The Fiscal Channel of Monetary Policy*

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Abstract

We empirically document that contractionary monetary policy shocks, in addition to lowering output and prices, trigger an expansion in primary deficits and government debt. Inflation follows an S-shaped adjustment, implying that monetary policy shifts rather than permanently alters inflation. Structural counterfactuals show that front-loading fiscal consolidation considerably amplifies the monetary effects, and that the timing of consolidation alters the composition of the fiscal adjustment, with distinct implications for real and nominal outcomes. The temporary impact of a monetary policy shock on prices is more than halved by the endogenous adjustment in social transfers, whereas the tax system significantly reduces the effect on output.

Keywords: Monetary policy, fiscal channel, monetary fiscal policy interaction, structural counterfactuals, Bayesian proxy structural VAR models.

JEL codes: E32, E52, E63.

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1 Introduction

Following the prolonged price stability characterizing the Great Moderation, shocks associated with the COVID-19 pandemic, the Russian invasion of Ukraine, and the surge in global tariffs have propelled inflation rates well above target. In response to the elevated price pressure, central banks have tightened policy to curtail aggregate demand and ultimately inflation. However, this monetary contraction has coincided with public pressure for expansionary fiscal measures aimed at mitigating rising living costs and averting recessionary risks.[1] Such expansionary fiscal policy might well counteract the monetary tightening, thereby making monetary policy less effective in fighting inflation (BIS, 2023; Bańkowski et al., 2023; Adrian and Gaspar, 2022).

The interconnectedness of monetary and fiscal policy is governed by the intertemporal government budget constraint (IGBC), which dictates that any monetary effect on debt servicing, inflation, or output must ultimately be balanced by adjustments in fiscal revenues, expenditures, or debt issuance. As the US government is a major issuer of debt, a nominal rate hike directly raises the servicing costs on outstanding debt. These higher refinancing costs must be accommodated through fiscal consolidation unless offset by future inflation or accelerated output growth. Moreover, automatic stabilizers, such as proportional taxes or mandatory social transfers, give rise to an indirect channel: by impacting output and inflation, interest rate hikes induce changes in the primary fiscal deficit. Across time, the IGBC implies that following a monetary policy shock, the government must adjust revenues and spending to maintain debt sustainability. This paper provides two contributions to the understanding of the monetary-fiscal nexus. First, we empirically characterize the endogenous response of US fiscal policy to monetary policy shocks through these direct and indirect channels. Second, we evaluate the importance of the fiscal response in shaping the broader monetary policy transmission mechanism and the resulting debt dynamics.

Contemporaneous macroeconomic models demonstrate that the impact of the fiscal response is particularly acute when Ricardian equivalence fails, e.g. due to liquidity constraints or informational frictions. In such settings, the timing and distribution of the fiscal consolidation become first-order determinants of monetary transmission (see, e.g., Kaplan, 2025). For instance, delaying the fiscal adjustment may cushion the short-run spending drop for non-Ricardian households (Angeletos et al., 2026), while the specific incidence of the fiscal response across households with

[1] For example, the Inflation Reduction Act implemented by the Biden Administration includes a large-scale fiscal stimulus toward energy and climate-related expenditures.

varying marginal propensities to consume (MPC) can significantly amplify or dampen the aggregate effects of the initial monetary shock (Auclert et al., 2020; Alves et al., 2020; Kaplan et al., 2018; Eusepi and Preston, 2018; Sterk and Tenreyro, 2018). However, also in the presence of Ricardian equivalence and positive government debt, it is possible that the macroeconomic response to monetary policy actions depends on the fiscal adjustment (Cochrane, 2024; Caramp and Silva, 2023; Leeper, 2021; Sims, 2011). Our empirical analysis responds to the call to bridge the gap between a rich theoretical literature and the sparse empirical evidence regarding the specific fiscal adjustments that materialize in practice following a monetary shock (Kaplan et al., 2018).

As a first step of our analysis, we document that a monetary policy shock, besides affecting real and nominal macroeconomic variables, also significantly affects fiscal variables. We augment a standard monetary vector-autoregressive model of the US with main fiscal measures like tax revenues, social transfer payments, discretionary government spending, the fiscal deficit, and government debt. To trace out the dynamic impact of exogenous interest rate changes, we estimate a Bayesian proxy structural vector-autoregressive (BPSVAR) model put forward in Arias et al. (2021).

In line with previous literature, we find that an exogenous increase in the interest rate lowers output and the price level (see, e.g., Jarociński and Karadi, 2020; Gertler and Karadi, 2015). While these effects are consistent with the conventional view of monetary policy, taking the fiscal response into account provides important qualifications that are key for understanding the monetary transmission mechanism more broadly.

Specifically, we find that a contractionary monetary intervention triggers a significant decline in tax revenues coupled with a significant increase in social transfer payments and a moderate rise in discretionary spending. As a result of lower revenues and higher expenditures, the fiscal deficit and government debt considerably increase before they return to their pre-shock levels far out. With the government running persistent primary deficits, the question arises how increased interest payments are finally paid for.

Looking at the implied inflation response, we observe a novel empirical finding. As the fall in the price level is only temporary, with a recovery to the pre-shock level within roughly five years, we observe an unambiguously S-shaped adjustment in the implied inflation rate. This overshoot is consistent with the idea that in the presence of government debt, a rate hike ultimately pushes up inflation, balancing higher interest rate payments (Cochrane, 2024; Kaplan, 2025). Thus, our results suggest that rather than controlling inflation, the central bank can only postpone inflation due to the fiscal feedback along the lines of a phenomenon that Sims (2011) calls “stepping on a rake” and Cochrane (2024) describes as “unpleasant interest rate arithmetic”. However, while this S-shaped inflation overshoot drives the price level back to its long-run trajectory, the nominal adjustment alone does not fully absorb the higher financing costs. Consequently, consistent with the long-run requirements of the IGBC, a subsequent fiscal consolidation appears to be ultimately required to stabilize the debt trajectory in the limit.

Moreover, we document that the increase in government debt following the monetary contraction is mainly driven by an indirect channel via automatic stabilizers, whereas the direct channel related to higher interest payments plays a secondary role. As most models that analyze monetary-fiscal interactions emphasize the direct channel via interest payments, our results call for a more prominent role of indirect effects via automatic stabilizers in theoretical models, as, for example, in Angeletos et al. (2026); Blanchard (2025); McKay and Reis (2016).

The strong impact of monetary policy shocks on fiscal measures motivates our second set of results, where we conduct structural counterfactuals altering the fiscal response to understand how the fiscal channel shapes the transmission of monetary policy. Specifically, we construct structural counterfactuals along the lines of Antolín-Díaz et al. (2021) and McKay and Wolf (2023). In a first set of counterfactual results, we manipulate the timing of the fiscal consolidation, respectively the increase in government debt. In particular, we construct two alternative scenarios with a more front-loaded fiscal adjustment compared to the baseline, where the fiscal consolidation is shifted far into the future. In an “accelerated fiscal adjustment” scenario, we impose a much more limited and short-term increase in government debt than observed in the baseline. In the “balanced budget” scenario, we require the government to equalize expenditures and revenues each period so that the fiscal contraction sets in immediately in response to the monetary shock.

The results reveal that changing the timing of the fiscal adjustment significantly affects the overall effects of monetary policy. In the accelerated fiscal adjustment scenario, the temporary deflationary impact following the interest rate increase is more than twice as large compared to the baseline model. In contrast, the decline in GDP is rather similar to the baseline. Moving to the balanced budget scenario, we find a different conclusion: the contraction in GDP is substantially amplified, whereas the price response remains similar to the baseline. The finding that front-loading the fiscal consolidation amplifies the aggregate effects of monetary policy shocks aligns well with theoretical frameworks where the failure of Ricardian equivalence is central to the monetary-fiscal nexus (Kaplan, 2025; Angeletos et al., 2026). In such settings, a fiscal tightening in the event of a rate hike drags on aggregate demand when households face liquidity constraints. Notably, while we observe that the initial drop in the price level depends on the timing of the fiscal adjustment, the S-shaped adjustment prevails across the different scenarios.

What explains the differences between nominal and real effects across these alternative fiscal adjustment scenarios? When looking at the composition of the fiscal actions necessary to impose the counterfactual, i.e. the prevalence of counterfactual fiscal policy shocks, it turns out that, whereas the balanced budget scenario is mainly imposed by a sequence of tax hikes, the accelerated fiscal adjustment scenario relies heavily on expenditure cuts.

To further investigate any differences across the fiscal instruments, we conduct a second set of counterfactuals where we sequentially neutralize the responses of taxes, transfers, and public spending and demonstrate that the effects indeed vary across fiscal measures. When shutting down any endogenous tax revenue response to the monetary policy shock, real GDP falls by more than twice as in the baseline. At the same time, the endogenous tax response has only a limited impact on the monetary transmission into prices. In stark contrast, adjustments through expenditures have much stronger nominal but limited real effects. Assuming that social transfers do not adjust in response to the contractionary monetary policy shock pertains to an output response that shows only small differences compared to the baseline. However, the fall in prices is more than three times as large when holding transfer payments constant.[2] While government spending responds rather unsystematically to monetary policy, we find that expenditures share the strong effect on prices. Additional results document that (i) the real effects linked to changes in tax revenues primarily materialize through changes in personal consumption and personal income rather than the corporate income tax code, and (ii) the nominal effects in case of changes in expenditures are closely linked to changes in firms' unit labor costs. Overall, these results help us understanding the differences across the scenarios on the timing of the fiscal adjustment. Counterfactuals imposed by disproportionately relying on tax changes rather than spending adjustments, like the balanced budget scenario, will amplify

[2]The strong inflationary effects of changes in transfer payments are well in line with recent theoretical contributions highlighting either the role of partly unfunded fiscal debt (Bianchi et al., 2023) or targeted transfers (Kaplan et al., 2023).

the real effects of the contractionary monetary policy shock while keeping the nominal impact rather unchanged. The opposite is true for scenarios which heavily rely on changes in spending like the accelerated fiscal adjustment scenario: stronger nominal effects while leaving the real effects relatively unaffected.

Related literature. Several previous studies have shown that the monetary policy stance significantly influences the size of the government spending multiplier (Klein and Winkler, 2021; Cloyne et al., 2020; Miyamoto et al., 2018; Ramey and Zubairy, 2018). However, there exists much less evidence on the opposite relationship, i.e., how the fiscal stance impacts the way monetary policy affects real and nominal outcomes. We provide empirical evidence to fill this gap. Following previous contributions focusing on fiscal policy shocks (Favero and Giavazzi, 2012; Chung and Leeper, 2007), we explicitly account for the IGBC in driving the empirical fiscal response to monetary policy shocks. Moreover, by applying recently-developed structural counterfactuals, we contribute to the literature by demonstrating how changing fiscal adjustments affects the transmission of monetary policy. Sterk and Tenreyro (2018) emphasize the importance of government debt for the transmission of monetary policy. They first provide empirical evidence that an expansionary monetary policy shock raises inflation and lowers real public debt, and rationalize these findings in a flexible price model with overlapping generations where open market operations can have real consequences through distributional wealth effects. Our empirical finding of a persistent build-up in government debt following an exogenous interest rate hike is generally in line with their evidence. Furthermore, we use the IGBC to study the driving forces of the debt response, and the counterfactual scenarios allow for a quantification of the fiscal channel without relying on a structural model.

Our work speaks to a rich volume of theoretical papers emphasizing the role of government debt and primary surpluses in determining the equilibrium in response to monetary interventions.[3] In particular, our paper informs a growing Heterogeneous Agent New Keynesian (HANK) literature. A key insight from this literature is that once households are non-Ricardian, the fiscal response naturally influences aggregate demand and thereby the propagation of monetary policy (Auclert et al., 2020; Alves et al., 2020; Kaplan et al., 2018; Eusepi and Preston, 2018). Our empirical results are generally consistent with the incidence of non-Ricardian households. Yet, our

[3]Much of this literature focuses on the determination of the price level through monetary and fiscal actions, generally known as the Fiscal Theory of the Price Level (Leeper, 1991; Sims, 1994; Cochrane, 2001). See Leeper and Leith (2016) for an overview. Moreover, by focusing on a period of a relatively stable monetary-fiscal framework, namely the early 1980s up until the Corona pandemic, we abstract from any non-linearities stemming from regime changes as studied in, for example, Chung et al. (2007).

results contrast with canonical theoretical models featuring short-term government debt, where inflation only falls following a nominal rate hike when coupled with a fiscal contraction because of positive wealth effects from government bonds (see, e.g., Caramp and Silva, 2023; Kaplan, 2025; Leeper, 2021). Importantly, we find that the maturity structure of public debt matters and interest payments are not of first-order importance for the monetary induced debt build-up because the increase in short-term debt is limited. Our empirical findings thus generally support recent theoretical contributions that highlight the role of long-term debt when studying the interaction between monetary and fiscal policy (Caramp and Feilich, 2025; Cochrane, 2024; Sims, 2011).

The important role of automatic stabilizers in the transmission of monetary policy shocks documented by our results accords well with Angeletos et al. (2026). Along the lines of amplifying effects through constrained, non-Ricardian households, Angeletos et al. (2026) show that indirect effects via automatic stabilizers are an important feature of the fiscal channel and postponing the necessary fiscal adjustment helps stabilizing aggregate spending in the event of demand shocks. Our findings echo their conclusions on the timing of the fiscal consolidation.

We further contribute to the literature on how monetary-fiscal interactions influence the effect of monetary policy shocks on prices and inflation. Studies which explicitly account for the IGBC emphasize that, in the presence of short-term debt, raising nominal rates without a fiscal contraction leads to higher inflation (Kaplan, 2025; Sims, 2011; Cochrane, 2024). In the presence of long-term debt, a rate hike can temporarily lower inflation without a fiscal contraction but only at the expense of higher inflation in the future. Our empirical findings on an unambiguously S-shaped response of inflation support these theoretical predictions. However, we also show that the inflationary effects are not sufficient to balance the additional debt burden and our results suggest that in addition a fiscal consolidation implemented far out in the future ensures that the IGBC holds in the limit.

Finally, in contemporaneous work, Bouscasse and Hong (2026) and Kurcz (2025) study the fiscal response to a monetary shock. While Bouscasse and Hong (2026) also rationalize the impulse responses using empirical counterfactuals, Kurcz (2025) relies on a theoretical model. In contrast to both papers, we allow for dynamic interactions among different fiscal policy instruments.

The remainder of the paper is organized as follows: Section 2 describes the BPSVAR model, the data, and the proxies used for identification. Section 3 presents our baseline VAR results regarding the impact of monetary policy shocks on macroeconomic variables and fiscal measures as well as the responses to identified fiscal shocks. Section 4 explains the structural counterfactuals and presents results from scenarios where we first change the timing of the fiscal adjustment and then shut down the endogenous responses of taxes, social transfers, and government spending one by one. Finally, Section 5 concludes.

2 Methodology

We estimate a Bayesian proxy structural vector-autoregressive (BPSVAR) model that renders the simultaneous evaluation of multiple proxies for monetary and fiscal shocks possible. The structural parameters of the model then allow us to characterize the fiscal channel of US monetary policy in structural counterfactuals as proposed by Antolín-Díaz et al. (2021) and McKay and Wolf (2023), which we detail further below in Section 4.

2.1 The BPSVAR model

To simultaneously identify multiple shocks by multiple instruments within one empirical framework, we consider the BPSVAR by Arias et al. (2021), an efficient algorithm to independently draw from the posterior over the structural parameters of a proxy-SVAR conditional on the exogeneity restrictions and the relevance condition. Let $\boldsymbol{y}_t$ be a $n \times 1$ vector of macroeconomic variables, $\boldsymbol{m}_t$ be a $k \times 1$ vector of instruments (proxies), both observed in time t, then the BPSVAR is given by

$$\widetilde{\boldsymbol{A}}_0 \widetilde{\boldsymbol{y}}_t = \widetilde{\boldsymbol{c}} + \sum_{l=1}^{p} \widetilde{\boldsymbol{A}}_l \widetilde{\boldsymbol{y}}_{t-l} + \widetilde{\varepsilon}_t, \tag{1}$$

where $\widetilde{\boldsymbol{y}}'_t = [\boldsymbol{y}'_t, \boldsymbol{m}'_t]$ is a $\widetilde{n} \times 1$ vector with $\widetilde{n} = n + k$, $\widetilde{\boldsymbol{c}}$ is a $\widetilde{n} \times 1$ column vector of constants, $\widetilde{\boldsymbol{A}}_l$ are the corresponding $\widetilde{n} \times \widetilde{n}$ coefficient matrixes, and $\widetilde{\boldsymbol{\varepsilon}}'_t = [\boldsymbol{\varepsilon}'_t, \boldsymbol{\nu}'_t] \sim N(\boldsymbol{0}, \boldsymbol{I}_{\widetilde{n}})$.

In order to use the proxies $\boldsymbol{m}_t$ as "external instruments" so that they do not directly affect the endogenous variables $\boldsymbol{y}_t$, the corresponding autoregressive coefficients are set to zero,

$$\widetilde{\boldsymbol{A}}_i = \begin{bmatrix} \underset{(n \times n)}{\boldsymbol{A}_i} & \underset{(n \times k)}{\boldsymbol{0}} \\ \underset{(k \times n)}{\boldsymbol{\Gamma}_{i,1}} & \underset{(k \times k)}{\boldsymbol{\Gamma}_{i,2}} \end{bmatrix}, \text{ for } 0 \leq i \leq p. \tag{2}$$

This setup allows us to fit the proxy variables $\boldsymbol{m}_t$ together with the endogenous variables $\boldsymbol{y}_t$

with a single structural model estimated in one step while at the same time accounting for measurement error $\boldsymbol{\nu}_t$.[4]

The k structural shocks of interest $\boldsymbol{\varepsilon}_t^*$ are identified by imposing the standard exogeneity and relevance conditions:

$$E[\boldsymbol{m}_t \boldsymbol{\varepsilon}_t^{o\prime}] = \mathbf{0} \tag{3}$$

$$E[\boldsymbol{m}_t \boldsymbol{\varepsilon}_t^{*\prime}] = \boldsymbol{V}, \tag{4}$$

where $\boldsymbol{\varepsilon}_t^o$ indicates $n-k$ unidentified shocks, and $\boldsymbol{V}$ represents a non-singular covariance matrix of the proxy variables and the k identified structural shocks. To achieve exact identification between the multiple proxies and structural shocks in our context we set $\boldsymbol{V}$ to be upper triangular (see also Georgiadis et al., 2024). According to the high-frequency nature we order the monetary policy shock last thereby purging the fiscal shocks from potential endogeneity issues associated with monetary surprises.[5] Arias et al. (2021) show that the exogeneity condition in Equation (3) implies $k \times (n-k)$ additional zero restrictions on the contemporaneous impact matrix $\widetilde{\boldsymbol{A}}_0^{-1}$. Moreover, to improve efficiency we follow Caldara and Herbst (2019) and Arias et al. (2021) and impose a relevance threshold to express a prior belief that the proxy variables are relevant instruments. In particular, similar to Breitenlechner et al. (2022) we require that each of the identified shocks accounts for at least 10% of the variance of the respective proxy variable.

To ensure that the restrictions on $\widetilde{\boldsymbol{A}}_0^{-1}$ as well as on $\widetilde{\boldsymbol{A}}_l$ are simultaneously satisfied, i.e. the estimation identifies the structural shocks $\boldsymbol{\varepsilon}_t^*$, we follow the Bayesian estimation algorithm as described in Arias et al. (2021). Due to the large dimensionality of our system we consider informative priors. Specifically, we opt for a standard Minnesota shrinkage prior, where the tightness and decay hyperparameters are selected hierarchically as described in Giannone et al. (2015).

[4]In contrast, frequentist proxy-SVARs are generally estimated in two steps (see, e.g., Mertens and Ravn, 2013; Gertler and Karadi, 2015; Stock and Watson, 2018), which complicates inference.

[5]In Appendix B we represent the restrictions in more detail. Importantly, in the robustness checks below we document that our results do not depend on the specific ordering of the fiscal policy shocks nor on the additional zero restrictions imposed in $\boldsymbol{V}$ to achieve exact identification (Section 3.3).

2.2 Specification and data

Building on a standard monetary VAR specification consisting of measures of output, prices, financial frictions, and a short-term interest rate (see, e.g., Gertler and Karadi, 2015), we additionally consider various fiscal measures. Specifically, we include in $\boldsymbol{y}_t$ real GDP, the GDP deflator, the Gilchrist and Zakrajšek's (2012) excess bond premium (EBP), the one-year treasury bill rate, real tax revenues, real social transfers, real (discretionary) government spending, the primary deficit ratio, and the government debt ratio. The primary deficit captures the difference between total government expenditures and receipts minus net interest payments. We consider the deficit and debt as ratios of nominal GDP to preserve the flow identity of the IGBC . As a measure for social transfers we follow Romer and Romer (2016) and use social security benefits to persons paid by the government. Nominal tax revenues and nominal social transfers are converted into real terms by deflating with the GDP price deflator. All variables except the interest rate, the EBP, and the ratios enter $\boldsymbol{y}_t$ in log levels times 100. The interest rate, the EBP, and the ratios are measured in percent. In the baseline specification, we set $p = 4$.

We estimate the BPSVAR model on quarterly data ranging from 1983Q1 to 2019Q4. Thus, we exclude the pre-Volcker period as well as the turbulence created by the Coronavirus pandemic potentially impairing sharp identification of the structural parameters.[6] While monetary policy VARs are usually estimated on monthly data, we use quarterly series because the main fiscal measures are only available at a quarterly frequency. We discuss the effects of switching from the monthly to the quarterly frequency below and show that the standard monetary policy transmission mechanism on e.g. prices and output is preserved in quarterly data.

All data except the EBP are taken from the Federal Reserve Bank of St. Louis database, Federal Reserve Economic Data (FRED). Data for the EBP are obtained from the Board of Governors of the Federal Reserve System, who provide the latest estimates of Gilchrist and Zakrajšek's (2012) original EBP series. Table A.1 in the Appendix lists all variables with the corresponding sources and data codes.

[6]A substantial body of work suggests that the transmission mechanism of US monetary policy materially changed following the end of the Volcker disinflation (e.g. Boivin and Giannoni, 2006). Several other studies also detect a change in the fiscal transmission mechanism at the beginning of the 1980s (Bilbiie et al., 2008; Perotti, 2005). Thus, the sample choice has the advantage that we focus on a period in which the monetary-fiscal policy framework was relatively stable. However, we obtain qualitatively similar results if we consider an updated sample including observations up to 2024Q4 (see Section 3.3).

2.3 Proxies and identification

To identify monetary policy shocks, we use high-frequency data from Gürkaynak et al. (2022) that contain asset price surprises in a half-hour window around FOMC press releases. These high-frequency changes should capture only the effect of the monetary policy announcement and can be plausibly viewed as exogenous (e.g. Kuttner, 2001; Gürkaynak et al., 2005). In our baseline specification, we use interest rate surprises in the three-month ahead monthly fed funds future rates (see, e.g., Gertler and Karadi, 2015; Jarociński and Karadi, 2020).[7]

While macroeconomic shocks, such as aggregate demand or supply shocks, should not occur systematically within the short time window around monetary policy announcements, several contributions stress that these announcements convey information about the central bank's assessment of the economic situation (e.g. Campbell et al., 2012; Nakamura and Steinsson, 2018; Jarociński and Karadi, 2020). Since a monetary tightening, for instance, is typically a reaction to an improved economic outlook of the central bank, the associated announcement may lead to increased optimism among market participants and, hence, may counteract the effect of the increase in the interest rate.[8] To avoid our policy surprise measure being contaminated by these information effects, we follow Jarociński and Karadi (2020) and Jarociński (2022) and use stock market data to obtain a pure policy surprise that is orthogonal to the central bank information surprise (see also Miranda-Agrippino and Ricco, 2021; Andrade and Ferroni, 2021). The main identifying assumption is that a contractionary pure policy shock results in lower stock market prices as it reduces the present value of expected future dividends. Instead, an information shock that is associated with the announcement of higher interest rates results in higher stock prices as market participants adopt a more optimistic outlook. Thus, we impose the restrictions that interest rates and stock prices move in opposite directions following a policy shock, but in the same direction in response to an information shock. The implementation is carried out in the form of rotational sign restrictions as in Jarociński (2022). Along these lines, we obtain a particularly clean monetary policy instrument with an unambiguous economic interpretation.

While monetary policy instruments of the type that we use are well established in the literature, they are typically evaluated using monthly data. However, fiscal measures and proxies that we

[7]To capture monetary policy in a broader sense, especially during the more recent period, we also consider (i) an estimation using the first principal component of surprises in interest rate derivatives with maturities up to one year (see, e.g., Nakamura and Steinsson, 2018), as well as (ii) an estimation, in which we replace the one-year treasury bill rate as a measure of the monetary policy stance with a spliced shadow rate, in the robustness section (see Section 3.3).

[8]Alternatively, Bauer and Swanson (2023a) argue that these counteracting effects might be rather related to the response of monetary authorities to incoming economic news.

exploit in our analysis are only available at a quarterly frequency. Thus, in the estimation exercise below, we aggregate the pure monetary policy surprises to the quarterly frequency. To see whether aggregation to the quarterly frequency affects the estimated impulse responses, we compare estimations of otherwise standard monetary VARs with monthly and quarterly frequency in Figure A.2 in the Appendix. It turns out that the main transmission mechanism of the high-frequency surprise is preserved at quarterly frequency as the dynamics of the estimated responses are quite similar.

To construct structural counterfactuals investigating the interactions between monetary and fiscal policy, we have to identify exogenous fiscal interventions on top of the monetary policy shocks. In particular, we construct scenarios that rely on the identification of shocks to tax revenues, transfer payments and government spending.

As an instrument for exogenous changes in US tax revenues, we use the narrative series provided by Mertens and Ravn (2011), which is an extension of the original series by Romer and Romer (2010). To achieve identification the authors exploit the narrative information in official historical documents in two ways. First, they verify that the policy documents do not discuss a desire to respond to current or prospective economic conditions and return growth to normal. Second, within the set of policy changes not motivated by the near-term economic outlook, they focus on tax changes motivated either by a desire to reduce the budget deficit or by raising long-run growth. Thus, the identified tax shocks measure changes in the tax system that are not related to the state of the economy. To properly account for the well-known fiscal foresight problem, we follow Mertens and Ravn (2011) and use only those tax shocks to instrument for exogenous policy changes for which potential anticipation effects are arguably unlikely. More precisely, we omit all tax liability changes that were implemented more than 90 days (one quarter) after becoming law. We combine the original Mertens and Ravn (2011) narrative series which ends in 2006 by the measure provided by Hanson et al. (2021) which extends the series until 2019.

As a proxy for structural shocks to transfer payments, we rely on the narrative series constructed by Romer and Romer (2016). They use documents from the Social Security Administration, Congress, and the executive branch to identify the nature, motivation, timing, and size of benefit increases over several decades. This narrative analysis allows us to focus on increases that raised payments to existing beneficiaries and to exclude the few increases that were explicitly made for countercyclical purposes. In particular, Romer and Romer (2016) classify as exogenous the changes in Social Security benefits to keep up with past inflation, or to increase the insurance provided by the Social Security programs, i.e. ideological motivation of fairness or equity. We combine the original Romer and Romer (2016) narrative series which ends in 1991 by the measure provided by Párraga Rodríguez (2018) which extends the series until 2007.

Finally, we use government spending forecast errors to instrument for exogenous changes in government spending. This approach was also applied by, among others, Ramey (2011) and Auerbach and Gorodnichenko (2012). The underlying idea is that the forecast error captures only those changes in government spending that are not related to aggregate news and thus, are unanticipated by private agents. We extend the series provided by Auerbach and Gorodnichenko (2012), which covers the period 1966-2008 to include the remaining sample years.

We set the proxies in periods for which they are not available to zero. To do so in case of unavailability is well established in the proxy-SVAR literature (see e.g., Georgiadis et al., 2024; Känzig, 2023).[9] This treatment of missing observations takes advantage of the full sample to sharpen the estimation of the VAR parameters.

3 VAR results

We first establish our results for the monetary policy shock, and discuss responses of macroeconomic aggregates as well as fiscal measures. As a next step, we present the effects of the identified fiscal shocks, i.e. tax, social transfer, and government spending innovations. While these analyses already give a first intuition on the prevalence and mechanisms of the fiscal channel of monetary policy, we then continue by employing structural counterfactuals à la Antolín-Díaz et al. (2021) that allow us to change the endogenous fiscal responses. These counterfactuals will be imposed by different paths on the identified fiscal shocks which warrants a detailed discussion on how fiscal innovations affect macroeconomic outcomes in the first place.

3.1 Impulse responses to monetary policy shocks

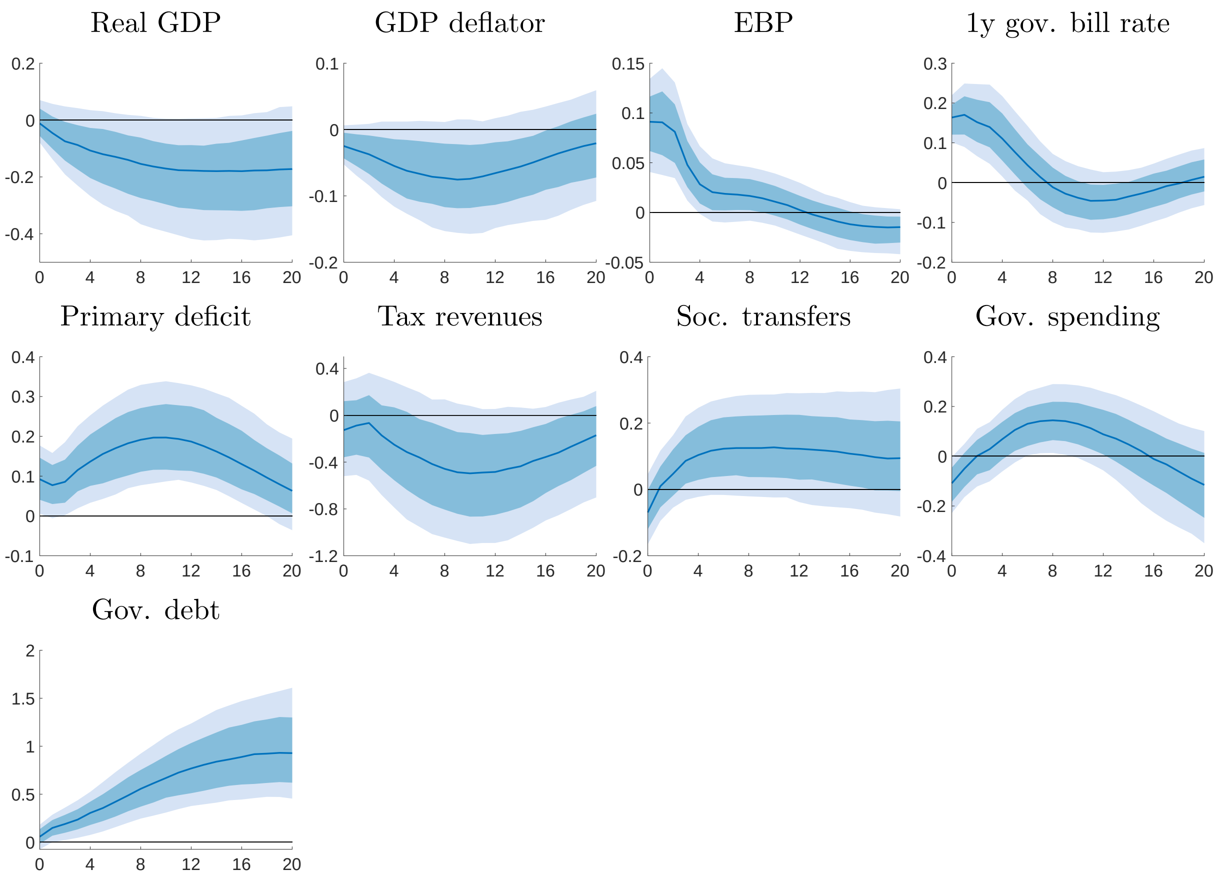
Figure 1 shows the responses to a contractionary monetary policy shock estimated with data ranging from the first quarter of 1983 to the end of 2019. The first row shows the responses of the main macroeconomic variables. The responses of the fiscal measures are shown in the second and third row. Solid lines show the posterior point-wise median impulse responses and

[9] Noh (2017) shows that it is valid to set missing observations to zero if the timing of proxy observations is independent of the structural shocks and measurement errors. Similarly, Paul (2020) shows that randomly placed zero observations in an instrument do not bias impulse responses when the instrument is treated as an exogenous variable.

shaded areas correspond to 68% and 90% probability bands. The responses are normalized to a contractionary one standard deviation monetary policy shock in the impact period.

We find that a contractionary monetary policy shock decreases real GDP and the GDP deflator. Even though the posterior bands are relatively wide, the mass of the distribution of responses is clearly below zero over most of the impulse horizon. While the drop in output is more persistent, we document that the fall in the price level is only temporary with a recovery back to its pre-shock level within roughly five years. The one-year treasury bill rate markedly increases on impact and gradually returns to the long-run equilibrium after approximately one year. The response of the excess bond premium (EBP) indicates a sharp and immediate tightening of financial conditions that is particularly pronounced over the first year after the shock sets in. As the interest rate decreases in the medium run, financial conditions ease. The overall aggregate effects are largely consistent with standard macroeconomic models and well in line

Figure 1: Impulse response functions to contractionary monetary policy shocks



Notes: Lines show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Shaded areas represent 68% and 90% centered point-wise probability bands.

with the empirical literature (see, e.g., Ramey, 2016), with an important qualification: Whereas the conventional view is that monetary policy permanently shifts the price level path as inflation eventually reverts to target, our estimated price level response implies an unambiguously overshooting, S-shaped inflation adjustment.[10] The remaining responses show similar dynamics as in Jarociński and Karadi (2020), while they tend to be more pronounced compared to Gertler and Karadi (2015), who do not abstract from the signaling channel of monetary policy. Notably, evaluating the effects of monetary policy on quarterly data turns out to yield similar results in terms of dynamics compared to estimations with monthly data, a frequency which is typically considered in the context of monetary policy. Moreover, additional estimations reveal that without the fiscal block in the VAR, the price level responds more persistently, with no reversion back to its pre-shock level 20 quarters after the shock.[11]

Beside the effects on main macroeconomic variables, Figure 1 also reveals that a monetary policy shock has a significant impact on fiscal variables. We observe a hump-shaped response of the primary deficit alongside an expansionary reaction of fiscal policy. The maximum response is reached two to three years after the shock with an elevated fiscal deficit of around 0.2 percentage points. The decline in economic activity induced by the monetary intervention leads to a fall in taxable income and thus lowers revenues collected by the government. Three years after the shock, tax revenues are around 0.5% below their pre-shock level. In addition, the economic contraction triggers a persistent increase in social transfer payments. At the end of the impulse response horizon, social transfers are elevated by around 0.1%. Through its automatic stabilizing effects, social transfers generally increase (decrease) in economic downturns (expansions). Finally, government consumption expenditures show a mild increase in the medium run after a short-lived decline on impact. Such a moderate rise in (discretionary) public spending following a monetary policy shock is also found by Tenreyro and Thwaites (2016). The rather unsystematic behavior of government spending in response to a monetary policy shock might be explained by the discretionary nature of the series such that business cycle fluctuations should not trigger strong changes in discretionary expenditures. Together with the fiscal easing we see a persistent increase in the debt-to-GDP ratio. Five years after the shock, public debt is around 1 percentage point above its pre-shock level.

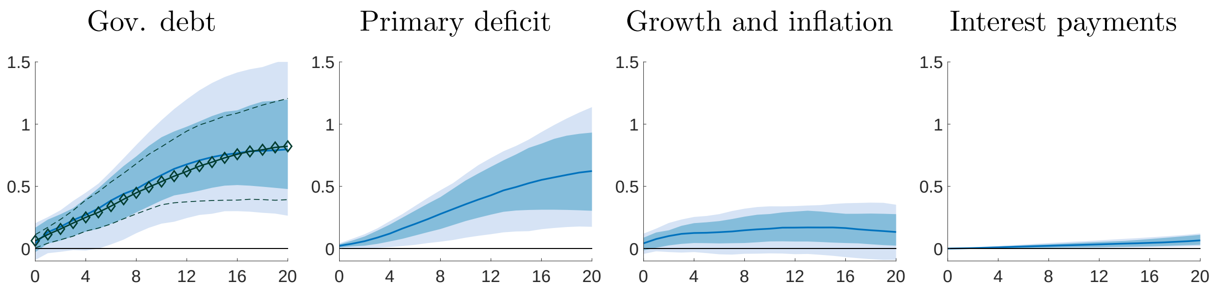
[10] Figure A.1 in the Appendix reports the implied inflation response of our baseline model and shows a significant overshoot in inflation after three years. In addition, the figure documents that we observe exactly the same S-shaped inflation response, when we do not check for the stability of the posterior draws as in the baseline, indicating that the inflation dynamic is driven by the data rather than by the specification.

[11] Figure A.2 in the Appendix provides results from monthly and quarterly VARs in which we leave fiscal shocks and variables out of considerations, as they are only available at quarterly frequency.

The role of the intertemporal government budget constraint. How can our results—in particular subdued growth and the S-shaped inflation response together with a fiscal expansion in the form of a higher primary deficit—be understood from the perspective of the IGBC and the refinancing of public debt? In standard theoretical models with short-term government debt, inflation only falls following a nominal rate hike when coupled with a fiscal contraction (Caramp and Silva, 2023; Kaplan, 2025). To better understand our empirical results, we first assess the internal consistency of the impulse responses with the IGBC. Specifically, we re-estimate the baseline model to include interest payments. This allows us to construct the IGBC-implied path of government debt and to compare it directly with the estimated debt response shown in Figure 1. In Appendix C, we derive the flow constraint for computing the IGBC-implied government debt response and further assess the internal consistency of our empirical impulse responses with the IGBC using alternative checks.

The first panel of Figure 2 plots the estimated response of government debt from the extended baseline model (solid line) together with the IGBC-implied debt path (diamonds). The remaining panels report the IGBC components that cumulate into the implied debt response: the build-up of the primary deficit, the joint effect of output growth and inflation, and cumulative interest payments. We see that the IGBC-implied debt path closely tracks the estimated one, indicating internal consistency.[12] Looking at the IGBC components, we see that the primary

Figure 2: IGBC-implied government debt path and components



Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Shaded areas represent 68% and 90% centered point-wise probability bands. The line with markers shows the posterior point-wise median values of the IGBC-implied government debt path, equal to the sum of the components shown in columns two to four. Dashed lines represent the corresponding 68% centered point-wise probability bands. All variables are expressed as percentages of GDP, and IGBC components (columns two to four) are accumulated.

[12]Figures A.3 and A.4 in the Appendix show very similar IGBC-implied debt responses, obtained with two alternative consistency checks described in Section C. These checks allow for a dynamic feedback between the IGBC-implied debt trajectory and the remaining impulse responses either by iterating the model forward based on the estimated VAR-coefficients and the implied debt response following Favero and Giavazzi (2007, 2012) or by solving the model in the Antolín-Díaz et al. (2021) counterfactual framework where we impose the IGBC to hold per restrictions on observables.

deficit is clearly the main driver at longer horizons. As the government runs persistent primary deficits over the impulse response horizon of five years, the fiscal consolidation associated with the rate hike is pushed relatively far into the future. As shown in Figure A.5 in the Appendix, government debt converges back to zero only after approximately 16 years, indicating that any fiscal stabilization effort is considerably postponed. The very much delayed reduction in public debt is due to a fiscal consolidation visualized by a shift from a fiscal deficit towards a fiscal surplus that happens after around six years. This finding is comparable to Sterk and Tenreyro (2018) who find that temporary interest changes have long-lasting effects on real public debt.

Figure 3 presents the debt components implied by the IGBC as relative contributions. In the very short run (up to about one year), negative output growth and lower inflation account for roughly 60% of the increase in debt. As the impulse horizon extends, the contribution of the primary deficit becomes dominant accounting for up to 75% at the end of the forecast horizon. The share of interest payments builds up over time but remains limited. Notably, the uptick in interest payments coincides with a positive inflation response that lowers the real burden of the additional debt. However, while this S-shaped inflation overshoot drives the price level back to its long-run trajectory, the nominal adjustment alone does not fully absorb the higher financing costs. Consequently, consistent with the long-run requirements of the IGBC, a subsequent fiscal consolidation appears to be ultimately required to stabilize the debt trajectory in the limit. The prominence of the primary deficit and the limited contribution of interest payments indicate that the increase in government debt following the monetary contraction is mainly explained through the indirect channel via automatic stabilizers—lower revenues and higher transfers—whereas the direct channel related to higher interest payments plays a minor role.

The muted rise in debt-service costs despite higher public debt suggests that automatic stabilizers are financed at long maturities rather than by expanding short-term funding. With a long average maturity, coupon and rollover needs adjust slowly, dampening the immediate pass-through of higher policy rates to interest expenditures. Figure 4 reports the responses of long and short-term debt as a share of GDP.[13] Even though short-term debt picks up in response to the rate hike as a result of the deficit accumulation, the magnitude is rather small compared to the long-term debt response. As a result, the vast majority of the total increase in public debt is indeed explained by a significant rise in long-term debt obligations.[14]

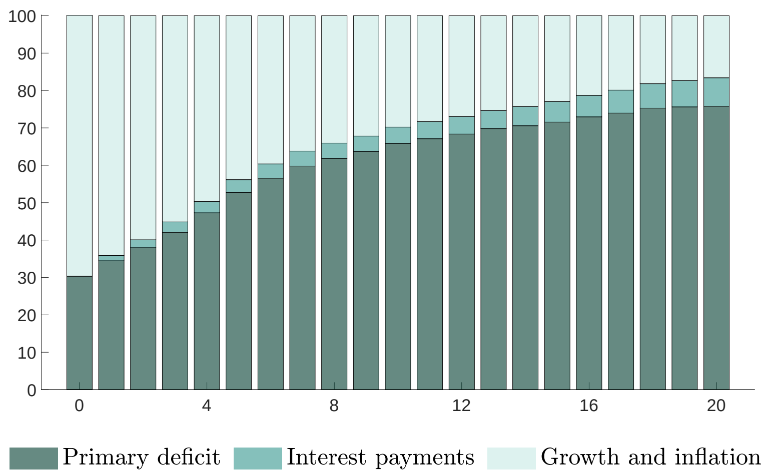
[13]The responses of long-term as well as short-term government debt are estimated separately by replacing total government debt-to-GDP in the baseline specification.

[14]The limited impact of interest payments for the overall effect on the fiscal deficit can be explained by a large share of long-term US government debt, and thus the average maturity of public debt amounts to roughly 5 years

The secondary role of debt servicing together with the maturity structure of government debt in the US in turn help to explain the fact that we observe initially lower inflation combined with a higher deficit. According to theory, a rate hike gives rise to negative wealth effects for holders of long-term debt, ultimately lowering consumption and inflation (Caramp and Silva, 2023). At the same time, through intertemporal substitution, higher real rates bring down consumption and cool down aggregate demand.[15]

As interest payments pick up, however, we observe a reversion in the price level back to trend with an overshoot in the inflation response. Thus, our results suggest that rather than controlling inflation, the central bank can only postpone it. Our empirical finding of a S-shaped inflation trajectory provides evidence for the intertemporal mechanisms formalized by Sims (2011) and Cochrane (2024). Through the lens of the IGBC, a monetary tightening can only permanently lower the price level path if it is accompanied by a future fiscal contraction. Because we document that primary surpluses do not increase in the foreseeable future—and indeed exhibit short-run deficits due to automatic stabilizers—the long-run price level trajectory remains fiscally anchored. Consequently, consistent with Cochrane's (2024) neutrality framework, the initial monetary-driven disinflation represents a intertemporal shift in the timing of inflation

Figure 3: Relative contributions of the IGBC-implied debt components

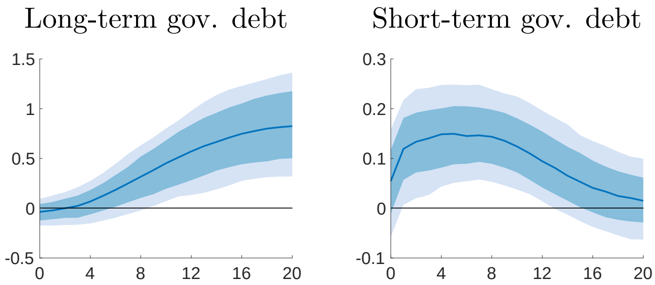


Notes: Bars display the posterior point-wise median values of the percentage contributions of each IGBC component (output growth, inflation, primary deficit, and interest payments) to the IGBC-implied debt path shown in Figure 2.

in our sample (see also Caramp and Silva, 2023; Andreolli and Rey, 2024). Figure A.6 in the Appendix shows the maturity distribution of outstanding treasury debt as well as the average maturity across our sample.

[15]In models with short-term financed government debt, positive wealth effects usually dominate, as households can reinvest their savings at higher rates after the monetary shock.

Figure 4: Impulse responses of long-term and short-term government debt to contractionary monetary policy shocks



Notes: Lines show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Shaded areas represent 68% and 90% centered point-wise probability bands. Variables are expressed as ratios to GDP and reported in percent.

rather than a permanent reduction in the price level, resulting in the subsequent inflationary overshoot mandated by the IGBC. As the price level itself does not overshoot, the inflation response, however, is not sufficient to finance the monetary induced burden of debt. Ultimately, it appears that the fiscal consolidation very far out in the future, with the deficit gradually turning negative approximately six years after the shock materialized, ensures that the IGBC holds in the limit.

To summarize, an exogenous monetary contraction "leaves considerable fiscal footprints" (Kaplan, 2025). Revenues decline and expenditures increase, leading to a higher fiscal deficit and a persistent increase in government debt. In addition, the increase in public debt is mainly related to a strong rise in long-term debt, whereas short-term debt accounts only for a small share. Consequently, the direct channel via higher interest payments is of rather limited importance but indirect effects through activated automatic stabilizers matter much more. Whether and how much these fiscal side-effects matter for the monetary transmission is theoretically ambiguous and depends on important theoretical assumptions. Several recent contributions show that the impact of the fiscal response is particularly acute when households are non-Ricardian. If Ricardian equivalence fails, for example in the form of liquidity constrained households with a higher marginal propensity to consume, how the fiscal authority absorbs the monetary contraction becomes of first-order importance (Angeletos et al., 2026; Kaplan et al., 2018): changes in the fiscal response to the monetary shock significantly shape the aggregate effects. This reasoning motivates our counterfactual analysis below where we construct scenarios scrutinizing the implications of the timing of government debt response, and to isolate the responses of the different fiscal measures, that is revenues, transfers and spending, in the transmission of monetary policy.

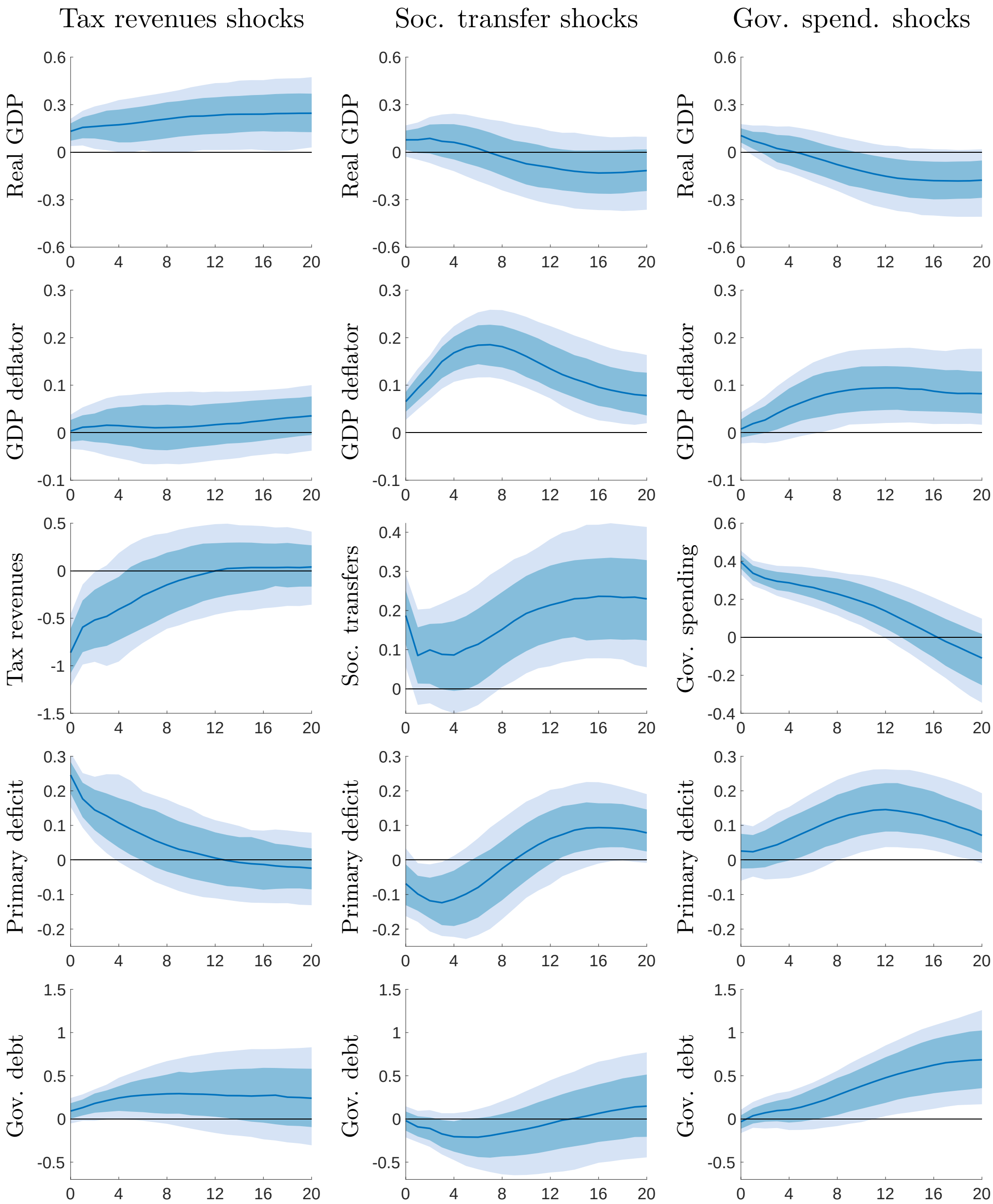
3.2 Impulse responses to fiscal policy shocks

Figure 5 presents for selected variables the estimated impulse responses to the identified fiscal shocks, i.e. the tax, social transfer, and government spending shock. These shocks will be used later on to construct the structural counterfactuals. The first column shows the responses to the tax shock, the second column to the transfer shock, and the third column to the spending shock, respectively. The first row presents the respective GDP responses, the second row depicts the price responses and the third row shows the responses of the respective fiscal measure. The last two rows display the responses of the fiscal deficit and government debt, respectively. In the main text, we focus our attention on the central variables of interest but report the responses of the remaining variables in Figure A.7 in the Appendix. The shocks are normalized to be expansionary and of one standard deviation in size triggering an increase in economic activity on impact. Thus, the responses pertain to an exogenous decline in tax revenues and increases in social transfer payments and government spending.

Overall, the estimated responses are well in line with the findings of previous studies. The tax revenue shock leads to a significant increase in GDP reaching its peak at the end of the impulse response horizon. A similar expansionary impact of exogenous tax reductions is also found by e.g., Mertens and Ravn (2014), Ramey (2016) and Klein and Linnemann (2019). Moreover, the tax cut produces some price pressure with a delayed increase in the GDP deflator of around 0.05% five years after the shock. Mertens and Ravn (2012) and Klein and Linnemann (2019) estimate a comparable muted increase in prices following an exogenous tax reduction. In addition, the tax shock leads to a significant increase in the fiscal deficit over the first couple of quarters that implies a quick build up in public debt, very much in line with the results reported in Klein and Linnemann (2019, 2024).

Compared to the tax shock, an exogenous increase in social transfers is associated with a much more short-lived increase in GDP. The response peaks already three quarters after the shock and becomes negative, albeit not statistically different from zero, in the medium run. Romer and Romer (2016) and Párraga Rodríguez (2018) also find that higher social transfers stimulate output only in the short run. Overall, the result that exogenous tax changes have a stronger impact on economic activity than exogenous changes in transfer payments is well in line with the evidence reported by Romer and Romer (2016). Contrary to the quite limited

Figure 5: Impulse response functions to expansionary fiscal policy shocks



Notes: Lines show the posterior point-wise median values of the baseline impulse responses to an expansionary one standard deviation tax revenue shock (first column), social transfer shock (second column), and government spending shock (third column). Shaded areas represent 68% and 90% centered point-wise probability bands.

real effects of a transfer shock, prices significantly increase following the fiscal stimulus. Two years after the shock, the GDP deflator is 0.2% above its pre-shock level. A similar strong price impact of shocks to social transfer payments is also found by Párraga Rodríguez (2018). Moreover, the particularly strong inflationary effect of positive transfer shocks supports recent theoretical contributions. Bianchi et al. (2023) propose a model with partly unfunded debt.

In response to business cycle shocks, the monetary authority controls inflation and the fiscal authority stabilizes debt. However, the central bank accommodates unfunded fiscal shocks, causing persistent movements in inflation. When estimating the model, they find that such fiscal inflation accounts for the bulk of inflation dynamics in post-WWII data. Relatedly, Kaplan et al. (2023) show in a HANK model that an increase in targeted transfers towards poorer households can have strong inflationary effects. Somewhat surprisingly, an exogenous increase in social transfers first lowers the fiscal deficit before the response turns positive after around three years. As a consequence, the shock also leads to a reduction in public debt over the short to medium run with the debt response turning positive only after around four years. These results can be explained by the fact that an increase in transfer payments triggers an increase in tax revenues and a significant decline in government spending as can be seen in Figure A.7 in the Appendix. Higher tax revenues and lower discretionary spending imply an improvement in the fiscal balance which outweighs the deterioration via the temporal increase in transfer payments. These documented fiscal consequences of an exogenous transfer shock are very similar to the ones reported in Bouscasse and Hong (2026).

Finally, similar to the transfer shock, the government spending shock induces only a limited and short-lived GDP expansion. GDP significantly increases in the impact period by around 0.1% but then converges back to zero and even turns negative in the medium run. Corsetti et al. (2012) find a comparable GDP response following an exogenous government spending increase when starting the sample in the early 1980s as we do.[16] Similar to the transfer shock, while leading to only mild real effects, the spending increase also triggers a more pronounced rise in prices. The GDP deflator is up by around 0.1% two years after the spending shock materialized. The shock has rather limited immediate effects on the fiscal deficit and public debt but leads to delayed increases in both measures. The peak response of the fiscal deficit is reached after around three years and the increase in public debt lasts until the end of the forecast horizon. Such a delayed impact of a government spending shock on the fiscal balance is also found by Corsetti et al. (2012) and can be explained by an increase in tax revenues over the first couple of quarters as shown in Figure A.7 in the Appendix.

In summary, while the tax shock leads to strong real but limited price effects, the transfer and

[16] Also Ramey (2011), Forni and Gambetti (2016) and Bredemeier et al. (2022) find a similar short-lived output expansion following a positive government spending shock when considering a comparable sample period to ours. Moreover, similar to Corsetti et al. (2012) and Forni and Gambetti (2016) our estimates show that after the initial increase, government spending falls below trend in the medium term; a phenomenon they call "spending reversals".

spending shocks are associated with strong price changes but have a muted impact on real economic activity. Moreover, exogenous tax changes have an immediate impact on the fiscal deficit and public debt, whereas both fiscal measures react with a significant delay to government spending shocks. Given the significant responses of fiscal variables to monetary policy shocks as shown in Figure 1, a natural next step is to analyze the impact of exogenous changes in the interest rate in scenarios where fiscal responses deviate from the baseline. In particular, we proceed to investigate how the transmission of monetary policy shocks changes when changing the speed of the fiscal adjustment. Moreover, we also zoom into the importance of each fiscal instrument namely, revenues, transfers, and government spending, by constructing scenarios where we neutralize their responses at a time. The structural counterfactuals presented below provide us with the appropriate framework for investigating these issues.

3.3 Robustness

Before we turn to the structural counterfactuals, Figures A.8 to A.10 in the Appendix document the robustness of our underlying impulse response functions. In Figure A.8 we first consider two alternative approaches to purge the daily high-frequency monetary policy surprises from information effects, namely (i) the "poor-man's approach" by Jarociński and Karadi (2020) in which the surprises are pre-selected depending on whether the policy surprise and the stock market surprise reveal opposite signs, and (ii) the approach by Miranda-Agrippino and Ricco (2021) in which the policy surprises are purged from Greenbook projections. Second, we consider the federal funds rate factor provided by Swanson (2021) purged from information effects as suggested in Miranda-Agrippino and Nenova (2022), and construct the monetary policy proxy based on surprises of interest rate derivatives with maturities up to one year (see, e.g., Nakamura and Steinsson, 2018). Finally, we consider two estimations, in which we either use the original tax proxy measure provided by Mertens and Ravn (2011) or Romer and Romer (2010). Because both series end in 2006, we fill the missing observations with zeros. All these modifications produce very similar results compared to our baseline model.

Moreover, in Figure A.9 we evaluate whether the endogenous response of fiscal policy potentially depends on the sign of the monetary policy shock by considering either positive or negative high-frequency monetary policy surprises for identification. Second, to evaluate implications of the zero lower bound for our identification, we re-estimate our baseline model replacing the one-year treasury bill rate with the effective with the shadow rate provided by Wu and Xia

(2016), spliced with the federal funds rate before 1990. This measure of the monetary policy stance is not bounded by zero and is constructed to capture unconventional policies such as quantitative easing or forward guidance. Third, we extend the sample up to 2024Q4. Due to data availability, we replace in the extended sample our baseline high-frequency measure with the orthogonalized high-frequency monetary policy surprise by Bauer and Swanson (2023b). Again, we obtain qualitatively very similar responses compared to our baseline specification.

Finally, Figure A.10 in the Appendix shows that our baseline impulse responses are robust to the exact ordering of the fiscal policy proxies, as well as the additional zero restriction imposed on $\boldsymbol{V}$ to achieve point identification.

4 Structural counterfactuals

The impulse response analysis shows that, following contractionary monetary policy actions, the endogenous response of automatic fiscal stabilizers increases government financing needs. Consistent with the IGBC, the resulting fiscal adjustment is accommodated through higher government debt and the fiscal consolidation is pushed far into the future. At the same time, we find that identified exogenous fiscal interventions—via taxes, transfers, and government spending—affect real and nominal aggregates. To evaluate how these fiscal policy actions shape the transmission of monetary policy, we construct structural counterfactuals.

First, we consider the timing of the fiscal consolidation and constrain the build-up in government debt. Under Ricardian equivalence, the timing of repayment of monetary-policy-induced expenditures should not affect macroeconomic outcomes (Clarida et al., 1999), while failure of Ricardian equivalence can reinforce them (Auclert et al., 2020; Alves et al., 2020; Kaplan et al., 2018; Eusepi and Preston, 2018). To evaluate this channel, we replicate the impulse responses shown in Figure 1 for counterfactual scenarios in which government debt is (i) kept constant in response to the monetary policy shock, or (ii) repaid twice as quickly as in the unrestricted baseline with the debt to GDP ratio being restricted to converge back to zero until eight years out.

We then continue with a second set of counterfactuals where we characterize the mechanisms pertaining to the individual fiscal measures, namely tax revenues, social transfer payments, and government spending. Because the fiscal measures might have different distributional consequences, in particular how they redistribute income between low and high marginal propensity to consume households, the aggregate impact of the monetary intervention could well differ across the endogenous fiscal responses (Kaplan et al., 2018; Kaplan, 2025). Moreover, as already reported in Figure 5, the fiscal shocks affect real and nominal variables differently. We study the different fiscal adjustment channels by separately neutralizing the respective fiscal responses following the monetary policy shock.

4.1 Formal framework

Following Antolín-Díaz et al. (2021), we formalize these counterfactual scenarios as conditional forecasts of the endogenous variables in which we restrict the path of specific variables and shocks. We start by rewriting the SVAR implied by Equation (1) as an unconditional forecast of the endogenous variables based on information available up to period τ,

$$\boldsymbol{y}_{\tau+1,\tau+h} = \boldsymbol{b}_{\tau+1,\tau+h} + \boldsymbol{\Theta}\boldsymbol{\varepsilon}_{\tau+1,\tau+h}, \tag{5}$$

where $\boldsymbol{y}'_{\tau+1,\tau+h} = [\boldsymbol{y}'_{\tau+1}, \ldots, \boldsymbol{y}'_{\tau+h}]$ stacks the unconditional forecasts of the endogenous variables and $\boldsymbol{\varepsilon}'_{\tau+1,\tau+h} = [\boldsymbol{\varepsilon}'_{\tau+1}, \ldots, \boldsymbol{\varepsilon}'_{\tau+h}]$ the realizations of the future shocks in periods $\tau+1$ through $\tau+h$. The $nh \times 1$ vector $\boldsymbol{b}_{\tau+1,\tau+h}$ denotes the base projection predetermined by initial conditions and past shocks up to $\tau-1$, and the $nh \times nh$ matrix $\boldsymbol{\Theta}$ is a function of the structural parameters that maps the future shocks into the unconditional forecasts of the endogenous variables.

Antolín-Díaz et al. (2021) provide a general solution to obtain a counterfactual forecast conditional on restrictions on the future path of specific endogenous variables and shocks. Let $\boldsymbol{f}_{\tau+1,\tau+h}$ be a column vector that collects k_o restrictions on the path of endogenous variables and k_s restrictions on the path of future shocks, and define $\boldsymbol{C}' = [\boldsymbol{O}', \boldsymbol{\Theta}^{-1\prime}\boldsymbol{S}']$, where $\boldsymbol{O}$ and $\boldsymbol{S}$ are $k_o \times nh$ and $k_s \times nh$ selection matrices. A structural counterfactual can be expressed as

$$\boldsymbol{C}\overline{\boldsymbol{y}}_{\tau+1,\tau+h} = \boldsymbol{C}\boldsymbol{b}_{\tau+1,\tau+h} + \boldsymbol{C}\boldsymbol{\Theta}\overline{\boldsymbol{\varepsilon}}_{\tau+1,\tau+h} = \boldsymbol{f}_{\tau+1,\tau+h}. \tag{6}$$

To obtain impulse responses we set $\boldsymbol{b}_{\tau+1,\tau+h} = \boldsymbol{0}$. The counterfactual path of future shocks $\overline{\boldsymbol{\varepsilon}}_{\tau+1,\tau+h}$ and impulse responses $\overline{\boldsymbol{y}}_{\tau+1,\tau+h}$ are then given by $\overline{\boldsymbol{\varepsilon}}_{\tau+1,\tau+h} = \boldsymbol{D}^*\boldsymbol{f}_{\tau+1,\tau+h}$ and $\overline{\boldsymbol{y}}_{\tau+1,\tau+h} = \boldsymbol{\Theta}\boldsymbol{D}^*\boldsymbol{f}_{\tau+1,\tau+h}$, with $\boldsymbol{D}^*$ being the Moore-Penrose inverse of $\boldsymbol{D} = \boldsymbol{C}\boldsymbol{\Theta}$.

Equation (6), for instance, recovers the baseline impulse responses to the monetary policy shock, as shown in Figure 1, if we do not impose any restrictions on the endogenous variables (i.e. set

$\boldsymbol{O}$ to be empty), but restrict all shocks over the entire forecast horizon h to zero, except that the monetary policy shock equals one on impact. These restrictions on the shocks imply that $\boldsymbol{S} = \boldsymbol{I}_{nh}$, and $\boldsymbol{f}_{\tau+1,\tau+h}$ is a $nh \times 1$ vector of zeros with unity in the first entry of the monetary policy shock in $\boldsymbol{\varepsilon}_{\tau+1,\tau+h}$.

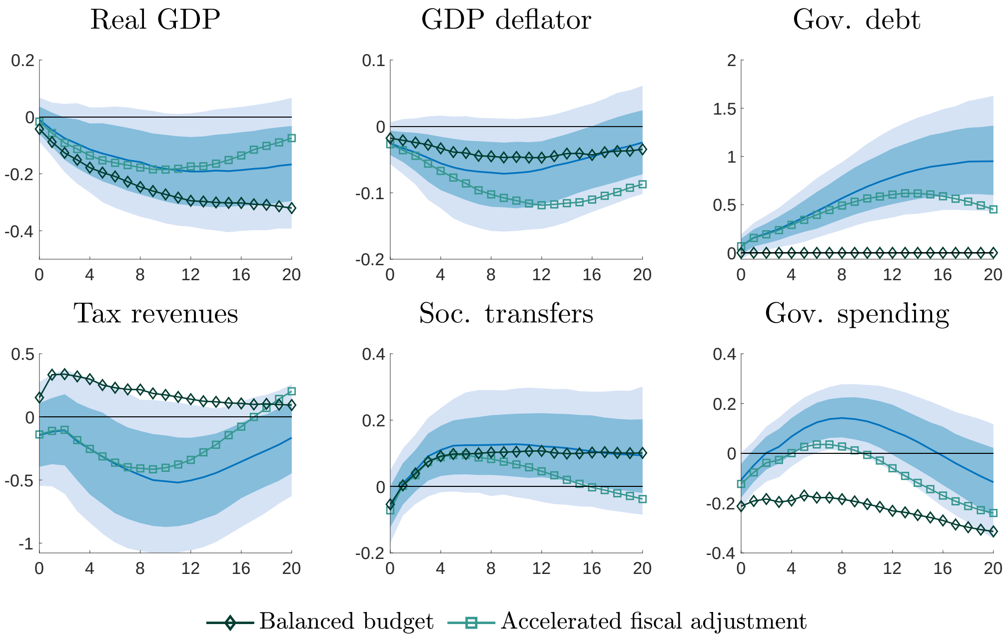
The counterfactual in which government debt is balanced over the entire impulse horizon implies $k_o = h$ restrictions on $\overline{\boldsymbol{y}}_{\tau+1,\tau+h}$ (in the accelerated fiscal adjustment scenario $k_o = h - 32$ as debt is balanced after 8 years). To only allow fiscal policy shocks to materialize to impose the constraints on government debt making sure that the counterfactual responses are the result of a different fiscal policy response, we restrict all non-fiscal policy shocks to be zero over the entire impulse horizon except the monetary policy shock on impact that is set to unity, adding up to $k_s = (n-3)h$ restrictions on $\overline{\boldsymbol{\varepsilon}}_{\tau+1,\tau+h}$. As in either case, the number of $k_o + k_s$ restrictions is smaller than the number of nh unknown shocks $\overline{\boldsymbol{\varepsilon}}_{\tau+1,\tau+h}$ the system is underdetermined and multiple solutions exist. Antolín-Díaz et al. (2021) document that the solution based on the Moore-Penrose inverse of $\boldsymbol{D}$, selects the combination of fiscal policy shocks whose distributions deviate as little as possible from their unrestricted counterparts. In other words, this solution provides the most likely fiscal policy mix that imposes the constraints.[17]

4.2 Timing of the required fiscal adjustment

In the baseline model, the monetary policy shock pertains to a pronounced response of tax revenues, social transfers, and government spending financed through sustained fiscal deficits and a persistent build-up in government debt. The fiscal consolidation required to fulfill the IGBC is pushed far into the future. We now investigate how changes in the timing of the fiscal adjustment impact the effectiveness of the monetary intervention. The timing might matter because of the potential failure of Ricardian equivalence: the much delayed fiscal consolidation observed in the baseline model can cushion the rate hike through spending expenditures by high marginal propensity to consume, liquidity constrained households, while an immediate fiscal response in the form of higher taxes or lower public expenditures can drag on spending (see, e.g., Caramp and Silva, 2023; Angeletos et al., 2026). Thus, studying how changes in the timing of the fiscal consolidation alter the responses to monetary policy shocks provides relevant insights on the importance of failure from Ricardian equivalence for the monetary transmission

[17] In Appendix D we document the exact specifications of the selection matrices $\boldsymbol{O}$ and $\boldsymbol{S}$, and the vector of restrictions $\boldsymbol{f}_{\tau+1,\tau+h}$ for all counterfactuals. In the additional counterfactuals in which we neutralize each fiscal instrument separately by the respective fiscal policy shock, the number of $k_o + k_s = nh$ restrictions and the solution is unique with $\boldsymbol{D}^* = \boldsymbol{D}^{-1}$.

Figure 6: Impulse responses and counterfactuals when fiscal policy balances government debt at different horizons



Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Lines with markers depict the posterior point-wise median values of the counterfactual impulse responses when fiscal policy balances government debt either over the entire impulse horizon (diamonds) or after 8 years (squares). The counterfactuals are imposed using all three fiscal policy shocks. The median values of the corresponding q-divergence statistic are 0.53 and 0.51. Shaded areas represent 68% and 90% centered point-wise probability bands for the baseline impulse responses.

mechanism.

To investigate this issue, we impose two different fiscal adjustment paths compared to the very long-lasting increase in government debt as observed in the baseline model. In particular, the first scenario implies a faster adjustment as in the baseline with government debt being back at its pre-shock level eight years after the shock, a scenario we call “accelerated fiscal adjustment”. Keep in mind that in the baseline model, the government debt response is back to zero only after around 16 years. In the second counterfactual, the “balanced budget” scenario, we impose that the government has to equalize expenditures and revenues and thus holds government debt constant throughout the impulse response horizon. Thus, the fiscal contraction required to fulfill the IGBC happens immediately after the monetary shock.

The structural counterfactuals in the form of alternative paths of the debt-to-GDP ratio are achieved through appropriately scaled consecutive tax revenue, social transfer, and government spending shocks. The neutralizing shocks are selected as the most likely combination of fiscal policy shocks to effectively impose the constraints of earlier fiscal consolidation. The most likely solution implies that the distributions of the neutralizing shocks deviate as little as possible from their unrestricted counterparts and therefore represent the most modest fiscal intervention conditional on the scenario. Figure 6 shows point-wise median counterfactuals together with the baseline results as reported in Figure 1.[18]

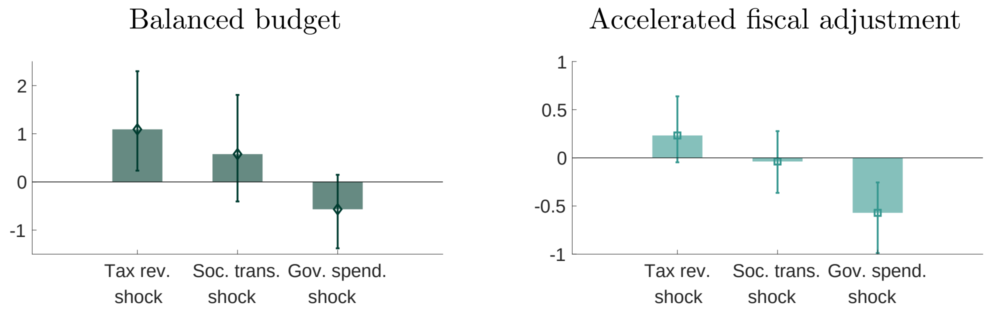
Changes in the timing of the fiscal adjustment considerably affect the monetary transmission. For example, in the accelerated fiscal adjustment scenario the temporary nominal effects of monetary policy are amplified: in the baseline, the peak decline in prices amounts to around 0.05%, whereas prices fall by more than 0.1% in the alternative scenario. While the initial drop in the price level is larger and more persistent than in the baseline case, the S-shaped adjustment prevails also in the alternative fiscal scenario with inflationary pressure setting in after around three years. Contrary to the considerable differences in the nominal effects, the output response is fairly similar compared to the baseline. Thus, limiting the increase in government debt, both in terms of magnitude and in terms of persistence, changes the temporary nominal effects of monetary policy while leaving the real effects rather unaffected.

This picture flips when imposing a hard constraint in the form of a balanced government budget across all periods. In the balanced budget scenario, monetary policy has a much larger effect on output compared to the baseline case: the peak decline in GDP is slightly above 0.3%, while output falls by less than 0.2% in the baseline. The impact on prices, however, is rather similar between the baseline and the alternative scenario. In this regard, our empirical findings are very much in line with the theoretical predictions of Kaplan et al. (2018) and Angeletos et al. (2026). They show in different models in which Ricardian equivalence fails that front-loading the fiscal adjustment significantly amplifies the real effects of monetary policy shocks.

To better understand the discrepancies between real and nominal effects across the two counterfactuals, the second row of Figure 6 provides the implied fiscal responses of tax revenues, social transfers, and government spending following the monetary policy shock. When imposing a balanced budget, adjustments in tax revenues are most effective in stabilizing debt. Put differently, tax revenues do not fall as observed in the baseline, but rather increase in the short run. In turn, the imposed tax hikes reinforce the real effects of the rate hike given the strong impact of tax shocks on GDP as documented in Figure 5. While the social transfer response is similar compared to the baseline, also discretionary government spending is cut back to avoid any

[18] Figure A.11 in the Appendix reports the implied differences between the baseline and counterfactual impulse responses.

Figure 7: Neutralizing shocks imposing the counterfactuals



Notes: The bars show the posterior point-wise median values of the cumulated neutralizing shocks imposing the balanced budget counterfactual (left panel), and the accelerated fiscal adjustment counterfactual (right panel). The whiskers represent 68% centered point-wise probability bands. The shocks are cumulated over the impulse horizon of 5 years. Figures A.13 and A.14 in the Appendix show the neutralizing shocks over the entire impulse horizon.

increase in government debt. Thus, a combination of higher revenues and lower expenditures, mainly in the form of discretionary spending, is most effective in holding government debt constant following the monetary intervention. In the accelerated fiscal adjustment scenario, debt stabilization appears to be rather implemented through a cut in government spending, while tax revenues and social transfers respond relatively similar compared to the baseline. As government spending exerts strong inflationary but only limited real effects, as shown in Figure 5, lowering government spending amplifies the transmission of monetary policy to prices while not significantly affecting the output response.

The composition of the fiscal adjustment is also reflected by the prevalence of the neutralizing fiscal policy shocks in the different counterfactuals, as shown in Figure 7. Corroborating the previous discussion, the balanced budget scenario is achieved by a sequence of positive tax shocks coupled with government spending cuts and contractionary tax shocks overall dominating spending reductions. Positive tax shocks account for roughly half of the total share of the neutralizing shocks. The stronger weight on tax increases implies larger real effects following the monetary policy shock, while the price response is rather unaffected. In contrast, the accelerated fiscal adjustment scenario is implemented by mainly imposing negative government spending shocks. In particular, contractionary spending shocks make up around two thirds of the total share of neutralizing shocks. With spending shocks having a strong impact on prices but limited real effects, this explains the amplified nominal effects of the monetary intervention compared to the baseline.

Why does the algorithm choose this particular sequence of shocks? As described in Section 3.2, the fiscal shocks have different consequences for the fiscal deficit and government debt. Because tax shocks trigger an immediate impact on the deficit and government debt, they dominate in the balanced budget scenario. Government spending shocks have only a muted impact on deficit and debt on impact but imply a strong response in both measures over the medium run, which helps explaining why government spending cuts prevail in the accelerated fiscal adjustment scenario.

To address possible concerns about the plausibility of our counterfactual exercises with respect to the Lucas critique we report in Figure A.12 in the Appendix the q-divergence proposed by Antolín-Díaz et al. (2021). The q-divergence builds on the Kullback-Leibler divergence and compares the distribution of shocks in the counterfactual scenario to the distribution of shocks implied by the baseline.[19] The q-divergence transforms the Kullback-Leibler statistic such that values close to 0.5 indicate that the two distributions are similar and unproblematic. In contrast, values close to 1 would indicate that a rather unusual distribution of shocks is necessary to construct the counterfactual, making it likely that economic agents update their beliefs about the structure of the economy. Figure A.12 shows that in each of the two counterfactual scenarios, the distribution of q-values lies very close to 0.5 which implies that the Lucas critique is unlikely to be a major concern for our analysis so far.

In addition, we follow McKay and Wolf (2023) and implement counterfactuals along similar lines by allowing only for a one-off linear combination of shocks. In this case we use tax revenue, social transfer, and government spending shocks that enforce the desired counterfactual rule of short and medium run budget balance as well as possible. As this approach involves no ex-post surprises after impact, it is immune to the Lucas critique. As visible in Figure A.15 in the Appendix, this approach echoes the importance of the fiscal channel, with an even stronger impact of the fiscal channel on the transmission of monetary policy to both prices and output. When we require the counterfactual scenario to be imposed with only a one-off counterfactual fiscal response, relatively large tax and government spending shocks materialize on impact. As the fiscal authority can only react on impact to achieve the counterfactual, these types of counterfactuals fail, however, to enforce different time paths for the fiscal adjustment effectively. In particular, the accelerated fiscal adjustment scenario is akin to the balanced budget scenario, as the IGBC can be best met in the medium run, by neutralizing debt accumulation right from the start.

[19] To obtain distributions of the shocks implied by the unconstrained baseline impulse responses and the structural scenarios we follow the calculation of the q-divergence as described in Breitenlechner et al. (2022).

To summarize, our findings demonstrate that the timing of fiscal consolidation affects the composition of the fiscal adjustment, with distinct implications for the effects of monetary policy. The finding that front-loading the fiscal consolidation amplifies the aggregate effects of monetary policy shocks aligns well with theoretical frameworks where the failure of Ricardian equivalence is central to the monetary-fiscal nexus (Kaplan, 2025; Angeletos et al., 2026). In such settings, fiscal tightening vis-à-vis the rate hike drags on aggregate demand, as liquidity-constrained households are unable to smooth consumption.

4.3 Neutralizing endogenous fiscal responses

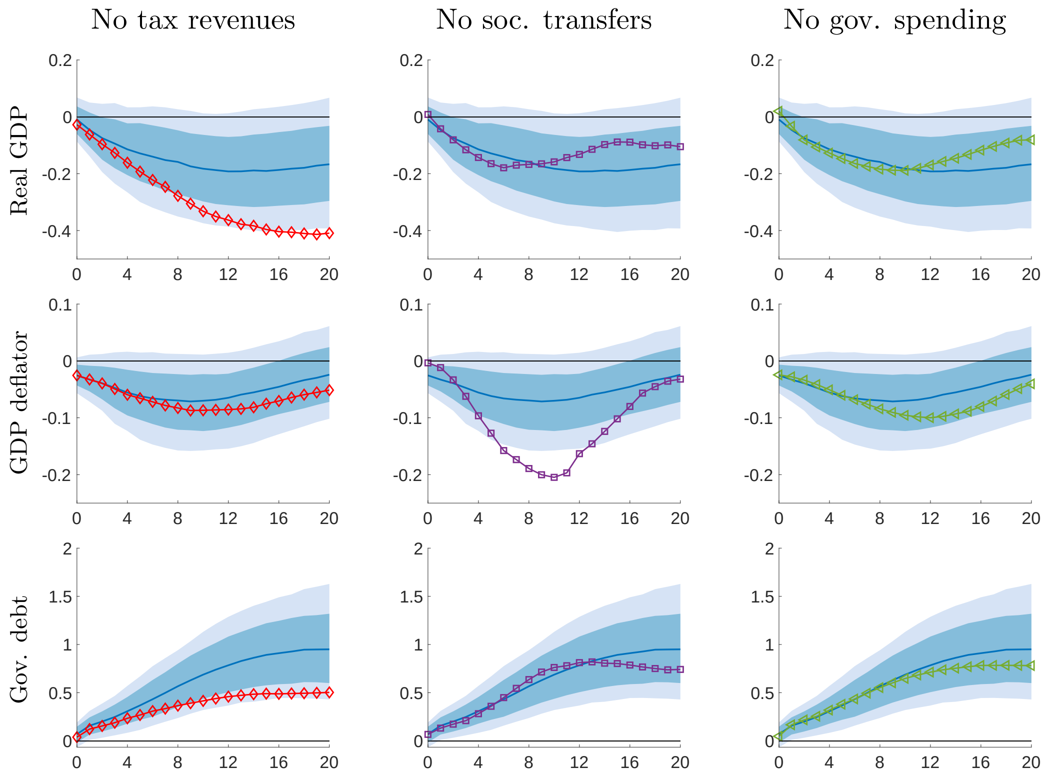
Depending on the time path of the fiscal adjustment to meet the IGBC, we have seen that the consolidation is enforced through different fiscal instruments. In the following, we scrutinize the composition of the fiscal channel further and study structural counterfactuals where the endogenous responses of the fiscal instruments, namely taxes, social transfers, and government spending are shut down one by one. More specifically, we construct counterfactual impulse responses to a monetary policy shock where the endogenous response of either taxes, social transfers, or government spending is nil. These restrictions on the future path of observables are imposed by allowing the respective fiscal policy shock to neutralize the endogenous adjustment. As documented in Section 3.2, the real and nominal effects vary between the different fiscal shocks and thus the aggregate effects of the monetary policy shock depend on the specific fiscal instrument chosen to be offset.[20]

Figure 8 shows the effects when assuming no endogenous responses in tax revenues, social transfers, and government spending in each of the measures separately. Consider the first column shutting off the tax response: instead of a fall in tax revenues as reported in Figure 1, the tax response is nil. Lines without markers and shaded areas correspond to the baseline estimates as reported in Figure 1, while lines with markers show the counterfactual responses.

When the endogenous response of tax revenues to the monetary policy shock is shut down, the effects on output and prices are larger (in absolute terms) compared to the baseline case. The discrepancy is particularly strong for GDP. When not allowing tax revenues to fall following the contractionary monetary intervention, at the end of the impulse horizon GDP declines by more than twice as much. Thus, allowing for a temporary decline in tax revenues is quantitatively important to limit the recessionary effects induced by the exogenous increase in the interest rate.

[20] See Appendix D for the specification of the matrices $\boldsymbol{O}$, $\boldsymbol{S}$, and $\boldsymbol{f}_{\tau+1,\tau+h}$.

Figure 8: Impulse responses and counterfactuals when fiscal policy measures are separately kept constant



Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Lines with markers depict the posterior point-wise median values of the counterfactual impulse responses when the individual response of tax revenues (first column), social transfers (second column), or government spending (third column) is neutralized separately. The median values of the corresponding q-divergence statistics are 0.52, 0.53, and 0.51. In counterfactuals with exact solutions, we discard counterfactuals when the offsetting shock at the end of the impulse horizon is larger (in absolute terms) as compared to the offsetting shock on impact. Shaded areas represent 68% and 90% centered point-wise probability bands for the baseline impulse responses.

A qualitatively similar picture emerges for prices. While the baseline estimates indicate that the GDP deflator is close to zero at the end of the impulse horizon, prices would still be lowered by a bit less than 0.08% when holding tax revenues constant. However, the future inflationary pressure is further postponed with the price level starting to converge back to steady state around three years after the shock. Holding tax revenues constant also limits the increase in government debt. At the end of the impulse horizon, the debt increase is around 0.4 percentage points, roughly half of the debt build-up observed in the baseline case. Thus, the debt-financed endogenous decrease in tax revenues effectively smooths the cycle.

In a scenario where social transfers do not respond to the monetary policy shock, as shown in the second column of Figure 8, the real effects are quite close to the baseline estimates. This can be explained by the limited impact of exogenous changes in social transfers on real GDP as presented in Figure 5. In contrast, the temporary effect on prices is quantitatively much more pronounced. Two years after the shock materialized, the baseline estimates show a fall in the price level by around 0.05%, whereas prices would fall by around 0.2% when assuming no change in social transfers following the monetary policy shock. Thus, the transfer system considerably dampens the short-run deflationary effects of contractionary monetary policy interventions. Notably, the S-shaped adjustment in inflation prevails and the price level is close to its pre-shock level after around five years. There are no systematic differences in the government debt response between the baseline and the counterfactual scenario. This might seem surprising at first sight but can be explained by the limited impact of social transfer shocks on deficit and government debt, as discussed in Section 3.2.

For government spending, the differences between the baseline responses and the counterfactual scenario are more, yet qualitatively similar than in the case of social transfers. This is due to the mostly insignificant response of government spending to the monetary policy shock in the first place (see Figure 1).

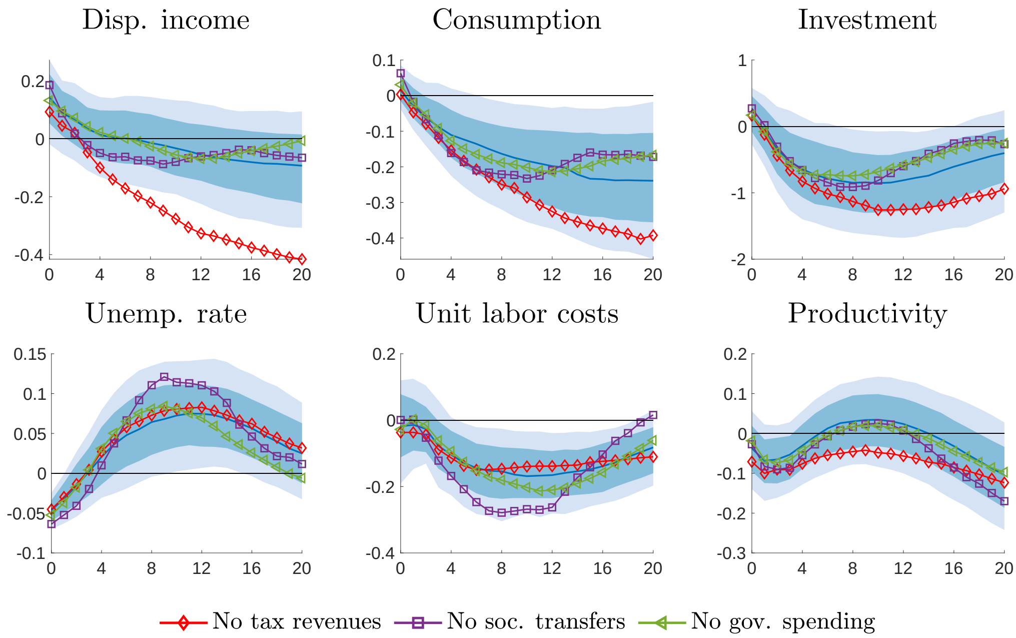
4.4 Inspecting the mechanism

The previous comparison of actual versus counterfactual impulse response functions already suggests that depending on the fiscal policy instrument, different mechanisms are at play in the endogenous adjustment of fiscal policy after monetary policy shocks. In particular, it appears that the adjustment of taxes rather stabilizes output, while the social transfer system primarily influences prices. In order to better understand the different mechanisms, in the following, we extend our analysis and investigate several important variables that help rationalizing these findings.

The first row of Figure 9 shows the actual and counterfactual impulse responses of disposable income, private consumption, and investment to understand the demand side effects of the fiscal channel. In the structural counterfactuals we shut down the endogenous adjustment of taxes, social transfers and government spending one-by-one with the respective fiscal shocks.

Clearly, the rate hike drags on consumption and lowering the tax burden substantially stabilizes consumption, which cushions the real effects. Without lower taxes, the fall in consumption would be around twice as much five years out. While the endogenous adjustment in government spending does not stabilize consumption, we see that higher social transfer dampen the consumption response to the monetary policy shocks only temporarily, yet initially by a similar

Figure 9: Impulse responses and counterfactuals of the unemployment rate, unit labor costs, and productivity



Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Lines with markers depict the posterior point-wise median values of the counterfactual impulse responses when either the response of tax revenues (diamonds), social transfers (squares), or government spending (triangles) is neutralized separately. The median values of the corresponding q-divergence statistics lie between 0.52 and 0.53. Shaded areas represent 68% and 90% centered point-wise probability bands for the baseline impulse responses.

magnitude than lower taxes.

High effectiveness of lower taxes in dampening the output effects of monetary policy can be explained by the corresponding income adjustment. Absent of the endogenous tax adjustment of tax revenues to the rate hike, we see a much more pronounced drop in disposable income. Social transfers stabilize disposable income, if anything, only marginally and less so than taxes, even though their dampening effect on consumption is similar for short horizons. This discrepancy might reflects that social transfers are more targeted towards liquidity constrained, high-MPC households (see, e.g., Auclert et al., 2020; Kaplan et al., 2018). Thus, higher real effects of lower taxes are associated with strong output effects not because they are particularly targeted, but because they are much more effective in stabilizing income. Overall, demand-side effects in the transmission of monetary policy shocks through government expenditures appear to be less prominent. In sum, the real effects in the case of tax revenues primarily materialize through stabilization of personal consumption expenditures. By contrast, investment activity is largely unaffected by the endogenous fiscal adjustment to monetary policy shocks in the short run.

After approximately two years, we see that the adjustment in taxes effectively cushions the investment response, while government spending and social transfers drag on it.[21]

The dominant role of private income and spending for understanding the strong output effect of the tax system is also corroborated by a further counterfactual experiment that we run by discriminating between personal and corporate income tax shocks to neutralize the endogenous tax adjustment. In doing so, we rely on the decomposition of narrative (aggregate) tax shocks into changes in personal income and corporate income taxes provided by Mertens and Ravn (2013). Whereas so far, our analysis relied on a measure of aggregate tax revenues, this exercise allows us to zoom into the particular changes in the tax system by differentiating between personal income and corporate income tax adjustments. Thus, we modify our baseline specification by including real personal (corporate) tax revenues instead of aggregate revenues as endogenous variable in the BPSVAR and using the Mertens and Ravn (2013) proxy to extract exogenous changes in personal (corporate) taxes. The results are shown in Figure A.17 in the Appendix and indicate that the tax channel is predominantly driven by changes in personal income taxes relative to changes in corporate income taxes.

Turning to the second row of Figure 9, we intend to better understand the strong temporary price effects of the transfer system as shown in Figure 8, and assess selected labor market variables. We present the responses of the unemployment rate, unit labor costs and labor productivity, respectively. In the baseline, a contractionary monetary policy shock leads to a significant increase in the unemployment rate. Interestingly, when shutting down the endogenous adjustments in taxes and government spending, the resulting counterfactual unemployment responses show only minor differences to the baseline case. However, the transfer system limits the increase in the unemployment rate following exogenous interest rate hikes. At the two to three year horizon, the unemployment rate is elevated by around 0.08 percentage points in the baseline, whereas it increases by around 0.13 percentage points in the no-transfers counterfactual. Thus, endogenous adjustments in transfer payments reduce the detrimental labor market effects of contractionary monetary policy shocks. Notably, the transfer system also limits the decline in unit labor costs. Absent the strong increase in transfer payments following the monetary policy shock, unit labor costs fall by a larger magnitude than in the baseline. For the neutralized tax revenues and neutralized government spending scenarios, the differences in the unit labor costs responses, relative to the baseline, are rather limited. The unemployment and unit labor cost

[21] The real effects cannot be explained by trade effects as import and export effects off-set each other (see Figure A.16 in the Appendix, which also shows the responses of the current account and the real effective exchange rate).

responses should be interpreted together. Our results suggest that the endogenous adjustment in transfer payments, raises the reservation wage of workers and thus, leads to a smaller decline in unit labor costs, relative to the neutralized social transfers counterfactual. The large effects of social transfers on the stabilization of unemployment and wages together suggest that in the face of higher wage growth, firms are reluctant to lay off employees because, in the next economic upswing, they would have to offer even higher wages. The transfers keep insiders in their jobs, and lead to higher prices in the short-run along the lines of labor hoarding motives (Burnside et al., 1993). Given that firms' productivity does not change differently in the baseline and counterfactual scenarios, as shown in the right panel of Figure 9, production costs increase. Part of these higher costs might be passed on by firms into higher goods prices. Thus, the strong short-run price effects of the transfer system seem to be related to a supply channel, where higher transfer payments raise unit labor costs and, ultimately, goods prices.

In general, positive transfer and government spending shocks are associated with a significant increase in unit labor costs whereas exogenous changes in tax revenues, besides its strong impact on economic activity, leave unit labor costs mainly unaffected as shown in Figure A.18 in the Appendix. However, given the rather unsystematic response of government spending following the monetary policy shock, we do not find a clear pattern for the counterfactuals neutralizing the endogenous government spending response in Figures 8 and 9.

5 Conclusion

This paper provides novel empirical evidence that the fiscal framework crucially affects the monetary transmission mechanism. We find that fiscal policy influences the effectiveness of monetary policy primarily through automatic stabilizers, whereas the increase in interest payments plays a secondary role. Lower tax revenues together with higher social transfer payments lead to a build-up of government debt, with the necessary consolidation efforts deferred into the future. Inflation follows an S-shaped adjustment implying that monetary policy shifts rather than permanently alters inflation. Counterfactual exercises reveal that front-loading the fiscal consolidation associated with a rate hike amplifies the real and nominal consequences of the monetary policy intervention. In addition, we document that the timing of the consolidation alters the composition of the fiscal adjustment, with distinct implications for real and nominal outcomes. Lower tax revenues, precipitated by the monetary policy tightening, significantly dampen the output response. Absent of an endogenous adjustment of tax revenues, the impact of a monetary policy shock on output is more than doubled emphasizing the role of adjustments in taxes as effective automatic stabilizers. The endogenous response of public expenditures is less relevant for the transmission of monetary policy to output but significantly affects the transmission to prices.

Our results have important policy implications for the calibration of the fiscal reaction to monetary actions. Depending on the instruments through which a potential change in the fiscal framework is implemented—primarily through the revenue or the expenditure side of the public sector—the effects on the transmission of monetary policy to prices and output will differ.

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Appendix

A Additional tables and figures

Table A.1: Data description

Variables	Description	Source	Code
Real GDP	Real gross domestic product (quarterly, seasonally adjusted, billions of chained 2012 Dollars)	FRED[1]	GDPC1
Nominal GDP	Gross domestic product (quarterly, seasonally adjusted, billions of Dollars)	FRED	GDP
GDP deflator	Gross domestic product: chain-type price index (index 2012=100, quarterly, seasonally adjusted)	FRED	GDPCTPI
EBP	Favara et al.'s (2016) updated EBP series (quarterly average, not seasonally adjusted)	Web[2]	ebp
IP	Industrial production index (index 2012=100, monthly, seasonally adjusted)	FRED	INDPRO
CPI	Consumer price index for all urban consumers: all items in US city average (index 1982-1984=100, monthly, seasonally adjusted)	FRED	CPIAUCSL
1y gov. bill rate	1-year treasury constant maturity rate (percent, quarterly average, not seasonally adjusted)	FRED	GS1
Gov. spending	Real government spending (quarterly, seasonally adjusted, billions of 2017 Dollars)	FRED	GCEC1
Tax revenues	Federal government total current receipts (quarterly, seasonally adjusted, billions of Dollars)	FRED	FGRECPT
Soc. transfers	Government social benefits to persons - Social Security[3] (quarterly, billions of Dollars)	FRED	W823RC1
Fiscal expenditures	Federal government total current expenditures (quarterly, seasonally adjusted, billions of Dollars)	FRED	FGEXPND
Interest payments	Federal government interest payments (quarterly, seasonally adjusted, billions of Dollars)	FRED	A091RC1Q027SBEA
Interest receipts	Federal government interest receipts (quarterly, seasonally adjusted, billions of Dollars)	FRED	B094RC1Q027SBEA
Net interest payments	Interest payments - interest receipts		
Primary deficit	Fiscal expenditures - net interest payments - tax revenues		
Gov. debt	Federal debt held by the public (quarterly, not seasonally adjusted, millions of Dollars)	FRED	FYGFDPUN
Short-term debt	Federal government short-term debt securities (quarterly, not seasonally adjusted, millions of Dollars)	FRED	BOGZ1FL364122405Q
Long-term debt	Federal government long-term debt securities (quarterly, not seasonally adjusted, millions of Dollars)	FRED	BOGZ1FL364122605Q
Pers. tax revenues	Personal current taxes plus contributions for government social insurance Federal government current tax receipts, quarterly, seasonally adjusted, billions of Dollars) deflated with the GDP deflator	FRED	(A074RC1Q027SBEA+ W780RC1Q027SBEA)/ GDPCTPI
Corp. tax revenues	Taxes on corporate income minus Federal Reserve Bank income (quarterly, seasonally adjusted, billions of Dollars) deflated with the GDP deflator	FRED	(B075RC1Q027SBEA− B677RC1Q027SBEA)/ GDPCTPI
Interest rate surprises	High frequency policy surprises (changes in the three month ahead federal funds future rate, measured 30 min around FOMC announcements)	Gürkaynak et al. (2022)	FF4
Target factor surprises	Swanson's (2021) federal funds rate factor	Swanson (2021)	
Tax shock proxy	Extended Mertens and Ravn's (2011) narrative tax shocks accounted for anticipation effects	Caldara and Kamps (2017)	
Mertens and Ravn (2011) tax proxy	Mertens and Ravn's (2011) narrative tax shock accounted for anticipation effects	Mertens and Ravn (2011)	
Romer and Romer (2010) tax proxy	Romer and Romer's (2010) narrative tax shock	Romer and Romer (2010)	
Soc. transfer proxy	Extended Romer and Romer's (2016) narrative transfer shock	Párraga Rodríguez (2018)	

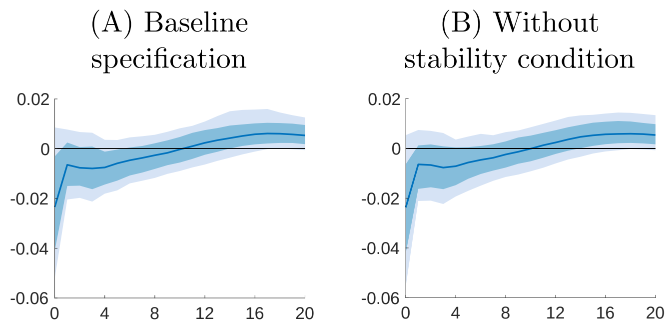
Notes: [1]Federal Reserve Economic Data ; [2]available at `https://doi.org/10.17016/2380-7172.1836`; [3]seasonally adjusted using the standard X12-ARIMA method, developed by the US Bureau of the Census; [4]extended up to the end of our sample in 2019Q4; [5]available at `https://www.atlantafed.org/cqer/research/wu-xia-shadow-federal-funds-rate`.

Table A.1: Data description (continued)

Variables	Description	Source	Code
Gov. spending proxy	Forecast error government spending	Auerbach and Gorodnichenko (2012)[4]	
Pers. inc. tax proxy	Narrative personal income tax shock	Mertens and Ravn (2013)	
Corp. inc. tax proxy	Narrative corporate income tax shock	Mertens and Ravn (2013)	
Investment	Real gross private domestic investment (quarterly, seasonally adjusted, billions of chained 2017 Dollars)	FRED	GPDIC1
Consumption	Real personal consumption expenditures (quarterly, seasonally adjusted, billions of chained 2017 Dollars)	FRED	PCECC96
Imports	Real Imports of Goods and Services (quarterly, seasonally adjusted, billions of chained 2017 Dollars)	FRED	IMPGSC1
Exports	Real Exports of Goods and Services (quarterly, seasonally adjusted, billions of chained 2017 Dollars)	FRED	EXPGSC1
Current account	NIPA's Balance on Current Account (quarterly, seasonally adjusted, billions of Dollars) divided by nominal GDP	FRED	NETFI/GDP
Real eff. exch. rate	Real narrow effective exchange rate for United States (quarterly average, index 2020=100, not seasonally adjusted)[3]	FRED	RNUSBIS
Disp. income	Real Disposable Personal Income (quarterly average, seasonally adjusted, billions of chained 2017 Dollars)	FRED	DSPIC96
Private savings	Gross Private Saving (quarterly, seasonally adjusted, billions of Dollars) deflated with the GDP deflator	FRED	GPSAVE/GDPCTPI
Unemp. rate	Unemployment rate (quarterly average, seasonally adjusted, percent)	FRED	UNRATE
Unit labor costs	Unit labor costs for all workers (nonfarm business sector, quarterly, index 2017=100, seasonally adjusted)	FRED	ULCNFB
Productivity	Labor productivity for all workers (nonfarm business sector, output per hour, quarterly, index 2017=100, seasonally adjusted)	FRED	OPHNFB
Federal funds rate	Federal funds effective rate (quarterly average, not seasonally adjusted, percent)	FRED	FEDFUNDS
Shadow rate	Updated Wu and Xia's (2016) shadow rate (monthly, percent)	Atlanta Fed[5]	WuXiashadowfederal-fundsrate

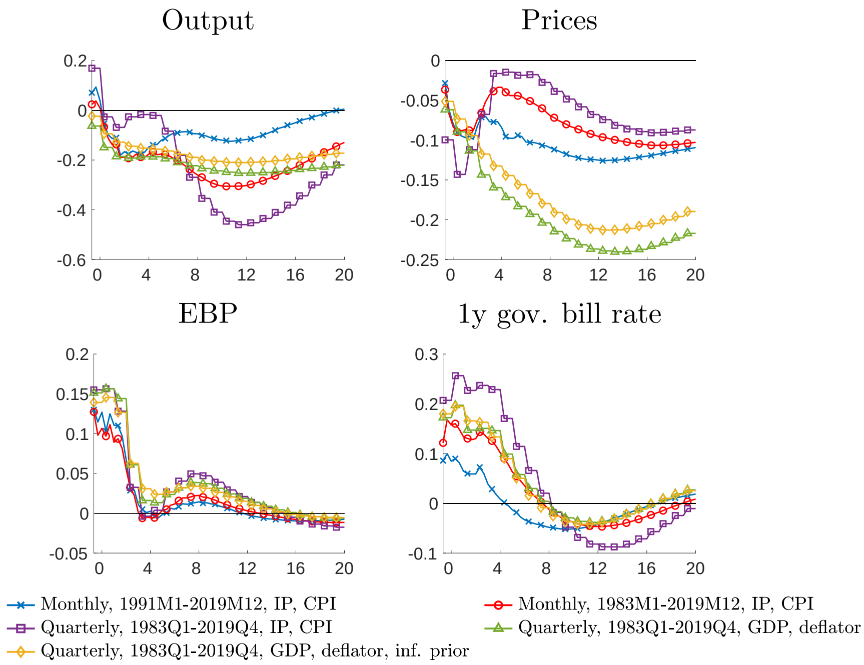
Notes: [1]Federal Reserve Economic Data ; [2]available at https://doi.org/10.17016/2380-7172.1836; [3]seasonally adjusted using the standard X12-ARIMA method, developed by the US Bureau of the Census; [4]extended up to the end of our sample in 2019Q4; [5]available at https://www.atlantafed.org/cqer/research/wu-xia-shadow-federal-funds-rate.

Figure A.1: Implied inflation response to contractionary monetary policy shocks



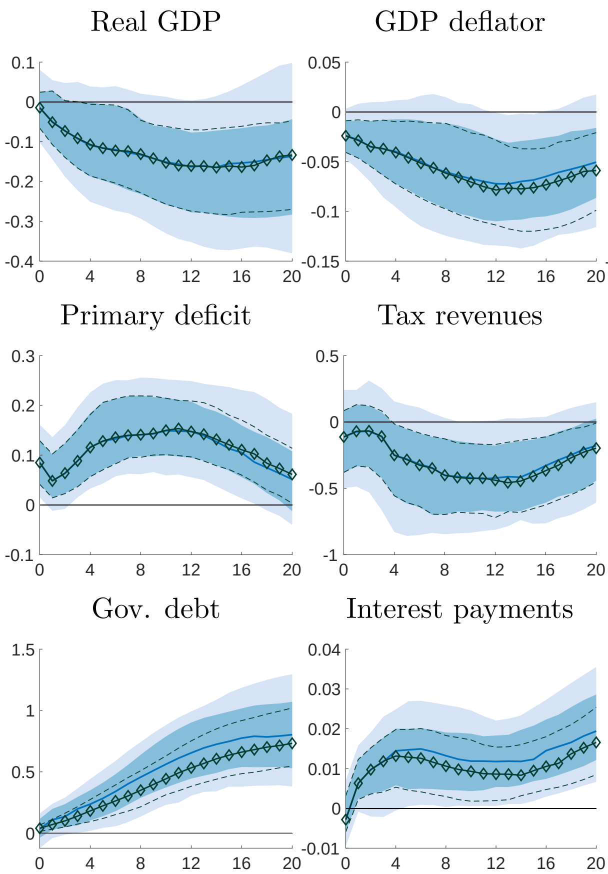
Notes: Lines show the posterior point-wise median values of the implied inflation response to a contractionary one standard deviation monetary policy shock constructed as the first-difference of the corresponding log-level price response. Shaded areas represent 68% and 90% centered point-wise probability bands.

Figure A.2: Impulse response functions to a contractionary monetary policy shocks from different data frequencies and sample periods



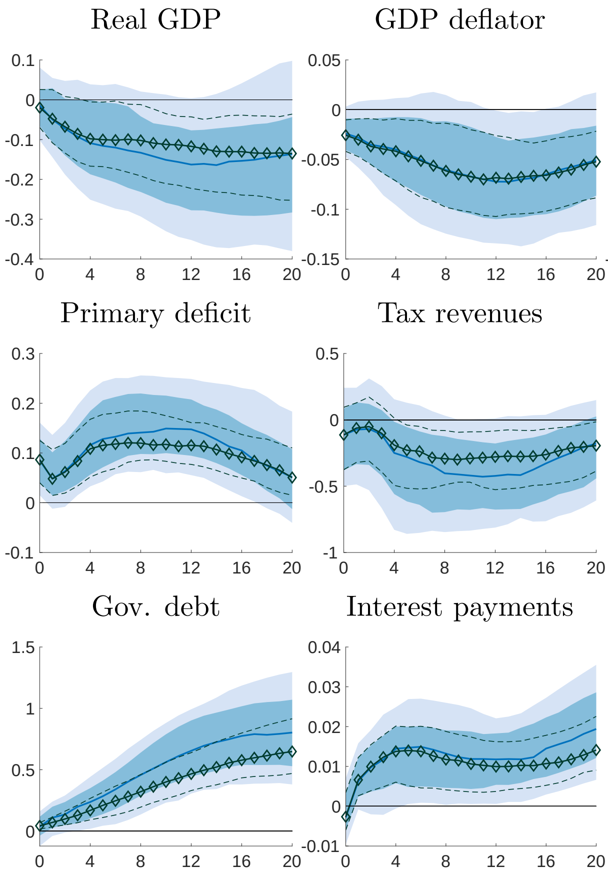
Notes: Lines with markers show the posterior point-wise median impulse responses to a contractionary one standard deviation monetary policy shock from estimations across different samples and data frequencies. The vector of endogenous variables in each estimation includes an output measure (industrial production or real GDP), a price measure (CPI or GDP deflator), the excess bond premium, and the one year government bond yield.

Figure A.3: Impulse response functions to contractionary monetary policy shocks and IGBC-implied responses from forward iteration, with government debt computed using the linearized IGBC (as in Favero and Giavazzi, 2012)



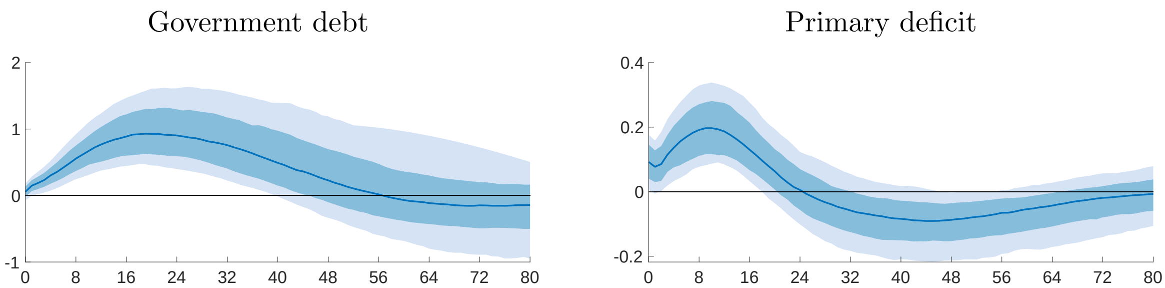
Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Shaded areas represent 68% and 90% centered point-wise probability bands. Lines with markers capture deviations from the SVAR projections if we replace the government debt-to-GDP equation by the linearized IGBC flow identity described in Section C in the Appendix. Dashed lines represent the corresponding 68% centered point-wise probability bands.

Figure A.4: Impulse response functions to contractionary monetary policy shocks and counterfactual responses imposing the linearized IGBC



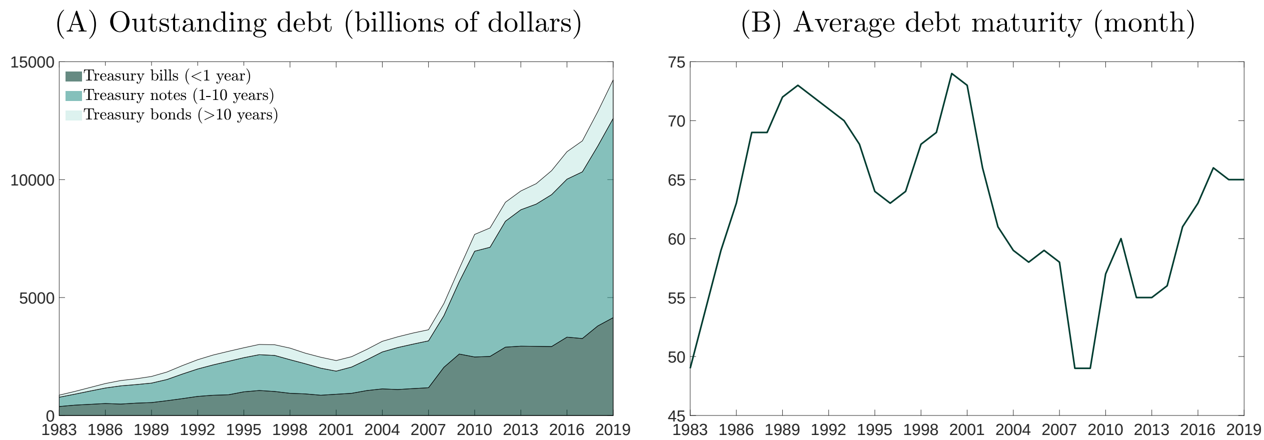
Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Shaded areas represent 68% and 90% centered point-wise probability bands. Lines with markers show counterfactual impulse responses where the linarized IGBC is imposed on all components simultaneously without imposing any restrictions on the neutralizing shocks. Dashed lines represent the corresponding 68% centered point-wise probability bands.

Figure A.5: Selected baseline impulse response functions to contractionary monetary policy shocks over longer horizon



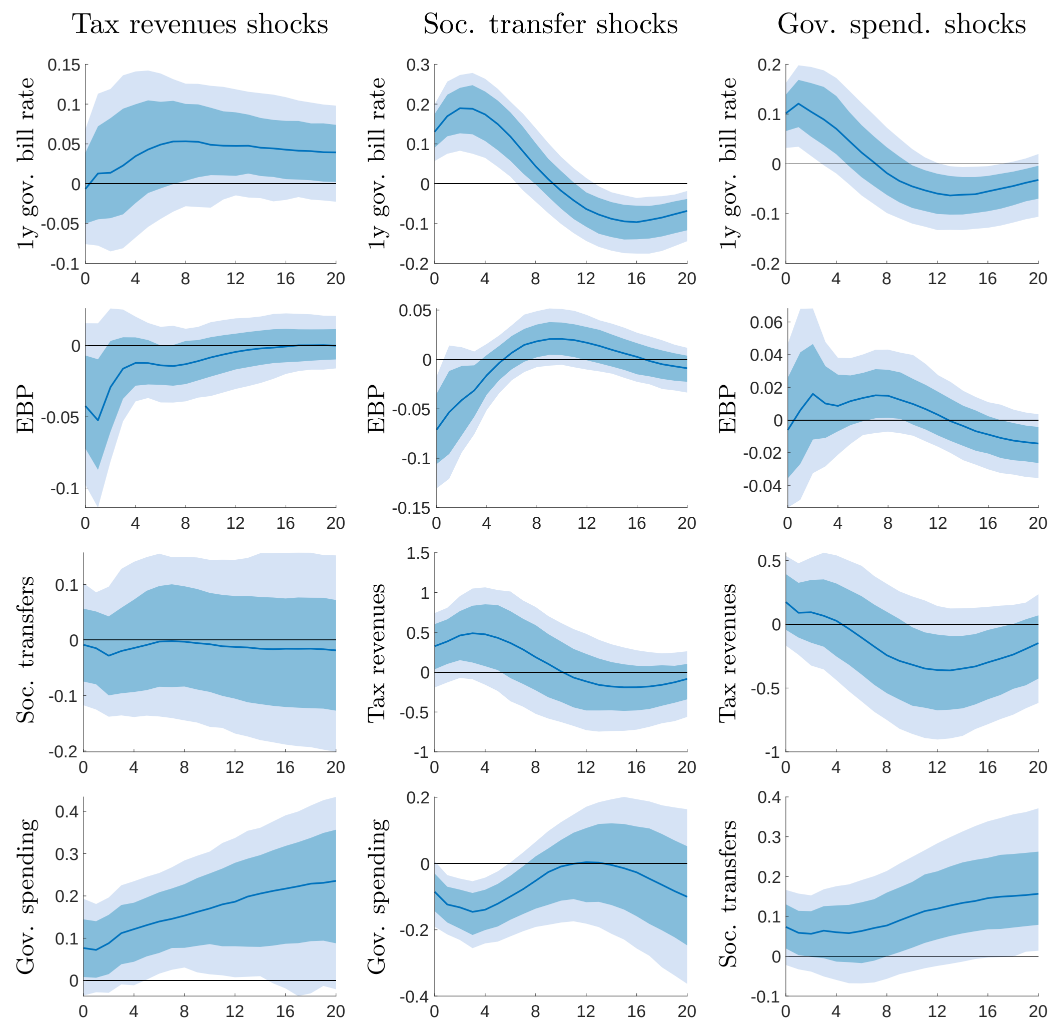
Notes: Lines show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Shaded areas represent 68% and 90% centered point-wise probability bands.

Figure A.6: Maturity distribution of outstanding government debt



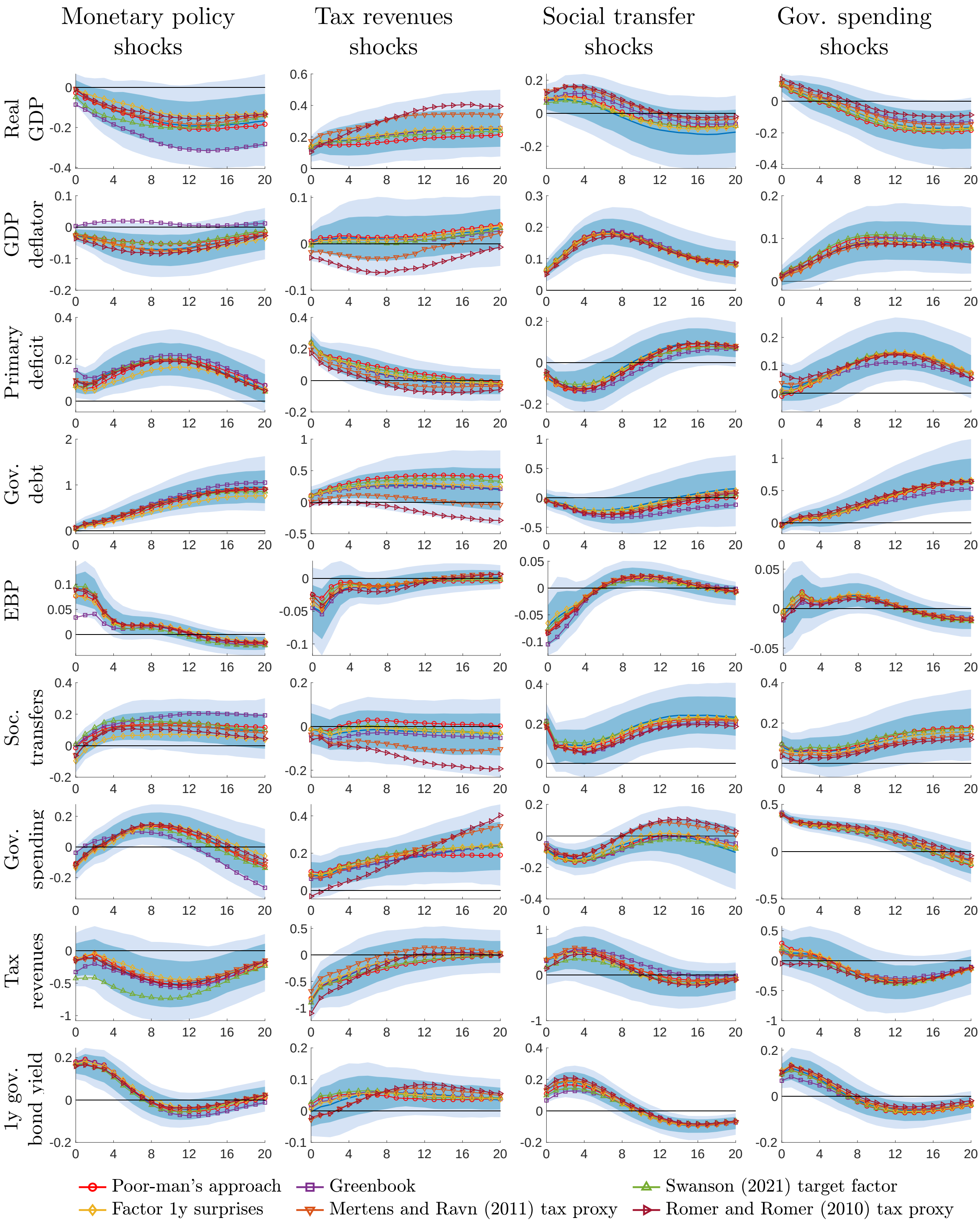
Source: Treasury Bulletin, FD-5 Table, Maturity distribution and average length of marketable interest-bearing public debt held by private investors.

Figure A.7: Remaining impulse response functions to expansionary fiscal policy shocks



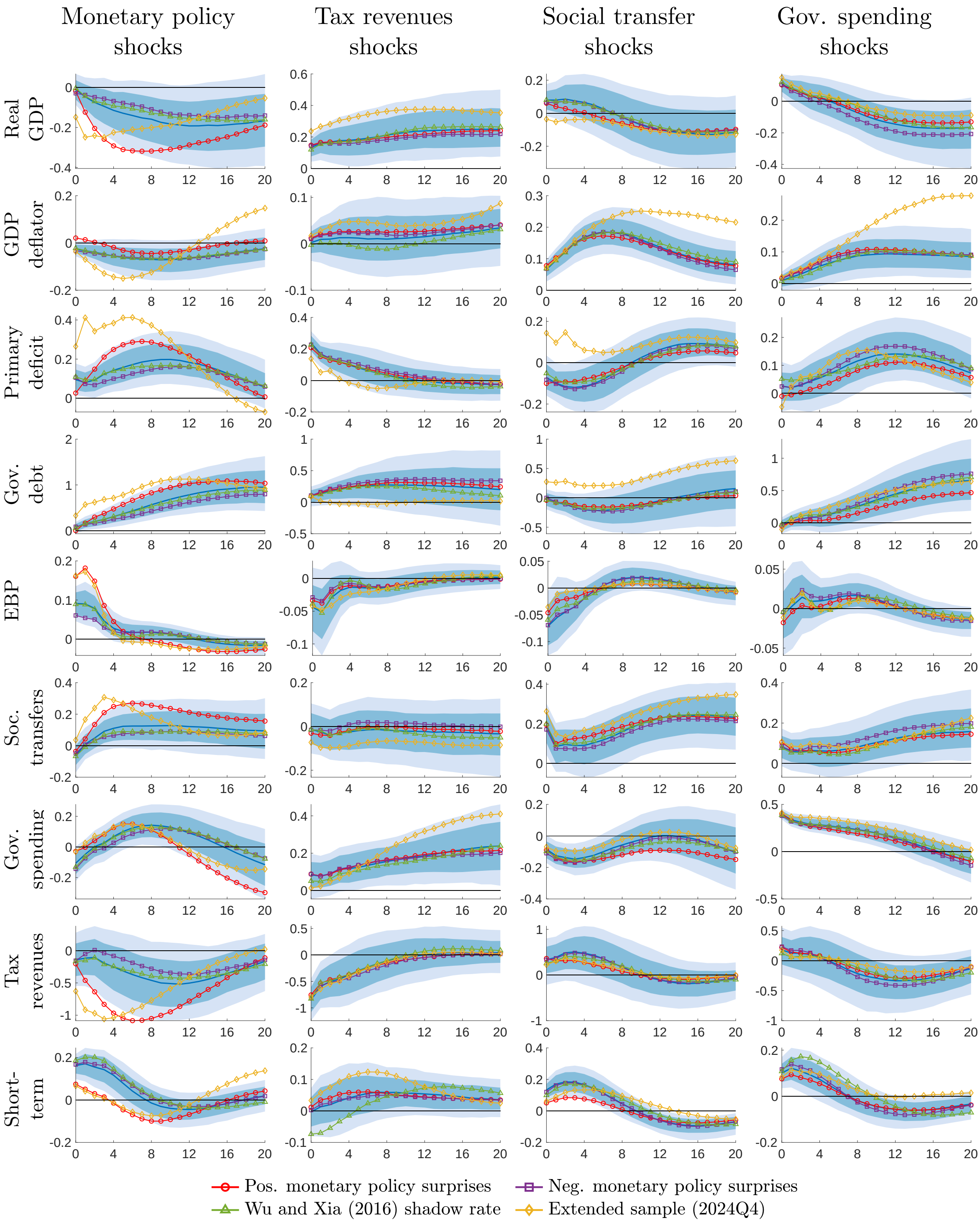
Notes: Lines show the posterior point-wise median values of the baseline impulse responses to an expansionary one standard deviation tax revenue shock (first column), social transfer shock (second column), and government spending shock (third column). Shaded areas represent 68% and 90% centered point-wise probability bands.

Figure A.8: Impulse response functions to contractionary monetary and expansionary fiscal policy shocks from various robustness checks



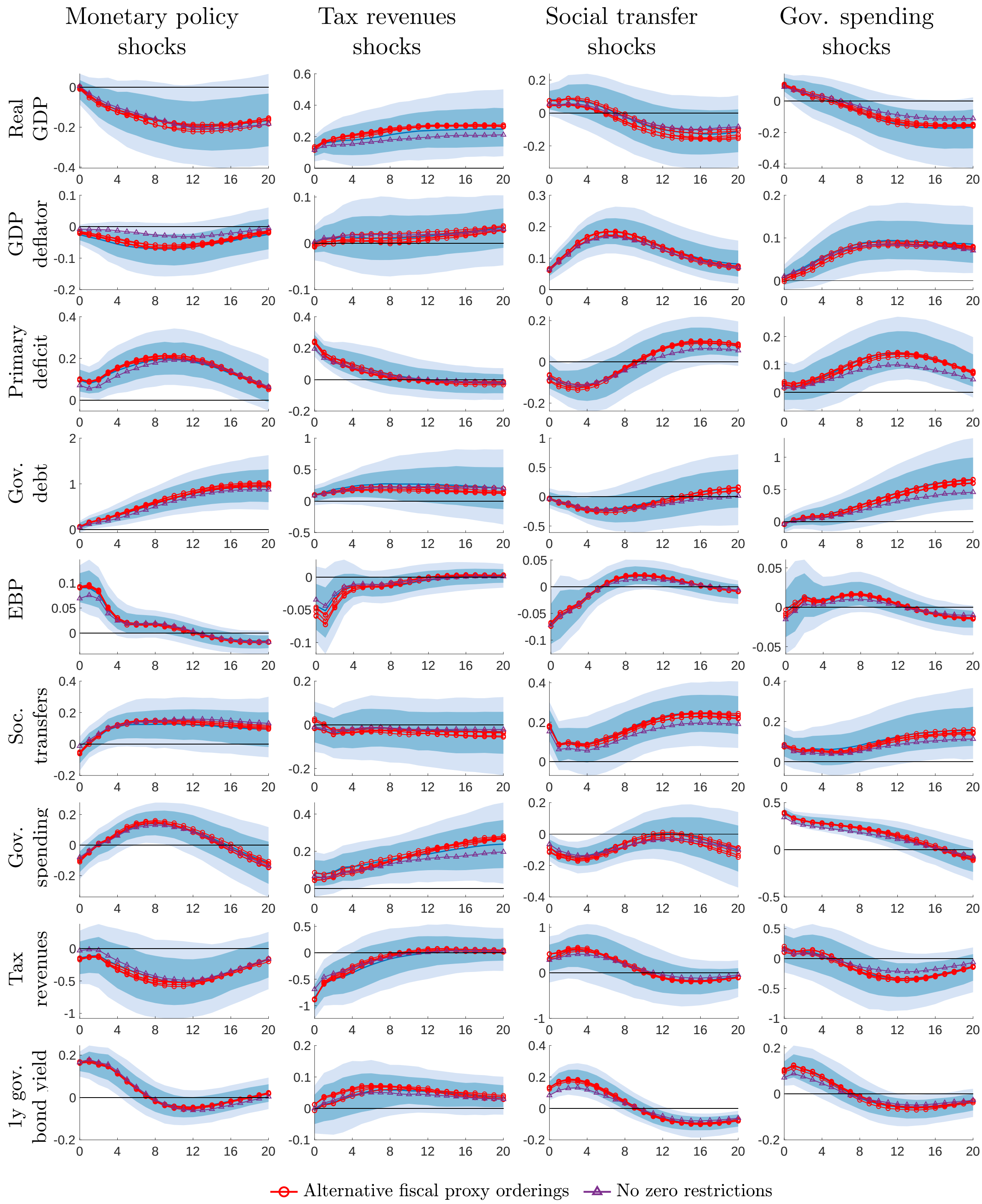
Notes: Lines without markers show the posterior point-wise median impulse responses of the baseline specification to a one standard deviation contractionary monetary policy shock (first column), expansionary revenue shock (second column), expansionary social transfer shock (third column), and expansionary government spending shock (fourth column). Shaded areas represent 68% and 90% centered point-wise probability bands of the baseline specification. Lines with markers show posterior point-wise median impulse responses of alternative specifications. In the specification labeled 'poor-man's approach' and 'Greenbook' we purge the policy surprises from information effects as described in Jarociński and Karadi (2020) and Miranda-Agrippino and Ricco (2021); in 'Swanson (2021) target factor' we use the federal funds rate factor provided by Swanson (2021) purged from information effects (see also Miranda-Agrippino and Nenova, 2022); in 'Factor 1y surprises' we use a factor of interest rate surprises of interest rate derivatives with maturity up to one year (see, e.g., Nakamura and Steinsson, 2018); and in 'Mertens and Ravn (2011) tax proxy' and 'Romer and Romer (2010) tax proxy' we either use the tax proxy provided by Mertens and Ravn (2011) or Romer and Romer (2010) and set missing values to zero.

Figure A.9: Impulse response functions to contractionary monetary and expansionary fiscal policy shocks from additional robustness checks



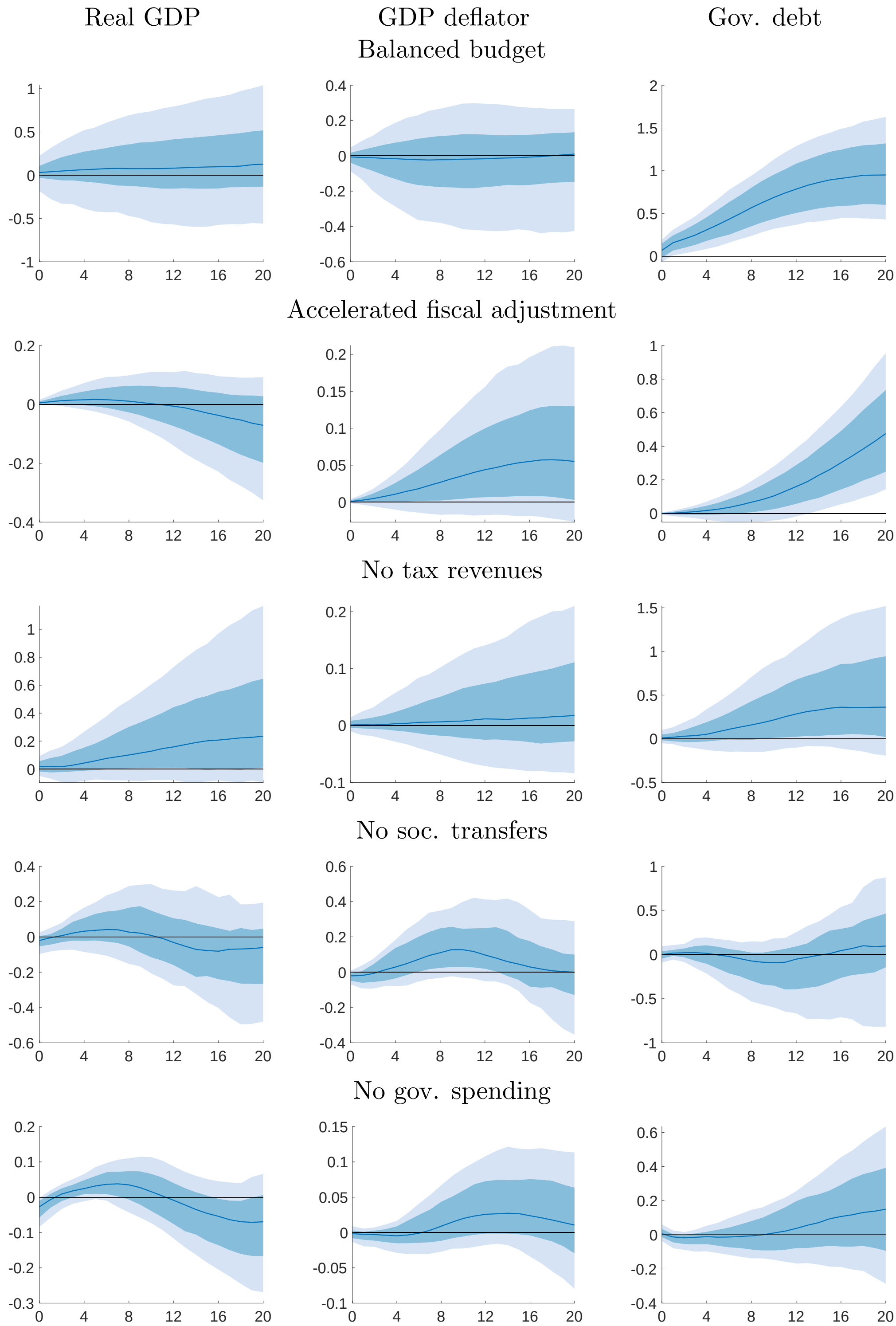
Notes: Lines without markers show the posterior point-wise median impulse responses of the baseline specification to a one standard deviation contractionary monetary policy shock (first column), expansionary revenue shock (second column), expansionary social transfer shock (third column), and expansionary government spending shock (fourth column). Shaded areas represent 68% and 90% centered point-wise probability bands of the baseline specification. Lines with markers show posterior point-wise median impulse responses of alternative specifications. In the specifications labeled 'Pos./Neg. monetary policy surprises' we separately re-estimate the baseline specification and identify monetary policy shocks with either positive or negative high-frequency monetary policy surprises; in 'Wu and Xia (2016) shadow rate we replace the one-year treasury bill rate with the effective federal funds rate spliced with the Wu and Xia's (2016) shadow rate between 1990M1 and 2022M2; In 'Extended sample (2024Q4)' we estimate our baseline specification on an extended sample including observations up to 2024Q4.

Figure A.10: Impulse response functions to contractionary monetary and expansionary fiscal policy shocks from alternative orderings of the fiscal policy proxies



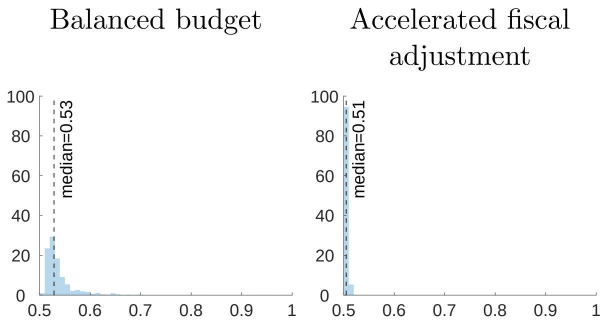
Notes: Lines without markers show the posterior point-wise median impulse responses of the baseline specification to a one standard deviation contractionary monetary policy shock (first column), expansionary revenue shock (second column), expansionary social transfer shock (third column), and expansionary government spending shock (fourth column). Shaded areas represent 68% and 90% centered point-wise probability bands of the baseline specification. Lines with markers show posterior point-wise median impulse responses of alternative specifications. In the specifications labeled 'Alternative fiscal proxy orderings' we consider all possible alternative orderings of the three fiscal policy proxies (keeping the monetary policy proxy to be the most exogenous proxy); in 'No zero restrictions' we drop all additional restriction in the contemporaneous impact matrix $\boldsymbol{V}$ but increase the minimum relevance threshold of all policy proxies to 15% (see Section B in the Appendix for details).

Figure A.11: Difference between baseline and counterfactual impulse responses when fiscal policy balances government debt



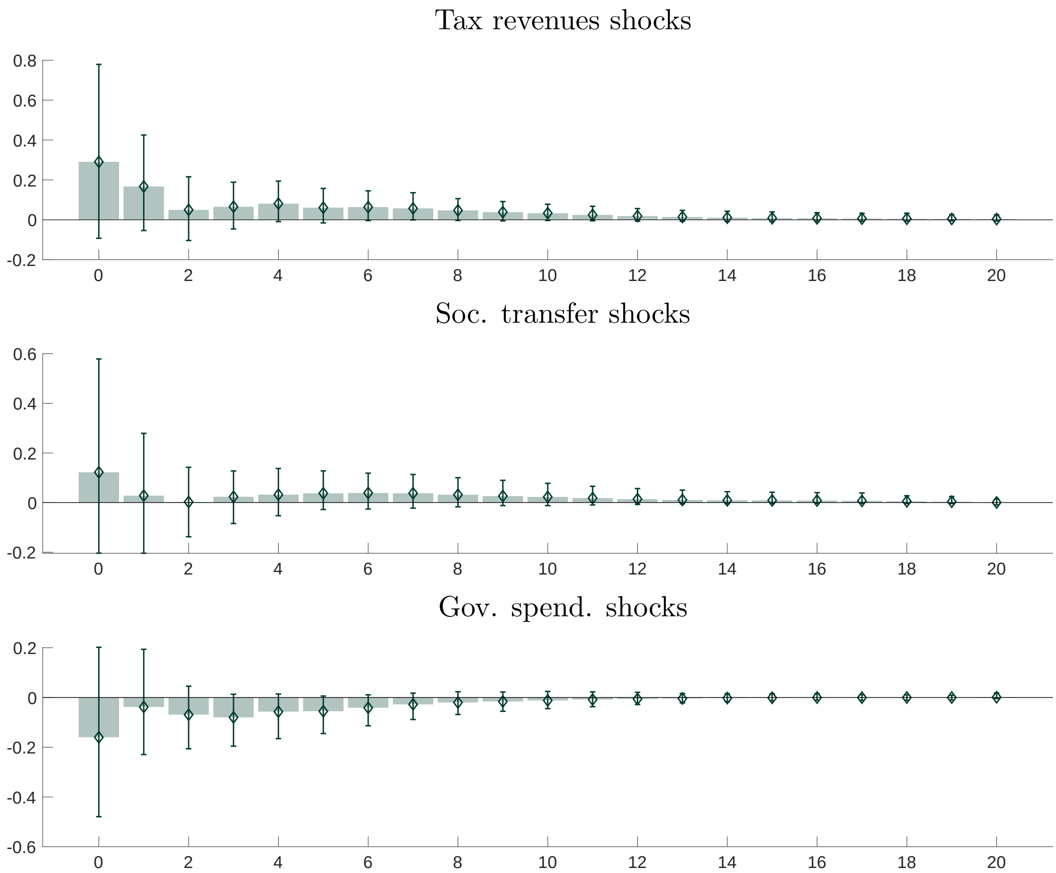
Notes: Lines show the posterior point-wise median of the difference between the baseline impulse responses to a contractionary one standard deviation monetary policy shock and the counterfactual impulse responses when fiscal policy balances government debt over the entire impulse horizon (first row); government debt is balanced after 8 years (second row); or when either the response of tax revenues (third row), social transfers, (fourth row), or government spending (fifth row) is kept constant over the entire impulse horizon. Shaded areas represent 68% and 90% centered point-wise probability bands.

Figure A.12: q-divergence of Antolín-Díaz et al. (2021) when fiscal policy balances government debt



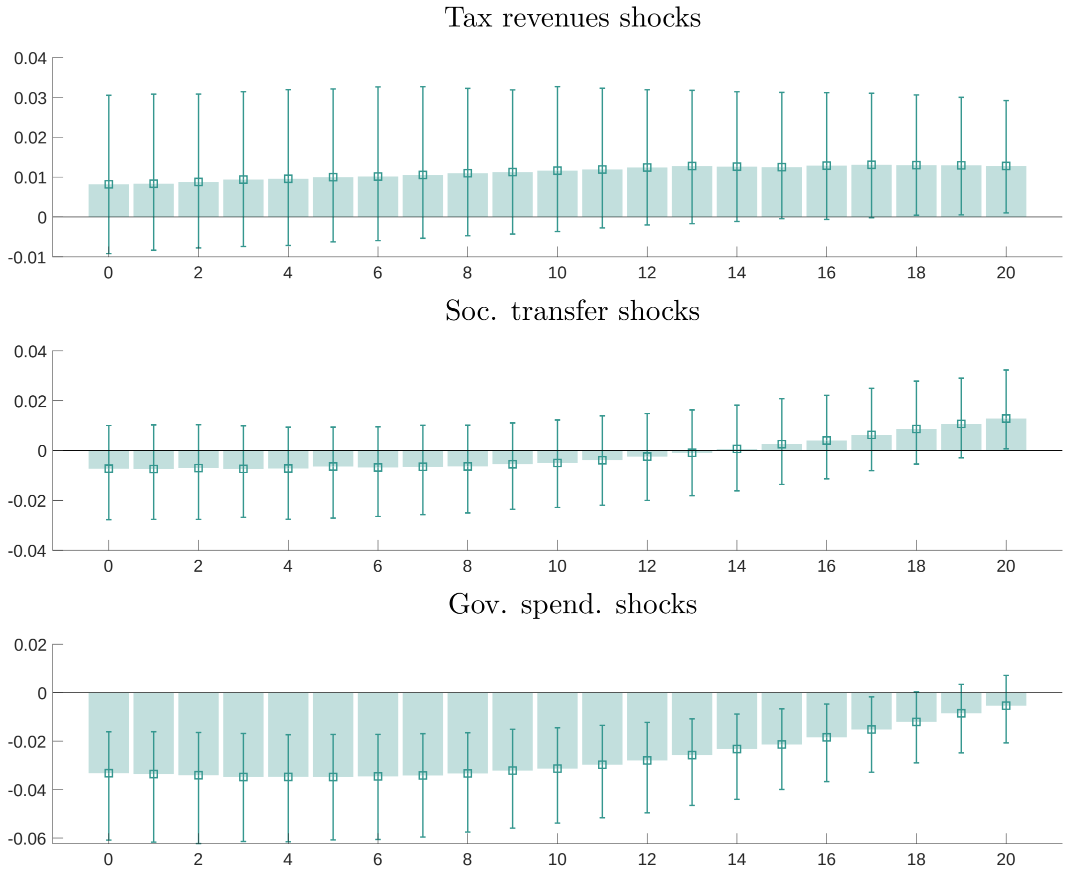
Notes: The histograms show the distribution of the q-divergence of Antolín-Díaz et al. (2021) for the counterfactual impulse responses when fiscal policy balances government debt either over the entire impulse horizon (first column) or starting after 8 years (second column). The y-axis is measured in percent.

Figure A.13: Neutralizing shocks imposing the balanced budget counterfactual



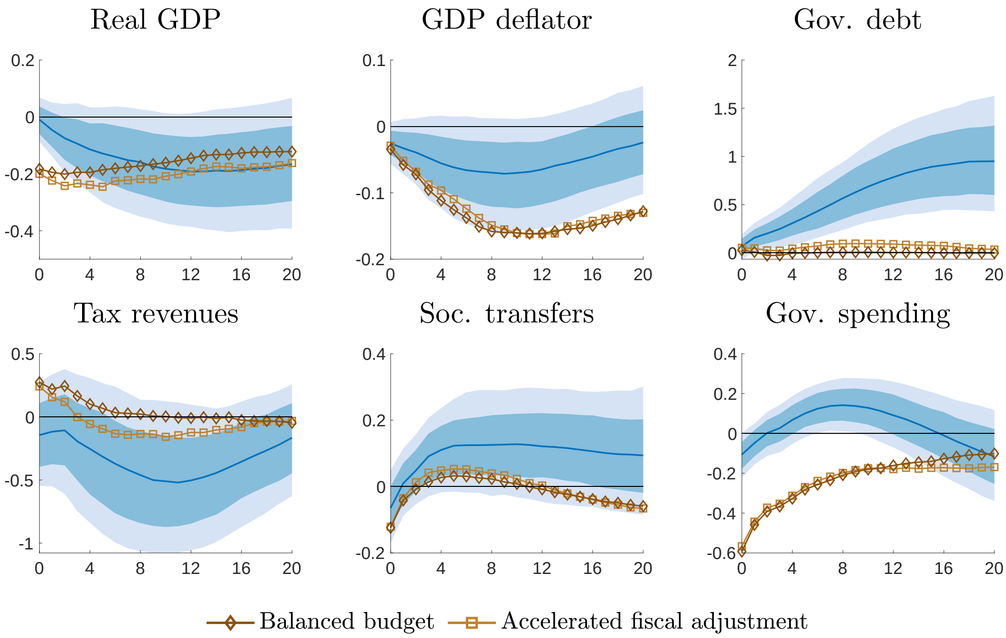
Notes: Bars display the point-wise median prevalence of fiscal shocks to impose the balanced budget counterfactual. The whiskers indicate 68% centered point-wise probability bands.

Figure A.14: Neutralizing shocks imposing the accelerated fiscal adjustment counterfactual



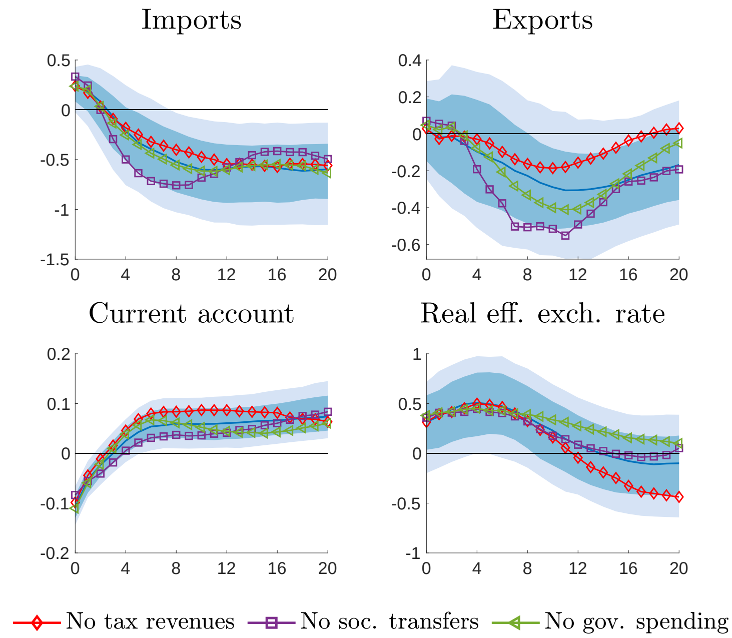
Notes: Bars display the point-wise median prevalence of fiscal shocks to impose the accelerated fiscal adjustment counterfactual. The whiskers indicate 68% centered point-wise probability bands.

Figure A.15: Impulse responses and counterfactuals when fiscal policy balances government debt at different horizons but if the fiscal neutralizing shocks materialize on impact only



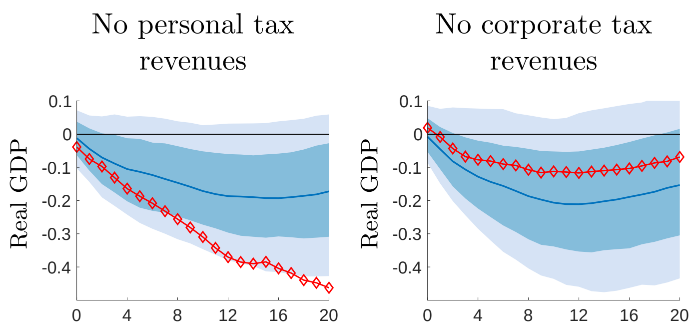
Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Lines with markers depict the posterior point-wise median values of the counterfactual impulse responses when fiscal policy balances government debt either over the entire impulse horizon (diamonds) or starting after 8 years (squares). The counterfactuals are imposed using all three fiscal policy shocks on impact only. The median values of the corresponding q-divergence statistic are 0.55 and 0.55. Shaded areas represent 68% and 90% centered point-wise probability bands for the baseline impulse responses.

Figure A.16: Impulse responses and counterfactuals of imports, exports, the current account, and the real effective exchange rate



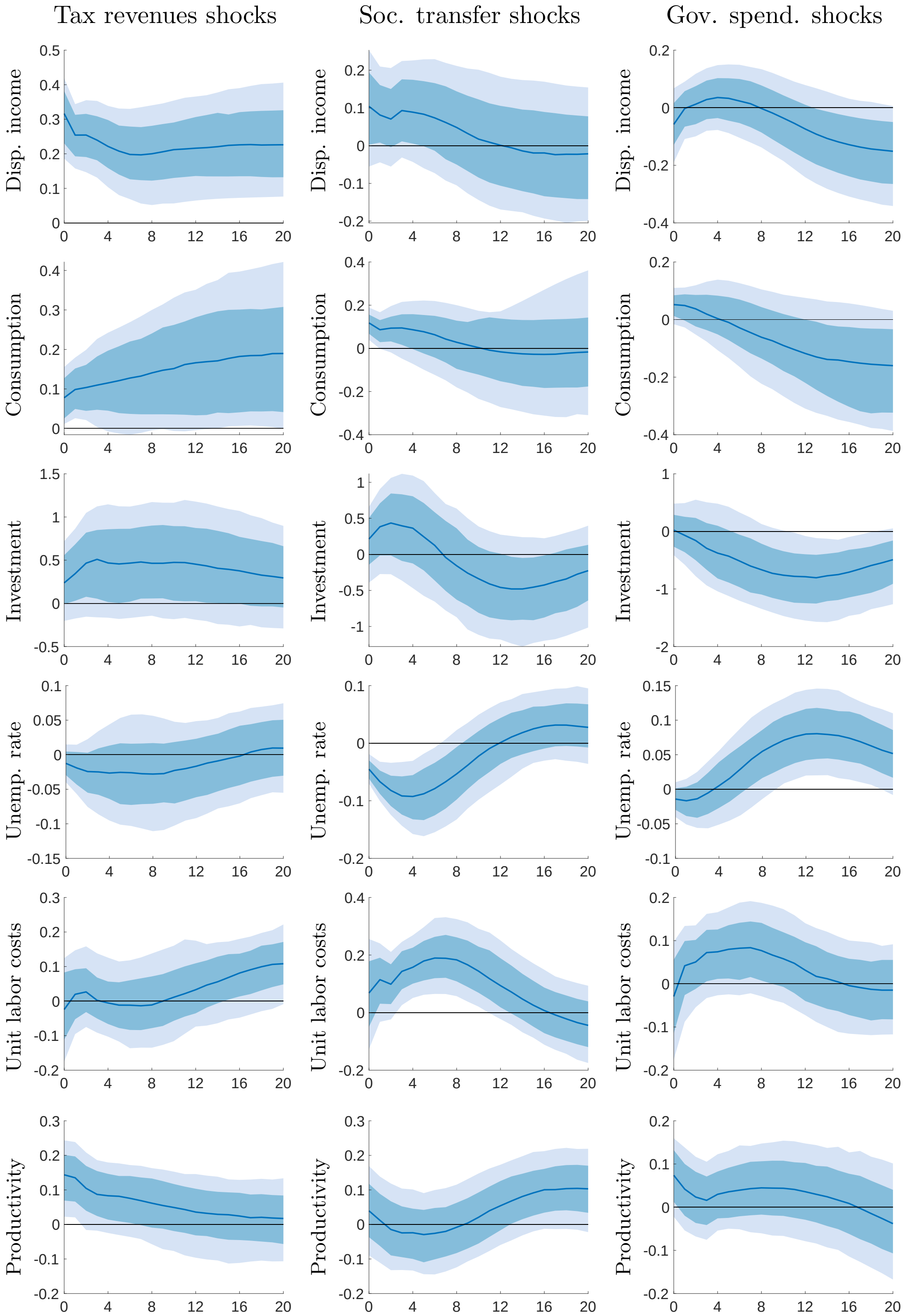
Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock. Lines with markers depict the posterior point-wise median values of the counterfactual impulse responses when either the response of tax revenues (diamonds), social transfers (squares), or government spending (triangles) is neutralized separately. The median values of the corresponding q-divergence statistics lie between 0.51 and 0.52. Shaded areas represent 68% and 90% centered point-wise probability bands for the baseline impulse responses.

Figure A.17: Impulse responses and counterfactuals using personal versus corporate income tax



Notes: Lines without markers show the posterior point-wise median values of the baseline impulse responses to a contractionary one standard deviation monetary policy shock and the lines with circles depict the posterior point-wise median values of the counterfactual impulse responses when either the response of personal tax revenues (first column), or corporate tax revenues (second column) is neutralized. The median values of the corresponding q-divergence statistics are 0.51 and 0.53. Shaded areas represent 68% and 90% centered point-wise probability bands for the baseline impulse responses.

Figure A.18: Additional impulse response functions to expansionary fiscal policy shocks



Notes: Lines show the posterior point-wise median values of the baseline impulse responses to an expansionary one standard deviation tax revenue shock (first column), social transfer shock (second column), and government spending shock (third column). Shaded areas represent 68% and 90% centered point-wise probability bands. Additional variables are added separately to the baseline specification.

B Contemporaneous zero restriction in the BPSVAR

The reduced form of the model in Equation (1) is

$$\widetilde{\boldsymbol{y}}_t = \widetilde{\boldsymbol{A}}_0^{-1}\widetilde{\boldsymbol{c}} + \sum_{l=1}^{p} \widetilde{\boldsymbol{A}}_0^{-1}\widetilde{\boldsymbol{A}}_l\widetilde{\boldsymbol{y}}_{t-l} + \widetilde{\boldsymbol{A}}_0^{-1}\widetilde{\boldsymbol{\varepsilon}}_t, \tag{B.1}$$

where the inverse of $\widetilde{\boldsymbol{A}}_0$ is given by

$$\widetilde{\boldsymbol{A}}_0^{-1} = \begin{bmatrix} \underset{(n\times n)}{\boldsymbol{A}_0^{-1}} & \underset{(n\times k)}{\boldsymbol{0}} \\ \underset{(k\times n)}{-\boldsymbol{\Gamma}_{0,2}^{-1}\boldsymbol{\Gamma}_{0,1}\boldsymbol{A}_0^{-1}} & \underset{(k\times k)}{\boldsymbol{\Gamma}_{0,2}^{-1}} \end{bmatrix} \equiv \begin{bmatrix} \underset{(n\times n)}{\boldsymbol{A}} & \underset{(n\times k)}{\boldsymbol{0}} \\ \underset{(k\times n)}{\boldsymbol{B}} & \underset{(k\times k)}{\boldsymbol{C}} \end{bmatrix}. \tag{B.2}$$

Then, the reduced form equations of the proxy variables are

$$\boldsymbol{m}_t = \begin{bmatrix} \boldsymbol{B} & \boldsymbol{C} \end{bmatrix} \widetilde{\boldsymbol{c}} + \sum_{l=1}^{p} \begin{bmatrix} \boldsymbol{B} & \boldsymbol{C} \end{bmatrix} \widetilde{\boldsymbol{A}}_l\widetilde{\boldsymbol{y}}_{t-l} + \boldsymbol{B}\boldsymbol{\varepsilon}_t + \boldsymbol{C}\boldsymbol{\nu}_t. \tag{B.3}$$

Given that the k structural shocks of interest are the last k elements of $\boldsymbol{\varepsilon}_t$, i.e. $\boldsymbol{\varepsilon}_t' = [\boldsymbol{\varepsilon}_t^{o\prime}, \boldsymbol{\varepsilon}_t^{*\prime}]$, the exogeneity condition $E[\boldsymbol{m}_t\boldsymbol{\varepsilon}_t^{o\prime}] = \boldsymbol{0}$ implies that the first $n-k$ columns of $\boldsymbol{B}$ are set to zero:

$$\widetilde{\boldsymbol{A}}_0^{-1} = \begin{bmatrix} \underset{(n\times n)}{\boldsymbol{A}} & \underset{(n\times k)}{\boldsymbol{0}} \\ \left(\underset{(k\times n-k)}{\boldsymbol{0}} \quad \underset{(k\times k)}{\boldsymbol{V}} \right) & \underset{(k\times k)}{\boldsymbol{C}} \end{bmatrix}. \tag{B.4}$$

The relevance condition requires that $\boldsymbol{V}$ is non-singular. As the number of zero restrictions is larger than $\widetilde{n}(\widetilde{n}-1)/2$ Arias et al. (2021) use the Gibbs sampler of Waggoner and Zha (2003).

Following Caldara and Herbst (2019), we require that the proxies are relevant instruments (see also Mertens and Ravn, 2013). Specifically, we impose that each of the identified shocks accounts for at least 10% of the variance of the respective proxy variable. Arias et al. (2021) show that these restrictions imply that the minimum eigenvalue of the reliability matrix $\boldsymbol{R} = (\boldsymbol{V}\boldsymbol{V}' + \boldsymbol{C}\boldsymbol{C}')^{-1}\boldsymbol{V}\boldsymbol{V}'$ lies above 0.1.

C Internal consistency with the intertemporal government budget constraint (IGBC)

To check for the internal consistency of the estimated impulse responses with the IGBC we consider three different approaches: (i) We calculate the government debt-to-GDP response based on the estimated impulse responses of real GDP, the GDP deflator, primary deficit, and interest payments. (ii) We calculate the government debt-to-GDP response by iterating the identified VAR system forward and replacing the empirically predicted debt path with the IGBC-implied debt path (similar to Favero and Giavazzi, 2012). (iii) We impose the IGBC on the estimated impulse responses based on the solution of the model in the Antolín-Díaz et al. (2021) counterfactual framework where we impose the IGBC to hold per restrictions on observables.

The IGBC in nominal terms captures that government debt (B_t) is the sum of previous period debt (B_{t-1}), interest payments (INT_t), and the primary deficit (PD_t):[1]

$$B_t = B_{t-1} + INT_t + PD_t. \tag{C.5}$$

To preserve internal consistency with the IGBC, we consider in our empirical analysis components of the IGBC as ratios of GDP. Dividing the nominal flow constraint above by nominal GDP (P_tY_t) yields with some rearranging:

$$b_t = \frac{b_{t-1}}{(1+g_t)(1+\pi_t)} + pd_t + int_t, \tag{C.6}$$

where $b_t \equiv \frac{B_t}{P_tY_t}$, $b_{t-1} \equiv \frac{B_{t-1}}{P_{t-1}Y_{t-1}}$, $g_t \equiv \frac{Y_t - Y_{t-1}}{Y_{t-1}}$, $\pi_t \equiv \frac{P_t - P_{t-1}}{P_{t-1}}$, $pd_t \equiv \frac{PD_t}{P_tY_t}$, $int_t \equiv \frac{INT_t}{P_tY_t}$.

To directly relate the IGBC to our estimated impulse responses we consider a linearized approximation of Equation (C.6). Specifically, we use a first-order Taylor linearization around the steady state. Moreover, assuming that real GDP growth and inflation are sufficiently small in steady state, such that $(1+\bar{g})(1+\bar{\pi}) \approx 1$ and $\frac{1}{1+\bar{g}} \approx \frac{1}{1+\bar{\pi}} \approx 1$, we get:

$$b_t = b_{t-1} - \bar{b}(g_t + \pi_t) + pd_t + int_t, \tag{C.7}$$

where the variables now capture deviations from steady state. For $\bar{b}$ we use the sample average

[1] We neglect stock-flow adjustment deviations as any accounting and valuation effects should be negligible in steady state.

of 0.4781 (ratio of GDP).

Impulse response-implied debt path. By adding interest payments to our baseline specification, we are able to directly calculate the IGBC-implied debt path based on Equation (C.7) and the estimated impulse responses. Let $\theta_h^{z\leftarrow\epsilon^{MP}}$ for $h = 0, 1, ...H$ and $z \in \{Y, P, pd, int\}$ represent the impulse response function of real GDP, the GDP deflator, the primary deficit-to-GDP, and interest payments-to-GDP to the identified monetary policy shock (ϵ^{MP}), then we can calculate the IGBC-implied debt-to-GDP response as:

$$b_h = b_{h-1} - \bar{b}((\theta_h^{Y\leftarrow\epsilon^{MP}} - \theta_{h-1}^{Y\leftarrow\epsilon^{MP}}) + (\theta_h^{P\leftarrow\epsilon^{MP}} - \theta_{h-1}^{P\leftarrow\epsilon^{MP}}) + \theta_h^{pd\leftarrow\epsilon^{MP}} + \theta_h^{int\leftarrow\epsilon^{MP}}, \qquad \text{(C.8)}$$

where the initial values of debt-to-GDP, real GDP, and the GDP deflator are set to zero. As the primary deficit and the interest payments are reported at annual rate we divide the respective impulse responses by four. Figure 2 in the main text compares the IGBC-implied debt path with the empirically estimated impulse response.

Forward iterated debt path. To allow for dynamic feedback between the IGBC-implied debt path and the other variables in the system we follow Favero and Giavazzi (2012) and calculate the impulse response of government debt based on the VAR projections. Specifically, we recursively iterate the VAR forward and replace the empirically projected value of government debt with the IGBC-implied debt value. Technically, we replace the debt-to-GDP equation in the VAR with the IGBC represented in Equation (C.7) and simulate the system dynamically forward. To obtain the respective impulse response we compute the difference between the projection in which the monetary policy shock appears on impact and the base projection in which no shock takes place over the entire projection horizon (see Favero and Giavazzi, 2012, for further details). Figure A.3 in the Appendix compares the IGBC-implied responses with the empirically estimated impulse responses.

Counterfactual debt path. To obtain the most likely solution of IGBC-consistent impulse responses given the empirically estimated impulse responses, we finally follow Antolín-Díaz et al. (2021) and consider a generic counterfactual in which we remain agnostic about the shocks imposing the counterfactual constraints. Antolín-Díaz et al. (2021) show that if no assumptions are imposed on the neutralizing shocks, and thus their distribution follows the unconditional distribution, restrictions on observables yield under Gaussianity exactly the same soliton as entropic tilting (see, e.g., Robertson et al., 2005). The idea of entropic tilting is to obtain a constrained forecast which is informationally as close as possible to the unconstrained forecast.

As described in Section 4, impulse responses and counterfactuals can be expressed as conditional forecast (in stacked moving average representation):

$$\boldsymbol{C}\overline{\boldsymbol{y}}_{\tau+1,\tau+h} = \boldsymbol{C}\boldsymbol{b}_{\tau+1,\tau+h} + \boldsymbol{C}\boldsymbol{\Theta}\overline{\boldsymbol{\varepsilon}}_{\tau+1,\tau+h} = \boldsymbol{f}_{\tau+1,\tau+h}, \tag{C.9}$$

where $\boldsymbol{C}' = [\boldsymbol{O}', \boldsymbol{\Theta}^{-1\prime}\boldsymbol{S}']$, $\boldsymbol{O}$ and $\boldsymbol{S}$ are selection matrices mapping the restrictions in $\boldsymbol{f}_{\tau+1,\tau+h}$ to the respective impulse responses $\overline{\boldsymbol{y}}_{\tau+1,\tau+h}$ and shocks $\overline{\boldsymbol{\varepsilon}}_{\tau+1,\tau+h}$ over the forecast horizon h, and $\boldsymbol{b}_{\tau+1,\tau+h}$ is set to zero.

To impose the (linearized) IGBC on the impulse responses, we first re-arrange Equation (C.7) to match the order of our VAR system (where real GDP, the GDP deflator, primary deficit, government debt, and interest payments are ordered at the first five positions in $\boldsymbol{y}_t$) and the stacked structure in Equation (C.9):

$$
\begin{aligned}
b_t &= b_{t-1} - \bar{b}(g_t + \pi_t) + pd_t + int_t && \mid g_t \approx Y_t - Y_{t-1},\ \pi_t \approx P_t - P_{t-1} && \text{(C.10)}\\
&= b_{t-1} - \bar{b}[(Y_t - Y_{t-1}) + (P_t - P_{t-1})] + pd_t + int_t && \mid -b_t && \text{(C.11)}\\
0 &= \bar{b}Y_{t-1} + \bar{b}P_{t-1} + b_{t-1} && && \text{(C.12)}\\
&\quad - \bar{b}Y_t - \bar{b}P_t + pd_t - b_t + int_t. && && \text{(C.13)}
\end{aligned}
$$

Accordingly, we specify $\boldsymbol{O}$ as follows:

$$\underset{(h\times nh)}{\boldsymbol{O}} = (\boldsymbol{U}_h \otimes \boldsymbol{e}_{h-1}) + (\boldsymbol{I}_h \otimes \boldsymbol{e}_h) \tag{C.14}$$

with

$$
\begin{aligned}
\underset{(1\times n)}{\boldsymbol{e}_{h-1}} &= \left[\bar{b}, \bar{b}, 0, 1, \mathbf{0}_{(n-4)\times 1)}\right] && \text{(C.15)}\\
\underset{(1\times n)}{\boldsymbol{e}_{h}} &= \left[-\bar{b}, -\bar{b}, 1/4, -1, 1/4, \mathbf{0}_{(n-5)\times 1)}\right] && \text{(C.16)}\\
\underset{(h\times h)}{\boldsymbol{U}_{h}} &= \begin{bmatrix} 0 & 0 & 0 & \cdots & 0 \\ 1 & 0 & 0 & \cdots & 0 \\ 0 & 1 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0 & 0 & \cdots & 1 & 0 \end{bmatrix} && \text{(C.17)}
\end{aligned}
$$

and set the respective h entries in $\boldsymbol{f}_{\tau+1,\tau+h}$ to zero ($\boldsymbol{I}_h$ is an $h \times h$ identity matrix). To make sure that we study the responses after a monetary policy shock, we also require that the monetary policy shock materializes on impact with one standard deviation in size. This requires one entry in $\boldsymbol{S}$ and a respective entry in $\boldsymbol{f}_{\tau+1,\tau+h}$ set to one:

$$
\begin{aligned}
\underset{(1\times nh)}{\boldsymbol{S}} &= \left[\boldsymbol{e}_n^{mp}, \mathbf{0}_{(1\times(n-1)h)}\right] && \text{(C.18)}\\
\underset{(h+1\times 1)}{\boldsymbol{f}_{\tau+1,\tau+h}} &= \begin{bmatrix} \mathbf{0}_{(h\times 1)} \\ 1 \end{bmatrix}, && \text{(C.19)}
\end{aligned}
$$

where $\boldsymbol{e}_n^{mp}$ is a $1 \times n$ vector of zeros with unity in the position of the monetary policy shock in $\boldsymbol{\varepsilon}_{\tau+1}$. The counterfactual responses are then given by $\overline{\boldsymbol{y}}_{\tau+1,\tau+h} = \boldsymbol{\Theta}\boldsymbol{D}^{*}\boldsymbol{f}_{\tau+1,\tau+h}$, with $\boldsymbol{D}^{*}$ being the Moore-Penrose inverse of $\boldsymbol{D} = \boldsymbol{C}\boldsymbol{\Theta}$ (Antolín-Díaz et al., 2021). Figure A.4 in the Appendix compares the IGBC-consistent counterfactual responses with the empirically estimated impulse responses.

D Selection matrices and restrictions in the structural counterfactuals

D.1 Restrictions on $\overline{n}$ observables with $\overline{k}$ neutralizing shocks over forecast horizon h

We study structural counterfactuals with restrictions on a different number of observables $\overline{n}$, and considering a different number of neutralizing shocks $\overline{k}$. In all cases, we set

$$\underset{(\overline{n}h \times nh)}{\boldsymbol{O}} = \boldsymbol{I}_h \otimes \boldsymbol{I}'_{(n,\boldsymbol{e}_n^o)} \tag{D.20}$$

$$\underset{((n-\overline{k})h \times nh)}{\boldsymbol{S}} = \begin{bmatrix} \boldsymbol{I}_h \otimes \boldsymbol{e}_n^{mp} \\ \boldsymbol{I}_h \otimes \boldsymbol{I}'_{(n,\boldsymbol{e}_n^s)} \end{bmatrix} \tag{D.21}$$

$$\underset{((n-\overline{k}+\overline{n})h \times 1)}{\boldsymbol{f}_{\tau+1,\tau+h}} = \begin{bmatrix} \mathbf{0}_{(\overline{n}h \times 1)} \\ \boldsymbol{e}_h^{mp\prime} \\ \mathbf{0}_{((n-\overline{k}-1)h \times 1)} \end{bmatrix}, \tag{D.22}$$

where $\boldsymbol{e}_n^o$ is a $1 \times n$ vector of zeros with unity in $\overline{n}$ positions corresponding to the position of the restricted observables in $\boldsymbol{y}_{\tau+1}$, selecting $\overline{n}$ columns of $\boldsymbol{I}_n$, $\boldsymbol{e}_n^{mp}$ is a $1 \times n$ vector of zeros with unity in the position of the monetary policy shock in $\boldsymbol{\varepsilon}_{\tau+1}$, $\boldsymbol{e}_n^s$ is a $1 \times n$ vector of ones with zeros in $\overline{k}$ positions, selecting all columns of $\boldsymbol{I}_n$ except the columns corresponding to the $\overline{k}$ neutralizing shocks, and $\boldsymbol{e}_h^{mp}$ is a $1 \times h$ vector of zeros with unity in the first position. In the counterfactual, when government debt is only set to zero after 8 years we set $h = 37$ and drop the first 32 rows of $\boldsymbol{O}$.

D.2 Restrictions on $\overline{n}$ observables with $\overline{k}$ neutralizing shocks on impact only (as in McKay and Wolf, 2023)

To account that the $\overline{k}$ neutralizing shocks materialize only on impact we restrict the conditional forecast to shocks in the impact period $\tau + 1$

$$\boldsymbol{C}\overline{\boldsymbol{y}}_{\tau+1,\tau+h} = \boldsymbol{C}\boldsymbol{b}_{\tau+1,\tau+h} + \boldsymbol{C}\boldsymbol{\Theta}\overline{\boldsymbol{\varepsilon}}_{\tau+1} = \boldsymbol{f}_{\tau+1,\tau+h}, \tag{D.23}$$

where $\boldsymbol{\Theta}$ is now $nh \times n$. And accordingly, we set

$$\underset{(\overline{n}h \times nh)}{\boldsymbol{O}} = \boldsymbol{P} \otimes \boldsymbol{I}'_{(n,\boldsymbol{e}_n^o)} \tag{D.24}$$

$$\underset{(n-\overline{k} \times n)}{\boldsymbol{S}} = \begin{bmatrix} \boldsymbol{e}_n^{mp} \\ \boldsymbol{I}'_{(n,\boldsymbol{e}_n^s)} \end{bmatrix} \tag{D.25}$$

$$\underset{(n-\overline{k}+\overline{n}h \times 1)}{\boldsymbol{f}_{\tau+1,\tau+h}} = \begin{bmatrix} \boldsymbol{0}_{((\overline{n}-1)h \times 1)} \\ \boldsymbol{\theta}_h^{mp} \\ 1 \\ \boldsymbol{0}_{(n-\overline{k}-1 \times 1)} \end{bmatrix}. \tag{D.26}$$