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The Effects of Macroeconomic and Budget Balance Shocks on Public Debt Trajectories in the Euro Area*

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Abstract

This paper examines the effects of macroeconomic and budget balance shocks on public debt trajectories in the euro area. Country-specific SVAR models are used to identify various shocks, which are subsequently incorporated into local projection models that use panel data to estimate the impulse responses. The analysis indicates that a positive GDP shock leads to a persistent decline in the debt-to-GDP ratio, while a positive GDP deflator shock reduces the debt ratio only temporarily. A positive interest rate shock results in a substantial and lasting increase in the debt ratio. A positive primary balance shock, reflecting discretionary austerity, lowers the debt ratio considerably, albeit with a lag of around one year. We find evidence of state-dependent and non-linear effects. Fiscal austerity is more effective in reducing debt after periods of economic expansion than after recessions, and more effective when the initial public debt is low than when it is high. Moreover, a positive GDP shock reduces the debt stock to a larger extent when the debt stock is large than when it is low. Finally, the response of debt to a positive budget balance shock is more persistent and statistically significant when the shock is large.

Keywords: public debt; fiscal policy; macroeconomic shocks; euro area

JEL Codes: H6, H63, E62

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1 Introduction

This paper studies the effects of budget balance and macroeconomic shocks on public debt trajectories in a panel of euro area countries. It is motivated by a number of related developments. Many European economies have experienced substantial fiscal strain and growing stocks of public debt since the inception of the euro in 1999. The growing debt has taken place despite the provisions in the Stability and Growth Pact and numerous changes in the fiscal and macroeconomic governance frameworks of the EU.

The European economies have since the early 2000s encountered numerous macroeconomic shocks that may have affected the dynamics of public debt through various channels. The challenges include the global financial crisis, the European debt crisis, the Covid-19 lockdowns, and the disruptions caused by the Russian invasion of Ukraine. It follows that it is important to provide quantitative estimates of the effect of various macroeconomic shocks on public debt trajectories.

Our study is also motivated by the revised EU fiscal governance framework that was put into effect in May 2024. The revised framework stipulates that fiscal policy should ensure debt sustainability in the medium term and calls for projections of the trajectory of debt for all the EU countries (EC 2024, Darvas et al. 2024). The revised institutional setup makes it important to establish how various macroeconomic and budget balance shocks affect debt sustainability.

This paper employs a two-step methodology where the structural shocks are first identified in a structural VAR model, and the identified shocks are subsequently used in panel local projections to produce impulse responses for public debt and other variables of interest. This methodology allows an analysis of how public debt responds to various shocks over different time horizons without imposing very restrictive structural assumptions. The method also allows for the modelling of state-dependencies and non-linearities, while accounting for cross-sectional dependence. Data are quarterly and cover the period from the inception of the euro in 1999 to the fourth quarter of 2023.

Several studies have previously examined the effects of macroeconomic and budget balance shocks on the dynamics of public debt. The methodologies employed in these studies span scenario simulations using the debt accumulation equation, large-scale macroeconometric models, DSGE models and structural vector autoregressive models and local projections. This study contributes most directly to the latter literature.

The literature leaves key gaps, some of which we address in this study. First, the existing

literature has predominantly concentrated on examining the effects of various fiscal policy shocks on macroeconomic aggregates, such as output, consumption, or investment. By contrast, less attention has been devoted to analysing the determinants of public debt. Studying the impact of various macroeconomic and budget balance shocks on public debt seems fitting given the volatile dynamics of these variables in recent decades. While a number of studies on fiscal multipliers already account for state-dependence and certain forms of non-linearities, this study extends this type of analysis by exploring state-dependent effects and non-linear mechanisms in the responses of public debt to macroeconomic and budget balance shocks, thereby filling a gap in the literature.

Second, most studies either focus on the USA or rely on large panels that encompass countries with varying levels of economic development, institutional quality, and governance frameworks. To the best of our knowledge, this paper constitutes the first attempt to comprehensively investigate the drivers of public debt—including both non-linearities and state-dependence—within a group of countries that share a common monetary policy and broadly similar institutional arrangements. The specific choice of sample may be very important given that the literature has produced quite diverse results for different samples, depending on the institutional framework.

The empirical analysis in this paper finds distinct responses of public debt to various macroeconomic and budget balance shocks in the euro area. A positive shock to real GDP leads to a sustained decline in the public debt-to-GDP ratio, with most of the effect present within the first year. Higher inflation, which is modelled as a positive shock in the GDP deflator, initially reduces the public debt ratio, but the effect is transitory as the fiscal policy stance adjusts. A rise in interest rates exerts upward pressure on the public debt ratio, though the effect materialises with a lag. Finally, fiscal austerity results in a persistent decline in public debt, though the effect is initially small as austerity dampens economic growth.

The study also explores how debt responds under different conditions. A key finding is the impact of GDP shocks on public debt is more pronounced when the initial public debt is high than when it is low. Fiscal austerity measures are effective in reducing public debt during periods of economic expansion, while their effectiveness is limited during recessions. Fiscal austerity appears to be most effective at reducing public debt when the initial public debt is small. The paper further investigates whether the debt responses by the sign and magnitude of the shocks. Specifically, it finds that the negative response of public debt to an inflation shock is more prolonged when the shock is small than when it is large. Conversely, public debt response to a budget balance shock is

both more persistent and statistically significant when the shock is large.

This study contributes to debates on fiscal governance and debt sustainability in the euro area and provides results that may be of immediate relevance for fiscal policymaking. The dynamics of public debt is very sensitive to various macroeconomic shocks, although the effect exhibits some heterogeneity and appears to differ depending on the existing debt stock, the cyclical position, and the sign and size of the shocks. Importantly, the study also shows that fiscal austerity can effectively bring down the stock of public debt, though the effect may also here exhibit some heterogeneity.

The remainder of the paper is structured as follows. Section 2 reviews the literature. Section 3 describes the dataset and key variables used in the empirical analysis. Section 4 outlines the econometric methodology, detailing the SVAR identification strategy and the local projections approach. Section 5 presents the baseline results, analysing the impulse responses of public debt to different macroeconomic and budget balance shocks. Section 6 considers whether the impulse responses depend on the state of the economy, while Section 7 examines heterogeneity in the responses of debt under different characteristics of shocks. Finally, Section 8 concludes and provides some policy implications.

2 Literature on shocks and the dynamics of debt

How fiscal and macroeconomic shocks affect the dynamics of debt is important for economic analysis, research and policymaking. The macroeconomic environment has exhibited large volatility since the 2000s which spurred studies examining the impact of various macroeconomic shocks on public debt trajectories. The relationships between many of the variables involved are at the core of macroeconomic theory, though it is beyond the scope of this paper to discuss the numerous linkages and feedback mechanisms between them. We divide the studies into three partly overlapping categories depending on the methodology used, i.e. scenario simulations, structural models, and vector autoregressive and local projection models.

Scenario simulation is used to trace the effects of various shocks on the dynamics of debt. Assumptions about macroeconomic variables such as the interest on government debt, real GDP growth, inflation and the primary balance are fed into the equation of debt accumulation. The simulations may consider short-term developments using forecasts of the primary balance and the macroeconomic variables, or it may consider longer-term developments where trend values are used.

Key advantages of this methodology are its simplicity and that it is straightforward to simulate the effects of changing assumptions.¹

Scenario simulation is widely used by ministries of finance, fiscal councils and central banks. A cornerstone of the EU’s fiscal governance framework since 2024 has been the Debt Sustainability Analysis (DSA), which combines deterministic and stochastic scenario simulations (EC 2024). [Dardas et al. \(2024\)](#) use the methodology to compute the expected requirements for fiscal adjustment in each euro area country under the new EU fiscal governance framework.² Scenario simulations have been used by researchers at central banks, such as [de Cos et al. \(2018\)](#) and [Alloza et al. \(2024\)](#).

A drawback of scenario simulations is that using pre-determined assumptions or forecasts for the variables in the simulations means that feedback from the debt to other variables is not incorporated. This is particularly problematic if the dynamics of debt have a major impact on variables such as the interest rate, inflation or economic growth. Structural econometric models can be used to address this issue.

Ministries of finance, central banks, international organisations and financial institutions often use large or medium-sized structural models, many of which exhibit Keynesian or New Keynesian features ([Biro et al. 2008](#), [Bullen et al. 2021](#)). Such models are typically used to simulate a baseline scenario and then simulate the effects of changes in various variables. [Cwik and Wieland \(2011\)](#) use five different Keynesian-type models to find the effects of the large spending packages passed by many European countries in 2009 and 2010 in response to the global financial crisis. [Fall and Fournier \(2015\)](#) present a semi-structural model developed to assess whether the dynamics of debt are sustainable in individual OECD countries. Several papers have focused on debt dynamics using a DSGE model with New Keynesian properties, such as [Furceri and Mourougane \(2010\)](#), [Antonini et al. \(2013\)](#) and [Casalin et al. \(2020\)](#).

The literature that considers the dynamics of public debt increasingly uses econometric methods that impose few structural assumptions, such as vector autoregressive models and local projection. These methods allow researchers to explore the implications of various shocks on the trajectories of debt without pre-imposing information on the functioning of the economy or economies considered.

The study arguably most closely related to ours is [Auerbach and Gorodnichenko \(2017\)](#), which investigates the impact of fiscal spending shocks in a sample of advanced economies. The authors

¹[Wyplosz \(2011\)](#) argues that it is challenging to assess the sustainability of debt as doing so builds on numerous assumptions that are seldom satisfied in practice.

²[Erce et al. \(2025\)](#) provides an in-depth analysis and assessment of the EU’s Dynamic Sustainability Analysis. One concern raised is that the macroeconomic effects induced by fiscal policy are not well integrated into the analysis.

identify the shocks using a structural VAR model and subsequently apply local projections to panel data to trace the dynamic response of public debt. Their findings suggest that positive spending shocks exert only a minimal effect on the debt-to-GDP ratio, particularly during economic downturns. We also draw on [Cherif and Hasanov \(2018\)](#), who conduct an analysis of the effects of fiscal austerity, inflation and growth shocks on public debt in the USA. They employ a SVAR model and a modified identification strategy based on [Blanchard and Perotti \(2002\)](#) and find that positive GDP growth shocks lead to a sustained decrease in the debt ratio. Positive inflation shocks can reduce the debt-to-GDP ratio temporarily, but the longer-term effect is negligible. Discretionary fiscal tightening initially lowers the debt ratio, but its effect diminishes over time, suggesting that austerity may be of limited effect in the longer term.

Other studies that use SVAR to investigate public debt dynamics include [Favero and Giavazzi \(2007\)](#), who present a VAR model for the USA which explicitly incorporates a debt accumulation equation. Their approach identifies fiscal shocks using both the [Blanchard and Perotti \(2002\)](#) methodology and narrative records. [Attinasi and Metelli \(2017\)](#) examine the effects of austerity measures in major euro area countries. Their analysis uses a panel VAR framework augmented with a debt accumulation equation and employs sign restrictions for identification. Similarly, [Patel and Peralta-Alva \(2025\)](#) apply narrative sign restrictions to study the trajectories of debt in a panel of 17 advanced economies. [Di Serio \(2024\)](#) adopts a Bayesian Interacted Panel VAR model (BPIVAR-X) to analyse the dynamics of debt in the euro area countries.

Studies that use local projections include [Fukunaga et al. \(2022\)](#), who explore the impact of inflation shocks on debt dynamics in a panel of advanced economies, employing panel local projections and two different identification strategies. [Valencia et al. \(2024\)](#) identify demand and supply shocks using SVAR models with sign restrictions and then incorporate these shocks into dynamic panel regressions and local projections.

3 Data

We use a quarterly panel dataset comprising 11 of the first 12 euro area countries: Germany, France, Italy, Spain, Portugal, Greece, Austria, Finland, the Netherlands, Belgium, and Luxembourg. Ireland is not included because of the extreme volatility of its macroeconomic and fiscal data, and because the GDP data for Ireland are very dependent on the activities of multinational corpora-

tions operating in the country. All data are quarterly. Quarterly fiscal data are available from 2000q2 except for Austria (2001q1) and Luxembourg (2002q1); the end of the sample is in all cases 2023q4. All the data are sourced from Eurostat. We discuss here the variables used in the econometric analysis. For reference, Appendix A provides detailed variable definitions and descriptive statistics.³

Public debt. Eurostat’s nominal debt series is the consolidated gross public debt at face value as defined in the Maastricht Treaty. We seasonally adjust the quarterly variable using the multiplicative ARIMA X-12 algorithm. The debt-to-GDP ratio is then calculated as the nominal debt in the quarter divided by the sum of nominal GDP in the four quarters preceding the current one. By dividing by the annual nominal GDP, and not quarterly nominal GDP, we avoid that fluctuations in quarterly GDP affect the debt-to-GDP ratio unduly, and we get a measure which align with annual debt-to-GDP measures. By not including the current quarter in the sum of four quarters of nominal GDP, we remove automatic contemporaneous relation between public debt ratio to GDP and GDP growth in the same quarter.

Fiscal flows. Our analysis includes total revenue, primary expenditure, and their difference, the primary balance. Primary expenditure is calculated as total expenditure minus interest payments. The data for total revenue and total expenditure are seasonally and calendar-adjusted by Eurostat for all the countries except Greece and Italy; we seasonally adjust the variables for those two countries using the ARIMA X-12 algorithm. The data for interest payments are originally unadjusted, and this series is therefore seasonally adjusted using the same method.

We use the data on revenues and expenditures to derive the cyclically adjusted primary balance, which is not available from public sources on a quarterly basis. We describe the method of cyclical adjustment in the next section.

Macroeconomic variables. The series for real GDP is seasonally and calendar-adjusted by Eurostat. The GDP deflator is preferred over the Harmonised Index of Consumer Prices (HICP) since the public debt ratio is computed as nominal debt over nominal GDP. The GDP deflator is also seasonally and calendar-adjusted by Eurostat.

Interest rates. The implicit interest rate is the average interest rate a government pays on its debt, and it is calculated as the ratio of spending on interest payments in a quarter to public debt in the previous quarter. The implicit interest is a direct measure of the burden of paying the interest

³All variables employed in this study are ex-post, i.e., they were collected at the time of working on the paper

on public debt. In some robustness analyses we use the 10-year interest rate on government debt instead of the implicit interest rate; the 10-year interest rate is the one used for analysis of interest rate convergence under the Maastricht Treaty.

4 Empirical strategy

This study uses a two-step approach to estimate the impact of macroeconomic and budget balance shocks on the dynamics of debt. In the first step, we estimate a SVAR for each country to identify four types of structural shocks, i.e. shocks to real GDP growth, inflation, the primary budget balance and the interest rate. In the second step, we incorporate the structural shocks identified previously into local projections, following the methodology proposed by [Jordà \(2005\)](#), to derive impulse responses for the public debt ratio and various other variables. An analogous two-step approach combining structural vector autoregression and local projection (SVAR-LP) has previously been used in a few studies of fiscal policy such as [Auerbach and Gorodnichenko \(2017\)](#), [Ramey and Zubairy \(2018\)](#), [Deleidi et al. \(2023\)](#), and [Valencia et al. \(2024\)](#).

The two-step SVAR-LP approach is appealing because it can produce impulse responses for any macroeconomic variable of interest, and because it allows state-dependencies and non-linearities to be incorporated in a straightforward manner.

4.1 Identifying structural shocks

Our approach to identifying structural shocks is to use a modified [Blanchard and Perotti \(2002\)](#) identification strategy, which relies on the recursive ordering of variables in a SVAR. The original framework of [Blanchard and Perotti \(2002\)](#) comprises three variables, i.e. budget revenues and expenditures in real terms, and real GDP. Our model instead contains five variables. We use the cyclically and inflation adjusted primary balance instead of revenues and expenditures, while we follow [Blanchard and Perotti \(2002\)](#) by retaining the rate of GDP growth, but then add the rate of inflation, the debt-to-GDP ratio, and the implicit interest rate.

[Perotti et al. \(2007\)](#) was the first to extend the original [Blanchard and Perotti \(2002\)](#) framework by incorporating inflation to capture its lagged effects on fiscal variables. The debt ratio is included as in [Favero and Giavazzi \(2007\)](#), [Attinasi and Metelli \(2017\)](#), [Cherif and Hasanov \(2018\)](#), and [Patel and Peralta-Alva \(2025\)](#). Some of these studies incorporate an equation for the accumulation of

debt, where the debt stock is computed from other variables using the standard equation for debt accumulation. We follow the approach of [Patel and Peralta-Alva \(2025\)](#) and include the changes in the debt as an endogenous variable in the SVAR.⁴ Lastly, the implicit interest rate accounts for interest payments and their impact on debt accumulation; see for instance [Cherif and Hasanov \(2018\)](#) and [Patel and Peralta-Alva \(2025\)](#).

The framework of [Blanchard and Perotti \(2002\)](#) assumes that the fiscal variables do not respond contemporaneously to the macroeconomic variables. The argument for this is that fiscal policy decisions are decided with substantial lags, making it unlikely that discretionary fiscal policy will respond to economic developments within a quarter. It is crucial to use quarterly data for this ordering of the variables to work, as fiscal policy is typically set annually, and discretionary policy measures in response to macroeconomic changes often take more than a quarter to materialise.

Although there may not be a discretionary reaction to changes in macroeconomic variables, some of the fiscal variables are likely to react automatically to macroeconomic outcomes within a quarter. Revenues for instance, and to a lesser extent expenditures, contain automatic stabilisers that respond to cyclical changes in the economy because of taxes. We remove the cyclical components from the primary balance by removing them separately from revenues and expenditures.

We estimate the potential GDP and output gap for each country in the sample using the Hodrick-Prescott filter ($\lambda = 10,000$ as in [Auerbach and Gorodnichenko 2017](#)). We then compute the cyclical components by multiplying the output gap by the revenue and expenditure elasticities calculated by the European Commission ([Mourre et al. 2019](#)). Expenditure elasticities are generally low given that unemployment benefits are the main cyclical expenditure component, while revenue elasticities are approximately unity across countries.⁵

[Garcia-Macia \(2023\)](#) and [Staehr et al. \(2024\)](#) find that inflation or inflation shocks affect fiscal outcomes, at least in the short term. We therefore follow [Favero and Giavazzi \(2007\)](#) and [Perotti et al. \(2007\)](#) and remove the contemporaneous automatic effects of inflation on revenues and primary expenditures. We convert the semi-elasticities estimated by [Staehr et al. \(2024\)](#) into revenue and expenditure elasticities to inflation. This transformation is based on the revenue-to-GDP and expenditure-to-GDP ratios for each country.⁶ Finally, we calculate the cyclically adjusted primary

⁴The SVAR is only used to identify the various shocks, and so the forward dynamics of the debt stock are not needed. [Patel and Peralta-Alva \(2025\)](#) find that the standard debt accumulation equation often fails to hold empirically because of noticeable stock-flow adjustments.

⁵There are limitations to this approach. Elasticities may change over time because of changes in tax legislation, and they may also vary across different phases of the economic cycle ([Morris et al. 2009](#)).

⁶A limitation of this approach is that the semi-elasticities estimated in [Staehr et al. \(2024\)](#) come from a sample

balance (CAPB) as the difference between revenue adjusted cyclically and for inflation, and primary expenditure also adjusted cyclically and divided by the nominal potential GDP of the previous quarter.⁷

The following VAR model is estimated for each country in our sample:

$$Z_t = \alpha_0 + \sum_{j=1}^4 \alpha_j Z_{t-j} + \varepsilon_t \quad (1)$$

The vector Z_t comprises the following variables: ΔB_t is the quarter-on-quarter (q-o-q) change in the CAPB ratio to GDP, Δy_t is the q-o-q growth rate of real GDP, π_t is the q-o-q growth rate of the GDP deflator, ΔD_t is the q-o-q change in the public debt ratio to GDP, and ΔI_t is the q-o-q change in the implicit interest rate.

The structural shocks are identified using Cholesky ordering along the lines of [Blanchard and Perotti \(2002\)](#). Changes in cyclically adjusted primary balance (ΔB_t) are ordered first to reflect the assumption that discretionary fiscal policy does not react to changes in GDP growth, inflation, debt or the interest rate within the quarter. The ordering of the rest of the variables is then GDP growth (Δy_t), GDP deflator inflation (π_t), changes in the debt-to-GDP ratio (ΔD_t), and changes in the implicit interest rate (ΔI_t).

Figure 1 shows plot with the median of the shocks, computed for each quarter separately, across the 11 euro area countries in the sample.⁸

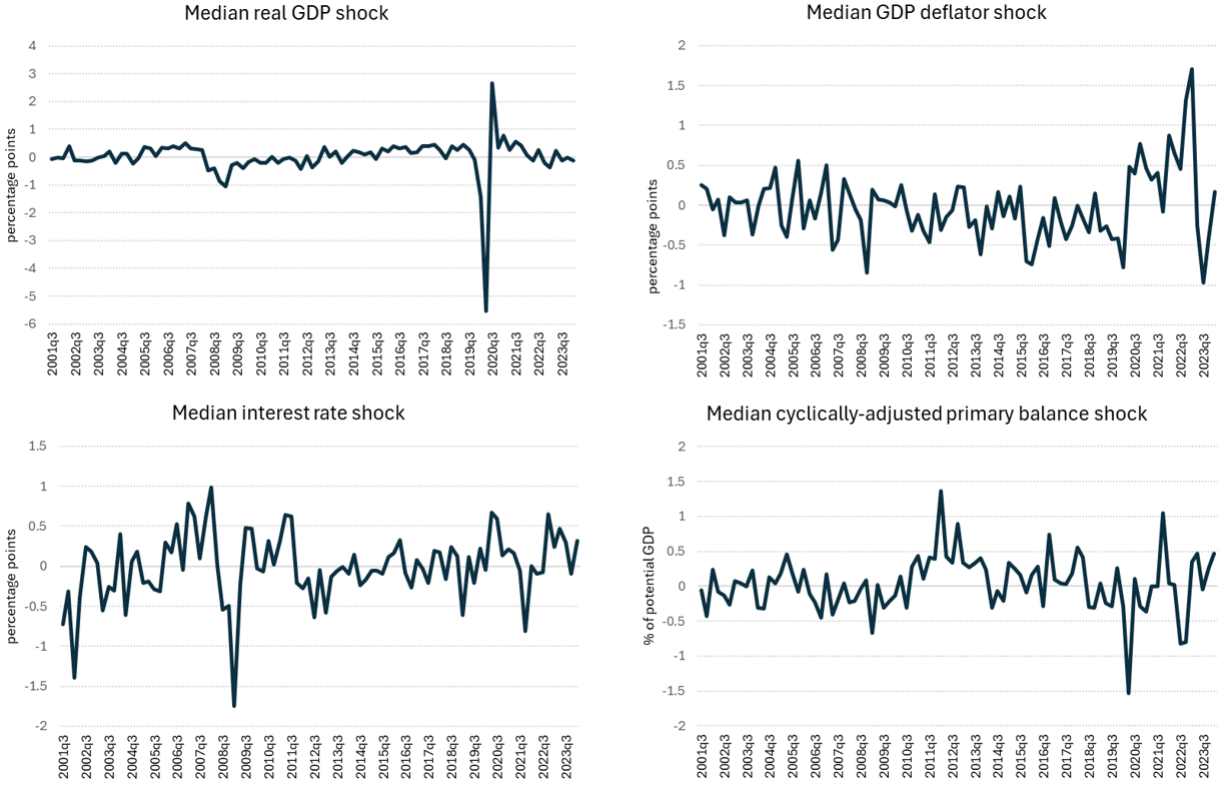
The plot of the median real GDP shock reveals large negative shocks following the global financial crisis, and extreme negative and positive shocks in the first year of the Covid pandemic. The three other shocks also exhibit large movements during the pandemic. The median of the GDP deflator shocks is often negative during the decade leading up to the Covid pandemic, but then positive and very large during the pandemic and following the Russian invasion of Ukraine. The median of the interest rate shocks is negative and large in numerical terms during the global financial crisis but positive in the periods before and after. The median of the cyclically adjusted primary balance shocks is positive in the periods after the global financial crisis, reflecting the austerity measures

of euro area countries and thus do not fully capture country-specific differences. Furthermore, those estimates are derived from annual data and so may not fully apply to quarterly frequencies.

⁷We divide by lagged potential GDP, which is meant to prevent GDP growth and GDP deflator inflation having a contemporaneous impact in VAR through the denominator. To be precise, this variable could be labelled the *cyclically and inflation adjusted primary balance*, but we use the widely known cyclically adjusted primary balance (CAPB) notation throughout the text. We examined whether the results change if we ignore inflation adjustment, but they appear to be almost identical to those reported in the paper.

⁸The scales of the vertical axes differ across the shocks identified in the four plots.

Figure 1: Median of estimated structural shocks



Notes: Median values, computed for each quarter separately, of structural shocks across 11 euro area countries using SVAR for each individual country.

taken then, but negative during the Covid pandemic.

The extreme volatility of several of the variables during the pandemic means that we should take measures to make sure that the extreme and unique events during the four quarters of 2020 do not affect the results unduly. We discuss these measures in the next subsection. Appendix B illustrates the historical decomposition of the quarterly change in the public debt ratio for each country. We decompose the deviations of the change in the debt ratio from its unconditional mean, net of deterministic/exogenous and initial-condition effects. The contribution labeled *Debt* reflects the impact of debt-specific structural innovations, which are shocks orthogonal to the primary balance, GDP growth, inflation, and the interest rate, and which may include stock-flow adjustments and other debt-related surprises.

4.2 Local projections

The next step is to estimate the effects of the structural shocks identified previously on various macroeconomic variables, primarily the debt-to-GDP ratio, using the local projection method as suggested by [Jordà \(2005\)](#). We estimate the following specification:

$$Q_{i,t+h} - Q_{i,t-1} = \beta_h + \theta_h \text{shock}_{i,t} + \gamma_h \Delta Q_{i,t-1} + \sum_{k=1}^4 \phi_k^{(h)} X_{i,t-k} + u_{i,h} + \varepsilon_{i,t+h} \quad (2)$$

The subscript i denotes the country and t the quarter. The variable $Q_{i,t}$ is the dependent variable, $\text{shock}_{i,t}$ represents the structural shock, $\Delta Q_{i,t-1}$ is the lagged first difference of the dependent variable, $X_{i,t-k}$ is a vector of the other lagged control variables for GDP growth and inflation with up to four lags, β_h is a constant, $u_{i,h}$ is a country fixed effect, and $\varepsilon_{i,t+h}$ is the error term. We also include a dummy variable for each of the four quarters of 2020 to account for the extraordinarily volatile dynamics during the first year of the Covid-19 pandemic (not shown in Equation (2)). The dependent variables are the log real GDP, the log GDP deflator, the primary balance in per cent of GDP, public debt in per cent of GDP, and the implicit interest rate on government debt.

The impulse responses are the collections $\{\theta_h\}_{h=0}^H$ recouped from a series of fixed effect regressions where the time horizon h is varied from zero to a maximum of H . We use [Driscoll and Kraay \(1998\)](#) standard errors for statistical inferences as these standard errors account for cross-sectional dependence and for serial correlation in the error term.

Section 6 investigates various state-dependencies; see [Cloyne et al. \(2023\)](#). To account for state-dependencies, we modify Equation (2) and interact all of the regressors with a state indicator I_{t-1} , which takes the value 1 or 0:

$$\begin{aligned} Q_{i,t+h} - Q_{i,t-1} = & I_{t-1} \left[\beta_{A,h} + \theta_{A,h} \text{shock}_{i,t} + \gamma_{A,h} \Delta Q_{i,t-1} + \sum_{k=1}^4 \phi_{A,k}^{(h)} X_{i,t-k} \right] \\ & + (1 - I_{t-1}) \left[\beta_{B,h} + \theta_{B,h} \text{shock}_{i,t} + \sum_{k=1}^4 \phi_{B,k}^{(h)} X_{i,t-k} + \gamma_{B,h} \Delta D_{i,t-1} \right] \\ & + u_{i,h} + \varepsilon_{i,t+h} \end{aligned} \quad (3)$$

The estimated impulse responses $\{\theta_{A,h}\}_{h=0}^H$ and $\{\theta_{B,h}\}_{h=0}^H$ then show the dynamics of the public debt or other variables in each of the two different states. We consider state-dependence for different

debt levels and different cyclical positions.

To explore potential state-dependence in the responses of public debt at different debt levels, we allow the coefficients to vary depending on the level of public debt in the previous quarter. We define the high-debt threshold as a debt ratio exceeding 80 per cent of GDP, which broadly corresponds to the sample mean. The state indicator I_{t-1} takes the value 1 if a debt ratio exceeds 80 per cent of GDP and takes the value 0 if it is below 80 per cent of GDP. The coefficients with subscript A are then those obtained when the state indicator I_{t-1} is 1, and the coefficients with subscript B are those when the indicator is 0. The estimated impulse responses $\{\theta_{A,h}\}_{h=0}^H$ and $\{\theta_{B,h}\}_{h=0}^H$ show the dynamics of public debt in scenarios where the debt is high and low, respectively.

Another issue debated in the literature is whether the responses are dependent on the business cycle stance. We examine the responses of public debt in slumps and in booms. We use two approaches that distinguish between states of the business cycle and capture the impact of cyclical conditions.

The first approach is to use the sign of the output gap. A country is classified as experiencing a boom if its output gap in the previous quarter is positive or zero, and it is classified as being in recession if the output gap is negative. We use the lagged value of the output gap to avoid reverse causality. Hence I_{t-1} from Equation (3) represents booms with a positive output gap, and $(1 - I_{t-1})$ is slumps with a negative output gap.

The second approach is to apply a smooth transition between states of the business cycle. We compute the smooth transition function $F(z_{i,t-1})$, which replaces I_{t-1} in Equation (3):

$$F(z_{i,t-1}) = \frac{\exp(-\xi z_{i,t-1})}{1 - \exp(-\xi z_{i,t-1})} \quad (4)$$

The index $z_{i,t-1}$ is the average GDP growth rate over the eight quarters ending in $t-1$ normalised to have zero mean and unit variance.⁹ The parameter ξ is set to 1.5 in line with the choice in other studies.¹⁰ The value of $F(\cdot)$ ranges from 0 to 1 and takes the value 0.5 if $z_{i,t-1} = 0$. The transition function can be interpreted as the probability of the economy being in a slump (Auerbach and Gorodnichenko 2017, Amendola 2023, Ciaffi et al. 2024). A high value of $F(\cdot)$ means that there is a

⁹We replace the output gap with the GDP growth rate to assess the robustness of our estimates to an alternative measure of the business cycle. The output gap is an unobservable indicator whose estimation relies on several assumptions and may be revised over time.

¹⁰It was initially calibrated by Auerbach and Gorodnichenko (2012) to satisfy the assumption that a country spends 20 per cent of the time in recession, which is derived from the duration of recessions in the USA according to NBER business cycle data. We also used an alternative value of ξ equal to -1, but the results remain close to those reported here; the results are available upon request.

high probability that the economy is in a slump, while a low value indicates a high probability of a boom.¹¹ Hence, $\{\theta_{A,h}\}_{h=0}^H$ traces the estimated impulse response when (there is a high probability that) the economy is in a slump, while $\{\theta_{B,h}\}_{h=0}^H$ traces the impulse response when (there is a high probability that) the economy is in a boom.

Finally, Section 7 considers possible non-linear effects of various shocks. We modify Equation (3) so that it takes the form:

$$\begin{aligned} Q_{i,t+h} - Q_{i,t-1} = & I_t \left[\beta_{A,h} + \theta_{A,h} \text{shock}_{i,t} + \gamma_{A,h} \Delta Q_{i,t-1} + \sum_{k=1}^4 \phi_{A,k}^{(h)} X_{i,t-k} \right] \\ & + (1 - I_t) \left[\beta_{B,h} + \theta_{B,h} \text{shock}_{i,t} + \sum_{k=1}^4 \phi_{B,k}^{(h)} X_{i,t-k} + \gamma_{B,h} \Delta D_{i,t-1} \right] \\ & + u_{i,h} + \varepsilon_{i,t+h} \end{aligned} \quad (5)$$

The only difference between Equations (3) and (5) is that the indicator variable now enters contemporaneously. The indicator variable I_t in Equation (5) now takes the value 1 when the shock variable is within a specified interval and the value 0 when the shock is outside the specified interval. In this way, it is possible to ascertain whether the impulse responses differ for different sizes and signs of the shocks.

5 Baseline results

This section presents the impulse response functions (IRFs) to various macroeconomic and budget balance shocks. We focus on the IRFs for public debt, but to provide further understanding of the mechanisms behind the accumulation of public debt, we are also considering the IRFs for the drivers of the debt, i.e. real GDP, the GDP deflator, the implicit interest rates, and the primary balance. The IRFs are estimated over a forecasting horizon of 20 quarters.

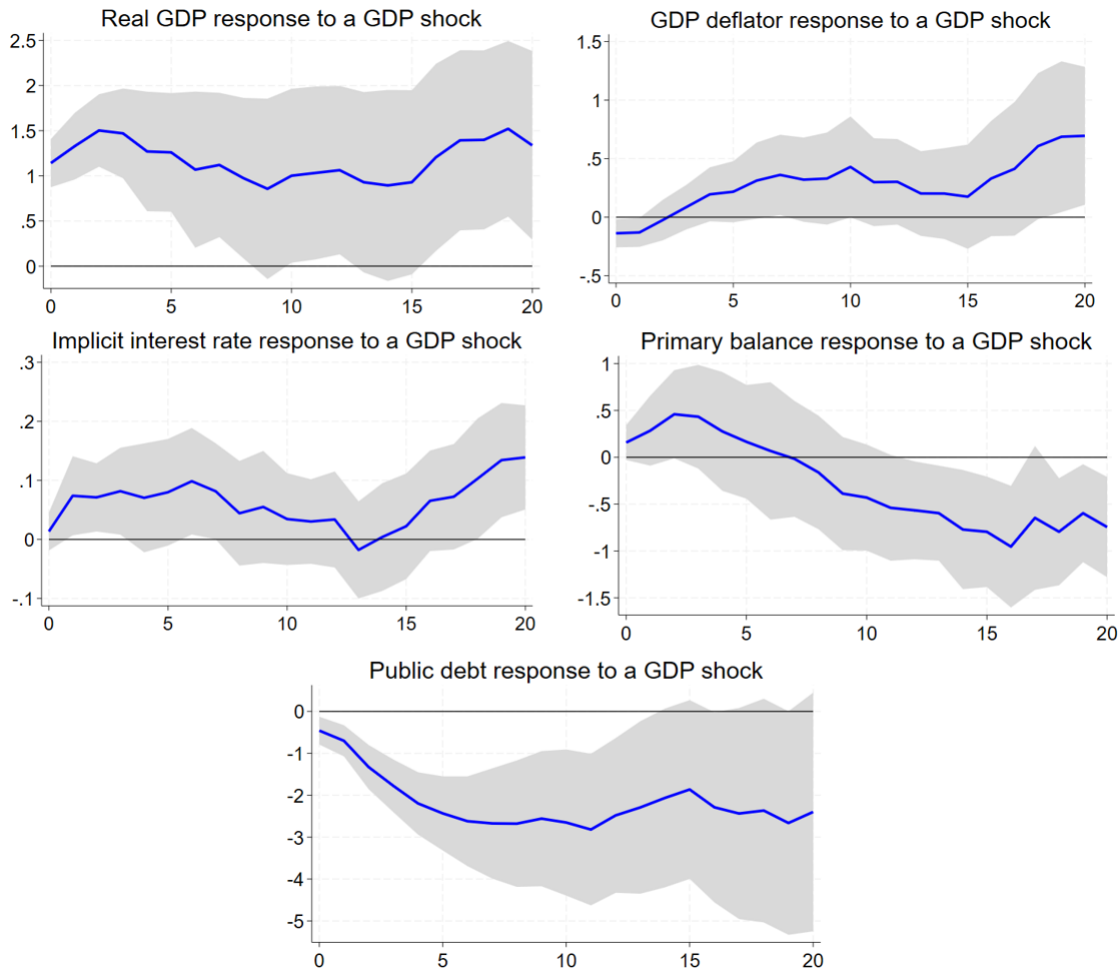
GDP shock

Figure 2 shows the IRFs and the associated 90 per cent confidence interval for a positive shock to real GDP growth of 1 percentage point. The increase in real GDP appears to be very persistent. The better performance of GDP is followed by the GDP deflator eventually rising, resembling a positive demand shock. The implicit interest rate also increases, perhaps due to increased money

¹¹The sample mean of $F(\cdot)$ was 0.981 in the second quarter of 2020, implying a slump with almost 100% certainty.

demand or the reaction of monetary authorities to rising inflation, though the effect is estimated imprecisely in most of the forecasting horizon. The primary balance initially improves on the back of the higher GDP and inflation, but its response turns negative after two or three years, perhaps because there is some form of fiscal slippage given the declining public debt or other macroeconomic developments.

Figure 2: IRFs to a GDP growth shock of 1%-point



Notes: The horizontal axis shows quarters. The 90% confidence bands are constructed using Driscoll-Kraay standard errors.

The public debt-to-GDP ratio declines in response to the shock, with most of the effect occurring within the first year. The public debt ratio falls by about 0.5 percentage point of GDP on impact and 1.8 percentage points of GDP after the first year, and by the end of the fifth year, the public debt ratio has fallen by around 2.4 percentage points. The finding that the improvement of the debt stock largely takes place within the first year or two is consistent with the improvement of the

primary budget balance being short-lived. Our results for the euro area are broadly in line with those for the USA in [Cherif and Hasanov \(2018\)](#) and [Di Serio \(2024\)](#), who find that GDP growth shocks lower the US debt-to-GDP ratio markedly.

GDP deflator shock

Figure 3 illustrates the response of the public debt-to-GDP ratio and other variables to a positive GDP deflator shock. Unlike the real GDP shock, the inflation shock does not cause a sustained reduction in the public debt ratio. The inflation shock leads to a decline in the public debt ratio of up to 1 percentage point of GDP after approximately two years. The decline is partly driven by the increase in the GDP deflator, which increases the denominator of the ratio. It is also driven by a small improvement in the primary balance in per cent of GDP, which is in line with the findings of [Bańkowski et al. \(2023\)](#), [Briodeau and Checherita-Westphal \(2024\)](#), and [Staehr et al. \(2024\)](#).

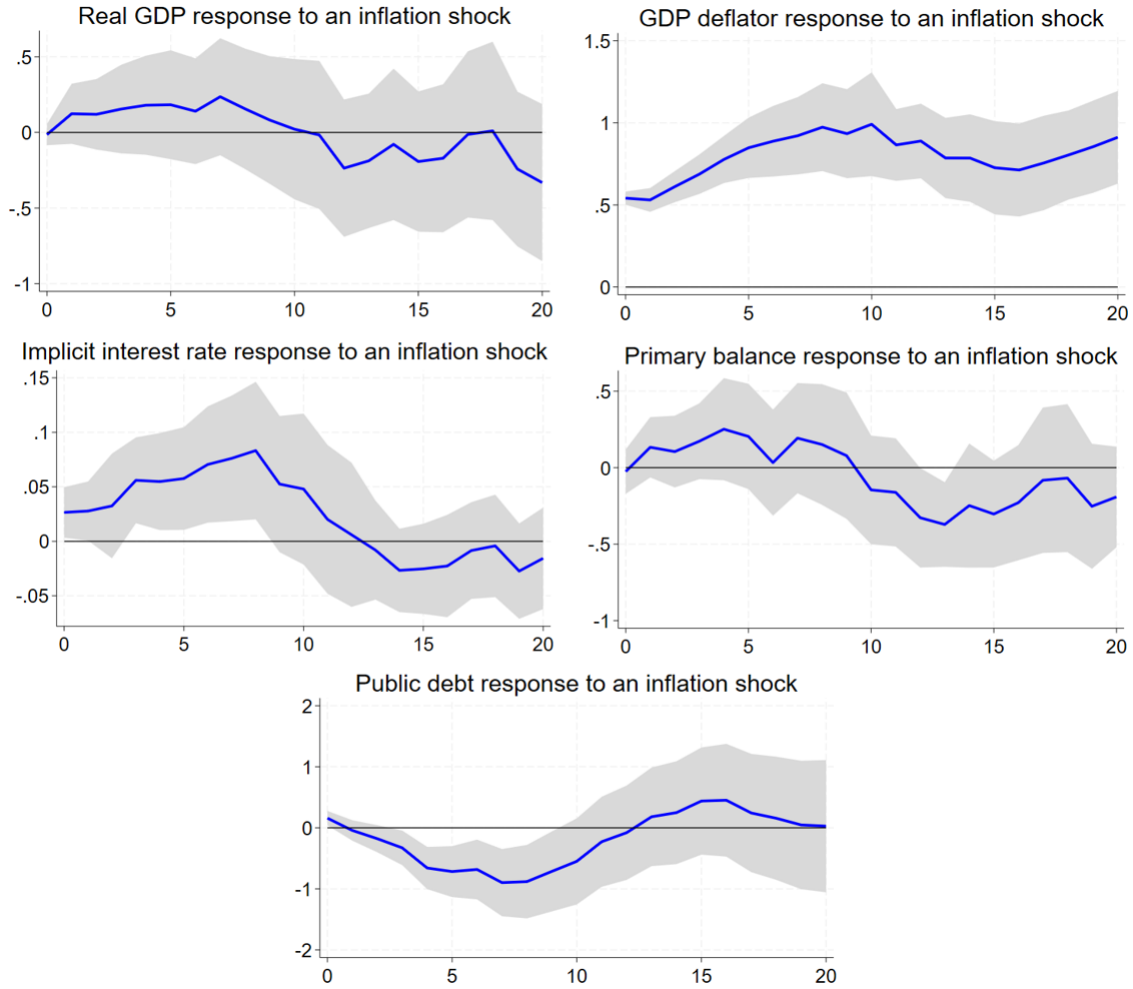
The initial positive response of the primary balance fades over time in line with the results in [Garcia-Macia \(2023\)](#), who finds that inflation shocks only improve fiscal balances temporarily. Inflation additionally exerts downward pressure on economic growth, and so after around three years the public debt ratio has returned to its initial pre-shock level. The higher GDP deflator contributes to a reduction in the debt-to-GDP ratio through the denominator, but this decline in the debt ratio represents a one-off effect, which is subsequently counteracted by other macroeconomic developments.

Interest rate shock

Figure 4 shows the impact of a shock to the implicit interest rate on public debt. The positive interest rate shock negatively affects economic growth and, subsequently, the GDP deflator but does not appear to influence the primary balance to any noticeable extent. This suggests that the fiscal authorities do not fully adjust their fiscal stance in response to rising interest payments, at least in the short to medium term.¹² The public debt consequently increases over time, with the increase reaching about 2.5 percentage points by the end of the fifth year. [Di Serio \(2024\)](#) similarly finds that interest payments play a key role in the dynamics of the accumulation of public debt.

¹²[Tkačevs and Vilerts \(2019\)](#) find in a large panel of OECD and Eastern European countries that higher government borrowing costs lead to an improvement in the cyclically adjusted primary balance, but their result stems in large part from the non-core countries in their sample. The 11 countries in the panel dataset that we use are all in the core of the euro area.

Figure 3: IRFs to a GDP inflation shock of 1%-point

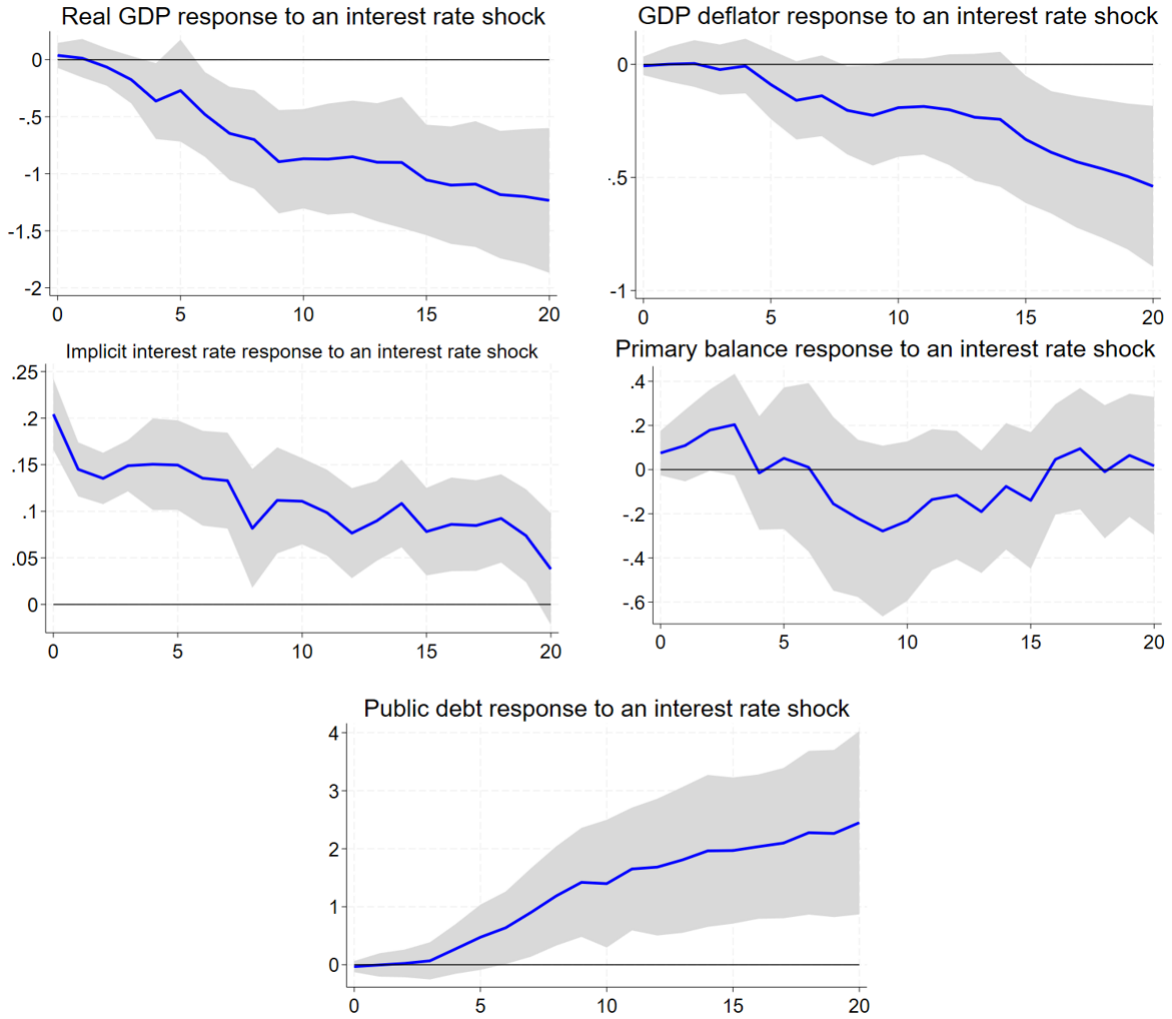


Notes: The horizontal axis shows quarters. The 90% confidence bands are constructed using Driscoll-Kraay standard errors.

Primary balance shock

Figure 5 shows that the response of public debt to an austerity shock, i.e. a positive cyclically-adjusted primary balance shock of 1 per cent of GDP, is less frontloaded but more persistent than the response to GDP shocks. The debt ratio barely falls on impact following an austerity shock but then does so sharply in the second half of the second year. The initial sluggish response of public debt can be attributed to fiscal austerity having a negative impact on economic growth, which counteracts the positive effects of the improved fiscal stance. However, fiscal consolidations may, in the longer term, improve confidence and reverse the initial GDP decline, thereby undoing some of their immediate negative effects. This finding contrasts [Alesina and Ardagna \(2010\)](#) and [Alesina and Ardagna \(2013\)](#) who show that spending cuts can be associated with immediate positive

Figure 4: IRFs to an implicit interest rate shock of 1%-point



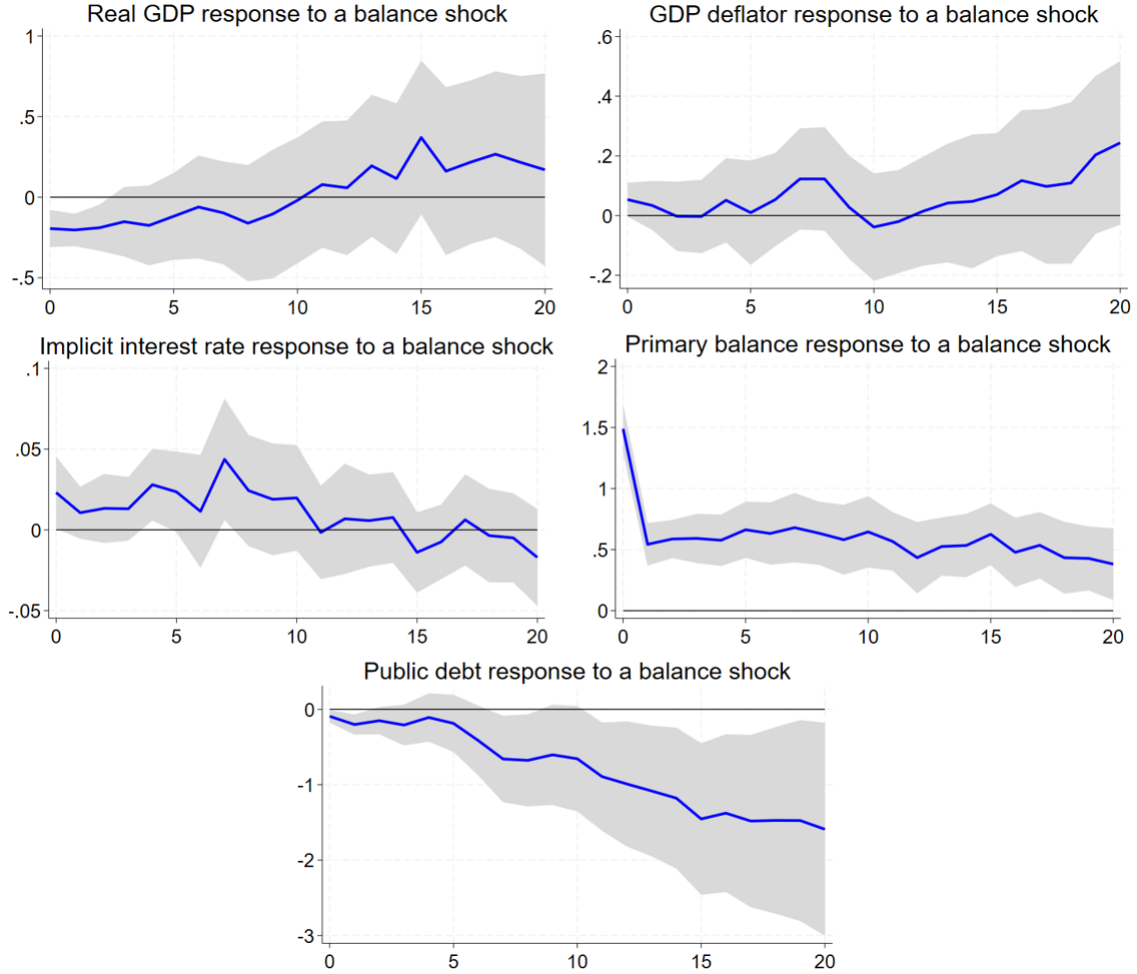
Notes: The horizontal axis shows quarters. The 90% confidence bands are constructed using Driscoll-Kraay standard errors.

economic effects. This amplifies the reduction in the public debt ratio that stems from the better fiscal stance. These findings differ from those in [Cherif and Hasanov \(2018\)](#), who find that fiscal austerity can be self-defeating, but are closer to those of [Di Serio \(2024\)](#) and [Patel and Peralta-Alva \(2025\)](#), who find that primary balance shocks play a large role in historical decompositions of public debt.

Robustness

The analysis in this section provided results for the euro area that are broadly in line with those of earlier empirical studies from the USA and broad panels, though they also offer additional insights. Some of these are related to the endogenous reaction of the primary balance to macroeconomic

Figure 5: IRFs to a primary balance shock of 1% of GDP



Notes: The horizontal axis shows quarters. The 90% confidence bands are constructed using Driscoll-Kraay standard errors.

developments, including changes in the debt stock. These endogenous responses mean that the dynamics of debt in several cases are more subdued than would otherwise had been the case. We also find that austerity measured as a positive primary balance shock reduces the debt ratio over time, but that there is a noticeable lag. We now conduct a series of checks to examine the robustness of the estimation results presented in this section.

First, we include four dummy variables for the four quarters of 2020 in Equation (1), which implies that we essentially drop the first year of the Covid pandemic when we estimate the structural shocks. The choice to keep those quarters could have impacted the shock estimation for other periods and therefore affected the resulting IRFs, but we find however only minor changes in the resulting IRFs; the results are available upon request.

Second, we replace the implicit interest rate with the interest rate on 10-year government bonds, which can react faster than the implicit interest rate. Figure C.1 in Appendix C shows the impulse responses of the public debt to four different shocks when we use the interest rate on 10-year bonds instead of the implicit interest rate. The effects of interest rate shocks are somewhat smaller than before, but the impulse response functions for the other shocks remain close to those for the baseline.

Third, we examine whether individual countries affect the results unduly. We run the local projections as before but now exclude one country at a time from the sample. The impulse responses of the public debt to all four shocks remain broadly similar to the baseline ones, apart from minor changes in coefficients and confidence intervals; the results are available upon request.

Fourth, we consider the possible limitations of the two-stage approach by omitting the second stage entirely and instead producing the impulse response functions using a VAR model applied to the panel of 11 countries. We identify the shocks using the identification scheme detailed in Subsection 4.1, but this scheme is now applied to the full panel of 11 euro area countries, rather than to each country individually. In this way we examine whether the baseline results are consistent with the results from using a single-step estimation method. Figure C.2 in Appendix C shows that the impulse responses for a GDP shock and an interest rate shock are a little smaller in magnitude but retain the direction and dynamics, and stay within the confidence interval of the local projections.¹³ The effects of inflation and of fiscal austerity prove remarkably robust across both methods, further corroborating the baseline findings.¹⁴

Fifth we examine the importance of the particular methodology used to identify the shocks by using the generalised impulse response (GIR) methodology instead. The shocks in the GIR framework are generated using the correlations between the shocks. The impulse responses are computed using local projections as before, and they are broadly similar to those obtained using the two-step approach; the results are available upon request.

6 State-dependence of the public debt response

The results in Section 5 come from the panel of 11 early members of the euro area. The 11 countries share many institutional and structural features, but they have also over time seen different economic

¹³We also estimated LP IRFs using the same panel SVAR shocks. However, we find that our main conclusions remain robust regardless of the source of the shocks. The IRFs are available upon request.

¹⁴These findings are consistent with econometric theory, which has established that local projections and SVAR models produce the same impulse responses if they are correctly specified (Plagborg-Møller and Wolf 2021, Olea et al. 2025).

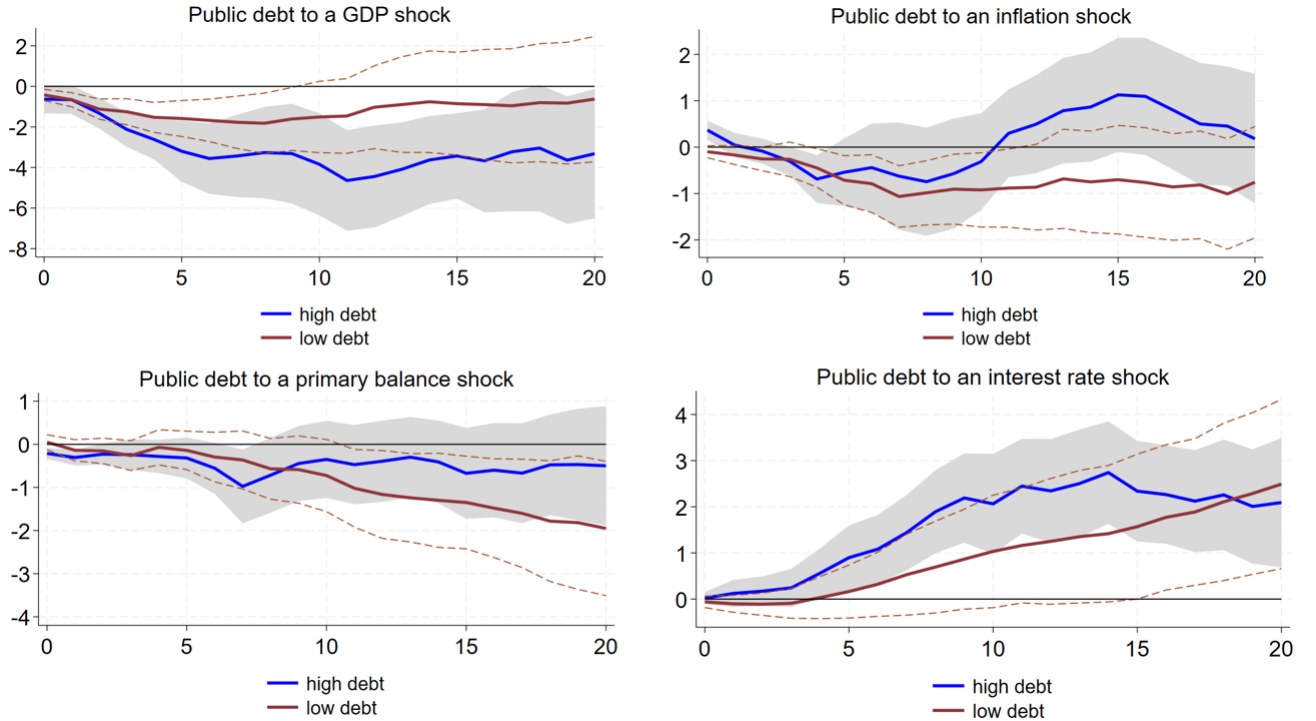
conditions or developments, which might have affected how various shocks impact the accumulation of debt and other variables. This section exploits the flexibility of the local projection methodology to investigate possible state-dependences.

6.1 High and low levels of debt

How effective fiscal instruments are at influencing output in environments with high or low levels of government debt remains a topic of debate (e.g., [Ilzetzi et al. 2013](#), [Auerbach and Gorodnichenko 2017](#), [Valencia et al. 2024](#)). We take the debate to the euro area and consider state-dependent impulse responses not only for fiscal shocks but also for the macroeconomic shocks considered in Section 5.

Figure 6 presents the results. To save space, we report only the impulse responses for the public debt, though we refer to the responses of other variables in some of the explanations provided.¹⁵

Figure 6: Response of public debt to shocks when debt is high or low



Notes: The horizontal axis shows quarters. Red lines represent IRFs obtained for the low debt state (public debt ratio is below 80 per cent of GDP); blue lines represent IRFs for the high debt state (public debt ratio is above 80 per cent of GDP). Dashed lines and shaded areas represent 90% confidence intervals constructed using Driscoll-Kraay standard errors.

¹⁵The full set of impulse responses is available upon request.

It is noticeable that the confidence intervals are quite wide, so they overlap for the low and high debt cases for all four shocks for the entire forecasting horizon. This means that possible differences between the low and high debt should be interpreted with caution.

A positive GDP shock results in a decline in the public debt ratio, both when debt is low and when it is high. The effect is however most pronounced when the public debt ratio is high, and it remains statistically significant throughout the forecast horizon. When public debt is low, the effect is subdued and statistically insignificant after the second year. A key factor behind this difference is the direct effect on the public debt ratio stemming from a higher denominator; this direct effect on the debt ratio is large when the initial debt is large, but less important when the initial debt is relatively small.

The response to a fiscal austerity shock is muted and statistically insignificant, both when debt is high and when it is low, but after approximately two years the effect is somewhat larger for the low debt case. This outcome may partly be the result of fiscal austerity shocks being more credible in countries that have shown fiscal discipline in the past, which consequently results in more favourable long-term effects on GDP (and the GDP deflator). The upshot is that the effectiveness of austerity measures may depend on the level of public debt.

The effect of an inflation shock on public debt is negative and broadly similar for the first two years, but the effect is then positive for the high debt case, while it remains negative for the low debt case. Countries with high debt appear to utilise the “breathing space” afforded by the initially declining debt to pursue fiscal policies later on that lead to higher debt, whereas this is not the case in countries with low debt.

The IRFs for the interest rate shock show that a positive interest rate shock leads to a larger increase in public debt when the initial debt is high than when it is low, except at the very end of the forecast horizon. This finding is reasonable, as a higher interest will evidently be more costly for a country with a large stock of debt than for a country with little debt.

The results in Figure 6 remain broadly unchanged when we apply alternative thresholds such as the threshold of 60 per cent of GDP stipulated in the Maastricht Treaty or a higher threshold of 100 per cent of GDP.

6.2 Slumps and booms

Primary balance and macroeconomic shocks may have different effects dependent on the cyclical stance of the economy (Auerbach and Gorodnichenko 2012, Ramey and Zubairy 2018). We investigate this issue for the euro area using the two methodologies outlined in Subsection 4.2. Figure 7 presents the impulse responses of public debt during economic slumps and booms when we use a dummy variable based on the sign of the output gap, while Figure 8 displays the impulse responses when we model the cyclical stance using a smooth transition function. The results are broadly analogous and will therefore be discussed together.

A positive GDP shock reduces the debt-to-GDP ratio in the short term irrespective of the cyclical stance, but the effects differ over time, in part due to different trajectories of the primary fiscal balance. In the short to medium term, the negative impact of inflation on public debt is more pronounced during booms, whereas the effects of GDP shocks do not exhibit a consistent pattern.

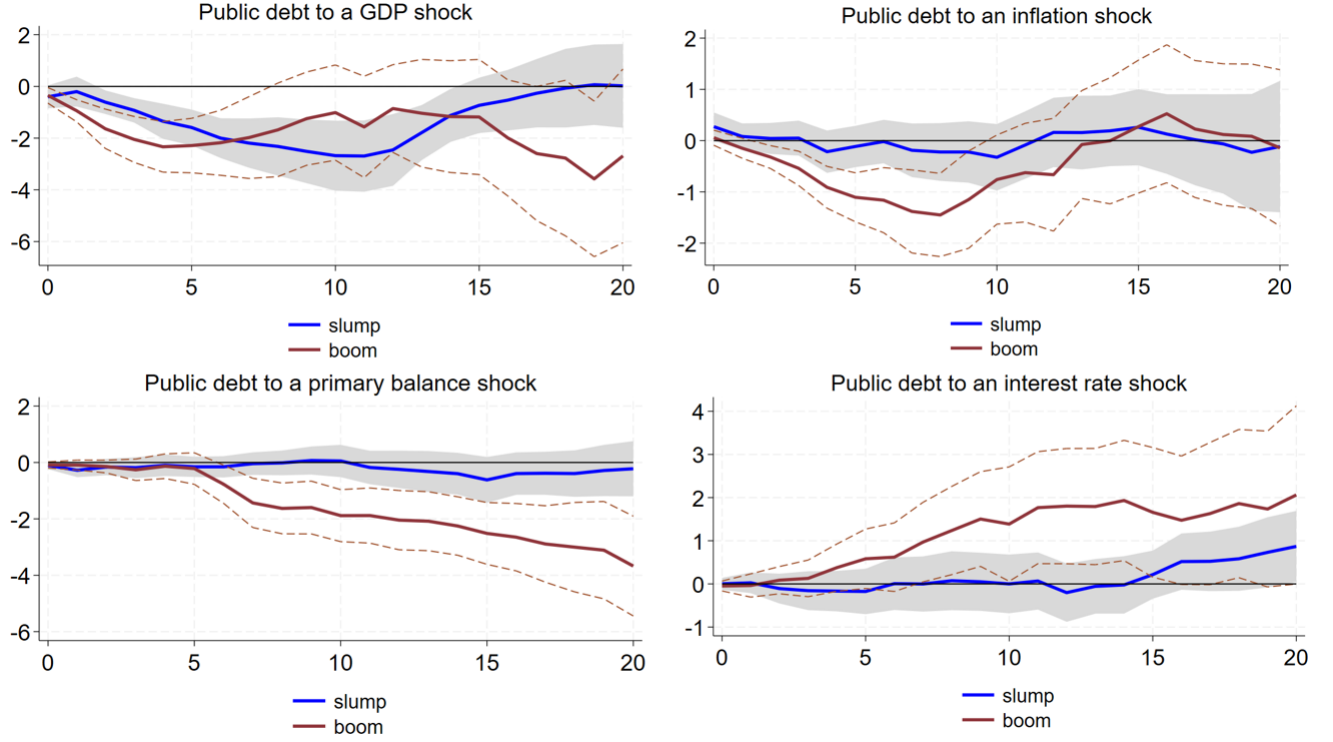
There is a clear difference in how the public debt ratio responds to primary balance shocks, as fiscal austerity is effective during booms, but ineffective during slumps. The difference in responses arises from the more enduring improvement in the fiscal stance that follows a positive primary balance shock during boom periods compared to slumps.

The impact of interest rate shocks on public debt is stronger in booms than it is in slumps. An exogenous interest rate shock in booms (possibly reflecting monetary policy tightening decisions) lowers inflation and economic growth, while it has zero effect on both variables in slumps. This result is robust to leaving out countries such as Greece, Italy and Spain which experienced substantial increases in their government bond yield risk premium during the European sovereign debt crisis.

7 Non-linear responses of public debt

This section investigates whether there are non-linear effects of macroeconomic and austerity shocks. We consider first the effects of positive and negative shocks and then the effects of different sizes of shocks.

Figure 7: Response of public debt to shocks in booms and slumps using the value of output gap



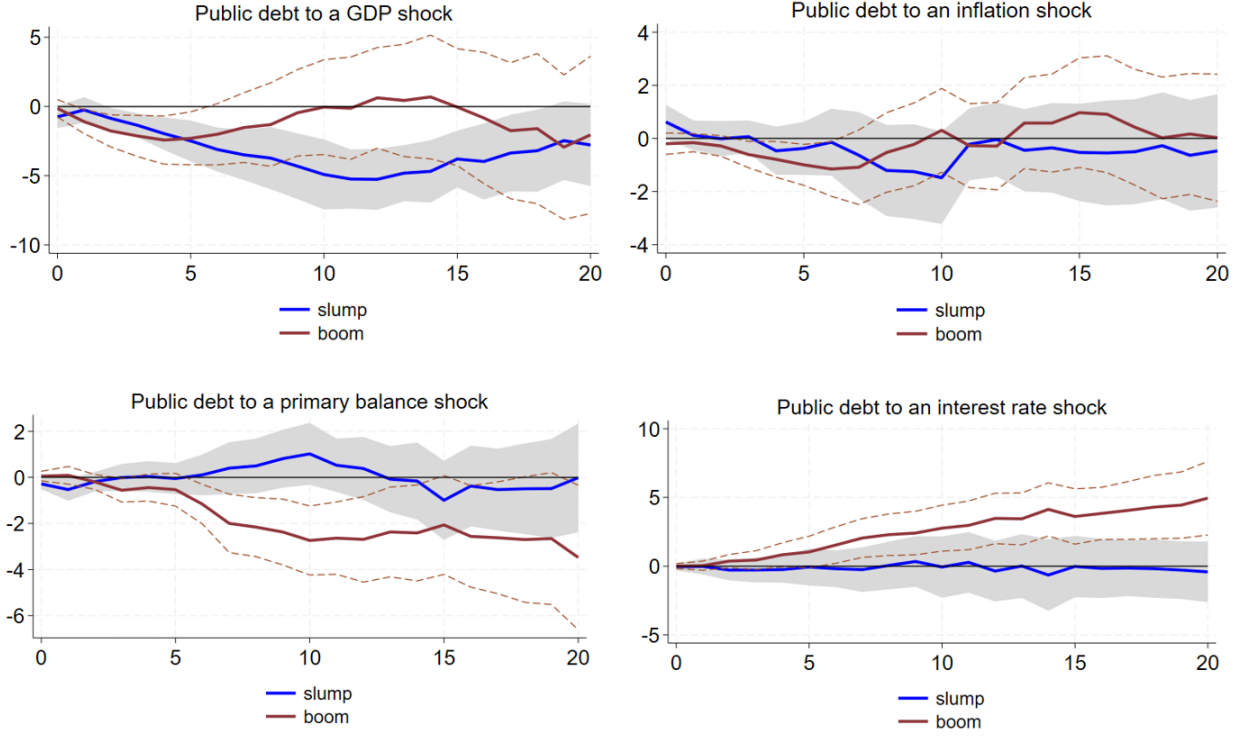
Notes: The horizontal axis shows quarters. Red lines represent IRFs obtained for booms (the value of the output gap is positive); blue lines represent IRFs for recessions (the value of the output gap is negative). Dashed lines and shaded areas represent 90% confidence intervals constructed using Driscoll-Kraay standard errors.

7.1 Positive vs negative shocks

Positive and negative shocks may result in different reactions by private and public entities and thus lead to different impulse responses (Pragidis et al. 2015, Ramey 2016, Ben Zeev et al. 2023). We distinguish between positive and negative shocks using the dummy approach described in Subsection 4.2. The IRFs presented below are responses to a shock of the same sign, with positive and negative shocks distinguished using a binary dummy variable. I_t in Equation (5) is specified as a dummy variable indicating the occurrence of a positive shock, while $(1 - I_t)$ indicates a negative shock.

Figure 9 shows the impulse response for the debt-to-GDP ratio for each of the four shocks we consider. The overall conclusion from the impulse response functions is that the effects are broadly similar for positive and negative shocks in most cases, except for interest rate shocks. For GDP, inflation and primary balance shocks, the IRFs for the public debt are broadly similar and the confidence intervals overlap. (The somewhat divergent effects of the GDP shock after four years may be seen in this context as a chance occurrence happening long time after the shock.)

Figure 8: Response of public debt to shocks in booms and slumps using the value of the transition function



Notes: The horizontal axis shows quarters. Red lines represent IRFs obtained for the strong boom state (the value of the transition function is zero); blue lines represent IRFs for the deep recession state (the value of the transition function is one). Dashed lines and shaded areas represent 90% confidence intervals constructed using Driscoll-Kraay standard errors.

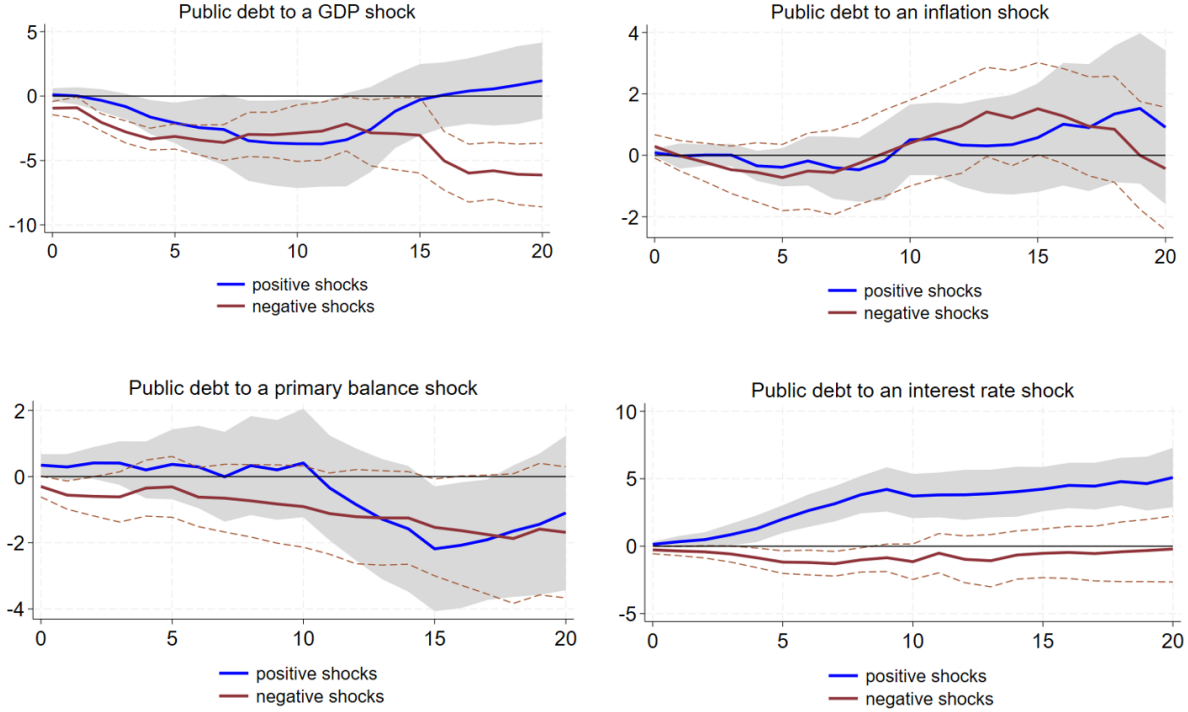
The broadly similar debt dynamics suggest that the reactions of policymakers and the public are broadly similar regardless of the sign of the shock.

The conclusion above does not apply to interest rate shocks, largely due to different reactions by the fiscal policymakers. A positive interest rate shock, meaning a higher interest rate on public debt, is not met by counteracting fiscal policy reactions, and the higher interest rate therefore leads to gradually higher public debt levels. A negative interest rate shock has an almost negligible effect, which suggest that the lower interest rate is followed by looser fiscal policy so that the debt stock declines only marginally.

7.2 Small vs large shocks

Our final set of analyses distinguishes between large and small shocks and, as such, contributes to a small number of studies that analyse this issue (Giavazzi et al. 2000, Gonzalo and Martínez 2006, Attinasi and Metelli 2017). We classify shocks as large if they exceed one standard deviation, which

Figure 9: Response of public debt to positive vs negative shocks



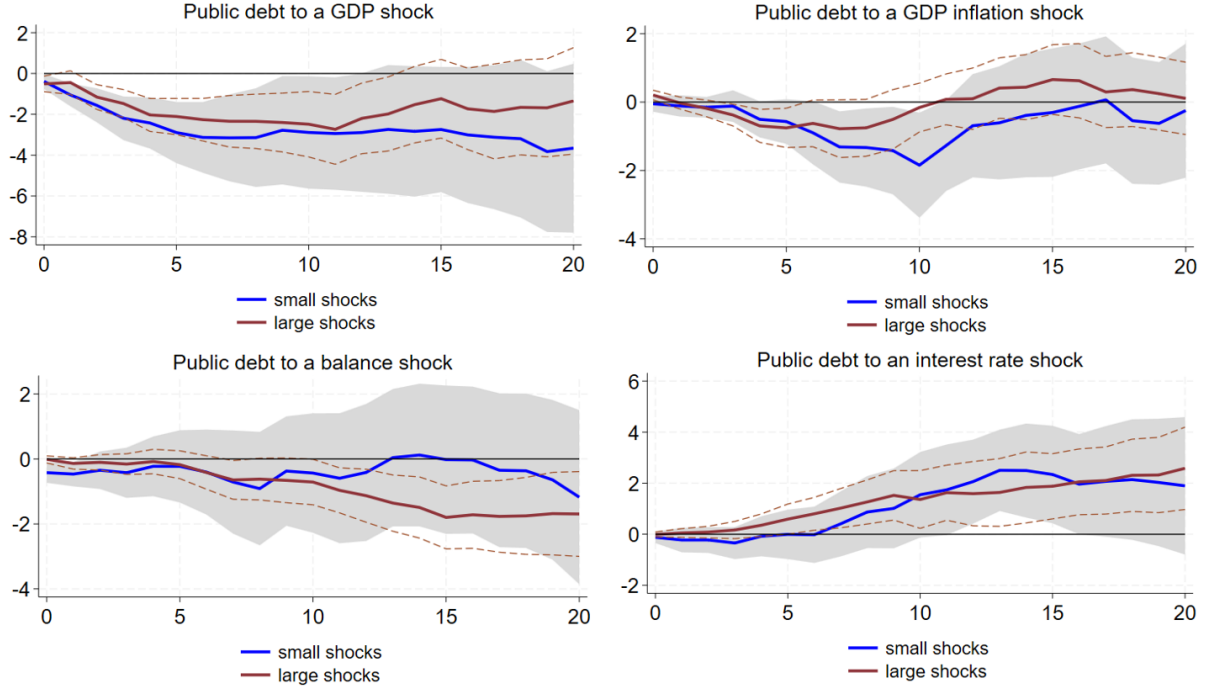
Notes: The horizontal axis shows quarters. Red lines represent IRFs obtained for negative shocks; blue lines represent IRFs for positive shocks. Dashed lines and shaded areas represent 90% confidence intervals constructed using Driscoll-Kraay standard errors.

is about 1 per cent for GDP shocks and for GDP inflation shocks, 1 percentage point for interest rate shocks, and 1 percentage point of GDP for budget balance shocks; other shocks are classified as small. The IRFs presented below are responses to a shock of the same magnitude, with large and small shocks distinguished using a binary dummy variable.

The results in Figure 10 reveal several distinct patterns. The negative response of public debt to a GDP inflation shock tends to be more prolonged when the shock is small. This is partly because smaller inflation shocks do not appear to lead to higher spending (perhaps to compensate for increased living costs), and so the budget balance improves over a longer horizon; detailed results available upon request.

The responses to debt shocks and to interest rate shocks are fairly similar for small and large shocks. However, the negative response of public debt to a positive budget balance shock is both persistent and statistically significant when the budget balance shock is large, while the effect is small and statistically insignificant when the shock is small. This outcome can be attributed to the more sustained improvement in the primary balance that is associated with large shocks, a conclusion also reached in [Giavazzi et al. \(2000\)](#) using various datasets; detailed results are available

Figure 10: Response of public debt to small vs large shocks



Notes: The horizontal axis shows quarters. Red lines represent IRFs obtained for large shocks (with the magnitude exceeding 1 standard deviation); blue lines represent IRFs for positive shocks (with the magnitude below 1 standard deviation). Dashed lines and shaded areas represent 90% confidence intervals constructed using Driscoll-Kraay standard errors.

upon request.

8 Final comments

This paper considers the effects of fiscal and macroeconomic shocks on the trajectories of public debt in the euro area using quarterly data for 11 early adopters of the euro and a two-step approach that first uses SVAR models to identify the shocks and then uses those shocks in local projections to produce impulse responses. The focus on the euro area is particularly relevant given the fiscal strain in many euro area countries, the abundance of macroeconomic shocks, and the revision of the EU fiscal governance framework in 2024.

The analysis demonstrates that shocks to GDP growth, interest rates, and the primary balance influence the dynamics of debt markedly over time, whereas the impact of GDP deflator shocks is short-lived. A positive GDP shock results in a persistent decline in the debt-to-GDP ratio, primarily because of an increase in the denominator of the debt-to-GDP ratio. In contrast, a rise in interest rates exerts upward pressure on public debt, and the effect intensifies over time. Fiscal

austerity, which is captured as a positive primary balance shock, also contributes to a decline in the debt-to-GDP ratio, albeit with a delay of approximately one year.

The study provides evidence of state-dependence in the response of public debt. Fiscal austerity measures are found to be more effective at reducing public debt during periods of economic expansion, while they become less effective during recessions. Fiscal austerity is also found to be more effective when initial public debt levels are low. By contrast, the impact of GDP shocks on public debt is more pronounced and remains statistically significant over a five-year horizon when the initial public debt is high.

The paper further investigates the heterogeneity of debt responses by the size and magnitude of shocks. It finds that the negative response of public debt to an inflation shock lasts longer when the shock is small. Conversely, the negative response to a positive budget balance shock is both more persistent and statistically significant when the shock is large.

The findings in this paper contribute to ongoing debates on debt sustainability and fiscal governance in the euro area, issues that are of particular importance given the revisions to the fiscal rules in 2024 that are intended to ensure the dynamics of debt are sustainable while preserving economic flexibility. A key insight is that while fiscal policy is essential for managing public debt, macroeconomic conditions, particularly economic growth and interest rates, also play decisive roles. Moreover, the evidence of state-dependence in debt dynamics presented in this paper highlights the need for fiscal authorities to conduct countercyclical policies. Implementing austerity measures during economic downturns is less effective in reducing public debt and may exacerbate recessionary pressures. Also, when debt is very high, cutting spending or raising taxes by itself may not be enough, because debt levels can still rise sharply if the economy slows down. In such situations, fiscal tightening should be combined with broader reforms that make the economy stronger and support long-term growth. This underscores the importance of designing fiscal policy frameworks that are responsive to country-specific economic conditions and changes in macroeconomic and macro-financial conditions.

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Appendices

A Data and definitions

Table A.1: List of variables, definitions and measurements

Variable	Definition	Measure
Public debt	General government consolidated gross debt	% of GDP
Change in public debt		q-o-q, percentage points of GDP
Primary balance	General government net lending, excluding interest payable	% of GDP
Change in primary balance		q-o-q, percentage points of GDP
Cyclically-adjusted primary balance (CAPB)	General government net lending, excluding interest payable, seasonally and cyclically adjusted	% of GDP
Change in cyclically-adjusted primary balance		q-o-q, percentage points of GDP
Real GDP	GDP in constant prices	Index
Growth rate of real GDP	Relative change in real GDP in constant prices	q-o-q, %
GDP deflator (inflation)	GDP deflator	Index
Growth rate of GDP deflator (GDP inflation)	Relative change in GDP deflator	q-o-q, %
Implicit interest rate	Ratio of general government interest spending in quarter to public debt in the previous quarter	%
Change in implicit interest rate		q-o-q, percentage points
10-year interest rate	Nominal long-term interest rate, 10-year sovereign bond yield	%
Change in 10-year interest rate		q-o-q, percentage points

Table A.2: Summary statistics of main variables

Variable	Mean	Median	Standard devia- tion	Min	Max
Public debt	83.279	75.512	39.285	7.020	216.034
Change in public debt	0.247	-0.024	2.299	-31.215	13.554
Primary balance	-0.062	0.232	3.518	-23.407	10.534
Change in primary balance	-0.032	-0.005	2.335	-14.473	19.968
Cyclically-adjusted primary balance (CAPB)	-0.058	0.258	3.241	-17.771	9.806
Change in cyclically-adjusted primary balance	-0.013	-0.031	2.027	-13.230	18.073
Real GDP growth rate	0.335	0.411	1.975	-19.407	15.052
GDP deflator growth rate (inflation)	0.523	0.459	0.732	-3.925	5.450
Implicit interest rate	3.200	3.091	1.383	0.603	6.933
Change in implicit interest rate	-0.038	-0.036	0.333	-2.952	3.051
10-year interest rate	3.251	3.490	2.494	-0.061	25.400
Change in 10-year interest rate	-0.001	-0.050	0.565	-7.530	5.710

B Historical decompositions

Figure B.1: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Austria

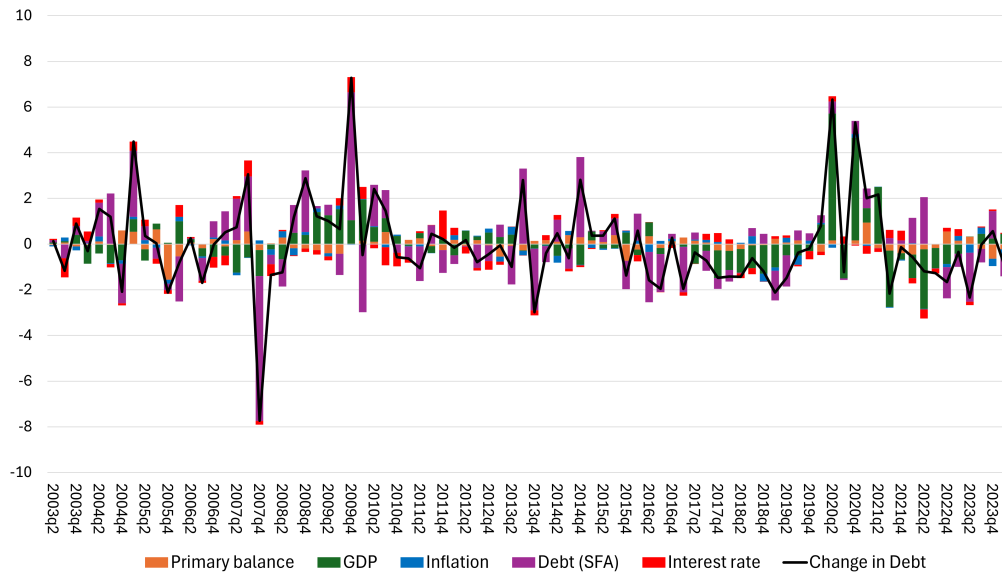


Figure B.2: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Belgium

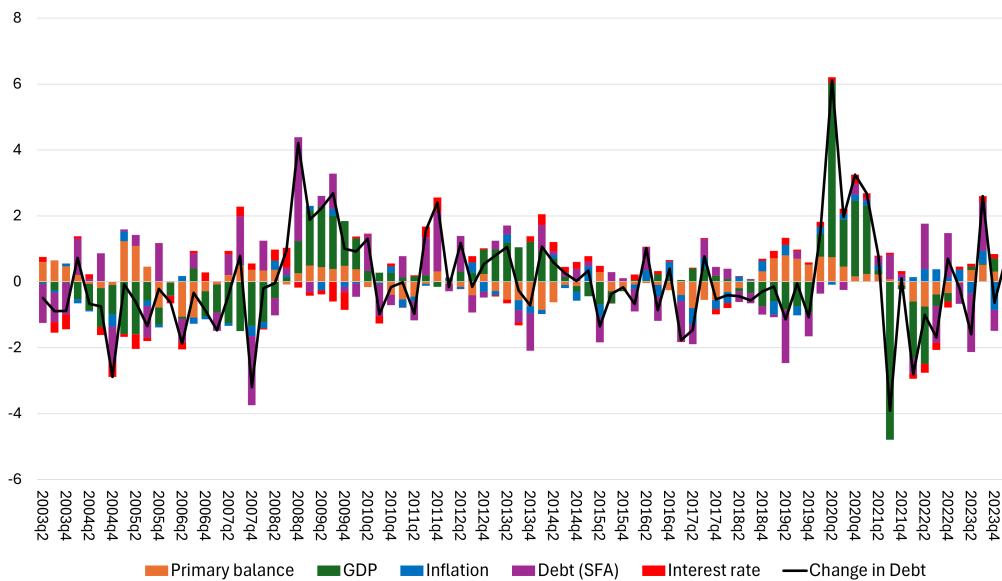


Figure B.3: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Germany

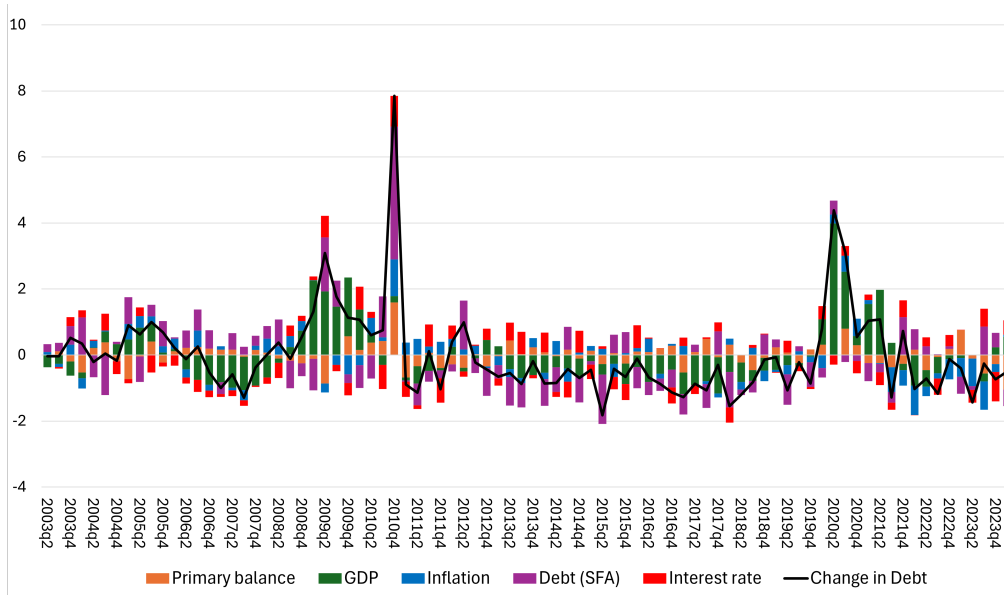


Figure B.4: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Spain

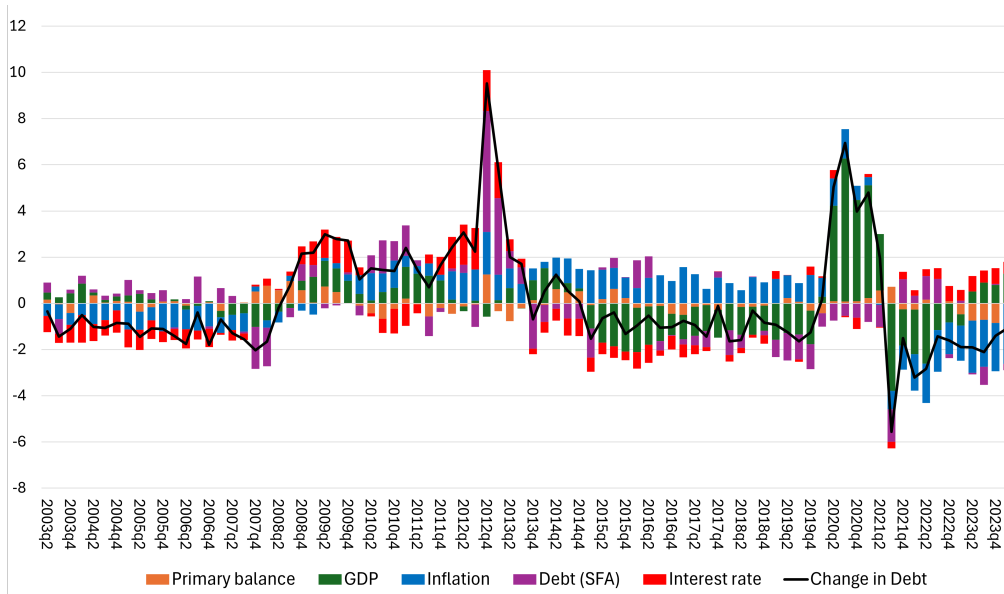


Figure B.5: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Finland

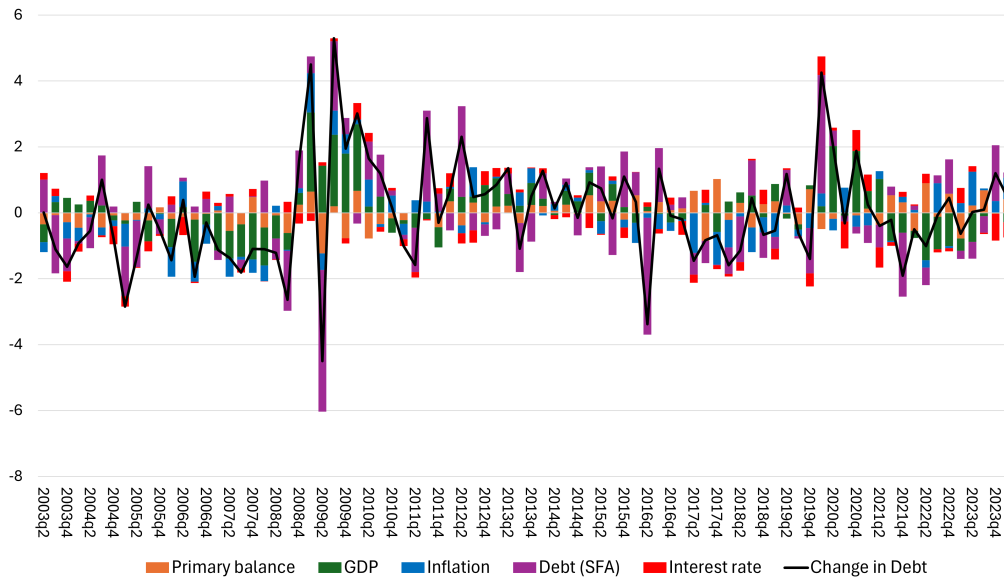


Figure B.6: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in France

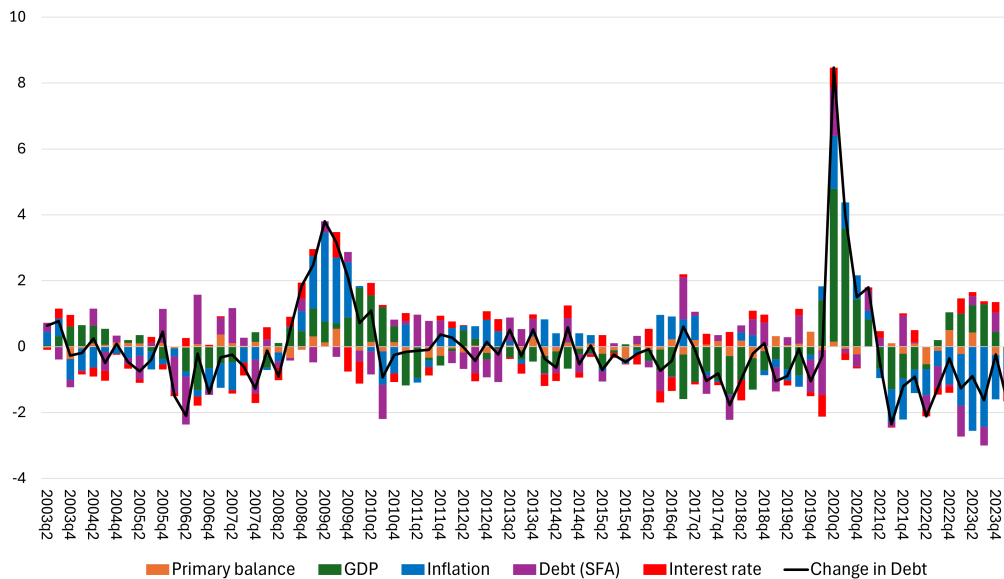


Figure B.7: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Greece

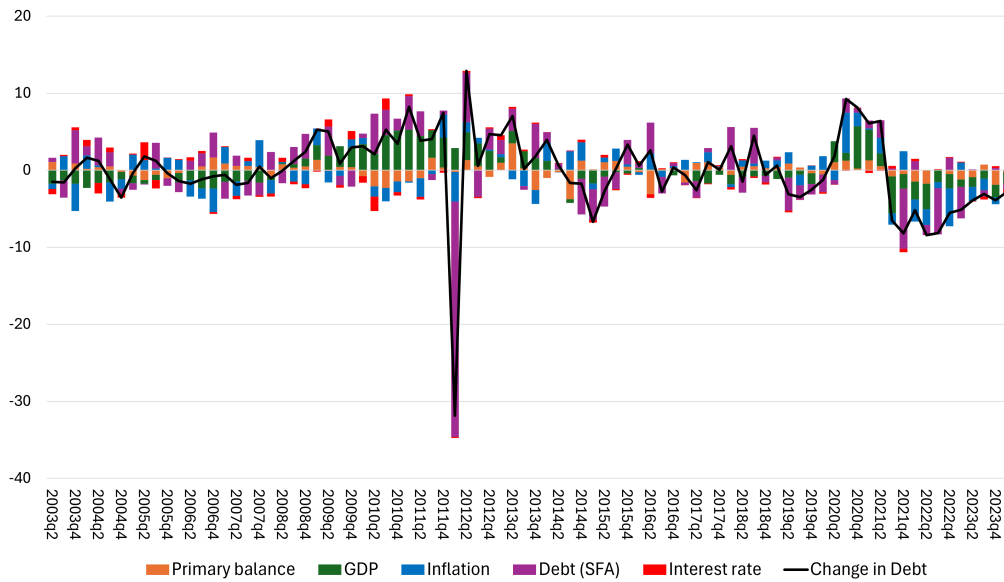


Figure B.8: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Italy

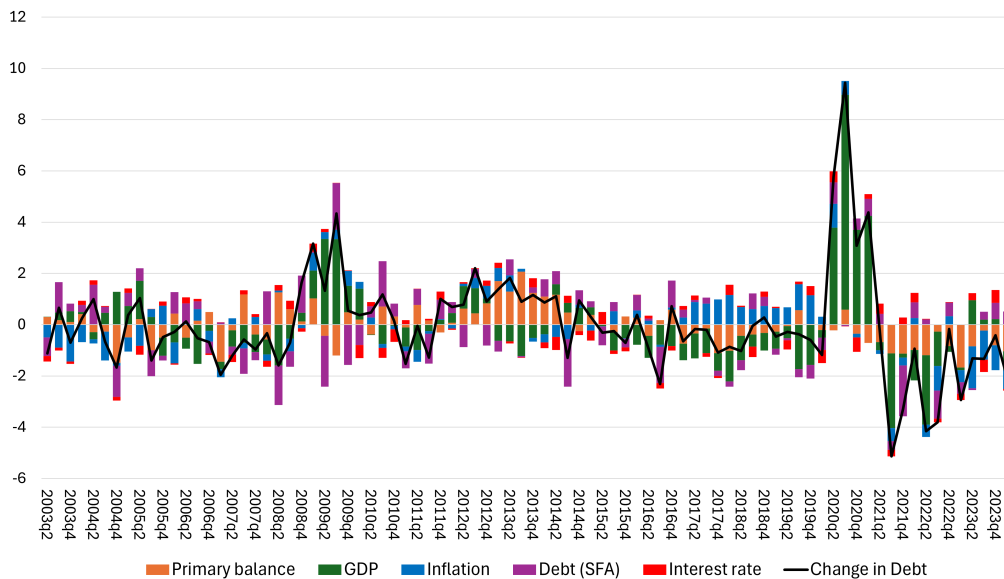


Figure B.9: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Luxembourg

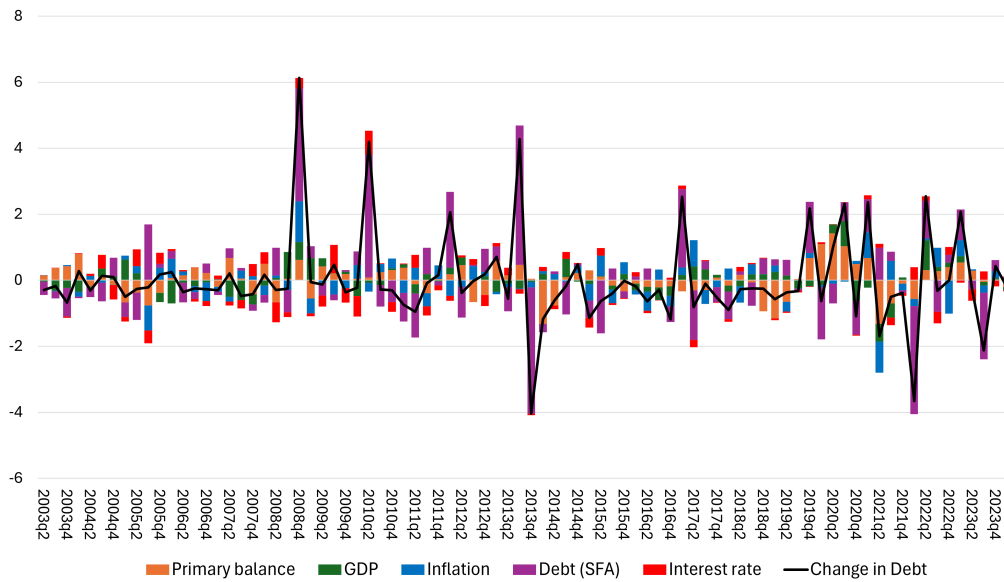


Figure B.10: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Netherlands

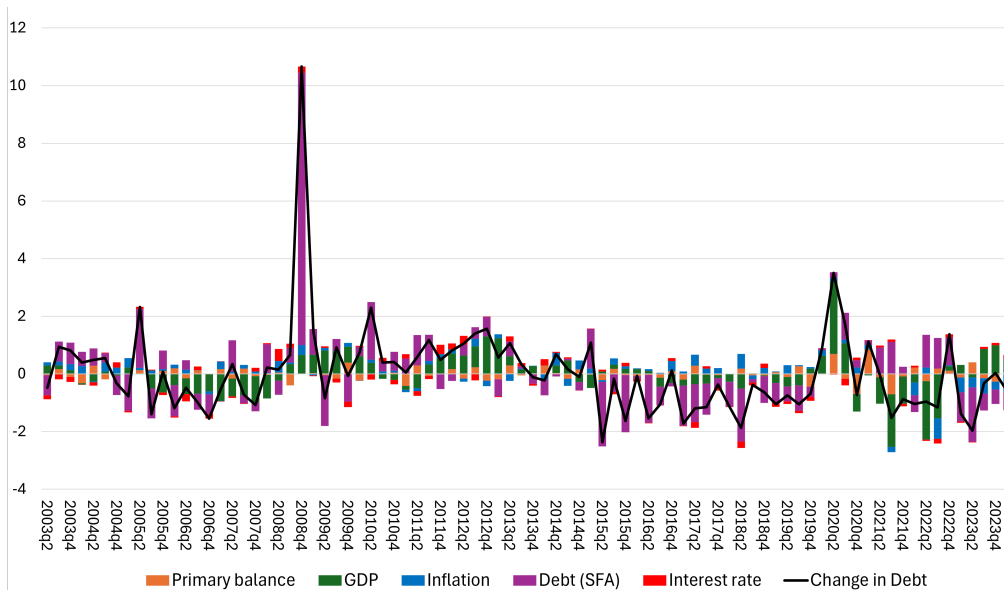
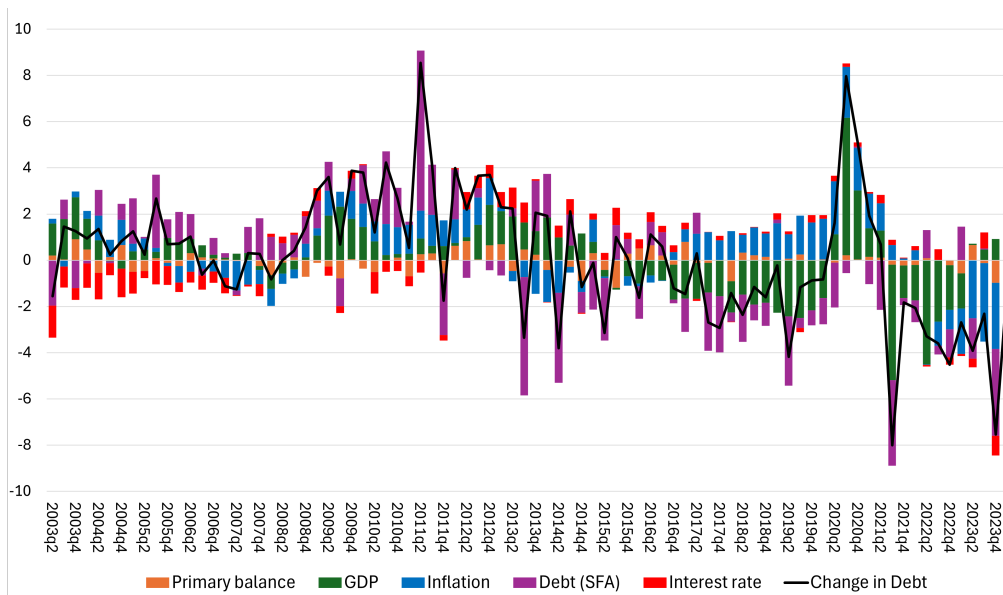
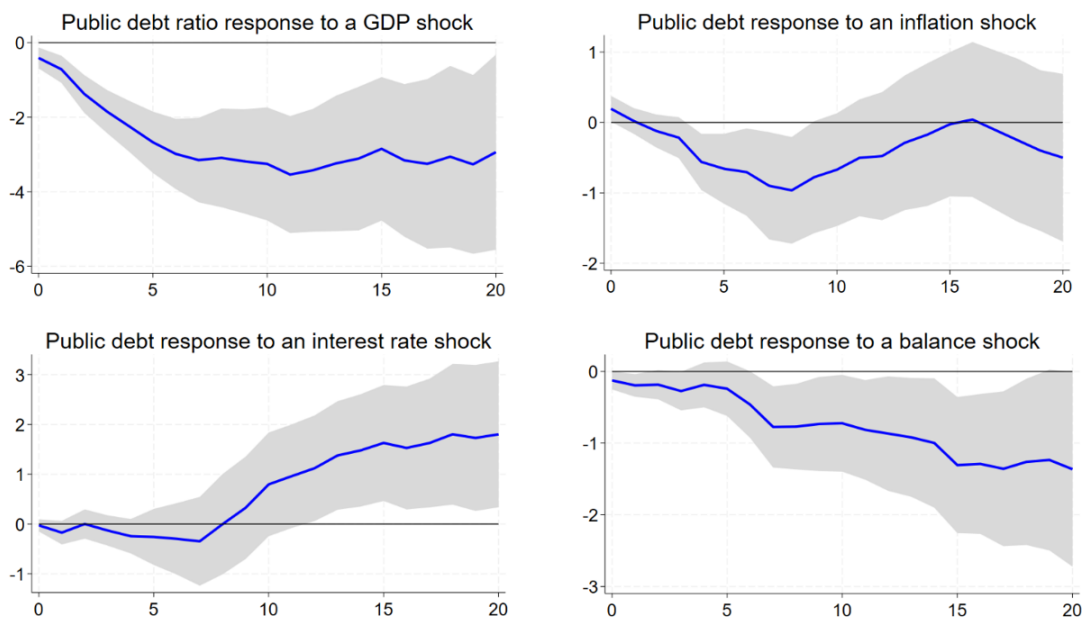


Figure B.11: Historical decomposition of the quarter-on-quarter change in the public debt-to-GDP ratio in Portugal



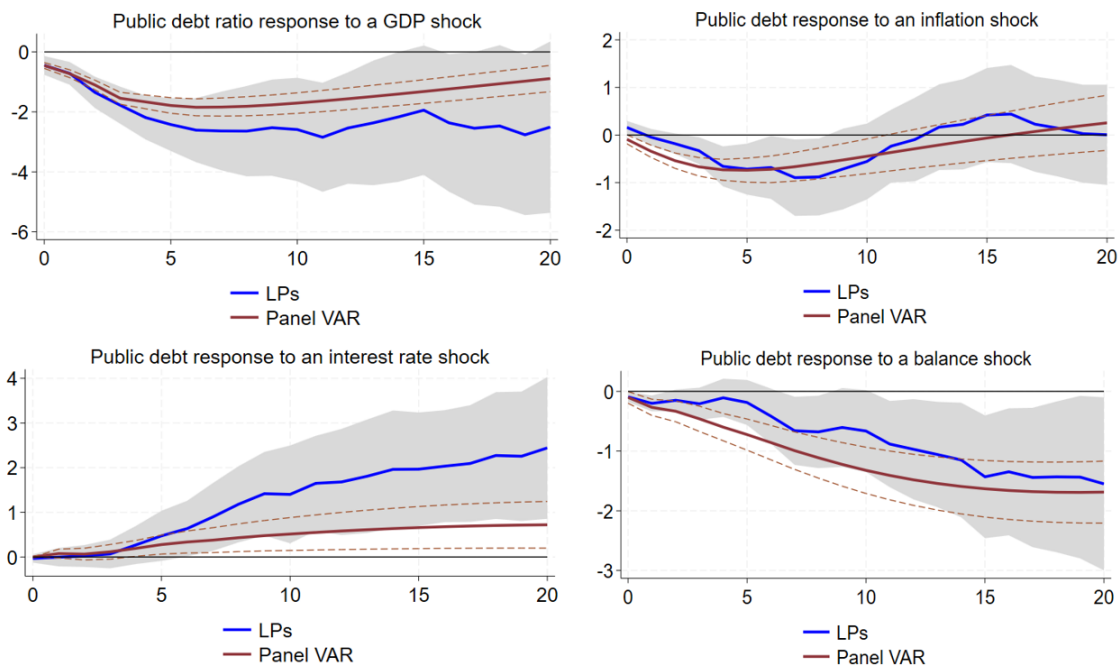
C Robustness analysis

Figure C.1: Response of public debt to various shocks, model with 10-year interest rate



Notes: The horizontal axis shows quarters. The 90% confidence band are constructed using Driscoll-Kraay standard errors.

Figure C.2: Response of public debt to various shocks, LPs vs PVAR



Notes: The horizontal axis shows quarters. The 90% confidence band are constructed using Driscoll-Kraay standard errors.