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# ON THE EMPIRICAL (IR)RELEVANCE OF THE ZERO LOWER BOUND CONSTRAINT: THE CASE OF FISCAL MULTIPLIER IN JAPAN

Hirokuni Iiboshi
Yasuharu Iwata
Takayuki Tsuruga

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The Institute of Social and Economic Research
The University of Osaka
6-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan

# On the Empirical (Ir)Relevance of the Zero Lower Bound Constraint: The Case of Fiscal Multiplier in Japan*


Hirokuni Iiboshi† Yasuharu Iwata‡ Takayuki Tsuruga§

*Nihon University* *Dokkyo University* *The University of Osaka*


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**Abstract**

Japan's prolonged ZLB period alongside substantial debt accumulation makes it a compelling laboratory for testing whether fiscal multipliers differ across normal and ZLB periods. This paper investigates this question using a sign- and zero-restricted TVP-VAR that jointly identifies fiscal rules and structural shocks. We find: (1) government spending and distortionary tax multipliers remain similar across regimes, contradicting standard New Keynesian predictions; (2) fiscal adjustment matters more than the debt-to-GDP ratio in shaping multiplier size; and (3) inflation responses are dampened at the ZLB across various macroeconomic shocks. Our results suggest that the ZLB is irrelevant for output but consequential for inflation.



*JEL classification*: E32, E62, H60.

*Keywords*: Time-varying parameters; Vector autoregression; Fiscal policy; Government spending multiplier; Tax multiplier; Zero lower bound.



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†Nihon University, 1-3-2 Misaki-cho, Chiyoda-ku, Tokyo 101-8360, Japan (Email: iiboshi.hirokuni@nihon-u.ac.jp).

‡Dokkyo University, 1-1 Gakuencho, Soka-shi, Saitama 340-0042, Japan (Email: yiwata@dokkyo.ac.jp).

§Institute of Social and Economic Research, The University of Osaka; 6-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan (Email: tsuruga@iser.osaka-u.ac.jp)

# 1 Introduction

Understanding how macroeconomic shocks propagate when nominal interest rates are constrained by the zero lower bound (ZLB) has become a central question in modern macroeconomics. A large theoretical literature argues that the ZLB fundamentally alters the economy's response to structural shocks. Recent evidence from the United States challenges the conventional view. Using a time-varying parameter VAR (TVP-VAR), Debortoli, Galí and Gambetti (2020) conclude that the ZLB was largely irrelevant for the US economy during the Great Recession and its aftermath. They find that the economy's responses to a variety of macroeconomic shocks are broadly similar between normal and ZLB periods.

Their findings stand in sharp contrast with the prediction of standard New Keynesian (NK) models that inflation dynamics become the central channel of shock transmission at the ZLB. In standard NK models, when the nominal interest rate cannot adjust downward, inflation becomes the key mechanism through which fiscal or supply shocks influence real activity. Government spending raises output by increasing inflation and thereby lowering the real interest rate (e.g., Christiano, Eichenbaum and Rebelo (2011); Woodford (2011); Erceg and Lindé (2014)). Distortionary tax cuts can become contractionary because they generate deflation and raise real rates (e.g., Eggertsson (2011)). Even positive supply shocks—normally expansionary—can become contractionary at the ZLB, as the resulting decline in inflation drives up the real interest rate (e.g., Eggertsson (2012)).

However, a growing empirical literature fails to find the strong inflation responses predicted by the NK models at the ZLB. For the US, several studies find that government spending shocks generate little inflationary pressure (e.g., Dupor and Li (2015); Jørgensen and Ravn (2022); Choi, Shin and Yoo (2022)). Cloyne, Dimsdale and Hürtgen (2025) show that distortionary tax cuts in the United Kingdom are expansionary both at and away from the ZLB, providing further evidence against ZLB-specific transmission. On the supply side, Garín, Lester and Sims

(2019) document that positive supply shocks are expansionary in the US even at the ZLB. These findings imply that the NK models' real interest rate channel may be empirically muted.

Nevertheless, as Debortoli, Galí and Gambetti (2020) emphasize, their analysis pertains to a specific economy and episode. Several studies argue that the ZLB environment in Japan differs substantially from that of the US, particularly with respect to inflation dynamics and the duration of the ZLB episode—a point emphasized by Aruoba, Cuba-Borda and Schorfheide (2018). Indeed, the Japanese evidence appears far more mixed. Miyamoto, Nguyen and Sergeyev (2018) find that government spending multipliers are larger during Japan's ZLB period, consistent with the NK models' prediction. In contrast, Kato et al. (2018) show that tax cuts in Japan stimulate output by similar magnitudes in both ZLB and non-ZLB periods. Likewise, Wieland (2019) finds that negative supply shocks remain contractionary in Japan, contrary to NK predictions. Thus, whether and how the ZLB shapes fiscal transmission in Japan remains an open empirical question.

Japan's ZLB period was notably prolonged, during which fiscal adjustment in response to rising public debt proved insufficiently strong to stabilize debt (e.g., Doi, Hoshi and Okimoto (2011)). Consequently, Japan's ZLB period coincided with a sharp rise in public debt outstanding, as shown in Figure 1. A growing body of empirical evidence suggests that the level of public debt outstanding affects the size of the fiscal multiplier. Ilzetzki, Mendoza and Végh (2013) find that government spending multipliers are substantially smaller in high-debt economies, while Fotiou, Shen and Yang (2020) document analogous debt dependence for the effects of capital income tax cuts. Huidrom et al. (2020) attribute the debt dependence of multipliers to expectations of future fiscal adjustment, which in turn relates to the active and passive policy mix in the sense of Leeper (1991). Multipliers tend to be larger when fiscal policy behaves actively while monetary policy remains passive (e.g., Leeper, Traum and Walker (2017)), a finding further corroborated by Caldara and Kamps (2017), who demonstrate that the policy rule specification plays a crucial role in determining the size of the fiscal multipliers. Most closely related to the present paper, Iwata and Iiboshi (2023) document a declining fiscal multiplier in the US and attribute it to an increase in the magnitude of fiscal adjustment rather than to debt accumulation.

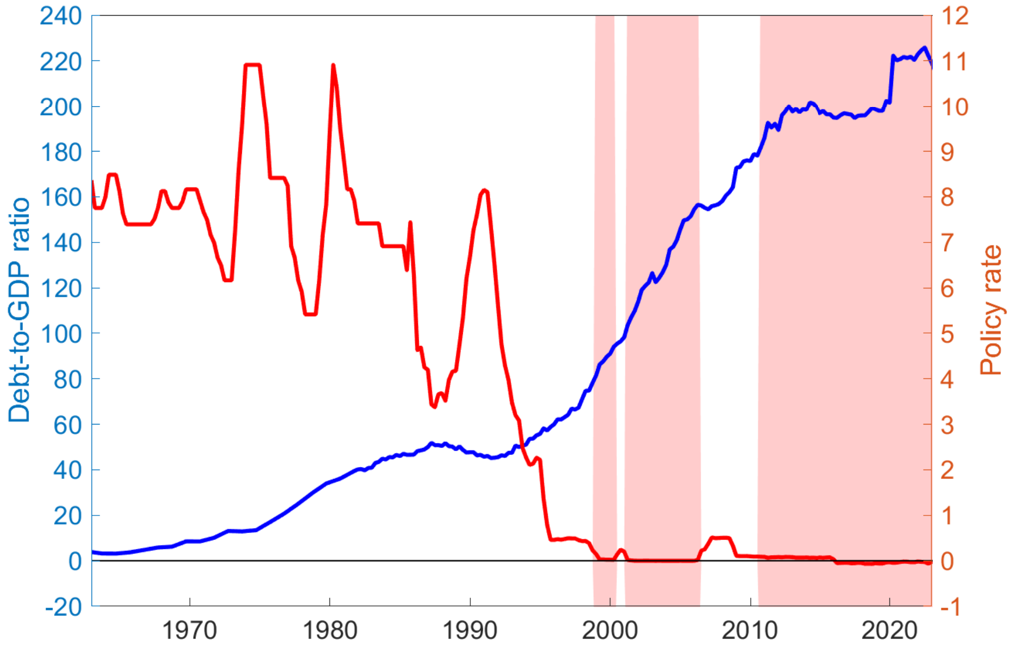


Figure 1. Japan's policy rate and debt-to-GDP ratio

*Notes:* The red and the blue solid lines represent the policy rate (right axis) and debt-to-GDP ratio (left axis), respectively. The shaded areas indicate the ZLB period (1999Q1–2000Q2; 2001Q2–2006Q2; 2010Q4–2023Q4).

Motivated by these studies, this paper reassesses the relevance of the ZLB for Japanese fiscal policy transmission within a TVP-VAR framework in the spirit of Debortoli, Galí and Gambetti (2020), while simultaneously examining the debt-dependence of fiscal multipliers in Japan. Identification is achieved by imposing sign and zero restrictions on the systematic components of monetary and fiscal policy rules as well as on short- and long-run impulse responses, following Iwata and Iiboshi (2023).[1] Since NK models predict that the ZLB amplifies government spending multipliers while rendering distortionary tax cuts contractionary, we estimate fiscal feedback rules for both instruments separately. This allows us to assess the relevance of the ZLB

[1]Incorporating the algorithms of Rubio-Ramírez, Waggoner and Zha (2010) and Arias, Rubio-Ramírez and Waggoner (2018) into the TVP-VAR framework of Primiceri (2005), Iwata and Iiboshi (2023) identify structural shocks and simultaneously estimate time-varying coefficients of monetary policy and government spending rules. This approach extends the identification procedure of Arias, Caldara and Rubio-Ramírez (2019).

for fiscal policy transmission and to investigate how fiscal adjustment shapes debt dependence across both instruments.

Comparing average output responses to government spending and distortionary tax shocks between normal and ZLB periods, we find that differences are negligible for both shocks, in line with the observation of Debortoli, Galí and Gambetti (2020) for the US. The finding that fiscal multipliers at the ZLB are similar in size to those in normal times, despite high debt accumulation, contradicts two conventional views: the debt dependence of fiscal multipliers, and the NK models' real interest rate channel predicting larger government spending multipliers and contractionary tax cuts at the ZLB.

To explore the sources of the lack of debt dependence, we examine time variation in fiscal adjustment as measured by the coefficients of the fiscal feedback rule. We find that fiscal multipliers are more strongly correlated with the magnitude of fiscal adjustment than with the debt-to-GDP ratio, consistent with Iwata and Iiboshi (2023) for the US. This underscores that systematic fiscal adjustment, rather than the debt outstanding per se, drives multiplier variation. However, the feedback coefficients remain broadly stable over the sample, explaining the lack of debt dependence.

Turning to the real interest rate channel, we find some differences in inflation responses between normal and ZLB periods, in contrast to the case of output. In response to a government spending shock, inflation rises only weakly at the ZLB, explaining why the spending multiplier is no larger than in normal times. In response to a negative distortionary tax shock, inflation falls more at the ZLB, yet expansionary tax multipliers of similar magnitude to normal times are observed. This is partly attributable to the small real interest rate differential between the two regimes, and also aligns with Garín, Lester and Sims (2019), who document using US data that despite a somewhat larger decline in inflation at the ZLB in response to a positive productivity shock, the output response remains expansionary.

We then ask whether the change in inflation responses at the ZLB is specific to fiscal policy shocks or also present for aggregate demand and supply shocks. We find that the responsiveness of inflation to a demand shock decreases during the ZLB period, while inflation declines slightly more in response to a positive supply shock at the ZLB. Unlike Debortoli, Galí and Gambetti (2020), who argue using US data that the ZLB was largely irrelevant for macroeconomic dynamics, we find that the Japanese ZLB appears consequential for inflation dynamics in response to demand, supply, and fiscal policy shocks.

The remainder of this paper is organized as follows. Section 2 discusses the empirical methodology. Section 3 examines the size of fiscal multipliers across normal and ZLB periods and the role of fiscal adjustment. Section 4 investigates the inflation responses to fiscal policy, demand, and supply shocks during the ZLB. Section 5 concludes.

## 2 Estimation and Identification

In this section, we describe our empirical framework. We rely on a TVP-VAR to capture structural changes that the Japanese economy may have experienced at the ZLB, in the spirit of Debortoli, Galí and Gambetti (2020), and employ the identification scheme of Iwata and Iiboshi (2023).

### 2.1 The TVP-VAR model

We consider the following TVP-VAR model with stochastic volatility:

$$\mathbf{y}_t'\mathbf{A}_{0,t} = \sum_{l=1}^{P} \mathbf{y}_{t-l}'\mathbf{A}_{l,t} + \varepsilon_t'\mathbf{H}_t^{1/2}, \tag{2.1}$$

where $\mathbf{y}_t$ is a $n\times 1$ vector of observed variables, $\mathbf{A}_{l,t}$ are $n\times n$ matrices of time-varying parameters, $\varepsilon_t$ is Gaussian with mean zero and covariance matrix $\mathbf{I}_n$ (the $n \times n$ identity matrix), and $\mathbf{H}_t^{1/2}$ is a diagonal matrix of time-varying standard deviations. Let $\mathbf{A}_{+,t}' = [\mathbf{A}_{1,t}' \quad \cdots \quad \mathbf{A}_{P,t}']$ and

$\mathbf{x}'_t = [\mathbf{y}'_{t-1} \ \cdots \ \mathbf{y}'_{t-P}]$, then, the model (2.1) can be written compactly as follows:

$$\mathbf{y}'_t \mathbf{A}_{0,t} = \mathbf{x}'_t \mathbf{A}_{+,t} + \varepsilon'_t \mathbf{H}_t^{1/2}. \tag{2.2}$$

The reduced-form representation is given by the following equation:

$$\mathbf{y}'_t = \mathbf{x}'_t \mathbf{B}_t + \mathbf{u}'_t, \tag{2.3}$$

where $\mathbf{B}_t = \mathbf{A}_{+,t}\mathbf{A}_{0,t}^{-1}$. Like Mumtaz and Zanetti (2015), we factor the covariance matrix of the innovations $\mathbf{u_t}$ as $VAR(\mathbf{u_t}) \equiv \mathbf{\Sigma}_t = (\mathbf{A}_t^{-1})'\mathbf{H}_t\mathbf{A}_t^{-1}$, where $\mathbf{H}_t$ is a diagonal matrix with variances of structural shocks defined as $\mathbf{H}_t = \text{diag}\,[h_{1,t}, \ldots, h_{n,t}]'$ and $\mathbf{A}_t$ is a $n \times n$ upper triangular matrix with all the diagonals equal to one. Let $\widetilde{\mathbf{A}}_{0,t}$ be a matrix that satisfies $\mathbf{\Sigma}_t = \widetilde{\mathbf{A}}_{0,t}{}'\widetilde{\mathbf{A}}_{0,t}$. Using a $n \times n$ orthogonal matrix, $\mathbf{Q}_t$, a candidate structural impact matrix is given as $\mathbf{A}_{0,t} = \widetilde{\mathbf{A}}_{0,t}\mathbf{Q}_t$. The time-varying VAR model

$$\mathbf{y}'_t = \mathbf{x}'_t \mathbf{B}_t + \varepsilon'_t \widetilde{\mathbf{A}}_{0,t} \tag{2.4}$$

represents an observationally-equivalent rotation of the model's equation (2.3). We impose sign and zero restrictions on some elements of $\mathbf{A}_{0,t}$ and on the impulse responses at the short- and long-run horizons exploiting the algorithms developed by Rubio-Ramírez, Waggoner and Zha (2010) and Arias, Rubio-Ramírez and Waggoner (2018).[2]

Following Primiceri (2005), we estimate the reduced-form parameters in time-varying matrices $\mathbf{B}_t$, $\mathbf{A}_t$, and $\mathbf{H}_t$. The stacked vector of the elements in the columns of $\mathbf{B}_t$ and the stacked vector of non-zero and non-one elements in $\mathbf{A}_t$ are assumed to follow a random-walk process. The elements of $\mathbf{H}_t$ are assumed to evolve as geometric random walks. We assume that all innovations are jointly normally distributed and mutually uncorrelated across blocks, and, for simplicity, we impose a block-diagonal structure on each covariance matrix.

[2] Arias et al. (2026) recently establish the rotation-invariant framework for structural inference in sign-restricted TVP-SVARs, which was developed independently of our own.

## 2.2 Variables and data

Following Bohn (1998), a feedback rule based on the debt-to-GDP ratio has become a standard approach. Recently, however, Auerbach and Yagan (2024) emphasize that primary balance-based fiscal feedback is essential for capturing actual US congressional behavior. In Japan, the government targets both measures as fiscal consolidation objectives. Motivated by these practices, we estimate two versions of the fiscal feedback rule employing the debt-to-GDP ratio and the primary balance-to-GDP ratio as stabilization targets.

Because estimating a TVP-VAR model imposes a substantial computational burden, the dimension of the system must be kept small. Given that key macroeconomic variables, such as output, inflation, and nominal interest rate need to be included, we estimate these variables with one of the fiscal instruments—government spending and distortionary tax revenue.[3] This separate treatment of fiscal instrument follows the established practice (e.g., Leeper, Traum and Walker (2017)). Estimating different combinations of two fiscal instruments and two stabilization targets allows us to keep each specification computationally tractable while examining how fiscal instruments interact with different target variables.

Specifically, our models consist of five variables, and we estimate four specifications in $\mathbf{y}_t$ ordered as $\mathbf{y}_t = [g_t, y_t, d_t, \pi_t, i_t]'$ ; $[g_t, y_t, b_t, \pi_t, i_t]'$ ; $[\tau_t, y_t, d_t, \pi_t, i_t]'$ ; $[\tau_t, y_t, b_t, \pi_t, i_t]'$ , where $g_t$ is the government spending, $\tau_t$ is the distortionary tax revenue, $y_t$ is the gross domestic product (GDP), $d_t$ is the debt-to-GDP ratio, $b_t$ is the primary balance-to-GDP ratio, $\pi_t$ is the inflation rate measured by the GDP deflator, and $i_t$ is the nominal interest rate. We refer to these models as (i) Model GD, (ii) Model GB, (iii) Model TD, and (iv) Model TB, respectively. Accordingly, we consider government spending rules for Model Gs (GD and GB) and distortionary tax rules for Model Ts (TD and TB), where spending and taxes respond to stabilization targets—either the debt-to-GDP ratio or the primary balance-to-GDP ratio. Both rules are also assumed to

[3] The contractionary effects of labor and capital tax cuts at the ZLB are well-known results in standard NK models. See Cloyne, Dimsdale and Hürtgen (2025) for the importance of focusing on distortionary taxes,

respond systematically to output, following Caldara and Kamps (2017), who show that even small differences in the fiscal policy response to output can generate large differences in estimated spending and tax multipliers.

We use Japanese quarterly data for the period from 1962Q1 to 2023Q4. The lag length is set to $P = 4$, following Blanchard and Perotti (2002). We construct a long historical series to ensure a sufficiently long sample for estimating the TVP-VAR and for credible comparisons between normal and ZLB periods. Because Japan's ZLB period begins in 1999, a long pre-1999 span is also required to provide a comparably sized normal-time benchmark. The government spending, distortionary tax revenue, and GDP are expressed in real per-capita logarithmic terms. We extract trend components of output, government spending, distortionary tax revenue, and the debt-to-GDP ratio, using the methodology of Hamilton (2018).[4] The variables used in the estimation are shown in Figure 2. See Appendix for a detailed description of the data.

[4] The procedure suggests that the detrended component of a variable at horizon $h$ can be constructed as the residual of the linear projection of the variable on a constant and its four most recent values. We choose a horizon of $h = 8$ as suggested by Hamilton (2018) for quarterly data.

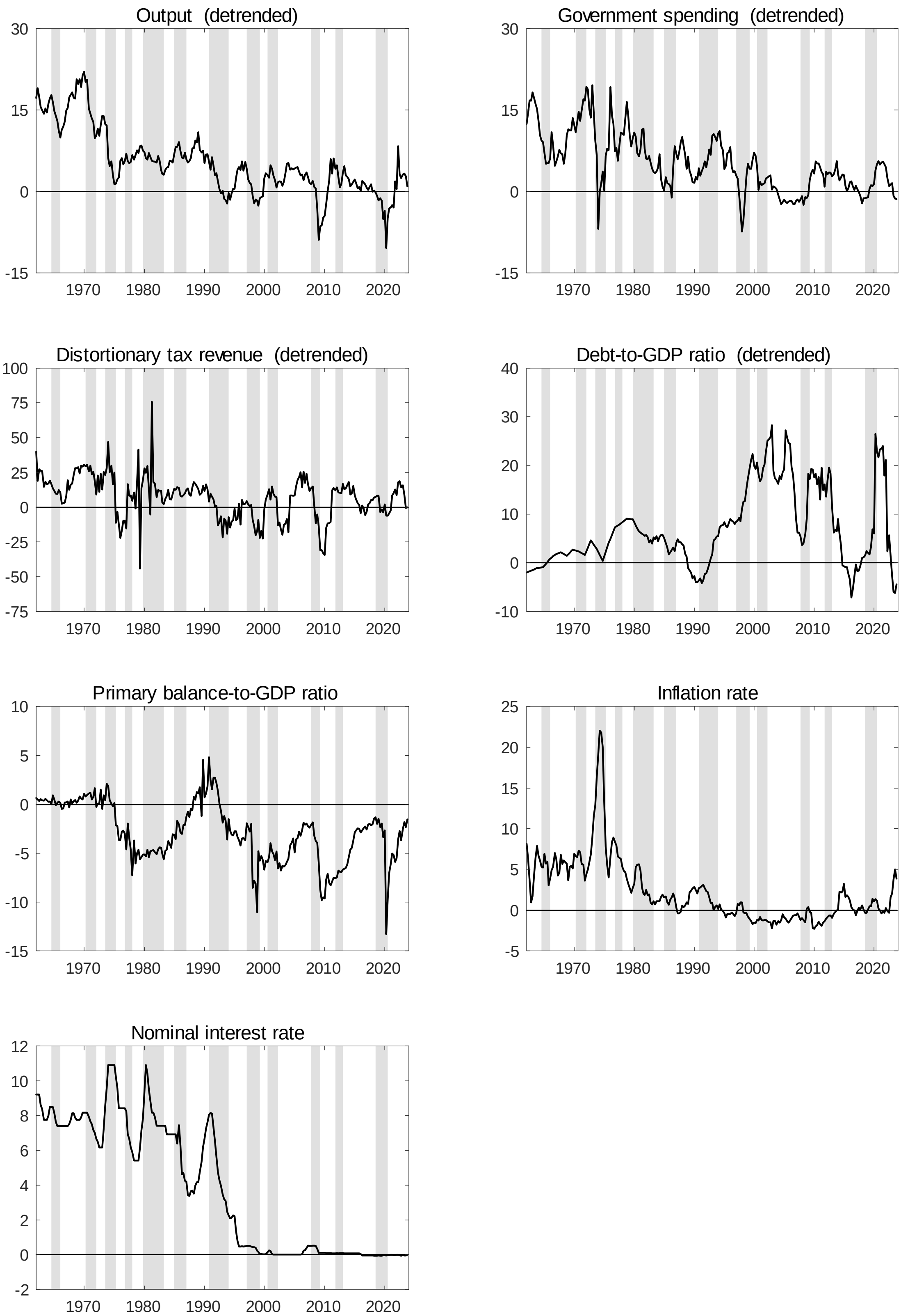


Figure 2. Variables used in the estimation

*Notes:* For the first four variables, we detrend the raw series using the methodology of Hamilton (2018). The shaded areas indicate recessions as defined by the Economic and Social Research Institute (ESRI), Cabinet Office of Japan.

### 2.3 The identification scheme

We identify four structural shocks in each model. Without loss of generality, the shocks are ordered as monetary policy, fiscal policy, demand, and supply shocks. A fiscal shock is either a government spending shock or a negative distortionary tax shock, depending on the fiscal instrument included. In light of the findings of Caldara and Kamps (2017), we impose sign and zero restrictions on both the coefficients of fiscal policy rules and the short- and long-run impulse responses, building on the techniques developed in Iwata and Iiboshi (2023).

Following Iwata and Iiboshi (2023), we combine restrictions on impulse responses with the identification procedure of Arias, Caldara and Rubio-Ramírez (2019), which Wolf (2020) describes as a refinement of Uhlig (2005)'s sign-restricted identification of monetary policy shocks, and additionally impose analogous restrictions on the coefficients of the government spending and tax rules. The identification procedure of Arias, Caldara and Rubio-Ramírez (2019) consists of two sets of restrictions: the first assumes the contemporaneous impulse response of the nominal interest rate to a contractionary monetary policy shock to be positive, and the second requires that the nominal interest rate reacts contemporaneously only through the monetary policy rule.

To implement the first set of restrictions, we impose sign restrictions on the contemporaneous impulse responses of the nominal interest rate, government spending, and GDP to a contractionary monetary policy shock, an expansionary government spending shock, and a positive demand shock, respectively, requiring each to be positive. Correspondingly, the contemporaneous impulse responses of distortionary tax revenue and the inflation rate to a negative distortionary tax shock and a positive supply shock, respectively, are required to be negative.

The second set of restrictions focuses on the contemporaneous coefficients of the policy rules. Designating the first and second shocks in the TVP-VAR model described in equation (2.1) as monetary and fiscal policy shocks, respectively, we restrict the coefficients corresponding to the elements of these columns of $\mathbf{A}_{0,t}$. Abstracting from the constant and lagged variables, we write the monetary policy equation as

$$i_t = \varphi_{f,t} f_t + \varphi_{y,t} y_t + \varphi_{s,t} s_t + \varphi_{\pi,t} \pi_t + u_{i,t}, \tag{2.5}$$

where $f = g, \tau$ and $s = d, b$ depending on the combination of fiscal instruments (government spending ($g$) or tax revenue ($\tau$)) and target variable for fiscal stabilization (debt-to-GDP ratio ($d$) or primary balance-to-GDP ratio ($b$)). Letting $a_{0,t,jk}$ denote the $(j,k)$ entry of $\mathbf{A}_{0,t}$, coefficients are expressed as $\varphi_{f,t} = -a_{0,t,51}^{-1} a_{0,t,11}$, $\varphi_{y,t} = -a_{0,t,51}^{-1} a_{0,t,21}$, $\varphi_{s,t} = -a_{0,t,51}^{-1} a_{0,t,31}$, $\varphi_{p,t} = -a_{0,t,51}^{-1} a_{0,t,41}$, and $u_{r,t} = -a_{0,t,51}^{-1} h_{1,t}^{1/2} \varepsilon_{1,t}$. In line with the standard specification of the Taylor rule, we assume that the central bank only reacts contemporaneously to an increase in output and prices by raising the interest rate as in Arias, Caldara and Rubio-Ramírez (2019). This assumption implies $\varphi_{f,t} = \varphi_{s,t} = 0$ and $\varphi_{y,t}$, $\varphi_{\pi,t} > 0$. Following Arias et al. (2026), $\varphi_{y,t}$ and $\varphi_{\pi,t}$ are left unrestricted during the ZLB period.[5] Similarly, the fiscal policy equation is expressed as

$$f_t = \psi_{y,t} y_t + \psi_{s,t} s_t + \psi_{\pi,t} \pi_t + \psi_{i,t} i_t + u_{f,t}, \tag{2.6}$$

where $\psi_{y,t} = -a_{0,t,12}^{-1} a_{0,t,22}$, $\psi_{s,t} = -a_{0,t,12}^{-1} a_{0,t,32}$, $\psi_{\pi,t} = -a_{0,t,12}^{-1} a_{0,t,42}$, $\psi_{i,t} = -a_{0,t,12}^{-1} a_{0,t,52}$, and $u_{f,t} = -a_{0,t,12}^{-1} h_{2,t}^{1/2} \varepsilon_{2,t}$. Because we are interested in the role of fiscal adjustment in determining the size of multipliers, we assume that the fiscal instrument only reacts contemporaneously to output and the target variable for fiscal stabilization. This assumption implies $\psi_{\pi,t} = \psi_{i,t} = 0$. While Blanchard and Perotti (2002) suggest imposing numerical restrictions on $\psi_{y,t}$ using institutional information, Caldara and Kamps (2017) demonstrate that such restrictions affect the size of the fiscal multiplier. We therefore leave $\psi_{y,t}$ unrestricted. By the same token, although spending-based and tax-based fiscal adjustments correspond to $\psi_{d,t} < 0$, $\psi_{b,t} > 0$ and $\psi_{d,t} > 0$, $\psi_{b,t} < 0$ for the spending and tax rules, respectively, we leave $\psi_{d,t}$ and $\psi_{b,t}$ unrestricted

[5] This, however, does not affect our main findings. Nakajima (2011) documents that a zero lower bound on nominal interest rates has negligible effects on impulse responses in a TVP-VAR model with stochastic volatility estimated on Japanese data.

to remain agnostic about fiscal adjustment in our estimates.

As in Iwata and Iiboshi (2023), we combine the identification procedure of Arias, Caldara and Rubio-Ramírez (2019) described above with the restrictions on short- and long-run impulse responses. The long-run exclusion restrictions contribute not only to the identification of the structural shocks but also to satisfying the rank condition required for sign- and zero-restricted SVARs.[6] Table 1 reports the sign restrictions imposed on the impulse responses one quarter after the shocks. An expansionary government spending shock and a negative distortionary tax shock are assumed to increase the debt-to-GDP ratio and decrease the primary balance-to-GDP ratio, which distinguishes fiscal policy shocks from other shocks. These restrictions share similarities with those in previous studies (e.g., Canova and Pappa (2011)).

[6] See Arias, Rubio-Ramírez and Waggoner (2018). As in Iwata and Iiboshi (2023), the short- and long-run restrictions are imposed at the one- and forty-quarter horizons, respectively. These choices do not affect the basic results, and imposing restrictions over multiple periods is additionally computationally burdensome when estimating impulse responses from a TVP-VAR model.

Table 1. Sign restrictions on short-run impulse responses

| *Variables* | *Monetary Policy* | *Gov. spending* | *Demand* | *Supply* |
|---|---|---|---|---|
| | *Shocks (Model GD / GB)* | | | |
| Government spending | | + | | |
| GDP | − | + | + | + |
| Debt / Primary balance | | +/− | −/+ | −/+ |
| Inflation | − | + | + | − |
| Nominal interest rate | | | | |
| | *Shocks (Model TD / TB)* | | | |
| *Variables* | *Monetary Policy* | *Tax cuts* | *Demand* | *Supply* |
| Distortionary tax revenue | | − | | |
| GDP | − | + | + | + |
| Debt / Primary balance | | +/− | −/+ | −/+ |
| Inflation | − | − | + | − |
| Nominal interest rate | | | | |

*Notes:* The table shows the sign restrictions imposed on the impulse responses of the variables to a contractionary monetary policy shock, an expansionary government spending shock, a negative distortionary tax shock, a positive demand shock, and a positive supply shock at the one-quarter horizon. A blank indicates that the variable's response is unrestricted.

When implementing the procedure of Arias, Caldara and Rubio-Ramírez (2019), two additional zero restrictions on monetary policy and demand shocks and one additional zero restriction on fiscal policy and supply shocks must be imposed to satisfy the rank condition. As demand and supply shocks represent private sector disturbances and are therefore orthogonal to fiscal policy actions, we impose exclusion restrictions on their systematic responses to fiscal variables (i.e., government spending for Model Gs, distortionary tax revenue for Model Ts). Furthermore, we impose long-run exclusion restrictions on the responses of output to the monetary policy, fiscal policy, and demand shocks following the work of Blanchard and Quah (1989). While not economically informative, a long-run exclusion restriction is imposed on the inflation response to a monetary policy shock solely to satisfy the rank condition.

# 3 Main Results

In this section, we examine whether output responds differently to fiscal policy shocks across normal and ZLB periods. We then analyze the time variation in the systematic component of fiscal rules and assess its role in shaping the size of the multiplier.

### 3.1 Volatility of identified structural shocks

The stochastic volatility incorporated into our TVP-VAR model requires Bayesian inference via Markov Chain Monte Carlo (MCMC) methods. We run eight parallel MCMC chains, each chain executing 35,000 replications and discarding the first 10,000 draws. Figure 3 presents the stochastic volatility of the identified structural shocks. We compute the volatility using the structural impact matrix. The estimated stochastic volatilities reveal several episodes aligned with well-known macroeconomic developments in Japan.

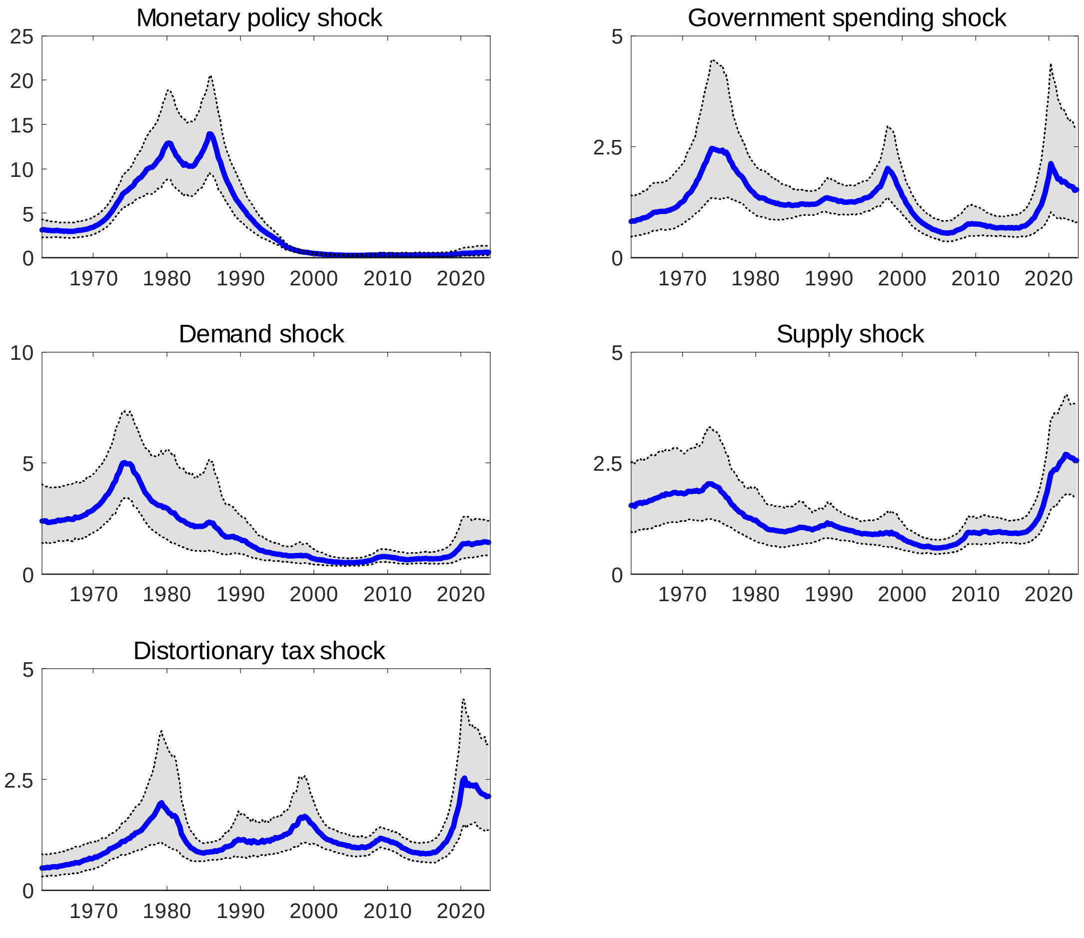


Figure 3. Stochastic volatility of the structural shocks

*Notes:* The solid lines represent the posterior means, and the shaded areas represent the corresponding 16th–84th percentile ranges. The stochastic volatility of the distortionary tax shock is computed for Model TB, while the others are computed for Model GB.

Monetary policy shock volatility rises from the late 1970s, reflecting the Bank of Japan's policy swings between the first oil shock in 1973 and the second in 1979—easing during the recovery from the former and aggressively tightening in response to the latter—and again in the late 1980s, reflecting protracted easing following the Plaza Accord of 1985 before an abrupt tightening from 1989 to contain soaring asset prices. Both demand and supply shock volatilities spike in the mid-1970s, when the first oil shock simultaneously disrupted production conditions and destabilized private spending. A modest increase in demand shock volatility in the mid-1980s may partly capture the demand euphoria accompanying the asset price bubble. Both volatilities rise modestly in the late 2000s, coinciding with the commodity price surge and the subsequent Global Financial Crisis, and spike following the COVID-19 pandemic of 2020, reflecting supply chain disruptions and abrupt shifts in consumption patterns.

Government spending shock volatility rises in the mid-1970s with countercyclical responses to the oil shocks, and rises again around 1990 as the collapse of the asset price bubble triggers stabilization efforts. It rises more clearly in the late 1990s as the domestic financial crisis prompted fiscal expansion, with further increases in the late 2000s and around 2020 corresponding to crisis-driven fiscal expansions. Distortionary tax shock volatility rises notably during the late 1970s amid large swings in tax revenues in the wake of the two oil shocks. It increases modestly around 1990 amid personal income and corporate tax cuts introduced to offset the introduction of the consumption tax in 1989, as well as the collapse of the asset price bubble, and rises noticeably in the late 1990s following income and corporate tax cuts alongside the consumption tax hike and the domestic financial crisis. It increases modestly again in the late 2000s and surges around 2020, both episodes reflecting sharp swings in tax revenues in the wake of the Global Financial Crisis and the COVID-19 pandemic, respectively.

Some co-movement in estimated volatilities around major common disturbances is expected, given that large macroeconomic disruptions simultaneously affect monetary policy, fiscal policy, and various private sector behaviors. Nevertheless, the close correspondence between the estimated volatilities and key historical episodes provides empirical support for the incorporation of stochastic volatility into our TVP-VAR model.

### 3.2 Output responses and the systematic component of fiscal policy

Following Debortoli, Galí and Gambetti (2020), we compare average impulse responses estimated over normal and ZLB periods. In our sample covering 1963Q1–2023Q4, ZLB periods are identified as 1999Q1–2000Q2, 2001Q2–2006Q2, and 2010Q4–2023Q4 based on the Bank of Japan's announcements. Figure 4 plots the dynamic fiscal multipliers across the four model specifications. Output responses are converted to government spending and tax multipliers through scaling with the sample-average ratio of output to government spending and distortionary tax revenue, respectively, as in Caldara and Kamps (2017). Although standard NK models predict larger government spending multipliers and contractionary output effects of distortionary tax cuts at the ZLB, we find virtually no difference in output responses between normal and ZLB periods for either shock. Regardless of the fiscal stabilization target, the mean government spending and distortionary tax multipliers peak at around 1 and 0.5, respectively—both consistent with the estimates reported in Caldara and Kamps (2017) for US data.

Japan's ZLB period coincides with persistently high public debt, raising the question of whether expectations of future fiscal adjustment attenuate the effects of fiscal policy. Recent evidence by Iwata and Iiboshi (2023) suggests that, for the US, spending multiplier size correlates more strongly with the estimated coefficients of the debt-stabilizing spending rule than with the debt-to-GDP ratio itself—indicating that what matters is not the debt level per se but the strength of fiscal adjustment. Since realized fiscal adjustment, as captured by estimated feedback coefficients, shapes expectations of future consolidation, this finding aligns with the broader literature on debt-dependent multipliers, which emphasizes that such expectations can substantially dampen the stimulative effects of fiscal expansions (e.g., Huidrom et al. (2020)). Iwata and Iiboshi (2023) further show that the strengthening of fiscal adjustment following the enactment of the Omnibus Budget Reconciliation Act of 1993 (OBRA93) accounts for the observed secular decline in US spending multipliers.

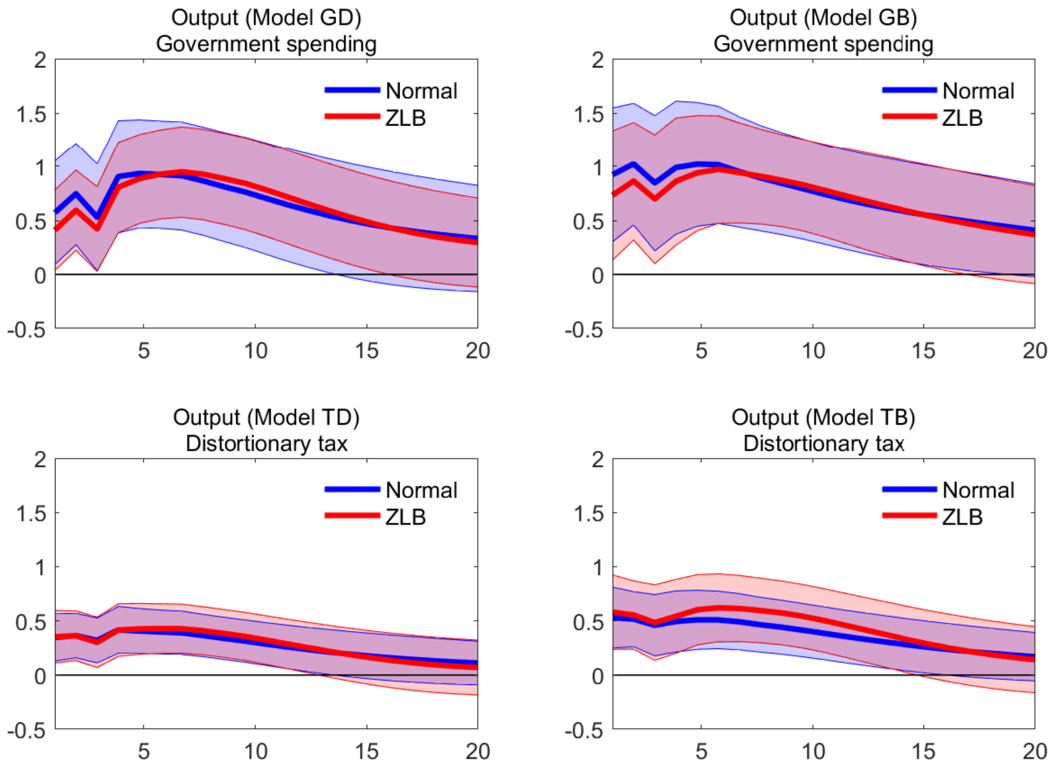


Figure 4. Dynamic fiscal multipliers during the normal and ZLB periods

*Notes:* The blue solid lines represent the average posterior mean responses to a one-dollar increase in government spending (Model Gs, upper panels) and a one-dollar decrease in distortionary tax revenue (Model Ts, lower panels), with the light-blue shaded areas representing the corresponding 16th–84th percentile ranges for the normal period. The red solid lines and light-red shaded areas represent the corresponding quantities for the ZLB period.

To assess whether an analogous mechanism operates in Japan, it is first necessary to examine fiscal adjustment during both normal times and the ZLB period. Figures 5 and 6 present the time variation in the estimated coefficients of the government spending and tax rules, respectively. Importantly, although these coefficients are left unrestricted, their estimated signs are both empirically and theoretically consistent. Regardless of the fiscal stabilization target—whether the debt-to-GDP ratio or the primary balance-to-GDP ratio—the contemporaneous output response coefficient $\psi_{y,t}$ is broadly negative for Model Gs and positive for Model Ts, with confidence intervals encompassing zero throughout the sample. This is consistent with the findings reported by Caldara and Kamps (2017) for the US using a constant-parameter VAR. The debt-feedback coefficient $\psi_{d,t}$ carries a negative sign in the government spending rule and a positive sign in the tax revenue rule, while the primary balance-feedback coefficient $\psi_{b,t}$ displays the opposite pattern—both in accordance with theoretical predictions. However, unlike Iwata and Iiboshi (2023), who document a clear downward trend in US spending debt-feedback coefficients consistent with the post-OBRA93 fiscal consolidation episode, no evident trend is observed in any of these coefficients. This absence of any clear trend is consistent with the findings of Doi, Hoshi and Okimoto (2011), who document that Japan's fiscal adjustment was insufficiently strong to ensure debt stabilization from the 1980s through the 2000s.

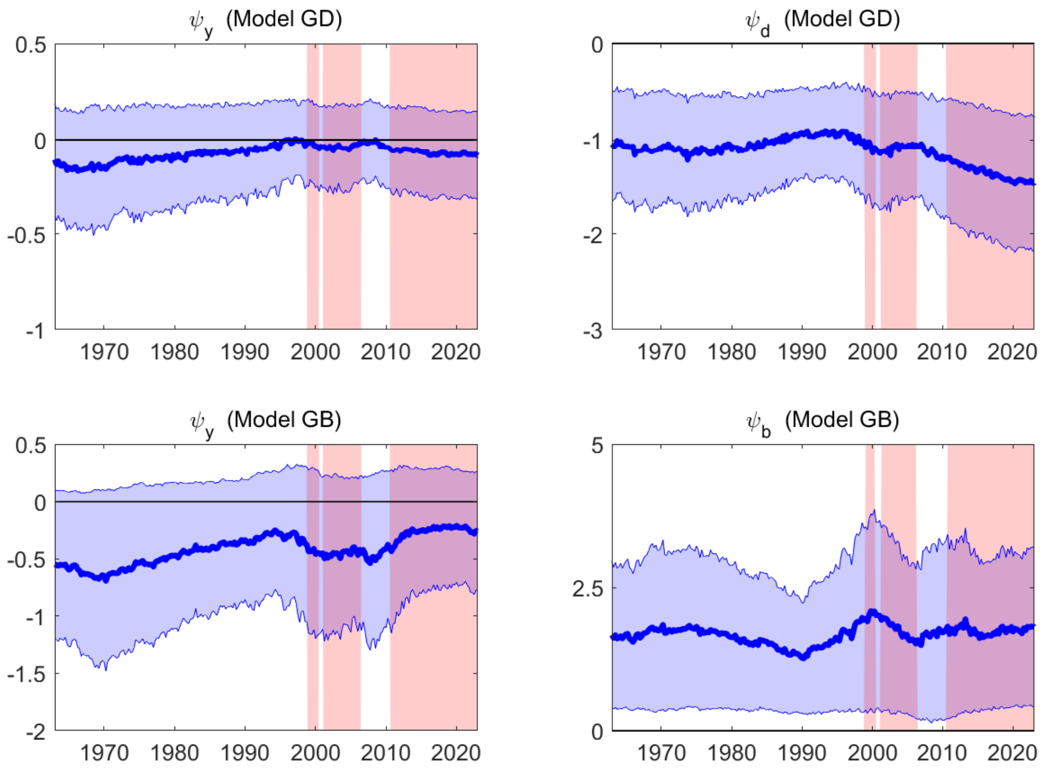


Figure 5. Evolution of government spending rule coefficients

*Notes:* The blue solid lines represent the posterior means of the coefficients, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges. The light-red shaded areas indicate the ZLB period.

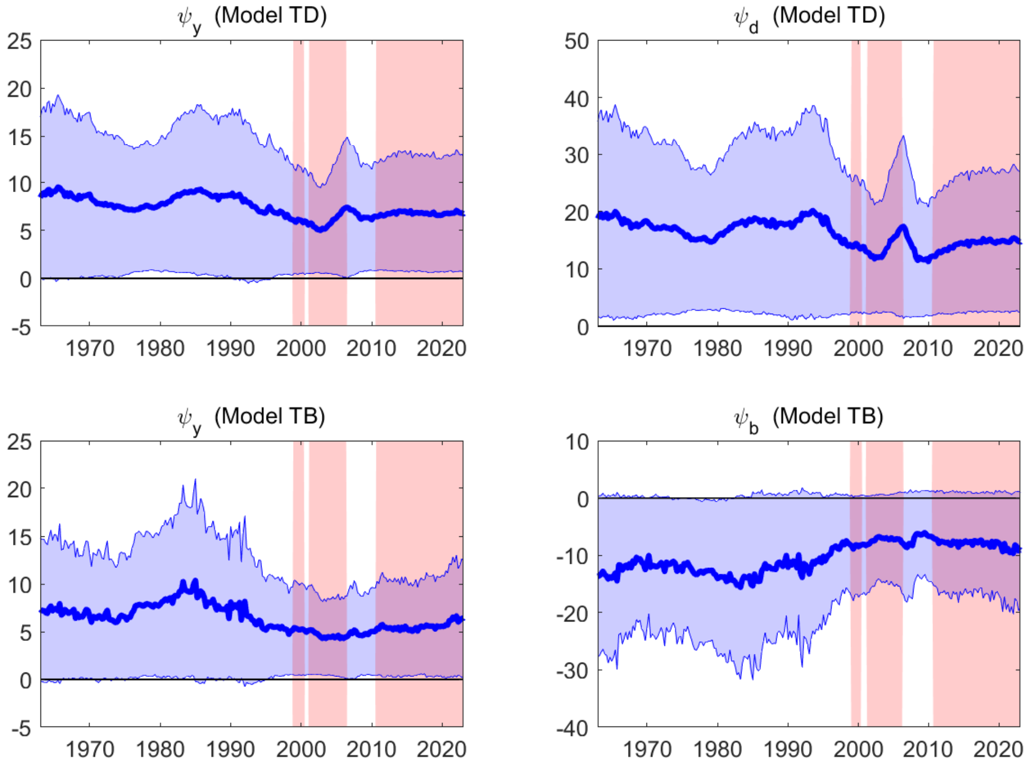


Figure 6. Evolution of distortionary tax rule coefficients

*Notes:* The blue solid lines represent the posterior means of the coefficients, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges. The light-red shaded areas indicate the ZLB period.

### 3.3 Multiplier and fiscal adjustment

We find that the estimated feedback coefficients for Japan remain broadly stable across specifications and over time, including during the ZLB period, despite persistent and sizable increases in the debt-to-GDP ratio. This stability is consistent with our earlier finding that fiscal multipliers at the ZLB are similar in size to those in normal times. Nevertheless, given that Iwata and Iiboshi (2023) report that US spending multipliers correlate more strongly with the magnitude of fiscal adjustment than with the level of public debt, we next examine whether this pattern holds for Japan.

Following Iwata and Iiboshi (2023), we use mean estimates of peak multipliers, defined as the ratio of the peak output response to the initial government spending shock. The upper and lower panels of Figure 7 report results for Models GD and GB, respectively. The left panels plot the multipliers against the debt-to-GDP ratio, illustrating their debt-dependence, while the right panels relate them to the mean estimates of the fiscal feedback coefficients on either the debt-to-GDP or primary balance-to-GDP ratio.

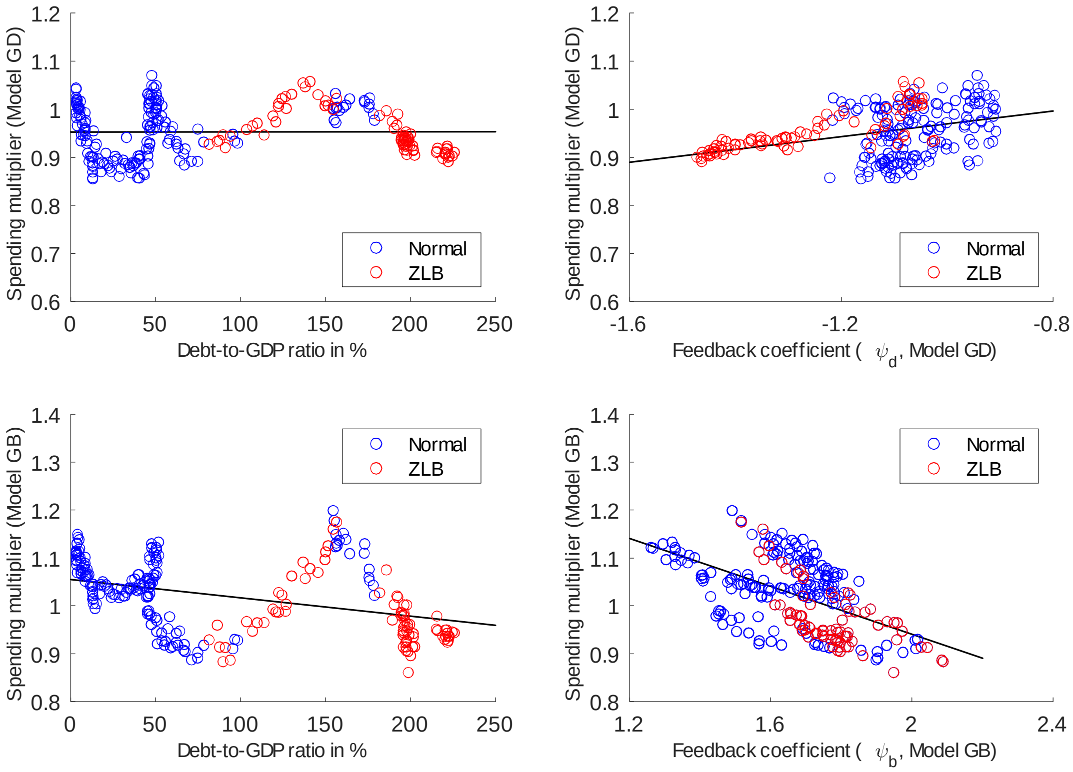


Figure 7. Relationship between debt (left) [fiscal adjustment (right)] and government spending multipliers

*Notes:* The left [right] panel plots the debt-to-GDP ratio [feedback coefficients of government spending rule] and the government spending multipliers. Normal-period observations are shown as blue circles and ZLB observations as red circles. R-squared: 0.00 (upper left); 0.14 (upper right); 0.16 (lower left); 0.30 (lower right).

In both specifications, multipliers correlate more strongly with the magnitude of fiscal adjustment than with the debt-to-GDP ratio, and the signs are consistent with theoretical predictions. The positive correlation between the multiplier and the debt-feedback coefficient indicates that a larger negative value of the coefficient—reflecting stronger spending-based fiscal adjustment—is associated with a smaller multiplier. The negative correlation observed under the primary balance-feedback rule admits the same interpretation: a larger positive value of the coefficient reflects stronger spending-based fiscal adjustment and is similarly associated with a smaller multiplier. Nevertheless, the explanatory power is considerably weaker than in the US case: the R-squared for the debt-feedback coefficient of the government spending rule is 0.14, compared with 0.68 reported by Iwata and Iiboshi (2023). Notably, no systematic differences in these correlation patterns are detected between normal and ZLB periods.

The upper and lower panels of Figure 8 report tax multipliers from Models TD and TB, respectively. As with government spending, tax multipliers correlate more strongly with the magnitude of fiscal adjustment than with the debt-to-GDP ratio, and the estimated signs are consistent with theoretical predictions. The negative correlation between the multiplier and the debt-feedback coefficient indicates that a larger positive value of the coefficient—reflecting stronger tax-based fiscal adjustment—is associated with a smaller multiplier. The positive correlation observed under the primary balance-feedback rule admits the same interpretation: a larger negative value of the coefficient reflects stronger tax-based fiscal adjustment and is similarly associated with a smaller multiplier. Again, no systematic differences in these correlation patterns are detected between normal and ZLB periods.

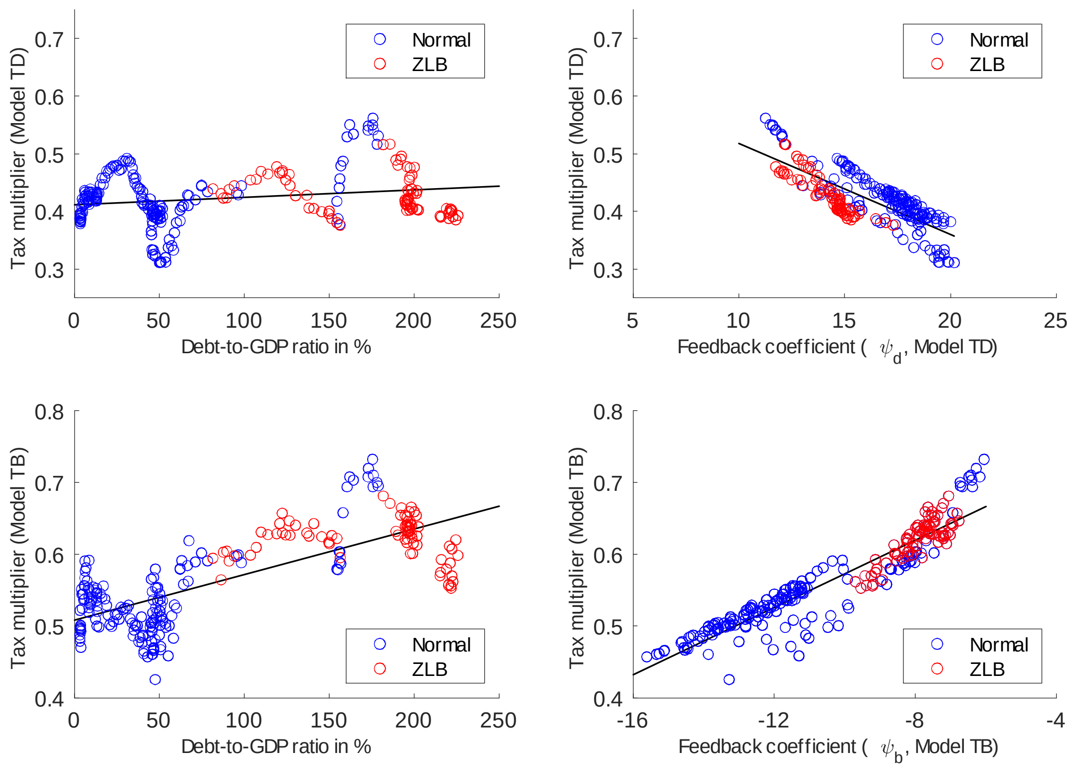


Figure 8. Relationship between debt (left) [fiscal adjustment (right)] and distortionary tax multipliers

*Notes:* The left [right] panel plots the debt-to-GDP ratio [feedback coefficients of distortionary tax rule] and the tax multipliers. Normal-period observations are shown as blue circles and ZLB observations as red circles. R-squared: 0.05 (upper left); 0.59 (upper right); 0.56 (lower left); 0.87 (lower right).

Iwata and Iiboshi (2023) show that the US government spending multiplier exhibits a steady downward trend from the 1970s through the early 1990s, driven by a strengthening of fiscal adjustment in response to rising debt. Our Japanese estimates reveal no analogous pattern: across all four specifications, the feedback coefficients governing fiscal adjustment to either the debt-to-GDP or primary balance-to-GDP ratio show no systematic strengthening, despite Japan's far more rapid and sustained debt accumulation. Correspondingly, no trend is observed in the estimated fiscal multipliers. Nevertheless, in both spending and tax specifications, multipliers correlate more strongly with the magnitude of fiscal adjustment—as captured by the estimated feedback coefficients—than with the level of debt itself. This reinforces the central conclusion of Iwata and Iiboshi (2023) that fiscal adjustment matters more than the debt-to-GDP ratio in shaping multiplier size. However, while this mechanism operates qualitatively in Japan, elevated debt levels did not trigger stronger fiscal adjustment and, consequently, multipliers did not systematically decline during high-debt periods.

# 4 Inflation Responses during the ZLB

Contrary to the predictions of NK models, we find that output responses to fiscal policy shocks are broadly similar across normal and ZLB periods. Recent work has questioned the empirical relevance of the real interest rate channel in NK models, highlighting the role of inflation dynamics. If the ZLB fundamentally alters macroeconomic transmission, this should be reflected in inflation responses to major structural shocks. This section examines that possibility by comparing inflation responses to government spending and distortionary tax shocks across normal and ZLB periods, before extending the analysis to demand and supply shocks.

## 4.1 Fiscal policy shocks

The left panels of Figure 9 compare the average inflation responses to a government spending shock across normal and ZLB periods for Models GD and GB. Although the differences are not statistically significant, inflation tends to respond somewhat more weakly during the ZLB period than in normal times under both specifications. The right panels report the real interest rate response, constructed as the difference between the nominal interest rate and actual inflation responses. Since the weakness in inflation attenuates the nominal rate response at the ZLB, the two effects offset each other, yielding real rate responses that are nearly indistinguishable across the two monetary policy regimes.

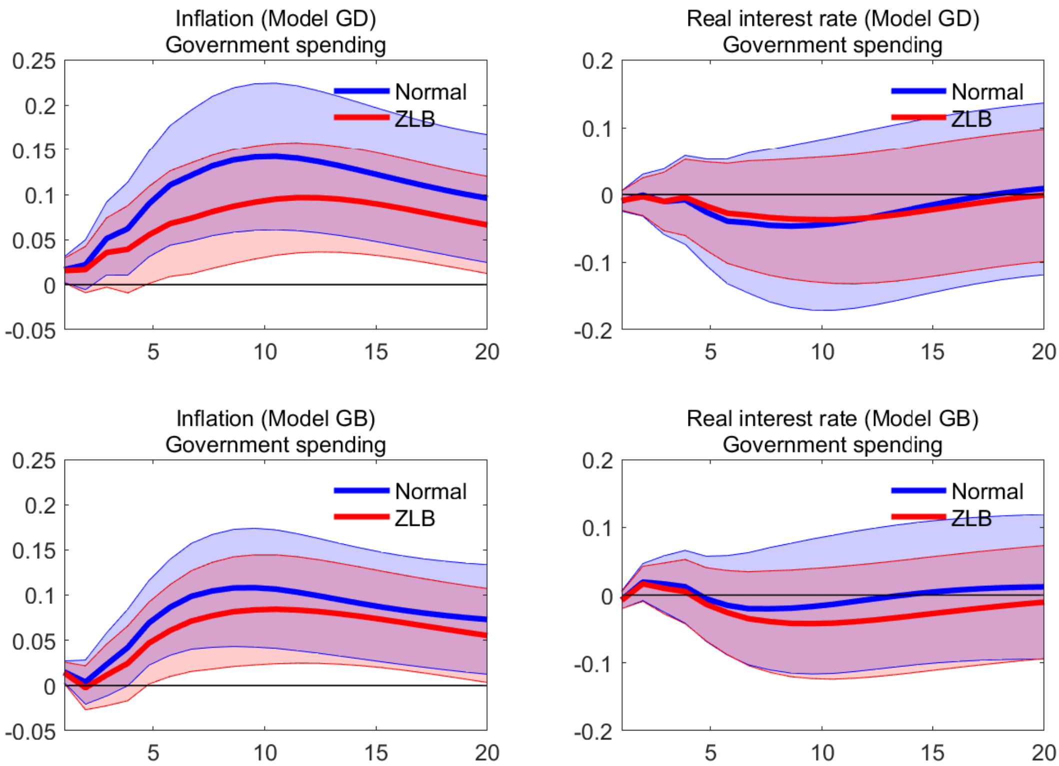


Figure 9. Inflation and real interest rate responses to a government spending shock during the normal and ZLB periods

*Notes:* The blue solid lines represent the average posterior mean responses to a one-percentage-point increase in government spending, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges for the normal period. The red solid lines and light-red shaded areas represent the corresponding quantities for the ZLB period.

Figure 10 displays the responses of inflation and the real interest rate to a negative distortionary tax shock. Consistent with standard NK models, a tax cut reduces inflation on impact while generating a mild increase in subsequent periods, a pattern similar to that reported by Nguyen, Onnis and Rossi (2021) for UK data. Inflation falls more sharply during the ZLB period than in normal times. Although modest in magnitude, the real interest rate rises in the initial periods before declining as inflation begins to recover in later periods.

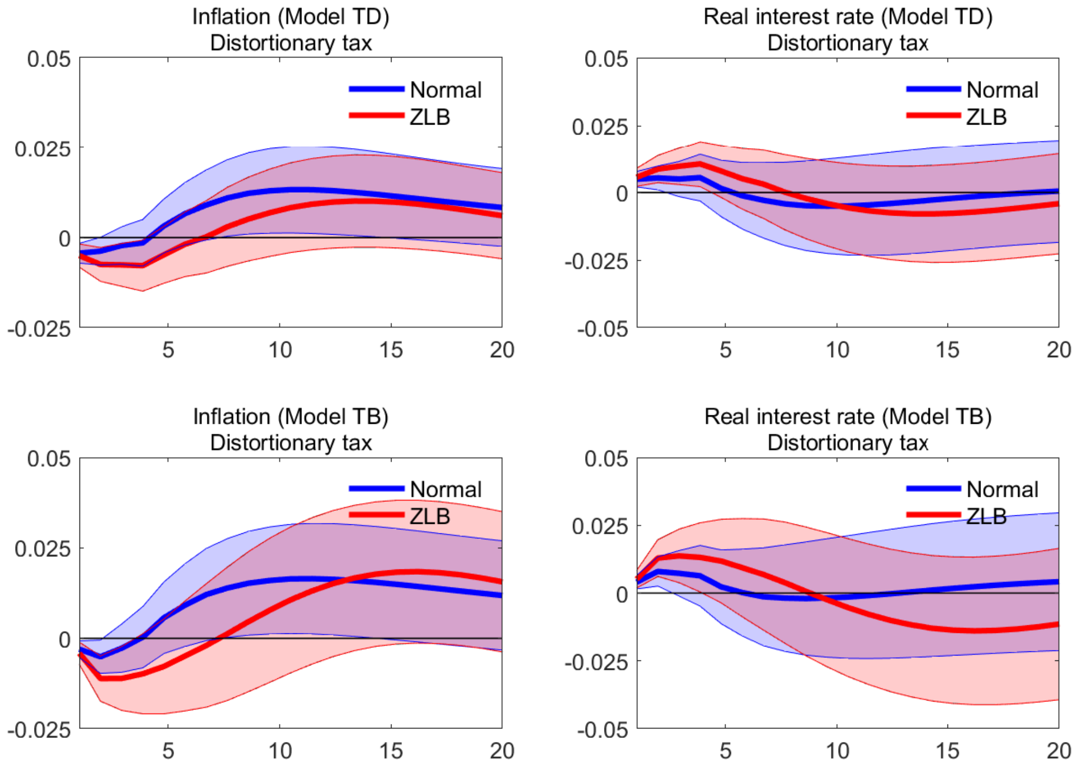


Figure 10. Inflation and real interest rate responses to a negative distortionary tax shock during the normal and ZLB periods

*Notes:* The blue solid lines represent the average posterior mean responses to a one-percentage-point decrease in distortionary tax revenue, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges for the normal period. The red solid lines and light-red shaded areas represent the corresponding quantities for the ZLB period.

Overall, both government spending and distortionary tax shocks produce an additional downward shift in the inflation response during the ZLB period relative to normal times. For government spending shocks, the attenuation of both the nominal interest rate and inflation at the ZLB largely offset each other, leaving the real interest rate broadly unchanged relative to normal times. For distortionary tax shocks, the picture is qualitatively different: since the nominal interest rate cannot be lowered further at the ZLB, the additional downward shift in inflation translates into a somewhat larger increase in the real interest rate relative to normal times, even if the difference remains modest in magnitude.

In the previous section, we documented that output responses to both government spending and distortionary tax shocks are nearly identical across normal and ZLB periods. For government spending shocks, the absence of a difference in real interest rate dynamics across regimes provides a natural explanation for the similar output responses. The case of tax cuts is more nuanced: although the real interest rate rises more at the ZLB than in normal times, output responses remain similar across the two regimes. This is partly because the real interest rate differential itself is modest in magnitude—too small to generate a noticeable difference in output responses. More broadly, it is worth noting that Garín, Lester and Sims (2019) document a related disconnect using US data: despite a somewhat larger decline in inflation at the ZLB in response to a positive productivity shock, output remains expansionary, suggesting that a larger real interest rate increase need not translate into weaker output at the ZLB. Taken together, these findings suggest that the real interest rate channel is not strongly operative for either fiscal instrument in the Japanese data, and that the ZLB period does not meaningfully alter fiscal transmission through this channel.

### 4.2 Demand shocks

The evidence presented above indicates that both government spending shocks, typically characterized as demand-side disturbances, and distortionary tax shocks, which operate primarily through supply-side channels, generate a downward shift in the inflation response during the ZLB period.[7] A natural question is whether this pattern of state dependence in inflation dynamics is specific to fiscal shocks or reflects a broader feature of the ZLB environment. To investigate, we next examine the inflation responses to demand and supply shocks.

[7] Canova, Gambetti and Pappa (2007) explicitly treats government spending shocks as real demand shocks. Mertens and Ravn (2012) emphasize the supply-side effects of tax changes.

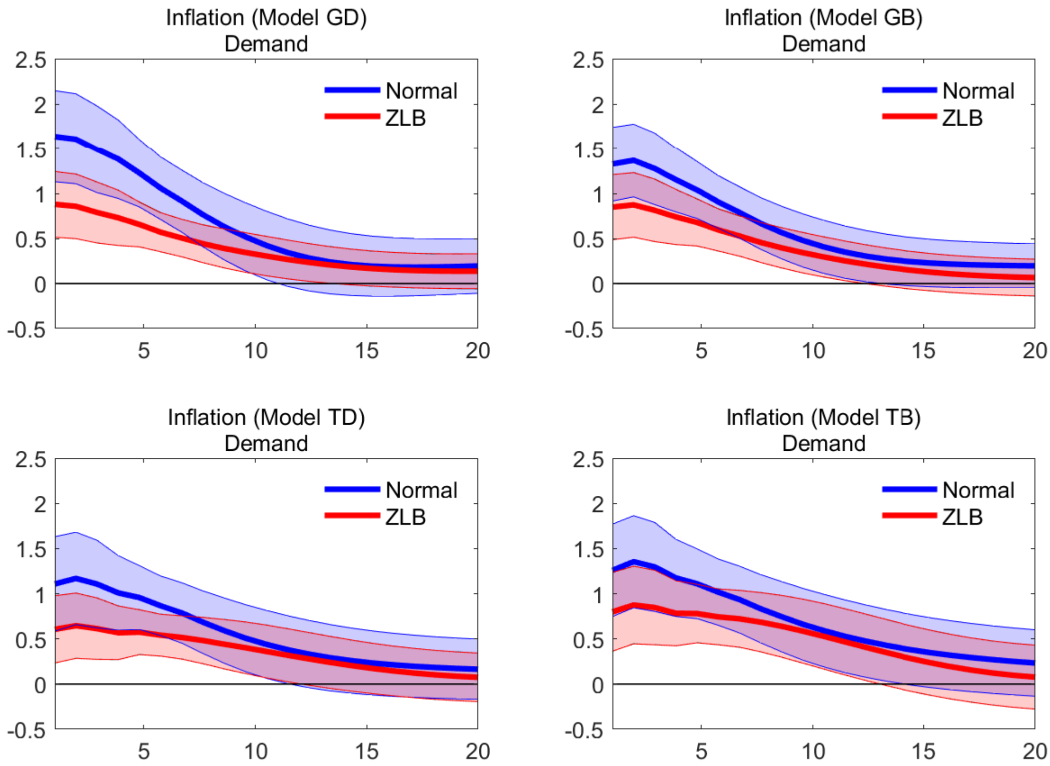


Figure 11. Inflation responses to a demand shock during the normal and ZLB periods

*Notes:* The blue solid lines represent the average posterior mean responses to a demand shock that increases output by one percentage point, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges for the normal period. The red solid lines and light-red shaded areas represent the corresponding quantities for the ZLB period.

We begin by examining the inflation response to a demand shock, as shown in Figure 11. The impulse response exhibits the familiar pattern documented in the literature (e.g., Canova, Gambetti and Pappa (2007)), rising on impact, reaching a slightly higher but still modest delayed peak, before gradually decaying over time. Across all four model specifications, inflation responds more weakly during the ZLB period than in normal times—a pattern qualitatively similar to that observed for government spending shocks. Notably, however, the downward shift in the inflation response is more pronounced for the demand shock than for the government spending shock.

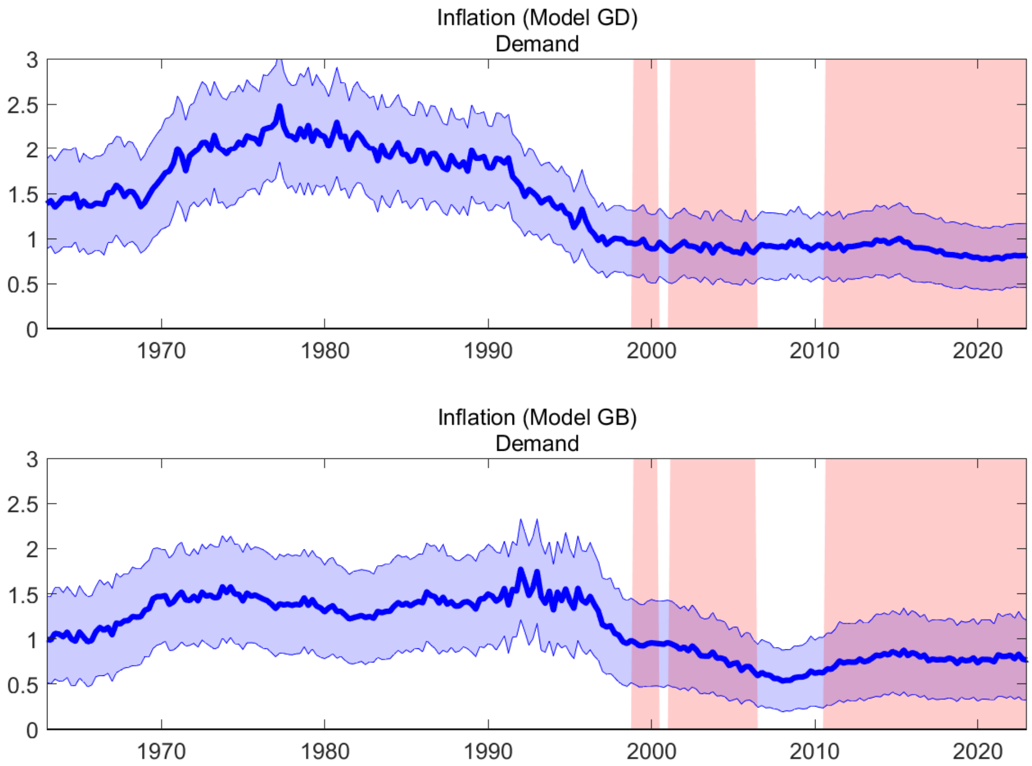


Figure 12. Evolution of impact response of inflation to a demand shock (Model Gs)

*Notes:* The blue solid lines represent the posterior mean responses on impact to a demand shock that increases output by one percentage point, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges. The light-red shaded areas indicate the ZLB period.

Figures 12 and 13 trace the time variation in the impact response of inflation to a demand shock for Model Gs and Model Ts, respectively. Although the precise time path differs somewhat across specifications, a common pattern emerges: the impact response of inflation is systematically smaller during the ZLB period than in normal times. The consistent attenuation of the inflation response across specifications suggests that the ZLB period is associated with a general weakening of inflation dynamics in response to demand shocks—not limited to government spending—fundamentally altering how such shocks transmit to inflation.

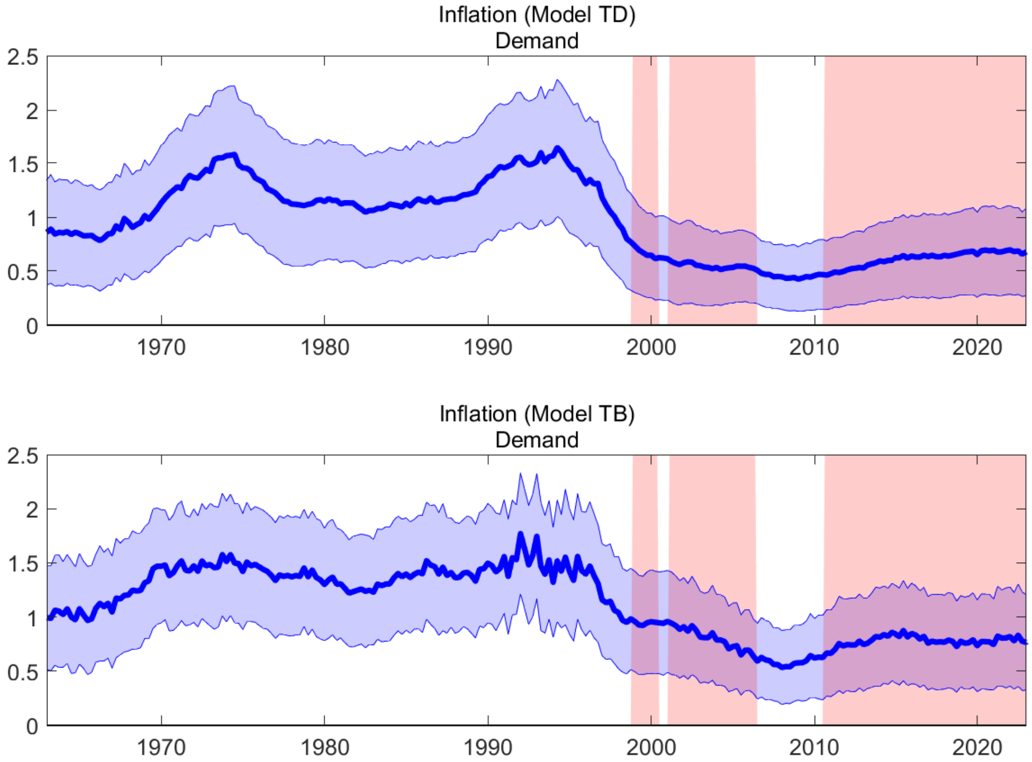


Figure 13. Evolution of impact response of inflation to a demand shock (Model Ts)

*Notes:* The blue solid lines represent the posterior mean responses on impact to a demand shock that increases output by one percentage point, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges. The light-red shaded areas indicate the ZLB period.

## 4.3 Supply shocks

We next examine the inflation response to a supply shock. Figure 14 compares the impulse responses between normal and ZLB periods. Across all four specifications, the response exhibits the familiar pattern documented in the literature, with inflation declining on impact over the first few quarters before gradually recovering (e.g., Dedola and Neri (2007)). In each specification, the initial disinflation is slightly larger during the ZLB period than in normal times—a pattern qualitatively similar to that observed for distortionary tax shocks, which also generate a downward shift in the inflation response at the ZLB. However, the magnitude of this shift is considerably smaller for the supply shock than for the tax shock.

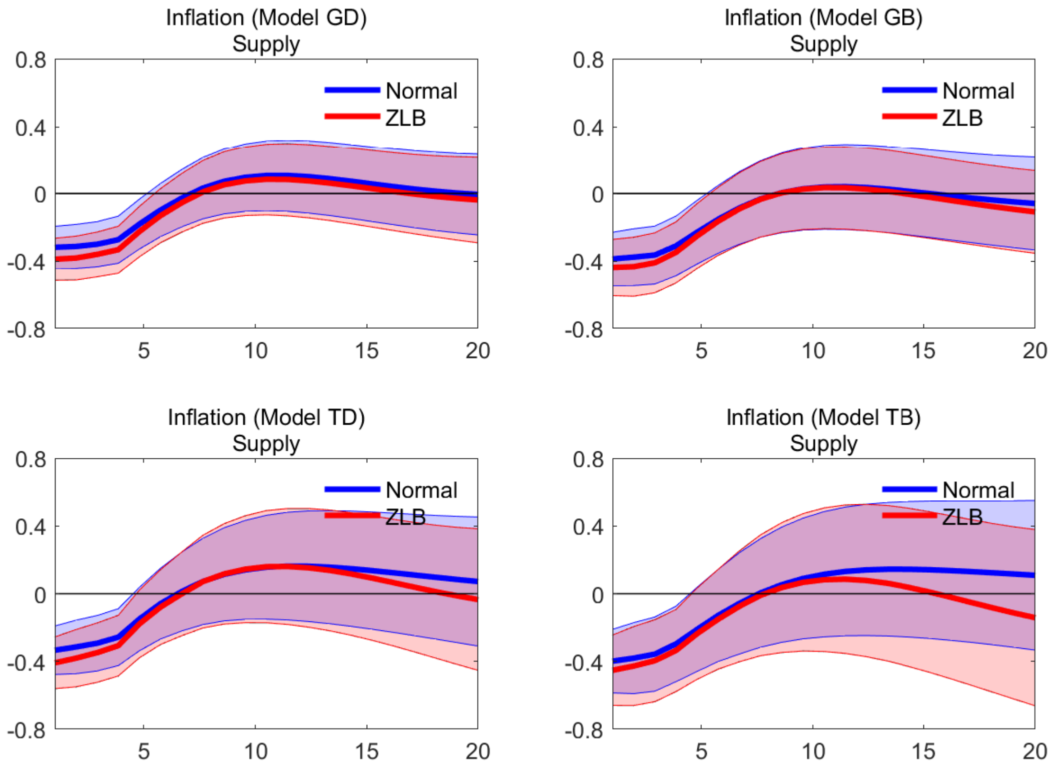


Figure 14. Inflation responses to a supply shock during the normal and ZLB periods

*Notes:* The blue solid lines represent the average posterior mean responses to a supply shock that increases output by one percentage point, and light-blue shaded areas represent the corresponding 16th–84th percentile ranges for the normal period. The red solid lines and light-red shaded areas represent the corresponding quantities for the ZLB period.

Figures 15 and 16 trace the time evolution of the impact response of inflation to a supply shock for Models Gs and Ts, respectively. As with demand shocks, a common feature emerges across specifications despite some variation in the precise time paths: the on-impact decline in inflation tends to be somewhat larger during the ZLB period than in normal times. Although modest in magnitude, this shift is consistent in direction across all specifications, further reinforcing the view that the ZLB fundamentally alters the transmission of supply shocks to inflation—a pattern that also aligns with the downward shift observed in the inflation response to a distortionary tax shock.

Taken together, the comparisons of average inflation responses to government spending, distortionary tax, demand, and supply shocks across regimes point to a remarkably consistent pattern: during the ZLB period, inflation responses exhibit a downward shift relative to normal times, regardless of the nature or source of the underlying shock. This pervasive attenuation is not specific to any particular type of shock, suggesting that it reflects a general feature of the ZLB environment. One possible interpretation is that the ZLB is associated with a structural change in the inflation formation process. While a definitive assessment of the underlying mechanism lies beyond the scope of the present paper, the consistency of this finding across diverse shock types and multiple model specifications lends it considerable empirical credibility.

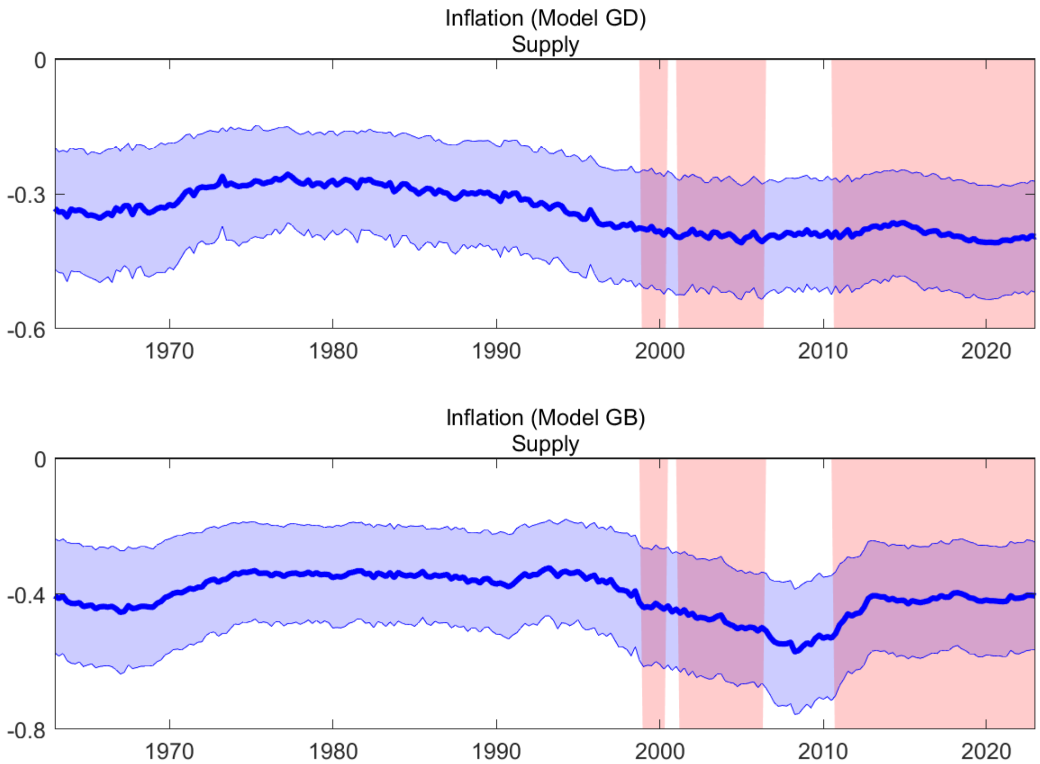


Figure 15. Evolution of impact response of inflation to a supply shock (Model Gs)

*Notes:* The blue solid lines represent the posterior mean responses on impact to a supply shock that increases output by one percentage point, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges. The light-red shaded areas indicate the ZLB period.

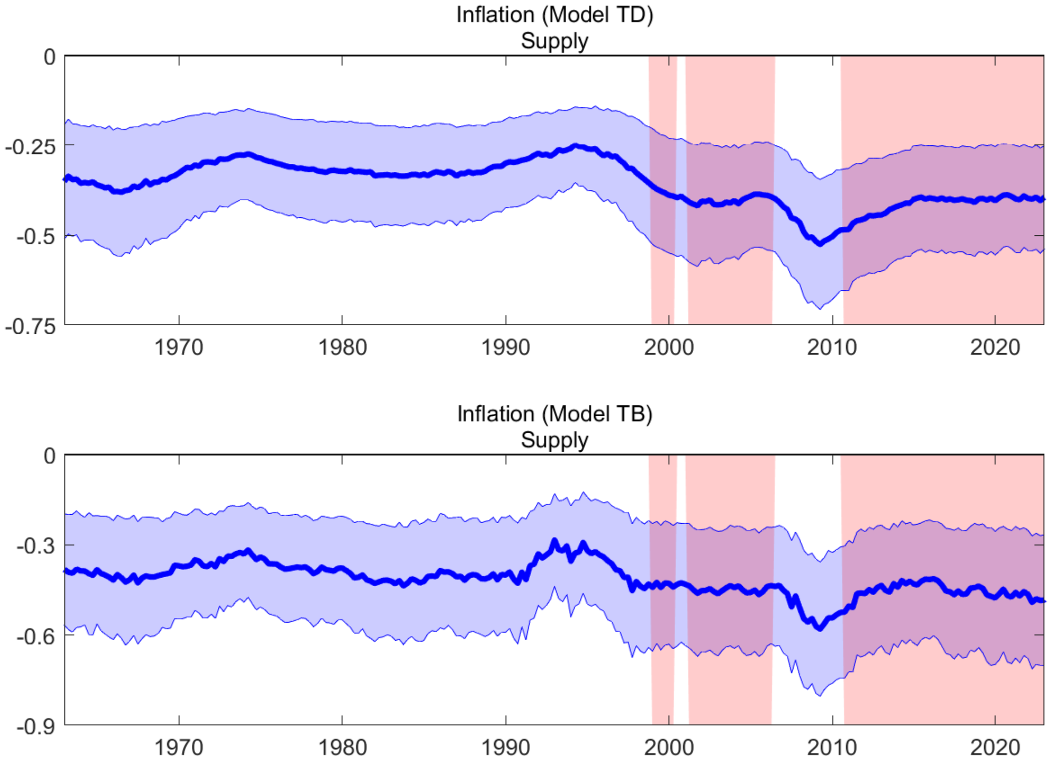


Figure 16. Evolution of impact response of inflation to a supply shock (Model Ts)

*Notes:* The blue solid lines represent the posterior mean responses on impact to a supply shock that increases output by one percentage point, and the light-blue shaded areas represent the corresponding 16th–84th percentile ranges. The light-red shaded areas indicate the ZLB period.

## 5 Conclusions

This paper reassesses the relevance of Japan's ZLB for fiscal policy transmission using a sign- and zero-restricted TVP-VAR that jointly identifies fiscal rules and structural shocks. Japan's prolonged ZLB experience alongside substantial debt accumulation makes it a compelling testing ground. This framework provides the first unified empirical analysis in which both fiscal transmission and the feedback behavior of the government are allowed to evolve over time. By estimating all combinations of two fiscal instruments—government spending and distortionary taxes—and two fiscal targets—the debt-to-GDP ratio and the primary balance-to-GDP ratio—we obtain robust and consistent results across specifications.

Three main findings emerge. First, output responses to fiscal policy shocks are broadly similar across normal and ZLB periods, contrary to the predictions of standard NK models. This is consistent with Debortoli, Galí and Gambetti (2020), who find that the ZLB was largely irrelevant for the US—at least with respect to output responses to fiscal policy shocks. Second, fiscal multipliers are more strongly correlated with the magnitude of fiscal adjustment than with the debt-to-GDP ratio, confirming the finding of Iwata and Iiboshi (2023) for the US. Unlike the US, however, fiscal adjustment in Japan shows no systematic strengthening over the sample period—as documented in Doi, Hoshi and Okimoto (2011)—and the estimated multipliers accordingly exhibit no corresponding downward trend. Third, inflation responses are dampened at the ZLB not only to fiscal policy shocks but also to demand and supply shocks. Government spending shocks raise inflation only weakly, a pattern that helps account for the muted real interest rate dynamics and, in turn, the similarity of output responses across regimes. Somewhat surprisingly, distortionary tax cuts generate a moderately greater decline in inflation at the ZLB, yet output multipliers remain similar across regimes. This is partly attributable to the small real interest rate differential, but more broadly accords with Garín, Lester and Sims (2019), who document a similar disconnect between inflation and output at the ZLB using US data. Demand and supply shocks mirror these patterns, producing muted inflation increases and slightly larger disinflation, respectively.

This paper contributes to the ZLB literature by documenting a broad downward shift in inflation responses, complementing the findings of Debortoli, Galí and Gambetti (2020) for the US and establishing a ZLB-specific regularity not previously documented. Notably, while the ZLB proves largely irrelevant for output dynamics, it appears consequential for inflation—a contrast that sets the Japanese experience apart from that of the US. The underlying mechanism, however, remains an open question: whether the dampened inflation responses reflect a structural change in price-setting behavior, a weakening of demand pressures, or a downward de-anchoring of inflation expectations. Disentangling these competing explanations calls for a more structural approach, and we leave this to future work. Such an investigation would help transform the empirical regularity documented here into a fuller structural account of how the ZLB shapes the transmission of fiscal policy in Japan.

## Appendix: Data Description

The TVP-VAR models are estimated using quarterly data for the Japanese economy from 1962Q1 to 2023Q4. We construct extended historical series to ensure sufficient sample length for stable estimation of the TVP-VAR and for meaningful comparisons between normal and ZLB periods.

**National accounts data** All variables, except the nominal interest rate, public debt, and labor force, are obtained from the National Accounts of Japan. The accounts are reported under the 2008 SNA (System of National Accounts) beginning in 1994, the 1993 SNA from 1980, and the 1968 SNA from 1955. Because provisional GDP estimates provide 2008 SNA expenditure components back to 1980, we splice these to the earlier 1968 SNA series. Other variables are similarly constructed by splicing across the 1968, 1993, and 2008 SNA versions. When growth rates are available, we backcast levels using the older version's growth rates and the 2008 SNA level. When growth rates are not available, we splice levels directly over the overlapping periods.

**Nominal interest rate** To identify the monetary policy rule during the period outside the ZLB, we use the current policy rate as the nominal interest rate throughout the estimation period. The Bank of Japan adopted open market operations in 1995 and began targeting the uncollateralized overnight call rate as the operating target for money market operations. Because the call rate is unavailable prior to the second half of 1985, we splice it with the official discount rate, the previously used policy rate. The official discount rate is level adjusted to match the call rate over the overlapping sample.

**Public debt** The public debt-to-GDP ratio prior to 1982Q2 is constructed by linearly interpolating the annual IMF public debt series to obtain quarterly observations. From 1982Q2 onward, the ratio is computed directly using public debt from the Bank of Japan and nominal

GDP from the Cabinet Office. Because the two series coincide closely at the splice point, no level adjustment is required.

**Variable definitions and sources** Unless otherwise noted, data are obtained from the National Accounts, Economic and Social Research Institute, Cabinet Office of Japan.

- GDP
  - GDP (Expenditure approach), real and nominal, quarterly, seasonally adjusted.
- Government spending
  - Sum of government consumption and public investment, real and nominal, quarterly, seasonally adjusted.
- Inflation rate
  - Year-over-year percent change in the GDP deflator, quarterly, seasonally adjusted.
- Nominal interest rate
  - Basic discount rate and basic loan rate, percent per annum, monthly (Source: Bank of Japan).
  - Call rate, uncollateralized overnight, average, percent per annum, monthly (Source: Bank of Japan).
- Distortionary tax revenue
  - Sum of taxes on production and imports and current taxes on income, wealth, etc., quarterly, seasonally adjusted and converted to real terms by the authors.
- Primary balance
  - Sum of net lending/net borrowing and interest paid, minus interest received, general government, nominal, quarterly, seasonally adjusted by the authors. For the components without quarterly series, we construct quarterly data using linear interpolation.
- Public debt
  - The historical public debt database, nominal, annual (Source: IMF).
  - National government debt, total, nominal, monthly (Source: Bank of Japan).
- Labor Force
  - Labour force, total, seasonally adjusted series (Source: Labour Force Survey, Statistics Bureau, Ministry of Internal Affairs and Communications)

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