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Fiscal policy in the semi-structural model ECB-BASE

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Abstract

Fiscal policy constitutes a key tool for business cycle stabilisation next to monetary policy. In this context, having a well-suited macroeconomic model for analysing fiscal policy at a central bank is of primary importance. This paper documents the fiscal block of the ECB-BASE, which is a semi–structural model for the euro area developed at the ECB for projections and policy analysis. The set-up of the fiscal block ensures comprehensive coverage of the government sector and tight links to the quarterly fiscal accounts. Thanks to this design, it is possible to simulate the model with a wide range of fiscal shocks, which, as shown in the paper, have distinct propagation mechanisms. Having discussed the set-up and the potency of fiscal policy in the model, this paper also includes the following applications for fiscal policy analysis: counterfactual scenarios with alternative fiscal rules, assessment of fiscal policy conducted in the euro area in the past and stochastic fiscal projections.

Keywords: Semi-structural model, euro area, simulations, forecasting, fiscal policy

JEL Codes: C3, C5, E1, E2, E6

Acknowledgements

This paper constitutes a part of a broader effort undertaken at the ECB to create a new family of semi-structural macroeconomic models. Under the umbrella of the ECB-MC project fall other related papers already published:

- Angelini et al. (2019) presenting the blueprint of a new ECB semi-structural model – the ECB-BASE model
- Angelini et al. (2020) extending the ECB-BASE model with the SIR (Susceptible-Infectious-Recovered) model – the ECB-BASIR model – in order to assess the interplay between epidemiological fundamentals, containment policies and the macroeconomy amid the COVID-19 pandemic
- Bańkowski et al. (2021) augmenting the ECB-BASE model with a set of various monetary and fiscal policy rules with a view to investigating different policy constellations in the euro area before the recent inflation surge

The application of the ECB-BASE to fiscal policy analysis presented in this paper builds upon the legacy of numerous contributors to the ECB-MC project led by M. Ciccarelli (see the preamble of Angelini et al. (2019) for a list of contributors). In particular, this paper benefited from constructive discussions held in the context of the model development (most notably with K. Christoffel, M. Lalik, J. Paredes and S. Zimic) and the IT infrastructure established for the project (powered by N. Bokan).

Non-technical summary

Since the Great Financial Crisis fiscal policy has been regarded as one of the primary tools for business cycle stabilisation at the disposal of policymakers. It became particularly relevant once monetary policy faced its limit in the form of a lower bound on nominal interest rates. The COVID-19 crisis, if anything, made the fiscal policy even more essential as a solution to stimulate the economy or parts of it. In the end, fiscal policy, unlike monetary policy, is well-suited to address disturbances in selected sectors without leading to excessive overall demand. Going forward, even if the effects of the pandemic on economic activity fade away, fiscal policy will remain quintessential in tackling the most pressing economic problems, such as currently existing inflationary pressures or a critical need for the environmental transition. Against this background, having a macroeconomic model well-suited for fiscal analysis at a central bank is a necessity rather than a luxury.

An advancement in fiscal policy modelling at the European Central Bank is a part of a broader effort to establish a well-functioning semi-structural macroeconomic model for projections and policy simulations. The ECB-BASE model, which covers the euro area as a whole, discussed throughout this paper, constitutes a blueprint version of a multi-country model under development. Semi-structural models' key advantage is balancing theoretical rigour with a good fit to economic data. In this context, a semi-structural model equipped with a good representation of the government sector can become a valuable tool for fiscal policy analysis. This paper documents the fiscal block devised for the ECB-BASE model.

The design of the fiscal block follows the fundamental principles underlying the entire model. In particular, the block maintains close links to the data, notably quarterly fiscal accounts. This feature allows for covering a wide range of fiscal variables. A substantial disaggregation ultimately provides for a rich set of fiscal shocks, which all have distinct propagation mechanisms in the model. The tight links to the data make it possible that most equations characterising the government sector are estimated. This, in turn, benefits the fiscal block's empirical properties. Overall, these modalities enable the analysis of various fiscal policy initiatives in a realistic manner.

This paper includes several relevant applications to demonstrate the capacity of the ECB-BASE in the field of fiscal policy analysis. First, there is a presentation of counterfactual scenarios, in which euro area fiscal policy followed consistently in the past countercyclical fiscal rules (i.e. expansionary during downturns and contractionary during upturns). Such rules contrast with a procyclical policy, which occurred to some degree in reality and which is economically inadvisable. The model simulations suggest that a countercyclical policy would have significantly reduced the business cycle fluctuations. Second, the paper contains an evaluation of the actual fiscal policy conducted in the past. The analysis shows that while the undertaken fiscal measures alleviated the adverse consequences of the Great Financial Crisis, they deepened the second downturn amid the sovereign debt crisis. Finally, the last application emphasises the model's usefulness for fiscal forecasting, particularly the value of stochastic projections, which explore information in past model residuals.

1 Introduction

The global financial crisis of 2008-09 (GFC) and the following euro area sovereign debt crisis greatly revived the interest of academics and policymakers in fiscal policy as a tool for business cycle stabilisation.[1] Multiple studies emerged arguing that fiscal multipliers, which measure the relationship between the effects on the output and the budgetary cost, can be high, even exceeding unity. The property occurs particularly during recessions (see, for instance, Auerbach and Gorodnichenko (2012)) or at times when interest rates are at the ZLB (see, for instance, Christiano et al. (2011)) provided that government debt is not excessively high (see, for instance, Ilzetzki et al. (2013)). The academic debate made an impact on thinking among policymakers, who, as documented by Górnicka et al. (2020), adjusted their beliefs on fiscal multipliers upward. More recently, fiscal policy stood at the forefront of the policy response to the COVID-19 crisis, with many emphasising its essential role (see, for instance, Woodford (2022)). Against this background, having a macroeconomic model that enables a thorough analysis of fiscal policy becomes quintessential.

This paper documents the government sector and the role of fiscal policy in the ECB-BASE — a large-scale semi-structural model of the euro area described in Angelini et al. (2019). The ECB-BASE model is the blueprint of a new ECB semi-structural multi-country model (ECB-MC) intended to replace the current ECB multi-country model (i.e. NMCM documented in

[1] Fatás and Mihov (2012) shows that discretionary fiscal policy has become more aggressive in recent decades in all OECD countries. Alesina and Giavazzi (2013) contains a collection of articles debating the role of fiscal policy shortly after the GFC. More recently Ramey (2019) has taken stock of research on fiscal policy conducted during the last ten years.

Dieppe et al. (2011)). It features optimising behaviour by households and firms, a comprehensive representation of monetary policy transmission channels, and, importantly for this paper, a well-developed fiscal sector. The latter makes the model well-suited for analysing fiscal policy questions in the euro area.

Similarly to other blocks of the ECB-BASE model, the fiscal block draws on the experience of other semi-structural models at other policy institutions. These are, most notably, the FRB/US model by the Federal Reserve Board described in Brayton and Tinsley (1996) and the LENS model by the Bank of Canada documented in Gervais and Gosselin (2014).[2] These models foresee a role for fiscal policy in influencing the private sector's behaviour. In other words, they deviate from the Ricardian equivalence hypothesis, usually embedded into full-employment models of the business cycle, like real business cycle (RBC) models or simple neo-Keynesian models.[3] This paper can also be seen as a follow-up to Angelini et al. (2019) introducing the ECB-BASE, which included only a brief description of the fiscal block. The richness and the policy relevance of the topic warrants a dedicated work exclusively devoted to fiscal policy. Against this background, this paper provides a comprehensive account of the fiscal block set-up, gauges the potency of various fiscal instruments by explaining the underlying propagation mechanisms and, finally, offers a range of model applications in the field of fiscal policy analysis.

The design of the new ECB semi-structural model is geared towards its main two applications, namely providing input to macroeconomic projections and conducting policy simulations or counterfactual scenarios. Against this background, the model has specific properties imperative for fulfilling the assigned objectives (see Angelini et al. (2019)). This principle also applies to the fiscal block, which carries the following characteristics facilitating the achievement of the model goals.

First, the fiscal block of the ECB-BASE features a high degree of disaggregation on both revenue and spending side of the budget. While this approach brings some complications to the model set-up, it comes with a range of advantages. Notably, the scope of the fiscal variables in the model is broadly consistent with the one covered by the Eurosystem/ ECB staff projection exercises, which makes the model well-suited for cross-checking fiscal projections.[4] Furthermore,

[2]Since the publication of the original model specification in Brayton and Tinsley (1996) the FRB/US model has undergone a number of modifications. A recent version of the documentation is available as a part of FRB/US Model Packages (`https://www.federalreserve.gov/econres/us-models-package.htm`).

[3]Other policy institutions that also recently developed a semi-structural macroeconomic model with a role for fiscal policy are Banque de France (FR-BDF Model, see Lemoine et al. (2019)) and De Nederlandsche Bank (DELFI 2.0 model, see Berben et al. (2018)).

[4]As laid out in a guide to the Eurosystem/ ECB staff macroeconomic projection exercises (see European

a high degree of granularity allows for a wide range of fiscal shocks, which helps analyse specific macroeconomic policies. Finally, the availability of various fiscal instruments ensures adequate fiscal assumptions for the other blocks of the model.

Second and similarly to the rest of the model, the equations of the fiscal block are constructed in a way so that they have a good empirical fit. Most of the variables are modelled as trends and deviations around trends. As a result, the equations are able to capture both low and high-frequency movements in fiscal variables. A good data fit is largely achieved by the fact that most of the coefficients in the fiscal block are estimated.

Having settled on the design issues, this paper devotes much attention to documenting the resulting properties of fiscal policy in the ECB-BASE. Most notably, it explains the propagation mechanism of all fiscal shocks and gauges their potency. Various instruments, even though they belong to one fiscal policy toolbox, are very different regarding how they influence the economy. Some, like government investment, directly affect output, while others work through private channels. Some, like government purchases, are very powerful in stimulating/ cooling down the economy, while others have only muted effects. Some, like indirect taxes, come with major implications for inflation, whereas others leave prices broadly unaffected – a crucial consideration for a central bank.

To illustrate how the model can be used in practice, this paper offers three applications in the field of fiscal policy analysis. First, it investigates the effects of alternative fiscal rules. In this context, it demonstrates that a countercyclical fiscal policy, if applied consistently in the past, would have a chance to reduce business cycle fluctuations significantly. Also, it would have made the lower bound on interest rates less binding. Second, the study looks into the effects of the actual fiscal policy conducted in the euro area. Here it concludes that while the undertaken fiscal measures significantly alleviated the recession during the GFC, they aggravated the second downturn amid the sovereign debt crisis. Third, it is also shown how the model can be used for fiscal projections. In particular, the application emphasises the value added of the information

Central Bank (2016)), the responsibility for the fiscal projections lies with the ESCB (European System of Central Banks) Working Group on Public Finance (June and December rounds) or with the ECB staff (March and September rounds). The fiscal projections take into account various country-specific institutional information, such as budget laws, supplementary budgets, other legal acts defining fiscal actions, as well as stability and convergence programmes. In addition, fiscal projections only incorporate measures that have been approved or that are sufficiently well specified and likely to be approved. In this context, macroeconomic models operated at the ECB are not primary tools for establishing fiscal projections. Notwithstanding this, the models are useful tools for cross-checking the projections. As a result, the consistency between the fiscal block of the new ECB macroeconomic model and the framework applied to fiscal projections remains important.

contained in the past residuals for devising stochastic fiscal projections.

The rest of the paper is organised as follows. Section 2 provides a detailed description of the structure of the fiscal block and its equations. Subsequently, Section 3 deals with the data underlying the fiscal block, estimation issues and long-run convergence. Once the fiscal block is described, Section 4 explains the propagation mechanism for each fiscal shock and summarises the potency of fiscal instruments by calculating output and inflation multipliers. What follows in Section 5 is the demonstration of the ECB-BASE's ability to deal with three typical fiscal policy questions (i.e. an analysis of fiscal rules, an evaluation of fiscal measures and fiscal forecasting). Finally, Section 6 concludes.

2 Government set-up in the model

As motivated in the introduction, the fiscal block of the ECB-BASE exhibits a high degree of granularity. Both government revenue and expenditure are decomposed to the extent that enables careful exploration of information contained in Government Finance Statistics and, at the same time, fulfils the objectives of the model. In addition, for selected variables that comprise final government demand (i.e. government consumption and investment), not only nominal values are modelled but also volumes and prices. Finally, some items describing the government labour sector complement the set of fiscal model variables.

The modelling of the government sector takes into account the trending nature of fiscal variables. This feature generally applies to both the revenue and expenditure side of the budget. Regarding the former, actual tax rates are modelled as deviations from their trends with autoregressive equations. On the latter, spending levels also oscillate around their trends in line with the Error Correction Model (ECM) type of equations. The block also includes multiple specific equations, which fall outside the two groups and a range of identities (a list of the identities is included in Appendix Section A). Finally, a term reminiscent of a debt rule is part of the other revenue category so that the debt-to-GDP ratio stabilises in the long run at its targeted value.

2.1 Structure of the fiscal block

For the sake of exposition, the government sector in the ECB-BASE can be split into three parts.

- Part I – **Non-financial accounts & gross debt** – decomposes the budget balance into underlying revenue and spending components (see Table 1, the first part). The suggested degree of disaggregation gives a comprehensive picture of the fiscal accounts, delivers variables of interest to the other parts of the model and respects the data availability constraints. The set of variables is complemented by the government debt, which in essence cumulates the budget balance over time.[5]

- Part II – **Fiscal demand (consumption & investment)** – includes all variables necessary to calculate the direct demand components of the general government, namely, consumption and investment (see Table 1, the second part). These variables are first formulated in real terms, given their key role in forming the overall demand volume. Subsequently, assuming certain price dynamics, their nominal values, which are relevant for the budget balance and debt, are devised. Government consumption is disaggregated into compensation and purchases. Such decomposition enables analysis of government average wages, employment and purchases separately, given the very different nature of fiscal shocks corresponding to these items.

- Part III – **Labour market** – embeds variables describing some of the government labour sector characteristics. These variables are distinguished primarily to provide sufficient input to the labour block of the model (see Table 1, the third part).

Table 1: Overall structure of the fiscal block.

Variable name	**Model code**	**Equation type**
Non-financial accounts & gross debt		
Total revenue	`GO_TRN`	identity
Direct taxes	`GO_DTN`	identity
o/w by households	`GO_HH_DTN`	implicit tax rate-based
o/w by firms	`GO_BU_DTN`	implicit tax rate-based
Indirect taxes	`GO_TIN`	implicit tax rate-based
Social contributions	`GO_SCN`	identity
o/w by households	`GO_HH_SCN`	implicit tax rate-based

[5] The change in government debt from quarter t-1 to t is not necessarily equal to the budget deficit. Discrepancies between the two are captured by the debt-deficit adjustment (DDA), also called the stock-flow adjustment (SFA). DDA reflects, in principle, transactions that affect government debt but not budget balance (or the other way around), for instance, financial investments and privatisations, use of reserves, some aspects of debt management and payment arrears (for detailed analysis of factors behind DDA see Kezbere and Maurer (2018)). DDA is not explicitly represented in the fiscal block but is captured by the residual in the debt accumulation equation.

Table 1 – continued from previous page

o/w by firms	GO_BU_SCN	implicit tax rate-based
o/w imputed	GO_RW_SCN	implicit tax rate-based
Other revenue	GO_RRN	specific
Total expenditure	GO_TOE	identity
Interest payments	GO_IPN	identity
Social transfers	GO_SBCN	ECM-based (nominal)
Gov. compensation (nominal)	GO_CEN	identity
Gov. purchases (nominal)[6]	GO_PUN	identity
Subsidies	GO_SIN	ECM-based (nominal)
Gov. investment (nominal)	GO_ITN	identity
Other expenditure	GO_REN	share of potential GDP
Budget balance	GO_B9N	identity
Gov. debt	GO_MAL	identity
Gov. final demand		
Gov. consumption (nominal)	GO_CON	identity
Gov. consumption (real)	GO_COR	identity
Gov. compensation (real)	GO_CER	ECM-based (real)
Gov. purchases (real)	GO_PUR	ECM-based (real)
Gov. investment (real)	GO_ITR	ECM-based (real)
Gov. consumption (deflator)	GO_COD	identity
Gov. investment (deflator)	GO_ITD	specific
Gov. labour		
Gov. employment	GO_LNN	identity
Gov. average compensation	GO_C_CEN	specific
Gov. productivity	TFPLG	specific

[6]Purchases consist of government intermediate consumption and social transfers in kind.

2.2 Equations in the government sector

To facilitate the presentation, the fiscal equations of the model can be grouped into those that characterise revenue and expenditure. In addition, there are multiple specific equations that warrant a dedicated explanation. The presentation of the equations follows this logic.

2.2.1 Typical revenue equations

A typical category on the revenue side $REV_{i,t}$ is calculated as a product of an implicit tax rate $\tau_{i,t}$ and a corresponding macro base $BASE_{i,t}$ (see Equation 1). This formulation is consistent with the nature of these variables, which in reality, are strictly linked to relevant tax bases. Given the unavailability of data on actual tax bases, the usual approach in fiscal modelling is to rely on macro bases.[7] Table 2 summarises the revenue variables in the model and the corresponding macro bases. The letter are determined in non-fiscal blocks of the model, thereby not being described here.

$$REV_{i,t} = \tau_{i,t} BASE_{i,t} \tag{1}$$

Table 2: Revenue items and their corresponding macro bases.

Revenue item	**Relevant macro base**
Direct taxes (`GO_DTN`)	
o/w by households (`GO_HH_DTN`)	Total economy wages & salaries
o/w by firms (`GO_BU_DTN`)	Gross operating surplus & mixed income
Indirect taxes (`GO_TIN`)	Final private consumption & gov. purchases
Social contributions (`GO_SCN`)	
o/w by households (`GO_HH_SCN`)	Total economy wages & salaries
o/w by firms (`GO_BU_SCN`)	Total economy wages & salaries
o/w imputed (`GO_RW_SCN`)	Total economy wages & salaries
Other revenue[8] (`GO_RRN`)	

[7] The data for an implicit tax rate are derived as a ratio of a certain government revenue category with respect to a corresponding macro base (i.e. $\tau_{i,t} = \frac{REV_{i,t}}{BASE_{i,t}}$). Subsection 3.1 includes a data illustration for the implicit tax rates in the model.

[8] Other revenue is modelled using the ECM approach similar to the one applicable to spending items. In addition, the trend equation for this category features a debt deviation term necessary for the debt-to-GDP ratio stability (see Subsection 3.3 for details).

The implicit tax rates are modelled as deviations $\left(\tilde{\tau}_{i,t} = \tau_{i,t} - \tau^T_{i,t}\right)$ from their trends according to an autoregressive process of order 2 (see Equation 2). Including the output gap term $\hat{y}_t$ in the equation enables a reaction of the implicit tax rates to the business cycle. The objective is to capture observed in the data cyclicality of tax receipts, be it as a result of discretionary policy or automatic reaction to the cycle (e.g. fiscal drag). The equation is estimated on 1999Q1-2019Q4 data (see the estimation results in Subsection 3.2). The tax rate trends $(\tau^T_{i,t})$ are assumed to converge to a long-run attractor τ^*_i (see the details in the construction of the attractors in Subsection 3.1) gradually, which is captured by Equation 3 containing calibrated coefficients values.[9]

$$\tilde{\tau}_{i,t} = \beta_1^{\tau_i} \tilde{\tau}_{i,t-1} + \beta_2^{\tau_i} \tilde{\tau}_{i,t-2} + \gamma^{\tau_i} \hat{y}_t + e_t^{\tau_i} \tag{2}$$

$$\tau^T_{i,t} = 0.9\tau^T_{i,t-1} + 0.1\tau^*_i + e_t^{\tau_i^T} \tag{3}$$

2.2.2 Typical spending equations

Government spending items, on the other hand, are modelled directly in levels with error-correction model (ECM) equations. In the long run, they converge to a constant share of potential output so that Equation 4 holds. Here $G_{i,t}$ is actual government spending within category i, $G^T_{i,t}$ is its trend, $G^{trg}_{i,t}$ is its target consistent with long-run share s_{G_i} of the nominal potential output $\overline{Y}_t^N$. Effectively, the following convergence takes place in the long run: $G_{i,t} \rightarrow G^T_{i,t} \rightarrow G^{trg}_{i,t}$. The construction of the long-run shares is described in Subsection 3.1.

$$G^{trg}_{i,t} = s_{G_i} \overline{Y}_t^N \tag{4}$$

Equation 5 describes the evolution of a variable in relation to its trend. The equation features a typical error correction term with coefficient α^{G_i}. The short-run evolution of $G_{i,t}$ is governed by the growth of $G^T_{i,t}$ and its own lags to increase persistence. Furthermore, the error correction term ensures that the level of $G_{i,t}$ converges to $G^T_{i,t}$ in the long run.[10] The presence of the output gap $\hat{y}_t$ in the equation enables that spending items, like tax rates, react to cyclical developments.

[9] Terms $e_t^{\tau_i}$ and $e_t^{\tau_i^T}$ in the implicit tax rate equations are residuals.

[10] The long-run consistency of $G_{i,t}$ to $G^T_{i,t}$ requires that the coefficient on the growth of $G^T_{i,t}$ (i.e. $\Delta \log(G^T_{i,t})$) is equal to $\left(1 - \sum_{k=1}^{2} \beta_k^{G_i}\right)$. The appendix (Subsection A.2) contains a detailed explanation.

The parameters of Equation 5 are estimated on 1999Q1-2019Q4 data with the results presented in Subsection 3.2.

$$\Delta \log(G_{i,t}) = \alpha^{G_i} \log \left(\frac{G_{i,t-1}}{G^T_{i,t-1}} \right) + \sum_{k=1}^{2} \beta_k^{G_i} \Delta \log(G_{i,t-k}) + \left(1 - \sum_{k=1}^{2} \beta_k^{G_i} \right) \Delta \log(G^T_{i,t}) + \gamma^{G_i} \hat{y}_t + e_t^{G_i} \quad (5)$$

Equation 6 specifies the evolution of a trend variable.[11] The formula also has a standard error correction form. In the short run, the growth of $G^T_{i,t}$ follows a smoothed version of the potential GDP.[12] In the long run, the equation ensures that the ratio of nominal trend variable with respect to the nominal potential output converges to a predefined value s_{G_i}.[13] The equations are calibrated with an adjustment coefficient on the ECM term equal to -0.1.

$$\Delta \log \left(G^T_{i,t} \right) = -0.1 \log \left(\frac{G^T_{i,t-1}}{\overline{Y}^N_{t-1}} \frac{1}{s_{G_i}} \right) + \frac{1}{4} \sum_{k=0}^{3} \Delta \log \left(\overline{Y}^N_{t-k} \right) + e_t^{G_i^T} \quad (6)$$

Terms $e_t^{G_i}$ and $e_t^{G_i^T}$ are residuals.

2.2.3 Specific equations

A number of fiscal variables, which are presented below, require a specific formulation and cannot be assigned to any of the two categories above.

Interest rate on government debt ($go\_r\_ipn_t$):

$$go\_r\_ipn_t = (1 - 0.04) \times go\_r\_ipn_t + 0.04 \times amir_t + e_t^{go\_r\_ipn} \quad (7)$$

where $amir_t$ is an average market interest rate on newly issued debt and $e_t^{go\_r\_ipn}$ is a residual. The equation implies that the market interest rate gradually feeds into the effective interest rate paid on the stock of debt. Consequently, $go\_r\_ipn_t$ converges in the long run to a 'steady-state' value of $amir_t$. The coefficient of 0.04, which is estimated on the historical data, reflects the pace of the pass-through. The value is consistent with the observed amounts of maturing debt within

[11] The trend equation for variables in real terms takes a slightly different form $\Delta \log \left(G^T_{i,t} \right) = -0.1 \log \left(\frac{G^T_{i,t-1} p^{G_i}_{t-1}}{\overline{Y}^N_{t-1}} \frac{1}{s_{G_i}} \right) + \frac{1}{4} \sum_{k=0}^{3} \Delta \log \left(\overline{Y}_{t-k} \right) + e_t^{G_i^T}$, where $p_t^{G_i}$ is the relevant fiscal deflator, and $\overline{Y}_t$ is the real potential output.

[12] Smoothing becomes necessary given that potential GDP time series are sometimes volatile in practice. Abrupt changes in potential GDP over time usually do not imply similar sudden adjustments in fiscal series, even though potential GDP remains a benchmark for the growth of many fiscal items, particularly on the spending side.

[13] The long-run relation in nominal terms also applies to variables that are modelled in real terms.

one quarter for the euro area. The implicit interest rate ($go\_r\_ipn_t$), together with the stock of debt (go_mal_t), determines interest payments (go_ipn_t) (see the equation in Subsection A.1 containing fiscal identities).

It should be clarified that the average market rate $amir_t$ on newly issued debt is a function of weighted short-term and long-term interest rates in the economy (both determined outside the fiscal block). The two rates do not depend on the level of debt-to-GDP ratio in the euro area. Thus, the model does not embed a country risk premium, which is important for individual countries not modelled here (see Corsetti et al. (2013) and Lalik (2017), among the others).

Government investment deflator (go_itd_t):

$$\Delta \log(go\_itd_t) = \alpha ECM_{t-1} + \sum_{k=1}^{4} \beta_k \Delta \log(go\_itd_{t-k}) + \left(1 - \sum_{k=1}^{5} \beta_k\right) \Delta \log(yed_t) + e_t^{go\_itd_t} \tag{8}$$

where yed_t is the GDP deflator and the cointegrating relationship (ECM_t) takes the following form

$$\log(go\_itd_t) = (1 - 0.12)\log(yed_t) + 0.12\log(mtd_t) \tag{9}$$

with mtd_t being the import deflator. The value of 0.12 parameter represents the extent to which government investment goods are imported and it is calibrated based on the input-output tables (see Subsection A.3 in the appendix for derivation).

Government labour productivity ($tfplg_t$) Government labour productivity ($tfplg_t$) follows the pace of the labour productivity growth in the total economy $tfpl_t$ in the long run based on the below equation

$$\Delta \log(tfplg_t) = 0.9\Delta \log(tfplg_t) + 0.1\Delta \log(tfpl_t) + e_t^{tfplg_t} \tag{10}$$

Average public compensation($go\_c\_cen_t$) Average public compensation ($go\_c\_cen_t$) evolves in line with average total economy compensation (c_cen_t).

$$\Delta \log(go\_c\_cen_t) = \Delta \log(c\_cen_t) + e_t^{go\_c\_cen_t} \tag{11}$$

3 Fiscal data, estimation and long-run convergence

3.1 Fiscal data

The primary data underlying the fiscal block of the ECB-BASE are quarterly Government Finance Statistics (GFS) published by Eurostat.[14] GFS data provide information on the economic activities of governments in a harmonised and country-comparable manner. They include both non-financial (i.e. revenue and expenditure) and financial (i.e. borrowing and lending) activities of the governments. Besides country-specific figures, the GFS dataset includes the aggregation for the euro area (19 countries) relevant for the ECB-BASE.

European GFS are conceptually consistent with the European system of national and regional accounts in the European Union (referred to as ESA 2010). In fact, the GFS compilation is based on re-arranging transactions recorded in various ESA accounts that are relevant to the government sector.[15] Regarding the precise coverage, GFS data rely on the activity of the general government sector, as denoted by S.13 in national accounts. The general government sector in the ESA 2010 is composed of the central government, state government (in countries where it exists), local government and social security funds (in countries where these exist).

While the GFS template tables are presented on both an annual and quarterly basis, the fiscal block of the ECB-BASE relies on the latter. Since the coverage of the quarterly GFS is more limited than the annual one, selected variables are subject to interpolation. This principle applies, for instance, to the split of social security contributions, which is not available in quarterly terms for all euro area countries and, hence for the aggregate. The interpolation method applied to the fiscal data preparation follows the methodology of Cholette (1984). All GFS time series utilised for the purpose of the ECB-BASE fiscal block are seasonally adjusted with the X-13-ARIMA method.

The main fiscal variables are presented in Figure 1. Given the presence of the growth in the model and the underlying data, all variables are rescaled to make them stationary and to facilitate their presentation. To this end, the items on the revenue side are divided by their corresponding

[14] A section dedicated to government finance statistics is available on Eurostat's website (https://ec.europa.eu/eurostat/web/government-finance-statistics).

[15] In addition to ESA 2010 EU accounting framework published in the Official Journal on 26 June 2013 (https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-02-13-269) and implemented in September 2014, Eurostat publishes the Manual on Government Deficit and Debt — ESA Implementation (the latest 2019 edition: https://ec.europa.eu/eurostat/documents/3859598/10042108/KS-GQ-19-007-EN-N.pdf/5d6fc8f4-58e3-4354-acd3-a29a66f2e00c). The manual complements ESA 2010 by providing specific guidance on the treatment of statistical issues regarding government finance statistics.

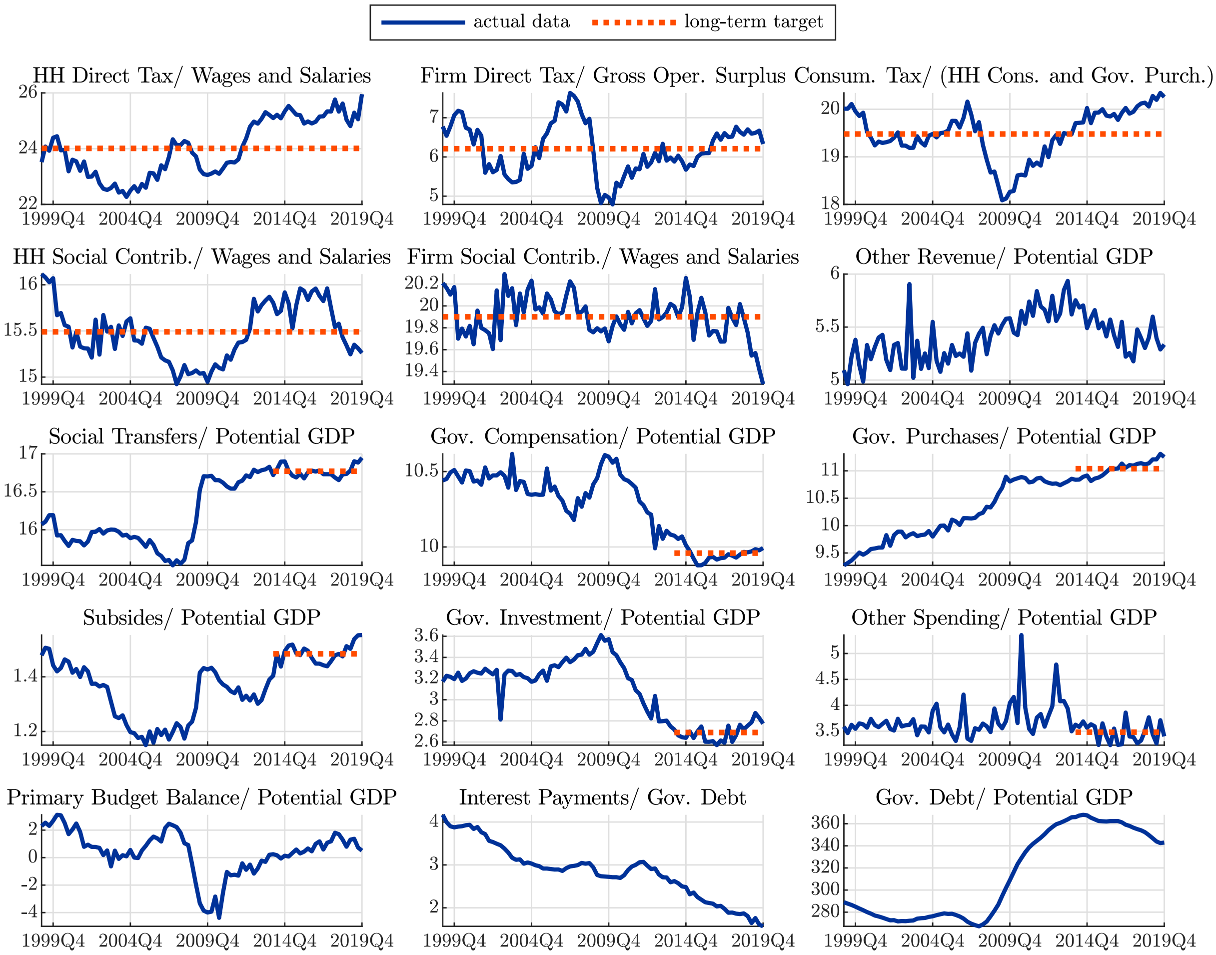
macro bases, which makes them interpretable as implicit tax rates. On the expenditure side, the variables are divided by the nominal potential GDP. The fiscal data are plotted for the 1999Q1-2019Q4 period, which is also the time period underlying the estimation of the fiscal block. The dataset goes back to the earliest point for which quarterly the GFS figures are available (i.e. 1999Q1) and ends with 2021Q4 (i.e. the most recent observation available at the time of drafting the paper).[16] While the figures for the years 2020-21 are used throughout the paper (see, for instance, Subsection 5.3 on forecasting), they are excluded from the estimation sample on the grounds that they are heavily affected by the pandemic.

The fiscal block requires specifying long-run values, which will act as attractors in the long-run convergence of the model to its balanced growth path. The overarching objective of the long-run values, which feature in equations presented in Subsections 2.2.1 and 2.2.2, is to represent the sustained steady-state course of fiscal policy. In principle, these values should rely on the longest possible period that could give a sense of a sustainable policy. In reality, however, fiscal data series for the euro area are relatively short as they cover only two decades. Moreover, even within this period, some of the observations may not necessarily represent the steady-state course of fiscal policy. This applies particularly to the spending side of the budget, where a major shift occurred in the context of the post-GFC adjustment. As evident from Figure 1, fiscal spending became geared towards transfers, which reflects pressures from the ageing society being more evident with time (European Central Bank (2017) provides a detailed account of the evolution of public finance composition in the euro area).

Given the above considerations, the paper establishes long-run targets differently for the revenue and expenditure variables. For the former, it uses the averages of observed implicit tax rates over the entire estimation sample 1999Q1-2019Q4. For the latter, however, it derives the average values only based on the post-crisis subsample. Specifically, it considers only the observations since 2014Q1, which is the point at which the post-crisis fiscal consolidation in the euro area was broadly completed and the fiscal policy eventually entered its ordinary course. The long-run targets are illustrated next to the observed data in Figure 1.

[16] Quarterly fiscal series for the euro area constructed by Paredes et al. (2009) go as far back as 1980. Nevertheless, the ECB-BASE does not make use of this extended dataset. As numerous series in other blocks do not reach further than 1999, the extension of the entire dataset underlying the model is unfeasible. Consequently, the focus is on the period from 1999 onwards, for which the fiscal data do not require imputation and during which EMU was in place.

Figure 1: Main fiscal variables in the model (% shares)



Sources: Government Finance Statistics, Main National Accounts (for macro bases), Economic Forecast of the European Commission (for potential GDP) and own calculations.

3.2 Estimation results

The values of the coefficients in key fiscal equations (Equation 2 and 5), which were introduced in Subsection 2.2, are estimated. Tables 3 and 4 contain the estimation results. The overarching objective of the estimation is to pin down equations that best characterise the data rather than to identify any causal relationships. Notwithstanding this, there are at least two aspects on which the estimation results can shed some light, namely the persistence of fiscal variables and the tendency of how fiscal variables react to the business cycle (i.e. cyclicality).

On the persistence aspect, Figure 2 depicts how specific fiscal instruments react to a standard unitary transitory shock. Estimated coefficients are instrumental in driving these dynamics, even though they might not be straightforward to interpret on their own. Ultimately, they determine

Table 3: Estimated coefficients of the revenue equations

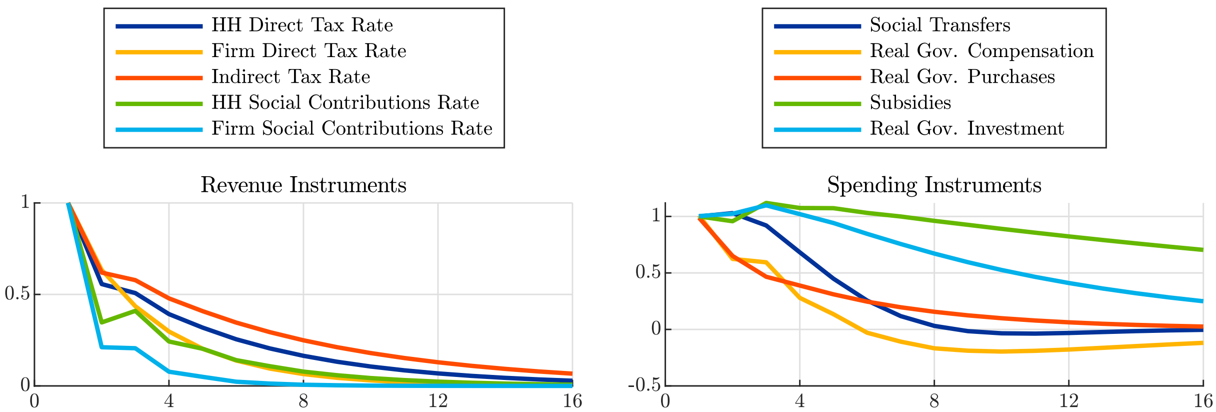
Item	β_1	β_2	γ
HH Direct Tax Rate	0.5567	0.1976	0.0156
	(0.1138)	(0.1113)	(0.0071)
Firm Direct Tax Rate	0.6338	0.0337	0.0284
	(0.1154)	(0.1074)	(0.0093)
Indirect Tax Rate	0.6194	0.1944	0.0025
	(0.1111)	(0.1139)	(0.0085)
HH Social Contribution Rate	0.3469	0.2898	-0.0059
	(0.1069)	(0.1057)	(0.0033)
Firm Social Contribution Rate	0.2115	0.1612	-0.0009
	(0.1128)	(0.1135)	(0.0039)

Sources: Own calculations.

Notes: The figures in parenthesis denote standard errors of estimated coefficients. The values of γ coefficients are rescaled by the share of a fiscal instrument with respect to output so that they are comparable across fiscal instruments.

whether a one-period shock fades away quickly or has a long-lasting effect. Figure 2 suggests that the degree of persistency across fiscal instruments is uneven. On the revenue side, the indirect tax rate is the most persistent, whereas the firm social contribution rate is the least. On the spending side, in turn, real government investment and subsidies stand out as particularly persistent.

Figure 2: The dynamics of transitory fiscal shocks (deviations in % of GDP)



Sources: Own calculations with the ECB-BASE.

Notes: The charts present the deviations of fiscal instruments from their balanced growth paths following a standard unitary transitory shock in the first period.

The issue of the cyclicality of fiscal policy is a primary consideration for macroeconomic policy. While a countercyclical policy could be a tool to stabilise the business cycle, a procyclical

Table 4: Estimated coefficients of the spending equations

Item	α	β_1	β_2	γ
Social Transfers	-0.2313	0.2606	0.1213	-0.0179
	(0.0575)	(0.1051)	(0.1089)	(0.0058)
Real Gov.	-0.2584	-0.0434	0.1868	0.0084
Compensation	(0.0712)	(0.1146)	(0.1142)	(0.0028)
Real Gov. Purchases	-0.2372	-0.0971	-0.0580	-0.0108
	(0.0832)	(0.1172)	(0.1131)	(0.0057)
Subsidies	-0.0309	-0.0117	0.1912	-0.0032
	(0.0559)	(0.1229)	(0.1192)	(0.0030)
Real Gov. Investment	-0.0833	0.1010	0.1535	0.0029
	(0.0407)	(0.1126)	(0.1134)	(0.0030)

Sources: Own calculations.

Notes: The figures in parenthesis denote standard errors of estimated coefficients. The values of γ coefficients are rescaled by the share of a fiscal instrument with respect to output so that they are comparable across fiscal instruments.

policy can aggravate undesirable swings in economic activity. There appears to be overwhelming empirical evidence that fiscal policy in the euro area was on average pro-cyclical (see Eyraud et al. (2017), Commission (2020), Larch et al. (2020) and Gootjes and de Haan (2022), among others). The presence of the output gap in the fiscal equations enables the investigation of cyclicality from the euro area aggregate perspective independently.

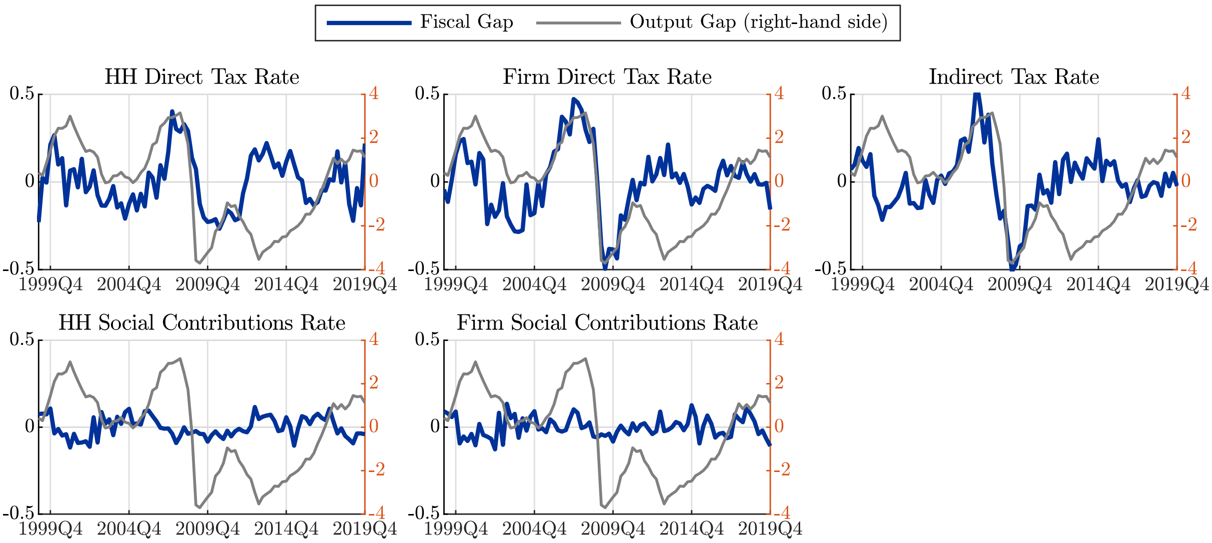
The estimation results for single fiscal instruments indicate a mixed picture regarding cyclicality. On the revenue side, most of the tax rates increase together with the output gap (i.e. positive γ coefficients), thereby exhibiting a countercyclical tendency.[17] Households social contribution rate, with a material negative coefficient pointing to procyclicality, constitutes a notable exemption. On the spending side, some of the instruments fall when the output gap improves (i.e. a negative γ coefficient for social transfers, real government purchases, and subsides), which is characteristic of countercyclicality. However, real compensation of employees and, to a lesser degree, real government investment are associated with an increase, which is tantamount to procyclicality.

A simple look at the detrended fiscal instruments contrasted against the output gap, which

[17] An increase in a tax rate coinciding with an improvement in the output gap does not need to originate from a discretionary policy action. Effective tax rates tend to increase automatically during upturns as a result of a fiscal drag (i.e. taxpayers moving upwards along the tax brackets) or a tax buoyancy (i.e. extraordinarily strong tax collection going beyond what would be suggested by the dynamics of macroeconomic variables). Kremer et al. (2006) lays out a standardised framework that distinguishes between the effects of discretionary fiscal policy and other developments determining a structural fiscal position.

is, in principle, a detrended output, can shed some light on the issue of cyclicality. On the revenue side, the instruments with the most positive output gap coefficients (i.e. household direct tax rate and firm direct tax rate), indeed, tended to co-move with the output gap. The exception to this was the post-GFC consolidation period when the tax rates did not fall despite the significant downturn. The rate associated with household social contributions, which was assessed as pro-cyclical based on the estimated coefficient, indeed exhibited a slightly negative co-movement with the output gap.

Figure 3: Fiscal gaps on the revenue side (% of potential GDP)



Sources: Government Finance Statistics, Main National Accounts, Economic Forecast of the European Commission (for potential GDP) and own calculations.

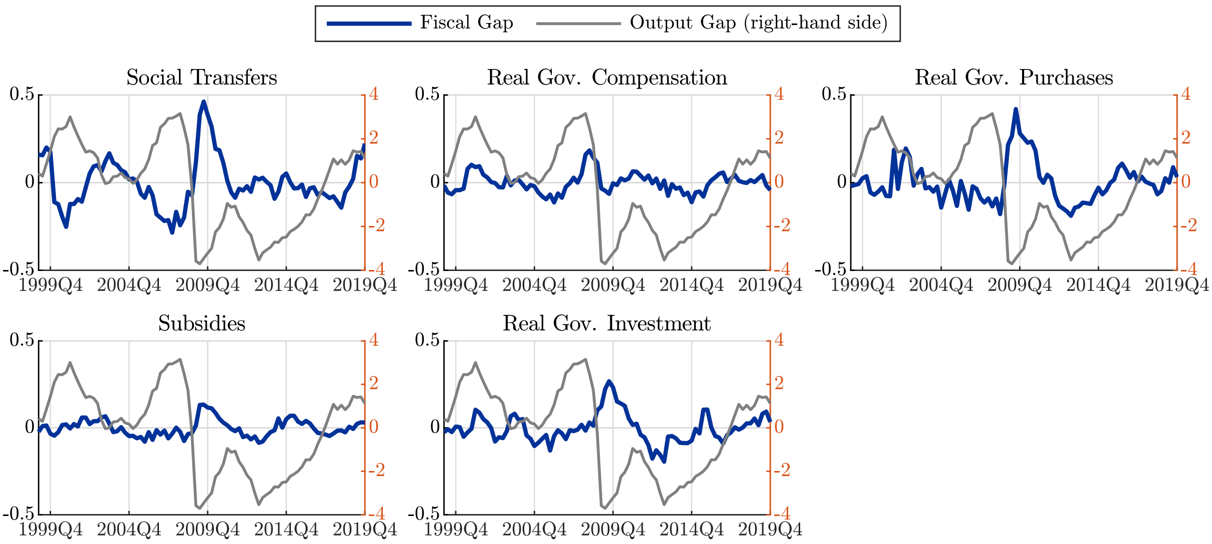
Notes: Fiscal gaps are calculated by detrending data series with the HP filter. In addition, the gaps are rescaled so that they can be presented as a share of potential GDP. The rescaling enables comparability across instruments and to the output gap. The output gap is calculated on the basis of potential GDP coming from the European Commission's AMECO database, given that the Eurosystem/ECB does not publish potential GDP estimates.

On the spending side, social transfers, real government purchases and subsidies, which were all associated with countercyclicality, are indeed negatively correlated with the output gap. The observed relation means that spending used to fall at the time of the improving output gap and the other way around. Like in the case of the revenue, the exception to this regularity is the post-GFC consolidation period, during which spending remained constant (e.g. social transfers) or even fell (e.g. real government purchases) at the time of the downturn.[18] Real

[18] Multiple studies, like Gootjes and de Haan (2022), emphasise that the procyclicality of fiscal policy in Europe is particularly pronounced during good economic times. Looking at the euro area data disaggregated across fiscal instruments, one can conclude that procyclicality is especially evident during the post-GFC period. At the time, the euro area experienced a downturn, and a usual automatic fiscal policy reaction was hindered by the consolidation effort leading to a strongly procyclical fiscal policy.

government compensation and real government investment, which were gauged as procyclical, indeed somewhat co-move with the output gap. In the case of spending instruments, such behaviour is likely to lead to an aggravation of the business cycle volatility.

Figure 4: Fiscal gaps on the spending side (% of potential GDP)



Sources: Government Finance Statistics, Main National Accounts, Economic Forecast of the European Commission (for potential GDP) and own calculations.
Notes: Fiscal gaps are calculated by detrending data series with the HP filter. In addition, the gaps are rescaled so that they can be presented as a share of potential GDP. The rescaling enables comparability across instruments and to the output gap. The output gap is calculated on the basis of potential GDP coming from the European Commission's AMECO database, given that the Eurosystem/ECB does not publish potential GDP estimates.

3.3 Long-run convergence

Achieving long-run convergence, or in other words, stability within the fiscal block requires that all variables included therein need to follow a balanced growth path eventually. This property implies that from a certain remote point onwards, they become constant as a proportion of other variables, such as output. It is the primary reason why this paper concentrates on variables expressed as ratios to GDP when assessing long-run convergence. Another important consideration is that the overall stability of the fiscal block needs to apply to all variables, namely flows – budget balance and its components – and stocks – government debt.

The stability of the flows is a necessary but not sufficient condition to ensure the stability of the stock of debt. In fact, there exists only one value of the primary balance-to-GDP ratio that is compatible with the debt-to-GDP ratio stabilisation at a certain value. One can see this simply by looking at the simple debt accumulation equation, which is at the core of a typical debt sustainability analysis (see, for instance, Bouabdallah et al. (2017)). The debt accumulation equation (see Equation 12) states that an increase in debt-to-GDP ratio Δb_t is equal to the sum of the so-called snow-ball effect $\frac{i_t - g_t}{1+g_t} b_{t-1}$, primary deficit-to-GDP ratio $(-pb_t)$ and the deficit-debt adjustment expressed as a share of GDP dda_t.[19]

$$\Delta b_t = \frac{i_t - g_t}{1 + g_t} b_{t-1} - pb_t + dda_t \tag{12}$$

A constant over time debt-to-GDP ratio with zero dda_t in the long run brings Equation 12 to the below form that pins down the primary balance compatible with debt-to-GDP ratio stabilisation at a certain level. 'Bared' variables denote long-run values.

$$\bar{pb} = \frac{\bar{i} - \bar{g}}{1 + \bar{g}} \bar{b} \tag{13}$$

Having recognised the following long-term values of variables on the right-hand side of Equation 13:

- the long-run debt target imposed in the model $\bar{b} = 340\%$, which corresponds to 85% when the annual GDP is used in the ratio calculation and which is close to the values observed for the euro area in recent years,
- the long-run quarterly interest rate $\bar{i} = 1\%$, which corresponds to approximately 4% in annual terms,
- the long-run q-o-q output growth $\bar{g} = 1\%$, which is equivalent to the year-on-year growth of approximately 4%,

one can easily derive the long-run value of the primary balance-to-GDP ratio in the fiscal block, which is 0% of GDP ($\bar{pb} = \frac{1\% - 1\%}{1 + 1\%} \times 340\% = 0\%$).

Reaching the desired value of the primary balance in the long run derived above is achieved in the model is achieved by adjusting the residual category of other revenue. As shown in Subsection 4.7, other revenue does not have macroeconomic implications in the model. Thus, it can be changed freely without introducing distortions. Precisely, the essential adjustment is imposed on the trend of other revenue, which is governed by Equation 14 where $r\bar{r}n$ is the long-

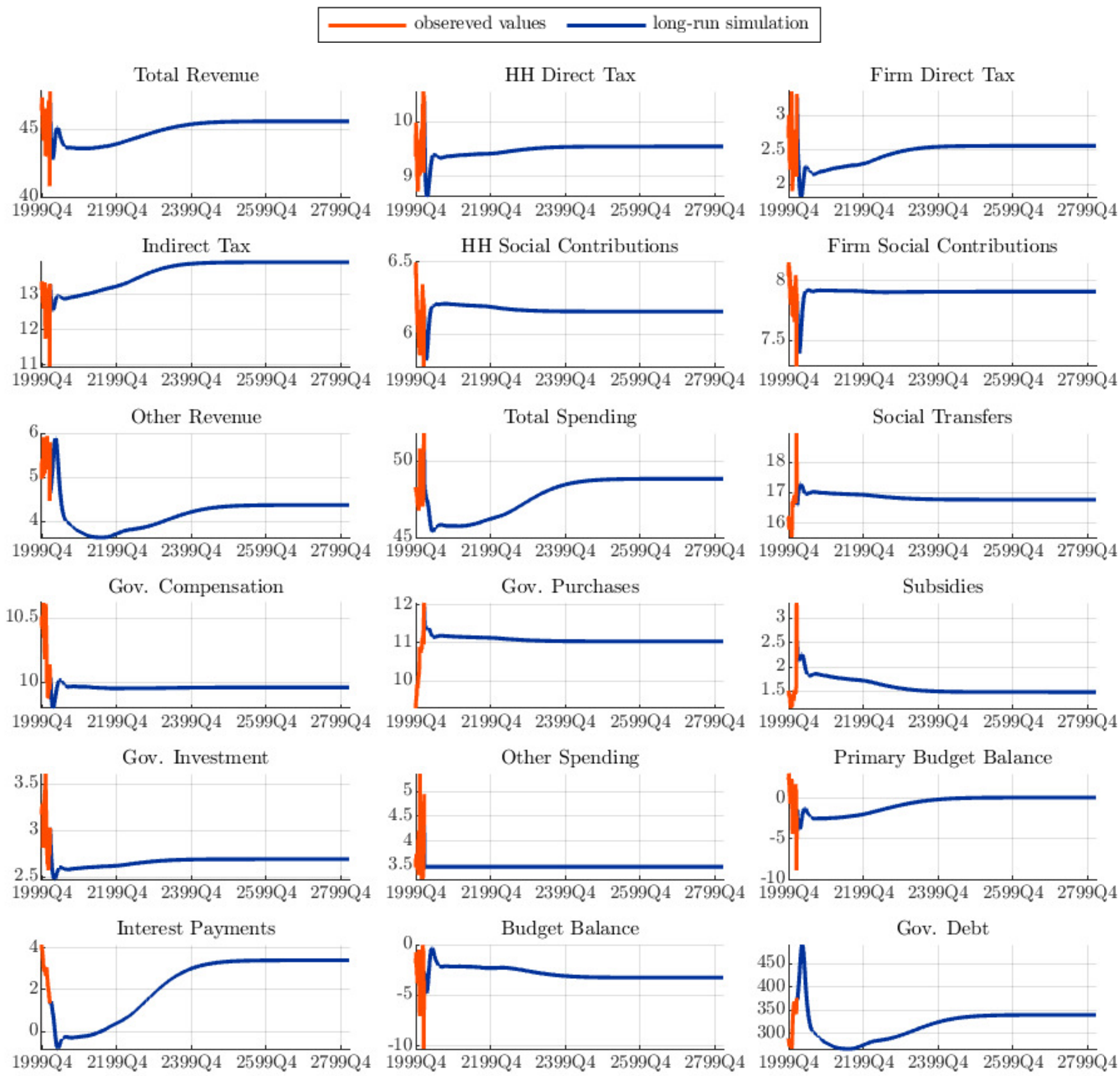
[19] The snowball effect is an inert change in the debt-to-GDP ratio that occurs even when the primary budget remains in balance, and the deficit-debt adjustments are absent. It is a function of the debt-to-GDP ratio in the previous period b_{t-1}, nominal growth g_t and the effective interest rate paid on debt i_t.

run value of other revenue in relation to GDP and $\left(\frac{MAL_{t-1}}{Y^{nom}_{t-1}} - \bar{b}\right)$ is the past deviation of the debt-to-GDP ratio from the target value. The debt correction term is needed to eliminate any existing deviations of the debt-to-GDP ratio from the target over time. Moreover, the long-run value of the other revenue-to-GDP ratio ensures the desired value of the primary balance-to-GDP. The identification accounts for the long-run values of other fiscal variables, which are guaranteed by their individual equations, as described in Subsection 2.2.

$$\frac{RRN_t^{trend}}{Y_t^{trend,nom}} = r\bar{r}n + 0.01 \quad \left. \frac{MAL_{t-1}}{Y_{t-1}^{tren,nom}} - \bar{b}\right) \tag{14}$$

Figure 5 illustrates the long-run simulation and the convergence within the fiscal block. The tax and social contribution variables, even though modelled as tax rates, attain constant values as a share of GDP. The convergence occurs because the macro bases, which link the tax rates and revenues in level, also account for a constant share of GDP in the long run. Spending variables stabilise relative to GDP, as ensured by their corresponding equations. Given this, other revenue takes the long-run value of above 4% of GDP to bridge whatever gap is needed to reach the desired primary balance of 0% of GDP. As interest payments stabilise relative to the stock of debt (see Figure 5) and, hence, to GDP the overall budget balance-to-GDP ratio converges to a constant value of around -3% of GDP.

Figure 5: Long-run simulation of fiscal variables (% of potential GDP)



Sources: Own calculations with the ECB-BASE.

Notes: The simulation serves only the purpose of illustrating the long-run convergence of fiscal variables in the model. The long-run simulation setup is simple in that it assumes zero values for the residuals during the simulation period. In this context, some variables (e.g. interest payments) reach implausible values before achieving convergence. This property should not cast doubts about the capacity of the long-run convergence of the model.

4 Effects of fiscal shocks in the model

The rich and comprehensive representation of the general government in the ECB-BASE enables to analyse a wide variety of fiscal shocks. Given the degree of granularity of the fiscal block, thirteen distinct fiscal shocks can be examined in the model (see Table 5). Six shocks operate through instruments on the revenue side of the budget and seven on the spending side. Some of the shocks are equivalent to budgetary items. For instance, shocking social transfers requires a change in social transfers themselves. For other shocks, however, a change in a budgetary item must be induced by some other shock instrument. This principle applies, particularly, to tax shocks, for which a change in collected taxes requires an adjustment in a tax rate (see the middle and right column in Table 5).

Table 5: Fiscal shocks in the model

Fiscal instrument	Shock instrument	Affected nominal budget item
Revenue side of the budget		
HH Direct Tax	HH Direct Tax Rate	HH Direct Tax
Firm Direct Tax	Firm Direct Tax Rate	Firm Direct Tax
Indirect Tax	Indirect Tax Rate	Indirect Tax
HH Social Contribution	HH Social Contribution Rate	HH Social Contribution
Firm Social Contribution	Firm Social Contribution Rate	Firm Social Contribution
Other Revenue	Other Revenue	Other Revenue
Spending side of the budget		
Social Transfers	Social Transfers	Social Transfers
Gov. Employment	Real Gov. Compensation	Gov. Compensation
Gov. Wage	Gov. Wage	Gov. Compensation
Gov. Purchases	Real Gov. Purchases	Gov. Purchases
Subsidies	Subsidies	Subsidies
Gov. Investment	Real Gov. Investment	Gov. Investment
Other Spending	Other Spending	Other Spending

To analyse the propagation of fiscal shocks, model simulations in this section assume a temporary 1% of GDP ex-ante fiscal expansion through different instruments. The calibration does not mean that the final change in the budget balance amounts to 1% of GDP because of the automatic reaction of fiscal variables, especially those on the revenue side. For this reason, the notion of an *ex-ante* budgetary cost is used throughout this section. The transitory nature of the fiscal shocks means that the size of the impulse amounts to 1% of GDP ex-ante only in the first period. In subsequent periods the impulse decays in an autoregressive fashion with the persistence parameter of 0.9. The model is shocked from its balanced growth path.[20] In this context, the shock propagation is independent of economic conditions.[21] Finally, the simulations

[20]Starting from the most recently available data, the model is simulated first until a balance growth path is reached (see Subsection 3.3). Only subsequently is the model shocked with specific fiscal instruments.

[21]The independence of the results from the economic situation is often labelled in the literature as a 'timeless perspective'. In the ECB-BASE, which is very closely linked to the data, analysing fiscal policy during various periods will likely lead to different results. For instance, in the environment prevailing during 2015-20 (i.e. binding

are conducted with the Taylor rule operating in the background and governing the reaction of monetary policy.

Given multiple fiscal shocks in the model and existing similarities between some of them, this section groups some of the shocks for the sake of exposition. For instance, it bundles together three fiscal shocks that affect the disposable income of households and, ultimately, private consumption in a similar fashion. Moreover, to facilitate an understanding of the differences between various instruments, a described shock is often plotted against another shock serving as a reference. The following panels of impulse response functions (IRFs) cover a set of main macro real and price variables (white subplots), main fiscal variables (light-yellow subplots) and shock-specific variables helpful for understanding the propagation (light grey subplots).

4.1 Shocks affecting disposable income of households

Three fiscal shocks crucially affect the disposable income of households. These shocks are associated with direct taxes paid by households, social contributions paid by households and social benefits received by households (i.e. social transfers in the model). Not only the current disposable income is influenced by the three fiscal instruments, but also the permanent disposable income. The former plays a crucial role in the consumption of rule-of-thumb consumers. The latter, in turn, drives the consumption of optimising households. Subsection C.1 in the appendix lays out the details on the formation of disposable income and how it affects private consumption for the two types of consumers.

The three fiscal instruments discussed here, if expansionary, all increase the current disposable income (see Figure 6). As rule-of-thumb households spend whatever income they have at their disposal, their consumption increases instantaneously. The baseline calibration of the ECB-BASE assumes 1/3 share of rule-of-thumb consumers.[22] The reaction of these consumers immediately provides a boost to economic activity. Following the improved economic conditions, the permanent disposable income also increases, positively influencing the target private consumption. As time passes by, optimising households adjust their consumption gradually towards

ELB on the short-term rate), fiscal policy is much more potent than otherwise when the reaction of the monetary authority is unconstrained. For the analysis of fiscal shocks, time dependency is avoided by initiating simulations at the balanced growth path.

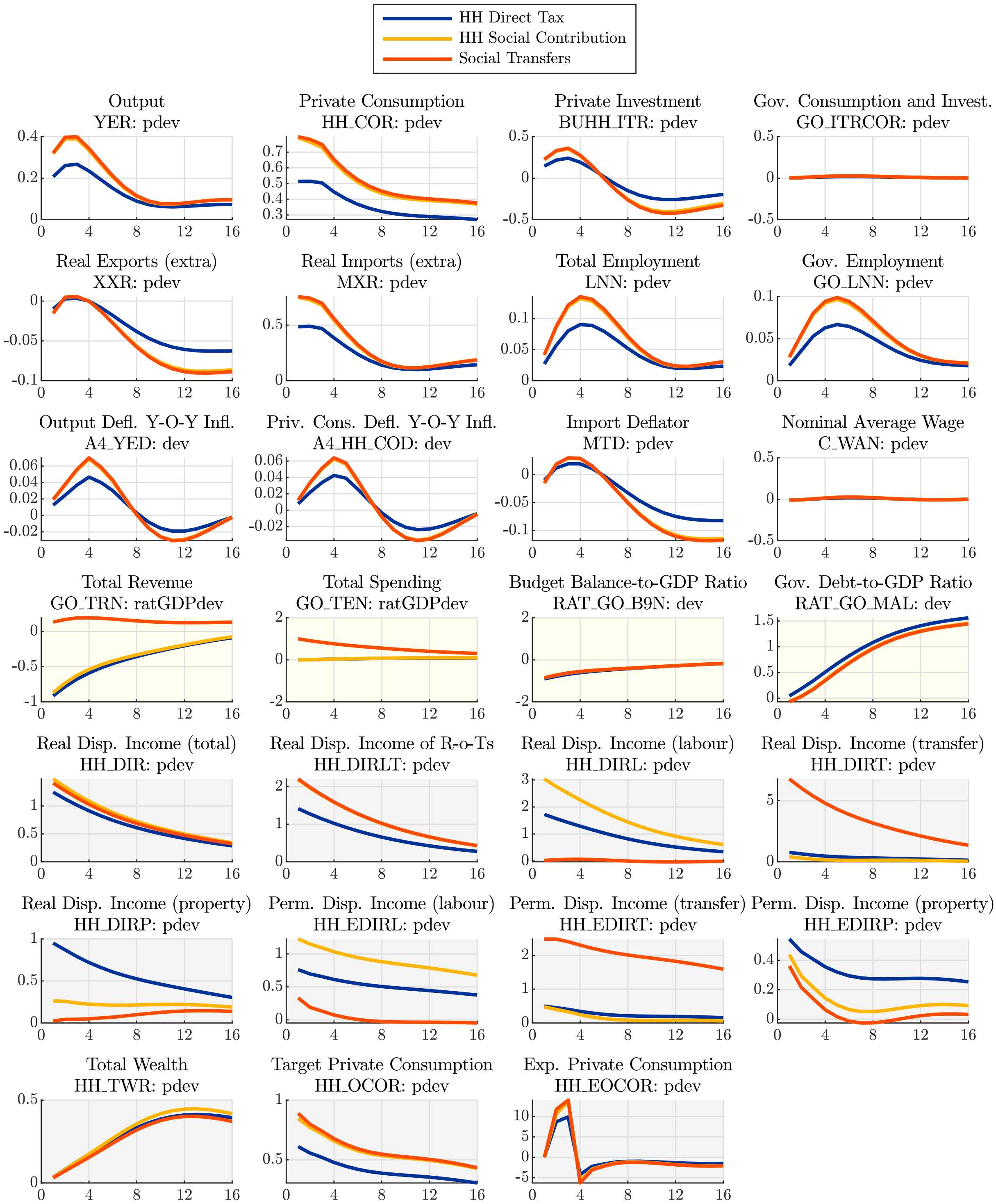
[22]The rule-of-thumb households are those who do not save but instead consume their after-tax disposable income. They are also referred to in models as non-Ricardian households (e.g. Coenen and Straub (2005)) or hand-to-mouth households (e.g. Erceg et al. (2006)).

the target in accordance with the polynomial adjustment costs (PAC) specification.[23] The reaction of optimising households makes the response of private consumption (and output) last longer than fiscal shocks themselves (note that the target consumption remains considerably above zero within the simulation horizon).

Rule-of-thumb households play a key role in the translation of income into consumption. They are also primarily responsible for the differences between the three shocks noticeable in Figure 6. R-o-T consumers do not own wealth, and as such, they do not benefit from the property income (i.e. only from labour and transfer income, see Subsection C.1 in the appendix for the detailed description of the disposable income). A considerable share of direct taxes paid by households, however, is related to property income (see Figure C.2 in the appendix). Therefore, any changes to direct taxes will impact more optimisers, who react sluggishly, than R-o-T consumers. For this reason, direct tax paid by households is less stimulative than household social contributions and government transfers. In addition, social contributions and government transfers induce bigger changes to the overall disposable income than direct taxes. This phenomenon occurs because a part of social contributions and social transfers (mostly pensions) is operated by private sector funds, which follow the policies of the government (see Figure C.3 in the appendix on the share of the government in total contributions/ transfers).

[23]The polynomial adjustment costs (PAC, as developed by Tinsley (1993)) play a central role in the ECB-BASE in the characterisation of rigidities applicable to variables involving an optimisation problem by economic agents.

Figure 6: Effects of the fiscal shocks affecting the disposable income of households (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

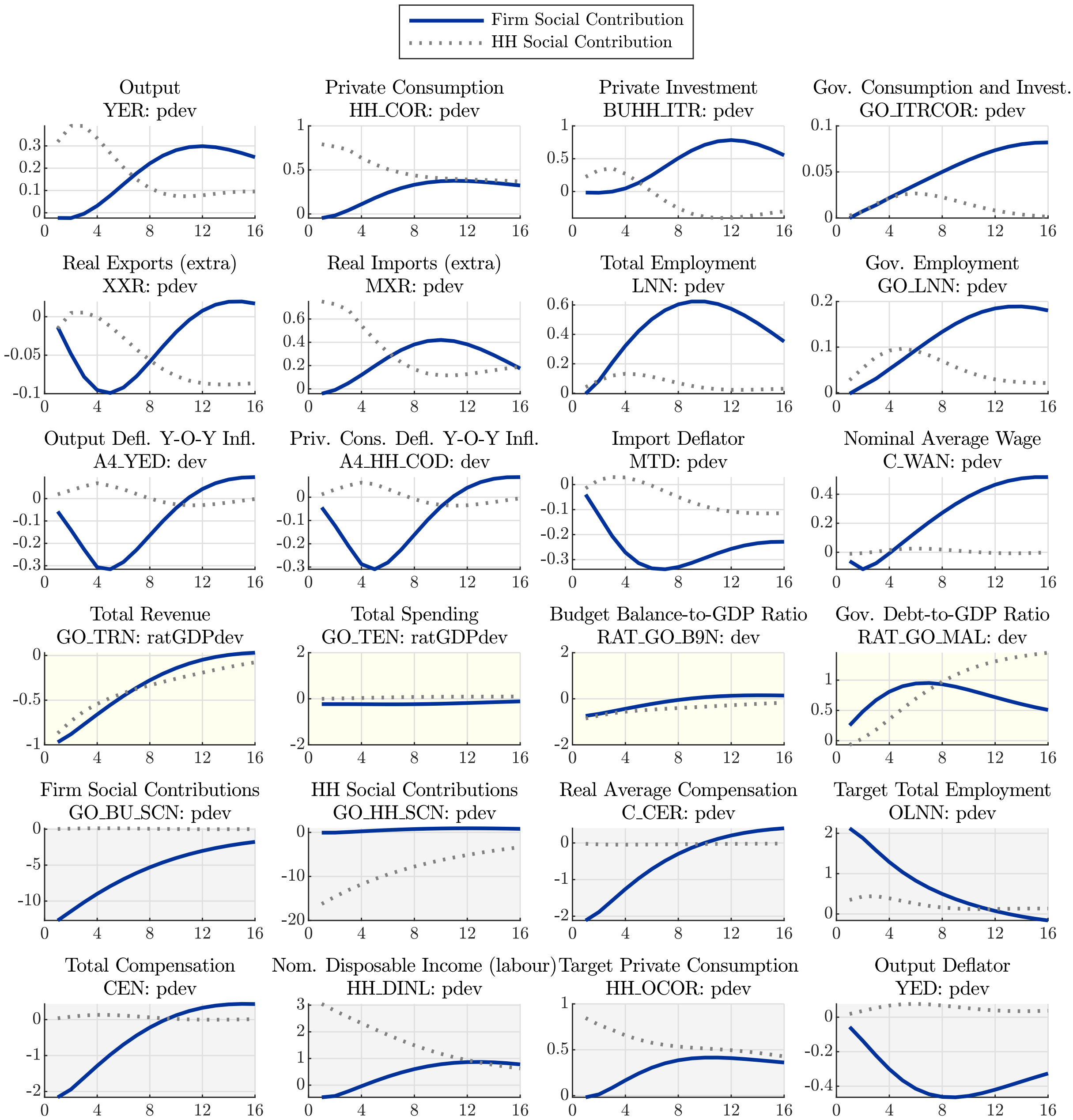
4.2 Firm social contributions shock

While social contributions paid by firms serve, in principle, the same purpose of funding the social security system, like those paid by households, their propagation mechanism and economic effects are quite different. Naturally, social contributions paid by firms directly affect employers rather than employees. This feature is primarily the reason for devoting a separate subsection to this shock and not bundling it together with the three shocks affecting the disposable income of households. Nevertheless, to give some perspective, the subsection contrasts the social contributions by firms against those by households (see Figure 7) and emphasises relevant differences.

A fiscal expansion of 1% of GDP through social contributions paid by firms directly affects total compensation, which initially drops by around 2%. As labour costs for employers fall, firms have incentives to increase employment. This development lifts the overall compensation with time and more than offsets the direct effects of the SSC cut during the outer quarters. Additional employment and lower prices due to the labour cost reduction eventually lift the disposable income of households. The gain leads to some increase in private consumption and stimulating output effects. The reaction of private investment to favourable economic conditions further strengthens the output, which eventually noticeably increases (by 0.3% after three years).

Since there is no immediate reaction of the disposable income to the cut in social contributions paid by firms, the shock propagation takes place only gradually. The shock omits the Rule-of-thumb consumers with a high marginal propensity to consume, which are able to provide an instant boost to private consumption. This situation stands in contrast to social contributions paid by households, which lead to a quick uplift in private consumption. Overall, the effects of the two shocks on real output are of a similar magnitude but different when it comes to the time profile (i.e. delayed vs instant). Another difference between the two shocks relates to the effects on prices. Since contributions paid by firms reduce labour costs, they put a noticeable downward pressure on inflation.

Figure 7: Effects of the firm social contributions shock (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

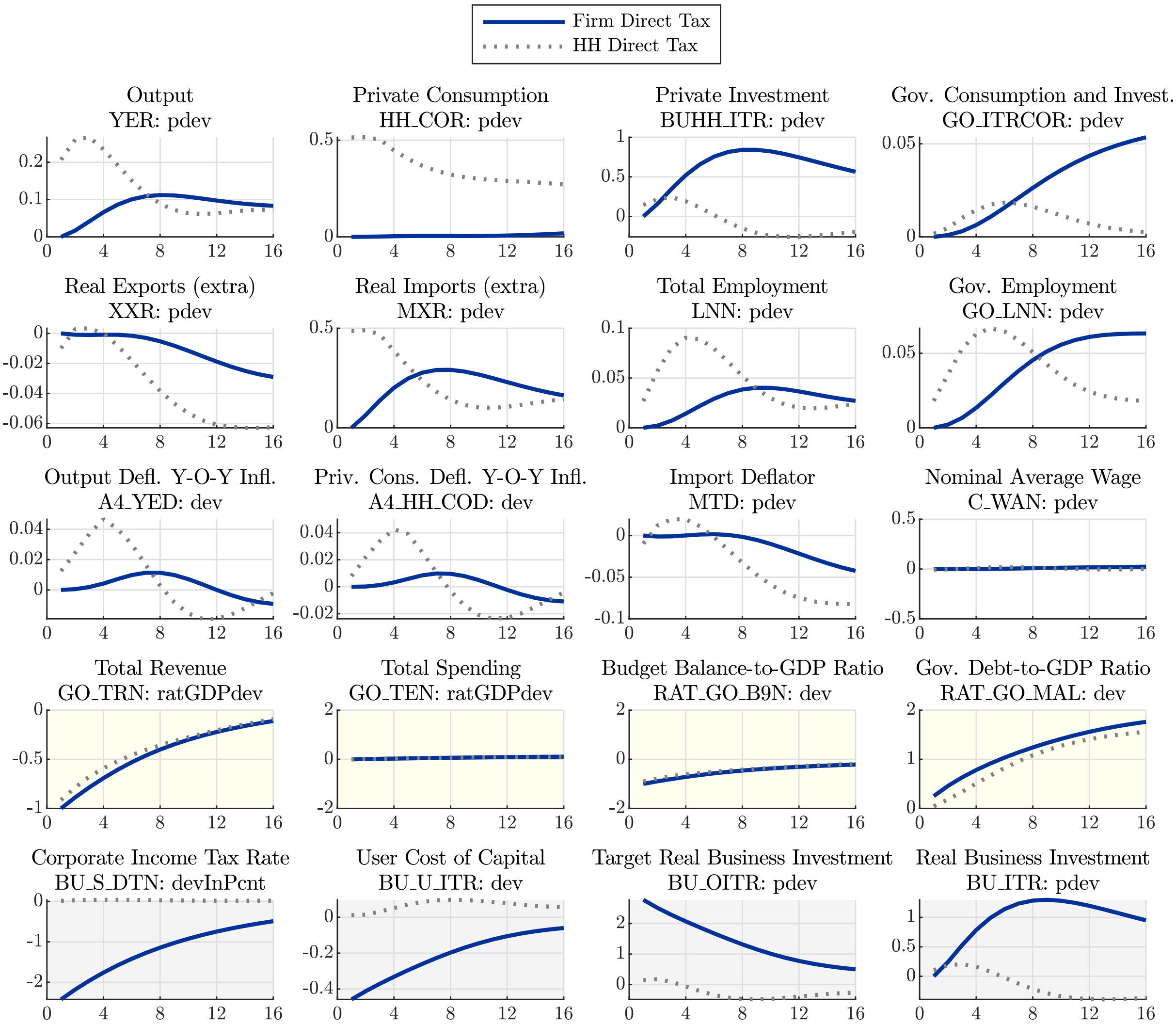
4.3 Firm direct tax shock

Corporate taxes constitute in the model a powerful tool to affect business investment. The corporate tax rate entering the business investment optimisation problem is linked to the direct taxes payable by firms present in the fiscal block. To put the propagation of the direct tax by firms shock into perspective, the below description features a comparison with the direct tax by households shock described in Subsection 4.1.

A reduction in direct taxes paid by firms by 1% of GDP is associated with a significant cut to the corporate income tax rate (above 2 percentage points, see Figure 8). The cut has immediate implications for the user cost of capital, which falls as a consequence. The reduction positively affects the target value of business investment (see Subsection C.2 in the appendix containing the description of the relationship between key investment variables). A change in the target value does not immediately induce adjustments to actual business investment. Only over time, in accordance with the PAC specification, private investment catches up, thereby gaining strength gradually.

It is evident from Figure 8 that the two types of taxes, namely those paid by firms and households, have distinct macroeconomic effects. The corporate tax cut operates primarily through private investment, which consists mainly of business investment (around 2/3 in the euro area). Also, the effects materialise gradually because the corporate tax rate directly influences only the target variable. By contrast, a cut in direct taxes paid by households manifests itself primarily through private consumption. Also, the response is imminent as changes in disposable income instantly operate through the consumption of R-o-T consumers.

Figure 8: Effects of the firm direct tax shock (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

4.4 Shocks affecting net indirect taxes

Adjustments to consumption taxes feature prominently in both policy and academic discussions as an option to stimulate the economy even in a situation of constrained interest rates and high deficits. A measure of this sort relates closely to the seminal proposal by Correia et al. (2013), who labelled it unconventional fiscal policy. According to this theory, even a temporary VAT cut – with an anticipated reversal – can substantially stimulate demand by lifting inflation expectations (see D'Acunto et al. (2021) for a description of the mechanism).[24] The success of such policies in the euro area, where final prices include consumption taxes, crucially depends on firms passing over consumption tax changes to consumers – the so-called pass-through rate.

Modelling consumption tax shocks in the ECB-BASE also requires taking a stance on the degree of the pass-through. The available literature on this topic remains somewhat inconclusive. Crossley et al. (2014) contains a survey of relevant studies, with most of the analysis pointing to an incomplete pass-through of around 70%. Some other studies, such as Benedek et al. (2015) and Büttner and Madzharova (2017), which draw insights from multiple incidences of tax reforms, indicate a full pass-through to prices.[25] One plausible explanation for the disagreement in the literature is that the pass-through rate may depend on various factors, such as increase vs decrease in the value-added tax, market competitiveness or financial soundness of firms (see Benzarti et al. (2020) and Montag et al. (2020) as examples of studies, which consider various determinants). In this context, it appears unavoidable that the degree of pass-through needs to be assessed individually depending on the characteristics of an evaluated tax change.

For a demonstration of a standard temporary consumption tax shock in the ECB-BASE, the paper assumes a partial pass-through of 60%. According to the analysis of Deutsche Bundesbank (see Deutsche Bundesbank (2020)), this was the degree to which the temporary VAT during Jul-Dec 2020 translated into overall prices, as measured by the standard HICP index.[26] Similarly to other fiscal shocks, the model simulations envisage a gradually fading away fiscal expansion with the ex-ante cost of 1% of GDP initially. The fiscal impulse related to consumption taxes can materialise through either a cut to payable consumption taxes or an increase in receivable subsidies. For this reason, the description refers to the net consumption tax rate (or net indirect taxes used in this subsection interchangeably), which is exactly calibrated in the simulations so that it ensures the desired ex-ante budgetary cost. The macro base on which the consumption

[24] Lifting inflation expectations, which lies at the core of unconventional fiscal policy, is particularly relevant when monetary policy is constrained (i.e. at the ELB or in a monetary union from a perspective of a single country). To this end, adjusting the future path of inflation can be achieved not only with an anticipated reversal of a temporary VAT reduction but also with a pre-announced permanent VAT increase (e.g. the VAT hike in Germany in Jan 2007 agreed in autumn 2005). D'Acunto et al. (2021) demonstrates that such an unconventional fiscal policy is more potent than other unconventional policies, such as forward guidance. The reason is that the former is easily understood by economic agents, while the latter requires a high degree of financial literacy, which many households do not possess.

[25] The empirical work of Benedek et al. (2015) finds a full pass-through only for standard VAT rates. In the case of reduced rates or reclassifications, the pass-through is considerably lower (i.e. 30% or even approximately non-existent for the latter).

[26] The overall effect on the price index in the analysis of Deutsche Bundesbank (2020) reflects the average of the pass-through in the goods sector, which was roughly full, and in the service sector, which was around one-third.

taxes are levied consists of not only private consumption but also government purchases. Its share in GDP is big (i.e. around 2/3) but still considerably smaller than 100%. Thus, the net consumption tax rate has to fall by more than 1 percentage point to ensure a budgetary expansion of 1% of GDP. Furthermore, a general reduction in net consumption taxes is assumed without relying on any particular type of tax.[27]

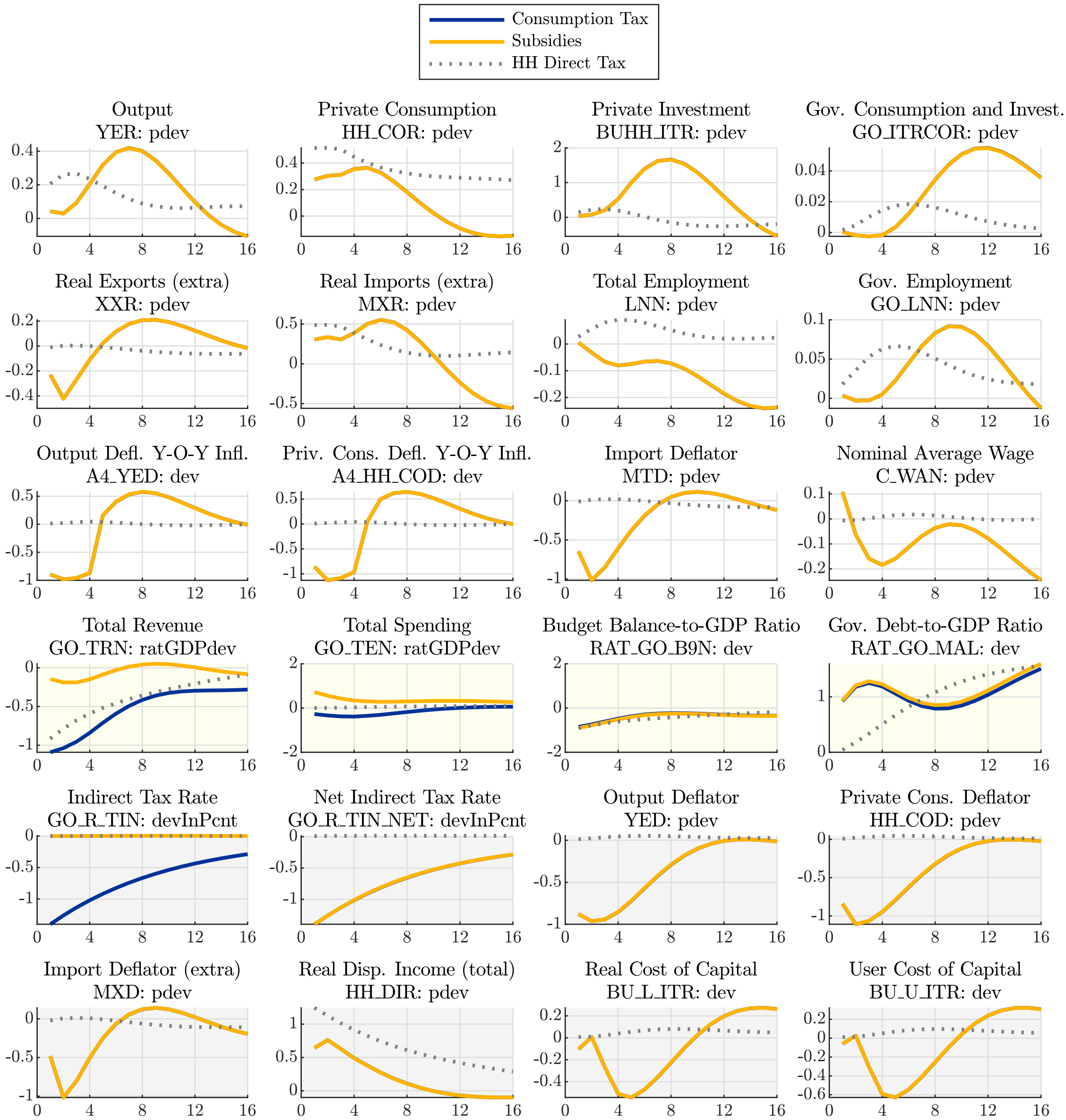
Consistently with the partial pass-through rate justified above, a cut to the net consumption tax rate of around 1.5 percentage points immediately affects the prices, which fall nearly 1% (see the output and private consumption delators in Figure 9). The effect is irrespective of the origin of the shock, namely whether it comes from payable consumption taxes or receivable subsidies. The combination of significantly dropping prices and nominal wages hardly reacting results in a material increase in the real disposable income. The rise drives up private consumption, which together with the consumption tax reversal, exerts upward pressure on prices in the following periods. As inflation goes up and monetary policy tightens sluggishly (following the estimated Taylor rule with persistence) real interest rates, including the real cost of capital, fall. The reduction causes a corresponding decline in the user cost of capital with positive implications for business investment. To sum up, the final effect on the output from a temporary cut in consumption taxes reflects an immediate positive reaction of private consumption and a significant boost to investment that occurs only after several quarters.

Compared to other tax shocks – for instance, to direct tax by households (see Figure 9) – the two shocks related to consumption taxes involve major adjustments to prices. In this context, they are similar to a cost-push shock, the propagation of which in the ECB-BASE is described in Angelini et al. (2019). Also, what makes the two consumption tax shocks distinctive is that they induce a simultaneous movement in various output components, namely private consumption and private investment. Other tax shocks impact largely either the former (e.g. direct tax by households) or the latter (e.g. direct tax by firms). The subsequent positive reaction of investment more than offsets the negative effect of the inter-temporal substitution in private consumption visible after some periods.[28]

[27] The exercise in the paper differs from a typical study investigating the effectiveness of a measure specified as a certain reduction of a specific tax rate (e.g. a cut from 19% to 16% of the standard VAT rate and from 7% to 5% of the reduced rate in the case of the temporary VAT reduction in Germany during Jul-Dec 2020).

[28] Front-loading private consumption at the cost of upcoming periods in response to consumption tax cuts involves the so-called inter-temporal substitution effect. In a fully micro-founded forward-looking model, this effect comes from the Euler equation (see, for instance, D'Acunto et al. (2021) for a formal exposition). Furthermore, the second effect impacting real interest rates would materialise in a forward-looking model more instantly through expectations and the Fisher equation than in the backwards-looking ECB-BASE.

Figure 9: Effects of the consumption tax shock (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

4.5 Non-wage government demand shocks

The two shocks that are probably the most common in fiscal policy analysis in macroeconomic models are associated with government consumption and investment spending. These are government demand shocks that directly affect the total final demand – in contrast to tax shocks. The government consumption in the ECB-BASE consists of purchases and wage components. In this section, only the former is considered on the grounds that it is usually the shock associated with the 'G' shock in macro models. The government wage shocks will be discussed thereafter in Subsection 4.6.

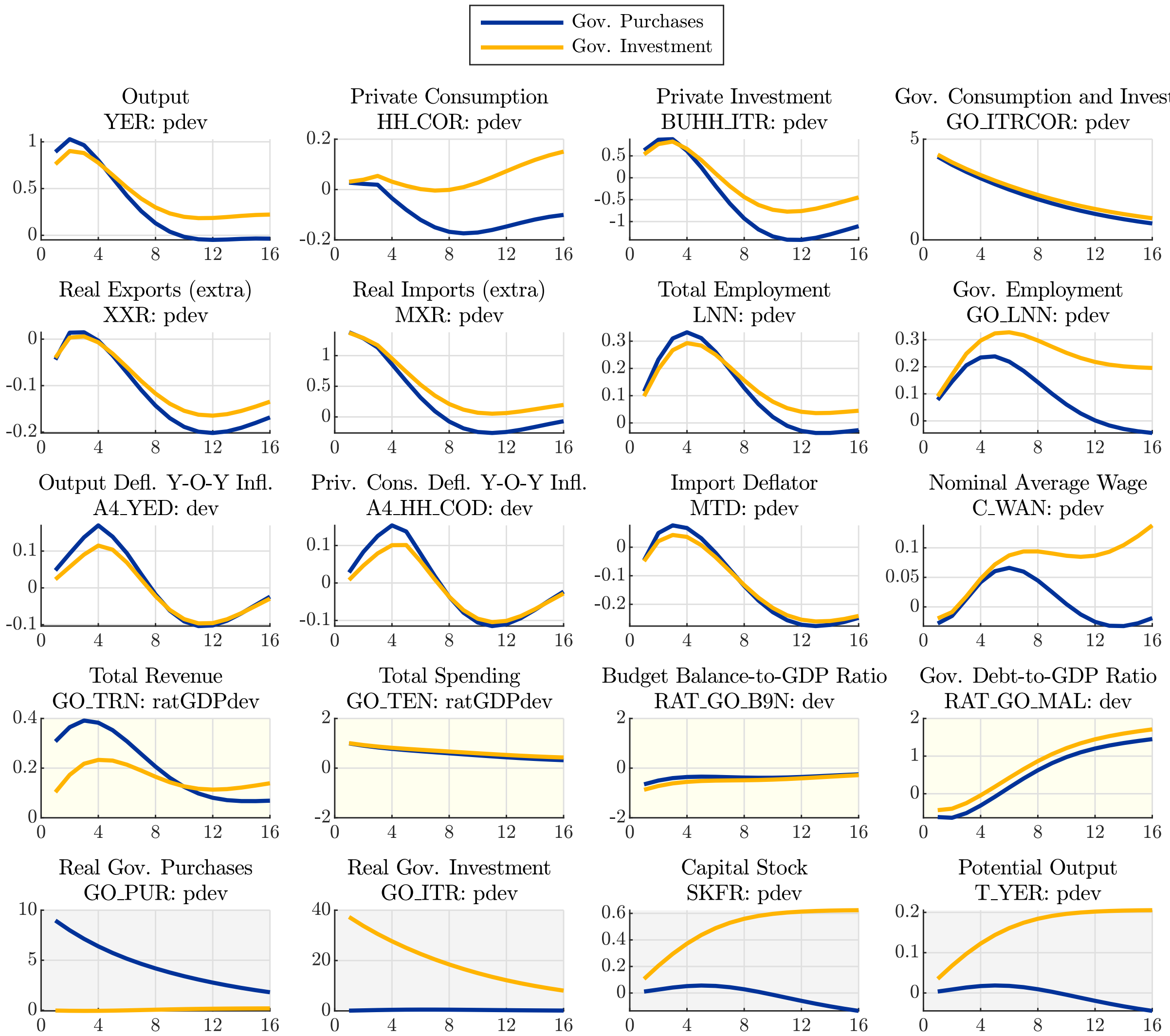
A fiscal expansion amounting to 1% of GDP through government purchases or investment requires a substantial increase in two spending categories, given their size. In particular, government investment has to expand by almost 40% (see Figure 10). The propagation of the two shocks is straightforward because the affected fiscal expenditure enters the identity that determines output. In this context, the output immediately increases roughly by 1%, equal to the size of the fiscal shocks. Besides, there are two counteracting forces at play. On the one hand, a part of the stimulus leaks out of the euro area through increased imports because a share of government purchases and investment goods comes from abroad. The import content is estimated based on the input-output tables at 12% (see the description of the methodology and calculations in Subsection A.3 in the appendix). The leakage reduces the stimulative effects of fiscal policy on the domestic output. On the other hand, the fiscal impulse gives rise to some crowding-in of private output components. Both private consumption and private investment increase on the back of improved macroeconomic conditions.[29] This effect magnifies the direct positive effects of the fiscal stimulus and to some degree offsets the leakage.

The macroeconomic effects of government purchases and investment are broadly similar. In the end, both shocks operate through final demand and affect output directly in the same way. Also, both spending categories have the same import content in the model, hence subject to the same leakage. One noticeable difference relates to their persistence. In this context, government investment has a more long-lasting impact on the economy than government purchases. This fact should not be surprising as government investment contributes to the overall stock of capital. Therefore, besides providing a demand-based stimulus in the short run it also increases the

[29]Both private consumption and business investment depend to a limited degree on current economic conditions. The former is affected by the behaviour of R-o-T consumers, which link their consumption directly to their disposable income. Similarly, the latter partially reflects liquidity-constrained firms, which rely on prevailing cash-flow conditions rather than optimising investment over a broad time horizon.

productive capacity of the economy, which is visible after some time (see the reaction of potential output in Figure 10).

Figure 10: Effects of the government purchases and investment shocks (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

4.6 Government wage shocks

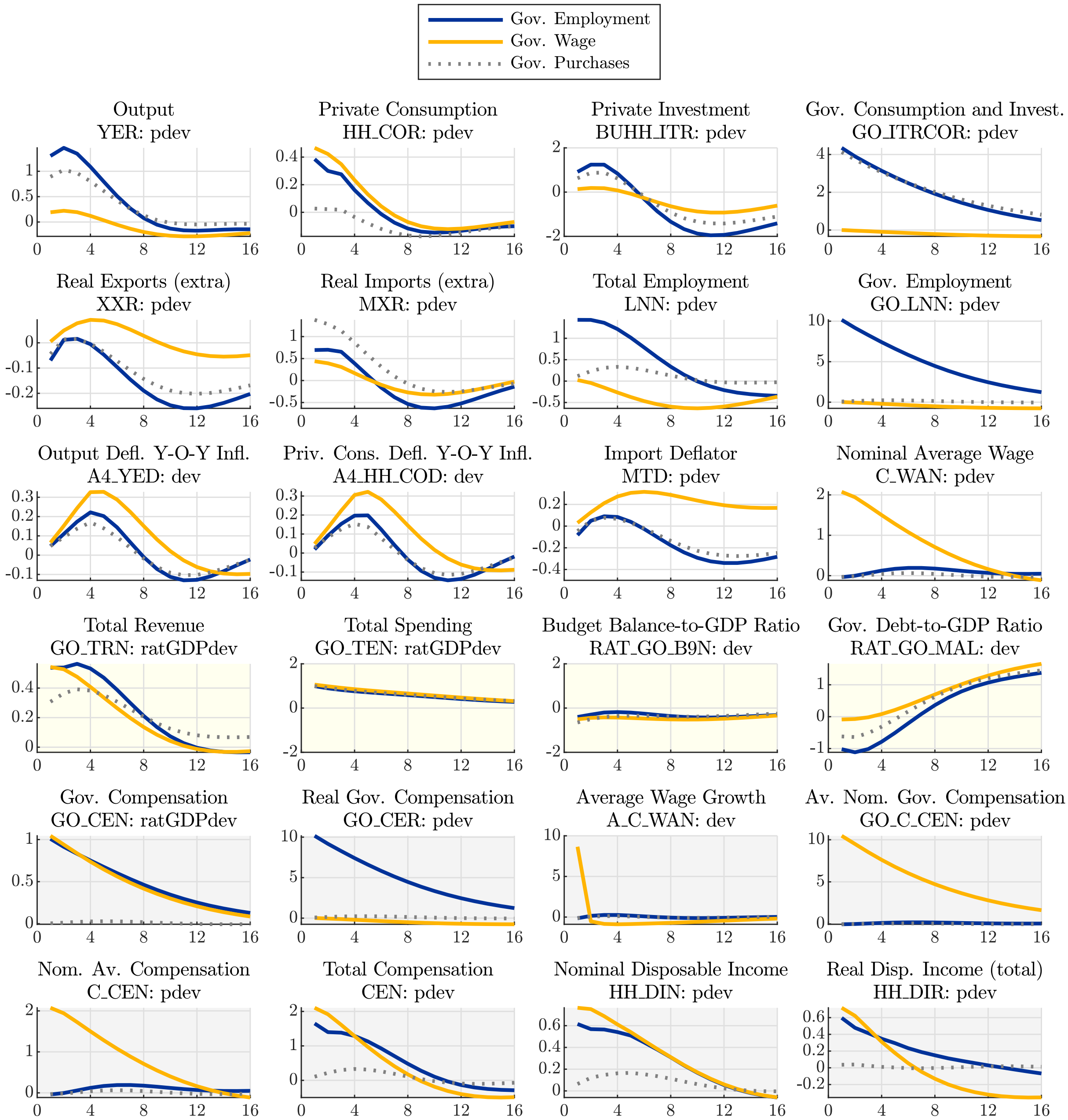
A change to government consumption does not necessarily need to involve government purchases, even if this is the case in most macroeconomic models. In reality, government consumption can also be adjusted through government compensation, which accounts for the other half of the government consumption. Furthermore, governments need to choose how to adjust compensation because they can do it at least twofold. First, they can increase government employment, which is an adjustment in real terms. Second, they can manipulate the average wage in the general government sector, which involves an adjustment to prices. The richness of the ECB-BASE allows for modelling the two shocks within the government compensation separately, which is the topic of this subsection.

On the government employment shock, a fiscal expansion of 1% of GDP requires a substantial increase in the number of government employees (around 10%, see Figure 11). This adjustment constitutes a significant increase in the real government consumption, which goes directly to the output. An immediate positive reaction of the output gap is tantamount in the model to an improvement in the economic conditions. Thus, both private consumption and private investment react favourably initially, thereby amplifying the direct output effect. Given the upbeat economic developments, inflation increases accordingly and public finances enjoy some benefits, which partly offset the original cost of the expansion.

Even though the government wage shock, like the government employment shock, manifests itself in the same increase in nominal government compensation, its propagation and effects are starkly different. Crucially, a rise in the average government wage, by contrast to the government employment, leaves real government consumption broadly unchanged (see Figure 11). Thus, it does not lead to any immediate improvement in the output gap. Instead, the government wage shock involving a 1% of GDP fiscal expansion requires a substantial increase in average wages (2% in the total economy and nearly 10% in the general government sector). While such a boost to nominal compensation positively influences the disposable income the benefits from the shock remain limited for the following reasons. First, the wage increase does not fully translate to the disposable income of households because labour taxes and social contributions are levied on it. Second, an increase in average wages has direct positive consequences for the unit labour cost, which brings additional inflation. Rising prices erode the original gains in the disposable income after several quarters, thereby eventually leading to even a negative overall output effect. Since public finances do not benefit from any positive developments, the ex-post cost of the expansion in terms of additional debt is high.

To bring some perspective into the analysis, Figure 11 compares the two government wage shocks to the government purchases shock described in the previous subsection. The propagation of the government employment and government purchases shocks and their effects are similar in the model. Ultimately, both shocks affect real government consumption to the same degree and spur the same dynamics. One noticeable difference is that government employment does not contain any import content while government purchases do (see the derivation of the import content in Subsection A.3 in the appendix). As a result, there is less leakage abroad from the government employment-based fiscal expansion compared to government purchases. Thus, the overall output effect is marginally higher. The government wage shock brings minimal impact on the real economy as benefits of additional nominal compensation, which are already limited, are offset by higher unit labour costs and prices.

Figure 11: Effects of the government wage shocks (deviations from the balanced growth path)



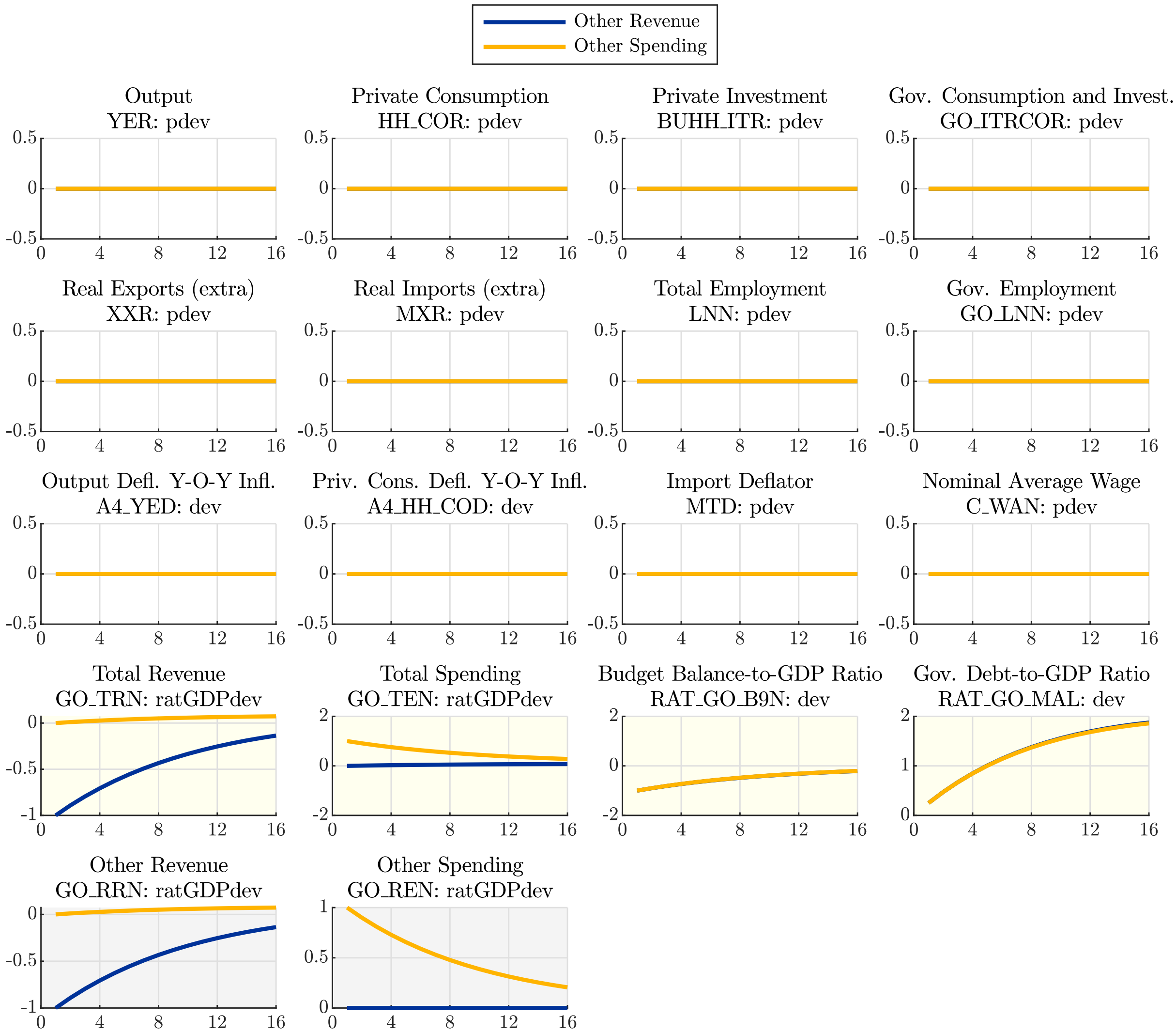
Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

4.7 Residual fiscal shocks

In addition to the shocks described heretofore, the ECB-BASE has two 'residual' fiscal shocks. The first shock is associated with other revenue, and the second with other spending. Given that the two fiscal categories are not linked to any macroeconomic variables, they do not give rise to any meaningful economic consequences (see Figure 12). Nevertheless, since other revenue and other spending are a part of the government accounts, they affect budget balance and government debt. The two shocks can be interpreted as lump-sum tax shocks featuring in most of the macroeconomic models (see Christoffel et al. (2008) for an example of a model with a stylised role of fiscal policy and Coenen et al. (2012b) for a model focusing on fiscal policy; both studies feature lump-sum taxes). As explained in Subsection 3.3 on long-run convergence, only the category of other revenue is used to ensure the stabilisation of the debt-to-GDP ratio. Since the coefficient on debt deviation in the other revenue equations is small, the two shocks are indistinguishable in terms of their public finance consequences (see Figure 12).

Figure 12: Effects of the residual fiscal shocks (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

4.8 Comparison of fiscal shocks

This subsection aims to bring all fiscal shocks together with a view to establishing a general comparison. First, the impulse response functions (IRFs) across various fiscal shocks are presented. Second, the potency of various fiscal shocks through the lens of fiscal multipliers is illustrated.

4.8.1 Impulse response functions

Given the considerable number of fiscal shocks, they are split into two groups: revenue and spending shocks (see Figures 13 and 14 correspondingly).[30] In addition, residual shocks are purposefully omitted, given that they do not yield any meaningful economic effects.[31] In each figure, only the most relevant macro (white subplots) and fiscal (light-yellow subplots) are presented. All fiscal shocks are based on an ex-ante 1% of GDP fiscal expansion and are temporary, as defined at the beginning of the section.

The fiscal shocks on the revenue side are able to stimulate the economy but their effects on output are relatively modest (see Figure 13). A temporary fiscal expansion through government revenue with an initial budgetary cost of 1% of GDP can stimulate output by significantly less than 1% of GDP (0.4% of GDP at best in the case of selected shocks). The three shocks affecting the disposable income of households (i.e. direct taxes by households, social contributions by households and social transfers) are able to provide an instant boost to output. The remaining shocks gradually bring benefits because they propagate through target variables in the model. Even when an adjustment to the target variables occurs instantaneously, it takes time for the actual variables to react in the presence of the PAC specification. The effects on inflation depend on whether fiscal shocks affect prices directly or operate through aggregate variables in the Phillips curves. A consumption tax shock involves major adjustments to prices, and as such, it can impact inflation strongly. Also to some degree, social contributions by firms can have meaningful inflation effects through the unit labour cost. The remaining shocks are much less potent as they affect prices only indirectly through slack.

The fiscal shocks on the expenditure side tend to be more powerful than revenue shocks (with the exception of the government wage shock) when it comes to the degree they can influence economic activity. The reason behind it is that they enter the output identity directly through either real government consumption (the government purchases shock and government employment shock) or real investment (the government investment shock). This stands in contrast with the government revenue-based instruments, which involve some tendency by households to save, thereby hardly stimulating the economy contemporaneously. The real expenditure shocks are

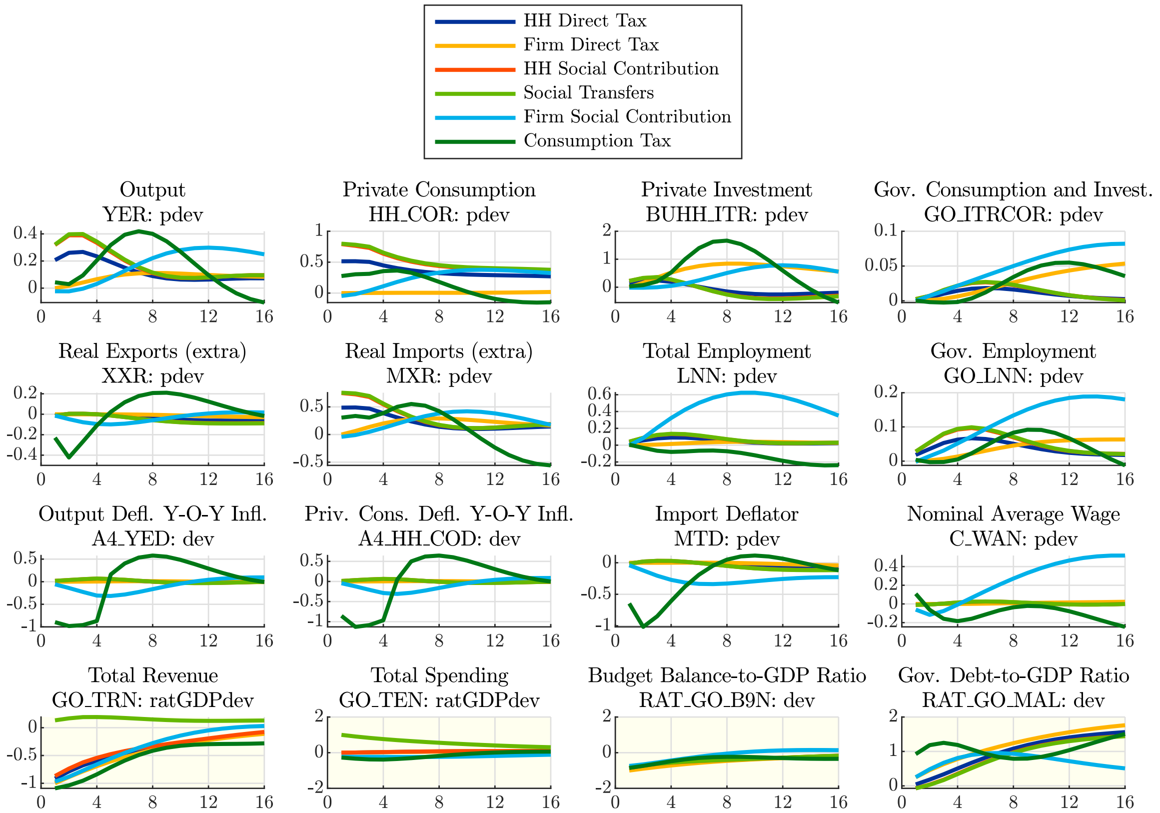
[30] The social transfer shock is similar in nature to the HH direct tax shock and to the HH social contributions shock, hence bundled with the revenue shocks. Actually, social transfers are often separated in fiscal policy analysis from expenditure shocks (see, for instance, the seminal contribution of Blanchard and Perotti (2002), who net out transfers from taxes for the estimation of revenue multipliers).

[31] The subsidies shock is also omitted, given that its macroeconomic effects are identical to the consumption tax shock included in the revenue shocks.

sufficiently powerful to lift output by 1% of GDP with a fiscal expansion of 1% of GDP. The capacity to strongly influence output translates into the ability to exert pressure on inflation. A meaningful inflationary effect also is expected from the government wage shock, which lifts prices by increasing the labour cost even without bringing material positive real effects.

As assumed, fiscal expansions associated with various shocks are of the same size initially (1% of GDP ex-ante). Thus, the ultimate cost for public finances is determined by the ability of fiscal shocks to generate additional output and inflation. Consumption tax shock increases the debt-to-GDP ratio initially as it involves a cut to prices, hence to the nominal GDP. Regarding the spending shocks, they even tend to reduce the debt-to-GDP ratio for a short period of time as they provide a sizeable boost to the economy. Given that budgetary costs accumulate over time, the debt-to-GDP ratio records a noticeable increase after four years in the range of 1-2 percentage points regardless of the shock.

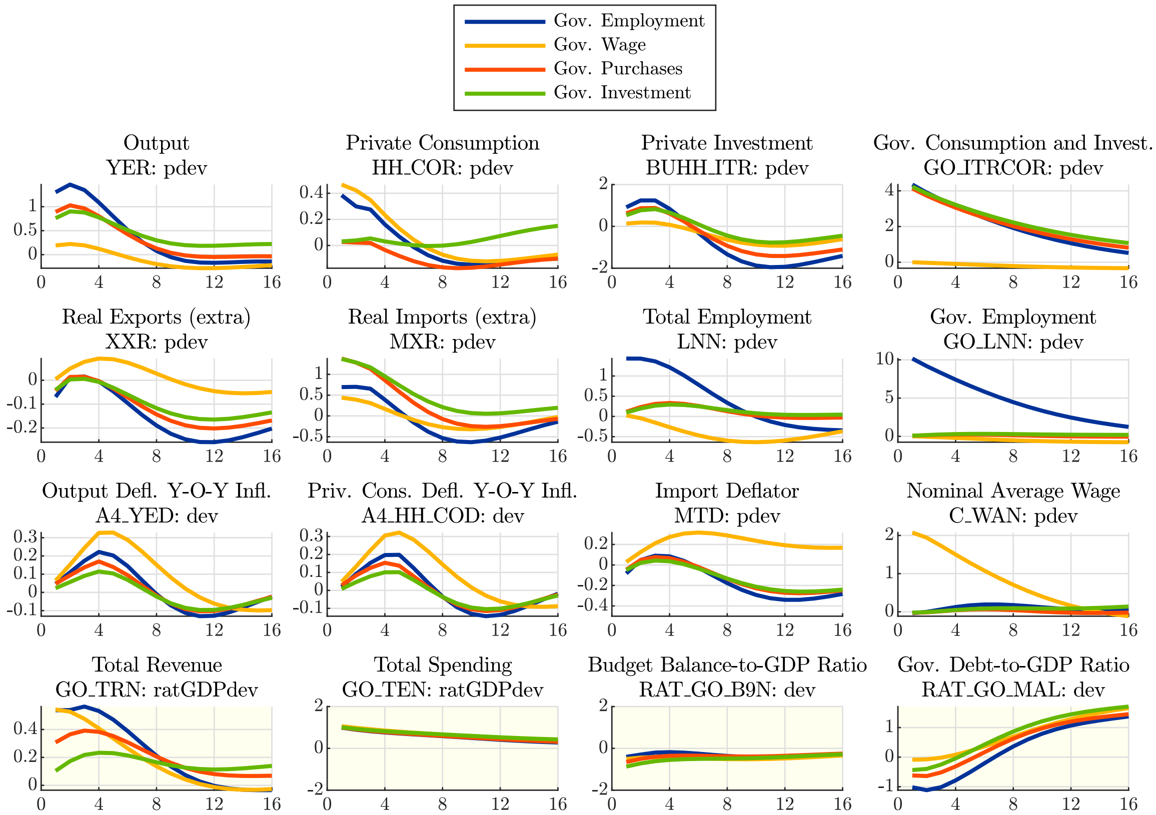
Figure 13: Comparison of the government revenue shocks (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

Figure 14: Comparison of the government spending shocks (deviations from the balanced growth path)



Sources: Own calculations with the ECB-BASE.

Notes: The charts illustrate the deviations from the balanced growth path in response to a transitory fiscal expansion amounting initially to 1% of GDP ex-ante. The subtitles in the charts denote a model code of plotted variables and the way the deviations are calculated (*pdev*: percentage deviation; *dev*: absolute deviations; *devInPcnt*: absolute deviations in percentage points; *ratGDPdev*: deviations as a percentage share of baseline GDP).

4.8.2 Fiscal multipliers

Besides the IRFs, another way to characterise the potency of fiscal instruments is to look at fiscal multipliers associated with fiscal shocks. While fiscal multipliers always attempt to relate the effect, usually, on the output to the budgetary cost, there are various ways to calculate them (Spilimbergo et al. (2009) provide a definition of a fiscal multiplier and various formulas to calculate it). This paper infers about fiscal multipliers simply by simulating a constant 1% of GDP ex-ante fiscal expansion throughout the entire simulation horizon for various fiscal shocks. There is no need to calculate any ratio in such a specification, and the observed output deviation can be directly interpreted as an output fiscal multiplier. Even though the model is quarterly, the deviations are aggregated to annual terms for ease of interpretation. Also, analogous inflation multipliers are calculated in addition to the output multipliers, given the strong interest among policymakers in the price implications of fiscal instruments.

Yearly fiscal multipliers for both output and inflation are presented in Table 6. On the revenue side, the output multipliers fall into 0.2-0.4 range in most cases. None of the revenue instruments is able to deliver a unitary fiscal multiplier. This means that the initial costs of fiscal expansions outweigh their benefits in terms of output gains. The inflation multipliers are material only for fiscal instruments that directly affect prices in the economy, namely the consumption tax and social contributions by firms. In particular, the inflation multiplier associated with the former reaches a value below -1 in the first year.

On the spending side, the output multipliers are significantly higher than on the revenue side (see also Table 6). For shocks that affect the real side of the economy (the government purchases, the government employment and the government investment), the values are close to or even exceed unity. This means that a fiscal expansion with these instruments brings equivalent-in-size or even higher gains in terms of output. Moreover, the values exceeding unity indicate a crowding-in of private components on the back of fiscal stimulus. Sizeable output effects are accompanied by small, albeit non-negligible, inflation effects (see the inflation multiplier going nearly to 0.15 for the government employment shock during the second year). The subsidies and government wage shocks affect inflation most profoundly, given the associated direct price effects. The multiplier values for the social transfers shock are unsurprisingly similar to those for the revenue shocks that operate through disposable income. Zero multiplier values for residual shocks are consistent with the fact that these instruments are non-distortionary and do not have any meaningful economic implications.

Fiscal multipliers in macroeconomic models are sensitive to the reaction of monetary policy. As explained before, the central bank follows an estimated Taylor rule within this evaluation. Effectively, it counteracts the stimulative effects of fiscal expansions in response to any inflationary pressures. The fiscal policy effects under the unresponsive monetary policy would persist for significantly longer compared to the situation in which the central bank reacts to economic developments. However, the results are relatively similar in the initial year, irrespective of the monetary policy regime (see Table D.5 in the appendix with fiscal multipliers calculated under unresponsive monetary policy).

To gauge whether the effects of fiscal policy in the ECB-BASE are realistic, it is crucial to compare the multipliers with the values coming from other comparable macroeconomic models. Coenen et al. (2012a) provide a useful study documenting fiscal multipliers across several structural models used by policy-making institutions.[32] In general, the fiscal multipliers of the ECB-BASE are in line with these embedded in other macroeconomic models. While the study of Coenen et al. (2012a) is only partially comparable because of a different simulation setup and a smaller degree of granularity, important similarities are visible. Most notably, fiscal output multipliers on the revenue side in other models are significantly smaller than unity (consumption taxes are characterised by the largest multiplier of around 0.6). Furthermore, the values of output multipliers linked to typical spending instruments (i.e. the government consumption and government investment) are relatively high, even exceeding unity.

[32] Kilponen et al. (2015) is another relevant study that combines fiscal multipliers from fifteen dynamic macroeconomic models maintained within the European System of Central Banks.

Table 6: Effects of fiscal shocks on output and inflation (fiscal multipliers)

Output	Y1	Y2	Y3	Y4
HH Direct Tax	0.28	0.26	0.23	0.26
Firm Direct Tax	0.03	0.13	0.17	0.20
Indirect Tax	0.10	0.47	0.45	0.22
HH Social Contribution	0.41	0.36	0.31	0.35
Firm Social Contribution	-0.01	0.17	0.38	0.49
Other Revenue	-0.00	-0.00	-0.00	-0.00
Social Transfers	0.42	0.37	0.31	0.36
Gov. Employment	1.50	1.02	0.53	0.45
Gov. Wage	0.21	-0.02	-0.27	-0.35
Gov. Purchases	1.06	0.79	0.48	0.45
Subsidies	0.10	0.47	0.45	0.22
Gov. Investment	0.94	0.83	0.70	0.80
Other Spending	-0.00	-0.00	-0.00	-0.00

Priv. Cons. Defl. Y-O-Y Infl.	Y1	Y2	Y3	Y4
HH Direct Tax	0.03	0.03	-0.01	-0.00
Firm Direct Tax	0.00	0.01	0.01	-0.00
Indirect Tax	-1.15	0.10	0.32	0.08
HH Social Contribution	0.04	0.05	-0.01	-0.01
Firm Social Contribution	-0.18	-0.36	-0.20	-0.09
Other Revenue	0.00	0.00	-0.00	-0.00
Social Transfers	0.04	0.05	-0.01	-0.01
Gov. Employment	0.12	0.15	-0.07	-0.05
Gov. Wage	0.19	0.36	0.18	0.07
Gov. Purchases	0.11	0.10	-0.06	-0.05
Subsidies	-1.15	0.10	0.32	0.08
Gov. Investment	0.06	0.06	-0.07	-0.07
Other Spending	0.00	0.00	0.00	0.00

Sources: Own calculations with the ECB-BASE.

Notes: The figures summarise percentage deviations in the case of output and absolute deviations in percentage points for inflation from the balanced growth path in response to a permanent fiscal expansion amounting to 1% of GDP ex-ante.

5 Selected applications to fiscal policy analysis

5.1 Alternative fiscal rules

As described in Subsection 3.2, the estimation results indicate that on average fiscal policy in the euro area was broadly acyclical. The small size of the coefficients on the output gap in fiscal rules gives support neither in favour of procyclicality nor in favour of countercyclicality. Some argue, however, that fiscal policy should play an important role in macroeconomic stabilisation by acting in a countercyclical fashion (see, for instance, Bartsch et al. (2021)). The recommendation appears particularly relevant in an environment of the low natural interest rate, in which the likelihood of hitting the lower bound and experiencing a protracted recession increases (see, for example, Schmidt (2017) advocating fiscal activism in the presence of an occasionally binding constraint on the nominal interest rates).[33] One important question in this context is how different macroeconomic outcomes would have been had there been a consistent countercyclical fiscal policy in place in the euro area during the last two decades.

The ECB-BASE model is well-equipped to answer the above-formulated question using counterfactual scenarios.[34] The investigation included in this subsection involves two counterfactual scenarios next to the baseline, which is a model replication of the observed values. In the first scenario, fiscal policy decisively reacts in a countercyclical fashion to real economic developments, represented by the output gap. The monetary policy, in turn, by remaining exogenous, does not internalise the consequences of fiscal policy activism and follows the same trajectory as in the baseline. In the second scenario, fiscal policy remains equally countercyclical but monetary policy reacts endogenously to the prevailing economic conditions in line with the model Taylor rule.

The formulation of countercyclical policy in the scenarios takes place through adjusting Equation 5 for selected spending instruments. Specifically, the estimated coefficient on the output gap, which is close to zero, is changed to a significantly negative value.[35] [36] This modification ensures a fiscal expansion during a downturn and a fiscal contraction during an upturn.[37] The instruments used as a policy tool are social transfers, government purchases and government investment. All three categories are, to a considerable degree, discretionary and were subject to a noticeable variation over the cycle (see Figure 4). Also, they are associated with relatively high fiscal multipliers (see Section 4), which makes them potent stabilisation tools.[38]

[33] The idea that fiscal policy should behave countercyclically beyond the usual operation of automatic stabilisers recently gained much traction. Thus, it featured multiple proposals for new fiscal rules and arrangements (see Eyraud et al. (2018) and Eichenbaum (2019), among others).

[34] The scenarios are limited to the 1999-2019 period, which captures the evolution of the regular business cycle. Including the pandemic period in the analysis would dominate the picture, given the extraordinary values of the output gap in 2020.

[35] The value is calibrated to ensure a meaningful, albeit realistic, change in the primary balance compared to the baseline (see Figure 15).

[36] One crucial assumption underlying the simulations is that all residuals in the model remain unchanged compared to those associated with the realised data.

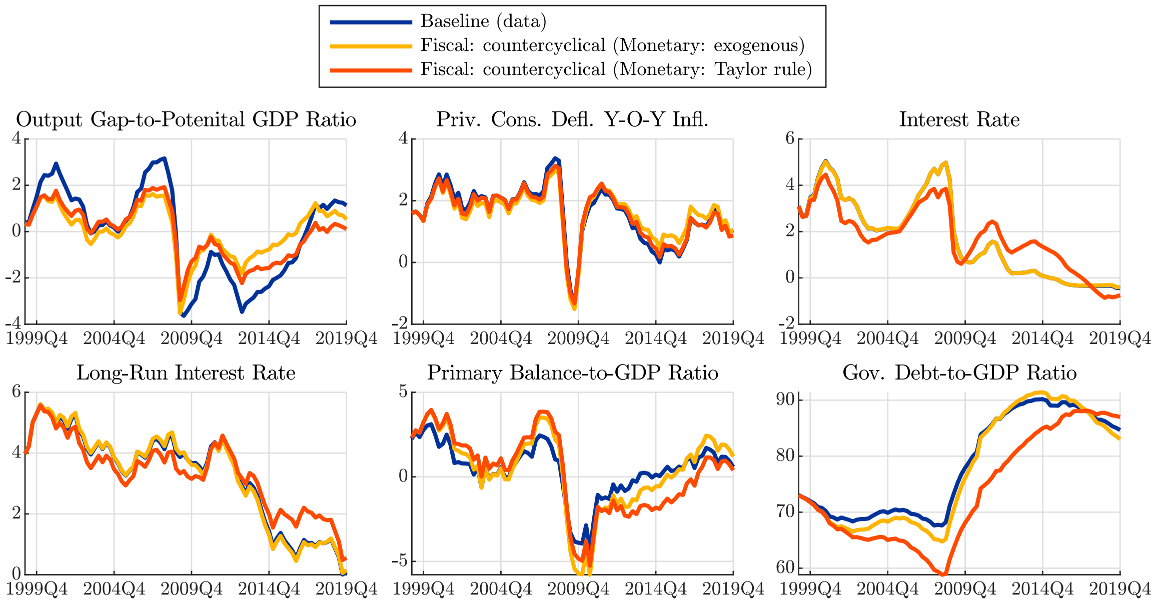
[37] Timely response of fiscal policy to the business cycle would have required the knowledge of the output gap in real time. Given the extent of the revisions to the output gap estimates, accurate fiscal policy fine-tuning in practice is hardly feasible.

[38] Expanding the set of instruments to the revenue side would not change the findings qualitatively. Since it would come at the cost of complexity, a restricted selection of instruments is analysed.

The counterfactual scenarios indicate that the above-devised countercyclical fiscal policy would have substantially smoothed the real output gap and noticeably reduced the distance between the realised inflation and its target (see Figure 15). Before the Great Financial Crisis during the good times, the spending retrenchment induced by the countercyclical policy would have considerably reduced the positive output gap. This policy would have come with the benefit of considerable primary surpluses, which would have led to building fiscal buffers (i.e. considerably lower debt-to-GDP ratio than in the baseline). Afterwards, the countercyclical fiscal policy would have facilitated the post-GFC recovery and alleviated the gravity of the second downturn. It would have been possible to finance this supportive policy with the buffer accumulated during the good times, hence broadly unchanged government debt at the end of the simulation period. The impact of the countercyclical policy on price dynamics is non-negligible. Notwithstanding this, the sizeable inflation gap during the post-GFC period would have largely remained even with the countercyclical fiscal policy, given the large size of the realised shortfalls.

Model simulations also suggest that with the counterfactual fiscal policy the monetary policy rate would have remained below the baseline prior to the GFC (see Figure 15). Subsequently, given the improved economic conditions, the rate would have been above the baseline and reached the lower bound only in late 2017 (rather than in mid-2015). The monetary policy reaction would have consequences for the efficacy of fiscal policy. The latter would not have been as potent as in the first scenario in influencing output and inflation developments. Also, monetary policy would have influenced the financing conditions of the sovereigns, which would have been able to accumulate a large fiscal buffer with interest rates remaining lower than in the baseline prior to the GFC.

Figure 15: Model simulations of countercyclical fiscal rules (%)



Sources: Own calculations with the ECB-BASE.

Notes: The output gap is calculated on the basis of potential GDP coming from the European Commission's AMECO database, given that the Eurosystem/ECB does not publish potential GDP estimates.

5.2 Fiscal policy evaluation

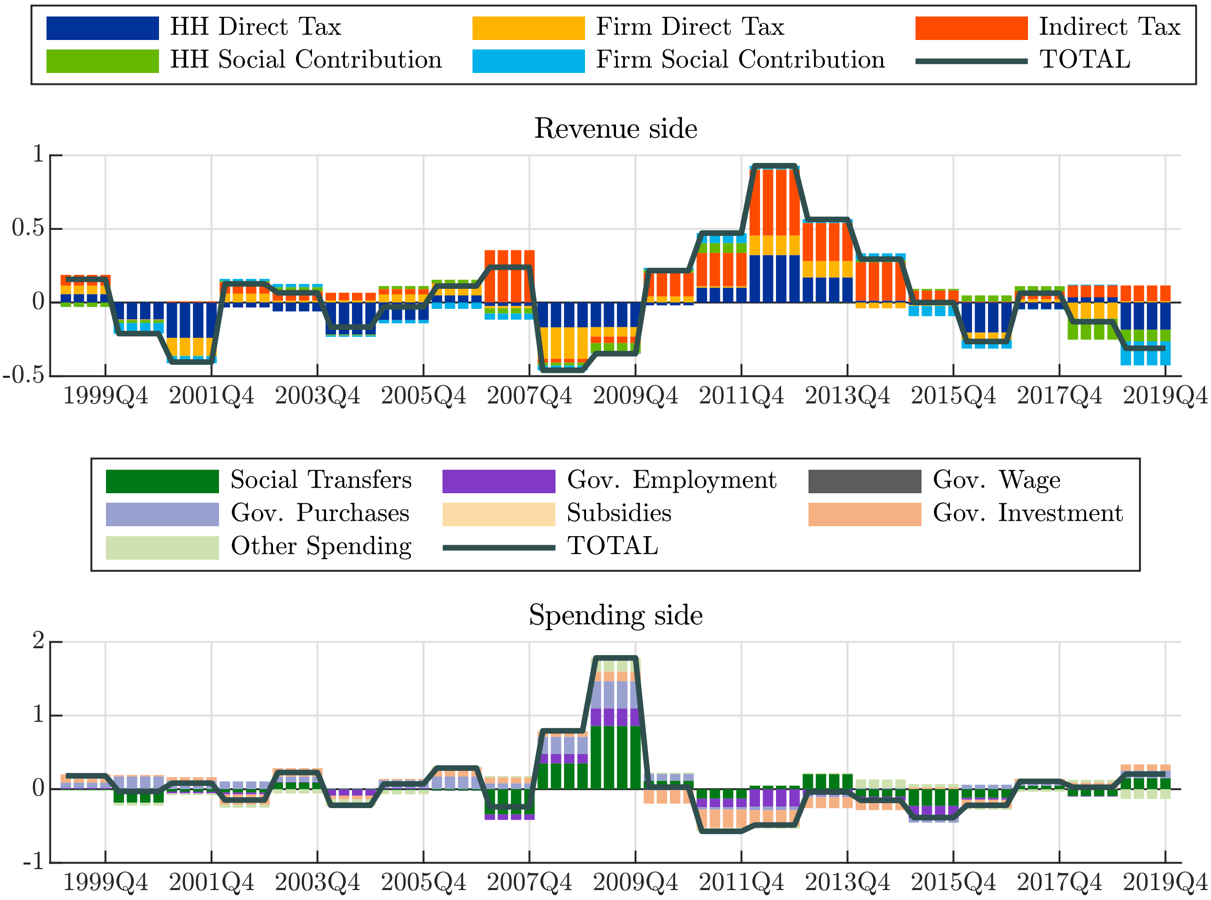
Discretionary actions by governments in the area of fiscal policy are often captured by the notion of the fiscal stance. To determine the fiscal stance, two approaches are used in practice. First, the stance can be based on the change in the cyclically adjusted budget balance, which excludes the effects of the cycle from the headline balance (*top-down approach*). Second, the fiscal stance can be derived by aggregating estimated yields of discretionary measures undertaken by a government (*bottom-up approach*). Both methodologies come with their drawbacks, and none of them is superior (see Bańkowski and Ferdinandusse (2017) for a discussion). However, one advantage of the second approach is that it allows for illustrating the contribution of single revenue and spending instruments to the overall fiscal stance and to the total macroeconomic impact of fiscal policy.

Information on both revenue and spending measures is needed to construct a complete bottom-up measure of the fiscal stance. The former is usually obtained from legislative records published by governments – narrative approach (Romer and Romer (2010) in their seminal work pioneered the use of narrative methods for fiscal policy analysis). The derivation of the latter is more challenging than the former because it is inherently difficult to decide upon what is a neutral no-policy change baseline. For the analysis conducted in this subsection, the strategy of Braz and Carnot (2019), who use a so-called '*semi-narrative*' approach, is adopted. The measure estimates on the revenue side rely on the 'narrative' dataset established within the Working Group on Public Finance at the European System of Central Banks. The spending measures, in turn, are based on deviations between the actual spending growth and the nominal potential GDP growth. The underlying idea is that a neutral fiscal stance is consistent with the economy's potential growth. Anything growing above/ below is tantamount to a discretionary fiscal expansion/ contraction.[39]

Figure 16 illustrates the fiscal stance for the euro area measured with the bottom-up approach and split into revenue and expenditure sides. The fiscal stance in the euro area varied considerably amid the GFC and in its aftermath. The loosening of 2008-10 reflects the impact of the stimulus measures, including the European Economic Recovery Plan. The plan was a coordinated initiative among EU Member States aimed at alleviating the downturn. Afterwards, a major fiscal consolidation followed in most of the euro area countries, which is visible in a tightening through both revenue and spending measures. Besides this, the movements in the fiscal stance in the euro area were significantly less pronounced. During most of the years, the fiscal stance remained in neutral territory. Nevertheless, it mirrored big policy initiatives undertaken in individual Member States in selected years (e.g. the German tax reform of 2000 incorporating a series of personal income tax reductions in the following years, the VAT rate hike in Germany in 2007, tax reforms in multiple countries undertaken in the post-consolidation phase with a view to reducing the tax wedge).

[39] Admittedly, the expenditure measures estimated through benchmarking with respect to potential growth are not genuinely bottom-up. This is because they do not use narrative information on fiscal policy actions. Nevertheless, applying the benchmarking separately to each spending category allows for disaggregation, which is instrumental for fiscal policy analysis.

Figure 16: Fiscal stance in the euro area (% of potential GDP, y-o-y change)



Sources: Dataset established within the Working Group on Public Finance and own calculations.

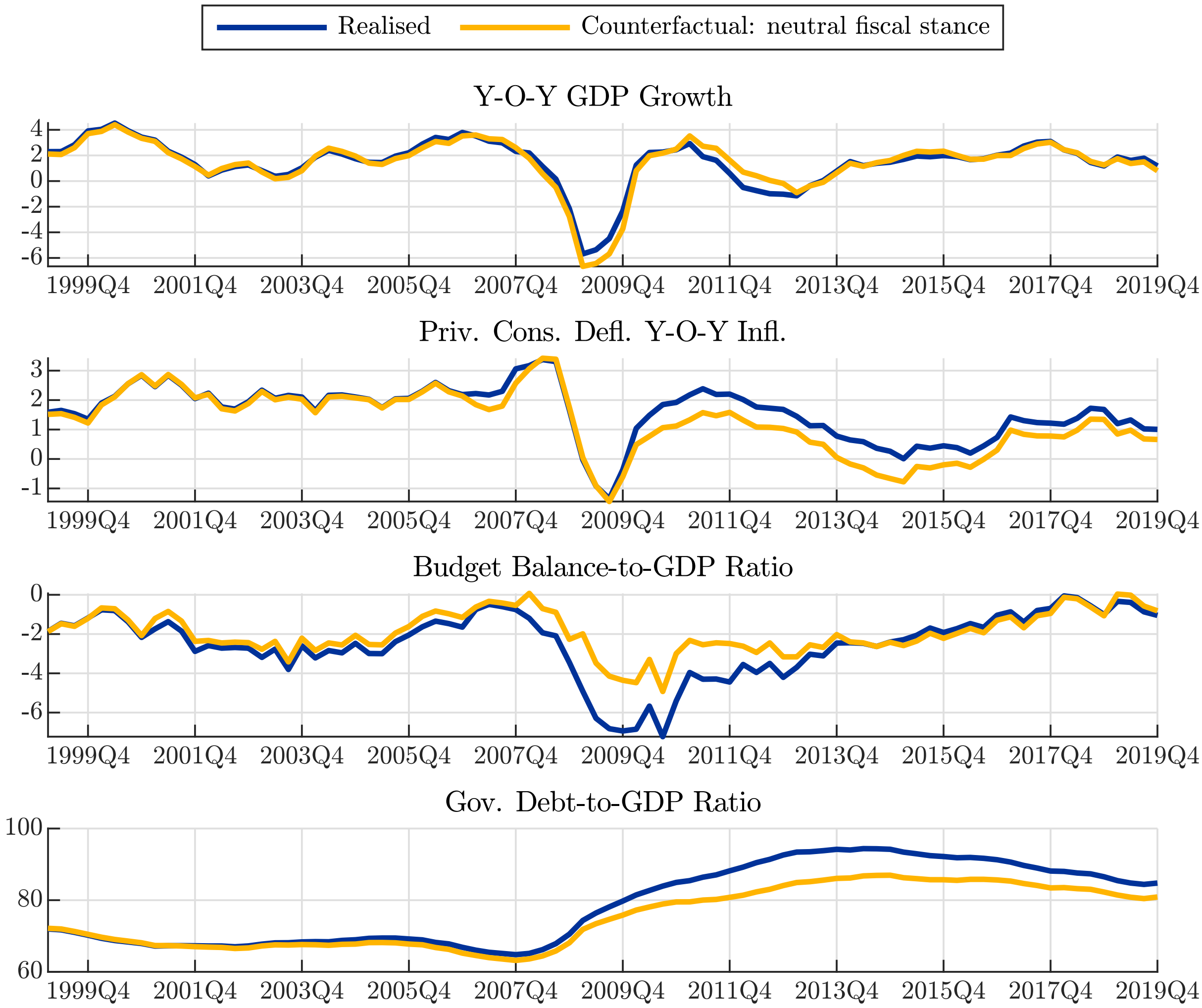
Notes: The quarterly figures for the model are obtained with a simple flat interpolation method. Positive values on the revenue side imply a fiscal tightening (e.g. tax hikes). By contrast, positive values on the spending side are associated with a fiscal loosening (e.g. increases in government outlays). The category of other revenue is omitted in the absence of relevant narrative measures. The fiscal measures within the category of government compensation are evenly attributed to government employment and average government wage.

One of the major advantages of macroeconomic models is that they enable the assessment of alternative policy configurations. This is done by means of counterfactual macroeconomic scenarios. A difference between adequately defined scenarios can be interpreted as a policy evaluation. One application of the ECB-BASE along this dimension is to analyse the above-described euro area fiscal stance and assess its macroeconomic effects. Non-zero values of the fiscal stance represent discretionary actions of governments – as per the definition of the stance. In this context, a natural counterfactual scenario for assessing the observed fiscal policy is one in which fiscal policy does not change, and the fiscal stance remains neutral (i.e. zero value). To this end, the counterfactual scenario in this subsection assumes an unchanged fiscal policy during the EMU period.

According to the model simulations, fiscal policy conducted in the euro area had important implications for the macroeconomic situation (see Figure 17).[40] Looking at the GDP growth, fiscal stimulus undertaken amid the GFC noticeably alleviated the downturn. At the same time, the post-GFC consolidation significantly aggravated the second recession in the euro area. Also, the fiscal policy provided a considerable boost to inflation dynamics in the second part of the sample, when inflation stubbornly remained below 2%. Finally, the cost of conducted fiscal policy, as measured by the headline budget balance and government debt, was significant. The stimulus undertaken during 2008-10 temporarily pushed the budget balance well below the Stability and Growth Pact reference value of -3% of GDP. Even though the excessive deficit was corrected afterwards, the excess of government debt remained largely unaddressed.

[40]The presentation period purposefully ends in 2019Q4. Considering the extraordinary values observed during the pandemic leads to an undesirable situation in which 2020-21 largely dominates the picture. Moreover, the fiscal policy conducted amid the pandemic deserves a dedicated investigation as many of the fiscal measures were non-standard (e.g. short-term working schemes to support employment were partially recorded as subsidies in the national accounts even though such measures are not related to typical subsidies affecting the cost of production).

Figure 17: Counterfactual scenario with a neutral fiscal stance (%)

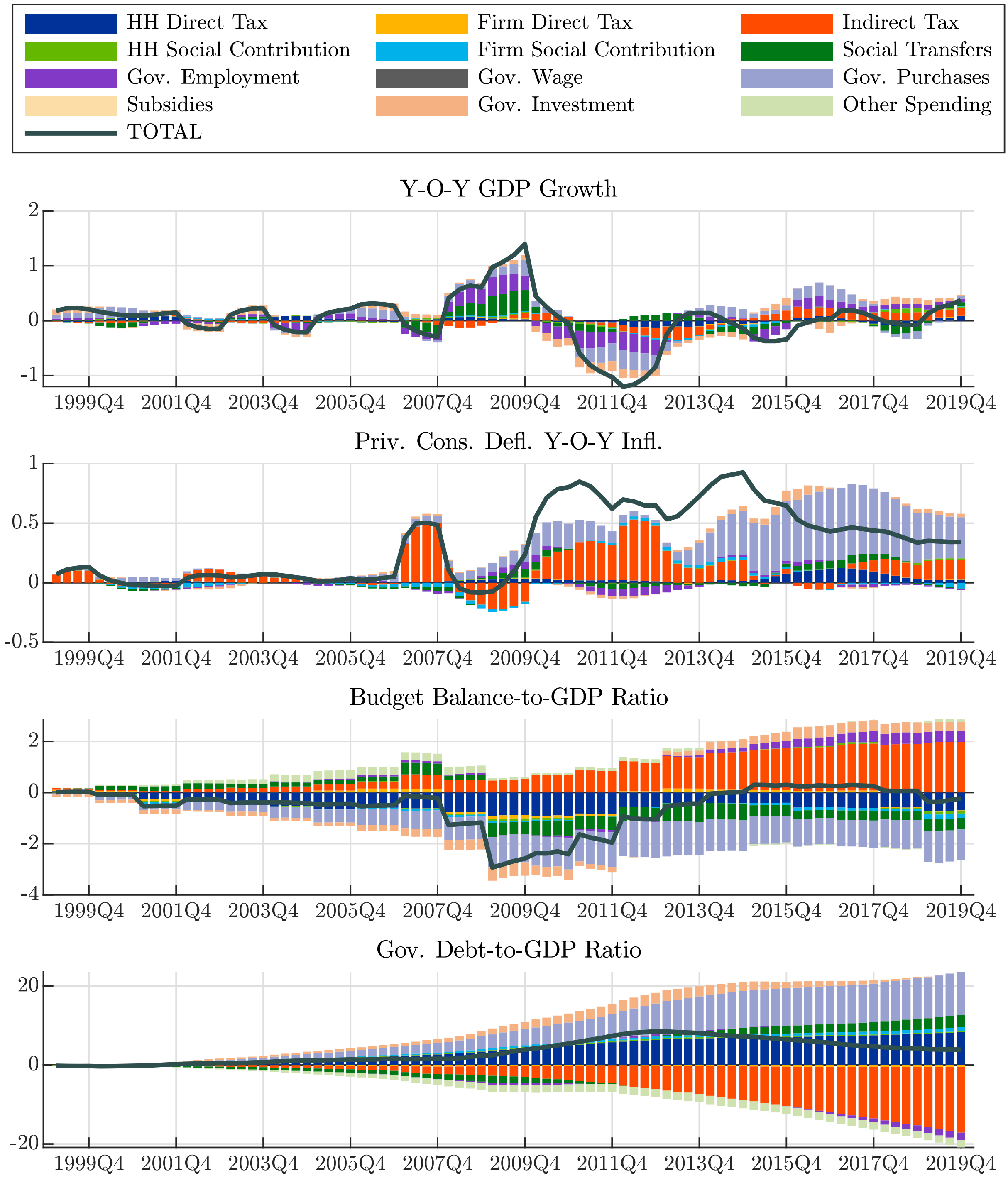


Sources: Own calculations with the ECB-BASE.

The contribution from various fiscal revenue/ spending instruments to the overall fiscal policy effects is very uneven. Fiscal policy measures have different macroeconomic effects (as demonstrated in Section 4). The ability of the ECB-BASE to distinguish between various fiscal instruments combined with the semi-bottom-up measurement of the fiscal stance allows to reveal further findings. Figure 18 aims to decompose the fiscal policy effects by assigning them to particular revenue/ spending categories. The impact of fiscal policy on growth is attributable to measures associated with relatively high values of fiscal multipliers (i.e. government purchases and investment, government employment) and to those that were large in size (i.e. social transfers). Interestingly, the inflation effect is driven by another set of measures featuring consumption taxes, which have a direct effect on prices (see Subsection 4.4 for a description of the propagation). Even when contractionary measures prevailed during the post-GFC period, fiscal policy exerted upward pressure on inflation through consumption tax hikes. This observation just demonstrates that accounting for the composition of fiscal policy is critical for understanding its overall effects. Looking at the budget balance and government debt, it is clear that various categories affected the fiscal cost drastically differently. Government purchases and social transfers, which increased steadily during the EMU period, explain a large chunk of the cost pressures. By contrast, indirect taxes, which were subject to hikes on multiple occasions, brought a significant cost-offsetting effect.[41]

[41] The potency of indirect taxes to affect fiscal cost does not only come through government revenue and budget balance. As explained in Subsection 4.4, consumption taxes significantly affect prices in the economy. Consequently, they play a big role in the evolution of the debt-to-GDP ratio, which embeds the nominal GDP in its calculation.

Figure 18: Macroeconomic effects of realised fiscal stance (%)



Sources: Own calculations with the ECB-BASE.

Notes: The contributions, expressed in percentage points, are constructed by estimating fiscal instruments one by one. The total effect is estimated by simulating all measures at once. The effects of single measures do not necessarily need to add to the total effect. This can occur for growth/ inflation rates, which involve non-linear transformations and thus are not additive.

5.3 Conditional fiscal projections

As explained in the introduction, the other main application of the ECB-BASE besides policy analysis are economic projections. The scope also covers projections of fiscal variables, which is the main topic of this subsection. While fiscal items (together with the exchange rate, oil prices, interest rates, etc.; see European Central Bank (2016) on items that constitute assumptions in ECB projections) usually act as underlying assumptions for macroeconomic projections, there are multiple cases when they constitute the main object of interest. This is, for instance, the case for projections conducted by fiscal authorities (see, for example, the updates of Stability Programmes) or any institution particularly interested in fiscal issues, like debt sustainability analysis (see, for example, Fiscal Sustainability Report 2021 of the European Commission).[42] With fiscal projections, the roles turn around, and it is the macroeconomic variables that act as assumptions. For instance, taxes are projected conditional on a given path of economic activity and prices. To this end, this subsection follows a strategy in which fiscal projections will be conditioned on the ECB/ Eurosystem macroeconomic projections.

Besides point estimates, many institutions publish nowadays confidence bands as a part of their projections (see, for instance, Office for Budget Responsibility (2021) using stochastic simulations to produce fan charts around budget deficit). Their main objective is to reflect upon macroeconomic uncertainty. The construction of confidence bands requires stochastic projections based on various shock constellations. A sufficiently large number of projections allows for devising forecast distributions, which are summarised by confidence bands. The fiscal projections presented in this subsection also feature forecast densities accounting for uncertainty and potential model misspecification.[43]

One of the key abilities to develop good forecasts (both point and density forecasts) is to explore the information contained in model residuals. Figure 19 illustrates fiscal residuals after the inversion of the model.[44] A key to extracting meaningful information from these residuals is

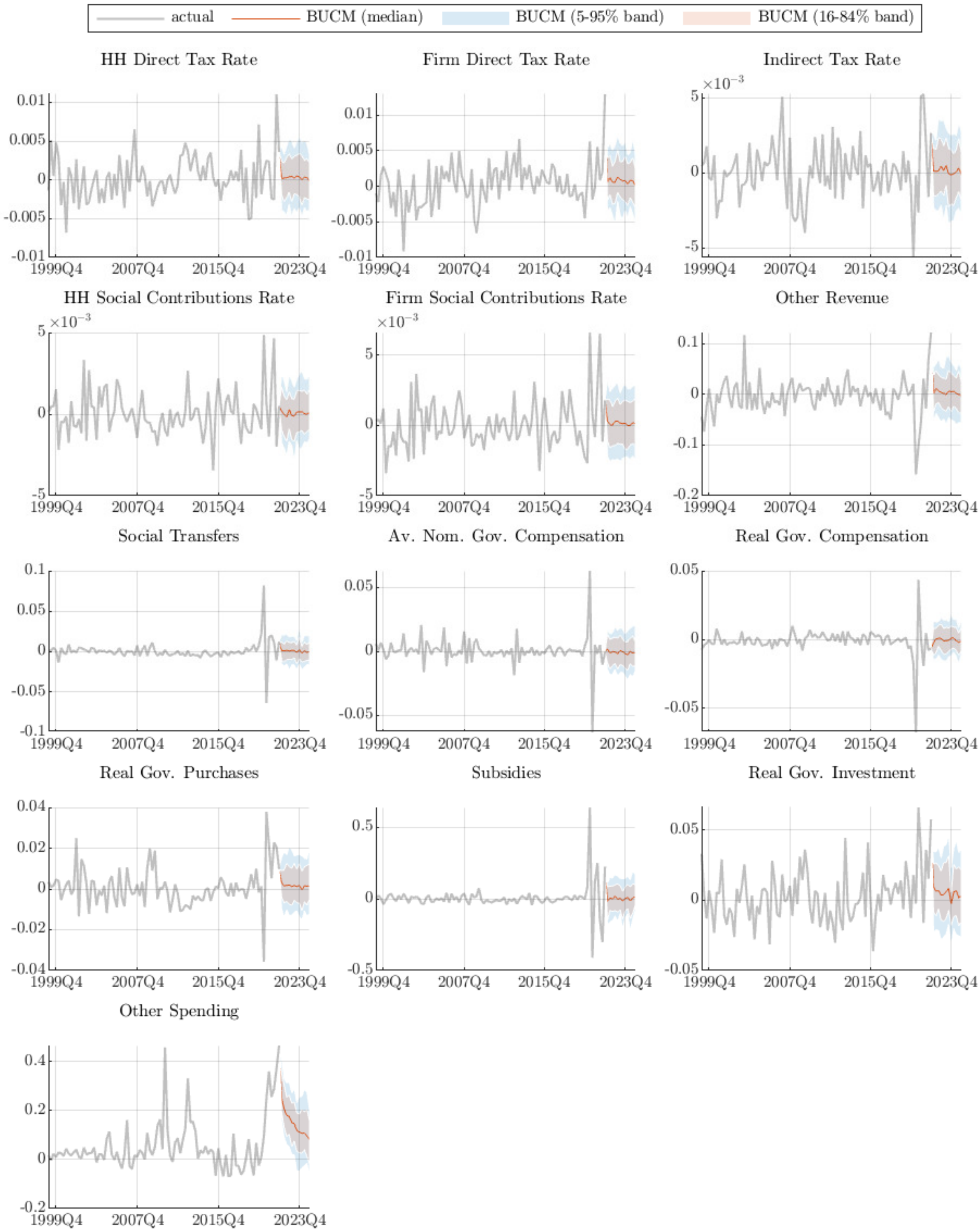
[42] The 2022 updates of Stability Programmes for the EU countries: https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/european-semester-timeline/national-reform-programmes-and-stability-or-convergence-programmes/2022-european_en; The latest Fiscal Sustainability Report of the European Commission: https://ec.europa.eu/info/publications/fiscal-sustainability-report-2021_en

[43] As explained in Angelini et al. (2019), a potential model misspecification of the ECB-BASE and its equation-by-equation estimation may give rise to auto and cross-correlation in the residuals. Methods exist that explore the information remaining in the residuals for improving forecasting performance.

[44] Given that fiscal equations are estimated, it is not surprising that the residuals are relatively well-behaved, most notably with a mean close to zero.

to retrieve a systematic component contained therein. This can be achieved using a state-space model (see Angelini et al. (2019) with the Bayesian Unobserved Component Model – BUCM – described therein) by retrieving a systematic component in the form of a distribution. The procedure enables then stochastic projections of residuals (see the bands in Figure 19), which ultimately can be used in simulations to create stochastic projections of fiscal variables. In particular, the median of the residuals can be used to obtain a central projection.

Figure 19: Stochastic projection of fiscal residuals (%)



Sources: Government Finance Statistics, Main National Accounts (for macro bases), European Commission Economic Forecast (for potential GDP) and own calculations with the Bayesian Unobserved Component Model (BUCM).

Figure 20 (see the BUCM line with the associated confidence bands) illustrates the projections with the ECB-BASE for the main fiscal variables until end-2024 – the end of the ECB projection horizon at the time of drafting the paper. The fiscal projections are conditional on the macroeconomic assumptions embedded in the ESCB Jun 2022 BMPE.[45] The projections suggest the continuation of the improvement in the budget balance as the effects of the COVID-19 crisis on public finances fade away. The main factor behind this development is the primary expenditure-to-GDP ratio declining towards the values observed before the pandemic. The projected deficits lead to a gradual reduction in the debt-to-GDP ratio, which nevertheless is projected to remain at the elevated level of above 90%. The confidence bands based on the stochastic projections suggest that a further deterioration of headline fiscal figures (i.e. budget balance and debt-to-GDP ratios) from the latest observed values (i.e. 2021Q4) is very unlikely.

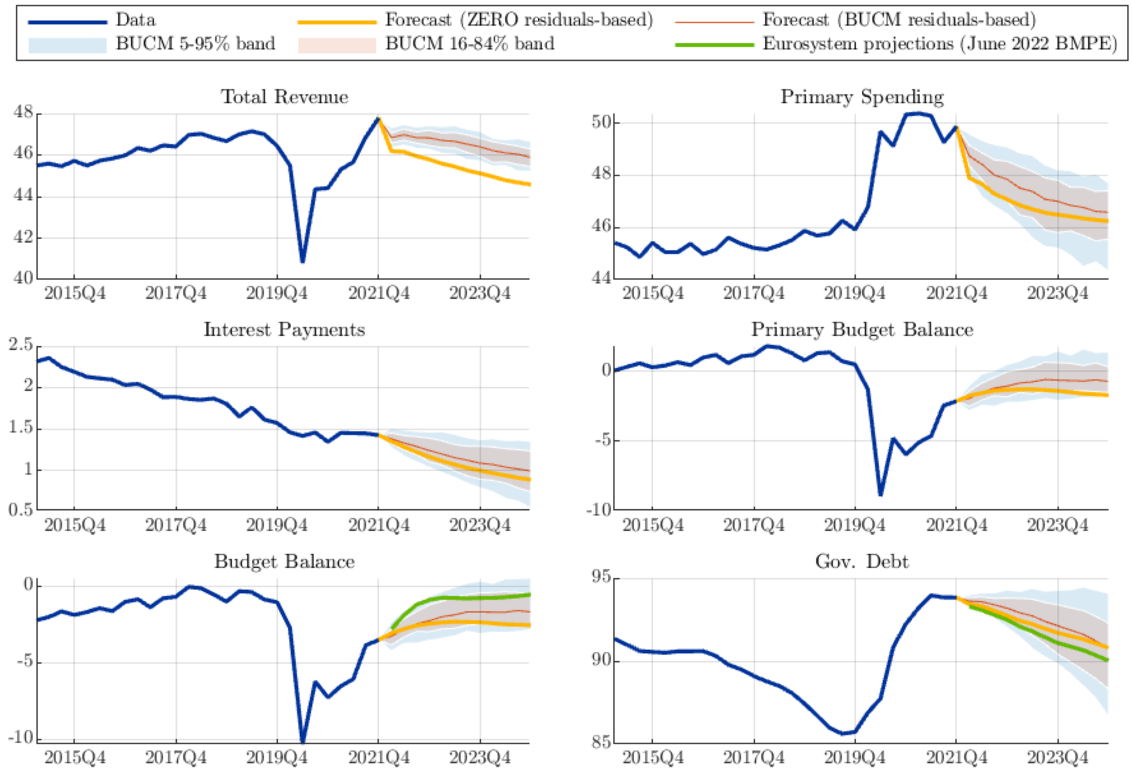
The central forecast is confronted in Figure 20 with a fiscal projection based on zero residuals and the corresponding Eurosystem projections (i.e. Jun 2022 BMPE).[46] The zero residuals-based forecast paints a more pessimistic picture than the central projection. The budget balance barely improves because the falling spending is accompanied by declining revenue. The projection is somewhat unrealistic, especially for government revenues. The projection path falls outside the confidence bands and goes below the values observed before the pandemic. This indicates that taking into account the information contained in the model residuals can turn out essential. The Eurosystem projections, by contrast, paint a more positive picture than the central model projection and indicate a pronounced improvement in the budget balance and a marked reduction in the government debt. The Eurosystem projections benefit from country expert knowledge and, as such, they ought to be the most realistic among all presented. It is somewhat reassuring that when assessed against the purely data-driven model stochastic projections, they are located within the confidence bands for most of the projected quarters.[47]

[45] See https://www.ecb.europa.eu/pub/projections/html/ecb.projections202206_eurosystemstaff~2299e41f1e.en.html for a description of the macroeconomic projections of the ESCB Jun 2022 BMPE.

[46] Only budget balance and government debt can be shown as other items do not belong to the set of variables released to the public in the context of Eurosystem/ ECB projections.

[47] Figures E.5-E.9 in the appendix provide some additional illustrations of the fiscal projections.

Figure 20: Stochastic projection of main fiscal variables (% of GDP)



Sources: Own calculations with the ECB-BASE.

Notes: Macroeconomic assumptions for the fiscal projections come from the Eurosystem projections of June 2022 BMPE. The BUCM residuals-based fiscal projections are based on median residuals.

6 Conclusions

Fiscal policy is a key macroeconomic stabilisation tool, especially when monetary policy faces a lower bound on nominal interest rates. Going forward, it will likely remain irreplaceable for tackling specific economic challenges, such as sector-specific shocks or a need for environmental transition, even when monetary authorities bring interest rates into positive territory. Given this having a macroeconomic model capable of analysing fiscal policy at the disposal of a central bank appears essential.

Embedding a well-developed fiscal block in the ECB-BASE creates an appealing tool for fiscal policy analysis. The design choice, which ensures wide coverage of fiscal variables and maintains close links to the data, offers tangible benefits. Most notably, the model obtains the capacity to simulate a broad range of fiscal shocks with distinct propagation mechanisms. Also, as demonstrated by the applications for fiscal policy analysis, the model can be used for relevant policy questions, such as the assessment of alternative fiscal rules, the evaluation of fiscal policy measures or fiscal forecasting.

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A Some auxiliary information about fiscal equations

A.1 Identities

Table A.1 presents identities featuring the fiscal block.

Table A.1: Fiscal identities in the model

Total revenue

$$go\_trn_t = go\_dtn_t + go\_tin_t + go\_scn_t + go\_rrn_t$$

Direct taxes

$$go\_dtn_t = go\_bu\_dtn_t + go\_hh\_dtn_t$$

Social contributions

$$go\_scn_t = go\_bu\_scn_t + go\_hh\_scn_t + go\_rw\_scn_t$$

Total expenditure

$$go\_toe_t = go\_ipn_t + go\_sbcn_t + go\_cen_t$$

$$+go\_pun_t + go\_sin_t + go\_itn_t + go\_ren_t$$

Interest payments

$$go\_ipn_t = \frac{1}{400} go\_r\_ipn_t \times go\_mal_{t-1}$$

Gov. compensation (nominal)

$$go\_cen_t = go\_lnn_t \times go\_c\_cen_t$$

Gov. purchases (nominal)

$$go\_pun_t = go\_pur_t \times hh\_cod_t$$

Gov. investment (nominal)

$$go\_itn_t = go\_itr_t \times go\_itd_t$$

Budget balance

$$go\_b9n_t = go\_trn_t - go\_toe_t$$

Gov. debt

$$go\_mal_t = go\_mal_{t-1} - go\_b9n_t$$

Gov. consumption (nominal)

$$go\_con_t = go\_cen_t + go\_pun_t$$

Gov. consumption (real)

$$go\_cor_t = go\_cer_t + go\_pur_t$$

Gov. consumption (deflator)

$$go\_cod_t = go\_con_t \div go\_cor_t$$

Gov. employment

$$go\_lnn_t = {}^{go\_cer_t}/_{tfplg_t}$$

Notes: The equations for direct taxes, gov. debt and gov. consumption also include a residual because they do not hold exactly in the data.

A.2 Spending in the long run

The starting point for the spending equation is the below ECM (Error Correction Model) specification, whereby the actual spending reverts to its trend. The reversion is supplemented with persistence terms and the output gap.

$\Delta \log(G_{i,t}) = \alpha^{G_i} \log\left(\frac{G_{i,t-1}}{G^T_{i,t-1}}\right) + \sum_{k=1}^{2} \beta_k^{G_i} \Delta \log(G_{i,t-k}) + \delta^{G_i} \Delta \log(G^T_{i,t}) + \gamma^{G_i} \hat{y}_t + e_t^{G_i}$

In the long run, disturbances play no role ($e^{G_i} = 0$), the output gap is closed ($\hat{y} = 0$), and spending is at its trend ($G_{i,t} = G^T_{i,t}$, which means that $\log\left(\frac{G_{i,t}}{G^T_{i,t}}\right) = 0$ for each t). Assuming in addition that the growth is independent of time t (i.e. $g_i = \Delta \log(G_{i,t})$ and $g_i^T = \Delta \log(G^T_{i,t})$), the spending equation in the long run can be simplified to the following form:

$g_i = \sum_{k=1}^{2} \beta_k^{G_i} g_i + \delta^{G_i} g_i^T$[48]

For spending to grow in line with its trend (i.e. $g_i = g_i^T$), the following relation between the coefficients must hold:

$\delta^{G_i} = 1 - \sum_{k=1}^{2} \beta_k^{G_i}$

This derivation justifies the coefficient on trend spending growth in Equation 5 in the main body of the paper.

A.3 Import content of government final demand.

One factor affecting the effectiveness of fiscal policy is the degree to which a fiscal impulse leaks abroad. In this context, the import intensity-adjusted demand (IAD_t) plays an essential role. The measure, established by Bussière et al. (2013), reflects the import intensity of different components of aggregate demand. Calculations of the measure rely on Input-Output tables, which distinguish the following ingredients of the final demand: private consumption (C_t), government consumption (G_t), total investment (I_t), and exports (X_t) with ω_i parameters being import intensity-based weights (see Equation A.1 below).

$$IAD_t = \omega_C C_t + \omega_G G_t + \omega_I I_t + \omega_X X_t \tag{A.1}$$

Since this paper breaks down government consumption and recognises government investment as a separate category, an extension of the standard import intensity-adjusted demand is needed. Consequently, the aggregate demand is disintegrated further by splitting government consumption into purchases (G_t^P) and compensation (G_t^C), as well as by dividing total investment into private (I_t^P) and public (I_t^G) investment (see Equation A.2 below).

$$IAD_t = \omega_C C_t + \omega_{G^P} G_t^P + \omega_{G^C} G_t^C + +\omega_{I^G} I_t^G + \omega_{I^P} I_t^P + \omega_X X_t \tag{A.2}$$

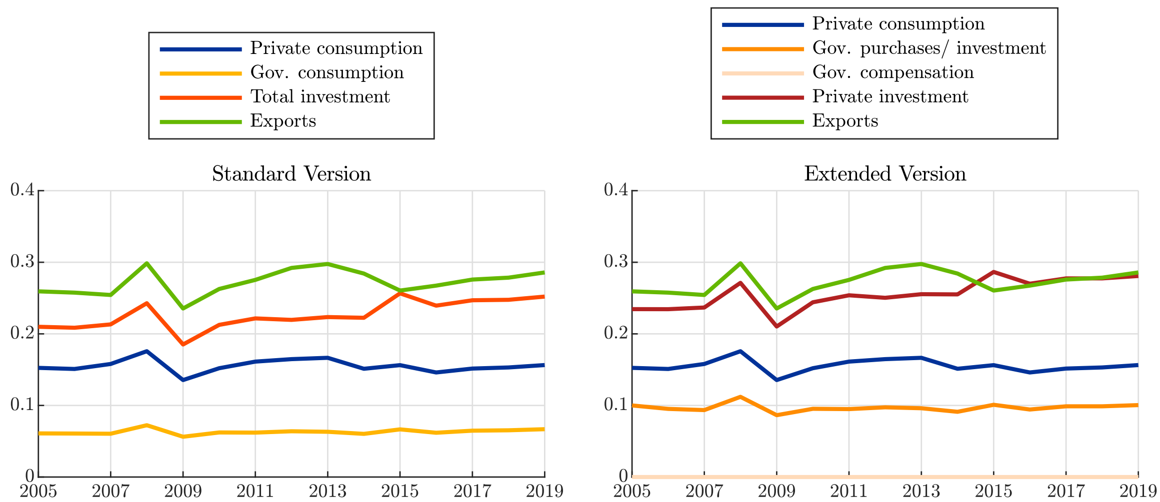
[48] For the variables that take the same value in the long run, irrespective of the period, the time index t is omitted.

As the new decomposition goes beyond what is available in the input-output data, additional assumptions are made to pin down the weights in the equation. First, it is assumed that the import content of government compensation is equal to zero. This means that only purchasing goods and services by the government involves imports but reimbursing employees does not. Second, it is also assumed that the import content of government investment is the same as one of the government purchases. In the absence of evidence that the two differ in import content, the model offers a possibility that government and private investment are distinct, which appears to be relevant. The former should have a higher import content than the latter because of a home bias, which is particularly ingrained in the public sector.[49]

The two assumptions allow for pinning down all import weights in the extended version of the equation, which is calculated over time (see Figure 2.2.2). The calculations indicate that the import content of government purchases/ investment is smaller than that associated with private demand components, consistently with the idea of a home bias in the public sector. At the same time, it is higher than the import content of the overall government consumption – as suggested by Deutsche Bundesbank (2016). Establishing this property would not be possible without extending the standard import intensity-adjusted demand equation. After inserting average values of import intensities calculated over time, the extended import intensity-adjusted (see Equation A.3) is used in the model.

$$IAD_t = 0.16C_t + 0.12G_t^P + 0.0G_t^C + +0.12I_t^G + 0.25I_t^P + 0.28X_t \tag{A.3}$$

Figure A.1: Import content of main final demand components (shares)



Sources: Own calculations based on the Eurostat's input-output tables.

[49] Corsetti and Müller (2014) provide calculations for import content of main demand components for advanced economies and conclude that the home bias associated with government spending is higher than for the private categories.

B Sources of fiscal data

Table B.2: Specification of the retrieval codes and formulas for fiscal variables

Variable name	Retrieval code/ variable calculation[50]
Non-financial accounts & gross debt	
Total revenue (GO_TRN)	GFS.Q.N.I8.W0.S13.S1.P.C.OTR._Z._Z._Z.XDC._Z.S.V.N._T
Direct taxes (GO_DTN)	GFS.Q.N.I8.W0.S13.S1.N.C.D5._Z._Z._Z.XDC._Z.S.V.N._T
o/w by firms (GO_BU_DTN)	QSA.Q.N.I8.W0.S11.S1.N.D.D5._Z._Z._Z.XDC._T.S.V.N._T + QSA.Q.N.I8.W0.S12.S1.N.D.D5._Z._Z._Z.XDC._T.S.V.N._T
o/w by households (GO_HH_DTN)	QSA.Q.N.I8.W0.S1M.S1.N.D.D5._Z._Z._Z.XDC._T.S.V.N._T
Indirect taxes (GO_TIN)	GFS.Q.N.I8.W0.S13.S1.N.C.D2._Z._Z._Z.XDC._Z.S.V.N._T
Social contributions (GO_SCN)	GFS.Q.N.I8.W0.S13.S1.N.C.D61._Z._Z._Z.XDC._Z.S.V.N._T
o/w by firms[51] (GO_BU_SCN)	GFS.A.N.I8.W0.S13.S1.N.C.D611._Z._Z._Z.XDC._Z.S.V.N._T
o/w by households (GO_HH_SCN)	GFS.A.N.I8.W0.S13.S1.N.C.D613._Z._Z._Z.XDC._Z.S.V.N._T
o/w imputed (GO_RW_SCN)	derived: GO_SCN - GO_BU_SCN - GO_HH_SCN
Other revenue (GO_RRN)	derived as a residual
Total expenditure (GO_TOE)	GFS.Q.N.I8.W0.S13.S1.P.D.OTE._Z._Z._T.XDC._Z.S.V.N._T
Interest payments (GO_IPN)	GFS.Q.N.I8.W0.S13.S1.C.D.D41._Z._Z._T.XDC._Z.S.V.N._T
Social benefits (GO_SBCN)	GFS.Q.N.I8.W0.S13.S1.N.D.D62._Z._Z._T.XDC._Z.S.V.N._T
Gov. compensation (GO_CEN)	GFS.Q.N.I8.W0.S13.S1.N.D.D1._Z._Z._T.XDC._Z.S.V.N._T
Gov. purchases (GO_PUN)	GFS.Q.N.I8.W0.S13.S1.N.D.P2._Z._Z._T.XDC._Z.S.V.N._T + GFS.Q.N.I8.W0.S13.S1.N.D.D632._Z._Z._T.XDC._Z.S.V.N._T
Subsidies (GO_SIN)	GFS.Q.N.I8.W0.S13.S1.N.D.D3._Z._Z._T.XDC._Z.S.V.N._T
Gov. investment (nominal) (GO_ITN)	GFS.Q.N.I8.W0.S13.S1.N.D.P51G._Z._Z._T.XDC._Z.S.V.N._T
Other expenditure (GO_REN)	derived as a residual
Budget balance (GO_B9N)	GFS.Q.N.I8.W0.S13.S1._Z.B.B9._Z._Z._Z.XDC._Z.S.V.N._T
Gov. debt (GO_MAL)	GFS.Q.N.I8.W0.S13.S1.C.L.LE.GD.T._Z.XDC._T.F.V.N._T
Gov. final demand	
Gov. consumption (nominal) (GO_CON)	MNA.Q.N.I8.W0.S13.S1.D.P3._Z._Z._T.XDC.V.N

[50] The codes can be used to retrieve data for the specified variables from the ECB's Statistical Data Warehouse (https://sdw.ecb.europa.eu). All series used in the context of the ECB-BASE are seasonally adjusted.
[51] The breakdown categories of social contributions are interpolated because their availability is limited to the annual frequency.

Table B.2 – continued from previous page

Gov. consumption (real) (GO_COR)	MNA.Q.N.I8.W0.S13.S1.D.P3._Z._Z._T.XDC.LR.N
Gov. compensation (real) (GO_CER)	derived[52]
Gov. purchases (real) (GO_PUR)	derived: GO_PUN / HH_COD[53]
Gov. investment (real) (GO_ITR)	based on the data collected within the Eurosystem
Gov. consumption (deflator) (GO_COD)	derived: GO_CON / GO_COR
Gov. investment (deflator) (GO_ITD)	derived: GO_ITN / GO_ITR
Gov. labour	
Gov. employment (GO_LNN)	based on the data collected within the Eurosystem
Gov. average compensation (GO_C_CEN)	derived: GO_CEN / GO_LNN
Gov. productivity (TFPLG)	derived: GO_CER / GO_LNN

C Selective description of non-fiscal parts of the model

This section of the appendix describes selected non-fiscal parts of the model that are relevant for the propagation of fiscal shocks. In this context, this part of the appendix constitutes a supplement to Section 4 of the main body of the paper discussing the effects of fiscal shocks in the model.

C.1 Private consumption and fiscal shocks affecting disposable income

Fiscal policy instruments affecting the disposable income of households have a meaningful effect on output and consumption (as illustrated in Figure 6). The definition of the disposable in the model is consistent with ESA 2010, particularly with the construction of *Distribution and use of income accounts* (see Table C.3). In addition and for modelling purposes, the disposable income of households in the ECB-BASE is split into three categories depending on its source (see Table C.4 for illustration). These are disposable income from labour (based on the mixed income and compensation of employees), disposable income from transfers (based on social benefits) and disposable property income (based on gross operating surplus and property income). All three types of disposable income are calculated by subtracting applicable direct taxes and net social security contributions paid on the corresponding sources of income (see Figure C.2 for shares associated with various types of income in the direct tax and SSC collection).

[52] The variable can be calculated given the availability of real gov. consumption and purchases.
[53] Government purchases are deflated with the private consumption deflator.

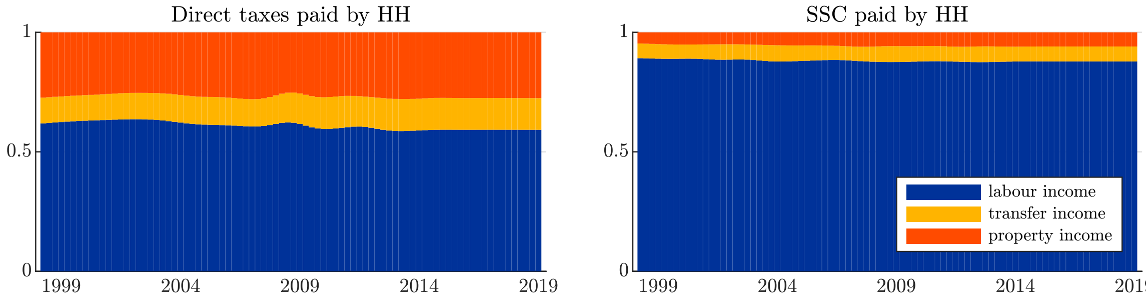
Table C.3: Underlying series of nominal gross disposable income

Item	Model code	SDW code
Gross operating surplus	HH_GOS	QSA.Q.N.I8.W0.S1M.S1._Z.B.B2A3G._Z._Z._Z.XDC._T.S.V.N._T -QSA.Q.N.I8.W0.S1M.S1._Z.B.B3G._Z._Z._Z.XDC._T.S.V.N._T
Mixed income	MIN	QSA.Q.N.I8.W0.S1M.S1._Z.B.B3G._Z._Z._Z.XDC._T.S.V.N._T
Compensation of employees	W0_CEN	QSA.Q.N.I8.W0.S1M.S1.N.C.D1._Z._Z._Z.XDC._T.S.V.N._T
Property income (net)		
interest income (net)	HH_B_IRN	QSA.Q.N.I8.W0.S1M.S1.N.C.D41._Z._Z._Z.XDC._T.S.V.N._T -QSA.Q.N.I8.W0.S1M.S1.N.D.D41._Z._Z._Z.XDC._T.S.V.N._T
distributed income (receiv.)	HH_C_DDN	QSA.Q.N.I8.W0.S1M.S1.N.C.D42._Z._Z._Z.XDC._T.S.V.N._T
other	HH_B_OPPN (1)	QSA.Q.N.I8.W0.S1M.S1.N.C.D4N._Z._Z._Z.XDC._T.S.V.N._T -QSA.Q.N.I8.W0.S1M.S1.N.D.D4N._Z._Z._Z.XDC._T.S.V.N._T -QSA.Q.N.I8.W0.S1M.S1.N.C.D42._Z._Z._Z.XDC._T.S.V.N._T
Direct taxes (payable)	HH_DTN	QSA.Q.N.I8.W0.S1M.S1.N.D.D5._Z._Z._Z.XDC._T.S.V.N._T
Net SSC (net)	HH_B_SCN	QSA.Q.N.I8.W0.S1M.S1.N.D.D61._Z._Z._Z.XDC._T.S.V.N._T -QSA.Q.N.I8.W0.S1M.S1.N.C.D61._Z._Z._Z.XDC._T.S.V.N._T
Social benefits (net)	HH_B_SBN	QSA.Q.N.I8.W0.S1M.S1.N.D.D62._Z._Z._Z.XDC._T.S.V.N._T -QSA.Q.N.I8.W0.S1M.S1.N.C.D62._Z._Z._Z.XDC._T.S.V.N._T
Other current transfers (net)	HH_B_OPPN (2)	QSA.Q.N.I8.W0.S1M.S1.N.C.D7._Z._Z._Z.XDC._T.S.V.N._T -QSA.Q.N.I8.W0.S1M.S1.N.D.D7._Z._Z._Z.XDC._T.S.V.N._T
Gross disposable income	HH_DIN	QSA.Q.N.I8.W0.S1M.S1._Z.B.B6G._Z._Z._Z.XDC._T.S.V.N._T

Table C.4: Sources of nominal gross disposable income

Labour	Transfers	Property
-	-	Gross operating surplus
Mixed income	-	-
Compensation of employees	-	-
-	-	Property income (net)
Direct taxes (payable, on labour)	Direct taxes (payable, on transfers)	Direct taxes (payable, on property)
Net SSC (on labour)	Net SSC (from transfers)	Net SSC (from property)
-	Social benefits (net)	-
-	-	Other current transfers (net)
Gross disposable income (from labour)	**Gross disposable income (from transfers)**	**Gross disposable income (from property)**

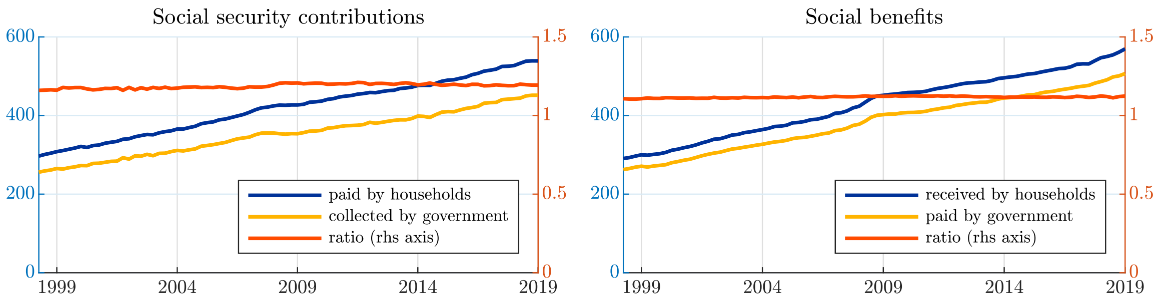
Figure C.2: Direct taxes and social contributions paid on various sources of income (shares)



Sources: Own calculations based on Government Finance Statistics and "Taxation trends in the European Union" reports of the European Commission.

For direct taxes paid by households, the link between collections and payments is very tight. The reason is that they all taxes paid by households are collected only by the government. In this context, the variable of the fiscal block can directly enter the calculation of the disposable income. For households social contributions and social benefits the exact relation between collections and payments does not hold. This is because not all social security contributions paid by households are collected by the government, as some go to private social security funds. By the same token, not all social benefits received by households come from the government (see Figure C.3 for the magnitude of the differences). In this context, both variables used in the calculation of the disposable income are bigger than those present in the fiscal block by the amounts collected/ paid out by the private funds. Still, the amounts involving the government explain a bulk of the overall flows. Moreover, the ratio between the two is stable, and it is the government that sets up the rules on pension contributions/ benefits. Against this background, the dynamics of social contributions and social benefits affecting households are linked in the model to the corresponding variables in the fiscal block through growth rates.

Figure C.3: Collection and payments of social contributions/ benefits (EUR billions)



Sources: Quarterly Sectoral Accounts and Government Finance Statistics.

The definition of disposable income, together with its role in the determination of private consumption, is fundamentally important for the effects of fiscal instruments in the ECB-BASE. The consumption of households in the model is based on the following PAC specification (see

Equation C.4). Its dynamics are driven by both optimising households and hand-to-mouth households. The former, which account for $1-\theta$ of all households, optimise their utility subject to the budget constraint. The latter, on the other hand, which comprises θ share, base their consumption on current after-tax income (see the Appendix of Angelini et al. (2019) for a detailed exposition).

$$\Delta c_t = (1-\theta)\left(a_0\left(c^*_{t-1}-c_{t-1}\right)+\sum_{i=1}^{m-1}a_i\Delta c_{t-i}+\beta_1 x_t+\mathbb{E}_{t-1}\sum_{j=0}^{\infty}d_j\Delta c^*_{t+j}\right)+\theta\Delta\left(yh^L_t+yh^T_t\right)+\epsilon^c_t \tag{C.4}$$

In any event, fiscal policy affects the consumption of households through the formation of disposable income. This, however, occurs differently for the two types of households. For hand-to-mouth households, the effect is direct through *current* disposable income, which drives, in turn, their actual consumption. For optimising households, on the other hand, the effect is indirect as it takes place through *permanent* disposable income, which only then affects the consumption target c^*_t.

In the case of hand-to-mouth households, two types of disposable income matter: the current disposable income from labour yh^L_t and current disposable income from transfers yh^T_t (see Equation C.4). The growth of both together directly shapes the growth of consumption of these households, with the contribution to the overall consumption governed by the share θ. In the case of optimising households, three types of income matter instead: the expected permanent income from labour eyh^L_t, expected permanent income from transfers eyh^T_t and expected permanent property income ey^P_t. All of them, together with financial and housing wealth, form the basis for consumption target c^*_t of optimising households (see Equation C.5) without affecting current consumption directly.[54] As permanent income variables are unobserved, they are calculated based on expected gaps using a VAR set-up.[55] Only income gaps, in turn, are a function of current disposable income. Consequently, the propagation of fiscal shocks into consumption of the 'optimisers' is not imminent.

$$c^*_t = \eta_0 + \eta_L eyh^L_t + \eta_T eyh^T_t + \eta_P ey^P_t + \eta_D hw^D_t \tag{C.5}$$

[54] η_L, η_T, η_P and η_D are weights on particular components, and they sum up by construction to unity (i.e. $\eta_L+\eta_T+\eta_P+\eta_D=1$).

[55] The expression of permanent K-type of income $Y^P_{k,t}$ takes the following form: $Y^P_{K,t} \approx \bar{\Omega}_t\bar{\Omega}^K_t\bar{X}_t\exp\left(\left(1-\tilde{\beta}\right)\mathbb{E}_t\sum_{i=0}^{\infty}\tilde{\beta}^i\left(\tilde{\Omega}_{t+i}+\tilde{\Omega}^K_{t+i}+\tilde{X}_{t+i}\right)\right)$, where the infinite sum of expected gap variables is calculated with a VAR setting (see B.1 subsection of the Appendix in Angelini et al. (2019) for the complete exposition).

C.2 Business investment and corporate tax rate

Business investment, similarly to private consumption, is modelled using the PAC approach in accordance with Equation C.6 (see a complete description in Angelini et al. (2019)). Besides some agents who base their investment on recent cash flows (represented by the additive term $\theta^{ib}\Delta y_{t-1}$), agents tend to adjust their investment towards the target value ib_t^*. The convergence to the target takes place over time and involves frictions, according to the PAC specification.

$$\Delta ib_t = \left(1-\theta^{ib}\right)\left(a_0^{ib}\left(ib_{t-1}^* - ib_{t-1}\right) + \sum_{k=1}^{m-1} a_k^{ib}\Delta ib_{t-k} + \sum_{j=0}^{\infty} d_j^{ib}\Delta ib_{t+j}^*\right) + \theta^{ib}\Delta y_{t-1} + \epsilon_t^{ib} \quad \text{(C.6)}$$

The target value of business investment is determined by forward-looking firms in line with the standard neoclassical investment theory by Jorgenson (1967). In this context, business investment target IB_t^* positively depends on the growth rate of the target capital stock G_{t+1}^{K*}, the depreciation rate $\grave{\delta}$, the capital-to-output share s_t^K, and the output Y_t (see Equation C.7). Moreover, it is inversely related to the user cost of capital u_t, which plays a key role in linking investment with the corporate tax rate.

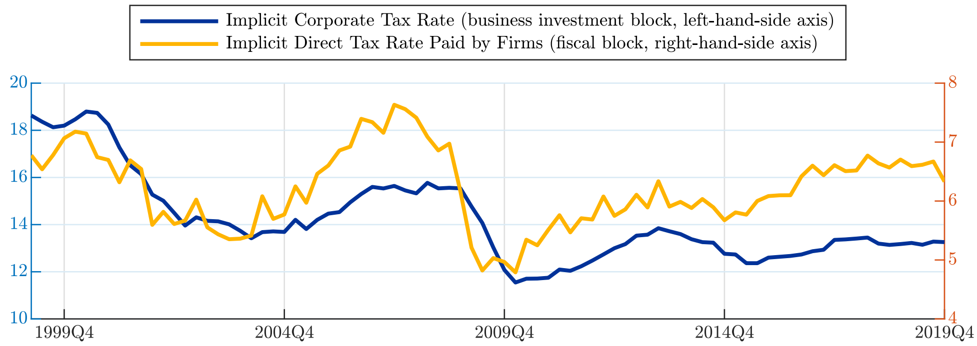
$$IB_t^* = \left(G_{t+1}^{K*} + \delta\right)\frac{s_t^K Y_t}{u_t} \quad \text{(C.7)}$$

The corporate tax rate, entering the user cost of capital (see Equation C.8 with a formal derivation following), is calculated as an implicit rate of direct taxes paid by both financial and non-financial firms with respect to gross entrepreneurial income adjusted for consumption of fixed capital. The rate during the sample is around 15% with a visible downward trend (see Figure C.4). The corporate tax rate influencing business investment is linked to the firm direct tax rate of śthe fiscal block. The two rates differ, particularly in terms of level, but they are strongly correlated (see Figure C.4).[56] When the tax rate increases, the user cost of capital rises, thereby having a dampening effect on the target value of investment.

$$RP_t\left[1 + R_{t+1} - (1-\delta) - (1-\delta)\left[\frac{RP_{t+1} - RP_t}{RP_t}\right]\right]\frac{1}{1-\tau_t^c} \equiv u_{t+1} \quad \text{(C.8)}$$

[56] The main difference between the two tax rates is that the calculation of the rate from the business investment block excludes the consumption of fixed capital from the base, which reduces the denominator. In the fiscal block, the tax rate is derived by dividing by the overall gross operating surplus and mixed income (see Subsection 3.1 describing the fiscal data).

Figure C.4: Corporate tax rates in the model (%)



Sources: Quarterly Sectoral Accounts.

User cost of capital derivation

The profit maximisation problem of a firm is given by:

$$\max_{\{K_{t+1},I_t\}} \sum_{j=0}^{\infty} \left(\frac{1}{1+R_{t+j}}\right)^j \{(1-\tau^c_{t+j})Y_{t+j} - (1-\tau^c_{t+j})W_{t+j}N_{t+j} - RP_{t+j}I_{t+j}\}$$

subject to capital accumulation equation $K_{t+j} = (1-\delta)\,K_{t+j-1} + I_{t+j-1}$ and the production function $Y_t = F\,(N_t, K_t)$.[57] Let λ_t denote the Lagrangian multiplier on the evolution of capital so that the maximisation problem can be written as:

$$L = \max_{\{K_{t+1},I_t\}} \sum_{j=0}^{\infty} \left(\frac{1}{1+R_{t+j}}\right)^j [(1-\tau^c_{t+j})F\,(N_{t+j}, K_{t+j}) - (1-\tau^c_{t+j})W_{t+j}N_{t+j} - RP_{t+j}I_{t+j}$$

$$+\lambda_{t+j}\,((1-\delta)\,K_{t+j} + I_{t+j} - K_{t+1+j})]$$

Subsequently, the two following FOCs (with respect to K_{t+1} and I_t) can be derived.

$$\frac{\partial L}{\partial K_{t+1}} = \underbrace{-\lambda_t}_{j=0} + \underbrace{\left(\frac{1}{1+R_{t+1}}\right)\left[\frac{\partial F\,(N_{t+1}, K_{t+1})}{\partial K_{t+1}}(1-\tau^c_{t+1}) + \lambda_{t+1}\,(1-\delta)\right]}_{j=1} = 0$$

$$\frac{\partial L}{\partial I_t} = -RP_t + \lambda_t = 0$$

[57]The below derivation of the user cost of capital is an extension of the presentation in Angelini et al. (2019) with a corporate tax rate. It also follows the illustration of Bond and Xing (2015), which defines the profit in the maximisation problem by $\{(1-\tau_t)Y_t - (1-\tau_t)W_tN_t - (1-\tau_t\phi_t)RP_tI_t\}$ where ϕ_t denotes a fraction of a unit of investment spending that can be deducted from taxable profits in the same year. This can also be seen through an alternative formulation: $\underbrace{Y_t - W_tN_t - RP_tI_t}_{overall-profits} - \tau_t \underbrace{(Y - W_tN_t - \phi_tRP_tI_t)}_{taxable-profits}$. The ECB-BASE features a special case of this framework whereby $\phi_t = 0$ and profits can be written as $\{(1-\tau_t)Y_t - (1-\tau_t)W_tN_t - RP_tI_t\}$. The items added as an extension are highlighted in red in the derivation.

The FOCs, after some re-arranging, yield the following results:

$$\left(\frac{1}{1+R_{t+1}}\right)\left[\frac{\partial F\left(N_{t+1},K_{t+1}\right)}{\partial K_{t+1}}(1-\tau^c_{t+1})+\lambda_{t+1}\left(1-\delta\right)\right]=\lambda_t$$

$$\frac{\partial F\left(N_{t+1},K_{t+1}\right)}{\partial K_{t+1}}(1-\tau^c_{t+1})+\underbrace{\lambda_{t+1}}_{=RP_{t+1}}\left(1-\delta\right)-\left(1+R_{t+1}\right)\underbrace{\lambda_t}_{=RP_t}=0$$

$$\frac{\partial F\left(N_{t+1},K_{t+1}\right)}{\partial K_{t+1}}=\frac{RP_t}{(1-\tau^c_{t+1})}\left[\left(1+R_{t+1}\right)-\frac{RP_{t+1}}{RP_t}\left(1-\delta\right)\right]$$

$$\frac{\partial F\left(N_{t+1},K_{t+1}\right)}{\partial K_{t+1}}=\frac{RP_t}{(1-\tau^c_{t+1})}\left[\left(1+R_{t+1}\right)-\left(1-\delta\right)\frac{RP_{t+1}}{RP_t}+\left(1-\delta\right)\frac{RP_t}{RP_t}-\left(1-\delta\right)\frac{RP_t}{RP_t}\right]$$

$$\frac{\partial F\left(N_{t+1},K_{t+1}\right)}{\partial K_{t+1}}=\frac{RP_t}{(1-\tau^c_{t+1})}\left[\left(1+R_{t+1}\right)-\left(1-\delta\right)-\left(1-\delta\right)\left[\frac{RP_{t+1}-RP_t}{RP_t}\right]\right]$$

Given the Cobb-Douglas production function in the model $\left(Y_{t+1}=A_{t+1}\left(\zeta^{t+1}N_{t+1}\right)^{\alpha}\left(K_{t+1}\right)^{(1-\alpha)}\right)$, which is characterised by $\frac{\partial F(N_{t+1},K_{t+1})}{\partial K_{t+1}}=\left(1-\alpha\right)\frac{1}{K_{t+1}}\underbrace{A_{t+1}\left(\zeta^{t+1}N_{t+1}\right)^{\alpha}\left(K_{t+1}\right)^{(1-\alpha)}}_{Y_{t+1}}$, the above equation can be written as below, where $u_{t+1}$is *the real user cost of capital.*

$$\left(1-\alpha\right)\frac{Y_{t+1}}{K_{t+1}}=\frac{RP_t}{(1-\tau^c_{t+1})}\left[\left(1+R_{t+1}\right)-\left(1-\delta\right)-\left(1-\delta\right)\left[\frac{RP_{t+1}-RP_t}{RP_t}\right]\right]\equiv u_{t+1}$$

$$\left(1-\alpha\right)\frac{Y_{t+1}}{K_{t+1}}=\frac{RP_t}{(1-\tau^c_{t+1})}\left[R_{t+1}+\delta-\left(1-\delta\right)\left[\frac{RP_{t+1}-RP_t}{RP_t}\right]\right]\equiv u_{t+1}$$

D Additional results for fiscal shocks evaluation

Table D.5: Effects of fiscal shocks on output and inflation (fiscal multipliers) under non-responsive monetary policy

Output	Y1	Y2	Y3	Y4
HH Direct Tax	0.30	0.39	0.47	0.60
Firm Direct Tax	0.03	0.14	0.23	0.30
HH Social Contribution	0.45	0.55	0.66	0.84
Firm Social Contribution	-0.03	0.01	0.07	0.14
Consumption Tax	-0.07	-0.16	-0.11	-0.07
Other Revenue	-0.00	-0.00	-0.00	-0.00
Social Transfers	0.46	0.56	0.67	0.85
Gov. Purchases	1.16	1.27	1.32	1.49
Subsidies	-0.07	-0.16	-0.11	-0.07
Gov. Employment	1.64	1.68	1.65	1.82
Gov. Wage	0.25	0.22	0.19	0.18
Gov. Investment	1.01	1.19	1.32	1.56
Other Spending	0.00	0.00	0.00	0.00

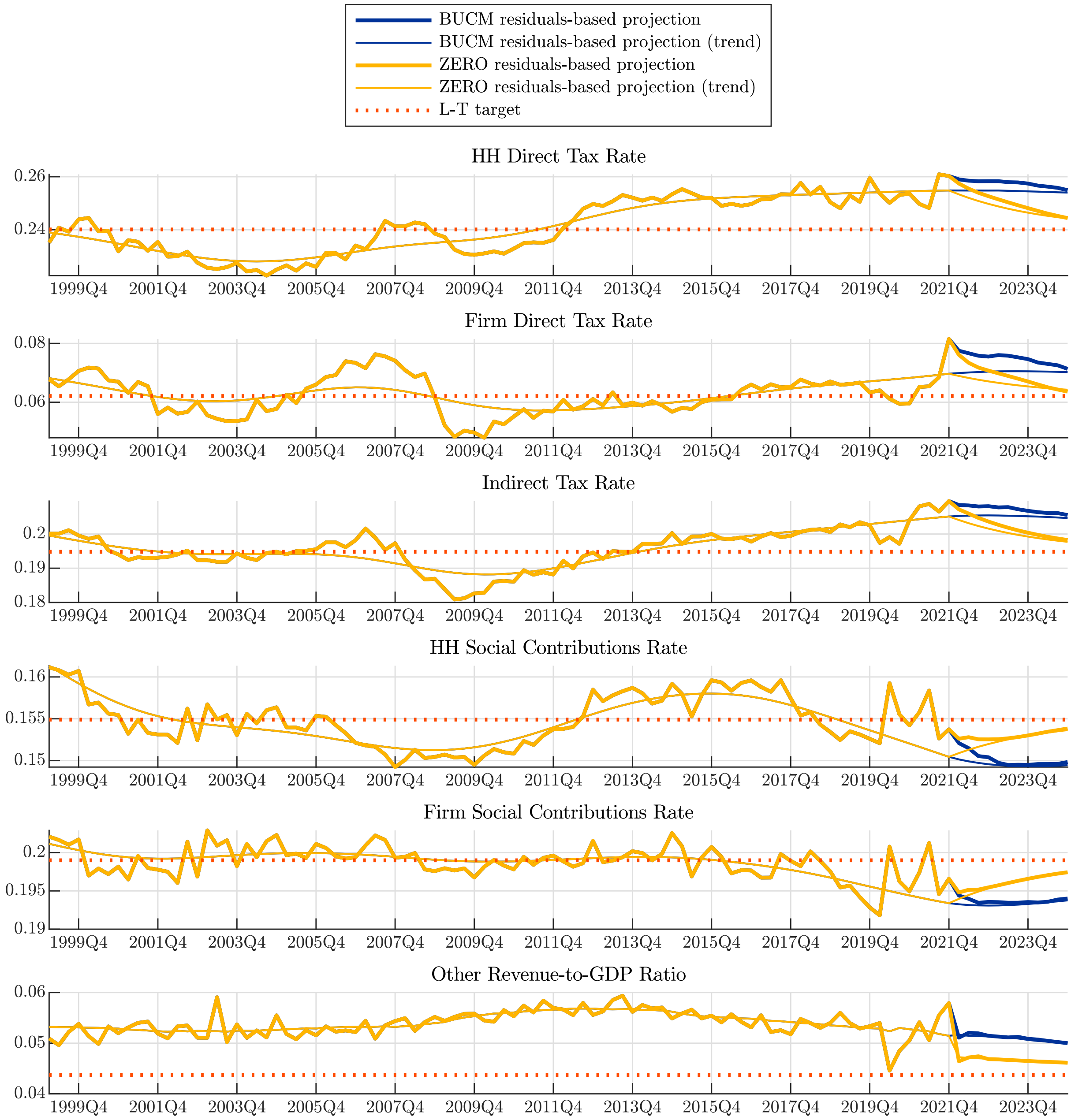
Private Cons. Deflator Y-O-Y Inflation	Y1	Y2	Y3	Y4
HH Direct Tax	0.04	0.11	0.14	0.18
Firm Direct Tax	0.00	0.02	0.04	0.06
HH Social Contribution	0.06	0.16	0.20	0.25
Firm Social Contribution	-0.19	-0.44	-0.40	-0.29
Consumption Tax	-1.24	-0.31	-0.04	0.03
Other Revenue	-0.00	-0.00	-0.00	-0.00
Social Transfers	0.06	0.16	0.20	0.26
Gov. Purchases	0.15	0.38	0.44	0.49
Subsidies	-1.24	-0.31	-0.04	0.03
Gov. Employment	0.19	0.53	0.61	0.66
Gov. Wage	0.21	0.50	0.46	0.37
Gov. Investment	0.10	0.27	0.30	0.33
Other Spending	0.00	0.00	0.00	0.00

Sources: Own calculations with the ECB-BASE.

Notes: The figures summarise percentage deviations in the case of output and absolute deviations in percentage points for inflation from the balanced growth path in response to a permanent fiscal expansion amounting to 1% of GDP ex-ante.

E Additional results for fiscal projections

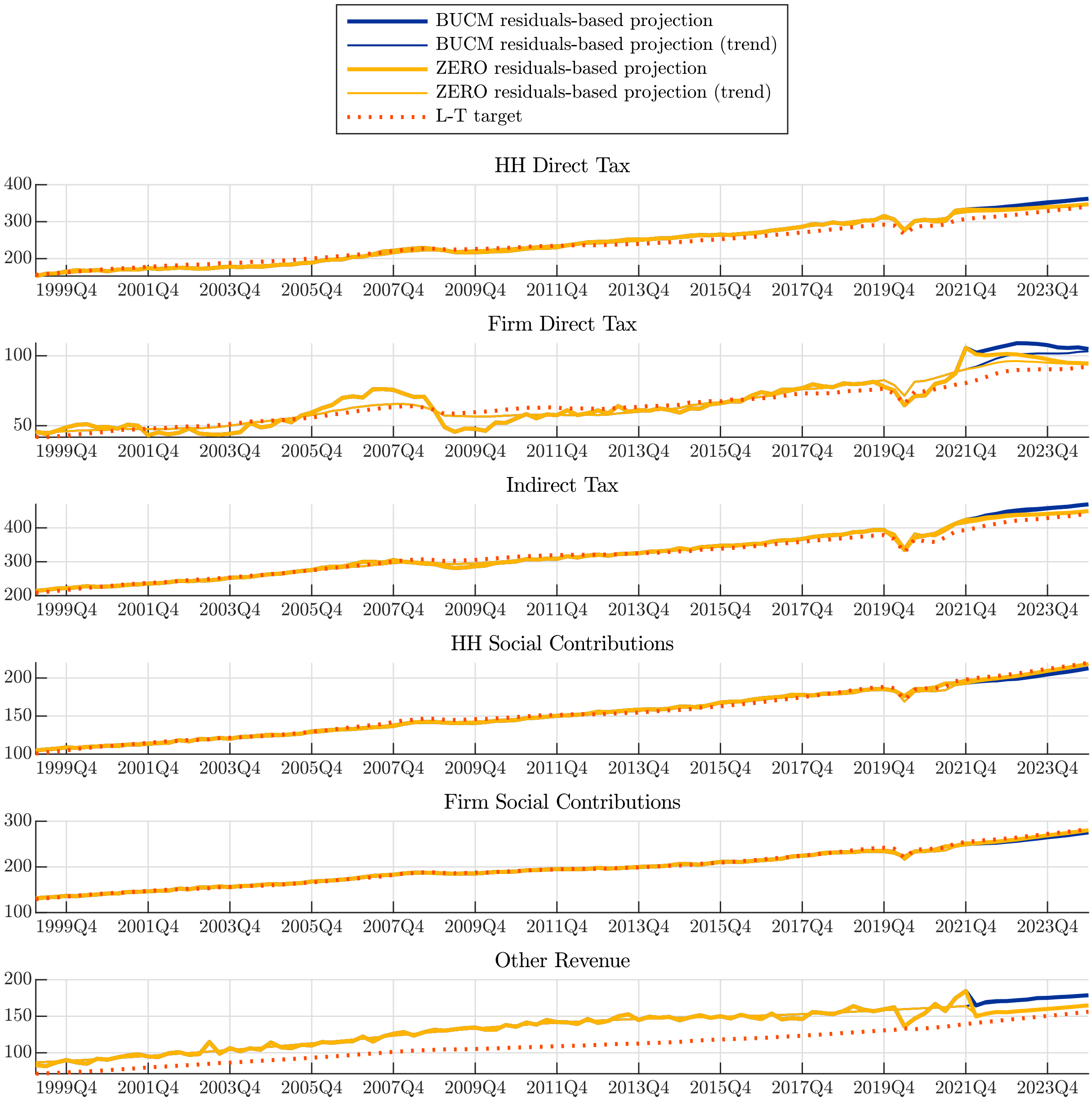
Figure E.5: Fiscal projections on the revenue side (%)



Sources: Own calculations with the ECB-BASE.

Notes: The projected variables during the historical period (up to 2021Q4) are equivalent to observed (derived in the case of trends) values.

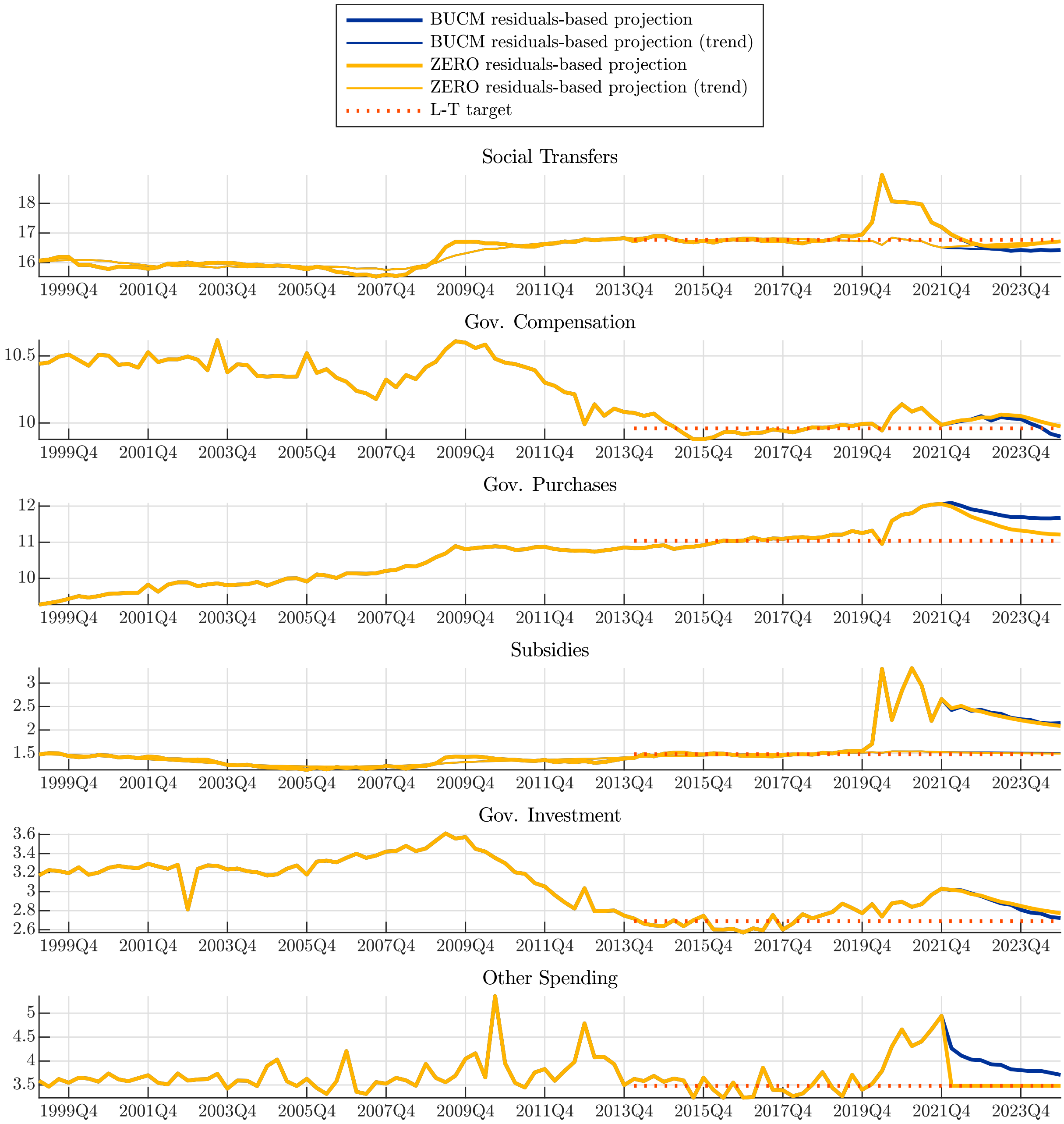
Figure E.6: Fiscal projections on the revenue side (EUR billions)



Sources: Own calculations with the ECB-BASE.

Notes: The projected variables during the historical period (up to 2021Q4) are equivalent to observed (derived in the case of trends) values.

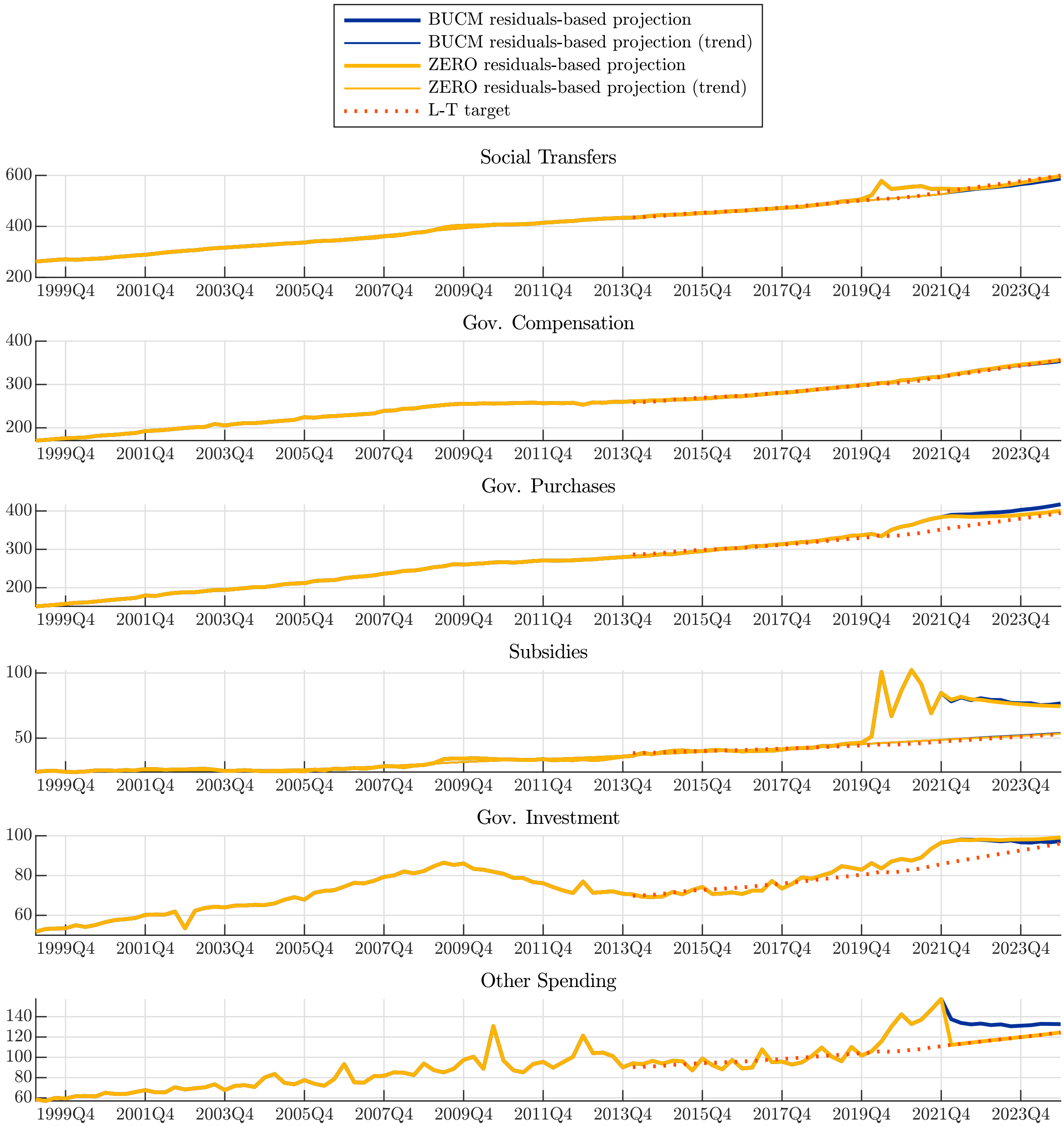
Figure E.7: Fiscal projections on the spending side (% of potential GDP)



Sources: Own calculations with the ECB-BASE.

Notes: The projected variables during the historical period (up to 2021Q4) are equivalent to observed (derived in the case of trends) values.

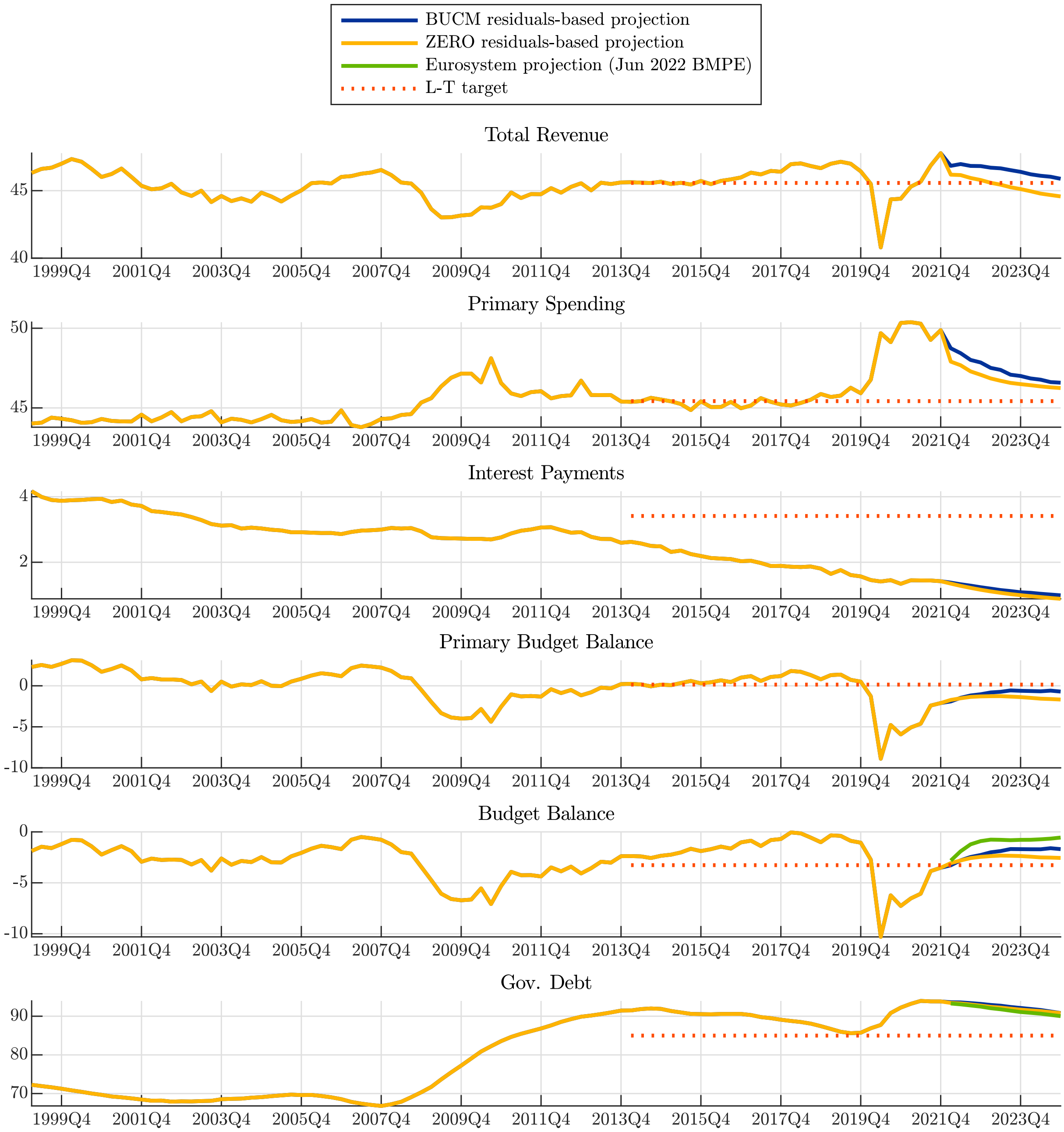
Figure E.8: Fiscal projections on the spending side (EUR billions)



Sources: Own calculations with the ECB-BASE.

Notes: The projected variables during the historical period (up to 2021Q4) are equivalent to observed (derived in the case of trends) values.

Figure E.9: Fiscal projections of the headline variables (% of potential GDP)



Sources: Own calculations with the ECB-BASE and ESCB Jun 2022 BMPE.

Notes: The projected variables during the historical period (up to 2021Q4) are equivalent to observed (derived in the case of trends) values. Only budget balance and government debt can be shown when it comes to the Eurosystem projections, as other items do not belong to the set of variables released to the public in the context of Eurosystem/ ECB projections.

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The views expressed in this paper, as well as all errors and omissions, should be regarded as those solely of the author and are not necessarily those of the European Central Bank.

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