against household-specific wage-income risk, associated with Calvo-type of wage rigidities. This guarantees that the marginal utility of consumption out of wage income is identical across households. As a result, Ricardian households will choose identical allocations in equilibrium.

We adapt the model to allow for non-separable valuable government consumption similar to Leeper, Walker, and Yang (2009). 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. As a result, aggregate consumption $\tilde{C}_{h,t}$ is defined as follows:

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

where $C_{h,t}$ denotes the aggregate consumption of private goods, and G_t measures government consumption. Note that $0 \leq \alpha_G \leq 1$ and $\upsilon_G > 0$, where υ_G measures the elasticity of substitution between private consumption and government consumption, i.e. $\upsilon_G \to 0$ implies perfect complements, $\upsilon_G \to \infty$ gives perfect substitutes, and $\upsilon_G \to 1$ yields the Cobb-Douglas case. Finally, the physical private capital stock owned by household h evolves according to the following private capital accumulation equation:

$$K_{h,t+1} = (1 - \delta)\, K_{h,t} + \epsilon_t^I \,(1 - \Gamma_I(I_{h,t}/I_{h,t-1}))\, I_{h,t}, \tag{2}$$

where $\Gamma_I(I_{h,t}/I_{h,t-1})$ are the adjustment cost of investment and ϵ_t^I is an investment specific technology shock.

2.1.2 Non-ricardian Households

We introduce non-Ricardian (rule-of-thumb) households following Gali et al. (2006) and Coenen and Straub (2005).[2] Non-Ricardian and Ricardian preferences are identical. Non-Ricardian households have, however, no access to financial markets. As in Coenen and Straub (2005), we assume that unions solve a standard optimization problem subject to i) the pooled wage income of Ricardian and non-Ricardian households and ii) the demand for labour. We assume that the union's choice variable is a common nominal wage for both groups. These assumptions imply that the wage Phillips curve is unaffected by the introduction of non-Ricardian households. Moreover, the common wage rate and identical separable preferences result in the same amount of labor supplied by Ricardian and non-Ricardian households[3]. Formally,

$$\begin{aligned} W_{j,t} &= W_{h,t} = W_t \\ N_{j,t} &= N_{h,t} = N_t. \end{aligned}$$

Therefore, each non-Ricardian household j sets nominal consumption expenditure equal to after-tax disposable wage income plus transfers, which results in:

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

Aggregate private consumption and government consumption is defined as:

$$C_t = (1-\omega) C_{h,t} + \omega C_{j,t}$$

Further, we have that total transfers are:

$$TR_t = (1-\omega) TR_{h,t} + \omega TR_{j,t}$$

Finally, lump-sum transfers are distributed in deviations from steady state among Ricardian and non-Ricardian by the following rule dynamically: $\epsilon TR_{h,t} = (1-\epsilon) TR_{j,t}$.

In steady state, we compute TR_j and TR_h such that $C_j/C_h \approx 0.8$. Note that the approach to introducing non-Ricardian households adopted here implies that: i) lump-sum taxes are only paid by Ricardian households and ii) government transfers affect the income distribution between the groups.

[2] There is a comparably large literature on rule-of-thumb consumers. Examples are Campbell and Mankiw (1989, 1990 and 1991), Mankiw (2000), Coenen and Straub (2005), Coenen, McAdam and Straub (2007), Gali, Lopez-Salido and Valles (2007)

[3] Two alternative sets of assumptions would yield the same result that wages and labor supply are identical in both groups. First, non-Ricardian households take the pooled (Ricardian and non-Ricardian) wage income as given and supply sufficient labour services to satisfy labour demand (which is identical for both groups). Second, non-Ricardian households set their wage equal to the average wage of Ricardian households and face identical labor demand.

2.2 Firms

2.2.1 Production Function and Public Capital

In contrast to standard DSGE models, public capital is added as an input for domestic intermediate goods production. In particular, each intermediate-good firm $f \in [0,1]$ which produces 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 $\tilde{K}^s_{f,t}$:

$$Y_{f,t} = \varepsilon_t \left(\tilde{K}^s_{f,t}\right)^{\alpha} (z_t N_{f,t})^{1-\alpha} - z_t \psi. \tag{3}$$

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 shifting the productivity of labour lastingly. The term $z_t\psi$ represents the fixed costs of production. The permanent technology shock introduces a unit root in the firms' output and evolves according to the following serially correlated process,

$$g_{z,t} = (1-\rho_{gz})g_z + \rho_{gz} g_{z,t-1} + \eta^{gz}_t \tag{4}$$

where $g_{z,t} = z_t/z_{t-1}$ represents the (gross) rate of labour-augmenting productivity growth with steady-state value g_z. Physical capital is a constant elasticity of substitution (CES) aggregate of private capital services $K^s_{f,t}$ and the public capital stock $K_{G,t}$:

$$\tilde{K}^s_{f,t} = \left(\alpha_K{}^{\frac{1}{\upsilon_K}} \left(K^s_{f,t}\right)^{\frac{\upsilon_K - 1}{\upsilon_K}} + (1-\alpha_K)^{\frac{1}{\upsilon_K}} \left(K_{G,t}\right)^{\frac{\upsilon_K - 1}{\upsilon_K}}\right)^{\frac{\upsilon_K}{\upsilon_K - 1}}. \tag{5}$$

where the parameter υ_K is the elasticity of substitution between private capital services and the public capital stock, and α_K is a share parameter. Hence, we assume that each intermediate-good firm f has access to the same public capital stock. We also assume that public capital grows at the same speed as private capital services along the balanced growth path of the model.

Recently, Leeper, Walker and Yang (2009) have argued that time-to-build for public capital is important to analyse 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 et al. (2009) model the delays between the authorization 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).

We allow for the possibility of several periods of time-to-build in public capital, adopting a similar specification, and we check in the empirical part whether the data support this feature compared to the usual case of a one-period time-to-build. 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 as:

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

where $\delta_G \in [0,1]$ denotes the depreciation rate of the public capital stock. $A_{I_G,t-L+1}$ is the authorized budget for government investment in period $t-L+1$. Government investment that is actually implemented (outlayed) is defined by:

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

where $I_{G,t}$ enters the government budget constraint and the resource constraint. Note that it must be the case that

$$\sum_{n=0}^{L-1} b_n = 1.$$

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

2.3 Government Budget and Fiscal Rules

The government budget constraint looks as follows:

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

where we have defined $\tau_t^{N,W_h} \equiv \tau_t^N + \tau_t^{W_h}$.[4] If $\mu^{RP} = 1$, we have the case of the risk premium affecting economy wide finanical markets. If $\mu^{RP} = 0$ we have the case of private sector financial risk.

As discussed above, we use a uniform specification for the fiscal rules. That is, we assume that all fiscal instruments react to its own lagged value, to government debt and the output gap. From the expenditure side, taking government consumption as an example, the log-linear specification of the rule looks as follows:

$$\hat{g}_t = \rho^G \hat{g}_{t-1} - \left(\theta_{GB} \hat{b}_t + \theta_{GY} \hat{y}_{t-1} \right) + \left(1 - \psi^G \right) \hat{\eta}_t^G + \psi^G \hat{\eta}_t^G.$$

Similarly, for demonstrating the structure of fiscal rules at the income side, the consumption tax rule has the following form:

$$\check{\tau}_t^C = \rho^C \check{\tau}_{t-1}^C + \theta_C \hat{b}_t + \theta_C \hat{y}_t + \left(1 - \psi^C \right) \hat{\eta}_t^C + \psi^C \hat{\eta}_{t-1}^C.$$

Note that we assume that fiscal feedback parameters on output as well as debt are such that fiscal policy is counter-cyclical.

[4]Furthermore, we have used the fact that the total wage sum paid by firms to the households equals $\int_0^1 W_{h,t}\, N_{h,t}\, dh = N_t \int_0^1 W_{h,t} \left(\frac{W_{h,t}}{W_t} \right)^{-\varphi_t^W / (\varphi_t^W - 1)} dh = W_t\, N_t$.

2.3.1 Market Clearing and Resource Constraint

Finally, the resource constraint of the economy has the following form:

$$\begin{aligned} P_{Y,t}\,Y_t &= P_{C,t}\,C_t + P_{I,t}\,(I_t + \Gamma_u(u_t)\,K_t) + P_{G,t}\,G_t + P_{I_{G,t}}\,I_{G,t} + S_t\,P_{X,t}\,X_t \\ &\quad - P_{IM,t}\left(IM_t^C\,\frac{1-\Gamma_{IM^C}(IM_t^C/Q_t^C)}{\Gamma^{\dagger}_{IM^C}(IM_t^C/Q_t^C)} + IM_t^I\,\frac{1-\Gamma_{IM^I}(IM_t^I/Q_t^I)}{\Gamma^{\dagger}_{IM^I}(IM_t^I/Q_t^I)}\right). \end{aligned}$$

where $P_{IM,t}$ is the import price level, IM_t^C is the imported consumption good, while IM_t^I is the imported investment good and Q_t^C and Q_t^I are the overall level of consumption and investment respectively. Note that both that imports are subject to adjustment costs denoted by $\Gamma^{\dagger}_{IM^C}(IM_t^i/Q_t^i)$ where $i \in \{C, I\}$. In a similar vein, $\Gamma_u(u_t)$ represent the capital utilization costs in the model. Exports and export prices are denoted by X_t and $P_{X,t}$ and , respectively. Finally the variable $P_{Y,t}$ stands for the GDP deflator.

3 Bayesian Estimation

We adopt the empirical approach outlined in Schorfheide (2000) and An and Schorfheide (2007) and estimate the NAWM employing Bayesian inference methods. This involves obtaining the posterior distribution of the model's structural parameters based on its log-linear state-space representation using the Kalman filter. [5]

3.1 Data and Shocks

3.1.1 Data

In estimating the model, we use times series for 17 macroeconomic (non-fiscal) variables:

- real GDP (Y)
- private consumption (C)
- real private investment (I)
- oil prices (P_O)†
- extra-euro area exports (X)
- extra-euro area imports (IM)
- GDP deflator (P_Y)
- consumption deflator (P_C)
- extra-euro area import deflator (P_{IM})
- total employment (E)
- compensation per head (W)
- nominal interest rate (R)
- nominal effective exchange rate (S)
- foreign demand ($Y^{d,*}$)†
- foreign prices (P_Y^*)†
- foreign interest rate (R^*)†
- competitors' export prices ($P_X^{c,*}$)†

[5] For all computations, we use YADA, a Matlab programme for Bayesian estimation and evaluation of DSGE models (cf. Warne, 2008).

All time series are taken from an updated version of the AWM database (see Fagan, Henry and Mestre, 2001), except for the time series of extra-euro area trade data (both volumes and prices) which stem from internal ECB sources. The sample period ranges from 1985Q1 to 2010Q2 (using the period 1980Q2 to 1984Q4 as training sample). The times series marked with a dagger ('†') are modelled using a structural vector-autoregressive (SVAR) model, the estimated parameters of which are kept fixed throughout the estimation.[6]

Prior to estimation, we transform real GDP, private consumption, total investment, extra-euro area exports and imports, the associated deflators, compensation per head (henceforth, wages), as well as foreign demand and foreign prices into quarter-on-quarter growth rates, approximated by the first difference of their logarithm. Furthermore, a number of additional transformations are made to ensure that variable measurement is commensurate with the properties of the model's balanced-growth path and in line with the underlying assumption that all relative prices are stationary. First, we match the sample growth rates of extra-euro area exports and imports as well as foreign demand with the sample growth rate of real GDP by removing the remaining growth rate differentials, reflecting the fact that trade volumes and foreign demand tend to grow at a significantly higher rate than real GDP. Furthermore, we take the logarithm of employment and remove a linear trend consistent with a labour force growth rate of 0.8 percent, noting that, in the absence of a reliable measure of hours worked, we use data on employment in the estimation.[7]

Also, we construct a measure of the real effective exchange rate from the nominal effective exchange rate, the domestic GDP deflator and foreign prices (defined as a weighted average of foreign GDP deflators) and then remove the mean. Finally, we deflate competitors' export prices and oil prices (both expressed in the currency basket underlying the construction of the nominal effective exchange rate) with foreign prices and then remove the remaining linear trends.

Turning to the fiscal variables, we use quarterly data on general government revenues and expenditures for the euro area compiled by Paredes et al. (2009). Note that Paredes et al. (2009) focus on intra-annual fiscal information for interpolation purposes which allows to capture genuine intra-annual "fiscal" dynamics in the data. Therefore, this avoids 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; (ii) the well-known decoupling of tax collection from the evolution of macroeconomic tax bases

[6]Identification within the SVAR model is achieved by a Choleski decomposition of its estimated variance-covariance matrix, the ordering of variables being: foreign prices, foreign demand, foreign interest rate, oil prices and competitors' export prices.

[7]We relate the employment variable, E, to the unobserved hours-worked variable, N, by an auxiliary equation following Smets and Wouters (2003),

$$\widehat{E}_t = \frac{\beta}{1+\beta}\,\mathrm{E}_t[\widehat{E}_{t+1}] + \frac{1}{1+\beta}\,\widehat{E}_{t-1} + \frac{(1-\beta\xi_E)\,(1-\xi_E)}{(1+\beta)\,\xi_E}\left(\widehat{N}_t - \widehat{E}_t\right),$$

where a hat ('$\widehat{\ }$') denotes the logarithmic deviation from trend in the case of employment and from the steady-state value in the case of hours worked. This is consistent with our assumption that the model can be expressed in per-capita terms. The parameter ξ_E determines the sensitivity of employment with respect to hours worked.

(revenue windfalls/shortfalls).

The data abbreviations follow the definitions in Paredes et al. (2009) and more importantly the methodology in the Government Finance Statistics Guide (ECB, January 2007):

- Real general government final consumption expenditure (GCR)
- Real general government transfers to households, i.e. social transfers other than in kind (THR)
- Real general government gross fixed capital formation (GIR)
- Nominal general government revenues from indirect taxes, total (TIR)
- 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 data (GDN)

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 1991Q1 in order to obtain data on employer and employee social security contributions.

Note that, we remove a linear trend from all fiscal data. Data on government consumption is available in real terms, while data on government investment is deflated using the private investment deflator from the AWM datatbase. Revenue data are constructed as ratio to consumption (indirect taxes) or wages (direct taxes as well as social security contributions).

In order to address the potential problem of mismeasurement associated with interpolated data, we allow for errors in the measurement of the fiscal variables. In particular, for all fiscal data iid measurement errors with a variance of 0.5% are assumed.

3.1.2 Shocks

We employ a total of 12 non-fiscal shocks, plus the 5 shocks from the SVAR models for the foreign variables, respectively:

- domestic risk premium shock (ϵ^{RP})
- external risk premium shock (ϵ^{RP^*})
- permanent technology shock (g_z)
- transitory technology shock (ε)
- investment-specific techn. shock (ϵ^{I})
- wage markup shock (φ^{W})
- price markup shock: domestic (φ^{H})
- price markup shock: exports (φ^{X})
- price markup shock: imports (φ^{*})
- import demand shock (ϵ^{IM})
- export preference shock (ν^{*})
-
- interest rate shock (η^{R})
- foreign demand shock ($\eta^{Y^{d,*}}$)
- foreign price shock ($\eta^{\Pi_Y^*}$)
- foreign interest rate shock (η^{R^*})
- competitors' export price shock ($\eta^{P_X^{c,*}}$)
- oil price shock (η^{P_0})

All shocks are assumed to follow first-order autoregressive processes, except for the interest rate shock and the shocks in the SVAR model, which are assumed to be serially uncorrelated. In addition, we account for measurement error in extra-euro area trade data (both volumes and prices) in view of the fact that they are prone to large revisions. We also allow for small errors in the measurement of real GDP and the GDP deflator to alleviate differences between the national accounts framework underlying the construction of official GDP data and the NAWM's aggregate resource constraint. With respect to the fiscal shock, we introduce following shocks into the model:

- government consumption shock(η^{G})
- direct tax shock (η^{N})
- government transfer shock (η^{TR})
- employer SSC shock (η^{W_f})
- government investment shock (η^{I_G})
- indirect tax shock (η^{C})
- lump-sum tax shocks (η^{T})
- employee SSC shock (η^{W_h})

This corresponds to the 8 fiscal variables and the fiscal rules described above.

3.2 Calibration and Prior Distributions

3.2.1 Calibration

Our calibration strategy follows the literature and assigns values to those parameters that affect the models non-stochastic steady state. Regarding the latter, all real variables are assumed to evolve along a balanced-growth path with a common growth rate of 2.0 percent per annum, which broadly matches observed real GDP growth in our estimation sample. The steady-state growth rate of 2.0 percent in turn is assumed to consist of two components: the steady-state growth rate of labour productivity g_z, which amounts to roughly 1.2 percent over our sample period, and a steady-state rate of population growth g_n, which is proxied by the sample growth rate of the labour force of approximately 0.8 percent. Hence, once trend labour force growth is accounted for, all non-fiscal quantities within the model can be interpreted in (approximate) per-capita terms. 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. Specifically, the expenditure shares of private consumption, government consumption are set to, respectively, 57.5 and 21.5 percent of nominal GDP, while the export and import shares are set to 16.0 percent, implying balanced trade in steady state.

Conditional on the steady-state rate of productivity growth, the discount factor β is chosen to imply an annualised equilibrium real interest rate of 2.5 percent, while the monetary authority's long-run (net) inflation objective $\bar{\Pi} - 1$ is assumed to equal 1.9 percent at an annualised rate, consistent with the ECB's quantitative definition of price stability of inflation being below, but close to 2 percent. We set the capital share of output α to 33% and both the depreciation rate of public capital δ_G and private capital δ to 1.25%. These values are chosen to match estimates of annual private and public capital-to-output ratios in the European Union of approximately 300% and 45%, respectively, as reported e.g. by Kamps (2005). Our calibration of the wage and price markups with $\varphi^W = 1.30$ and $\varphi^H = \varphi^X = 1.35$ is based on studies conducted at the OECD (cf. Martins, Scarpetta and Pilat, 1996, and Jean and Nicoletti, 2002).[8] The parameter ψ, determining the fixed costs of the intermediate-good firms' production technology, is calibrated such that profits are zero in steady state. Regarding final-good production, we choose steady-state values for the home-bias parameters ν_C and ν_I that allow the model to replicate the import content of consumption and investment spending—roughly 10 and 6 percent, expressed as shares of nominal GDP—utilising information from input-output tables for the euro area (cf. Statistics Netherlands, 2006). We calibrate a small number of additional parameters that are inherently difficult to identify. This concerns the inverse of the labour supply elasticity ζ, which we set equal to 2 in line with the range of available estimates, and the sensitivity of the external intermediation premium γ_{B^*}, which we fix at 0.01 so that the evolution of net foreign assets has only a small impact on the exchange rate and trade in the short run, while stabilising the net foreign asset position at zero in the long run.

Turning to 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. On the expenditure side, we also choose values for s_{TR} and s_{I_G} in order to match the average shares of government transfers over GDP and government investment over GDP in the data. Note that in the data the average government investment share is around 2.8% and the private investment share around 18.3%. We use this information to match the share of private investment in the data in the steady state optimization process. Furthermore, the model consistent government consumption share is at 21.5%, which is close to the average share in the at approximately 21%.

With respect to government debt, we assume a steady state debt-to-GDP ratio of 60% per annum. This value is close to the average share of government debt over GDP of approximately 65%. However, a steady state debt-to-GDP ratio of 60% is consistent with the rules of the Stability and Growth Pact, which provide an anchor for debt developments in the euro area over the medium to long term. A steady state value of 60% for the debt-

[8] See Bayoumi, Laxton and Pesenti (2004) for further discussion. We note that the foreign price markup φ^* neither affects the steady state nor does it enter the log-linearised version of the model.

to-GDP ratio implies a steady state value of 1.8% per annum for the government budget deficit-to-GDP ratio, compared to an average deficit-to-GDP ratio over the full estimation sample of 3.6% per annum.

3.2.2 Prior Distributions

We use the same priors as Christoffel et al. (2008) for the parameters that are common between their and our model.For the AR(1) parameters and the standard deviations of the fiscal shocks we use a beta distributions (restricted between 0 and 1) with mean 0.75 and standard deviation 0.10 for the AR(1) parameters and inverse gamma distributions (which have lower bound 0) with mode 0.10 and degrees of freedom 2 for the standard deviations, reflecting the fact that there is little prior information on these parameters.

For the feedback coefficients on output and debt in the fiscal rules, we adopt gamma distributions (with lower bound 0) with mean 0.15 and standard deviation 0.10. Hence, our prior is that the stance of fiscal policy in the euro area is counter-cyclical. Here we follow Leeper, Plante, and Traum (2009), who also adopt gamma distributions for fiscal feedbacks in the U.S. Through our choices for the center and dispersion of the priors, we assign prior probability on a region which is in the ballpark of Leeper, Plante, and Traum's estimates for those parameters.

The substitution elasticities υ_G and υ_K are restricted to be positive by the theory. We therefore specify gamma distributions with means 0.5 and standard deviations 0.05 for these parameters, our prior being that both public consumption and public capital are complementary to private consumption and private capital, respectively. Finally, for the parameter b_0, which determines the degree of time-to-build in the model, we specify a relatively diffuse beta prior with mean 0.5 and standard deviation 0.15 for the time-to-build profile b_0, and back out the parameter $b_1 = 1 - b_0$.

3.3 Estimation Results

to be written (see Table 1 for a selected number of parameters, and Table 2 for the corresponding fiscal multipliers)

4 Results

4.1 Comparing Historical Decompositions

In order to assess the implications of our enhanced model, we compare our results with the results produced by a model with a stripped down specification of the fiscal sector as described in Christoffel et al. (2008). Recall that this model is basically a small-open economy extension of the model by Smets and Wouters (2005), with government consumption being the only observable variable, and distortionary tax rates assumed being fixed over the business cycle. As the latter model also assumes balance budget, there is no role for fiscal rules in determining macroeconomic dynamics.

Let us first consider the historical decomposition of euro area GDP using an estimated version of this simplified DSGE model. Thereby, we decompose the q-o-q real GDP growth rate (in deviation from mean growth) into non-fiscal and fiscal (being only government consumption in this case) shocks. The results shown in Figure 2 indicate that fiscal shocks have played a little role in stabilizing real GDP growth in the years 2009/10. This could lead us to the conclusion that in a counterfactual world without discretionary fiscal spending, real GDP behavior would have not been significantly different from the observed one. In contrast, however, in our model with an enhanced fiscal sector, the role of discretionary fiscal spending is much more prominent. When decomposing real GDP growth, our results presented in Figure 3 show that discretionary fiscal shocks have pushed up q-o-q growth rates up to 0.5 percent.

Naturally, the question arises which fiscal shocks have had the strongest positive impact on euro area real GDP growth. In Figure 4, we present the contribution of each individual fiscal shock to shed some light on that question. According to our results, government investment, transfers, as well as labour income tax shocks have played a major role in pushing up euro area GDP growth. It is worth to point out also the prominent role of lump-sum tax shocks in stabilizing euro area GDP over the crisis. Thereby, we interpret the role of lump-sum tax shocks, as a type of transfer shock that does not have a distributional impact on the economy. For completeness, Figure 5 displays the non-fiscal shocks that drove real GDP during the crisis.

4.2 Inspecting the Mechanism

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) government investment and (iii) non-separable government consumption. Note that Table 1 displays the estimated posterirore model of some selected parameter estimates, which are useful to understand key implications of the model discussed below.

In Figure 6, we show the impact of transfer shocks on private consumption under three different parameterization. Setting $\omega = 0$ implies that all households in our model are Ricardians, so there is no distributional impact of transfer shock in our model. We would consider this as the benchmark, as most traditional DSGE model assume no role for non-Ricardian households. The negative impact can be rationalized by the fact that according to our fiscal rule, any increase in transfers need to be partly financed by an increase in distortinary taxes, which implies a negative response of private consumption. When $\omega = 0.5$, we observe a very strong impact of transfer shock on private consumption explained by the large share of non-Ricardian households, which are subject to a positive wealth effect triggered by the rise in transfers. Note that this impact is not only driven by the lack of the intertemporal optimization of non-Ricardian households, but also by the distributional effects of transfer shocks assumed above. The intermediate case is showing the impulse response function using the posteriore mode following the Bayesian estimation. As our estimated of non-Ricardian households is at $\omega = 0.21$, the reaction of private consumption is less pronounced.

In Figure 7, we evaluate the impact of government investment shock on private investment by varying the degree of substitution elasticity between private and public captial. We would see as the benchmark the Cobb-Douglas case, that is setting υ_K =1 and $\alpha_K = 0.95$.

There we see that the reaction of private investment to a government investment shock is relatively muted, implying even a negative response of private investment on impact. When setting the υ_K =100 and α_K to the estimated posteriore mode value, we observe a persistent negative impact of government investment shock on private investment. This is not surprising as the chosen parameterization implies that private and government investment are strong substitutes. Using the estimated posterior mode for simulating the impulse response function implies a persistent crowding in of private investment, as the data favours strong complementarity between government and private investment.

Finally, the third specification that is crucial for understanding the transmission of fiscal shocks in the model, is the assumption that government consumption is valued and non-separable. Figure 8 shows that starting with the benchmark case of modelling government consumption as a pure waste, i.e. $\alpha_G = 1$, we see a persistent negative response of private consumption following an exogenous increase in government spending. Note that the results are driven by the negative wealth effect of an increase government debt following the rise in government spending. The estimated share of non-Ricardians is under most general parameterizations not enough to overturn this effect; a result that is discussed in details in Gali et al. (2006) and Coenen and Straub (2005). Assuming that public and private consumption are substitutes, i.e. $\upsilon_G = 3$, induces a persistent negative reaction of private consumption as a response to a government consumption shock. At the same time, data favours a specification that implies a strong complementarity of public and private consumption, which is also demonstrated by the strong and persistent positive response of private consumption following an exogenous increase in public consumption.

Finally, Table 2 displays fiscal GDP multipliers by horizon and fiscal instrument. Most of the multipliers are in the ballpark of earlier studies. Note, however, that a full monetary policy response (i.e. no accommodation) is assumed. By contrast, the next section turns to a set up in which the monetary authority holds the nominal interest rate constant within the first two years.

4.3 Evaluating the European Economic Recovery Package (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 3 gives a breakdown of the different fiscal measures implemented at the euro area level, as estimated by the European Commission. In total, the fiscal stimulus measures amount to 1.1 percent and 0.8 percent 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 extrabudgetary actions such as capital injections, loans and guarantees to non-financial firms and investment by public corporations. Table 3 reveals that, within 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 direct taxes, social security contributions and VAT, 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 aimed 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.

Table 3 : Composition of fiscal stimulus packages (as a percentage of GDP)

	2009	2010	Model variable
Measures aimed at households	0.4	0.3	TR, τ^N, τ^C
Increased spending for labor market measures	0.1	0.1	G
Measures aimed at business	0.2	0.2	τ^{W_f}, τ^K
Increased public investment	0.3	0.2	I^G
Total	1.1	0.8	

We use our model to illustrate, by means of simulations, the likely economic effects of the EERP. To this end, Table 3 also provides information on how the different fiscal measures implemented within the framework of 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 countries and the model's fiscal variables, a certain amount of judgement was needed. For instance, labour market measures were allocated to government consumption since they are 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 the model, the paths of fiscal instruments specified in Table 3 are imposed and the endogenous response of the economy is simulated. It is assumed that the stimulus is initially almost fully debt-financed, that is all fiscal rules except the one for lump-sum taxes are switched off. Within the first two years, we also assume that the nominal interest rate is kept constant. Thereafter, the nominal interest rate is adjusted according to a Taylor rule. For comparison with the other literature (see Coenen et al., 2010 and Cogan et al., 2010), we also assume that the Taylor rule is static and reacts only to contemporaneous GDP growth and inflation.

Table 4 shows the simulation results. The impact on real GDP in 2009 and 2010 (relative to the steady-state baseline) is positive, amounting to about 0.7% and 0.7% respectively. Assuming that the fiscal stimulus measures are lifted in 2011, the effects on real GDP fade away rather quickly. In the next step, we switch-off part of the model extension by setting $\upsilon_K = 1, \alpha_K = 0.95$ and $\alpha_G = 1$. That is we assume non valued government consumption, and a Cobb-Douglas specification for the relationship between of government and private investment. The results (version 2) show that the package multiplier declines somewhat compared to the baseline case. The multiplier are further reduce in case no monetary accomondation takes place as demonstrated in the row below. All in all, the simulations suggest that the output gains of temporary fiscal stimulus measures are positive, albeit short-lived.

Table 4 : Real GDP Impact of the EERP (in percent deviations from baseline)

	2009	2010	2011	2012	2013
Version 1 (baseline fiscal model)	0.7	0.7	0.3	0.2	0.2
Version 2 (υ_K =1,α_K =0.95 and $\alpha_G = 1$)	0.5	0.3	0.0	0.0	0.0
Version 2 + no monetary accomondation	0.4	0.3	0.0	0.0	0.0

5 Summary and Conclusions

In this paper, we conducted a quantitative evaluation of discretionary fiscal policy on euro area economic activity during the Great Recession. To this end, we utilized a DSGE model that is characterized by a rich specification of the fiscal sector. We have estimated the model using Bayesian methods and by utilizing a large set of euro area fiscal data. Our results show that discretionary fiscal policies led to an increase of quarterly real GDP growth of up to 0.5 percentage points during the crisis. We have argued that the incorporation of many time series that characterize fiscal policy and a detailed modelling of the fiscal sector turns out to be pivotal for our result. Finally, we have shown that discretionary fiscal spending, associated with the European Economic Recovery Package, can generate sizeable, albeit short-lived fiscal multipliers.

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Table 1: A Selection of Estimated Parameters

	Prior	Posterior Mode		Description
ω	B(0.5,0.2)	**0.21**	**0.02**	Share of rule-of-thumb consumers
υ_G	IG(0.3,2)	**0.26**	**0.03**	CES priv.-public consumption
υ_K	IG(0.3,2)	**0.11**	**0.02**	CES priv.-public capital
α_G	B(0.9,0.05)	**0.73**	**0.02**	CES share priv.-public consumption
α_K	B(0.9,0.05)	**0.71**	**0.002**	CES share priv.-public capital
b_0	B(0.5,0.2)	**0.06**	**0.01**	Share of initial gov. investment outlays
ψ^G	B(0.5,0.2)	**0.87**	**0.01**	Weight pre-announced gov. consumption
θ_{GB}	IG(0.1,2)	**0.07**	**0.01**	Debt feedback gov. consumption
θ_{GY}	IG(0.1,2)	**0.09**	**0.01**	Output feedback gov. consumption

- **Note: total of 93 estimated parameters (structural, shocks)**

Table 2: Fiscal GDP Multipliers

Instrument	Impact	2years	Long-run
Gov. Expenditures			
Consumption	0.48	1.38	1.53
Investment	0.32	1.06	4.48
Transfers	0.24	0.13	-0.06
Gov. Revenues			
Consumption tax	0.25	0.26	0.14
Labour income tax	0.07	0.06	0.02
Employee SSC	0.20	0.10	0.11
Employer SSC	0.03	-0.03	-0.07
Lump-sum tax	0.00	0.31	0.80

- Notes: present value multiplier at estimated posterior mode, no monetary accommodation

Figure I: The Crisis and Euro Area Public Finances

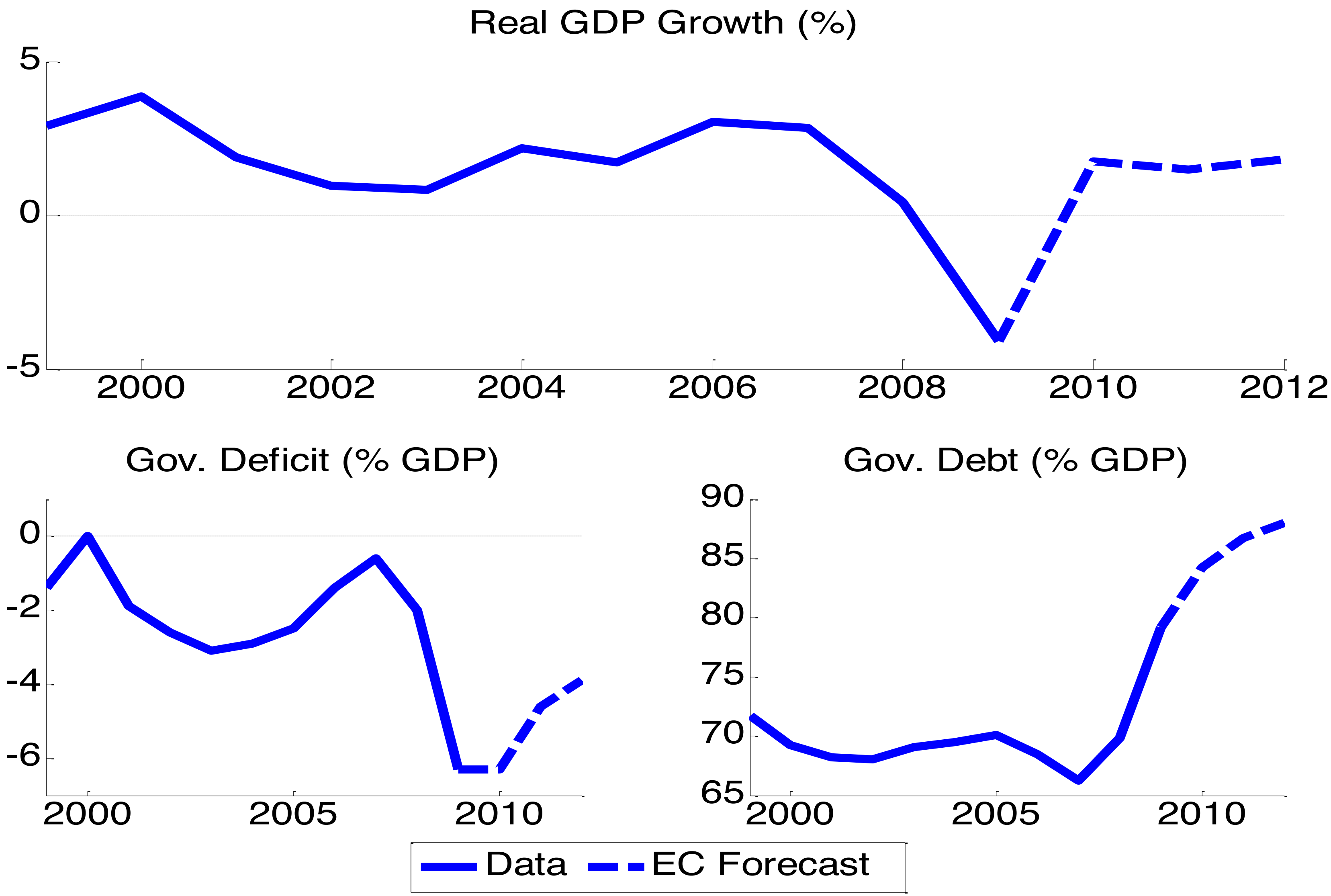

Figure 2: Baseline NAWM

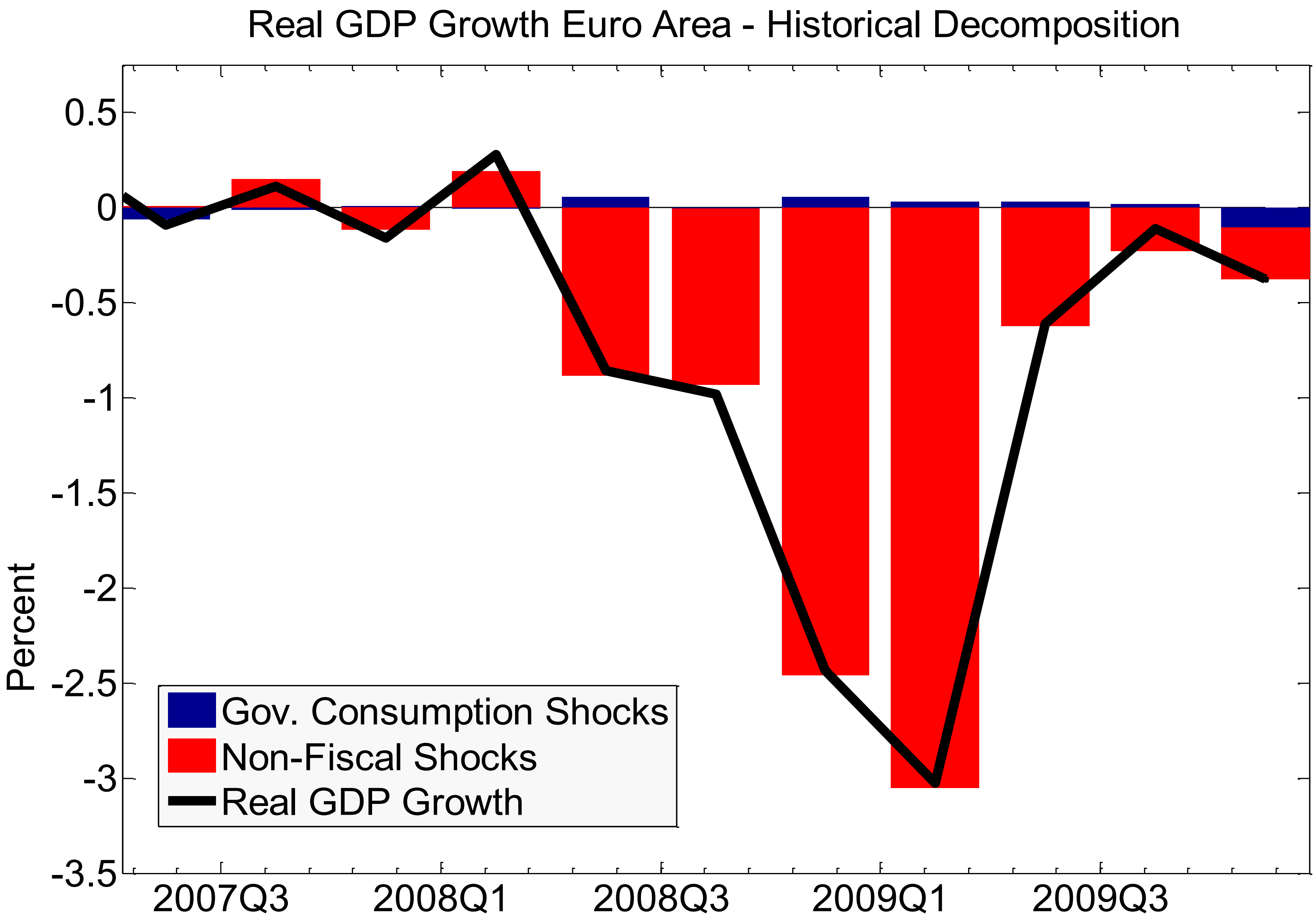

Figure 3: NAWM with Extended Fiscal Sector

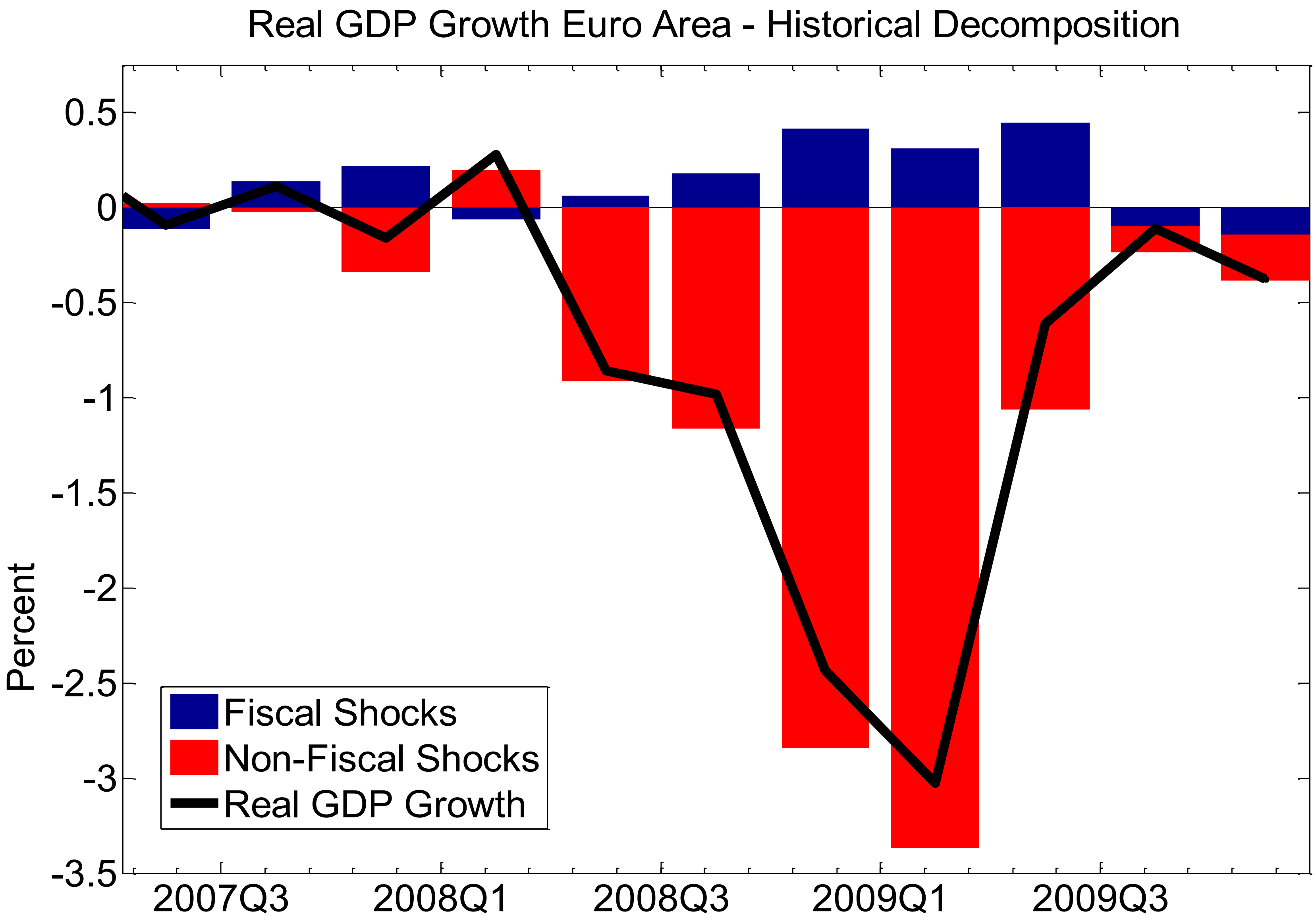

Figure 4: Contribution of Individual Fiscal Shocks

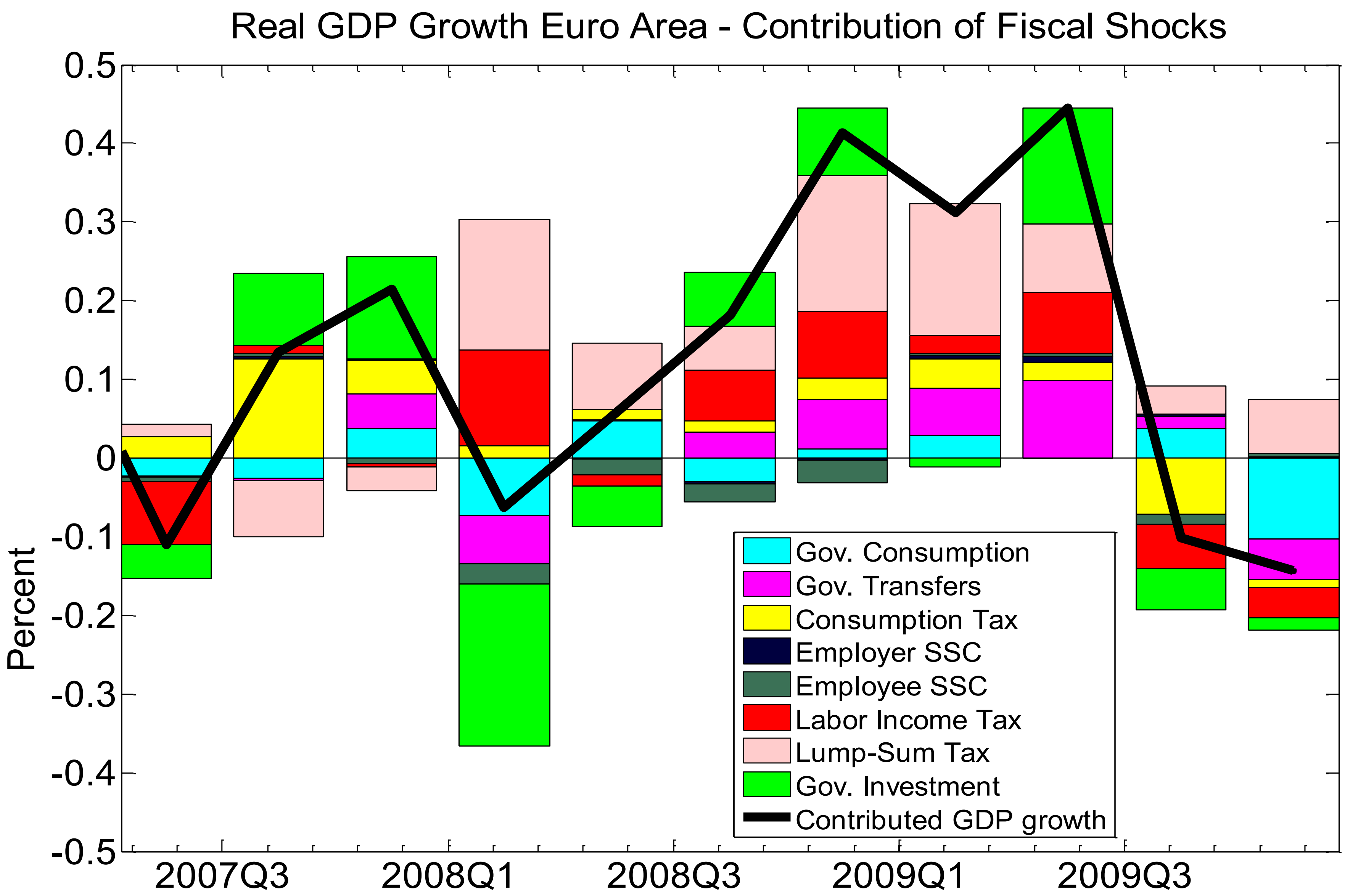

Figure 5: Contribution of Non-Fiscal Shocks

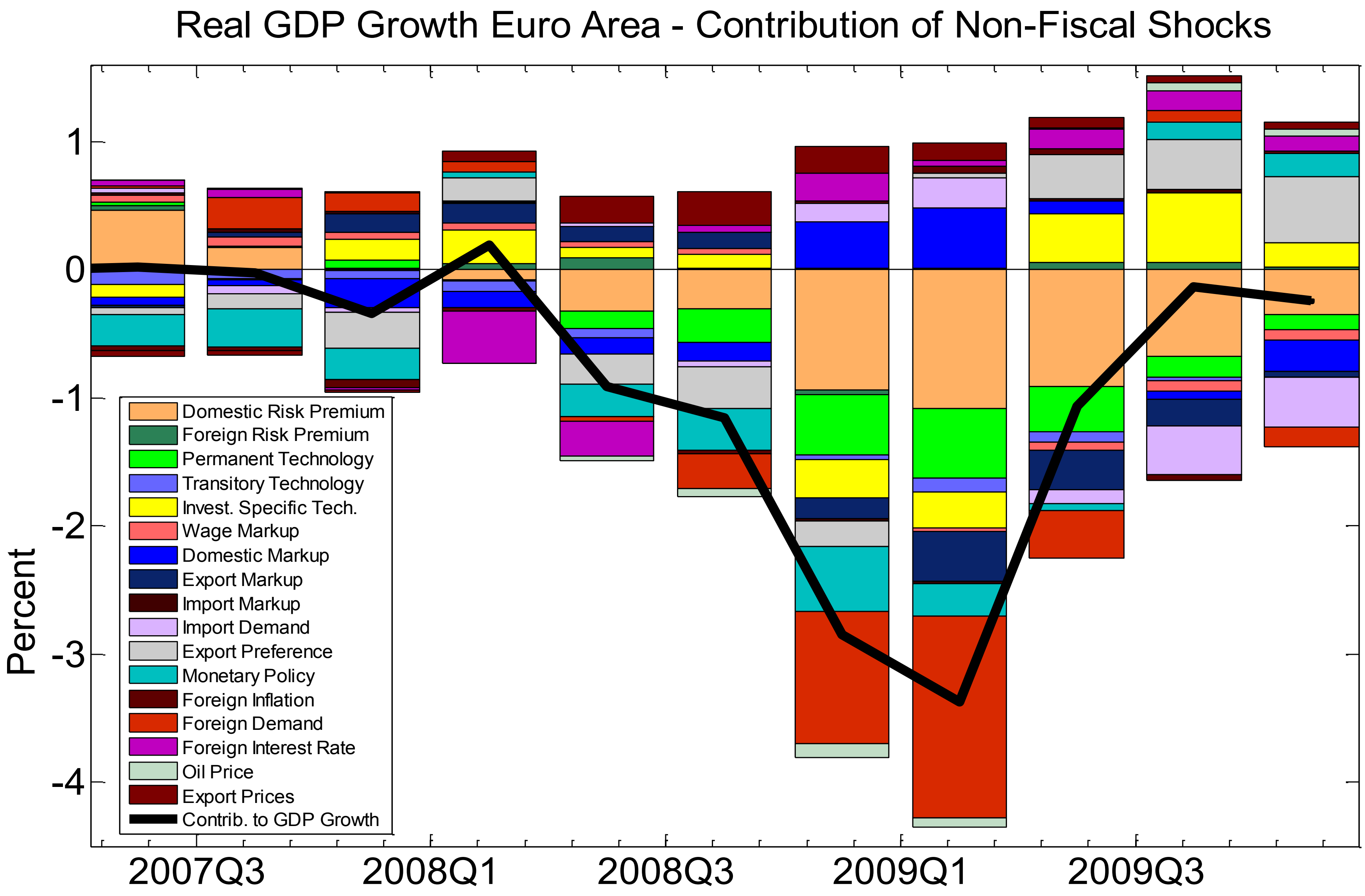

Figure 6: Inspecting the Mechanism I: Share of Rule-of-Thumb Consumers (ω)

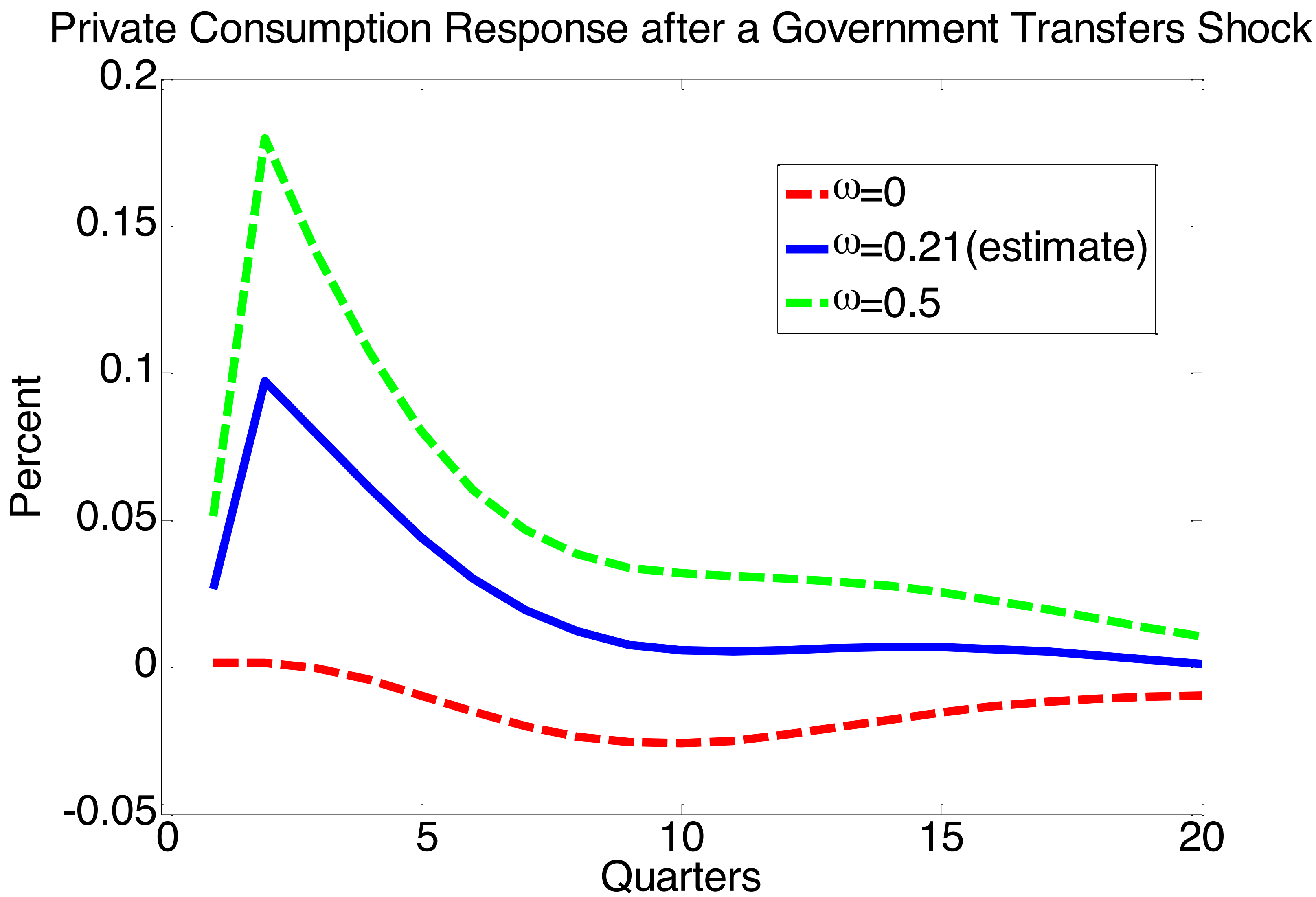

Figure 7: Inspecting the Mechanism II: Effects of government investment (CES private-public capital)

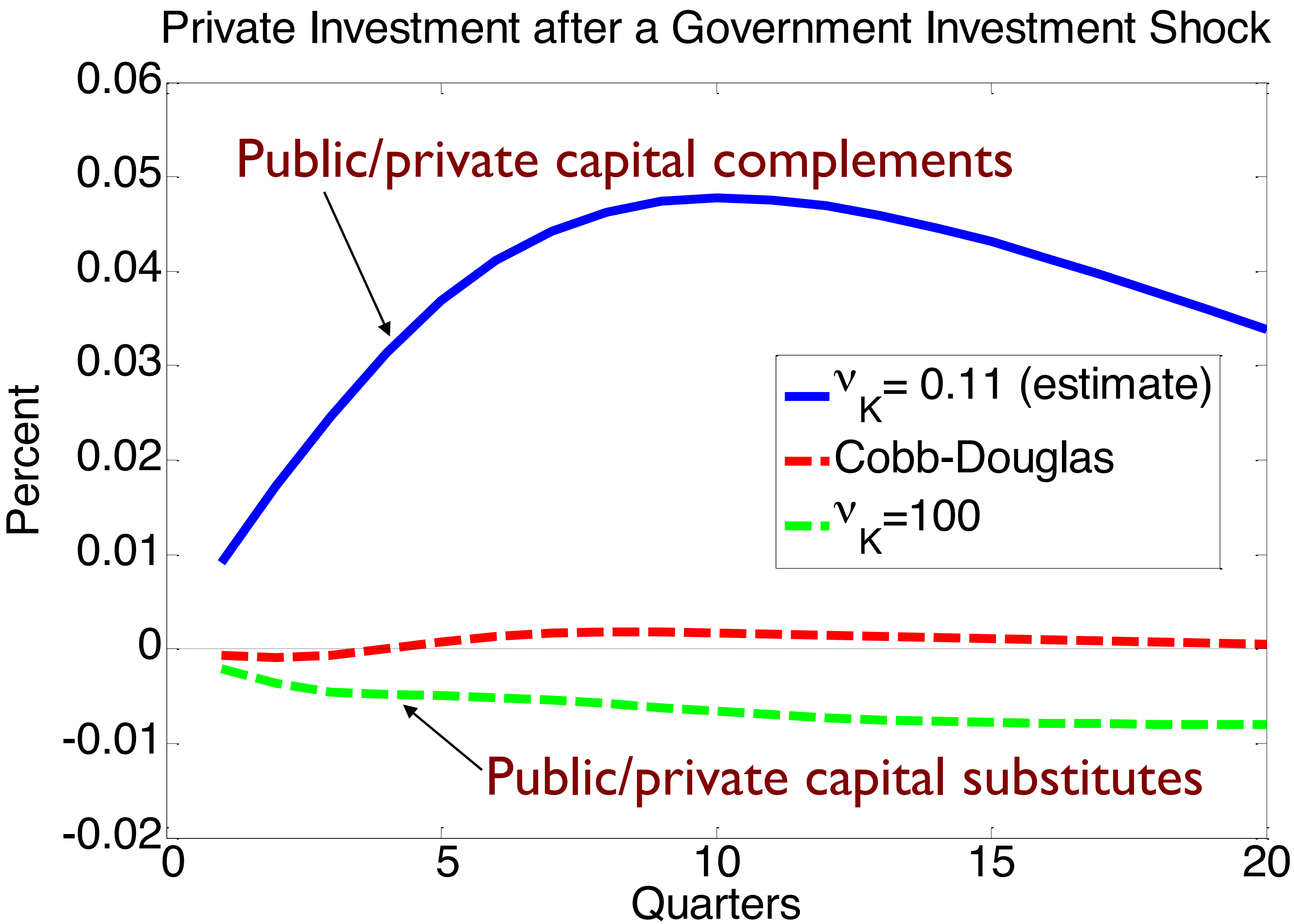

Figure 8: Inspecting the Mechanism III: Effects of valued/ non-separable government consumption (CES)