Auburn University
Department of Economics
Working Paper Series

Government Employment Shocks, Policy Coordination, and Debt Structure

Hyeongwoo Kim*, Ren Zhang†, and Shuwei Zhang ‡

*Auburn University; †Texas State University;
‡Towson University

AUWP 2026-04

Government Employment Shocks, Policy Coordination, and Debt Structure*

Hyeongwoo Kim†, Ren Zhang‡, and Shuwei Zhang§

April 2026

Abstract

The labor market effects of government employment shocks in the United States have varied markedly across the postwar period. Using a Bayesian structural VAR with max-share identification, we document three distinct regimes: before the Volcker disinflation, public hiring crowded in private employment, raised real wages, and reduced unemployment; during the Great Moderation, the same shocks became contractionary; and after the Global Financial Crisis, their effects were largely muted. We account for these changes with a New Keynesian DSGE model featuring public employment, alternative monetary–fiscal regimes, and a maturity structure of government debt. The model shows that while monetary–fiscal coordination holds in both the pre-Volcker and post-GFC periods, debt maturity differs sharply across them. Longer debt maturity weakens fiscal transmission even under passive monetary policy, whereas aggressive anti-inflationary policy renders government employment shocks contractionary regardless of debt maturity.

Keywords: Debt Maturity; Government Employment; Max-Share Identification; Policy Coordination; Time-varying Effectiveness

JEL Classification: E32; E61; E62

*We would like to thank the helpful suggestions of Juergen Jung, Carl A. Pasurka, Guanyi Yang and conference participants at the Midwest Macroeconomics Meeting, Southern Economic Association Meeting, and Towson University. Refine was used to check the paper for consistency and clarity.

†Department of Economics, Auburn University, 138 Miller, Auburn AL 36830, United States. Email: hzk0001@auburn.edu.

‡Department of Finance & Economics, McCoy College of Business, Texas State University, 601 University Dr, San Marcos, TX 78666, United States. Email: r_z79@txstate.edu.

§Corresponding Author: Department of Economics, College of Business & Economics, Towson University, 8000 York Road, Towson, MD 21252, United States. Email: shuweizhang@towson.edu.

1 Introduction

This paper shows that the labor market effects of government employment shocks are highly regime-dependent. Using postwar U.S. data, we document that public hiring crowded in private employment and raised real wages before 1980, crowded out private employment during the Great Moderation, and produced muted labor market effects in the aftermath of the Global Financial Crisis (GFC). We argue that these stark differences arise from changes in monetary–fiscal policy coordination and the maturity structure of government debt.

We focus on government employment as a distinct fiscal instrument. Over 60% of U.S. government consumption is allocated to salary payments for public employees, yet the employment component of government spending remains relatively understudied.[1] Much of the existing work treats all government spending as a single, aggregate fiscal instrument (see Edelberg et al. 1999; Yuan and Li 2000; Ravn and Simonelli 2007; Monacelli et al. 2010; Brückner and Pappa 2012; Kuo and Miyamoto 2019; Atems 2019; Kim et al. 2023). This aggregate approach may obscure heterogeneity across spending components.

In particular, the macroeconomic effects of public employment can diverge sharply from those of government purchases of goods and services (see Finn 1998; Linnemann 2009; Ramey 2012; Michaillat 2014; Boehm 2020). By isolating government employment, we uncover labor market dynamics that differ markedly from those associated with aggregate government spending, helping to reconcile conflicting evidence on whether public hiring crowds in or crowds out private sector employment.

Empirically, we estimate a Bayesian structural vector autoregression (SVAR) using quarterly U.S. data and identify government employment shocks with the "max-share" approach of Francis et al. (2014) and Kurmann and Sims (2021). This method selects the shock that maximizes its contribution to the forecast-error variance of government employment at a specified horizon. It offers a flexible alternative to recursive identification schemes, which impose restrictive contemporaneous exclusions.[2]

Our results reveal pronounced time variation. In the pre-Volcker era (1960Q1–1979Q3), government employment shocks stimulate aggregate demand, raising private employment and real wages while reducing the unemployment rate. During the Great Moderation (1980Q1–2008Q3), public hiring generates more-than-complete crowding-out of private employment, accompanied by declining real wages. In the post-GFC era (2008Q4–2025Q1), crowding-out

[1] Authors' calculation based on U.S. Bureau of Economic Analysis (BEA) National Income and Product Accounts data.

[2] While the max-share approach was originally developed by Kurmann and Sims (2021) to identify technology (TFP) news shocks, closely related max-share schemes have been applied to identify other structural shocks. See, for example, Antolin-Diaz and Surico (2025) and Yang et al. (2025).

effects attenuate, yet expansionary labor market responses observed before 1980 fail to re-emerge, despite a return to accommodative monetary policy. This final observation raises a puzzle that motivates our theoretical analysis.

We develop a New Keynesian (NK) Dynamic Stochastic General Equilibrium (DSGE) model with an explicit public employment sector, alternative monetary–fiscal regimes in the spirit of Leeper et al. (2017), and a maturity structure of government debt following Woodford (2001).[3] As emphasized by Leeper et al. (2017), the monetary–fiscal policy regime à la Leeper (1991) is a first-order determinant of fiscal transmission.[4]

Our theoretical model rationalizes the estimated time-varying labor market responses through several key findings. First, when fiscal policy is active, monetary policy is passive, and public spending is financed with short-term debt, government employment expansions stimulate aggregate demand and improve labor market outcomes, a pattern consistent with the evidence from the pre-Volcker era. Second, when monetary policy responds aggressively to inflation, public hiring becomes contractionary largely independent of debt maturity, consistent with the evidence from the Great Moderation. Third, even under passive monetary policy, the expansionary effect of government employment is substantially attenuated when fiscal financing shifts to long-term debt, a mechanism that accounts for the muted responses observed in the post-GFC era. Importantly, government debt maturity fundamentally shapes fiscal effectiveness under passive monetary policy: longer maturities dampen the decline in real interest rates and induce negative wealth effects through bond-price revaluation, substantially weakening the labor market stimulus of government hiring.

This paper makes the following main contributions. Empirically, we provide novel evidence that the labor market effects of government employment shocks are highly time-varying, shifting from crowding-in before 1980 to crowding-out during the Great Moderation and muted effects after the GFC. While previous studies have documented changes in the effects of aggregate government spending (e.g., Perotti 2005 and Brückner and Pappa 2012), to our knowledge this paper is the first to isolate government employment as a distinct fiscal instrument and to link its evolving effects to shifts in monetary–fiscal policy regimes. Our findings help reconcile the longstanding debate in the literature on whether government hiring crowds in or crowds out private employment.[5]

[3] Existing research documents that increases in government employment tend to raise both real wages and private employment, consistent with NK models emphasizing the aggregate demand channels (See Galí et al. 2007; Pappa 2009; Linnemann 2009; Brückner and Pappa 2012; Bermperoglou et al. 2017; Kuo and Miyamoto 2019). Our empirical results likewise exhibit a non-negative comovement between private employment and real wages across all subsamples.

[4] See also Mao and Yang (2020) and Kim et al. (2023).

[5] For evidence of crowding-in, see Fatás and Mihov 2001; **?**; Faggio et al. 2025. For crowding-out, see Demekas and Kontolemis 2000; Algan et al. 2002; Afonso and Gomes 2014; Caponi 2017; Behar and Mok

Theoretically, we show that the interaction between monetary–fiscal policy regimes and government debt maturity is key to explaining empirical patterns, highlighting debt duration as a critical determinant of fiscal effectiveness even under accommodative monetary policy. Previous work shows that NK models with rule-of-thumb consumers (e.g., Forni et al. 2009) or search and matching frictions (e.g., Michaillat 2014; Bermperoglou et al. 2017) generate small or mildly positive effects from public hiring. Distinct from these models, our framework emphasizes the importance of incorporating policy regimes and government debt maturity in matching the data.[6]

The remainder of the paper is organized as follows. Section 2 presents the econometric framework and discusses the main empirical results. Section 3 develops the theoretical model and characterizes the channels driving the time-varying effects documented in the data. Section 4 concludes.

2 The Empirics

In this section, we present the empirical model and the identification strategy for government employment shocks using the max-share approach. We then report our main results, which reveal pronounced time variation in the labor market effects of government employment shocks across three subsample periods: the pre-Volcker era, the Great Moderation and the post-GFC era, defined below.

2.1 The Empirical Model and Identification Strategy

We estimate a Bayesian SVAR model that identifies government employment shocks using the max-share approach similar to the work by Francis et al. (2014), Kurmann and Sims (2021), and Antolin-Diaz and Surico (2025).

Let $\mathbf{y}_t$ be a $k \times 1$ vector of endogenous variables. Consider the following reduced-form moving average (MA) representation:

$$\mathbf{y}_t = \mathbf{B}(L)\mathbf{u}_t, \tag{1}$$

where $\mathbf{B}(L) = \sum_{i=0}^{\infty} \mathbf{B}_i L^i$ is a lag polynomial with $\mathbf{B}_0 = \mathbf{I}$. $\mathbf{u}_t$ represents a $k \times 1$ vector of forecast errors satisfying $E(\mathbf{u}_t \mathbf{u'}_t) = \mathbf{\Sigma}$. We assume that there exists a *linear* mapping

2019; Becker et al. 2021.

[6] Two recent papers closely related to ours are Mao and Yang (2020) and Ghomi et al. (2025), both of which highlight debt maturity as a determinant of the fiscal multiplier. However, they focus on total government spending rather than government employment, and neither examines time variation across policy regimes.

between forecast errors and structural shocks, $\mathbf{u}_t = \mathbf{A}\varepsilon_t$, where ε_t is a $k \times 1$ vector of structural shocks ε_t, which are mutually orthonormal: $E(\varepsilon_t {\varepsilon'}_t) = \mathbf{I}$.

Equation (1) can be expressed in its structural MA representation as:

$$\mathbf{y}_t = \mathbf{C}(L)\varepsilon_t, \tag{2}$$

where $\mathbf{C}(L) = \mathbf{B}(L)\mathbf{A}$ and $\mathbf{AA'} = \mathbf{\Sigma}$. Note that $\mathbf{A}$ is not uniquely identified. The entire space of permissible matrices can be characterized by $\mathbf{A} = \mathbf{PD}$, where $\mathbf{P}$ is the unique lower-triangular Choleski factor of $\mathbf{\Sigma}$, and $\mathbf{D}$ is a $k \times k$ orthonormal matrix such that $\mathbf{DD'} = \mathbf{I}$.[7]

The h-period-ahead forecast error of $\mathbf{y}_t$ is written as:

$$\mathbf{y}_{t+h} - \hat{\mathbf{y}}_{t+h|t-1} = \sum_{\tau=0}^{h} \mathbf{B}_\tau \mathbf{PD}\varepsilon_{t+h-\tau} \tag{3}$$

The share of the h-period-ahead forecast error variance of variable i attributable to shock j is:

$$\text{FEV}_{i,j}(h) = \frac{\mathbf{i}'_i \left[\sum_{\tau=0}^{h} \mathbf{B}_\tau \mathbf{PD} \mathbf{i}_j \mathbf{i}'_j \mathbf{D}'\mathbf{P}'\mathbf{B}'_\tau\right] \mathbf{i}_i}{\mathbf{i}'_i \left[\sum_{\tau=0}^{h} \mathbf{B}_\tau \mathbf{\Sigma} \mathbf{B}'_\tau\right] \mathbf{i}_i} = \frac{\sum_{\tau=0}^{h} \mathbf{b}'_{i,\tau} \mathbf{P} \mathbf{d}_j \mathbf{d}'_j \mathbf{P}' \mathbf{b}_{i,\tau}}{\sum_{\tau=0}^{h} \mathbf{b}'_{i,\tau} \mathbf{\Sigma} \mathbf{b}_{i,\tau}}, \tag{4}$$

where $\mathbf{i}_s$ (selection vector) is the s^{th} column of the identity matrix $\mathbf{I}$ ($s = i, j$), $\mathbf{d}_j$ denotes the j^{th} column of $\mathbf{D}$, and $\mathbf{b}_{i,\tau}$ is the i^{th} column of $\mathbf{B}_\tau$.

The max-share approach generalizes recursive identification via the Cholesky decomposition by relaxing the strict zero-restriction constraints. Without loss of generality, we order government employment (n^g_t) first in $\mathbf{y}_t$ and identify the government employment shock as the column $\mathbf{d}_j$ that maximizes

$$\underset{\mathbf{d}_j}{\text{Max}}\ \text{FEV}_{1,j}(mathbfd_j(h)) = \frac{\sum_{\tau=0}^{h} \mathbf{b}'_{1,\tau} \mathbf{P} \mathbf{d}_j \mathbf{d}'_j \mathbf{P}' \mathbf{b}_{1,\tau}}{\sum_{\tau=0}^{h} \mathbf{b}'_{1,\tau} \mathbf{\Sigma} \mathbf{b}_{1,\tau}}, \tag{5}$$

subject to $\mathbf{d}'_j \mathbf{d}_j = 1$. The identified shock is thus the linear combination of innovations that maximizes its contribution to the h-period-ahead forecast error variance.

We set the forecast horizon to $h = 4$ quarters (one year) in our baseline model. Government employment adjusts gradually due to budgeting, authorization, and hiring procedures, implying that most of the response to structural shocks unfolds over several quarters rather than within a single quarter. A one-year horizon therefore captures the economically relevant

[7] For every real symmetric, positive-definite matrix $\mathbf{\Sigma}$, there exists a unique lower triangular matrix $\mathbf{P}$ with positive diagonal entries such that $\mathbf{\Sigma} = \mathbf{PP'}$. However, $\mathbf{A}$ is not restricted to be lower triangular, the factorization $\mathbf{AA'} = \mathbf{\Sigma}$ is not unique.

adjustment window. This choice is also consistent with Antolin-Diaz and Surico (2025).[8]

2.2 Data and Regime Specifications

Let $\mathbf{y}_t$ be a vector of five endogenous variables: (1) federal government employment (n_t^g); (2) real GDP per capita (gdp_t); (3) a labor market variable (lab_t) among one of the following three: private employment (n_t^p), the unemployment rate ($urat_t$), or the real wage ($wage_t$); (4) the effective federal funds rate (int_t); and (5) the monetary base (mon_t). All data are obtained from the Federal Reserve Economic Database (FRED) and cover the period from 1960Q1 to 2025Q1 at quarterly frequency. Detailed data descriptions are provided in the Online Appendix.

Government employment is defined as the number of federal civilian and military employees. All variables, except for $urat_t$ and int_t, enter the VAR in log levels (multiplied by 100). Prior to estimation, each series is demeaned and detrended using trends of up to quadratic order. The model is estimated with two lags using a conjugate normal-inverse Wishart prior, and credible intervals are constructed from the posterior distribution.

The extraordinary data fluctuations at the onset of the COVID-19 crisis can substantially distort conventional VAR estimation and require specialized treatment (Lenza and Primiceri 2022, Cascaldi-Garcia 2022). We therefore report post-GFC results both for the pre-COVID sample ending in 2019Q3 and for the full sample using the Pandemic Priors proposed by Cascaldi-Garcia (2022). Additional details on the treatment of post-COVID outliers are provided in the Online Appendix.

We divide the sample into three periods:

1. **pre-Volcker era** (1960Q1–1979Q3): characterized by relatively accommodative monetary policy, a gradual rise in inflation expectations, and recurring inflationary pressures associated with expansionary fiscal policy and oil price shocks.

2. **Great Moderation** (1980Q1–2008Q3): marked by the Federal Reserve's aggressive anti-inflationary stance following the Volcker disinflation and a stronger commitment to price stability, which contributed to better-anchored inflation expectations and reduced macroeconomic volatility.

3. **post-GFC era** (2008Q4–2025Q1): characterized by the zero lower bound on nominal interest rates and the extensive use of unconventional monetary policy tools, such as large-scale asset purchases and forward guidance.

[8] Our results are robust to alternative choices of the forecast horizon h. Results are available upon request.

As highlighted by Leeper et al. (2017), scrutinizing the monetary–fiscal policy regime is a first-order consideration when determining the effects of fiscal policy. Our division of the sample reflects two of the most widely recognized shifts in U.S. monetary policy: the Volcker disinflation beginning in 1979, which Goodfriend and King (2005) describes as "the most widely discussed and visible macroeconomic event of the last 50 years of U.S. history," and the GFC period, during which the Federal Reserve rapidly lowered its policy rate to near zero in response to the 2008 financial crisis.[9]

There is a caveat to our conjecture that the post-GFC era resembles the pre-Volcker era in terms of well-coordinated, jointly accommodative fiscal and monetary policy. Figure 1 shows, however, that average duration declines in the pre-Volcker era but rises in the post-GFC era, although the latter period includes sharp but temporary declines in 2008 and 2020.

These dips reflect emergency fiscal responses to the GFC and the COVID-19 pandemic, which required heavy issuance of short-term Treasury bills, temporarily reducing the weighted average maturity. The subsequent upward trend reflects the Treasury's effort to lock in low interest rates and reduce rollover risk by issuing more long-term bonds. This upward shift more than offset the Federal Reserve's Quantitative Easing and Operation Twist, creating a "policy tug-of-war" that indicates incoordination over the duration structure, even though fiscal and monetary policies were otherwise broadly aligned.

2.3 Estimation Results

Our central empirical finding is that the labor market effects of government employment shocks are time-varying, shifting from crowding-in before 1980 to crowding-out during the Great Moderation, and muted effects after the GFC. Figures 2–4 present the impulse response functions (IRFs) of three key labor market variables—private employment, the unemployment rate, and real wages-to an exogenous increase in government employment. Solid lines depict median posterior estimates, while dashed lines indicate 68% credible intervals. In each figure, panels (a)–(c) in the first row correspond to the pre-Volcker, Great Moderation, and post-GFC subsamples estimates, respectively.

[9] Our sample partition based on historical episodes aligns with structural breaks identified in the existing literature. For example, Bernanke and Mihov (1998) document breaks around 1980 and 1988 (or 1989), while Judd and Rudebusch (2020) reject parameter stability across the Burns–Miller, Volcker, and Greenspan periods. A large body of work similarly treats the Volcker disinflation and the transition to the Great Moderation as major regime shifts (see, among others, Taylor 1999, Stock and Watson 2002, Galí et al. 2003, and Galí and Gambetti 2009). More recently, Klose (2014) identifies additional structural breaks in the Fed's Taylor-rule coefficients during the GFC, with estimated break dates concentrated between 2007 and 2009.

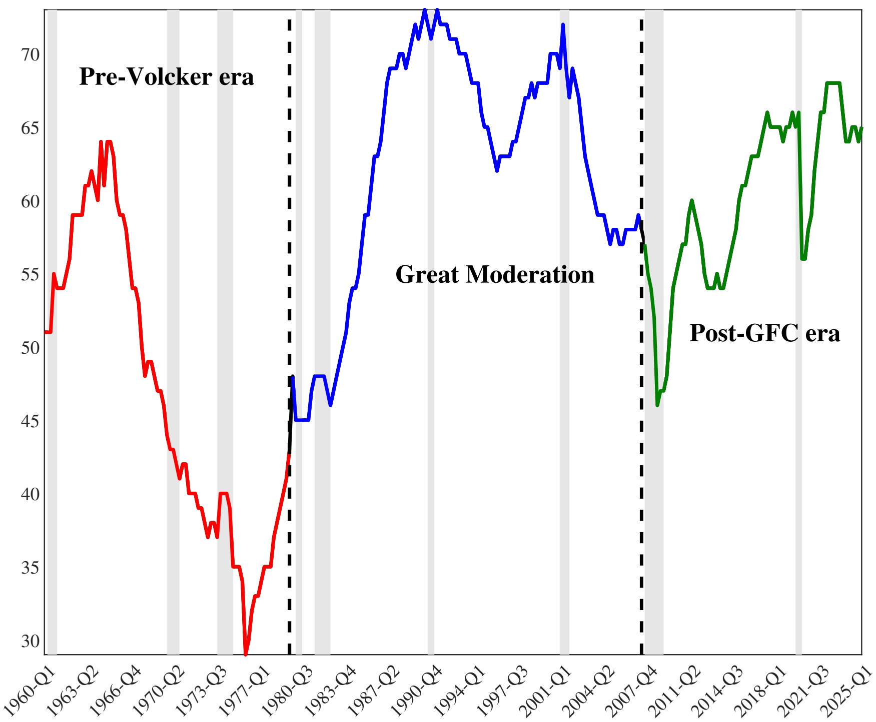

Figure 1: Average Maturity of Public Debt Outstanding

Notes: The figure reports the average maturity (in months) of marketable, interest-bearing public debt held by private investors. Inflation-indexed securities are excluded from the calculation. The data are obtained from the Office of Market Finance, Office of the Under Secretary for Domestic Finance.

During the pre-Volcker era, government employment shocks generate a large, statistically significant increase in private employment, accompanied by a substantial decline in the unemployment rate, as shown in Figures 2(a) and 3(a). Real wages also rise significantly (Figure 4(a)). The literature has debated the conditional correlation between private employment and real wages. Our estimates point to a positive comovement between private employment and real wages in response to government employment shocks. This pattern appears consistent with a New Keynesian interpretation in which fiscal expansions stimulate aggregate demand and shift labor demand outward.

During the Great Moderation, the labor market response reverses sharply. As shown in Figure 2(b), government employment shocks persistently crowd out private employment. The unemployment rate responses fluctuate around zero and are generally insignificant (Figure 3(b)), although they tend to rise at longer horizons. This suggests that the decline in private employment approximately offsets the increase in government employment, resulting in a near-complete crowding-out effect. Our finding is consistent with Malley and Moutos (1998) and Behar and Mok (2019), and is slightly weaker than the more-than-complete crowding out reported by Afonso and Gomes (2014). Other studies (e.g., Demekas and Kontolemis 2000, Michaillat 2014, Becker et al. 2021, Ramey 2012) report less than one-for-one displacement of private jobs by public hiring. Our results align with these findings during the Great Moderation but not in the *pre-Volcker* era.

Real wages exhibit a short-lived initial increase, followed by a rapid and persistent decline, as shown in Figure 4(b). The comovement between private employment and real wages continues to hold during the Great Moderation. As the decline in private employment accelerates in the long run under the anti-inflationary monetary policy of the Volcker–Greenspan period, real wages deteriorate rapidly, indicating that increases in government employment no longer translate into labor market stimulus.

The return to accommodative monetary policy following the 2008 GFC partially, but not fully, offsets the severe crowding-out effects observed during the Great Moderation.[10] Neither private employment nor the unemployment rate exhibits a statistically significant response to government employment shocks (Figures 2(c) and 3(c)). Real wages rise on impact for about one year, but gradually return to near zero over the remainder of the horizon (Figure 4(c)).

We supplement our subsample analysis with a fixed-size rolling-window scheme.[11] Panels

[10] To account for the nonlinearity introduced by the zero lower bound since 2008, we also utilize the shadow rate as the interest rate measure in our VAR estimation. Our results are robust to this modification.

[11] The first rolling window consists of the initial $T_0 < T$ observations, $\{\mathbf{y}_t\}_{t=1}^{T_0}$. We then sequentially roll the sample forward by one quarter, dropping the earliest observation and adding the next, while maintaining a constant window length. This process yields a total of $T - T_0 + 1$ sets of IRF estimates, with the last set

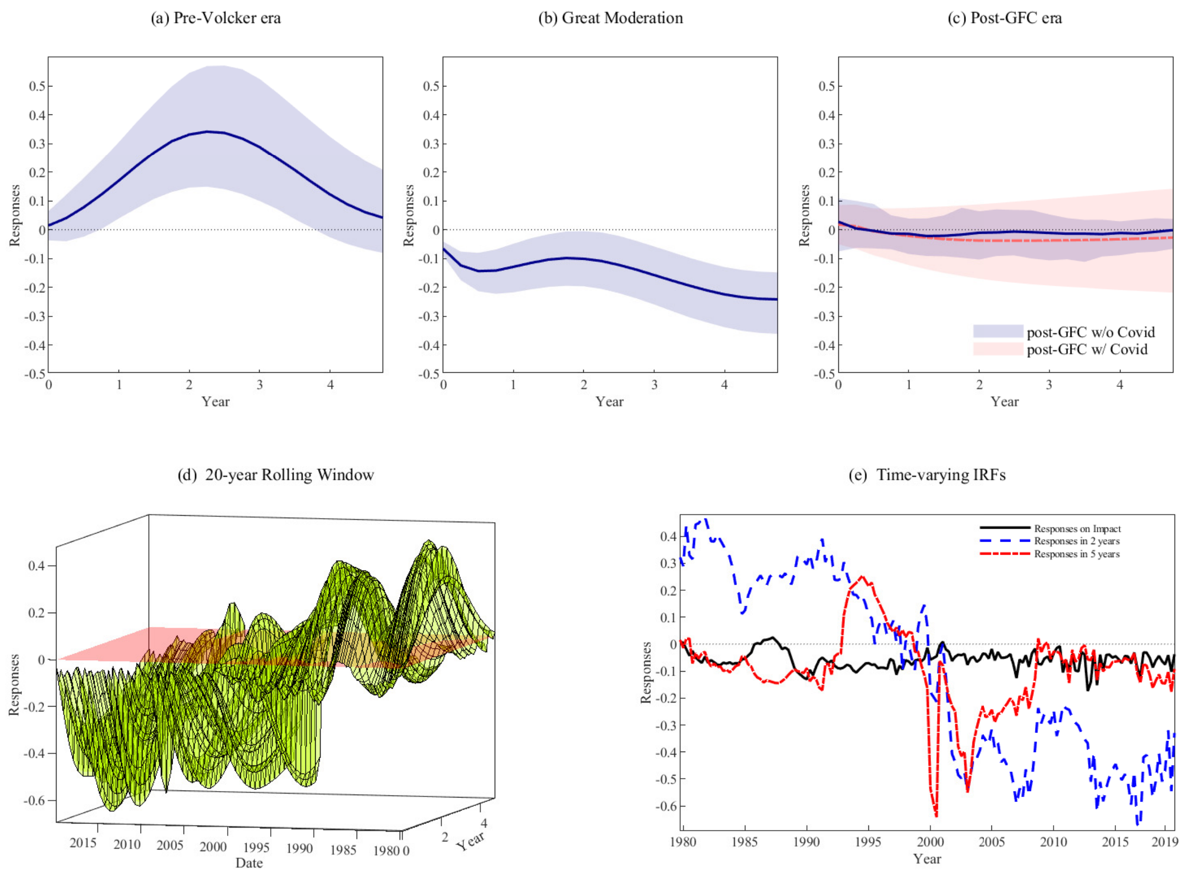

Figure 2: IRFs of Private Employment to Government Employment Shocks

Notes: We present the IRFs from $\mathbf{y}_t = [n_t^g, gdp_t, n_t^p, int_t, mon_t]'$ to a positive government employment shock identified using the max-share approach developed by Francis et al. (2014) and Kurmann and Sims (2021). Panels (a)–(c) in the top row report the median (50%) IRF estimates (solid line) for private employment along with the 68% credible intervals (dashed lines), constructed from draws from the posterior distribution. In the bottom row, panel (d) shows the sequence of IRFs to the government employment shock based on a 20-year fixed-size rolling window scheme, while panel (e) presents the short- to long-run responses obtained by slicing the surface plot in panel (d) at $year = 0, 2, 5$ along the time-axis. "post-GFC w/ Covid" in panel (c) is estimated using the Pandemic Priors of Cascaldi-Garcia (2022).

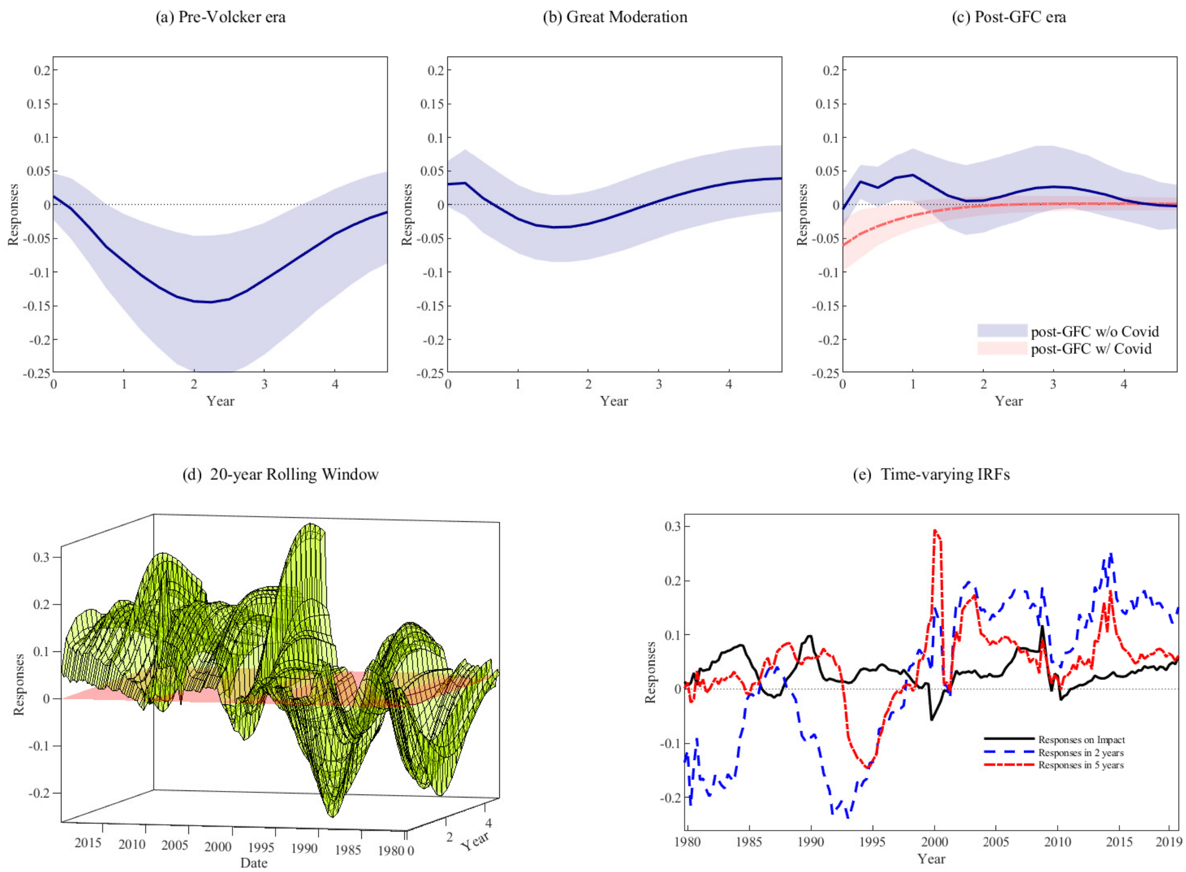

Figure 3: IRFs of the Unemployment Rate to Government Employment Shocks

Notes: We present the IRFs from $\mathbf{y}_t = [n_t^g, gdp_t, urat_t, int_t, mon_t]'$ to a positive government employment shock identified using the max-share approach developed by Francis et al. (2014) and Kurmann and Sims (2021). Panels (a)–(c) in the top row report the median (50%) IRF estimates (solid line) for private employment along with the 68% credible intervals (dashed lines), constructed from draws from the posterior distribution. In the bottom row, panel (d) shows the sequence of IRFs to the government employment shock based on a 20-year fixed-size rolling window scheme, while panel (e) presents the short- to long-run responses obtained by slicing the surface plot in panel (d) at $year = 0,\ 2,\ 5$ along the time-axis. "post-GFC w/ Covid" in panel (c) is estimated using the Pandemic Priors of Cascaldi-Garcia (2022).

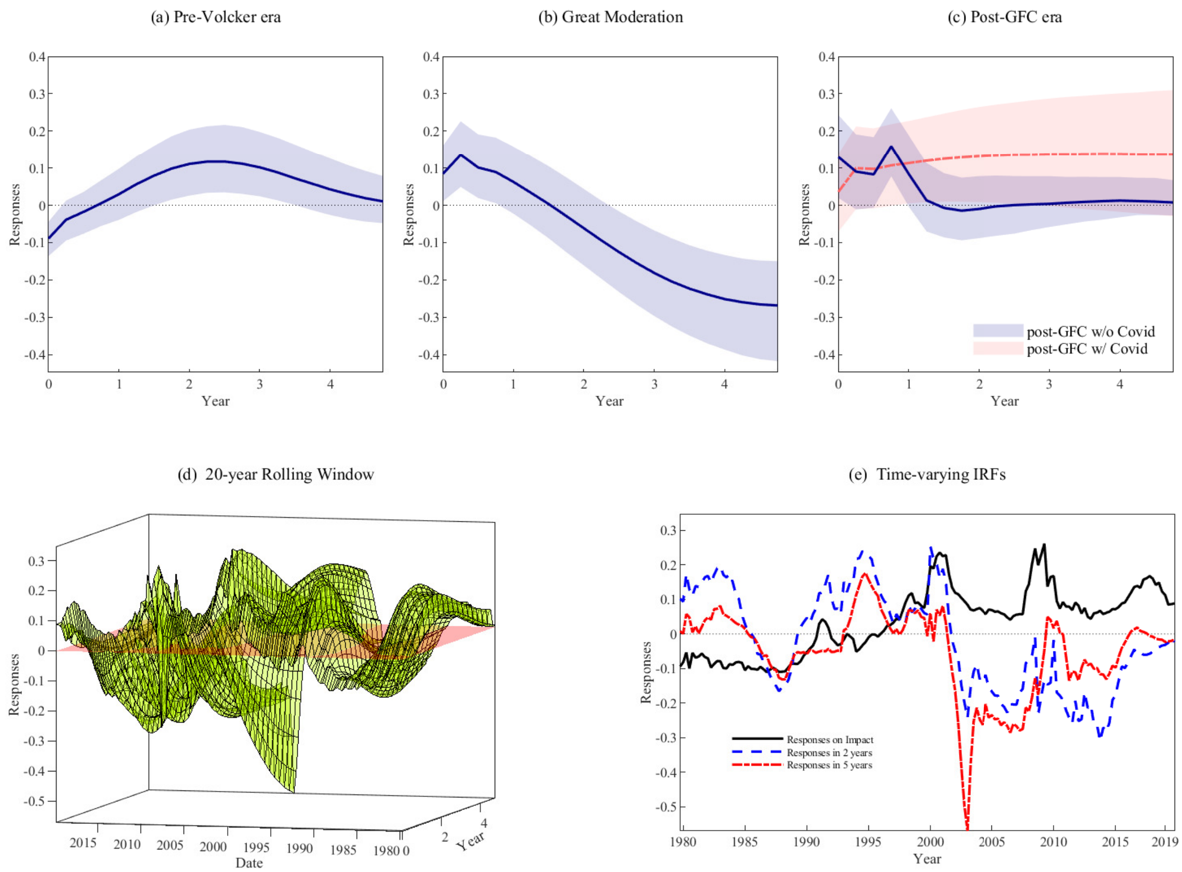

Figure 4: IRFs of Real Wages to Government Employment Shocks

Notes: We present the IRFs from $\mathbf{y}_t = [n_t^g, gdp_t, wage_t, int_t, mon_t]'$ to a positive government employment shock identified using the max-share approach developed by Francis et al. (2014) and Kurmann and Sims (2021). Panels (a)–(c) in the top row report the median (50%) IRF estimates (solid line) for private employment along with the 68% credible intervals (dashed lines), constructed from draws from the posterior distribution. In the bottom row, panel (d) shows the sequence of IRFs to the government employment shock based on a 20-year fixed-size rolling window scheme, while panel (e) presents the short- to long-run responses obtained by slicing the surface plot in panel (d) at $year = 0,\ 2,\ 5$ along the time-axis. "post-GFC w/ Covid" in panel (c) is estimated using the Pandemic Priors of Cascaldi-Garcia (2022).

(d) and (e) of Figures 2–4 report IRF estimates using a 20-year rolling window ($T_0 = 80$ quarters), such that the first rolling window roughly corresponds to the pre-Volcker era.[12] Each grid point on the x-axis corresponds to the end date of a rolling window, covering pre-COVID observations from 1979Q4 to 2019Q4. The y-axis indicates the response horizon (0–5 years), while the z-axis shows the magnitude of the IRF of each variable to government employment shocks.

The surface plots in panel (d) reveal a pronounced decline in fiscal effectiveness as the sample period moves forward in time. The positive responses of private employment and real wages (and the negative response of the unemployment rate) are rapidly dragged down (and lifted up) through the 1980s and 1990s before partially recovering in the post-GFC period.

To highlight these transitions, panel (e) presents the responses from the short-run to the long-run by dissecting panel (d) at $year = 0,\ 2,\ 5$ along the y-axis, read from right to left. While impact responses ($year = 0$) remain relatively stable, medium- ($year = 2$) and long-run ($year = 5$) responses clearly exhibit time variation with significant downward (or upward) trends through the Great Moderation and signs of reversal as the window enters the post-GFC era.

From the pre-Volcker era to the post-GFC era It's worth noting the stark contrast in the labor market effects of government employment shocks between the pre-Volcker and post-GFC: despite accommodative monetary policy in both periods, fiscal expansions through government hiring stimulate the labor market in the former but produce muted effects in the latter. Differences in monetary–fiscal regimes alone, therefore, cannot fully account for these divergent responses.

As discussed in the previous section, the average maturity of U.S. government debt shortened markedly during the pre-Volcker era but lengthened after 2008 in the post-GFC era. This observation motivates the theoretical framework developed in Section 3, which incorporates the maturity structure of government debt into a DSGE model and replicates these empirical patterns. In particular, the model shows that longer debt maturities dampen fiscal stimulus effects, even under accommodative monetary policy.[13]

of IRFs estimated from $\{\mathbf{y}_t\}_{t=T-T_0+1}^{T}$.

[12]Robustness checks using 30-year and 40-year rolling window schemes yield qualitatively similar results.

[13]Note that Figure 1 reports the average debt maturity held by private investors, i.e., the maturity structure of debt remaining on private balance sheets, excluding Federal Reserve holdings.

2.4 Robustness Checks

Given the ongoing debate on the transmission of fiscal shocks, we assess the robustness of our results along two dimensions. First, we examine sensitivity to the inclusion of additional fiscal controls. Because our baseline VAR does not explicitly account for fiscal deficits or restrict the contemporaneous response of tax revenues, omitted-variable concerns may arise. We therefore re-estimate the VAR including either tax revenues or government debt (as a share of GDP) as additional endogenous variables. The results are robust to these alternative specifications.

Second, we adopt a standard recursive identification strategy for fiscal shocks. Following Blanchard and Perotti (2002), we assume that fiscal policy is subject to decision and implementation lags exceeding one quarter, implying that government spending does not respond contemporaneously to other variables. We implement a Cholesky identification while preserving the variable ordering in the benchmark specification. The resulting impulse responses are consistent with our baseline findings. Both sets of results are reported in the Online Appendix.[14]

3 Theoretical Model

In this section, we develop a New Keynesian DSGE model that rationalizes the time-varying labor market effects of government employment shocks documented in Section 2. We embed a public employment sector in an otherwise standard NK framework and augment it with two key ingredients: (i) alternative monetary–fiscal policy regimes in the spirit of Leeper (1991): Regime F, which features active fiscal policy (independent of budgetary conditions) combined with passive monetary policy (weakly responsive to inflationary pressure), and Regime M, which features active monetary policy (strongly responsive to inflation) combined with passive fiscal policy (adjusting to stabilize government debt). (ii) a parameterized maturity structure of government debt following Woodford (2001). Wage and price rigidities are modeled as adjustment costs, following Rotemberg (1982) and Ireland (1997). The central bank's reaction function is specified by a Taylor rule, while fiscal policy is governed by explicit feedback rules that respond to government debt.

[14] Jia et al. (2022) consider total government expenditures, which include transfer payments in addition to discretionary government consumption and investment. Because transfer payments embed automatic stabilizers, they place g_t adjacent to y_t in the VAR ordering.

3.1 Production

Firms in the private sector produce intermediate and final goods. A perfectly competitive final goods firm produces the final good (y_t) from a continuum of differentiated intermediate goods ($y_t(j)$). The final goods aggregator is $y_t = \left[\int_0^1 (y_t(j))^{(\theta_p-1)/\theta_p} dj\right]^{\theta_p/(\theta_p-1)}$, where $\theta_p > 1$ governs the degree of substitution between the inputs (see Dixit and Stiglitz 1977). Taking the price of intermediate goods ($P_t(j)$) and final goods (P_t) as given, profit maximization of the final goods firm yields the demand schedule $y_t(j) = (P_t(j)/P_t)^{-\theta_p} y_t$, where $P_t = \left(\int_0^1 P_t^{1-\theta_p}(j)dj\right)^{1/1-\theta_p}$.

Intermediate goods firms are monopolistically competitive. Each firm j produces output according to,

$$y_t(j) = [n_t^p(j)]^{1-\alpha} [k_t^s(j)]^{\alpha} \tag{6}$$

where $\alpha \in (0,1)$. $k_t^s(j) \equiv u_t(j)k_{t-1}(j)$ and $n_t^p(j)$ are effective capital and private labor employed by firm j. Cost minimization, taking input prices (W_t, R_t^k) as given, yields the identical marginal cost:

$$MC_t = \Upsilon W_t^{1-\alpha} \left(R_t^k\right)^{\alpha} \tag{7}$$

$$\frac{W_t}{R_t^k} = \frac{1-\alpha}{\alpha}\frac{k_t^s(j)}{n_t^p(j)}, \tag{8}$$

where $\Upsilon = \alpha^{-\alpha}(1-\alpha)^{\alpha-1}$.

Each intermediate firm faces a Rotemberg price-adjustment cost $\frac{\phi_p}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - \bar{\pi}\right)^2 y_t$ (see Ireland 1997). Firm j chooses its price $P_t(j)$ to maximize the expected discounted present value of real profits:

$$\max_{P_t^*(j)} E_t \sum_{s=0}^{\infty} Q_{t,t+s}\left[\frac{P_{t+s}(j)y_{t+s}(j)}{P_{t+s}} - \frac{MC_{t+s}}{P_{t+s}}y_{t+s}(j) - \frac{\phi_p}{2}\left(\frac{P_{t+s}(j)}{P_{t+s-1}(j)} - \bar{\pi}\right)^2 y_{t+s}\right] \tag{9}$$

subject to the demand for $y_{t+s}(j) = (P_{t+s}(j)/P_{t+s})^{-\theta_p} y_{t+s}$. $Q_{t,t} = 1$, $Q_{t,t+s} = \beta^s \frac{\lambda_{t+s}}{\lambda_t}$ is the stochastic discount factor.

3.2 Private Labor Agency

A competitive labor agency combines differentiated labor services into a homogeneous composite input that, in turn, is sold to private intermediate firms according to

$$n_t^p = \left[\int_0^1 n_t^p(i)^{\frac{\theta_w-1}{\theta_w}} di\right]^{\frac{\theta_w}{\theta_w-1}}, \tag{10}$$

where $0 \leq \theta_w < \infty$ is the elasticity of substitution among different types of labor. Profit maximization, taking all differentiated wages ($W_t(i)$) and the aggregate wage (W_t) as given, yields:

$$n_t^p(i) = \left(\frac{W_t(i)}{W_t}\right)^{-\theta_w} n_t^p \tag{11}$$

where $W_t \equiv \left(\int_0^1 W_t^{1-\theta_w}(i)di\right)^{\frac{1}{1-\theta_w}}$.

3.3 Households

The economy is populated by a large number of identical households. Lifetime utility of each household i is a separable function of its composite consumption ($c_t^*(i)$) and labor ($n_t(i)$) given by:

$$E_t \sum_{t=0}^{\infty} \beta^t \left(\ln\left(c_t^*(i) - hc_{t-1}^*\right) - \frac{n_t(i)^{1+\eta}}{1+\eta}\right) \tag{12}$$

where $\beta \in (0,1)$ is the discount factor. $h \in (0,1)$ governs the degree of external habit formation in consumption, measured as a fraction of lagged aggregate consumption c_{t-1}^*.

Households receive after-tax wage and rental income, lump-sum transfers from the government ($z_t(i)$) and profits from firms (D_t). They spend income on consumption ($c_t(i)$), investment in future capital ($i_t(i)$), and government bonds. The nominal flow budget constraint of households is given by:

$$\begin{aligned} &P_t(1+\tau_t^c)c_t(i) + P_t i_t(i) + R_t^{-1}B_t^s(i) + P_t^m B_t^m(i) + \frac{\phi_w}{2}\left(\frac{W_t(i)}{W_{t-1}(i)} - \bar{\pi}^w\right)^2 W_t \\ &\leq B_{t-1}^s(i) + \left(1+\rho P_t^m\right) B_{t-1}^m(i) + (1-\tau_t^n)W_t(i)n_t(i) + \\ &\left[\left(1-\tau_t^k\right) R_t^k u_t(i) - a\left(u_t\right)\right] k_{t-1}(i) + D_t(i) + P_t z_t(i), \end{aligned} \tag{13}$$

where nominal private consumption ($P_t c_t(i)$) is subject to a sales tax τ^c. Labor income ($W_t(i)n_t(i)$) is taxed at the rate τ^n.

Following Kim (2000), wage rigidities are introduced through the cost of adjusting nominal wages, assumed to be quadratic and zero at the steady state. $\bar{\pi}^w$ is the steady-state wage inflation, which is assumed equal to price inflation $\bar{\pi}$. Rental income on capital, $R_t^k u_t(i) k_{t-1}(i)$, is taxed at the rate τ^k, where $u_t(i)$ is capital utilization.[15] $a\left(u_t(i)\right) k_{t-1}(i)$ describes the cost associated with variations in the degree of capacity utilization, which is

[15]Here we use the *end of period stock* timing convention. That is, variables get the timing at which they are determined. For example, the capital stock, k, used at time t in the production function for y_t was determined by investment at time $t-1$. In what follows, we provide a detailed explanation of our key setups.

parameterized by a quadratic function $a(u_t) = \zeta_1 (u_t - 1) + \frac{\zeta_2}{2} (u_t - 1)^2$. Note that $u = 1$ and $a(1) = 0$ in the steady state.

We also define $\frac{a''(1)}{a'(1)} \equiv \frac{\zeta_2}{1-\zeta_2}$ following Smets and Wouters (2007).[16] The law of motion for capital is:

$$k_t(i) = (1-\delta)\, k_{t-1}(i) + \left[1 - S\left(\frac{i_t(i)}{i_{t-1}(i)}\right)\right] i_t(i) \tag{14}$$

where δ is the depreciation rate and $S(\cdot)$ denotes an adjustment cost function, proposed by Christiano et al. (2005), such that $S(1) = S'(1) = 0$, and $\kappa \equiv S''(1) > 0$. We now describe the key elements of the model in detail.

3.3.1 Composite Consumption

Composite consumption in (12) is defined as:

$$c_t^*(i) \equiv c_t(i) + \alpha_g s_t^g, \tag{15}$$

where s_t^g denotes government services and the parameter α_g governs the degree of substitutability between private consumption $(c_t(i))$ and public services. Note that when $\alpha_g > 0$, $\frac{\partial}{\partial s_t^g}\left(\frac{\partial \ln c_t^*(i)}{\partial c_t(i)}\right) = \frac{\partial}{\partial s_t^g}\left(\frac{1}{c_t(i)+\alpha_g s_t^g}\right) = -\frac{\alpha_g}{\left(c_t(i)+\alpha_g s_t^g\right)^2} < 0$, implying that $c_t(i)$ and s_t^g are substitutes, whereas they are complements when $\alpha_g < 0$. The case of substitution will be the relevant one below.[17]

3.3.2 Household Labor Supply

Households supply labor to both private-sector firms and the government, with preferences over total labor supply given by:

$$n_t = n_t^p + \alpha_{n^g} n_t^g, \tag{16}$$

where n_t^p and n_t^g denote employment in the private and public sectors respectively. From the contemporaneous labor disutility function in (12),

$$\begin{aligned} \frac{\partial}{\partial n_t^g}\left(\frac{\partial}{\partial n_t^p(i)}\left(-\frac{n_t(i)^{1+\eta}}{1+\eta}\right)\right) &= \frac{\partial}{\partial n_t^g}\left(-(n_t^p(i) + \alpha_{n^g} n_t^g)^\eta\right) \\ &= -\alpha_{n^g}(n_t^p(i) + \alpha_{n^g} n_t^g)^{\eta-1} < 0, \end{aligned}$$

[16] We need this condition to linearize the model presented here.

[17] Empirical evidence on the substitution elasticity between private consumption and government services is mixed. Fiorito and Kollintzas (2004) and Bermperoglou et al. (2017) find that public services such as justice and defense tend to be substitutes for private consumption. Because our empirical analysis focuses on federal government employment, much of which consists of military and defense personnel, the substitution case is the more relevant one for our analysis.

where α_{n^g} is a strictly positive share coefficient.[18] Note that the marginal disutility of private labor increases when the government employment shock occurs, implying a *contemporaneous* decline in n_t^p.

One strand of the literature adopts the common-wage assumption across the public and private sectors (e.g., Cavallo 2005; Forni et al. 2009; Linnemann 2009; Pappa 2009; Becker et al. 2021), while another treats public wages as an exogenous policy instrument set by the government (e.g., Gomes 2010; Ardagna 2007; Bermperoglou et al. 2017; **?**). We adopt the former approach, which is consistent with evidence that public-sector hourly wages broadly track those in the private sector over the medium term. Under this assumption, we calibrate α_{n^g} to match the average share of public employment in total employment, as we do not explicitly model occupational choice between the private and public labor markets.

More generally, our theoretical framework abstracts from an explicit unemployment margin and instead focuses on private employment as the primary labor market outcome of interest. Accordingly, the model is designed to speak primarily the response of private employment and the reallocation of labor between the private and public sectors following government employment shocks across different institutional environments.[19]

3.3.3 Government Debt Maturity Structure

There are two types of bonds: one-period nominal government bonds, $B_t^s(i)$, in zero net supply with price R_t^{-1}, where R_t is the gross nominal interest rate set by the monetary authority; and a more general portfolio of nominal government bonds, $B_t^m(i)$, in non-zero net supply with price P_t^m. Following Woodford (2001), all government bonds are modeled as consols with coupon payments that decay exponentially at a constant rate ρ. Specifically, a bond issued in period t pays ρ^T dollars in period $t+T+1$ for $T \geq 0$, where the decay factor satisfies $0 \leq \rho < \beta^{-1}$.

Combining the household Euler equations for short- and long-term debt yields the log-linearized debt maturity structure equation:

$$\hat{R}_t = -\left(\hat{P}_t^m - \frac{\rho\beta}{\bar{\pi}} E_t \hat{P}_{t+1}^m\right) \tag{17}$$

where $\hat{x}_t \equiv \ln x_t - \ln x$ denotes log-deviations from steady state. Equation (17) represents

[18] Let total labor be defined as $\sigma n_t^p + (1-\sigma) n_t^g$. Normalizing by σ, this can be rewritten as $n_t^p + \alpha_{n^g} n_t^g$, where $\alpha_{n^g} = \frac{1-\sigma}{\sigma} > 0$.

[19] An important extension for future research would be to introduce search-and-matching frictions and equilibrium unemployment, which would allow the model to address unemployment responses to government employment shocks more directly.

an equilibrium restriction on the expected movements of asset prices.[20]

Solving equation (17) forward and using transversality determines the term structure relation:

$$\hat{P}_t^m = -\sum_{j=0}^{\infty} \left(\frac{\rho\beta}{\bar{\pi}}\right)^j E_t \hat{R}_{t+j} \tag{18}$$

Equation (18) shows that the long-term debt is priced as the expected present discounted value of all future one-period interest rates. The Macaulay average maturity of the debt (AD)-the weighted average of time until each of the debt's future payment with the weights determined by the proportion of the debt's present value on each payment date-can be expressed as

$$AD = \sum_{j=0}^{\infty} j \cdot \frac{\left(\frac{\rho\beta}{\bar{\pi}}\right)^j E_t \hat{R}_{t+j}}{\sum_{j=0}^{\infty} \left(\frac{\rho\beta}{\bar{\pi}}\right)^j E_t \hat{R}_{t+j}} = \frac{\bar{\pi}}{\bar{\pi} - \rho\beta} \tag{19}$$

The average maturity of government debt varies with the parameter ρ. When $\rho = 0$, government debt takes the form of a one-period (1-quarter) bond that repays the principal in the next period and nothing thereafter. When $\rho = 1$, it becomes a consol (perpetuity) that pays a constant coupon indefinitely. A central focus of our analysis is to examine how changes in the maturity structure of government debt influence the propagation of government employment shocks in the labor market.

3.4 Fiscal Policy

The government combines government employment (n_t^g) and goods purchased from the private sector (g_t) to provide public services (s_t^g) using the following production function:

$$s_t^g = \left(n_t^g\right)^{1-\gamma_g} g_t^{\gamma_g}, \quad \gamma_g \in (0, 1) \tag{20}$$

In each period, government's income consists of proceeds from sales of bonds and tax revenues to finance its expenditures that include repayment of bonds, salaries and wages ($W_t n_t^g$), government goods purchases (g_t) and transfer payments (z_t). The government's flow budget constraint is

$$\left(1 + \rho P_t^m\right) B_{t-1}^m + W_t n_t^g + P_t g_t + P_t z_t = P_t^m B_t^m + \tau_t^n W_t n_t + \tau_t^k R_t^k u_t k_{t-1} + P_t \tau_t^c c_t \tag{21}$$

[20] Details on the derivation of the equilibrium system are provided in the Online Appendix.

Following Leeper et al. (2017), the fiscal rule includes a response of fiscal instruments to the debt-to-GDP ratio to ensure determinacy of equilibrium and a nonexplosive solution for debt and an autoregressive term to allow for serial correlation. Government employment follows the rule

$$\hat{n}_t^g = \psi_{n^g} \hat{n}_{t-1}^g - (1 - \psi_{n^g}) \gamma_{n^g} \hat{s}_{t-1}^b + \nu_t^{n^g} \tag{22}$$

where $s_{t-1}^b \equiv \frac{P_{t-1}^m B_{t-1}^m}{P_{t-1} Y_{t-1}}$. The parameter $\psi_{n^g} \in (-1, 1)$ governs the degree of the persistence of the process and $\gamma_{n^g} > 0$ triggers a correction of fiscal expansion when debt deviates from its steady state. The government employment shock ($\nu_t^{n^g}$) follows a stationary ($\rho_{n^g} < 1$) AR(1) process:

$$\ln \nu_t^{n^g} = \rho_{n^g} \ln \nu_{t-1}^{n^g} + \varepsilon_t^{n^g}, \quad \varepsilon_t^{n^g} \sim \mathbb{N}(0, \sigma_{n^g}) \tag{23}$$

3.5 Monetary Policy

The monetary authority follows a Taylor rule, adjusting the gross nominal interest rate (R_t) in response to deviations of inflation (π_t) and output (y_t) from their respective steady state levels:

$$R_t = R_{t-1}^{\psi_r} \left[\bar{R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi} \left(\frac{y_t}{\bar{y}} \right)^{\phi_y} \right]^{1-\psi_r} \tag{24}$$

where $0 \leq \psi_r < 1$ is the interest rate smoothing parameter, $\bar{R}$ is the steady-state interest rate, and ϕ_π and ϕ_y are the policy responses to inflation and the output gap, respectively. In Regime F, $\phi_\pi < 1$ (passive monetary policy); in Regime M, $\phi_\pi > 1$ (active monetary policy).

3.6 Market Clearing and Aggregation

Aggregate consumption is $c_t = \int_0^1 c_t(i) di$ and aggregate bonds, private capital, investment, and dividends satisfy $x_t = \int_0^1 x_t(j) dj$ for $x = \{b, k, i, d\}$. Goods market clearing is

$$\begin{aligned} y_t &= c_t + i_t + g_t + adj_t \\ adj_t &= \frac{\phi_w}{2} (\pi_t^w - \bar{\pi}^w)^2 \frac{W_t}{P_t} + a(u_t) k_{t-1} + \frac{\phi_p}{2} (\pi_t - \bar{\pi})^2 y_t \end{aligned} \tag{25}$$

where adj_t denotes real adjustment costs. The full set of equilibrium conditions is provided in the Online Appendix. We solve the model by approximating the equilibrium conditions around the nonstochastic steady state using the Sims (2002) gensys algorithm. In the next section, we calibrate and simulate the model under each policy regime.

4 Calibration and Simulation

This section outlines the model calibration, distinguishing standard structural parameters from regime-specific policy rules. We then present simulated impulse responses to government employment shocks across regime–maturity combinations, and map them to the empirical patterns documented in Section 2. Our model highlights debt duration as a critical determinant of fiscal effectiveness.

4.1 Calibration

Our model is calibrated at a quarterly frequency. Standard parameter values follow the literature. The discount factor (β) is set to 0.99. We incorporate strong habit formation ($h = 0.99$) in consumption (see Ravn et al. 2006 and Leeper et al. 2017). The quarterly depreciation rate of capital (δ) is set to 0.025, implying an annual depreciation rate of 10%. The capital share in the production function (α) is set to 0.33, and the price elasticity of demand for intermediate goods (θ_p) is set to 6. The capital utilization parameter (ζ_2) and the investment adjustment cost parameter (κ) are set to 0.5 and 5, respectively.

The Rotemberg price adjustment cost (ϕ_p) is set to match an average duration of prices remaining unchanged for more than one year, as implied by an equivalent Calvo pricing formulation. The wage adjustment cost (ϕ_w) is calibrated analogously. The steady-state inflation rate ($\bar{\pi}$) is set to 1.

Following Galí et al. (2012), the inverse Frisch labor supply elasticity (η) is assumed to be 5 (i.e., a Frisch elasticity of 0.2) and the wage elasticity of substitution (θ_w) is set to 4.52.[21] The substitution elasticity of private consumption and government services, α_g, is set to 0.2 to match the fact that federal government services (primarily defense) substitute for private consumption. The share coefficient of government employment (α_{n^g}) is set to 0.2, which matches the sample mean.[22] The production share of government employment in public services ($1-\gamma_g$) is set to 0.64, which is the sample average of the share of government employee compensation in government consumption.

Regime-specific monetary policy parameters are drawn from the Taylor rule estimates of Clarida et al. (2000). In Regime F, the passive central bank responds only weakly to inflation to keep the balance between output and inflation so that the (long run) coefficients on inflation (ϕ_π) and on the output (ϕ_y) are set to 0.83 and 0.27, respectively and the interest rate smoothing parameter (ψ_r) is set to be 0.68.[23] The fiscal rule only includes an

[21] This setup implies an average unemployment rate of 5%.

[22] $\alpha_{n^g} = \frac{1-n^p/n}{n^p/n}$, where n^p/n is the mean value of the private-to-total employment ratio using the postwar U.S. data.

[23] We proxy an accommodative stance of conventional monetary policy in the post-GFC period by assuming

autoregressive term (ψ_{n^g}) to allow for serial correlation. In Regime M, however, the active central bank raises the interest rate aggressively to curb inflationary pressure so that ϕ_π, ϕ_y, and ψ_r are set to 2.15, 0.93, and 0.79, respectively.[24] In this case, the fiscal rule also includes a response to the debt-to-GDP ratio with $\gamma_{n^g} = 0.21$ (see Leeper et al. 2017).[25] The autoregressive coefficient is $\psi_{n^g} = 0.98$ in both regimes.

The remaining fiscal parameters are calibrated to match the postwar U.S. means: the government purchase-to-GDP ratio (g/y) is 0.052, debt-to-GDP ratio (s^b) is 1.501, the average federal labor tax rate (τ^n) is 0.217, the capital tax rate (τ^k) is 0.25 and the consumption tax rate is 0.023. The full list of our parameter choices is given in Table 1.

4.2 Simulation Results

Figures 5 and 6 display simulated IRFs to a 1% exogenous increase in government employment under two distinct policy regimes: (1) **Regime F**, which features an *active fiscal authority* that sets policy independently of budgetary conditions, while the monetary authority responds only weakly to inflation (passive monetary policy); and (2) **Regime M**, which features an *active monetary authority* that raises nominal interest rates aggressively to stabilize inflation, while the fiscal authority adjusts to ensure debt stability (passive fiscal policy). We further refine each regime according to alternative government debt maturity structures, ranging from **Short-Term** (1-quarter) to **Long-Term** (up to 60-quarter). All responses are expressed as percentage deviations from their respective steady states. For comparability across policy specifications, we calibrate all models using identical structural parameters and vary only the policy rules.

Our simulation exercises yield several key findings. First, under Regime F, government hiring generates a strong and persistent labor market stimulus only when fiscal shocks are financed with short-term bonds; when financing relies on long-term bonds, the stimulus is substantially muted and eventually turns negative, despite accommodative monetary policy. Second, under Regime M, government employment shocks generally worsen labor market conditions and fail to stimulate private employment, regardless of the debt-maturity structure. Overall, the labor market effects of government employment shocks depend crucially on the interaction between policy regimes and the maturity structure of government debt.

weaker responses in the Taylor rule. Simulations that vary policy responses within a neighborhood around the benchmark values yield qualitatively similar results. Unconventional monetary policy tools—such as quantitative easing and Operation Twist—are beyond the scope of this paper, although they were also employed during this period and may have influenced the overall policy stance. Incorporating such instruments is left for future research.

[24] Our results are robust to using the canonical Taylor-rule coefficients, $\phi_\pi = 1.5$ and $\phi_y = 0.5$.

[25] As a robustness check, we also follow Kim et al. (2023) in specifying policy regimes.

Table 1: Baseline Calibration

Preference and HHs	
β, discount factor	0.99
h, habit formation	0.99
η, inverse Frisch labor elast.	5
δ, depreciation rate	0.025
α_g, subs. of private/public cons.	0.2
α_{n^g}, govt employment share	$\frac{1-n^p/n}{n^p/n}$
Frictions and Production	
α, capital share	0.33
$1-\gamma_g$, govt employment share	0.64
θ_p, interm. goods demand price elast.	6
θ_w, labor demand wage elast.	4.52
$\phi_j, j = p, w$, price/wage adjustment cost.	$\frac{\omega_j(\theta_j-1)}{(1-\omega_j)(1-\omega_j\beta)}$
ζ_2, capital utilization	0.5
κ, investment adj. cost	5
Monetary/Fiscal Calibrations	
g/y, *steady state* govt purchase-to-GDP ratio	0.052
s^b, *steady state* debt-to-GDP ratio	1.501
ψ_{n^g}, lagged resp. for govt spending	0.98
τ^n, labor tax rate	0.217
τ^k, capital tax rate	0.25
τ^c, consumption tax rate	0.023
Regime F	
Monetary Policy	
ϕ_π, interest rate resp. to inflation	0.83
ϕ_y, interest rate resp. to output	0.27
ψ_r, resp. to lagged interest rate	0.68
Fiscal Policy	
γ_{n^g}, govt employment resp. to debt	0
Regime M	
Monetary Policy	
ϕ_π, interest rate resp. to inflation	2.15
ϕ_y, interest rate resp. to output	0.93
ψ_r, resp. to lagged interest rate	0.79
Fiscal Policy	
γ_{n^g}, govt employment resp. to debt	0.21

Note: Parameters are calibrated at a quarterly frequency.

In what follows, we demonstrate that these model simulations closely replicate the empirical patterns documented in Section 2 for the pre-Volcker, post-GFC, and Great Moderation eras.

4.2.1 Labor Market Effects under Regime F

Short-term Debt Figure 5 (solid red lines) shows that a government employment shock in Regime F, when financed with short-term debt, generates sharp increases in private employment and real wages on impact. These responses continue to build over subsequent quarters before gradually converging back to their steady states. Total employment closely mirrors the dynamics of private employment, both quantitatively and qualitatively. The large and rapid positive responses of all labor market variables indicate a strong stimulative effect of government hiring when accommodated by passive monetary policy and the debt issuance is concentrated at the short end of the maturity spectrum.

The strong positive comovement between private employment and real wages points to the aggregate-demand channel as the dominant transmission mechanism of fiscal shocks. As shown in the middle-row panels of Figure 5, the monetary authority responds weakly to inflation, resulting in a sizable decline in the real interest rate, which in turn leads to a substantial improvement in labor market conditions through an expansion in real economic activity.

These dynamics are consistent with empirical evidence from the pre-Volcker era (1960Q1–1979Q3), during which the average maturity of U.S. government debt shortened from the 1960s through the late 1970s (see Figure 1).

Long-term Debt The dotted green, dashed blue, and dash-dotted black lines of Figure 5 correspond to average maturities of 20, 40, and 60 quarters, respectively. Relative to the short-term debt case, the responses of total employment, private employment, and real wages decline substantially in magnitude as debt maturity lengthens. Moreover, the responses become flatter and less persistent, in contrast to the pronounced hump-shaped dynamics observed under short-term debt.

Notably, when the average debt maturity reaches 40 quarters or longer (dashed blue and dash-dotted black lines), there's virtually zero private-sector job creation on impact following government hiring. Then, the observed increase in total employment primarily reflects the expansion of government employment itself. Moreover, within one year, crowding-out effects emerge as th response of private employment turns negative.

This model-implied attenuation of fiscal effectiveness, even in the presence of accommodative monetary policy, is consistent with the muted labor market responses observed in

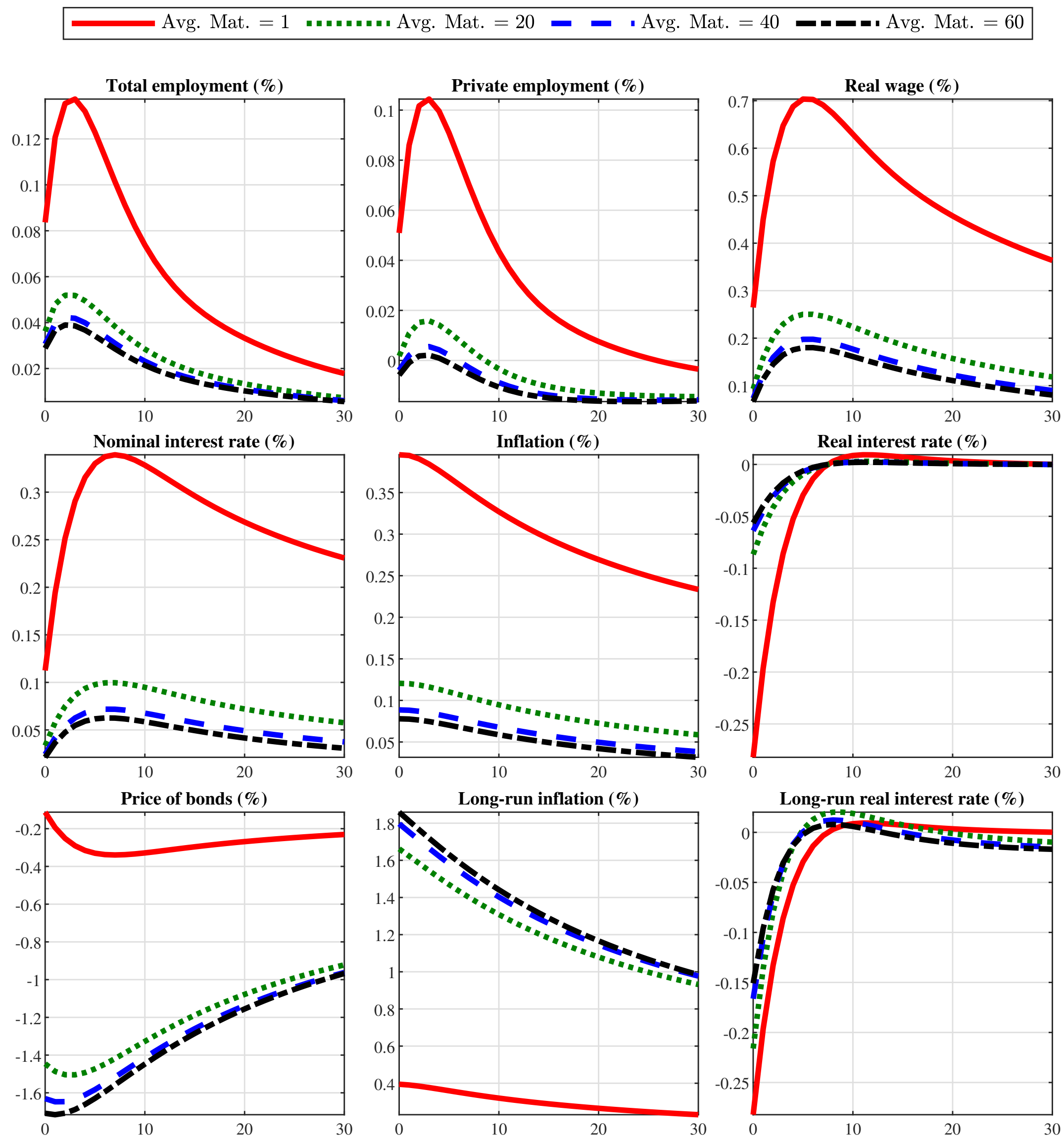

Figure 5: Simulated Impulse Responses to Government Employment Shocks in Regime F

Notes: We report simulated responses over 30 quarters to a 1% government employment shock in Regime F, where the Taylor rule inflation response ϕ_π is set to 0.83. The average maturity of government debt is 1 (solid red line), 20 (dotted green line), 40 (dashed blue line), and 60 (dash-dotted black line) quarters.

the post-GFC era (2008Q4–2025Q1), during which the average maturity of U.S. government debt increased as shown in Figure 1.

The Role of Debt Duration under Regime F Why does longer debt maturity systematically weaken the stimulative effects of government employment shocks, even when monetary policy remains accommodative? To get further insights, we derive the government's intertemporal budget constraint[26] and express it in the following log-linearized form:

$$\hat{b}_{t-1} = \underbrace{-\rho\beta\hat{P}_t^m + \hat{P}_{t-1}^m}_{\text{long-term debt}} + \hat{\pi}_t + (1-\beta)\,E_t\sum_{j=0}^{\infty}\beta^j\,\widehat{PS}_{t+j} - E_t\sum_{j=1}^{\infty}\beta^j\,\hat{r}_{t+j}^m, \tag{26}$$

where $\widehat{PS}_t$ denotes the primary surplus and $\hat{r}_t^m \equiv \rho\beta\hat{P}_t^m - \hat{P}_{t-1}^m - \hat{\pi}_t$ denotes the *ex post* real return on government bonds.[27,28]

In Regime F, government hiring does not generate expectations of sufficiently large future primary surpluses to stabilize debt. Consequently, debt stabilization relies heavily on debt revaluation. Equation (26) illustrates how the maturity structure of government debt alters the way in which the intertemporal budget constraint is satisfied. In particular, long-term debt shifts fiscal adjustment toward movements in bond prices and away from current inflation.

With long-term debt, the pronounced decline in long-term bond prices following a government employment shock reflects higher expected future inflation, which erodes the real value of outstanding debt (see the bottom-row panels of Figure 5). As a result, less contemporaneous inflation is required to satisfy the government's budget constraint. Put differently, the presence of long-term debt allows policymakers to choose a path in which inflation remains subdued initially but rises later. This result is consistent with prior work by Cochrane (2001), Sims (2013), Leeper and Leith (2016), and Teles and Tristani (2024), all of whom emphasize the role of long-term debt in reshaping inflation dynamics.

The contained current inflation translates into a smaller decline in real interest rates (see the middle-row panels of Figure 5), thereby dampening the increase in aggregate demand through the *IS* equation.[29] At the same time, the lower market value of debt, resulting from

[26] See the Online Appendix for the derivation of this expression.

[27] The primary surplus is defined as the sum of tax revenues less all government expenditures $\widehat{PS}_t \equiv \frac{\tau^k r^k k}{PS}\left(\hat{\tau}_t^k + \hat{r}_t^k + \hat{u}_t - \hat{k}_{t-1}\right) + \frac{\tau^c c}{PS}\left(\hat{\tau}_t^c + \hat{c}_t\right) + \frac{\tau^n wn}{PS}\left(\hat{\tau}_t^n + \hat{w}_t + \hat{n}_t\right) - \frac{wn^g}{PS}\left(\hat{w}_t + \hat{n}_t^g\right) - \frac{g}{PS}\hat{g}_t - \frac{z}{PS}\hat{z}_t$.

[28] Under short-term debt, equation (26) becomes to $\hat{b}_{t-1} = -\beta\hat{R}_t + \hat{\pi}_t + (1-\beta)\widehat{PS}_t + \beta E_t\hat{b}_t$, where $\beta\hat{R}_t$ denotes the *ex post* real return on short-term government bonds.

[29] *IS* equation in our model is $\hat{c}_t^* = \frac{1}{1+h}E_t\hat{c}_{t+1}^* + \frac{h}{1+h}\hat{c}_{t-1}^* - \frac{1-h}{1+h}(\hat{R}_t - E_t\hat{\pi}_{t+1}) - \frac{1-h}{1+h}\kappa_\tau\left(\hat{\tau}_t^c - E_t\hat{\tau}_{t+1}^c\right)$, where $\kappa_\tau \equiv \frac{\tau^c}{1+\tau^c}$.

the decline in bond prices, reduces bondholders' wealth and further dampens the increase in consumption demand.

The weaker aggregate demand response propagates to the labor market through two channels. First, contained inflation limits upward pressure on real wages via the wage Phillips curve.[30] Second, weaker demand reduces firms' incentives to expand production and capacity utilization, shifting inward the demand for private labor. As a result, private employment responds less positively—or even negatively—despite the more muted increase in real wages.

By contrast, when all debt is short-term, bond-price revaluation plays no role in absorbing fiscal expansions, since the debt matures and is repaid before inflation materializes. In this scenario, fiscal adjustment occurs solely through unexpected changes in current inflation. In the next part of this section, we demonstrate that this dependence on the debt maturity structure is almost irrelevant in Regime M.

4.2.2 Labor Market Effects under Regime M

Figure 6 reports impulse responses under Regime M with alternative government debt maturity structures. Unlike Regime F, the responses of employment and real wages display very similar patterns across debt maturities in Regime M. A comparison of Figures 5 and 6 further shows that the quantitative differences across maturities are much smaller than those observed in Regime F, although longer debt maturities slightly mitigate the adverse labor market effects of government employment shocks in Regime M.[31] In other words, while the maturity structure of government debt significantly affects fiscal transmission in Regime F, this dependence is much weaker in Regime M.

This divergence arises from the role of debt revaluation, as shown in equation (26), in fiscal financing under the two regimes. In Regime M, a Ricardian environment largely suppresses debt revaluation channels through bond prices and inflation, redirecting nearly all fiscal financing toward future reductions in government expenditures. As emphasized by Corsetti et al. (2012), government spending reversals are central to the transmission mechanism under Regime M.

Moreover, government employment shocks are contractionary across all debt maturities in Regime M, as hawkish monetary policy offsets fiscal expansions through aggressive interest rate hikes. As shown in Figure 6, an increase in government employment unequivocally crowds out private employment, with the largest decline occurring roughly two years after

[30] The wage Phillips curve: $\hat{w}_t = \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}E_t\hat{w}_{t+1} + \frac{1}{1+\beta}\hat{\pi}_t - \frac{\beta}{1+\beta}E_t\hat{\pi}_{t+1} - \frac{\kappa_w}{1+\beta}\hat{\omega}_t^w$, where $\hat{\omega}_t^w$ denotes the wage wedge, measuring deviations of the economy's average wage markup.

[31] Our finding is consistent with Leeper et al. (2017), who show that longer maturities are associated with higher fiscal multipliers in Regime M.

the shock. Real wages initially rise but quickly fall into negative territory, indicating that both private employment and real wages deteriorate over the medium to long run following the government employment shock. Total employment rises temporarily, reflecting the initial government hiring, but subsequently falls as the contraction in private employment accelerates.

Building on Finn (1998), who documents labor reallocation from the private to the government sector, our results suggest that government hiring under active monetary policy may not only induce sectoral reallocation but also generate a more-than-proportional contraction in private employment. Overall, the model's predictions under Regime M align closely with the empirical evidence from the Great Moderation (1980Q1–2008Q3).

5 Concluding Remarks

This paper examines how the labor market effects of government employment shocks have evolved across the major episodes of U.S. macroeconomic history. Treating government employment as a distinct fiscal instrument and applying max-share identification, our SVAR analysis demonstrates that private-sector labor market responses to government employment shocks differ markedly across policy environments.

To interpret these empirical patterns, we develop an extended New Keynesian DSGE model featuring alternative monetary–fiscal regimes in the spirit of Leeper (1991) and a government debt maturity structure following Woodford (2001). The model reconciles the qualitative differences in estimated labor market responses across subsamples by showing that the interaction between monetary–fiscal coordination and debt maturity structure determines whether fiscal expansions are accommodated or offset.

Three findings stand out. First, when the fiscal authority is active and spending is financed with short-term debt, government hiring crowds in private employment and raises real wages, matching evidence of the pre-Volcker era (1960Q1–1979Q3). Second, when government financing shifts to long-term debt, the stimulus effect is substantially dampened, even under accommodative monetary policy. In this scenario—representative of the post-GFC era (2008Q4–2025Q1)—debt maturity dictates how fiscal expansions transmit to household wealth and aggregate demand through bond prices and inflation. Third, when the monetary authority actively targets inflation, government employment shocks become contractionary, regardless of the debt maturity structure, consistent with the evidence from the Great Moderation (1980Q1–2008Q3).

Our findings carry broader policy implications. The labor market impact of fiscal policy is fundamentally shaped by the institutional features of monetary policy and public debt

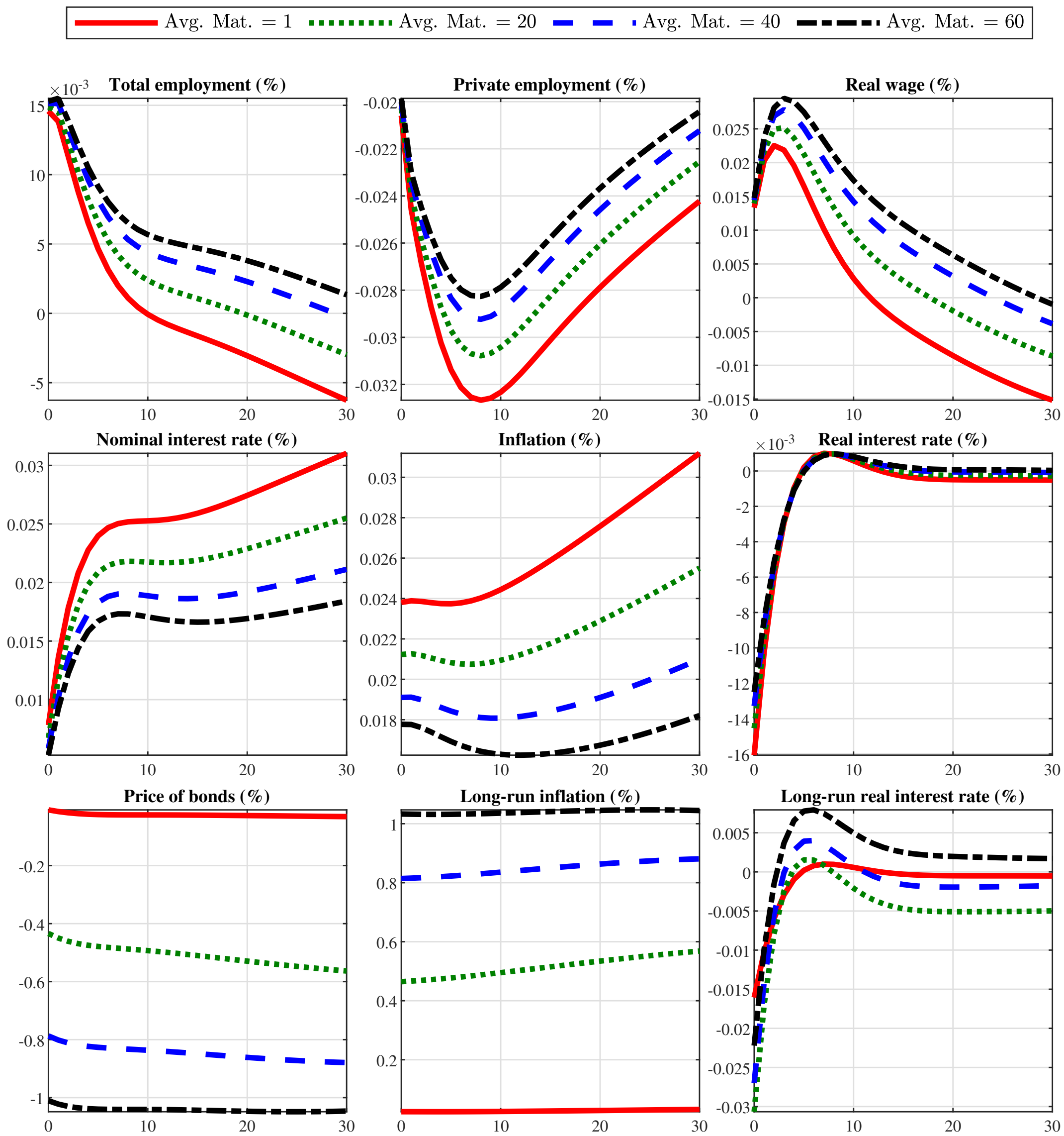

Figure 6: Simulated Impulse Responses to Government Employment Shocks in Regime M

Notes: We report simulated responses over 30 quarters to a 1% government employment shock in Regime M, where the Taylor rule inflation response ϕ_π is set to 2.15. The average maturity of government debt is 1 (solid red line), 20 (dotted green line), 40 (dashed blue line), and 60 (dash-dotted black line) quarters.

management, factors that must be prioritized when evaluating the expansionary or contractionary nature of public hiring.

Two promising directions for future research are to introduce heterogeneous households, allowing for explicit occupational choice between the private and public sectors, and to incorporate search-and-matching frictions in both sectors, thereby endogenizing unemployment dynamics. These extensions would enrich the model's labor-market structure and provide deeper insight into the mechanisms governing the crowding-in and crowding-out effects of government employment shocks.

References

Afonso, António and Pedro Gomes, "Interactions between private and public sector wages," *Journal of Macroeconomics*, 2014, *39*, 97–112.

Algan, Yann, Pierre Cahuc, and André Zylberberg, "Public employment and labour market performance," *Economic Policy*, 2002, *17* (34), 7–66.

Antolin-Diaz, Juan and Paolo Surico, "The long-run effects of government spending," *American Economic Review*, 2025, *115* (7), 2376–2413.

Ardagna, Silvia, "Fiscal policy in unionized labor markets," *Journal of Economic Dynamics and Control*, 2007, *31* (5), 1498–1534.

Atems, Bebonchu, "The effects of government spending shocks: evidence from US states," *Regional Science and Urban Economics*, 2019, *74*, 65–80.

Becker, Sascha O, Stephan Heblich, and Daniel M Sturm, "The impact of public employment: evidence from Bonn," *Journal of Urban Economics*, 2021, *122*, 103291.

Behar, Alberto and Junghwan Mok, "Does public-sector employment fully crowd out private-sector employment?," *Review of Development Economics*, 2019, *23* (4), 1891–1925.

Bermperoglou, Dimitrios, Evi Pappa, and Eugenia Vella, "The government wage bill and private activity," *Journal of Economic Dynamics and Control*, 2017, *79*, 21–47.

Bernanke, Ben S and Ilian Mihov, "Measuring monetary policy," *The Quarterly Journal of Economics*, 1998, *113* (3), 869–902.

Blanchard, Olivier and Roberto Perotti, "An empirical characterization of the dynamic effects of changes in government spending and taxes on output," *The Quarterly Journal of Economics*, 2002, *117* (4), 1329–1368.

Boehm, Christoph E, "Government consumption and investment: does the composition of purchases affect the multiplier?," *Journal of Monetary Economics*, 2020, *115*, 80–93.

Brückner, Markus and Evi Pappa, "Fiscal expansions, unemployment, and labor force participation: theory and evidence," *International Economic Review*, 2012, *53* (4), 1205–1228.

Caponi, Vincenzo, "Public employment policies and regional unemployment differences," *Regional Science and Urban Economics*, 2017, *63*, 1–12.

Cascaldi-Garcia, Danilo, "Pandemic priors," International Finance Discussion Paper 1352 2022.

Cavallo, Michele, "Government employment expenditure and the effects of fiscal policy shocks," 2005.

Christiano, Lawrence J, Martin Eichenbaum, and Charles L Evans, "Nominal rigidities and the dynamic effects of a shock to monetary policy," *Journal of Political Economy*, 2005, *113* (1), 1–45.

Clarida, Richard, Jordi Gali, and Mark Gertler, "Monetary policy rules and macroeconomic stability: evidence and some theory," *The Quarterly Journal of Economics*, 2000, *115* (1), 147–180.

Cochrane, John H, "Long-term debt and optimal policy in the fiscal theory of the price level," *Econometrica*, 2001, *69* (1), 69–116.

Corsetti, Giancarlo, André Meier, and Gernot J Müller, "Fiscal stimulus with spending reversals," *Review of Economics and Statistics*, 2012, *94* (4), 878–895.

Demekas, Dimitri G and Zenon G Kontolemis, "Government employment and wages and labour market performance," *Oxford Bulletin of Economics and Statistics*, 2000, *62* (3), 391–415.

Dixit, Avinash K and Joseph E Stiglitz, "Monopolistic competition and optimum product diversity," *American Economic Review*, 1977, *67* (3), 297–308.

Edelberg, Wendy, Martin Eichenbaum, and Jonas DM Fisher, "Understanding the effects of a shock to government purchases," *Review of Economic Dynamics*, 1999, *2* (1), 166–206.

Faggio, Giulia, Teresa Schlüter, and Philipp vom Berge, "Interaction of public and private employment: evidence from a German government move," *Regional Science and Urban Economics*, 2025, p. 104084.

Fatás, Antonio and Ilian Mihov, "The effects of fiscal policy on consumption and employment: theory and evidence," 2001. Working paper, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=267281.

Finn, Mary G, "Cyclical effects of government's employment and goods purchases," *International Economic Review*, 1998, *39* (3), 635–657.

Fiorito, Riccardo and Tryphon Kollintzas, "Public goods, merit goods, and the relation between private and government consumption," *European Economic Review*, 2004, *48* (6), 1367–1398.

Forni, Lorenzo, Libero Monteforte, and Luca Sessa, "The general equilibrium effects of fiscal policy: estimates for the euro area," *Journal of Public Economics*, 2009, *93* (3), 559–585.

Francis, Neville, Michael T Owyang, Jennifer E Roush, and Riccardo DiCecio, "A flexible finite-horizon alternative to long-run restrictions with an application to technology shocks," *Review of Economics and Statistics*, 2014, *96* (4), 638–647.

Galí, Jordi and Luca Gambetti, "On the sources of the great moderation," *American Economic Journal: Macroeconomics*, 2009, *1* (1), 26–57.

_ , Frank Smets, and Rafael Wouters, "Unemployment in an estimated New Keynesian model," *NBER Macroeconomics Annual*, 2012, *26* (1), 329–360.

_ , J David López-Salido, and Javier Vallés, "Understanding the effects of government spending on consumption," *Journal of the European Economic Association*, 2007, *5* (1), 227–270.

_ , J David López-Salido, and Javier Vallés, "Technology shocks and monetary policy: assessing the Fed's performance," *Journal of Monetary Economics*, 2003, *50* (4), 723–743.

Ghomi, Morteza, Jochen Mankart, Rigas Oikonomou, and Romanos Priftis, "Debt maturity and government spending multipliers," Working Paper, Banco de España 2025.

Gomes, Pedro M, "Fiscal policy and the labour market: the effects of public sector employment and wages," Technical Report, IZA Discussion Paper 2010.

Goodfriend, Marvin and Robert G King, "The incredible Volcker disinflation," *Journal of Monetary Economics*, 2005, *52* (5), 981–1015.

Ireland, Peter N, "A small, structural, quarterly model for monetary policy evaluation," in "Carnegie-Rochester Conference Series on Public Policy," Vol. 47 1997, pp. 83–108.

Jia, Bijie, Hyeongwoo Kim, and Shuwei Zhang, "Assessing the role of sentiment in the propagation of fiscal stimulus," *The BE Journal of Macroeconomics*, 2022, *22* (2), 699–728.

Judd, John P and Glenn D Rudebusch, "Taylor's rule and the Fed: 1970–1997," in "Handbook of Monetary Policy" 2020, pp. 961–980.

Kim, Hyeongwoo, Peng Shao, and Shuwei Zhang, "Policy coordination and the effectiveness of fiscal stimulus," *Journal of Macroeconomics*, 2023, *75*, 103489.

Kim, Jinill, "Constructing and estimating a realistic optimizing model of monetary policy," *Journal of Monetary Economics*, 2000, *45* (2), 329–359.

Klose, Jens, "Determining structural breaks in central bank reaction functions of the financial crisis," *The Journal of Economic Asymmetries*, 2014, *11*, 78–90.

Kuo, Chun-Hung and Hiroaki Miyamoto, "Fiscal stimulus and unemployment dynamics," *The BE Journal of Macroeconomics*, 2019, *19* (2), 20160211.

Kurmann, André and Eric Sims, "Revisions in utilization-adjusted TFP and robust identification of news shocks," *Review of Economics and Statistics*, 2021, *103* (2), 216–235.

Leeper, Eric M, "Equilibria under active and passive monetary and fiscal policies," *Journal of Monetary Economics*, 1991, *27* (1), 129–147.

_ **and Campbell Leith**, "Understanding inflation as a joint monetary–fiscal phenomenon," in "Handbook of Macroeconomics," Vol. 2 2016, pp. 2305–2415.

_ **, Nora Traum, and Todd B Walker**, "Clearing up the fiscal multiplier morass," *American Economic Review*, 2017, *107* (8), 2409–2454.

Lenza, Michele and Giorgio E Primiceri, "How to estimate a vector autoregression after March 2020," *Journal of Applied Econometrics*, 2022, *37* (4), 688–699.

Linnemann, Ludger, "Macroeconomic effects of shocks to public employment," *Journal of Macroeconomics*, 2009, *31* (2), 252–267.

Malley, Jim and Thomas Moutos, "Government employment and unemployment: with one hand giveth, the other taketh," Technical Report, Department of Economics, University of Glasgow 1998.

Mao, Ruoyun and Shu-Chun Susan Yang, "Government spending effects in a policy constrained environment," IMF Working Paper, International Monetary Fund 2020.

Michaillat, Pascal, "A theory of countercyclical government multiplier," *American Economic Journal: Macroeconomics*, 2014, *6* (1), 190–217.

Monacelli, Tommaso, Roberto Perotti, and Antonella Trigari, "Unemployment fiscal multipliers," *Journal of Monetary Economics*, 2010, *57* (5), 531–553.

Pappa, Evi, "The effects of fiscal shocks on employment and the real wage," *International Economic Review*, 2009, *50* (1), 217–244.

Perotti, Roberto, "Estimating the effects of fiscal policy in OECD countries," Technical Report, CEPR Discussion Paper No. DP4842 2005.

Ramey, Valerie A., "Government spending and private activity," NBER Working Papers 17787, National Bureau of Economic Research, Inc. Jan 2012.

Ravn, Morten O and Saverio Simonelli, "Labor market dynamics and the business cycle: structural evidence for the United States," *The Scandinavian Journal of Economics*, 2007, *109* (4), 743–777.

Ravn, Morten, Stephanie Schmitt-Grohé, and Martin Uribe, "Deep habits," *The Review of Economic Studies*, 2006, *73* (1), 195–218.

Rotemberg, Julio J, "Sticky prices in the United States," *Journal of Political Economy*, 1982, *90* (6), 1187–1211.

Sims, Christopher A, "Solving linear rational expectations models," *Computational Economics*, 2002, *20* (1–2), 1.

_ , "Paper money," *American Economic Review*, 2013, *103* (2), 563–584.

Smets, Frank and Rafael Wouters, "Shocks and frictions in US business cycles: a Bayesian DSGE approach," *American Economic Review*, 2007, *97* (3), 586–606.

Stock, James H and Mark W Watson, "Has the business cycle changed and why?," *NBER Macroeconomics Annual*, 2002, *17*, 159–218.

Taylor, John B, "A historical analysis of monetary policy rules," in "Monetary Policy Rules" 1999, pp. 319–348.

Teles, Pedro and Oreste Tristani, "The monetary financing of a large fiscal shock," *Journal of Monetary Economics*, 2024, *147*, 103630.

Woodford, Michael, "Fiscal requirements for price stability," *Journal of Money, Credit and Banking*, 2001, *33*, 669–728.

Yang, Yang, Ren Zhang, and Shuwei Zhang, "Deciphering dollar exchange rates and interest parity," 2025. Working paper, available at https://ssrn.com/abstract=5829609.

Yuan, Mingwei and Wenli Li, "Dynamic employment and hours effects of government spending shocks," *Journal of Economic Dynamics and Control*, 2000, *24* (8), 1233–1263.

Online Appendix to "Government Employment Shocks, Policy Coordination, and Debt Structure"

Hyeongwoo Kim* Ren Zhang† Shuwei Zhang‡

This version: April 17, 2026

Contents

*Auburn University; gmmkim@gmail.com.

†Texas State University; r_z79@txstate.edu.

‡Towson University; shuweizhang@towson.edu.

1 Data Description

Variable	Description	Data source
Government employment	Federal general government total employees + armed forces	Valerie A. Ramey's website
Real GDP per capita	Gross domestic product	FRED
Private employment	Nonprofit institutions + Private non-farm sector	Valerie A. Ramey's website
Unemployment rate	Unemployment rate	FRED
Real wages	Compensation of employees: Wages and salaries (Private industries)	FRED
Central bank policy rate	Federal funds effective rate	FRED
Monetary base	Monetary base	FRED
Gov't debt	Gross federal debt-to-GDP ratio	Market Value of U.S. Government Debt
Taxes	Average tax rate	Ramey and Zubairy (2018)

2 VAR Estimation Accounting for the Pandemic Period

The onset of COVID-19 generated a small number of extreme observations that lie far outside historical experience. In conventional Bayesian VARs, such outliers can distort the estimation of reduced-form persistence and cross-variable dynamics, potentially contaminating structural inference. To address this concern, we follow Cascaldi-Garcia (2022) and augment our Bayesian SVAR with pandemic-specific time dummies. Starting from our baseline reduced-form specification,

$$y_t = \sum_{i=1}^{K} B_i y_{t-i} + u_t$$

we estimate the augmented model

$$y_t = \sum_{i=1}^{K} B_i y_{t-i} + \sum_{s=1}^{h} \mathbf{1}_{t=t_s} d_s + u_t$$

where y_t is the 5×1 vector of endogenous variables defined in the main draft, $\mathbf{1}_{t=t_s}$ is an indicator function equal to one in pandemic quarter t_s and zero otherwise, and d_s is a 5×1 vector capturing intercept shifts during that quarter. In our implementation, $h = 2$ and $t_s \in \{2020Q1, 2020Q2\}$, corresponding to the collapse and initial rebound of economic activity. These dummies allow the model to accommodate temporary deviations from historical regularities without forcing the autoregressive coefficients $\{B_i\}_{i=1}^{K}$ to absorb pandemic-specific dynamics.

Following Cascaldi-Garcia (2022), we impose shrinkage on the dummy coefficients through

$$d_s \mid \Sigma \sim \mathcal{N}\left(0,\ \Sigma/\phi^2\right),$$

where $\phi > 0$ governs the degree of shrinkage. The parameter ϕ determines how much information is extracted from the pandemic observations. As $\phi \to 0$, the prior becomes diffuse and the time dummies absorb most of the abnormal variation, effectively down-weighting the pandemic quarters in the estimation of $\{B_i\}$ and Σ. As $\phi \to \infty$, the dummies shrink toward zero and the model converges to the standard Minnesota-prior VAR, treating the pandemic observations as ordinary data points. Hence, the specification nests the boundary cases of fully downweighting versus fully incorporating pandemic information. We select ϕ in a data-driven manner by maximizing the marginal likelihood over a discrete grid, as in Cascaldi-Garcia (2022). This balances model fit against overfitting of extreme realizations. The overall tightness parameter is set to 0.2, and the prior on deterministic terms is diffuse.

3 Robustness of VAR

3.1 Controlling for Taxes

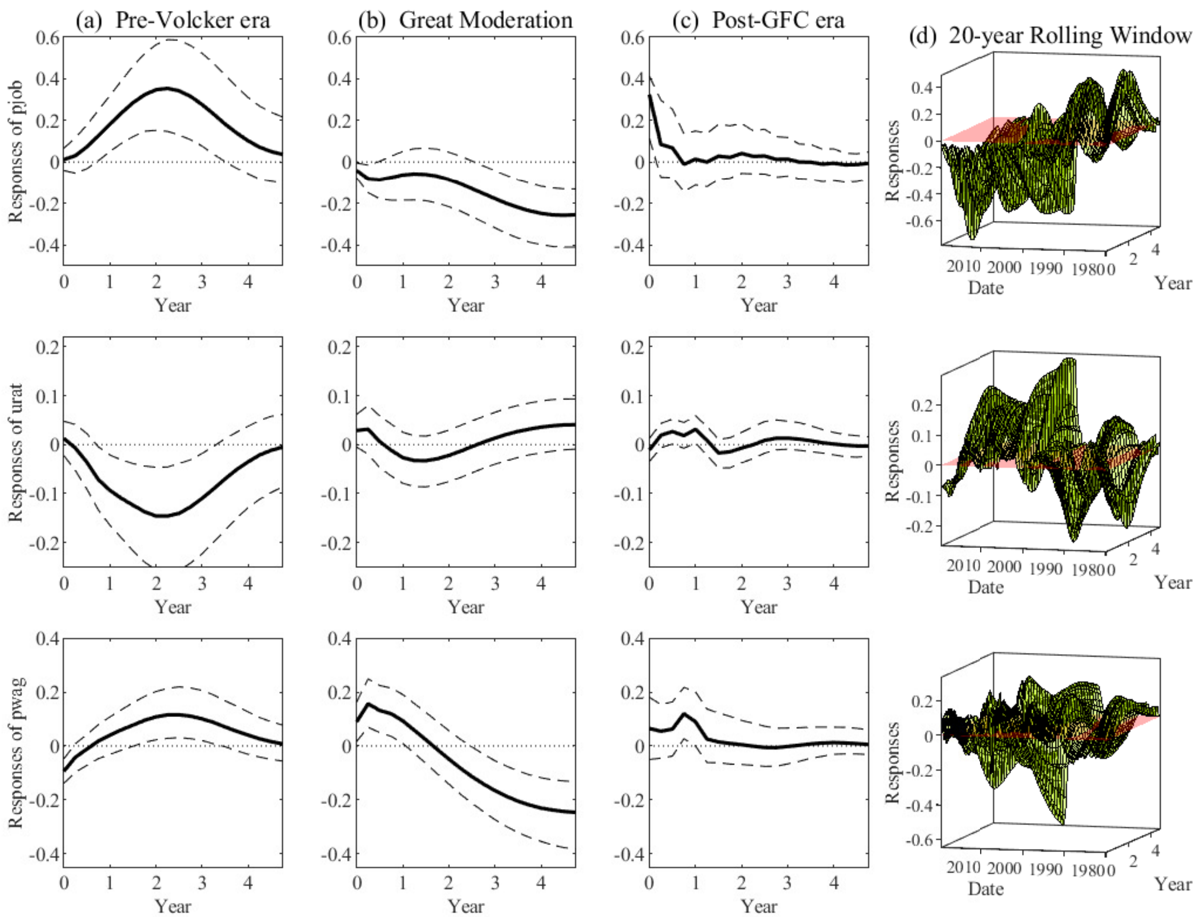

Figure 1: IRFs with Taxes Included as an Additional Control Variable

Notes: We present the IRFs from $\mathbf{y}_t = [n_t^g, gdp_t, lab_t, int_t, mon_t, tax_t]'$ to a positive government employment shock identified using the max-share approach. Panels (a)–(c) report the medium estimates (solid line) of a labor market variable along with its 68% credible intervals (dashed lines), constructed from draws from the posterior distribution. Panels (d) report an array of IRFs to the fiscal shock with a 20-year fixed-size rolling window scheme.

3.2 Controlling for Government Debt

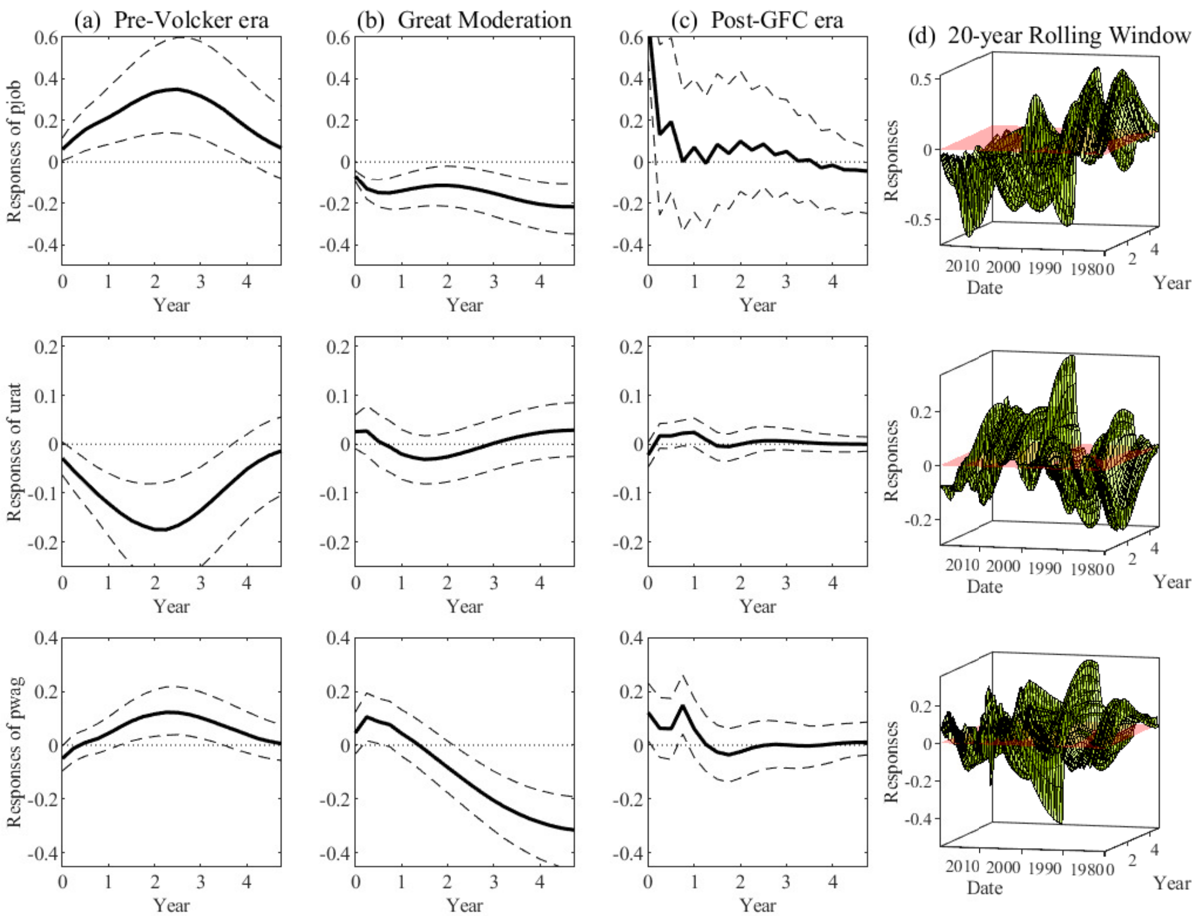

Figure 2: IRFs with Gov't Debt Included as an Additional Control Variable

Notes: We present the IRFs from $\mathbf{y}_t = [n_t^g, gdp_t, lab_t, int_t, mon_t, debt_t]'$ to a positive government employment shock identified using the max-share approach. Panels (a)–(c) report the medium estimates (solid line) of a labor market variable along with its 68% credible intervals (dashed lines), constructed from draws from the posterior distribution. Panels (d) report an array of IRFs to the fiscal shock with a 20-year fixed-size rolling window scheme.

3.3 Recursive (Cholesky) Identification

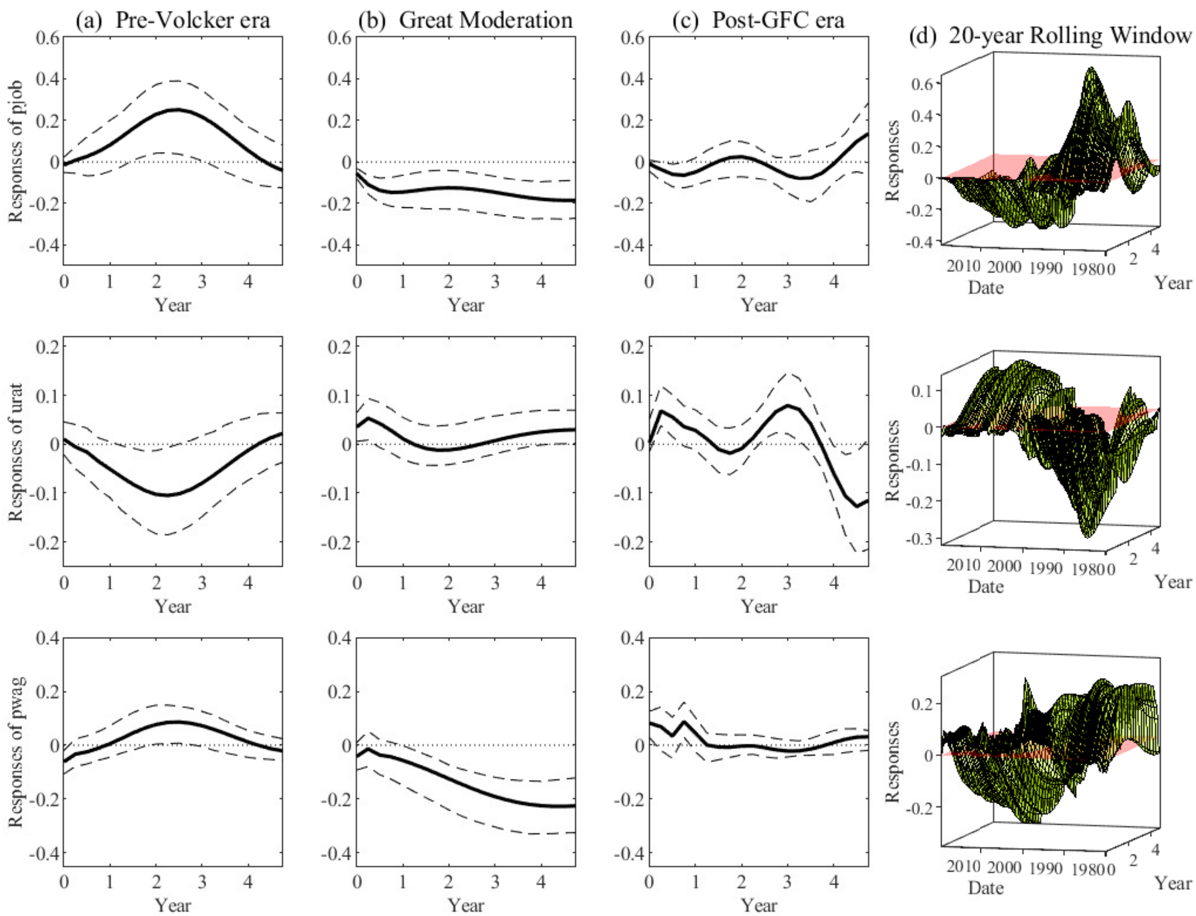

Figure 3: IRFs with Recursive Identification

Notes: We present the IRFs from $\mathbf{y}_t = [n_t^g, gdp_t, lab_t, int_t, mon_t]'$ to a positive government employment shock using the recursive identification method. Panels (a)–(c) report the point estimates (solid line) of a labor market variable along with its 68% credible intervals (dashed lines) computed by nonparametric bootstrap based on 1000 replications. Panels (d) report an array of IRFs to the fiscal shock with a 20-year fixed-size rolling window scheme.

3.4 Alternative Rolling Windows

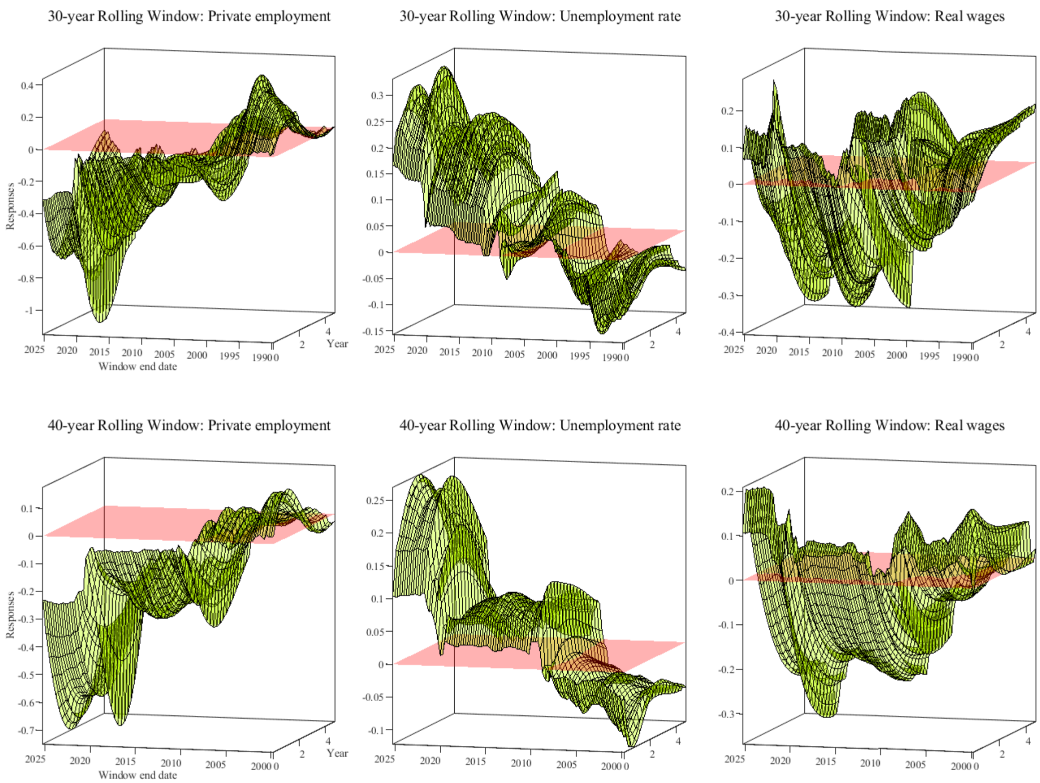

Figure 4: 30- and 40-Year Rolling Windows

Notes: We present the IRFs from $\mathbf{y}_t = [n_t^g, gdp_t, lab_t, int_t, mon_t]'$ to a positive government employment shock identified using the max-share approach, estimated over 30- and 40-year rolling windows.

4 Derivation of the Log-Linearized Model

4.1 The Equilibrium System

4.1.1 Households We define the real market value of government debt as $b_t = \frac{P_t^m B_t^m}{P_t}$ and λ_t as the Lagrange multiplier associated with the households' budget constraint.

• FOC for consumption:

$$\lambda_t(1+\tau_t^c) = \frac{1}{c_t^* - hc_{t-1}^*} \quad (1)$$

• c^* definition:

$$c_t^* = c_t + \alpha_g s_t^g \quad (2)$$
$$s_t^g = \left(n_t^g\right)^{1-\gamma_g} g_t^{\gamma_g} \quad (3)$$

• Euler equation for one-period private bonds:

$$R_t^{-1} = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t}\frac{1}{\pi_{t+1}}\right] \quad (4)$$

• Price relation between long and short bonds:

$$P_t^m = E_t \left(\frac{1+\rho P_{t+1}^m}{R_t}\right) \quad (5)$$

• FOC for capacity utilization:

$$a'(u_t) = \left(1-\tau_t^k\right) r_t^k \quad (6)$$

• FOC for capital:

$$q_t = \beta E_t \left\{\frac{\lambda_{t+1}}{\lambda_t}\left[\left(1-\tau_{t+1}^k\right) r_{t+1}^k u_{t+1} - a(u_{t+1}) + q_{t+1}(1-\delta)\right]\right\} \quad (7)$$

where the (marginal) Tobin's Q is defined as $q_t = \frac{Q_t}{\lambda_t}$.

• FOC for investment:

$$1 = q_t \left[1 - S\left(\frac{i_t}{i_{t-1}}\right) - S'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\right] + \beta E_t q_{t+1} \frac{\lambda_{t+1}}{\lambda_t} S'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2 \quad (8)$$

- Law of motion for capital:

$$k_t = (1-\delta)\,k_{t-1} + \left[1 - S\left(\frac{i_t}{i_{t-1}}\right)\right] i_t \tag{9}$$

4.1.2 Wage Determination

FOC for the optimal real wage:

$$\phi_w \pi_t^w \left(\pi_t^w - \bar{\pi}^w\right) = \left(1-\tau_t^n\right)\left(n_t - \theta_w n_t^p\right) + \theta_w \frac{n_t^p n_t^\eta}{\lambda_t w_t} \quad + \phi_w \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \frac{\left(\pi_{t+1}^w\right)^2}{\pi_{t+1}} \left(\pi_{t+1}^w - \bar{\pi}^w\right)\right] \tag{10}$$

where

$$n_t = n_t^p + \alpha_{n^g} n_t^g \tag{11}$$

$$\pi_t^w = \frac{w_t}{w_{t-1}} \pi_t \tag{12}$$

4.1.3 Intermediate Goods Firms

Production function:

$$y_t = \left(u_t k_{t-1}\right)^\alpha \left(n_t^p\right)^{1-\alpha} \tag{13}$$

- Capital-labor ratio:

$$\frac{u_t k_{t-1}}{n_t^p} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t^k} \tag{14}$$

- Real marginal cost:

$$mc_t = (1-\alpha)^{\alpha-1} (\alpha)^{-\alpha} w_t^{1-\alpha} \left(r_t^k\right)^\alpha \tag{15}$$

- Intermediate firm's FOC for price:

$$\phi^p \left(\pi_t - \bar{\pi}\right) \pi_t = \left(1-\theta^p\right) + \theta^p mc_t + \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \phi^p \left(\pi_{t+1} - \bar{\pi}\right) \pi_{t+1} \frac{y_{t+1}}{y_t}\right] \tag{16}$$

4.1.4 Fiscal and Monetary Policy

Government budget constraint:

$$b_t + \tau_t^n w_t n_t + \tau_t^k r_t^k u_t k_{t-1} + \tau_t^c c_t = \frac{\left(1 + \rho P_t^m\right)}{P_{t-1}^m} \frac{b_{t-1}}{\pi_t} + w_t n_t^g + g_t + z_t \tag{17}$$

• Monetary policy rule:

$$R_t = (R_{t-1})^{\psi^r} \left[\bar{R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi^\pi} \left(\frac{y_t}{\bar{y}} \right)^{\phi^y} \right]^{1-\psi^r} \tag{18}$$

• Aggregate resource constraint:

$$\begin{aligned} y_t &= c_t + i_t + g_t + adj_t \\ adj_t &= \frac{\phi^w}{2} \left(\pi_t^w - \bar{\pi}^w \right)^2 w_t + a\left(u_t\right) k_{t-1} + \frac{\phi^p}{2} \left(\pi_t - \bar{\pi} \right)^2 y_t \end{aligned} \tag{19}$$

4.2 Steady state

By assumption, in the steady state, $\pi^w = \pi = 1$. Given the average maturity of government debt, denoted AD in the main draft, the parameter ρ is

$$\rho = \left(1 - \frac{1}{AD}\right)\frac{\bar{\pi}}{\beta}$$

Given these values and the steady-state fiscal policy calibration, the variables are defined by the following system:

$$\begin{aligned}
P^m &= \frac{\beta}{1-\rho\beta} \\
r^k &= \frac{\frac{1}{\beta} - 1 + \delta}{1-\tau^k} \\
a'(1) &= r^k\left(1-\tau^k\right) \\
mc &= \frac{\theta^p - 1}{\theta^p} \\
w &= \left[(1-\alpha)^{1-\alpha}(\alpha)^{\alpha} mc \left(r^k\right)^{-\alpha}\right]^{\frac{1}{1-\alpha}} \\
\frac{k}{n^p} &= \frac{\alpha}{1-\alpha}\frac{w}{r^k} \\
\frac{i}{n^p} &= \frac{\delta k}{n^p} \\
\frac{y}{n^p} &= (\frac{k}{n^p})^{\alpha} \\
\frac{c}{n^p} &= \frac{y}{n^p}(1-\frac{g}{y}) - \frac{i}{n^p} \\
\frac{s^g}{n^p} &= \left(\frac{n^g}{n^p}\right)^{1-\gamma_g}(\frac{g}{y}\frac{y}{n^p})^{\gamma_g} \\
\frac{c^*}{n^p} &= \frac{c}{n^p} + \alpha_g\frac{s^g}{n^p} \\
\frac{n}{n^p} &= 1 + \alpha_{n^g}\frac{n^g}{n^p} \\
\frac{z}{n^p} &= \left(1 - \frac{1+\rho P^m}{\pi P^m}\right)\frac{b}{y}\frac{y}{n^p} + \tau^n w\frac{n}{n^p} + \tau^k r^k\frac{k}{n^p} + \tau^c\frac{c}{n^p} - w\frac{n^g}{n^p} - \frac{g}{y}\frac{y}{n^p}
\end{aligned}$$

Given n^p, all level variables can be defined from the steady state ratios given above.

4.3 The Log-Linearized System

We define the log deviations of a variable from its steady state as $\hat{x}_t = \ln x_t - \ln x$. The equilibrium system in the log-linearized form consists of the following equations:

- FOC for consumption:

$$\hat{\lambda}_t + \frac{\tau^c}{1+\tau^c}\hat{\tau}_t^c + \frac{1}{1-h}\hat{c}_t^* \quad = \quad \frac{h}{1-h}\hat{c}_{t-1}^* \tag{20}$$

- Consumption in utility:

$$\hat{c}_t^* - \frac{c}{c+\alpha_g s^g}\hat{c}_t - \frac{\alpha_g s^g}{c+\alpha_g s^g}\hat{s}_t^g \quad = \quad 0 \tag{21}$$

$$\hat{s}_t^g - \gamma_g \hat{g}_t - (1-\gamma_g)\hat{n}_t^g \quad = \quad 0 \tag{22}$$

- Euler equation:

$$E_t\hat{\lambda}_{t+1} - E_t\hat{\pi}_{t+1} - \hat{\lambda}_t + \hat{R}_t \quad = \quad 0 \tag{23}$$

- Maturity structure of debt:

$$\frac{\rho}{R}E_t\hat{P}_{m,t+1} - \hat{R}_t - \hat{P}_{m,t} \quad = \quad 0 \tag{24}$$

- FOC for capacity utilization:

$$\frac{\zeta_2}{1-\zeta_2}\hat{u}_t - \hat{r}_t^k + \frac{\tau^k}{1-\tau^k}\hat{\tau}_t^k \quad = \quad 0 \tag{25}$$

- FOC for capital:

$$E_t\hat{\lambda}_{t+1} - \hat{\lambda}_t + \beta\left(1-\tau^k\right)r^k E_t\hat{r}_{t+1}^k - \beta\tau^k r^k E_t\hat{\tau}_{t+1}^k + \beta\left(1-\delta\right)E_t\hat{q}_{t+1} - \hat{q}_t = 0 \tag{26}$$

- FOC for investment:

$$\beta E_t\hat{i}_{t+1} - (1+\beta)\,\hat{i}_t + \frac{1}{\kappa}\hat{q}_t \quad = \quad -\hat{i}_{t-1} \tag{27}$$

- Law of motion for capital:

$$\hat{k}_t - \delta\hat{i}_t \quad = \quad (1-\delta)\,\hat{k}_{t-1} \tag{28}$$

- FOC for the optimal real wage:

$$\frac{\phi_w \pi^2}{1-\tau^n}\left(\hat{\pi}_t^w - \beta E_t \hat{\pi}_{t+1}^w\right) + \left(\theta_w n^p - n\right)\left(\hat{\lambda}_t + \hat{w}_t\right)$$
$$-\frac{\tau^n}{1-\tau^n}\left(\theta_w n^p - n\right)\hat{\tau}_t^n + n\hat{n}_t^p - \left[\eta\theta_w n^p + (1-\eta)n\right]\hat{n}_t = 0 \tag{29}$$
$$n\hat{n}_t - n^p\hat{n}_t^p - \alpha_{n^g} n^g \hat{n}_t^g = 0 \tag{30}$$
$$\hat{w}_t - \hat{\pi}_{w,t} - \hat{\pi}_t = \hat{w}_{t-1} \tag{31}$$

- Production function:

$$\hat{y}_t - (1-\alpha)\,\hat{n}_t^p - \alpha\hat{u}_t = \alpha\hat{k}_{t-1} \tag{32}$$

- Capital-labor ration:

$$\hat{w}_t - \hat{r}_t^k - \hat{u}_t + \hat{n}_t^p = \hat{k}_{t-1} \tag{33}$$

- Real marginal cost:

$$\hat{mc}_t - (1-\alpha)\,\hat{w}_t - \alpha\hat{r}_t^k \;\;=\;\; 0 \tag{34}$$

- Intermediate firm's FOC for price:

$$\phi_p \pi^2\left(\hat{\pi}_t - \beta E_t\hat{\pi}_{t+1}\right) - \left(\theta_p - 1\right)\hat{mc}_t \;\;= 0 \tag{35}$$

- Government budget constraint:

$$b\hat{b}_t + \tau^k r^k k\left(\hat{\tau}_t^k + \hat{r}_t^k + \hat{u}_t - \hat{k}_{t-1}\right) + \tau^c c\left(\hat{\tau}_t^c + \hat{c}_t\right) + \tau^n w n\left(\hat{\tau}_t^n + \hat{n}_t\right) + \left(\tau^n n - n^g\right) w\hat{w}_t$$
$$-\tfrac{(1+\rho P^m)b}{\pi P^m}\left(\hat{b}_{t-1} - \hat{P}_{t-1}^m - \hat{\pi}_t\right) - \rho\tfrac{b}{\pi}\hat{P}_t^m - w n^g \hat{n}_t^g - g\hat{g}_t - z\hat{z}_t = 0 \tag{36}$$

- Taylor Rule

$$\hat{R}_t - (1-\psi_r)\left(\phi_\pi\hat{\pi}_t + \phi_y\hat{y}_t\right) \;\;=\;\; \psi_r\hat{R}_{t-1} \tag{37}$$

- ARC

$$y\hat{y}_t - c\hat{c}_t - i\hat{i}_t - g\hat{g}_t - \left(1-\tau^k\right) r^k k\hat{u}_t \;\;=\;\; 0 \tag{38}$$

- Impulse responses in Section 4.2 of the main draft plot results for the long run real interest rate and inflation rate. We derive these variables here. Substituting the consumption Euler equation (23) in the term structure equation (18) in the main draft, we obtain

$$\hat{P}_t^m = \sum_{j=0}^{\infty} (\rho\beta)^j E_t \left(\hat{\lambda}_{t+j+1} - \hat{\lambda}_{t+j} - \hat{\pi}_{t+j+1}\right) \tag{39}$$

The long-run real interest rate is

$$\hat{r}_t^L = -\sum_{j=0}^{\infty} (\rho\beta)^j E_t \left(\hat{\lambda}_{t+j+1} - \hat{\lambda}_{t+j}\right) \tag{40}$$

Using equations (39) and (40), we have

$$\begin{aligned} \hat{r}_t^L &= -\hat{P}_t^m - \sum_{j=0}^{\infty} (\rho\beta)^j E_t \hat{\pi}_{t+j+1} \\ &= -\hat{P}_t^m - E_t \hat{\pi}_{t+1} - (\rho\beta) \sum_{j=0}^{\infty} (\rho\beta)^j E_t \hat{\pi}_{t+j+2} \end{aligned} \tag{41}$$

Then the long-run expected inflation rate is defined as

$$\hat{\pi}_t^L = \sum_{j=0}^{\infty} (\rho\beta)^j E_t \hat{\pi}_{t+j+1} = -\hat{r}_t^L - \hat{P}_t^m$$

Equation (40) one period forward and taking expectations give

$$E_t \hat{r}_{t+1}^L = -E_t \hat{P}_{t+1}^m - \sum_{j=0}^{\infty} (\rho\beta)^j E_t \hat{\pi}_{t+j+2} \tag{42}$$

Combining equations (41) and (42), we can rewrite the long-run real interest rate recursively:

$$\hat{r}_t^L = -\hat{P}_t^m - E_t \hat{\pi}_{t+1} + \rho\beta \left(E_t \hat{r}_{t+1}^L + E_t \hat{P}_{t+1}^m\right)$$

4.4 Derivation of the Log-Linearized Intertemporal Government Budget Constraint

The primary surplus, $\widehat{PS}_t$, is defined as

$$\widehat{PS}_t \equiv \frac{\tau^k r^k k}{PS}\left(\hat{\tau}_t^k + \hat{r}_t^k + \hat{u}_t - \hat{k}_{t-1}\right) + \frac{\tau^c c}{PS}\left(\hat{\tau}_t^c + \hat{c}_t\right) + \frac{\tau^n w n}{PS}\left(\hat{\tau}_t^n + \hat{w}_t + \hat{n}_t\right) - \frac{wn^g}{PS}\left(\hat{w}_t + \hat{n}_t^g\right) - \frac{g}{PS}\hat{g}_t - \frac{z}{PS}\hat{z}_t.$$

All the non-debt fiscal terms in equation (36) can be collected as $PS\,\widehat{PS}_t$. Then equation (36) becomes

$$\frac{(1+\rho P^m)b}{\pi P^m}\left(\hat{b}_{t-1} - \hat{P}_{t-1}^m - \hat{\pi}_t\right) = b\,\hat{b}_t - \rho\frac{b}{\pi}\hat{P}_t^m + PS\,\widehat{PS}_t.$$

In the steady state, $\frac{(1+\rho P^m)b}{\pi P^m} = \frac{b}{\pi\beta}$. So the above equation can be written in the recursive form:

$$\hat{b}_{t-1} = -\rho\beta\,\hat{P}_t^m + \hat{P}_{t-1}^m + \hat{\pi}_t + (1-\beta)\,\widehat{PS}_t + \beta E_t\hat{b}_t. \tag{43}$$

Define the *ex post* real return on government bonds as

$$\hat{r}_t^m \equiv \rho\beta\,\hat{P}_t^m - \hat{P}_{t-1}^m - \hat{\pi}_t.$$

Substituting this into (43) yields

$$\hat{b}_{t-1} = (1-\beta)\,\widehat{PS}_t - \hat{r}_t^m + \beta E_t\hat{b}_t. \tag{44}$$

Iterate equation (44) forward

$$\hat{b}_t = (1-\beta)\,\widehat{PS}_{t+1} - \hat{r}_{t+1}^m + \beta E_t\hat{b}_{t+1}.$$

Substituting this into (44)

$$\begin{aligned}\hat{b}_{t-1} &= (1-\beta)\,\widehat{PS}_t - \hat{r}_t^m + \beta E_t\left[(1-\beta)\,\widehat{PS}_{t+1} - \hat{r}_{t+1}^m + \beta\hat{b}_{t+1}\right] \\ &= (1-\beta)\,\widehat{PS}_t + \beta(1-\beta)E_t\widehat{PS}_{t+1} - \hat{r}_t^m - \beta E_t\hat{r}_{t+1}^m + \beta^2 E_t\hat{b}_{t+1}.\end{aligned}$$

Repeating this argument J times gives

$$\hat{b}_{t-1} = (1-\beta)E_t \sum_{j=0}^{J} \beta^j \, \widehat{PS}_{t+j} - E_t \sum_{j=0}^{J} \beta^j \, \hat{r}^m_{t+j} + \beta^{J+1} E_t \hat{b}_{t+J}. \tag{45}$$

Imposing the transversality condition

$$\lim_{J \to \infty} \beta^{J+1} E_t \hat{b}_{t+J} = 0$$

and taking the limit of (45) as $J \to \infty$ yields

$$\hat{b}_{t-1} = (1-\beta)E_t \sum_{j=0}^{\infty} \beta^j \, \widehat{PS}_{t+j} - E_t \sum_{j=0}^{\infty} \beta^j \, \hat{r}^m_{t+j}. \tag{46}$$

Separate out the $j = 0$ terms in (46), we obtain equation (26) in the main draft

$$\hat{b}_{t-1} = -\rho\beta \, \hat{P}^m_t + \hat{P}^m_{t-1} + \hat{\pi}_t + (1-\beta)E_t \sum_{j=0}^{\infty} \beta^j \, \widehat{PS}_{t+j} - E_t \sum_{j=1}^{\infty} \beta^j \, \hat{r}^m_{t+j}.$$

References

Cascaldi-Garcia, D. (2022). “Pandemic priors”. International Finance Discussion Paper 1352 (cit. on p. 3).

Ramey, V. A. and S. Zubairy (2018). “Government spending multipliers in good times and in bad: evidence from US historical data”. In: *Journal of Political Economy* 126.2, pp. 850–901 (cit. on p. 2).