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### Monetary and fiscal policy interactions in the aftermath of an inflationary shock

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**Abstract**

This paper studies the effect of alternative monetary policy responses and the implementation of different fiscal policy measures to an inflationary shock in a monetary union, through the lens of a global DSGE model calibrated to the euro area. We find that a more aggressive monetary policy response mitigates the inflation surge, but has a detrimental impact on economic activity that imposes a stronger increase of public debt, reducing the fiscal policy space. We also find that some fiscal policy measures may alleviate the negative impact of the shock on households and firms, but do not significantly alter the inflation dynamics: a reduction of consumption taxes reduces inflation only temporarily, while an increase of transfers or of public investment slightly increase inflation initially, even if the latter may have a protracted negative impact. Overall, an appropriate mix of monetary and fiscal policies may be needed to ensure a swift return of inflation to target, while mitigating the impact on consumption. Targeting transfers to support constrained households has a mild impact on inflation, but may be a way to mitigate the impact on the most vulnerable with a less detrimental effect on public debt.

JEL: E52, E62, E63, F45

Keywords: Fiscal policy, monetary policy, public debt, inflation, cost-push shock.

## **Non-technical summary**

Inflation surged across advanced economies in 2021-2022. At first, this was due to the rebound in demand related to the easing of COVID-19 restrictions, while global supply chains remained disrupted. Inflationary pressures escalated further after Russia's invasion of Ukraine, triggering widespread price increases across a broad range of goods and services. The European Central Bank (ECB) responded by halting net asset purchases and raising interest rates to curb inflation. At the same time, euro area governments implemented support measures to help households and businesses cope with rising prices. However, broad-based subsidies, social transfers and tax cuts may have fuelled inflation by sustaining demand.

This backdrop highlights the challenging trade-offs faced by policymakers. Aggressive monetary policy tightening could help tame inflation more quickly but also risked triggering a recession and causing financial instability. Conversely, a more cautious approach could imply that inflation would remain persistently high. On the fiscal side, while subdued potential growth prospects and the uncertainty surrounding the post-pandemic recovery could justify continued government support, this needed to be calibrated to avoid undermining monetary policy transmission or hindering public debt sustainability.

The discussion on monetary-fiscal policy interactions is particularly relevant in the euro area context, as the policy mix reflects the decisions of a single monetary authority and several national governments, with distinct economic and fiscal positions. This paper contributes to a better understanding of how different policy choices – and their interplay – impact economic activity, inflation, and government debt.

The analysis relies on simulating a high-inflation environment that captures features of the recent inflationary surge in the euro area and examining the effects of alternative monetary and fiscal policy responses on economic activity, inflation and public debt. The simulations are conducted using the EAGLE (Euro Area and GLobal Economy) model, an open-economy structural model for the euro area.

The framework considered includes both low and high debt countries within the euro area.

The results of the simulations carry important policy implications. They show that delaying interest rate hikes can soften the economic downturn but prolong inflation, whereas a more aggressive approach can curb inflation faster at the cost of weaker economic activity and higher public debt. Certain government fiscal measures, such as cutting consumption taxes or increasing public investment, can help mitigate the impact on households and firms, but have only short-lived or relatively small effects on inflation.

## 1. Introduction

After remaining persistently low for over a decade, inflation increased significantly across most advanced economies in 2021-22. As COVID-19 restrictions eased, the surge was initially driven by a (temporary) mismatch between the strong rebound in demand and disruptions in global supply chains. In the euro area (EA), the resulting price pressures were further reinforced by the invasion of Ukraine in early 2022, the ensuing sanctions on Russia and its retaliations. However, inflation was more persistent and broad-based than initially expected, spanning several expenditure groups, including non-energy commodities, food and industrial goods.

In 2020-21, fiscal policy complemented the accommodative monetary policy stance in mitigating the pandemic fallout, resulting in record high levels of public debt. In 2022-24, despite the withdrawal of COVID-related measures, fiscal policy remained supportive in the EA owing to the rollout of Next Generation EU (NGEU)-financed investments and the new measures enacted to alleviate households and firms from the impact of the price surge. Such measures largely involved broad-based indirect tax cuts, subsidies to firms and untargeted social transfers, which may have added to inflationary pressures by sustaining domestic demand and providing incentives for fuel energy consumption.

Monetary policy started to normalise in end-2021, as the ECB ended net asset purchases and later lifted the policy rates from its lower bound. The pace of interest rate increases was unprecedented, as was the case in other major central banks, but, given the size of the inflationary shock, real rates remained low. Arguably, the policy stance turned tight only in the second half of 2023, when the (ex-ante) real rate surpassed most estimates of the natural rate.

The post-pandemic environment posed several challenges for both monetary and fiscal policymakers. While the inflation surge called for a less expansionary stance, both at the monetary and the fiscal fronts, the tightening pace has implications for the likelihood of a soft or hard-landing, as well as for the trajectory of inflation towards the central bank's objective. If central banks tightened too

fast, they risked triggering a recession and disrupting financial stability. If they tightened too slow, inflation could stay persistently higher, especially if it fed into higher inflation expectations. Additionally, the recovery from the pandemic was still uncertain and potential growth prospects remained subdued. While fiscal support was still warranted, it should not hinder the transmission mechanism of monetary policy nor jeopardise debt sustainability. After a prolonged period of low debt servicing costs and Eurosystem's government bond purchases, monetary policy tightening could have a significant impact on public debt. Despite the potentially favourable impact of unexpected inflation, higher nominal interest rates would in principle be detrimental for debt dynamics. In the euro area, this raised concerns that monetary tightening could also trigger adverse reactions in sovereign debt markets, especially for countries with high public debt levels.

Striking an appropriate balance between fiscal and monetary decisions in this juncture was not straightforward. Against this backdrop, it is key to understand the channels through which monetary and fiscal policies interact in a high inflation environment and how they affect the economy and debt dynamics depending on alternative policy designs and public debt levels.

This paper contributes to this discussion by shedding light on some of the issues related to the interaction of monetary and fiscal policies at times of high inflation. We simulate an inflationary environment stemming from a cost-push shock affecting the world economy. Then, we proceed in two steps: (i) study the effect of different monetary policy responses to this shock and (ii) analyse the impact of implementing alternative fiscal policy measures under those circumstances. We consider four possible measures aimed at mitigating the effects of the inflation surge on households and firms: a reduction of consumption taxes, an increase of targeted or untargeted transfers, and an increase of public investment. We analyse how these measures affect economic activity and inflation, and thus the conduct of monetary policy, through the lens of EAGLE (Euro Area and GLoBal Economy) model, an open-economy euro area structural model (Gomes *et al.* 2012).

The simulations show that the monetary authority can cushion the fall in economic activity if it chooses to delay the response to the inflationary shock. However, this comes at the cost of being more patient as regards inflation developments. On the contrary, a more aggressive monetary authority can reduce inflation faster, but the fallout in economic activity is larger and the detrimental impact on public debt is stronger.

The simulations also show that fiscal policy can mitigate the impact of the shock on consumption, while having a relatively small effect on inflation dynamics. Under these scenarios monetary policy generally delivers a more aggressive initial response, but it is also reversed faster, especially under an investment-based fiscal expansion. While most measures imply a stronger increase of the public debt-to-GDP ratio, the effect is milder under an increase of public investment, as it benefits from a stronger economic growth, and under targeted transfers, which imply a smaller fiscal effort for the same macroeconomic impact.

The paper is organised as follows. Section 2 reviews the existing literature on the interaction of monetary and fiscal policies and its relation with inflation. Section 3 briefly describes the composition of the fiscal response introduced to mitigate the impact of the inflation surge in 2022, also comparing with the impulse provided by the public investment funded through NGEU programmes. Section 4 characterises the model and its theoretical underpinnings. The simulations are presented in Section 5 and Section 6 provides sensitivity analyses. Section 7 concludes and highlights the policy implications of the analysis.

## **2. Literature review**

Monetary and fiscal policies interact with each other in many ways. The decisions of a monetary authority influence financial conditions and, as such, government's borrowing costs. Since they have an impact on economic activity and inflation, they therefore also indirectly influence public finances. Conversely, governments'

decisions impact economic activity and prices through spending and taxation, thereby shaping the environment in which monetary authorities operate.

There is broad agreement on the benefits of a separation of roles, with independent monetary policy responsible for ensuring price stability and fiscal policy guaranteeing public debt sustainability, while fulfilling distributive and efficiency objectives. This consensus derived from the seminal work of Sargent and Wallace (1981), who showed that the two policies were inextricably linked through the consolidated budget constraint of the public sector. Under a regime of 'fiscal dominance', where monetary policy is compelled to ensure the satisfaction of the intertemporal budget constraint (IBC) of the public sector, central banks may need to allow seignorage revenues to increase persistently and thus may be unable to control inflation.<sup>1</sup> For that reason, 'monetary dominance', a regime where fiscal policy is chosen in order to satisfy the IBC for any monetary policy trajectory, has been considered a necessary condition of an effective central bank's price stability mandate. We maintain this assumption throughout the analysis.<sup>2</sup>

Under 'monetary dominance', fiscal policy is generally perceived to play a secondary role as a macroeconomic stabilisation tool. However, in a low interest rate environment, a stronger role for fiscal policy may be optimal. The literature has shown that an expansionary fiscal policy is more effective when policy rates are left unchanged (see Coenen *et al.* 2012 or Kilponen *et al.* 2019). This is particularly the case when the policy rate is close to its effective lower bound (ELB), as the

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<sup>1</sup>Under the fiscal theory of the price level, if agents question the ability of the public sector to fulfil its financial obligations, an increase of the price level is required to deplete the real value of public sector liabilities. Under this alternative mechanism, the public sector IBC could determine the price level even in a cashless economy (Woodford 1995). See Cochrane (2023) for a detailed exposition of this 'fiscal theory of the price level'.

<sup>2</sup>Occasional departures from monetary dominance are feasible, and may even help stabilise the economy, yet also involve risks of de-anchoring inflation expectations (see Davig and Leeper 2007, Bianchi and Melosi 2014, Bianchi and Melosi 2017, or Bonam and Hobijn 2021).



lower borrowing costs of public debt relax the trade-off between macro stabilisation and debt sustainability (see Blanchard 2019, Bonam 2020, or Reis 2021).<sup>3</sup>

An environment of high inflation changes the nature of the challenges that these policies face independently and their interaction. On one hand, unexpected inflation reduces the real value of public debt, potentially increasing the fiscal space for stabilisation policy. A persistent increase of inflation may even be optimal if debt maturity is relatively long (see Teles and Tristani 2024). On the other hand, however, monetary policy is typically expected to respond to high inflation by increasing nominal policy rates, inducing an increase in the real interest rate, increasing the government's debt servicing costs and thus restricting the availability of fiscal space to stimulate the economy. If inflation is driven by supply factors, the lower economic activity puts additional pressure on public finances, further reducing the scope for expansionary fiscal policy (see Auclert *et al.* 2023 or Fornaro and Wolf 2023). In a monetary union, potential fragmentation risks may further exacerbate this trade-off.

This paper contributes to the existing literature by focusing on a high inflation environment modelled through a worldwide cost-push shock that captures features of the 2021/2022 inflationary surge in the euro area, to discuss how alternative monetary policy responses and variations in the composition of fiscal support differently affect the economy. This is directly related to the work presented in Bonam *et al.* (2024) that includes a comparison of alternative monetary and fiscal policy measures and rules across different models. We further explore how results differ depending on the level of public debt. We therefore add to the analysis by Dao *et al.* (2023), which, focusing on the recent inflationary surge, finds that 'unconventional' fiscal measures as those adopted in euro area countries in 2022-23 have temporarily reduced inflation by 1 to 2 percentage points in the monetary

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<sup>3</sup>When the economy hits the ELB monetary policy may actually need fiscal backing to escape a low inflation trap, as the effectiveness of changes in the nominal interest rate is severely affected when the ELB is binding (see Benhabib *et al.* 2001).

union, possibly helping to stabilise longer-term inflation expectations. Importantly, we pay special attention to the implications of alternative fiscal and monetary policy options, under different debt level regimes, for the dynamics of government debt. This complements the findings in Motyovszki (2023), which analyses the effects of a terms-of-trade inflationary shock on the public debt dynamics and concludes that this almost always leads to an increase of public debt, independently of most policy responses.

### **3. Fiscal policy measures**

Following the 2021-22 inflation surge, euro area governments adopted measures to alleviate its short term impact on households and firms. Compared to monetary policy, fiscal policy is best equipped to address this challenge, as governments have the appropriate tools to direct support specifically to most vulnerable firms and households. This targetting is all the more relevant given the unequal impact of the price surge and the ability to cushion it across the income distribution. However, governments have mostly resorted to untargeted, across-the-board measures, which risked reinforcing the inflationary pressures and hampering the transmission of monetary policy.

These measures were primarily designed to be temporary and concentrated in 2022 and 2023. In 2022, support measures are estimated to have worsened the euro area budget balance by around 1.5% of GDP (Figure 1). Although they began to be gradually phased out in the following year, their budgetary impact remained non-negligible by 2024. The fiscal support enacted as a response to the inflationary surge varied considerably across euro area countries, both in terms of magnitude and, importantly, of composition. The majority of the announced measures consisted of subsidies to firms, with some specifically targetting sectors particularly vulnerable to inflation, or compensating energy providers for price caps. However, most of the support was not targetted. Similarly, only a small share of social transfers was directed towards low-income households. Additionally, several governments have

implemented cuts in indirect taxation largely focusing on energy goods, thereby supporting demand for fossil fuel consumption.

[ PLACE FIGURE 1 HERE ]

The fiscal support stemming from these measures coincided with the initial years of the NGEU programme's implementation. Between 2022 and 2024, execution averaged 0.4% of GDP across euro area countries, falling significantly short of expectations. While also in this case there is wide cross-country variation, public investment and capital transfers to firms dominate the composition, the latter effectively aiming at propelling private investment (Figure 2). As the rollout of projects foreseen in the Recovery and Resilience Plans (RRPs) accelerates, the stimulus provided by these investments is set to become increasingly important in the euro area.

[ PLACE FIGURE 2 HERE ]

The fiscal support deployed throughout the euro area during and in the aftermath of the inflationary shock varied considerably across countries, both in magnitude and in composition. Different fiscal instruments have different impacts on economic activity and price developments and, therefore, may trigger different responses from monetary policy. In the next sections we look into these issues through the lens of the EAGLE model.

#### **4. The model**

In the simulations we use a large-scale, multi-country, open economy microfounded general equilibrium model of the euro area within the world economy, the EAGLE model.<sup>4</sup> In this version of the model, the euro area is split in three blocs: a low

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<sup>4</sup>The EAGLE model was developed as an ESCB project by a team composed of staff from the Bank of Italy, the Bank of Portugal and the ECB. For details of the baseline structure see Gomes

public debt bloc (representing around 30% of the euro area), a high public debt bloc (around 50%) and the rest of the euro area. The various blocs are modelled symmetrically, though with different calibrations. Consistently with the monetary union framework, the three euro area blocs share monetary policy and the nominal exchange rate against the rest of the world (RW). In each bloc, the EAGLE model includes several types of agents: households, firms, a monetary authority and a fiscal authority. Compared to Gomes *et al.* (2012), the model also includes an enhanced fiscal block where public expenditures are allowed to play a more relevant role than in more simple settings.

The size of the world economy is normalized to one. The size of each region measures the share of resident households and domestic sector-specific firms, both defined on a continuum of mass  $s$ . In what follows, the focus is on the Home economy ( $H$ ) of size  $s^H$ , as other countries are similarly characterized.

#### 4.1. Firms

On the firms' side, there are two types of firms: one producing intermediate goods and one producing final goods. Intermediate goods are produced by firms under monopolistic competition. A set of intermediate goods firms produces tradable goods and another set produces non-tradable goods, using domestic labour and capital, both private and public, combined according to a Cobb–Douglas technology. For the case of tradable goods:<sup>5</sup>

$$Y_{T,t} = z_{T,t} K_{G,t}^{\alpha_G} K_{T,t}^{\alpha_T} N_{T,t}^{1-\alpha_T} - \psi_T \quad (1)$$

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*et al.* (2012). The model shares a similar theoretical setup to the ECB New Area Wide model (NAWM, Coenen *et al.* 2008a).

<sup>5</sup>A similar production function holds for the non-tradable sector.

where  $\psi_T$  is a fixed cost. The inputs are homogenous private capital services,  $K_{T,t}$ , and labour services,  $N_{T,t}$ . Private capital services are supplied by domestic households under perfect competition. Government capital services ( $K_{G,t}$ ) enter the private sector's production function in a non-rivalrous way, enhancing the productivity of private capital in a similar manner to technological progress.  $z_{T,t}$  is a sector-specific productivity shock. Market power implies that firms set nominal prices and charge a markup over marginal costs. Nominal prices are sticky à la Calvo with partial indexation.

Final goods producing firms act under perfect competition. Final goods can be used for private consumption ( $Q_{C,t}$ ) and for private investment. Both are assembled in a similar way. Taking the consumption good as an example, it is assembled from tradable goods,  $TT_{C,t}$  and non-tradable goods,  $NT_{C,t}$  using a constant elasticity of substitution technology:<sup>6</sup>

$$Q_{C,t} = \left[ \nu_C^{\frac{1}{\mu_C}} TT_{C,t}^{\frac{\mu_C-1}{\mu_C}} + (1 - \nu_C)^{\frac{1}{\mu_C}} NT_{C,t}^{\frac{\mu_C-1}{\mu_C}} \right]^{\frac{\mu_C}{\mu_C-1}}. \quad (2)$$

Similarly, tradable goods are a composite bundle of domestic tradable goods,  $HT_{C,t}$ , and imports,  $IM_{C,t}$  which, in turn, are also a composite of imports from other regions:

$$TT_{C,t} = \left[ \nu_{TC}^{\frac{1}{\mu_{TC}}} HT_{C,t}^{\frac{\mu_{TC}-1}{\mu_{TC}}} + (1 - \nu_{TC})^{\frac{1}{\mu_{TC}}} IM_{C,t}^{\frac{\mu_{TC}-1}{\mu_{TC}}} \right]^{\frac{\mu_{TC}}{\mu_{TC}-1}}. \quad (3)$$

$$IM_{C,t} = \left[ \sum_{CO \neq H} \left( \nu_{IM_C}^{H,CO} \right)^{\frac{1}{\mu_{IM_C}}} \left( IM_{C,t}^{H,CO} \left( 1 - \Gamma_{IM_C}^{H,CO} \right) \right)^{\frac{\mu_{IM_C}-1}{\mu_{IM_C}}} \right]^{\frac{\mu_{IM_C}}{\mu_{IM_C}-1}} \quad (4)$$

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<sup>6</sup>Similar definitions hold for the case of investment goods.

Parameters  $\mu_C$ ,  $\mu_{TC}$  and  $\mu_{IM_C}$  are intratemporal elasticities of substitution between the inputs in the production functions, while  $\nu_C$ ,  $\nu_{TC}$  and  $\nu_{IM_C}$  are weights (quasi-shares) of the inputs into the production functions.<sup>7</sup> The term  $\Gamma_{IM_C}^{H,CO}$  represents adjustment costs on bilateral consumption imports of country  $H$  from partner country indexed by  $CO$ .

There are also final public goods. Following Clancy *et al.* (2016), and unlike in the original formulation of the EAGLE model, government spending on imported goods is allowed. We assume that governments purchase a composite final good which is produced by firms that act under perfect competition and assemble final government consumption and investment bundles. This is done with a CES technology, using tradable goods and non-tradable goods, in a similar way to that described above.

#### 4.2. Households

On the households' side, the model includes both Ricardian (indexed by  $i \in [0, s^H (1 - \omega)]$ ) and non-Ricardian households (indexed by  $j \in [s^H (1 - \omega), s^H]$ ), where  $\omega$  is the share of non-Ricardian households. Households gain utility from consuming and suffer disutility from working. They maximise lifetime utility:

$$E_t \left[ \sum_{k=0}^{\infty} \beta^k \left( \frac{1 - \kappa}{1 - \sigma} \left( \frac{\tilde{C}_{t+k}(s) - \kappa \tilde{C}_{S,t+k-1}}{1 - \kappa} \right)^{1-\sigma} - \frac{1}{1 + \zeta} h_{t+k}^{1+\zeta}(s) \right) \right] \quad (5)$$

where  $\tilde{C}_t(s)$  is consumption ( $s = i, j$ ), which is a CES aggregation of private and public consumption:<sup>8</sup>

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<sup>7</sup> Coefficients  $\nu_{IM_C}^{H,CO}$  are such that:  $0 \leq \nu_{IM_C}^{H,CO} \leq 1$  and  $\sum_{CO \neq H} \nu_{IM_C}^{H,CO} = 1$ .

<sup>8</sup> Changes in government consumption affect optimal private consumption decisions directly, as opposed to the indirect wealth effect observed with separable government consumption.

$$\tilde{C}_t = \left[ \nu_{CCES}^{\frac{1}{\mu_{CCES}}} C_t^{\frac{\mu_{CCES}-1}{\mu_{CCES}}} + (1 - \nu_{CCES})^{\frac{1}{\mu_{CCES}}} C_{G,t}^{\frac{\mu_{CCES}-1}{\mu_{CCES}}} \right]^{\frac{\mu_{CCES}}{\mu_{CCES}-1}} \quad (6)$$

and  $\beta$  is the discount rate,  $\sigma$  is the inverse of the intertemporal elasticity of substitution and  $\zeta$  is the inverse of the elasticity of hours worked with respect to the real wage.  $\kappa$  is the degree of habit formation in consumption of each type of households, where the habit depends on the aggregate consumption of the type,  $\tilde{C}_t(S)$ .

Ricardian households have access to financial markets, where they buy and sell domestic government bonds ( $B_t$ ) and internationally traded bonds denominated in US dollars ( $B_t^*$ ). They accumulate physical capital and rent out its services to firms ( $u_t K_t$ ) at the rental rate  $R_{K,t}$ . The intensity of capital utilization is subject to a proportional cost  $\Gamma_{u,t}$ . They hold money ( $M_t$ ) for transaction purposes where the transaction cost  $\Gamma_{v,t}$  depends on consumption-based velocity.

The fiscal authority levies taxes on gross income and spending. In particular,  $\tau_t^C$  denotes the tax rate levied on consumption purchases,  $\tau_t^L$ ,  $\tau_t^K$  and  $\tau_t^D$  represent tax rates levied respectively on wage income, rental capital income and dividends from firms ownership.  $TR_t(i)$  represents lump-sum transfers received from the government and  $T_t(i)$  lump-sum taxes. The individual budget constraint for household  $i$  is:

$$\begin{aligned}
& (1 + \tau_t^C + \Gamma_{v,t}) P_{C,t} C_t(i) + P_{I,t} I_t(i) + R_t^{-1} B_{t+1}(i) \\
& + ((1 - \Gamma_{B^*}) R_t^*)^{-1} S_t^{H,US} B_{t+1}^*(i) + M_t(i) + \Phi_t(i) + \Xi_t \\
= & (1 - \tau_t^L) W_t(i) N_t(i) + (1 - \tau_t^K) (R_{K,t} u_t(i) - \Gamma_u P_{I,t}) K_t(i) \\
& + \tau_t^K \delta P_{I,t} K_t(i) + (1 - \tau_t^D) D_t(i) + T R_t(i) - T_t(i) \\
& + B_t(i) + S_t^{H,US} B_t^*(i) + M_{t-1}(i)
\end{aligned} \tag{7}$$

where  $P_{C,t}$  and  $P_{I,t}$  are the prices of a unit of the private consumption good and the investment good, respectively.  $R_t$  and  $R_t^*$  denote, respectively, the risk-less returns on domestic government bonds, and internationally traded bonds that are denominated in US where  $S_t^{H,US}$  is the nominal exchange rate of Home currency, the euro, against the US dollar. The term  $\Gamma_{B^*,t}$  represents a financial intermediation premium. The incurred premium is rebated in a lump-sum manner ( $\Xi_t$ ) to domestic I-type households that own firms.

The introduction of constrained households allows for Keynesian effects of public expenditure in the model. Non-Ricardian households are liquidity constrained and only have access to the domestic money market. Their sole source of income is the labour supplied to domestic firms and government transfers. Even though they do not have access to capital and bond markets, they can intertemporally smooth consumption by adjusting their holdings of money. They choose purchases of the consumption good and holdings of money that maximize their lifetime utility function (assumed to be similar to that of Ricardian households), subject to the following budget constraint:



$$\begin{aligned}
& (1 + \tau_t^C + \Gamma_v) P_{C,t} C_t(j) + M_t(j) + \Phi_t(j) \\
& = (1 - \tau_t^L) W_t(j) N_t(j) + TR_t(j) - T_t(j) + M_{t-1}(j) \quad (8)
\end{aligned}$$

Following Coenen *et al.* (2008b), we calibrate transfers to non-Ricardian households, in per capita terms, relative to those of Ricardian households in the proportion of 3 to 1, to guarantee a meaningful level of consumption of constrained households in the steady state.

#### 4.3. Monetary authority

The euro area blocs share a common monetary authority. The monetary authority sets the nominal interest rate  $i_t$  according to a standard Taylor rule, reacting to the annual inflation rate ( $\Pi_t$ ) and the quarterly output growth rate ( $\hat{Y}_t = Y_t/Y_{t-1}$ ):

$$R_t^4 = \varphi_R R_{t-1}^4 + (1 - \varphi_R) \left( R^* + \Pi^* + \varphi_\pi (\Pi_t - \Pi^*) + \varphi_Y (\hat{Y}_t - 1) \right) + \varepsilon_t^R \quad (9)$$

where  $R_t^4$  is the annualised nominal interest rate,  $R^*$  is the annualised long-run equilibrium real interest rate and  $\Pi^*$  is the annual inflation target.  $\varepsilon_t^R$  is a shock.

#### 4.4. Fiscal authority

In the euro area, fiscal policy is decided at the national level and, to capture this, the version of the EAGLE model that is used incorporates an enhanced fiscal block (for details see Clancy *et al.* 2016). The fiscal authority sets public expenditure, lump-sum taxes and transfers, and distortionary taxes. Government spending on consumption and investment goods is specified as a fraction of steady-state nominal output. Government investment is not wasteful and contributes to the public capital

stock. As explained above, government capital enhances the productivity of private capital in a similar manner to technological progress (see equation 1 for the case of tradable goods). The model allows for a degree of complementarity between private and government consumption.

Government expenditure is financed by raising taxes or issuing public debt ( $B_t$ ) on domestic financial markets. Taxes can be lump-sum or distortionary (the latter are raised on labour income  $\tau_t^L$ , capital income  $\tau_t^K$ , dividends  $\tau_t^D$ , and consumption expenditure  $\tau_t^C$ ). Lump-sum transfers ( $TR_t$ ) are said targeted when they are distributed solely to the non-Ricardian households. The government also earns seigniorage on outstanding money holdings ( $M_t$ ), and levies a payroll tax on wages paid by firms (social contributions rate  $\tau_t^{W_f}$ ). Therefore, the fiscal authority's budget constraint is:

$$\begin{aligned}
& P_{G,t} (C_{G,t} + I_{G,t}) + TR_t + B_t + M_{t-1} \\
= & \tau_t^C P_{C,t} C_t + \tau_t^L \frac{1}{s^H} \left( \int_0^{s^H(1-\omega)} W_t(i) N_t(i) di + \int_{s^H(1-\omega)}^{s^H} W_t(j) N_t(j) dj \right) \\
& + \tau_t^{W_f} W_t N_t + \tau_t^K (R_{k,t} u_t - (\Gamma_u + \delta) P_{I,t}) K_t + \tau_t^D D_t \\
& + T_t + (R_t^G)^{-1} B_{t+1} + M_t
\end{aligned} \tag{10}$$

A fiscal rule guarantees a long-term target for public debt as a percentage of GDP through the smooth adjustment of lump-sum taxes ( $\tau_t$ ):

$$\tau_t = \varphi_{B_Y} \left( \frac{B_t}{\overline{P_Y Y}} - B_Y^* \right) \tag{11}$$

where  $B_Y^*$  is the fiscal authority's target for the ratio of government debt to output and  $\varphi_{B_Y} > 0$  is a parameter. All distortionary tax rates are assumed to be exogenously set by the fiscal authority and constant unless otherwise stated.

The law of motion for public capital stock,  $K_G$ , is:

$$K_{G,t+1} = (1 - \delta_G) K_{G,t} + I_{G,t} \quad (12)$$

where  $\delta_G > 0$  is the depreciation rate.

Finally, following Motyovszki (2023), we assume the interest rate on public debt,  $R_t^G$ , evolves according to an auto-regressive process to capture the duration of public debt. Even though we only have one-period debt in the model, this feature intends to generate a lower pass-through from changes of the policy rate into public debt service payments, by assuming that the effective nominal government interest rate adjusts gradually to a change in the policy rate. The effective interest rate on public debt is defined as:<sup>9</sup>

$$R_t^G = \rho^G R_{t-1}^G + (1 - \rho^G) R_t \quad (13)$$

#### 4.5. Calibration

Tables 1 to 3 summarise the (quarterly) calibration of the model. We set parameter values according to the empirical evidence or existing literature on the NAWM (Coenen *et al.* 2008a) and the GEM (Global Economy Model, Laxton and Pesenti 2003). We calibrate the model to broadly match two sets of countries within the euro area representing two different public debt levels: one with 60% of GDP public

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<sup>9</sup>This implies an average weighted maturity on the outstanding public debt stock equal to  $\frac{1}{1-\rho^G}$ .

debt (the low debt country bloc), another where it stands at 120% of GDP (the high debt country bloc).<sup>10</sup>

Table 1 reports preference and technology parameters. Preferences are the same across household types and regions. We set the discount factor, the habit persistence parameter, the intertemporal elasticity of substitution and the Frisch elasticity respectively to 0.9926 (implying a steady-state annualised real interest rate of about 3 percent), 0.65, 1 and 0.50. We set the share  $\omega$  of  $J$ -type (borrowing-constrained) households to 0.25 in all regions, except in the high debt bloc where it is set to 0.50.

[ PLACE TABLE 1 HERE ]

For the production side, the bias towards capital is set at 0.3 in the Cobb-Douglas production functions of tradable and non-tradable intermediate goods. As for the final goods composite baskets, the degree of substitutability between domestic and imported tradables is higher than that between tradables and non-tradables, consistent with existing literature. Specifically, we set the elasticity of substitution between tradables and non-tradables to 0.5 and the elasticity between domestic and imported tradables to 1.5. The biases towards the tradable bundle in the consumption and investment baskets are respectively equal to 0.45/0.50 and 0.75 in each region of the euro area, and to 0.35 and 0.75 in the rest of the world. The weight of domestic tradable goods in the consumption and investment baskets is different across countries, to match the multilateral import-to-GDP ratios.

Table 2 reports nominal and real rigidities. We set Calvo price parameters in the domestic tradables and non-tradables sector to 0.80 in the euro area, consistently with estimates by Coenen *et al.* (2008a) and Smets and Wouters (2003). Corresponding nominal rigidities outside the euro area are equal to 0.75,

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<sup>10</sup>The low debt bloc is calibrated to Germany, while the high debt bloc is calibrated to Spain, Italy and France. The rest of the euro area is assumed to have a 60% of GDP public debt level, as the low debt bloc.

in line with Faruquee *et al.* (2007). Calvo wage and price parameters in the export sector are equal to 0.75 in all regions. The indexation parameters on prices and wages are respectively equal to 0.50 and 0.75, so to get sufficiently hump-shaped response of wages and prices. For real rigidities, we set adjustment costs on investment changes to 2.5 in the euro area and to 1 in the case of the rest of the world; and set adjustment costs on consumption and investment imports respectively to 5 and 6, in euro area, and to 3 and 4, in the rest of the world.

[ PLACE TABLE 2 HERE ]

Table 3 reports parameters in the monetary and fiscal rules. The interest rate reacts to the its lagged value, annual inflation and quarterly output growth. In the monetary union, monetary policy reacts to euro area-wide variables. For fiscal rules, lump-sum taxes stabilise public debt. Steady-state ratios of government debt over output are equal to 2.40 in all regions (0.60 in terms of annual output) except in the high debt bloc, where it is equal to 4.80 (1.20 in terms of annual output). Consistently with the empirical evidence (see Coenen *et al.* 2008b), steady-state tax rates on consumption are respectively equal to 0.17 in the euro area and to 0.08 outside the euro area. Finally, the autoregressive parameter on the effective public debt interest rate ( $\rho^G$ ) is set to 0.857, so the average maturity of public debt is about 7 years.

[ PLACE TABLE 3 HERE ]

## 5. Simulation results

In this section we describe the impact of a worldwide supply shock in the model. We begin by considering different monetary policy responses, analysing their effect on economic activity, inflation and the public debt level. Then, we consider alternative fiscal policy measures and evaluate their impact at the macroeconomic level and on

the conduct of monetary policy. The effect of the different policy responses on the public debt level of the two blocs is compared by breaking down the determinants of public debt dynamics. Simulations are deterministic under perfect foresight.

### **5.1. *The supply shock***

We simulate a worldwide supply shock. This is an unanticipated cost-push shock that hits both the tradable and non-tradable sectors of the euro area and the rest of the world. The shock is modelled so to drive a maximum increase of (annual) inflation of around 1 p.p. in the second year, dying out smoothly. In particular, there is an unanticipated shock in the beginning of the first year and another at the beginning of the second year; after that, the shock dies out following an AR(1) process with parameter equal to 0.25. In the baseline case, monetary policy reacts according to the model's benchmark Taylor rule and the fiscal authorities react according to the model's fiscal rule.

Figure 3 shows the responses of a set of macroeconomic variables to the supply shock over five years (black line). Given the cost-push shock, there is an increase in production costs that drives up consumer price inflation. This requires a response of the monetary authority and thus the policy rate increases. At the same time, the shock drives a significant drop in economic activity, hours worked and real wages, negatively affecting both investment and private consumption, especially for constrained consumers. The public debt-to-GDP ratio gradually increases, as the negative impact on economic activity and a mild increase of the primary deficit more than offset the favourable impact of the unexpected inflation through the denominator effect. The policy rate hikes also increase public debt interest costs, even if only gradually, which amplifies the increase in public debt over time.

[ PLACE FIGURE 3 HERE ]

## **5.2. *Alternative monetary policy responses***

In the baseline simulation described above, monetary policy reacts according to the model's monetary policy reaction function that includes a mild response to the output growth and a stronger response to inflation. In this section, we illustrate two alternative scenarios: one in which the monetary authority delays the response to the inflation burst by two years (red); and a second one where the monetary authority responds more aggressively to the inflation burst than in the baseline scenario (we consider a +100 b.p. shock split over 2 years, i.e. +50 b.p. in the beginning of the first year that lasts for two years and an additional +50 b.p. in the beginning of the second year that lasts for one year, identified in blue in the chart). Figure 3 also summarises these results.

The simulations illustrate the trade-off faced by the monetary authority following a supply shock. The supply shock leads to a rise in inflation but a drop in output. If the monetary authority chooses to delay the response, then, in the short to medium run, it cushions the fall in economic activity but at the cost of being more patient as regards inflation developments. If the monetary authority is more aggressive, it is able to bring inflation to lower levels but with a larger drop in economic activity. The difference is particularly pronounced for the consumption of unconstrained households and investment.

## **5.3. *Alternative fiscal policy responses***

In face of the inflationary cost-push shock, alternative choices by the fiscal authority impact in different ways the monetary authority's ability to bring inflation closer to target over the short run. In this section, we consider four alternative discretionary fiscal policy measures to mitigate the recessionary effect of the cost-push shock. We consider a reduction of consumption taxes (green line in Figure 4), an increase of untargeted transfers (magenta) and an increase in productive public investment (blue). In these three cases the direct budgetary impact amounts to 1% of pre-shock output. We also consider the case of targeted transfers to support

constrained households only (red), which are calibrated to achieve the same impact on constrained households' consumption as in the case of untargeted transfers. All fiscal measures are implemented in the first quarter and last for four years. The fiscal rule that stabilises public debt using lump-sum taxes is inactive during this period. The monetary policy response is set at the benchmark rule considered in the previous section.

Figure 4 summarises the macroeconomic implications of the different fiscal measures. The increase of public investment has a strong positive impact on output, employment and consumption. As public investment feeds into higher productivity, this leads to stronger real wage growth, further supporting private consumption. The crowding-out implying an initial negative impact on private investment is reverted after some time, as interest rates decline more rapidly in this case. These effects provide persistent support to economic activity. The other measures considered also mitigate the reduction of economic activity over the short run, given their favourable impact on consumption. In the case of transfers, this occurs only through the consumption of constrained households (that represent around 35% of the euro area population). By contrast, the consumption of unconstrained households slightly drops, since transfers do not directly affect their decision but the increase in interest rates leads to an intertemporal shift towards the future. While measures support aggregate private consumption, private investment also underperforms in these cases due to crowding out, so the impact on real output is negligible.

[ PLACE FIGURE 4 HERE ]

The different fiscal policy actions imply a different impact on inflation, and, as such, prompt a different monetary policy response. The decrease in consumption taxes mitigates the inflationary shock in the short run, but the effect is short-lived as it also supports economic activity. Once the measure unwinds, there is an opposite impact on inflation. This requires a slightly stronger monetary policy response.



The increase in transfers cushions the fall in the consumption of constrained households with a mild rise in inflation, thus the monetary authority needs to raise the policy rate somewhat more strongly. Lump-sum (i.e., non-distortionary) transfers do not directly affect the choices of unconstrained households because these households behave in a Ricardian fashion. For this reason, the macroeconomic impact of targeted and untargeted transfers is identical, except for the fiscal cost. Even though we consider for simplicity fully Ricardian and non-Ricardian households, if the behaviour of (some) unconstrained households were to include non-Ricardian features, then untargeted transfers would imply an additional rise in inflationary pressures relative to the targeted transfers scenario. The increase in public investment also implies a positive impact on inflation in the short run and provides a stronger cushion against the negative impact of the shock on economic activity, inducing a stronger monetary policy response in the short term. As this feeds into stronger productivity, it exerts downward pressure on inflation in the medium term, implying a faster reversal of the monetary policy tightening.

#### ***5.4. Monetary-fiscal interactions through the public debt***

Monetary and fiscal policies are fundamentally interconnected through the government budget constraint and their interplay can be critically assessed by examining the drivers of the public debt-to-GDP ratio: primary deficit, nominal interest rate on public debt, real output growth and inflation. By changing the policy rate, the monetary authority directly affects the cost of servicing public debt, while the resulting impact on inflation and economic activity indirectly affects the government's fiscal space to steer discretionary spending and taxation. This occurs both through the impact of automatic stabilisers on the budget balance and the denominator effect on the debt-to-GDP ratio. In turn, governments' decisions regarding spending and taxes directly impact the primary deficit, while also influencing both real GDP and inflation dynamics and thus shaping the actions of the monetary authority.

Figure 5 shows the decomposition of public debt dynamics for each of the monetary policy alternative scenarios and for both low and high debt countries. The different paths of the interest rate imply significant differences for public finances. The public debt-to-GDP ratio increases more significantly when the monetary authority raises interest rates more aggressively and much less if monetary policy reaction is postponed. In the latter case, the increase in debt servicing costs is very mild. The higher inflation further limits the increase in debt through a favourable nominal impact on the budget balance and on the denominator. On the contrary, if monetary policy reacts more aggressively, the cost of servicing the debt is stronger and the debt-reducing effect of higher inflation becomes weaker.

[ PLACE FIGURE 5 HERE ]

When comparing the evolution of public debt in the two blocs, differences mainly stem from the snowball effect of real interest payments, as the cumulative contribution of the primary deficit is similar across the different monetary policy alternatives. In the baseline case, the increase in public debt is only slightly larger in the high public debt countries. The difference between the two blocs is somewhat starker if monetary policy responds more aggressively, further reducing the fiscal space in these countries. Interestingly, if the monetary policy response is postponed, the public debt increases to a lesser extent in high debt countries due to the stronger debt-reducing effect of higher inflation over this period.

Figure 6 shows the public debt decompositions for the four fiscal policy alternatives. Not surprisingly, all fiscal policy choices accentuate the increase in public debt, especially over the medium run, when compared with the baseline case. The different fiscal policy measures imply either an increase in government spending or a decrease in revenue, which thus leads to a larger primary deficit and an increase in public debt, but to varying degrees. The impact stemming from the increase in public investment is lower, mainly due to the favourable impact on economic activity (denominator effect). After four years, the impact on public debt

is similar to that implied by the increase in fiscal transfers targeted to constrained households, but in this case the smaller debt increase stems from a lower direct budgetary cost. The impact on public debt is greater in the case of the VAT reduction and the increase in untargeted transfers, especially in the latter, as it induces a slightly stronger monetary policy reaction.

[ PLACE FIGURE 6 HERE ]

The comparison across the two blocs does not show substantial differences, with the exception of the targeted transfers case. In this case, the increase in the debt-to-GDP ratio is somewhat stronger in the high debt bloc, owing to the larger budgetary cost stemming from the higher share of constrained households in these countries.

## **6. Sensitivity analysis**

In this section we try to understand the robustness of the results under alternative settings. In particular, we assess how the results depend on the frequency of price changes and on the productivity of public investment.

### **6.1. Frequency of price changes**

The evolution of inflation in an economy faced with a cost-push shock will critically depend on the frequency of price changes. Alvarez *et al.* (2018) present evidence suggesting that, above certain inflation levels, price changes become more frequent and larger in size, making inflation dynamics more difficult to control. Dedola *et al.* (2024) document that this also happened in the recent inflationary process in the euro area. Hence, it is important to understand how a higher frequency of price changes affects the monetary policy response. Figure 7 shows the response of output, inflation, the policy rate and the public debt to a global supply shock under different Calvo price parameters (changed from 0.8 in the baseline calibration to

0.7, more flexible case, and 0.9, more rigid case) for the three alternative monetary policy responses considered.

[ PLACE FIGURE 7 HERE ]

With a lower Calvo price parameter, implying more frequent price changes, inflation increases more in the beginning, requiring a stronger monetary policy response. In the medium run inflation also declines faster, implying a quicker reversal of monetary policy and faster recovery of output. Critically, the monetary policy response is more important to control inflation: under a delayed policy response, inflation reaches a higher level and takes longer to decline. With less frequent price changes, a more aggressive monetary policy response is able to almost mute the effects on inflation. This comes at the expense of a slightly more negative real impact and substantially higher public debt.

## **6.2. *Productivity of public investment***

The medium-run impact of an increase of public investment will crucially depend on the productivity of public investment. Figure 8 shows the response of output, inflation, the policy rate and the public debt to a global supply shock under different public investment productivity levels (changed from 0.1 in the baseline calibration to 0.05, less productive, and 0.15, more productive). On the real side, the effects are noticeable. Namely, with a lower productivity, the favourable impact of public investment on economic activity is more mitigated and short-lived compared to the baseline calibration. This also implies a stronger impact on public debt, which in the end stands in line with that of other fiscal policy measures. However, the results suggest that differences in public investment productivity have a very small impact on inflation and thus also imply small changes on the monetary policy response.

[ PLACE FIGURE 8 HERE ]

## 7. Concluding remarks

Monetary and fiscal policies interact through different channels. Whereas in a low inflation and low interest rate environment they may naturally align, in a high inflation environment new challenges may arise, in particular when shocks generate a trade-off between stabilising inflation and economic activity.

This paper looks at the issues related to how monetary and fiscal policy interact in a high inflation environment, considering the case of a worldwide supply shock that leads to an increase in inflation and a fall in economic activity. Results show that, if the monetary authority delays the response to the inflationary shock looking through the shock in the short term, it can cushion the fall in economic activity. However, this comes at the cost of being more patient as regards inflation developments. On the contrary, a more aggressive monetary authority can reduce inflation faster, but the fallout in economic activity is larger and the detrimental impact on public debt is stronger.

The simulations also show that fiscal policy can mitigate the negative impact of the shock on consumption, while having a relatively small impact on inflation dynamics. A consumption tax cut can mitigate the initial inflation surge, but the consumption support still implies a somewhat stronger monetary policy response. An investment-based fiscal expansion has a small initial positive impact on inflation and a negative impact in the medium run, implying a stronger initial monetary policy response, but also a swifter reduction of the interest rate at a later stage. The increases in untargeted transfers gives greater support to the consumption of constrained households, while generating somewhat higher inflation and thus implying a stronger response of the policy rate. Targeting transfers to constrained households calibrated to achieve a similar macroeconomic impact imply a lower aggregate fiscal cost.

Results highlight the challenges facing both monetary and fiscal authorities in a high inflation environment, underscoring the importance of achieving a balanced mix between them. Results also highlight that, when monetary policy needs to bring

inflation to target from a high level, it is important for fiscal policy to choose the appropriate measures that will support the part of the population that is mostly affected, while at the same time contributing only mildly against the disinflationary efforts. This speaks in favour of temporary and targeted fiscal measures, while productive public investments may also support growth.

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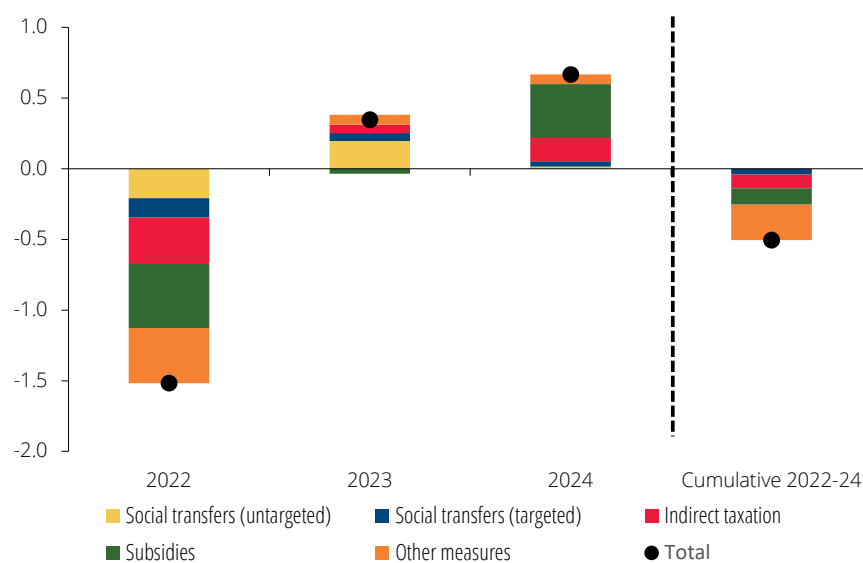


Figure 1: Fiscal measures to cushion the impact of the price surge in the euro area: impact on the budget balance. (% of euro area GDP)

Source: Own calculations based on data collected by the Eurosystem's Working Group on Public Finance.

Note: Both on the revenue and expenditure sides, the chart depicts the budgetary cost of fiscal measures in incremental terms, i.e., relative to the previous year. Negative (positive) bars imply fiscal stimulus (tightening).

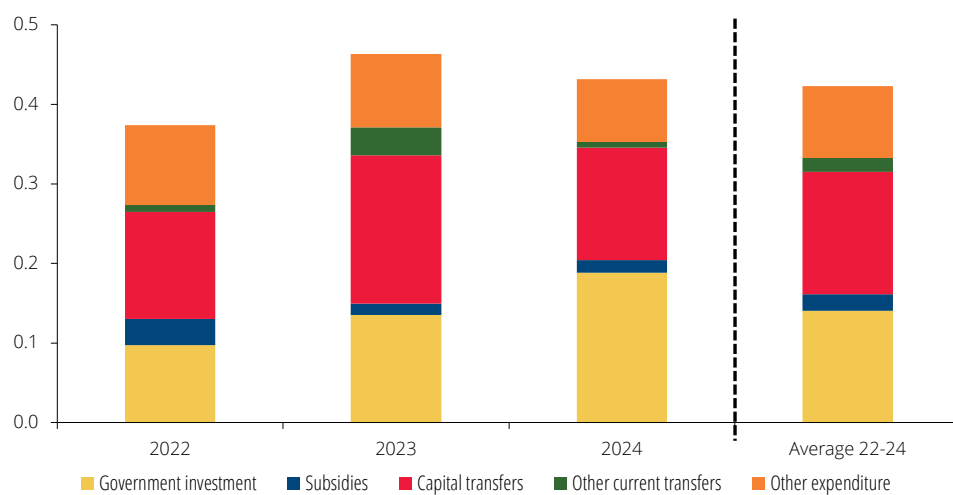


Figure 2: Fiscal measures financed by NGEU funds in the euro area (% of euro area GDP)

Source: Own calculations based on data collected by the Eurosystem's Working Group on Public Finance.

|                                                                                          | LDC                   | HDC                   | REA                   | RW                    |
|------------------------------------------------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>Households</b>                                                                        |                       |                       |                       |                       |
| Discount factor ( $\beta$ )                                                              | $1.03^{-\frac{1}{4}}$ | $1.03^{-\frac{1}{4}}$ | $1.03^{-\frac{1}{4}}$ | $1.03^{-\frac{1}{4}}$ |
| Intertemporal elasticity of substitution ( $\sigma^{-1}$ )                               | 1.00                  | 1.00                  | 1.00                  | 1.00                  |
| Inverse of the Frisch elasticity of labour ( $\zeta$ )                                   | 2.00                  | 2.00                  | 2.00                  | 2.00                  |
| Habit persistence ( $\kappa$ )                                                           | 0.65                  | 0.65                  | 0.65                  | 0.65                  |
| Share of non-Ricardian households ( $\omega$ )                                           | 0.25                  | 0.50                  | 0.25                  | 0.25                  |
| <b>Intermediate-good firms (trad. and non-trad. sectors)</b>                             |                       |                       |                       |                       |
| Substitution btw. labour and capital                                                     | 1.00                  | 1.00                  | 1.00                  | 1.00                  |
| Bias towards capital ( $\alpha$ )                                                        | 0.30                  | 0.30                  | 0.30                  | 0.30                  |
| Bias towards public capital ( $\alpha_G$ )                                               | 0.10                  | 0.10                  | 0.10                  | 0.10                  |
| <b>Final consumption-good firms</b>                                                      |                       |                       |                       |                       |
| Substitution btw. domestic and imported trad. goods ( $\mu_{TC}$ )                       | 1.50                  | 1.50                  | 1.50                  | 1.50                  |
| Bias towards domestic tradables goods ( $\nu_{TC}$ )                                     | 0.30                  | 0.30                  | 0.30                  | 0.70                  |
| Substitution btw. tradables and non-tradables ( $\mu_C$ )                                | 0.50                  | 0.50                  | 0.50                  | 0.50                  |
| Bias towards tradable goods ( $\nu_C$ )                                                  | 0.45                  | 0.45                  | 0.50                  | 0.35                  |
| Substitution btw. private and government consumption ( $\mu_{cces}$ )                    | 0.30                  | 0.30                  | 0.30                  | 0.30                  |
| Bias towards private consumption ( $\nu_{cces}$ )                                        | 0.75                  | 0.75                  | 0.75                  | 0.75                  |
| <b>Final investment-good firms</b>                                                       |                       |                       |                       |                       |
| Substitution btw. domestic and imported trad. goods ( $\mu_{TI}$ )                       | 1.50                  | 1.50                  | 1.50                  | 1.50                  |
| Bias towards domestic tradables goods ( $\nu_{TI}$ )                                     | 0.60                  | 0.60                  | 0.60                  | 0.80                  |
| Substitution btw. tradables and non-tradables ( $\mu_I$ )                                | 0.50                  | 0.50                  | 0.50                  | 0.50                  |
| Bias towards tradable goods ( $\nu_I$ )                                                  | 0.75                  | 0.75                  | 0.75                  | 0.75                  |
| LDC=low debt country; HDC=high debt country; REA=Rest of Euro Area; RW=Rest of the World |                       |                       |                       |                       |

Table 1. Households and Firms Behaviour

|                                                  | LDC  | HDC  | REA  | RW   |
|--------------------------------------------------|------|------|------|------|
| <b>Adjustment costs</b>                          |      |      |      |      |
| Imports of consumption goods ( $\gamma_{IM^C}$ ) | 5.00 | 5.00 | 5.00 | 3.00 |
| Imports of investment goods ( $\gamma_{IM^I}$ )  | 6.00 | 6.00 | 6.00 | 4.00 |
| Investment ( $\gamma_I$ )                        | 2.50 | 2.50 | 2.50 | 1.00 |
| <b>Calvo parameters</b>                          |      |      |      |      |
| Wages                                            | 0.75 | 0.75 | 0.75 | 0.75 |
| Prices - domestic tradables and non-tradables    | 0.80 | 0.80 | 0.80 | 0.75 |
| Prices - exports                                 | 0.75 | 0.75 | 0.75 | 0.75 |
| <b>Degree of indexation</b>                      |      |      |      |      |
| Wages                                            | 0.75 | 0.75 | 0.75 | 0.75 |
| Prices - domestic tradables and non-tradables    | 0.50 | 0.50 | 0.50 | 0.50 |
| Prices - exports                                 | 0.50 | 0.50 | 0.50 | 0.50 |

LDC=low debt country; HDC=high debt country; REA=Rest of Euro Area; RW=Rest of the World

Table 2. Real and Nominal Rigidities

|                                                                           | LDC  | HDC  | REA  | RW   |
|---------------------------------------------------------------------------|------|------|------|------|
| <b>Monetary authority</b>                                                 |      |      |      |      |
| Inflation target ( $\Pi^*$ )                                              | 1.02 | 1.02 | 1.02 | 1.02 |
| Interest rate inertia ( $\varphi_R$ )                                     | 0.87 | 0.87 | 0.87 | 0.87 |
| Interest rate sensitivity to inflation gap ( $\varphi_\Pi$ )              | 1.90 | 1.90 | 1.90 | 1.90 |
| Interest rate sensitivity to output growth ( $\varphi_y$ )                | 0.10 | 0.10 | 0.10 | 0.10 |
| <b>Fiscal authority</b>                                                   |      |      |      |      |
| Government debt-to-output ratio ( $B_Y^*$ )                               | 2.40 | 4.80 | 2.40 | 2.40 |
| Sensitivity of lump-sum taxes to debt-to-output ratio ( $\varphi_{B_Y}$ ) | 0.10 | 0.10 | 0.10 | 0.10 |
| Consumption tax rate ( $\tau_t^C$ )                                       | 0.17 | 0.17 | 0.17 | 0.08 |

LDC=low debt country; HDC=high debt country; REA=Rest of Euro Area; RW=Rest of the World

Table 3. Monetary and Fiscal Policy

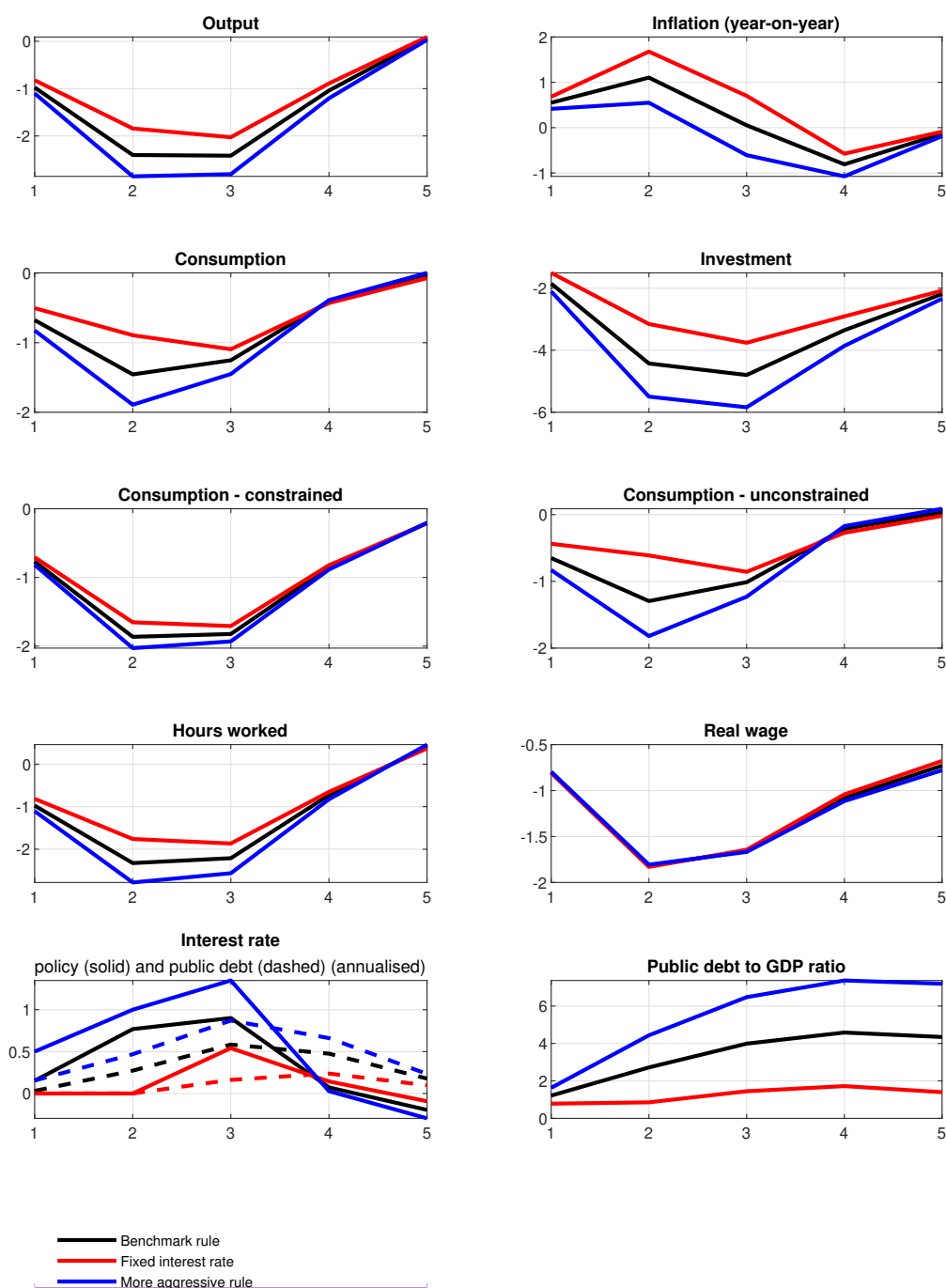


Figure 3: Macroeconomic impact of a worldwide supply shock under alternative monetary policy responses

Note: Output, consumption, investment, hours worked and real wage expressed as percent deviations from the steady state. Other variables as percentage points deviations from steady state.

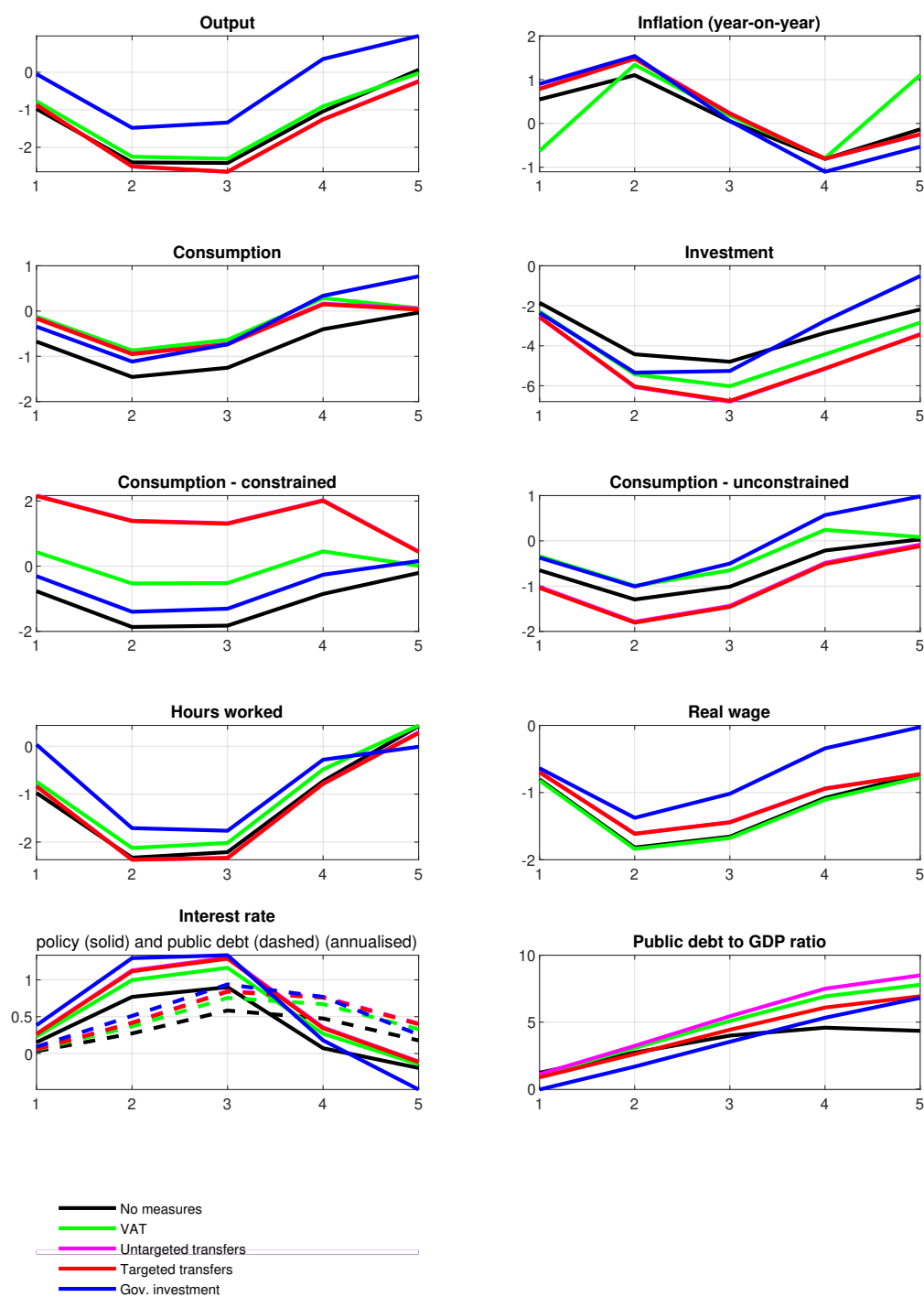


Figure 4: Macroeconomic impact of a worldwide supply shock under different fiscal policy measures

Note: Output, consumption, investment, hours worked and real wage expressed as percent deviations from the steady state. Other variables as percentage points deviations from steady state.

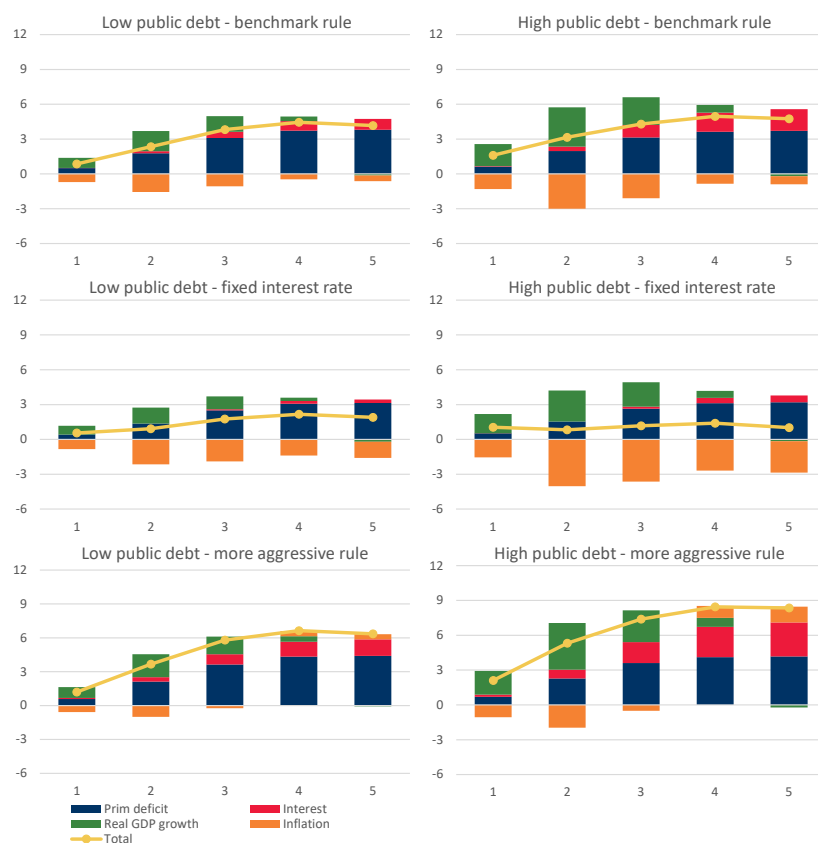


Figure 5: Decomposition of impact on public debt to GDP ratio in the two extreme euro area blocs under different monetary policy responses

Note: Public debt to GDP ratio expressed in percentage points deviations from steady state. All other variables represent the cumulative contribution to this deviation in percentage points of GDP.

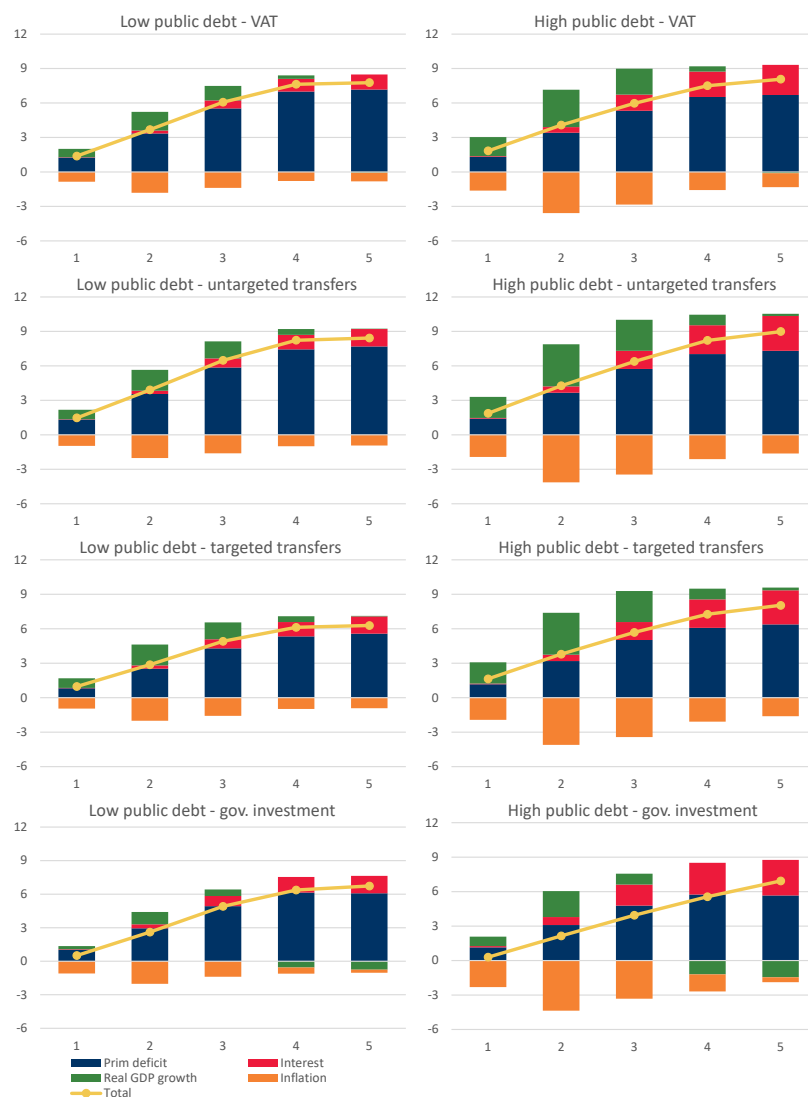
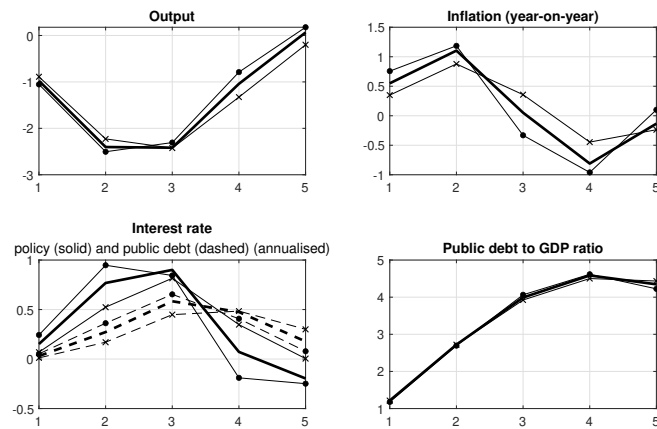


Figure 6: Decomposition of impact on public debt to GDP ratio in the two extreme euro area blocs under different fiscal policy measures

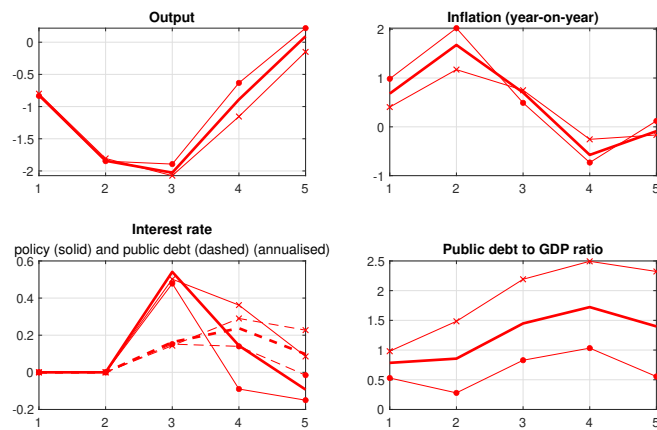
Note: Public debt to GDP ratio expressed in percentage points deviations from steady state. All other variables represent the cumulative contribution to this deviation in percentage points of GDP.



### Panel A: Standard monetary policy response



### Panel B: Fixed interest rate policy for two years



### Panel C: More aggressive monetary policy rule

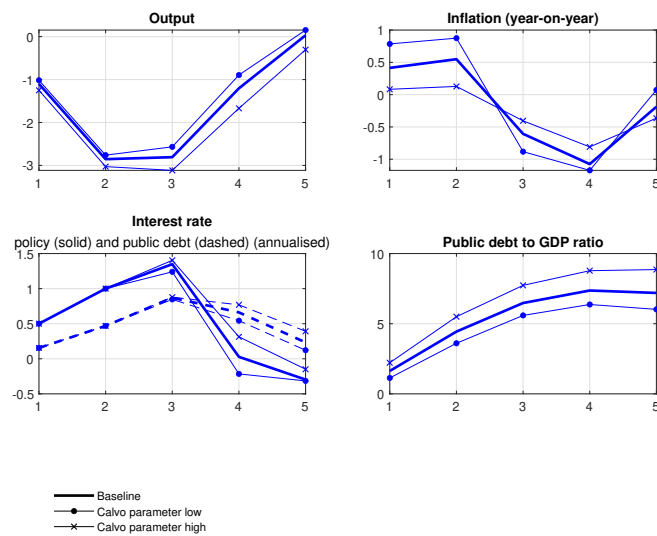


Figure 7: Macroeconomic impact of a worldwide supply shock under alternative Calvo price parameters (baseline = 0.8; low = 0.7, high = 0.9)

Note: Output expressed as percent deviations from the steady state. Other variables as percentage points deviations from steady state.

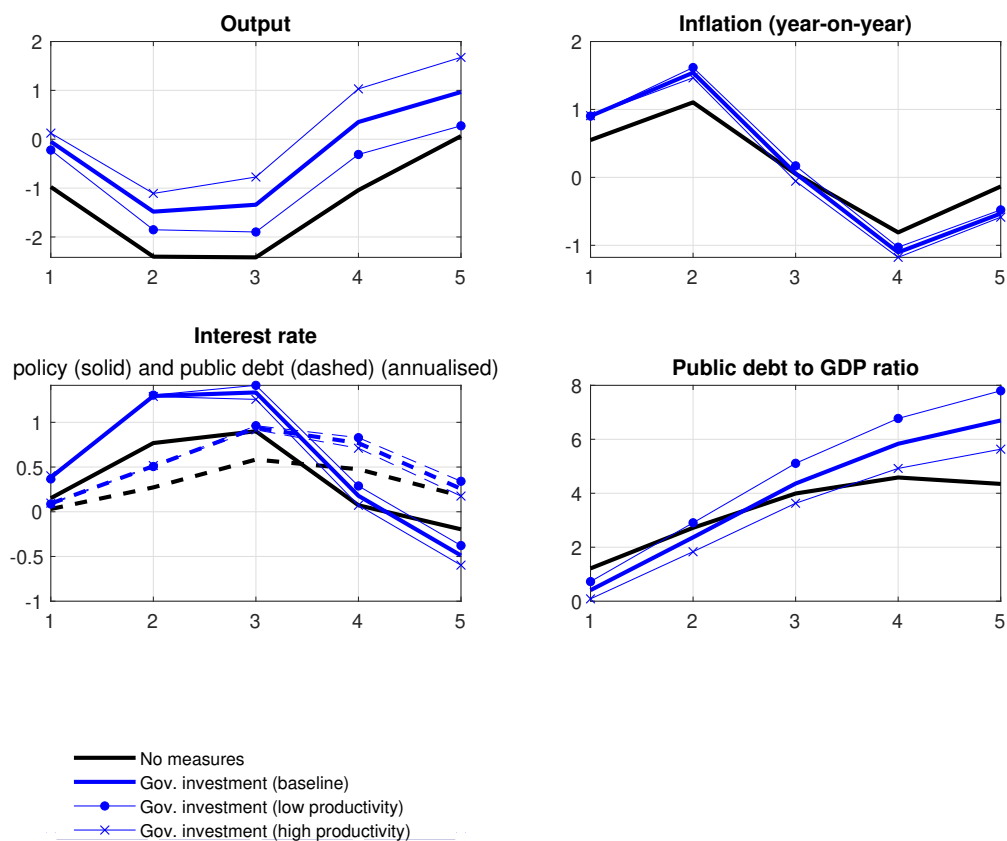


Figure 8: Macroeconomic impact of a worldwide supply shock coupled with an increase of public investment with different productivity

Note: Output expressed as percent deviations from the steady state. Other variables as percentage points deviations from steady state.

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