Government Spending Multipliers under the Zero Lower Bound: Evidence from Japan*

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Abstract

Using a rich data set on government spending forecasts, we estimate the effects of unexpected changes in government spending both when the nominal interest rate is near the zero lower bound (ZLB) and outside of the ZLB period (normal period) in Japan. The output multiplier in the ZLB period is significantly different from that in the normal period: it is 1.5 on impact in the ZLB period, and 0.6 in the normal period. We estimate that government spending shocks increase both private consumption and investment during the ZLB period but crowd them out in the normal period. We argue that these results are not driven by the amount of slack in the economy. We estimate a positive but mild inflation response in both periods. A simple New Keynesian model can generate a persistent ZLB period and reproduce some features of our empirical findings if the ZLB period is caused by self-fullfiling state of low confidence (deflationary trap).

JEL classification: E32, E62, E5.

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1 Introduction

How large is the output multiplier, defined as the percentage increase in output in response to an increase in government spending by one percent of GDP, during periods when nominal interest rates are at the zero lower bound? The global financial crisis of 2007-2008, which forced the central banks in many developed countries to keep their short-term nominal interest rates close to the zero lower bound, brought this question to the center of policy debates.[1]

The theoretical literature provides a wide range of answers. In a simple real business cycle model such as Baxter and King (1993), the output multiplier is below one and independent of the zero lower bound. In New Keynesian models, the output multiplier in the zero lower bound (ZLB) period ranges from a negative to a large positive number. For example, Woodford (2010), Eggertsson (2011), and Christiano, Eichenbaum, and Rebelo (2011) show that the multiplier can be substantially larger than one in a standard New Keynesian model in which the ZLB period is caused by a fundamental shock. In this environment, temporary government spending is inflationary, which stimulates private consumption and investment by decreasing the real interest rate. As a result, the output multiplier can be well above three, which is much larger than the prediction of this model under active monetary policy. At the same time, Mertens and Ravn (2014) argue that the output multiplier during the ZLB period is quite small in a New Keynesian model in which the zero bound period is caused by a non-fundamental confidence shock. In this situation, government spending shocks are deflationary, which increases real interest rates and reduces private consumption and investment. As a result, the output multiplier during the ZLB period is lower than one, it can even be negative, and it is lower than it is outside of the ZLB period.

Empirical estimation of the multiplier when the nominal interest rate is at the zero bound is challenging. First, in most countries, the ZLB periods are short, potentially leading to large sampling errors in multiplier estimation. Second, the ZLB periods often coincide with large recessions, making it difficult to separate evidence of the ZLB period from that of the recession.[2] Third, several important ZLB episodes coincide with World War II, when rationing was in place, which can compound the multiplier estimation.[3]

[1]As of this writing, a number of countries, including Denmark, Sweden, and Switzerland, have reduced their short-term nominal interest rates to less than zero, raising the question whether the zero bound is a constraint on monetary policy. Thus, the term "zero interest rate policy" might seem more appropriate than "zero lower bound." In this paper, we will use term "zero lower bound" in the sense of "zero interest rate policy." See, Rognlie (2015) for a theoretical analysis of monetary policy with negative interest rates.

[2]Using post-WWII data in the United States, Auerbach and Gorodnichenko (2012a) provide evidence that the multiplier is significantly larger in recession than in expansion.

[3]Ramey and Zubairy (2016) extend U.S. data back to 1889, which includes ZLB periods, and find that the high

This paper contributes to the literature by estimating the effects of government spending shocks on the aggregate economy when the nominal interest rate is at the zero lower bound (in the ZLB period) and outside of the ZLB period (in the normal period) using Japanese data from the period 1980Q1–2014Q1. We use Japan as our example because Japan has more information on the ZLB periods than other countries. The nominal interest rate in Japan has been near the zero bound since 1995Q4. During this period, Japan has gone through four business cycles, so we can distinguish between evidence coming from the ZLB period and evidence coming from periods of recession. We exploit a rich dataset that includes not only standard macroeconomic variables but also forecasts of government spending and other variables such as inflation to study the behavior of ex ante real interest rates after a government spending shock.

Our identification strategy is as follows. First, to identify exogenous changes in government spending, we assume that government spending does not react to output changes within the same quarter. This assumption proposed by Blanchard and Perotti (2002) relies on the idea that government needs time to decide on and implement changes in government spending.[4] We then investigate whether our results change if we assume a non-zero elasticity of contemporaneous reaction of government spending to output. Second, we control for expected changes in government spending using quarterly forecasts of future government spending produced by the Japanese Center for Economic Research (JCER), as well as predicted changes in government spending based on past macroeconomic variables. The motivation for including expectations is that people may begin reacting in anticipation of future government spending changes, which can bias the multiplier estimated without removing expected government spending changes. In fact, we find that omitting forecast data when identifying government spending shocks changes the estimated multiplier in a non-trivial way, implying that it is important to control for the expectations effect.

Using Jorda (2005) local projection method, we find that the output multiplier is 1.5 on impact in the ZLB period and 0.6 in the normal period. Over longer horizons, the output multiplier increases to greater than two in the ZLB period, and becomes negative in the normal period. The

value of the multiplier in the ZLB period is sensitive to the inclusion of the World War II period in the sample.

[4]This assumption was criticized in the case of the United States (Barro and Redlick, 2011; Ramey, 2011b). Non-defense spending can contemporaneously be affected by changes in aggregate output because a large part of state and local spending in the United States automatically responds to cyclical variations in state and local revenues. The issue may be less problematic in Japan. Prefecture and local spending is not restricted by prefecture and local contemporaneous revenues because the central government can finance a large part of local spending and the local government can issue debt. The central government can also issue debt to finance their spending, especially for public investment, which is a volatile component of total government spending. Therefore, the identification assumption may be less problematic for Japan than for the United States.

At the same time, defense spending is small and varies little over time in Japan, making it difficult to use the approach advocated in Barro and Redlick (2011) and Ramey (2011b).

differences between the ZLB and the normal periods multipliers of output are statistically significant at 5% significance level. This result holds even when we add several data series to control for real-time information. For example, we add several forecast data series including forecast of output to control for the information timing and the possibility that current government spending and output may react to future expected changes in output. We also consider additional sources of real time information such as the IMF, the OECD, and the Japanese Government Outlook.

We estimate that government spending shocks increase both private consumption and investment during the ZLB period. In contrast, private consumption and investment are crowded out in the normal period. The unemployment rate decreases in the ZLB period, but it does not respond significantly during the normal period. The differences between the ZLB and the normal periods for consumption, investment and unemployment multipliers are statistically significant. We find mixed evidence on the inflation responses. While the responses of inflation measured by the GDP deflator are mild in both periods, CPI inflation responds more positively and significantly in the ZLB period than in the normal period. Expected inflation measured by the one-period ahead forecast of inflation increases, though insignificantly, in both periods. The short term nominal interest rate in the normal period increases significantly while it remains constant in the ZLB period. This result implies that the real interest rate does not increase as much in the ZLB period as in the normal period in response to government spending shocks.

Our analysis suggests that the difference between the multiplier in the ZLB period and in the normal period is not driven by the effects of government spending in recessions. We exploit information from Japanese data which contain several business cycles during the ZLB period. The Japanese economy was in recession half of the time during the normal period but only a third of the time during the ZLB period. Therefore the multiplier during the ZLB period would be smaller than the multiplier during the normal period if the only fundamental difference is that the multipliers are larger in recessions. However, we find a larger multiplier in the ZLB period than in the normal period.

We relax one of our identification assumptions to consider the possibility that government spending has an automatic stabilizer component–i.e., it responds to the output changes within a quarter. To do this, we assume a non-zero elasticity of contemporaneous government spending reaction to output. The automatic contemporaneous reaction of government spending to output biases the multiplier estimates. However, if the elasticity of this reaction is the same in both the ZLB and normal periods, the bias will be approximately the same across the two periods, and our estimates of the difference in multipliers would remain roughly unchanged. To explain the difference in the multipliers in the ZLB period and the normal period, the elasticity of government spending in response to changes in current output has to be substantially different in the two periods.

We compare our empirical results to the predictions of a simple New Keynesian model calibrated using Japanese data. We use the estimated path of government spending response after a spending shock to compute the dynamic response of the model economy. We obtain the following results. First, in the normal period, the model generates output multipliers close to empirical estimates at horizons of up to a year. Second, the model generates cumulative output and inflation multipliers at different horizons close to our ZLB period empirical estimates if the ZLB period is caused by self-fulfilling low level of confidence. At the same time, the model in which the ZLB period is caused by a fundamental shock does not match our empirical estimates under our calibration.

Related Literature. Our paper contributes to a large body of work in macroeconomics that estimates the effects of government spending shocks on the economy. For example, Blanchard and Perotti (2002), Ramey (2011b), Barro and Redlick (2011), Fisher and Peters (2010) and many other papers identify the multipliers for the United States using different identification schemes such as the institutional information approach in a structural vector autoregression, military spending, war dates, and stock returns. Ramey (2011a) provides a comprehensive survey. The papers in this literature often find the output multiplier to be smaller than one. We also estimate the output multiplier to be smaller than one in the normal period in Japan.[5]

Recent literature estimates the output multiplier in different states of the economy. For example, Auerbach and Gorodnichenko (2012a,b, 2014) explore the difference in the output multiplier during recessions and expansions using U.S., OECD, and Japanese data. Here, we focus instead on comparing the multipliers in the zero lower bound period and in the normal period. We argue that the difference is not due to the nonlinear effects of government spending during expansion and recession. We also exploit more data on Japan. For example, we include quarterly forecast data of government spending in order to control for expectations throughout our sample between 1980Q1 and 2014Q1. Furthermore, we adjust the published government spending data to exclude transfers.

Few papers estimate the output multiplier in the zero lower bound periods. Ramey (2011b) estimates that the multiplier is not higher in the period between 1939 and 1951 in the United States. Crafts and Mills (2012) estimate that the multiplier is below one in the U.K. during the

[5] Watanabe, Tomoyoshi, and Arata (2010) estimated the output multiplier in Japan between 1965 and 2004. Their estimates range between 0.69 and 0.95 depending on specification.

1922-1938 period when the nominal interest rate is near zero. We present the evidence from a more recent and long ZLB period in Japan.

Our work complements that of Ramey and Zubairy (2016) who examine United States data from 1889, which include two ZLB periods, 1932Q2-1951Q1 and 2008Q4-2013Q4. They argue that the main government spending shocks during the ZLB periods occurred after the start of World War II and at the start of the Korean War in 1950, which could confound the effects of government spending shocks in states with rationing with those in states with the ZLB. When they exclude World War II from the sample, the multiplier is higher during the ZLB periods than during the normal periods. Instead, we present new evidence using Japanese data with a long spell of the ZLB occurring in the recent period. There were no wars in the economy in the period we consider. We also avoid the periods when the gold standard and the fixed nominal exchange rate regime were in effect, which can affect the estimates of the multipliers. We examine both output and other aggregate variables such as consumption, investment, inflation, and interest rates. Importantly, we exploit the fact there were several business cycles during the ZLB period in Japan to argue that our estimated multipliers are not driven by the difference in government spending multipliers during recessions and booms.

Some recent literature uses cross-regional panel data and various "natural experiments" to estimate the regional multipliers by keeping national monetary policy fixed. For example, Nakamura and Steinsson (2014) estimate the regional output multiplier for states within the United States, and Bruckner and Tuladhar (2014) do the same for Japanese prefectures. Chodorow-Reich et al. (2012) and Shoag (2010) estimate a positive effect on employment after an increase in state spending. Cohen, Coval, and Malloy (2011) found a decline in employment and investment after positive state spending changes. However, Nakamura and Steinsson (2014), Farhi and Werning (2012), and Ramey (2011a) note that the regional multiplier is not the same as the aggregate multiplier in the ZLB period. The reason is that the long-term real interest rate falls in the ZLB period, it does not fall in regions with a common monetary policy. One needs a model to map the regional multiplier to aggregate multiplier. In contrast, we directly estimate the aggregate multiplier in the ZLB period.

The paper is also related to the literature that tests the ZLB predictions of New Keynesian models. Our model and analyses build on the work of Woodford (2010), Eggertsson (2011), and Christiano, Eichenbaum, and Rebelo (2011). Wieland (2013) examines whether negative aggregate supply shocks, proxied by oil price shocks and the Great East Japan earthquake, are expansionary during the ZLB periods. He finds that oil price spikes decrease output but also decrease the real interest rate in the ZLB period. He concludes that these results are not consistent with a calibrated standard New Keynesian model with a fundamental-driven ZLB period. We compare the simple New Keynesian model predictions about the effects of government spending shocks with our empirical results. A simple New Keynesian model calibrated with Japanese data produces output and inflation multipliers close to our estimates during the ZLB period. However, the model misses the estimated multipliers in the normal period.

Our study also complements the work of Dupor and Li (2015) by focusing on the responses of both output and inflation to government spending shocks. Dupor and Li (2015) argue that to generate a large output multiplier when the interest rate is non-responsive to inflation in a calibrated New Keynesian model, inflation must respond by a lot, which is not consistent with the vector autoregression evidence in the United States.. We show that the output multiplier can be large and equal our empirical estimates even without a large inflation response in a new Keynesian model calibrated with Japanese data. The key difference between Dupor and Li (2015) and our calibration is the degree of monetary policy responsiveness to shocks: we assume that the nominal interest rate does not react to shocks during the ZLB period at all, while they assume a weak reaction of the nominal interest rate to inflation, making it harder for inflation to reduce the real interest rate.

The rest of the paper proceeds as follows. Section 2 explains the identification strategy. In Section 3, we discuss the data we use. Section 4 presents the baseline results. Section 5 discusses how we distinguish the effects of government spending during the ZLB period from those during recessions. In Section 6, we discuss the importance of using forecasts data. Section 7 presents the results of robustness checks. Section 8 compares predictions of a simple New Keynesian model with our empirical results. Section 9 concludes.

2 Measurement of Multipliers

Changes in government spending affects aggregate output, and changes in aggregate output can contemporaneously affect government spending. To extract variations in government spending unrelated to contemporaneous changes in aggregate output, we assume that government spending does not respond to changes in output within a quarter because it takes policymakers time to decide on, approve, and implement changes in fiscal policy. Blanchard and Perotti (2002) and subsequent studies by Auerbach and Gorodnichenko (2012a,b), Ilzetzki, Mendoza, and Végh (2013), and others have used this assumption to identify exogenous government spending changes.

Another way to identify government spending changes unrelated to aggregate output is to use large military-spending build-ups (Barro, 1981; Barro and Redlick, 2011; Ramey and Zubairy, 2016). However, Japanese military spending accounts for only one percent of GDP, and it varies little over time potentially leading to large sampling errors. At the same time, non-military spending in Japan represents a sizable portion of GDP, and it is more volatile than in the United States.

We remove the anticipated component of government spending changes using a measure of government spending forecast to compute *unexpected* exogenous changes in government spending. As emphasized by previous literature such as Ramey (2011a), it is important to control for expected changes in government spending.[6] The reason is that forward-looking agents can respond to news about future government spending before it materializes. The estimation without controlling for expected changes in government spending does not capture all of the effects of government spending and biases the results. Since past macroeconomic variables such as government spending and output may not be sufficient to fully capture expected changes in government spending, it is potentially important to include government spending forecasts data to control for the predicted government spending variation.

We implement the above strategy to measure the effects of government spending shocks using the local projection method (Jorda, 2005), which estimates impulse response functions by directly projecting a variable of interest on lags of variables usually entering a vector autoregression (VAR).[7] This method has some advantages over a VAR analysis, as well as some disadvantages. One advantage of the local projection method is that it does not impose linear restrictions on the dynamic patterns of responses. Additionally, it does not require the same variables to be used in each equation, which is important in computing fiscal multipliers as we explain below. At the same time, when a vector autoregression correctly captures the data-generating process, it produces more efficient estimates.

To compute multipliers, we use the following two-step estimation procedure. First, we identify the unexpected innovations in government spending by estimating the following specification:

$$\Delta \ln G_t = \alpha + \gamma F_{t-1} \Delta \ln G_t + \psi(L) y_{t-1} + \epsilon_t, \tag{1}$$

[6] Alesina, Favero, and Giavazzi (2015) measure the effects of shocks to fiscal plans to control for anticipated changes as well as expected duration of unanticipated changes.

[7] See Jorda (2005) and Stock and Watson (2007) for more details. This implementation has been used in Auerbach and Gorodnichenko (2012a,b), Ramey and Zubairy (2016) and others.

where $\Delta \ln G_t$ is the log difference of government spending, $F_{t-1}\Delta \ln G_t$ is the one-period-ahead forecast of $\Delta \ln G_t$, y_{t-1} is a vector of controls, and $\psi(L)$ is a lag operator. All variables are in real per capita terms. The estimated residuals, $\widehat{\epsilon}_t$, are the unexpected government spending changes orthogonal to the expected component of government spending and information in the control variables, so $\widehat{\epsilon}_t$ is our government spending shocks. If forecast $F_{t-1}\Delta \ln G_t$ incorporates all of the information available to agents, there is no need to add controls $\psi(L)y_{t-1}$ as additional regressors in equation (1). However, to account for the possibility that households' information set may be different from that of forecasters due to the timing of our forecast data as we discuss below, we include a vector of controls in the estimation.[8] Additionally, we note that forecast data for government spending does not correspond exactly with our "adjusted" government spending as explained in Section 3, so we include forecast data on the right hand side in the estimation instead of using forecast errors or assuming $\gamma = 1$. In what follows, we define "the standard controls" to be growth rate of government spending, growth rate of tax revenue, growth rate of output, and the unemployment rate. Note that we include the unemployment rate in the standard controls following Barro (1981) and Barro and Redlick (2011), who find that the unemployment rate contains important information about the state of the business cycle relative to output. We add four lags of the control variables in the regressions.

In the second step, we estimate a series of regression at each horizon h:

$$x_{t+h} = \alpha_h^x + \beta_h^x shock_t + \psi_h^x(L)y_{t-1} + \epsilon_{t+h}^x, \quad \text{for } h = 0, 1, 2, ... \tag{2}$$

where x_t is a variable of interest, $shock_t$ is the series of government spending shocks, proxied by the estimated $\widehat{\epsilon}_t$ in equation (1), $\psi_h^x(L)$ is a lag operator. Then, β_h^x is the response of x at horizon h to an unexpected government spending shock. When we estimate equation (2) for output, $\psi_h^x(L)y_{t-1}$ are lags of the standard controls. For all other variables of interest, $\psi_h^x(L)y_{t-1}$ are lags of the standard controls as well as lags of the variable of interest. We specify separately when we include additional controls.[9] Note that regression (2) uses generated regressor $shock_t$. In Section 4.3.3, we show that correcting for the generated regressors problem does not change our results significantly. In a related environment, Coibion and Gorodnichenko (2012) also demonstrated that correcting for

[8] We exclude the controls in one of the robustness exercises and the baseline results do not change.

[9] The Jorda projection method does not require us to use control variables in equation (2) if $shock_t$ is exogenous and serially uncorrelated. However, additional controls help reduce the variance of residuals making the standard errors of β_h^x smaller. This is why we add $\psi_h^x(L)y_{t-1}$. We also verify that the results do not change significantly if we include lags of $shock_t$ (see Figure A8).

the generated regressors problem has no significant effect on results.

The effects of government spending on output in both the normal and the ZLB periods can be estimated using equation (2) for output, $\frac{Y_{t+h}-Y_{t-1}}{Y_{t-1}} \approx \ln Y_{t+h} - \ln Y_{t-1}$, and government spending, $\frac{G_{t+h}-G_{t-1}}{Y_{t-1}} \approx (\ln G_{t+h} - \ln G_{t-1}) \frac{G_{t-1}}{Y_{t-1}}$. The first variable, output, is similar to the one used in the standard vector autoregression analysis. The second variable, government spending, is converted to the "same units" as output from percentage changes by multiplying by G/Y at each point in time.[10] With output and government spending expressed in the same units, the output multiplier at each horizon h, M_h, is defined as the cumulative output gain relative to government spending during a given period. This definition is consistent with that in Mountford and Uhlig (2009) and Ramey and Zubairy (2016). The cumulative multiplier can be easily estimated using the following IV regression at each horizon h:

$$\sum_{j=0}^{h} x_{t+j} = \alpha_h^x + M_h \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \psi_h^x(L) y_{t-1} + \epsilon_{t+h}^x, \tag{3}$$

where the instrument for $\sum_{j=0}^{h} \frac{G_{t+j}-G_{t-1}}{Y_{t-1}}$ is $shock_t$. In equation (3), $\sum_{j=0}^{h} x_{t+j}$ is the sum of the variable x from t to $t+h$ and $\sum_{j=0}^{h} \frac{G_{t+j}-G_{t-1}}{Y_{t-1}}$ is the sum of government spending from t to $t+h$ normalized by output. The estimated M_h is the cumulative multiplier and its standard errors can be easily calculated in a standard IV estimation. We use heteroskedasticity and autocorrelation consistent (HAC) standard errors that are robust to both arbitrary heteroskedasticity and autocorrelation.[11]

3 Data

We use Japanese quarterly data for the period between 1980Q1 and 2014Q1 in the baseline estimation. There are several benefits of using Japanese data over other countries including the United States to examine the effects of government spending on the economy in the ZLB period. First, Japan has more information about the ZLB period than other countries. As plotted in Figure 1, the overnight nominal interest rate in Japan has stayed near zero since the fourth quarter of 1995, providing approximately 20 years of data on the ZLB period.

Second, within the ZLB period, Japan has experienced both recessions and booms, so we can

[10] We also convert government spending and output changes to the same units by dividing them by potential output. We discuss the results using this alternative normalization in Section 4.3.3.

[11] We choose automatic bandwidth selection in the estimation.

potentially tell if the estimated multiplier is driven by the nonlinear effects of government spending in different states of the business cycle. In Figure 1, we plot output per capita growth rate in Japan, taken from the National Accounts, along with the recession dates classified by the Cabinet Office.[12] There are four business cycles after 1995 and three in the period between 1980 and 1995. This feature makes Japan an important case to study; the ZLB periods in other countries often coincide with recessions or wars, making it difficult to distinguish the effects of government spending in the ZLB period from those during other events.

We exploit a rich quarterly dataset that includes forecasts of government spending. Unlike the United States, Japan has short surveys of professional forecasters that contain little or no information about government spending. Therefore, previous studies on Japan such as that by Auerbach and Gorodnichenko (2014) rely on semiannual forecasts from the OECD starting in 1985 and the IMF starting in 2003 to make inferences about unexpected changes in government spending. An important difference in our study is that we obtain quarterly forecast data produced by the Japan Center for Economic Research (JCER) for many macroeconomic variables including government spending, output and the GDP deflator. This dataset starts in 1967Q1 and contains several forecast horizons, ranging from nowcast to eight quarters ahead forecasts (forecast horizons longer than four quarters are not published regularly).[13] The JCER publishes this dataset every quarter except in some years when the forecast is released in three of the four quarters.[14] In the quarters without updated forecast data, we assume that there were no revisions to the forecasts: the one-quarter ahead-forecast is replaced by the two-quarters-ahead forecast published in the previous quarter, i.e.: $F_{t-1}\Delta \ln G_t \equiv F_{t-2}\Delta \ln G_t = F_{t-2}[\ln G_t - \ln G_{t-1}]$, where $F_{t-j}\Delta \ln G_t$ denotes the forecast of quarterly growth rate of per capita government spending at horizon j.[15] We plot in Figure 2 our one-quarter ahead forecast of the four quarter growth rate of government spending, $F_{t-1}\Delta \ln G_{t-4,t}$, along with the realized government spending, $\Delta \ln G_{t-4,t}$.[16] Although the forecast misses some of the fluctuations such as those in the early 2000s, the one-quarter ahead forecast tracks the actual data relatively well. This suggests that the realized government spending may

[12] In the Cabinet Office, individual members classify recession in a similar manner as that used by the National Bureau of Economic Research in the United States. They then agree on the classification collectively. More information can be found at http://www.esri.cao.go.jp/jp/stat/di/150724hiduke.html (in Japanese).

[13] The JCER data also contain the initial release and up to seven subsequent revisions of realized data.

[14] The periods with three forecasts a year are: 1972 to 1995, 1999 to 2002, and 2004 to 2006.

[15] An alternative way to fill in the missing data by nowcast or an average of nowcast $F_t\Delta \ln G_t$ and two-quarter ahead forecast $F_{t-2}\Delta \ln G_t$. We find that using these alternative series for forecasts yields the same results as the baseline.

[16] Note that we construct the one-quarter-ahead forecast of the four quarter growth rate of government spending using real-time data, i.e. forecasters do not have the final release of government spending in $t-4$ when making their forecast at time $t-1$.

have some predictable components and including these forecast data in the estimation can help us obtain a purer measure of unexpected government spending shocks. We show in Section 4.3.1 that these forecast data are indeed important to control for the timing of the spending and can affect the estimated multipliers.

Consistent with previous literature on fiscal multipliers, we construct data for government spending (or government purchases) as the sum of adjusted government consumption and public investment. Adjusted government consumption is calculated as total government consumption excluding transfer of goods.[17] As plotted in Figure 1, government spending in Japan is volatile over the entire period between 1980Q2 and 2014Q1. The standard deviation of the growth rate of government spending is 1.73 times larger than that of output in Japan, compared to 1.21 in the United States, which potentially helps to precisely estimate the effects of government spending. Tax data, taken from the National Accounts starting in 1980Q1, are the sum of direct and indirect taxes less subsidies.[18] All variables are per capita and deflated by the GDP deflator. We list in Appendix B the data sources for all variables used in the paper.

We define the normal period as 1980Q1 to 1995Q3 and the zero lower bound period as 1995Q4 to 2014Q1. Although the earliest start date for our data with forecast is 1967Q1, we choose the start of the normal period as 1980Q1 for three reasons. First, the definition of government spending data changes in 1980. Second, although we adjust our government spending series and extend the data to before 1980, there is a break in the monetary policy regime when Japan switched from a fixed nominal exchange rate regime to a floating exchange rate regime in 1973. According to Ilzetzki, Mendoza, and Végh (2013), the fiscal multipliers in a fixed exchange rate regime are higher than those in a flexible exchange rate regime. Since we focus on periods with homogeneous monetary policy, we exclude the fixed exchange rate regime period before 1973. Third, the 1973 oil price crisis creates a large change in the price level and affects real government spending, which can bias the estimates of the multipliers.[19] Therefore, we restrict our attention to the normal period,

[17] After 1980, the total government consumption includes both transfers (payment to households for medical services is an example) and consumption (such as payment for textbooks is an example). Therefore, we construct the "adjusted government consumption" by excluding transfers from total government consumption from 1980. The sum of the "adjusted government consumption" and public investment is about 18% of GDP on average. Prior to 1980, Japan adopted the System of National Account 1968, which has a different definition of government consumption. Our adjusted government consumption series is similar to the data on government spending prior to 1980. Japan also has data for "actual final" government consumption after 1980. The definition of this series is the most narrow and it accounts for less than 8% of output, so the sum of "actual final government consumption" and public investment is about 14% of GDP. We note that the estimates using actual final government spending or the unadjusted measure of government consumption are similar to the baseline results.

[18] This series is almost identical to the series constructed by adding taxes on production and imports and taxes on income and wealth etc. less subsidies from Doi, Hoshi, and Okimoto (2011).

[19] To the extent that government spending is determined in nominal terms, a large unexpected change in the

1980Q1-1995Q3. We note that the baseline result presented below does not change if the normal period starts after the oil price shocks in 1975Q1. The zero lower bound period is from 1995Q4 to 2014Q1, when the short-term nominal interest rate falls to 0.25% and stays under 0.6%. We then estimate the multipliers using equation (3) for both periods.

4 Output Multipliers During and Outside of the Zero Lower Bound

This section first discusses the extracted shocks from our estimation and its relevance as an instrument for estimating multipliers. We then present the estimates of output multipliers in the zero lower bound and the normal periods, including the robustness of the estimates to alternative specifications.

4.1 Extracted Shocks

Figure 3 plots the extracted government spending shocks, $\widehat{\epsilon}_t$, from equation (1). There is no noticeable difference between the normal period and the ZLB period in terms of the sizes and the frequency of the shocks. Additionally, government spending variation during the ZLB period occurs not only during recessions but also during expansions. The extracted shocks are substantially volatile over time.

Since our extracted government spending shocks $\widehat{\epsilon}_t$ are the instrument for the estimates of the multipliers in equation (3), we test whether the instrument is relevant. To take into account possible serial correlations of the errors, we follow Ramey and Zubairy (2016) and apply the weak instrument tests in Olea and Pfueger (2013) for every horizons in the normal and the ZLB periods. Figure 4 plots the F-statistics obtained in the tests along with the thresholds for 5% and 10% critical values for testing the null hypothesis that the two stage least square bias exceeds 10% of the OLS bias.[20] In both the normal and the ZLB periods, the estimated shocks are highly relevant in very short horizons. The F-statistics fall below the thresholds in horizons longer than one year. This result is consistent with the tests conducted on U.S. data by Ramey and Zubairy (2016), who also find that the shocks identified from the Blanchard and Perotti (2002) identification have lower

current price level can bias the identification of government spending shocks using nominal government spending deflated by the current price level. We find that the estimated multiplier for the normal period starting in 1973Q1 is slightly higher than the baseline estimates in longer horizons. However, when we control for this change by deflating nominal government spending by a smoothed measure of inflation or one quarter lagged inflation, the estimate for the multiplier is similar to that in the baseline.

[20] The first stage regression includes all the standard controls in four lags.

F-statistics in longer horizons. To take into account that the instrument may be weak in longer horizons, we later test the differences in the output multipliers using both standard statistics and Anderson and Rubin (1949) statistics.

4.2 Baseline Estimates

We first consider the responses of government spending and output to an unexpected increase in government spending by one percent of output in period 0. As plotted in Figure 5, output increases on impact and up to two years in the ZLB period; it increases slightly on impact and then decreases significantly in the normal period. The one standard deviation confidence interval bands for these estimates do not overlap with each other in shorter horizons. At the same time, the responses of government spending in the normal period are similar to those in the ZLB period.

To take into account the paths of government spending in the normal period and in the ZLB period, we estimate the output multipliers. Figure 5 plots the output multipliers and their confidence bands in both normal and ZLB periods. The output multiplier in the ZLB period is significantly larger than zero in all horizons. It is larger than one and larger than that in the normal period. The output multiplier in the normal period is 0.6 on impact. This estimate is in line with previous estimates for the United States and other countries. The output multiplier in the ZLB period is larger: it is 1.5 on impact – more than twice as large as the on-impact multiplier in the normal period. This multiplier is larger than that documented in the baseline estimation of Ramey and Zubairy (2016), but it is similar to their estimate when they exclude the WWII period. The on-impact multipliers in both the normal period and the ZLB period are significantly larger than zero. The difference between the multipliers in the normal period and in the ZLB period are pronounced over all horizons. While the output multiplier in the normal period turns negative after the five quarters, the output multiplier in the ZLB period increases to about two after one year. The one-standard-deviation confidence bands of the multipliers do not overlap each other. Note that the results of the weak instrument test suggest that the estimates in longer horizons can be biased.

To formally test whether the multipliers in these two periods are statistically different from each other, we estimate the following specification:

$$\sum_{j=0}^{h} x_{t+j} = I_{t-1}^{ZLB} \times \left[\alpha_{A,h} + M_{A,h} \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \psi_{A,h}(L) y_{t-1}\right]$$
$$+ \left(1 - I_{t-1}^{ZLB}\right) \times \left[\alpha_{B,h} + M_{B,h} \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \psi_{B,h}(L) y_{t-1}\right] + \epsilon_{t+h}^{x}, \quad \text{for } h = 1, 2, ...,$$

where I_t is one if the economy is in the ZLB in period t.[21] We test the hypothesis that the multipliers in the ZLB and the normal periods are the same, i.e. $M_{A,h} = M_{B,h}$. Table 1 reports HAC p-values for this test over different horizons. We also include Anderson and Rubin (1949) p-values to account for the fact that the instrument may be weak in longer horizons. We plot in Figure 5 the differences between the multipliers for all horizons between zero and ten quarters and their confidence bands. The 95% confidence interval does not include zero. The Anderson and Rubin (1949) p-values are slightly higher than the standard p-values but they are all below 0.1, suggesting that the difference is statistically significant in both short and longer horizons.

4.3 Robustness

This section examines the importance of real-time information and other sources of information in estimating the output multiplier. We also show that the estimated multiplier is robust to other specifications of equation (3).

4.3.1 Importance of Real-time Information

Controlling for forecasts data is important for our analysis. To show this, we compare the baseline estimates of the output multipliers in the normal period and in the ZLB period with those estimated without forecast data, i.e. we extract $shock_t$ from (3) without controlling for forecast.[22] The results are displayed in the first panel of Table 2. Controlling for the information that agents have about future government spending tends to make the output multipliers larger in the normal period and to a lesser extent in the ZLB period. This result is similar to the findings for the United States in Auerbach and Gorodnichenko (2012a). Without controlling for expectations, we would have overstated the effects of government spending in the ZLB period relative to that in the normal

[21] Ramey and Zubairy (2016) also use this specification to estimate their state-dependent multipliers. If we use the indicator for the current period, I_t, instead of I_{t-1}, the results do not change.

[22] We plot the estimated multiplier without forecast data and the baseline in Appendix Figure A6.

period: government spending is almost five times more expansionary in the ZLB period than in the normal period on impact. These results suggest that forecast data can change the estimated multipliers in a non-trivial way and that it is important to control for the expectational effects.[23]

4.3.2 Additional Predictors of Future Government Spending

Since it is important that we include forecast data in our baseline estimation to obtain unexpected government spending shocks, we investigate whether our results are robust to adding more variables to the set of controls in equation (1).

Other JCER Forecasts. First, we add the government spending component of the fiscal packages approved by the Japanese government to our first step. These fiscal packages can contain important information on the stance of fiscal policy.[24] Second, we add a one-year-ahead forecast of the annual government spending growth rate, $F_t \Delta \ln G_{t,t+4}$, to our first step to control for the possibility that agents know the amount of annual spending but do not know the exact timing. Third, we add one- to four-quarters ahead forecasts of the quarterly government spending growth rate. Fourth, we include the one-quarter-ahead forecast of output as a variable that can summarize the expected future state of the economy. Fifth, we include the one-year-ahead forecast of the annual output growth rate. Because expected government spending can potentially react to expected changes in output, it may be important to control for expected output.[25]

We report in Table 2 the estimated multipliers in these cases.[26] The point estimates of the output multipliers in both the normal period and the ZLB period estimated with additional control variables are close to those in the baseline. The one standard deviation confidence intervals for the multipliers in the normal period do not overlap with those in the ZLB periods in most cases.

[23] We also examine the predictability of government spending shocks without controlling for forecast. The results are in Appendix Figure A5.

[24] The Japanese government implements fiscal packages from time to time. These packages often contain several measures such as tax cut, spending, and special transfer. We use the spending component of these packages when these fiscal packages are passed. We also use the information from the supplementary budget for the central government, which are additional budget items approved during a fiscal year. Appendix Figure A2 plots these data for the supplementary budget and fiscal packages as a percent of GDP. The estimated multipliers when these data are added as controls are similar to the baseline.

[25] We perform several additional robustness exercises. We include other variables that can contain important information about public investment. For example, we add four lags of contracted public work orders, orders received for public construction, and the excess returns of construction sector stock prices to control for expected government investment. We also considered variables that can include information on the state of the economy and the fiscal stance such as real exchange rates and the index of leading indicators. The results remain similar to the baseline estimates. In Appendix Figure A4, we report the estimates of cumulative multipliers of output in the specification with orders received for public construction and contracted public work orders.

[26] We plot the results for all horizons in Figure A3.

For example, when we add a one-year-ahead forecast of the annual government spending growth rate, the estimates for the multipliers in the ZLB period are significantly larger than those in the normal period. Overall, these results suggest that the JCER forecast of future government spending that we use in our baseline estimation contains much of the information present in the additional controls. Furthermore, these results provide additional evidence that the output multiplier in the ZLB period is substantially different from that in the normal period.

Other Forecast Sources. We next add other sources of forecast into our estimation of unexpected government spending shocks. In particular, the OECD Economic Outlook has released annual forecasts for government spending in May and November every year since 1983.[27] Other sources of government spending forecast data is the Japanese Government Outlook database, which has published a government spending forecast once a year in December since 1980, and the quarterly IMF forecast which starts in 2003.[28] We re-estimate (1) to include all of the available one-quarter ahead forecast of government spending from these sources and compute the multipliers for different horizons in the second to last panel of Table 2. The multipliers in the normal period estimated with additional data are similar to those in the baseline. Although the estimates for the multipliers in the ZLB period are slightly higher than the baseline, the difference is small. The differences between the multipliers in the ZLB period and in the normal period are significant over the shorter horizons. Overall, these results are in line with the baseline estimation.

4.3.3 Variations of the Baseline Specification

We show that the baseline results are robust to other estimation specifications.

First, we estimate a version of specification (2) with a quadratic trend since time series estimates can be sensitive to trends. Table 3 displays the output multipliers in this case. We find that the multipliers estimated with a trend are similar to those in the baseline, although the output multiplier estimated with a trend in the normal time is somewhat larger in longer horizons than in the baseline.

Second, we perform an alternative transformation of government spending and output by divid-

[27]We thank Yuriy Gorodnichenko for providing us the OECD and IMF data.

[28]We plot in Figure A1 the actual cumulative growth rate of government spending along with its one-quarter ahead JCER and the OECD forecasts, and the Government Outlook. This plot suggests that the JCER and the OECD forecasts track the actual government spending well before 2000 but less so after 2000. Notably, the JCER overestimates the growth rate of government spending around 2005 while the OECD underestimates it in this same period. The JCER forecast tracks the movement of government spending somewhat more accurate than the Government Outlook, especially before 2000.

ing them by potential output to calculate the multipliers. The motivation for this approach is as follows: In our baseline estimation, we convert government spending from the percentage changes to dollar changes using the value of the government spending–output ratio at each point in time, rather than using sample averages. A potential problem of the baseline transformation is that the cyclicality of output can bias the estimated multiplier. Formally, we estimate equation (3) for $(Y_{t+h} - Y_{t-1})/\overline{Y}_{t-1}$ and $(G_{t+h} - G_{t-1})/\overline{Y}_{t-1}$, where $\overline{Y}_t$ is potential output, estimated using the standard HP filter. The multipliers estimated in this case, reported in Table 3, are essentially the same as our baseline.

Third, one potential concern with our estimation is that we use the residuals $\widehat{\epsilon}_t$ of equation (1) to proxy for $shock_t$ without taking into account the uncertainty of the estimates. We address this concern and implement a one-step estimation of the effects of unexpected government spending on output. Formally, we estimate a version of equation (3) as follows:

$$\sum_{j=0}^{h} x_{t+j} = \alpha_h^x + M_h \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \gamma_h^x F_{t-1} \Delta \ln G_t + \psi_h^x(L) y_{t-1} + \epsilon_{t+h}^x, \quad \text{for } h = 0, 1, 2, ...$$

where the instrument for $\sum_{j=0}^{h} \frac{G_{t+j}-G_{t-1}}{Y_{t-1}}$ is simply given by current growth rate of government spending, since the regression includes for both forecast and lags of control variables. This approach amounts to the same interpretation in our two-step procedure. The results obtained from this estimation are shown in Table 3. The multipliers are virtually identical to our baseline estimates. The standard errors of the one-step and the baseline estimations are also similar.

Finally, we estimate a 15-year rolling-window regression version of our baseline specification between 1967Q1 and 2014Q1. Figure 12 plots the multiplier for different horizons. The multiplier is time-varying. Between 1967 and 1984, the cumulative output multiplier is about 1.2 on impact and increases to about 3 in the two year horizon. This result suggests that the multiplier may be larger than one in the 1960s and 1970s when the Japanese economy was under the fixed exchange rate regime. After the collapse of the fixed exchange rate regime, the multiplier is below unity for all years up to 1997. This result is consistent with the finding in Ilzetzki, Mendoza, and Végh (2013) that the multiplier is larger in the fixed exchange rate regime than in the flexible exchange rate regime. The multiplier becomes higher than unity starting in 1995. This tendency is similar across all horizons. Overall, the rolling regression results are consistent with our baseline estimates and suggests that the multiplier is larger in the ZLB period than in the periods up to 1995.[29]

[29] We also estimate the output multipliers from a five variable structural vector autoregression (SVAR). The five

5 The Multipliers of Other Variables

We now examine the multipliers of private aggregate consumption, investment, and unemployment rate in the ZLB period and compare them with those in the normal period.[30]

5.1 Private Consumption and Investment

The effects of government spending shocks on private consumption and investment can be estimated by applying (3) for consumption and investment. For example, the consumption multiplier can be estimated by the following set of IV regressions:

$$\sum_{j=0}^{h} \frac{C_{t+j} - C_{t-1}}{C_{t-1}} = \alpha_h^C + M_h^C \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{C_{t-1}} + \psi_h^C(L) y_{t-1} + \epsilon_{t+h}^x, \quad \text{for } h = 0, 1, 2, ..., \tag{4}$$

where the instrument for the cumulative changes in government spending is $shock_t$. We add four lags of consumption to the vector of controls. The private investment multiplier are estimated and defined in the same manner.[31]

Figure 6 plots the cumulative multipliers of consumption and investment to government spending for all horizons. The multiplier for consumption is positive and significantly different from zero in the ZLB period; it is negative and statistically different from zero in the normal period at one- and two-year horizon. The investment multiplier in the ZLB period is also positive and higher than that in the normal period in most horizons other than on impact. We formally test and report in Table 4 the differences between the consumption and investment multipliers in the normal period and in the ZLB period. The consumption multiplier is significantly larger in the ZLB period than in the normal period, less than 1% significance level. The difference in the investment multipliers is not significant on impact, but it is statistically significant with the p-value about 0.01 after four and eight quarters.[32]

variables are forecast of government spending, government spending, tax revenue and output growth rates, and the unemployment rate. We include four lags in the SVAR, similar to the baseline. The estimated output multipliers in both the ZLB period and the normal period are plotted in Appendix Figure A7. The SVAR results are similar to the baseline estimation using the local projection method. The differences in the multipliers are also statistically significant as in the baseline estimation.

[30] We also estimate the multipliers for net exports and the real effective exchange rate in Japan. The results are reported in Appendix Figure A11.

[31] Private consumption is the final consumption including transfer from the government. Private investment is the sum of residential and nonresidential investment. The results are the same if we use the final consumption data without transfer from the government.

[32] We also estimate the multipliers for components of consumption and investment including durables, nondurables, semi-durables, and services consumption as well as residential and non-residential investment using the same specification. The results are reported in Appendix Figure A12.

5.2 Unemployment

We examine the responses of the labor market to a government spending shock by estimating a version of equation (3) for the unemployment rate. The multiplier of the unemployment rate is defined as the cumulative percentage point changes in unemployment rate in response to a change in government spending by one percent of output at each horizon, in the ZLB period and in the normal period.[33] We plot the cumulative multipliers of the unemployment rate in Figure 6. During the normal period, the unemployment rate does not respond much after an increase in government spending by one percent of output. In contrast, in the ZLB period, the unemployment rate decreases substantially by 0.1 percentage point on impact and further to 0.5 percentage point a year after an increase in spending by one percent of output. The drop in the unemployment rate in the ZLB period is significantly different from zero for all horizons. Furthermore, the confidence intervals of the unemployment rate multipliers in the ZLB and the normal periods do not overlap for all horizons. We formally test the difference in the unemployment rate multipliers. As reported in Table 5, we find that the difference is significant at the 5% level for horizons between one and eight quarters after the shock.

To sum up, using Japanese data between 1980Q1 and 2014Q1, we find that:

1. The output multiplier in the ZLB period is larger than that in the normal period. Government spending is more than twice as expansionary in the ZLB period as in the normal period.
2. Government spending crowds private consumption and investment in during the ZLB period, but it crowds them out in the normal period.
3. Unemployment rate decreases in the ZLB period significantly more than in the normal period after a government spending shock.

6 What Explains Larger Multipliers During the Zero Lower Bound?

We investigate several hypotheses that can explain the larger multipliers in the ZLB period. We first examine the mechanism in New Keynesian models by documenting the effects of government spending on inflation, expected inflation and nominal interest rates. We then discuss whether the

[33]This measure of the multiplier is analogous to our definition of the output multiplier. Alternatively, one can define the unemployment multiplier by the absolute change in unemployment rate after h quarters normalized by the cumulative government spending changes. Both measures of unemployment multipliers imply significantly different behavior of the unemployment rate in the normal and the ZLB periods. See Monacelli, Perotti, and Trigari (2010) for more on empirical and theoretical analyses of unemployment multipliers.

effects of government spending in recessions, or the differences in the tax rates in the two periods can explain our empirical findings. We relax the Blanchard-Perotti identification assumption to check how it may explain the differences in the multipliers in the two periods. Lastly, we show that the composition of government spending in the two periods may not explain the difference in the multipliers.

6.1 The New Keynesian Mechanism

A response of current and future inflation is an important mechanism in the standard New Keynesian model to generate a large output multiplier in the ZLB period. Therefore, we investigate this mechanism empirically in this section. We note that Section 7 examines whether a theoretical New Keynesian model calibrated using Japanese data can deliver these empirical findings. Denoting inflation by π_t, we estimate the multipliers of inflation to government spending shocks from equation (3) with the variable of interest x_{t+j} being the inflation rate π_{t+j}, and the vector of controls includes four lags of the inflation rate, the standard controls and the five-year nominal interest rate.[34] We estimate the responses of both GDP deflator inflation and CPI inflation.

We find mixed evidence on the response of inflation to unexpected government spending shocks: while the responses of the GDP deflator inflation are mild and not statistically different from zero in both the normal and the ZLB periods, the responses of CPI inflation are more significantly positive in the ZLB period than those in the normal period. Figure 7 plots the multipliers of these two measures of inflation in both the normal and ZLB periods. Inflation calculated from the GDP deflator responds little to a positive government spending shock in both periods. As reported in Table 5, an increase in government spending by one percent of output leads to a 0.02 percentage point decrease in inflation in the normal period and 0.01 percentage point in the ZLB period on impact. The cumulative inflation multiplier is about 0.1 percentage point in the two-year horizon in the ZLB period but negative in the normal period. Overall, the responses of inflation is mild in both periods and the confidence intervals include zero in most horizons. The multipliers of CPI inflation are, however, significantly more positive than those of inflation calculated from the GDP deflator in the ZLB period. CPI inflation in the ZLB period responds more positively and is significantly larger than zero on impact: an increase in government spending by one percent of output leads to a 0.4 percentage point increase in CPI inflation in the ZLB period on impact. The

[34] The results do not change if we use other nominal interest rates or the yield of the ten-year bond. The results also do not change if we do not include current interest rate in the controls.

response of CPI inflation in the normal period is -0.2 percentage point.[35] This result suggests that there is some evidence of a positive inflation response in the ZLB period.

We also estimate the responses of the four-quarter ahead annual inflation forecast. In the estimation, we control for four lags of the dependent variables, the standard controls and the five-year nominal interest rate. Figure 7 plots the responses of the four quarter ahead expected annual inflation calculated from both a forecast of the GDP deflator and the CPI to an increase in government spending by one percent of output. The on-impact responses of inflation expectations calculated from the GDP deflator are negative but statistically insignificant in both the normal period and the ZLB period. Inflation expectations are negative in the normal period while they are positive in the ZLB period in the next two quarters. As reported in Table 5, inflation expectation increases by 0.65 percentage points after two quarters in the ZLB period but decreases by 0.25 percentage point in the normal period. The differences between inflation expectations in the normal period and those in the ZLB period are also present when we look at the CPI. The on-impact responses of the CPI inflation expectations are statistically insignificantly different from zero in both periods. However, in the next few horizons, the CPI inflation expectation responses are positive and significantly different from zero in the ZLB period but are negative in the normal period.

The last panel of Figure 7 plots the impulse responses of the overnight (short-term) nominal interest rate and the ten-year interest rate to an increase in government spending by one percent of output, respectively. These responses are estimated by adding to the baseline specification (2) four lags of the dependent variable, the standard controls and the inflation rate. We include $trend_t$ to control for the observed decline in nominal interest rate over time.[36] We report the results estimated with a quadratic trend, but the results do not change if we include a linear trend. In the normal period, the short term interest rate increases to 0.37 percentage point for the one year

[35] To examine the robustness of the response of CPI inflation in the normal period and in the ZLB period, we estimate the responses of core CPI inflation. Furthermore, since both total CPI and core CPI are affected by the consumption tax hikes in 1989 and 1997, we consider the responses of inflation adjusted for these consumption tax changes following Hayashi and Koeda (2014): We adjust the annual inflation rates from April 1989 to March 1990 and from April 1997 to March 1998 for the consumption tax increases, then recover the CPI level consistent with the adjusted annual inflation rates. The responses of inflation calculated from these series are plotted in Figure A10. The inflation responses using either tax-adjusted inflation or the core CPI resemble the baseline. The tax-adjusted CPI inflation responses are positive and significant on impact in the ZLB period. When food and energy are excluded, the core CPI inflation also increases significantly in the ZLB period on impact.

[36] There is a clear trend in the nominal interest rate in the normal period. If we exclude trend in the specification, as reported in Appendix Figure A13, the main difference from our results here is that the responses of the nominal interest rate in the normal period are not as positive. Note that we do not include trend in other variables since adding trend does not alter the results.

horizon in response to an increase in government spending by one percent of output. The response of the ten-year nominal interest rate is not statistically different from zero and only increases after ten quarters. In the ZLB period, the short-term interest rate does not react to government spending shocks, consistent with the idea that the central bank is not responsive to government spending shocks during the ZLB period. The long-term interest rate varies in the ZLB in response to a spending shock, which may be due to changes in the bond risk premium or changes in expectations about future monetary policy. These results together with the response of expected inflation suggest that the short-term real interest rate increases more in the normal period than in the ZLB period.

6.2 Output Multipliers in the ZLB Period and in Recessions

Recent studies by Auerbach and Gorodnichenko (2012a,b) find that the output multiplier is larger than one in recessions and smaller than one in expansions using U.S. and OECD data. As the ZLB period often coincides with recessions, it is important to differentiate evidence from the ZLB period and evidence from recessions. This section shows that our estimated multiplier in the ZLB period may not be attributed to the large effects of government spending in recessions. We also examine the possibility that the whole ZLB period coincides with a long period of elevated slack, which can also potentially explain our results.

We first estimate the multipliers during booms and recessions in Japan between 1980Q1 and 2014Q1 by estimating a state-dependent version of the baseline specification, similar to Ramey and Zubairy (2016):

$$\sum_{j=0}^{h} x_{t+j} = I_{t-1}^{Recession} \times \left[\alpha_{A,h} + M_{A,h} \cdot \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{G_{t-1}} + \psi^A(L) y_{t-1} \right] + \left(1 - I_{t-1}^{Recession}\right) \times \left[\alpha_{B,h} + M_{B,h} \cdot \frac{G_{t+j} - G_{t-1}}{G_{t-1}} + \psi^B(L) y_{t-1} \right] + \epsilon_{t+h} \text{ for } h = 1, 2, ...,$$

where $I_{t-1}^{Recession}$ is one if the economy is in recession in period $t-1$ and zero otherwise, and $\frac{G_{t+j}-G_{t-1}}{G_{t-1}}$ is instrumented by our measure of $shock_t$.[37] The recession indicator is based on the Cabinet Office of Japan classification of trough periods. Figure 8 plots the output multipliers in recessions and expansions and the difference between these two multipliers. The on-impact output multiplier in recessions is as large as 2.3, and it is 0.8 in expansions. The differences between the multipliers in

[37] We also estimate the multipliers in recessions and booms in each subperiod but the confidence interval is large due to the small sample, especially for recessions.

recessions and in expansions are smaller for horizons longer than three quarters. The differences are also not statistically significant over longer horizons, as reported in Table 3. This result for Japan is qualitatively similar to that for the United States in Auerbach and Gorodnichenko (2012a) but weaker in significance. The results in this section do not change if we use the peak-to-trough recession classification by the OECD.

Since the multiplier in recessions is larger than that in expansions, to explain the larger multiplier in the ZLB period, we would need more recessions in the ZLB than in the normal period. However, this is not the case. Japan is not always in recession during the ZLB period 1995Q4 and 2014Q1, as can be seen in Figure 1. The number of quarters in recession are slightly higher in the normal period than in the ZLB period: 45% of the quarters in the normal period are in recession but only 30% in the ZLB period. This implies that the multiplier during the ZLB period should be smaller than the multiplier during the normal period if the only fundamental difference is between the values of the multiplier in recessions and expansions. More precisely, the extracted shocks plotted in Figure 3 suggest that most government spending variations during the ZLB do not occur during recessions, and most government spending variations during the normal period do not occur during booms. Therefore, it is unlikely that the difference in multipliers across recessions and booms can explain the difference in multipliers between the ZLB and normal periods that we estimate. [38]

Our analysis above does not rule out the possibility that the whole ZLB period coincides with a long period of slack, which can potentially explain our results. Figure 9 plots the unemployment rate in Japan from 1980 to 2014. The unemployment rate was between 2% and 3.5% in the 1980-1995 period, and it varied between 3.5% and 5.5% during the ZLB period. Higher unemployment rate in the latter period may signal a permanently higher level of slack in the economy.

Recent theoretical literature emphasizes that the amount of slack in the economy affects the size of fiscal multipliers. For example, Michaillat (2014) shows that the public-employment multiplier is larger when labor market tightness is lower: one additional worker hired by the government crowds out only a few private sector workers. Our measure of public spending includes both purchases of privately produced goods and goods produced in the public sector. So it is reasonable to expect that the output multiplier that we measure should change with the tightness of the labor market.

Despite the higher average unemployment rate during the ZLB period, Japan does not seem

[38]It is possible that the multiplier is bigger in deeper recessions. However, it is not the case that Japan has experienced more severe recessions during the ZLB period than in the normal period.

to exhibit a structural break in labor market tightness. Figure 10 plots labor market tightness, defined as the ratio of job openings to applicants, in Japan.[39] There is a large increase in labor market tightness between 1986 and 1990 that could lead to a smaller estimated output multiplier in the normal period. However, there is also a sizable increase in labor market tightness between 2002 and 2007, and after 2009 that could also lower the estimated multiplier during the ZLB period. As a result, it is not obvious that the observed labor market tightness behavior in the two periods can explain the difference in our estimated multipliers.

6.3 Tax Rate

Another possible explanation for the difference in the output multipliers in the ZLB period and in the normal period is that tax rates respond differently in the two periods. We estimate the responses of average tax rates in the normal period and in the ZLB period after a government spending shock. We define the average tax rate T_t as a ratio of tax revenues to GDP. The cumulative multipliers of the average tax rate are estimated from equation (3), with the variable of interest T_{t+h}. We plot the multipliers of the average tax rate in the last panel of Figure 6. We find that in response to an increase in government spending by one percent of output, the average tax rate increases in both the normal period and the ZLB period. The increase in the tax rate is larger in the ZLB period than in the normal period for horizons longer than one year. For example, the cumulative response of the average tax rate is 0.5 percentage points in the ZLB period after two quarters, and it is near zero in the normal period. Over the longer horizons, the cumulative responses of the average tax rate is more negative in the normal period than in the ZLB period. This result suggests that to the extent that tax is contractionary, the different responses of the average tax rate in the two periods are not likely to explain the observed difference in the output multipliers.

6.4 Automatic Stabilizer

To obtain our main results, we assumed that variations in output do not automatically change current government spending–i.e., the elasticity of government spending with respect to current output $\eta_{G,Y}$ is zero. The idea behind this assumption, as Blanchard and Perotti (2002) discuss, is that the government needs some time to change government spending in response to current economic conditions. To examine whether this assumption can explain the difference in the multipliers between the ZLB period and the normal period, we assume, following Caldara and Kamps (2012),

[39] The data sources are listed in Appendix B.

a non-zero elasticity of government spending to current output. Specifically, we change the first step of our empirical procedure, equation (1), as follows

$$\Delta \ln G_t = \alpha + \eta_{G,Y} \Delta \ln Y_t + \gamma F_{t-1} \Delta \ln G_t + \psi(L) y_{t-1} + \epsilon_t,$$

and fix $\eta_{G,Y}$ to be either -0.1 or 0.1. Consistent with the analysis of Caldara and Kamps (2012), we find that the on-impact multiplier is lower than our baseline estimates when $\eta_{G,Y} = 0.1$. The on-impact multipliers in the ZLB and normal periods are 1.4 and 0.5, respectively. The on-impact multipliers in both periods are higher than the baseline when the elasticity, $\eta_{G,Y} = -0.1$: 1.7 in the ZLB period and 0.7 in the normal period, respectively. This result suggests that our estimated output multiplier is biased if the true elasticity $\eta_{G,Y}$ is non-zero. However, the non-zero elasticity is not important for the difference between the multipliers in the normal and the ZLB periods: the difference is quite stable when we vary $\eta_{G,Y}$, implying that the failure of the Blanchard and Perotti (2002) identification assumption alone may not explain the difference in the estimated output multipliers across the normal and ZLB periods.[40]

6.5 Composition of Government Spending

Another potential explanation for the difference in the multipliers between the ZLB period and the normal period is that the investment-consumption composition of government spending has changed over time. To examine this explanation, we document the responses of government investment and consumption to government spending shocks and plot the results in Figure 11. In response to an increase in total government spending by one percent of output, government investment increases by 0.8 percent of output on impact for both the ZLB period and the normal period. The paths of the responses of government investment are similar across the two periods. The paths of government consumption are also similar across these two periods with an increase of about 0.2 percent of output on impact.

If there was a substantial difference in the responses of public consumption and/or public investment after a government spending shock in the normal and in the ZLB periods, this could potentially account for some difference in the multipliers that we estimate. However, given that

[40] Only when we assume substantially different elasticities in the ZLB period and in the normal period can the automatic stabilizer effect alone explain the difference between the estimated output multipliers. We find that $\eta_{G,Y}$ should be -0.7 in the normal period for the on-impact multiplier in the normal period to be almost the same as our baseline on-impact multiplier in the ZLB period (1.5). Alternatively, if $\eta_{G,Y} = 0.5$ in the ZLB period, the on-impact multiplier in the ZLB period equals the on-impact output multiplier in the normal period in our baseline estimation (0.6).

there is no big difference in the responses, this is not likely to explain the difference in the output multipliers that we estimate.

7 A Model of Government Spending

The empirical part of the paper provides evidence of a larger multiplier in the ZLB period than that in the normal period. This section examines how far a simple New Keynesian model calibrated with Japanese data can go by numerically matching these results.[41] We use empirically estimated government spending process to compute government spending multipliers in the model. We take into account that the ZLB period can occur due to either fundamental shocks or self-fulfilling state of low confidence in a typical New Keynesian model. We obtain the following results. First, the model in which the ZLB period is caused by self-fulfilling state of low confidence can generate the output and cumulative inflation multipliers for different horizons close to the estimated ones in the ZLB period. At the same time, the model in which the ZLB period is caused by fundamental shocks does not quantitatively match the estimated output multipliers in the ZLB period. This difference in the results is explained by the persistence of the estimated government spending process. This process is more persistent than the longest possible ZLB period generated by a fundamental shock consistent with unique bounded equilibrium. As a result, the output multiplier is relatively small in the ZLB generated by fundamental shock.[42] When the ZLB is caused by deflationary trap, our government spending process is less persistent than the ZLB period. In this case, the output multiplier can be high. Second, the model matches the output multiplier in the normal period at short horizons.

We examine a standard New Keynesian model along the lines of Woodford (2010), Eggertsson (2011), and Christiano, Eichenbaum, and Rebelo (2011). The full model description can be found in Appendix A.1. In this model, there is a continuum of household types, each of which consumes,

[41] We only consider the standard closed economy New Keynesian model. We do not consider models with additional mechanisms that affect multipliers. First, Rendahl (2014) shows that a New Keynesian model with frictional labor market can generate a large output multiplier even with a negative expected inflation response. Second, A growing literature studies the effects of household heterogeneity on the fiscal policy in the New Keynesian environment and shows that fiscal policy efficacy depends on the way it is financed. See, for example, Eggertsson and Mehrotra (2014) and Violante, Moll, and Kaplan (2015). Third, openness to international trade can also affect the fiscal multipliers. See, for example, Wieland (2012) and Fujiwara and Ueda (2013). We do not pursue these extensions here.

Because our main focus is on the difference in multipliers between normal and ZLB periods, we do not consider the difference in the effects of fiscal policy across recessions and booms in the model presented here.

[42] Woodford (2010) theoretically emphasizes that the output multiplier depends on whether government spending stays elevated after the economy exits the ZLB period driven by a fundamental shock. In particular, the output multiplier can even be negative if government spending change is permanent.

and supplies a differentiated labor input. The model features monopolistic competition and Calvo-style sticky prices. There is no capital investment. The government finances wasteful spending through lump-sum taxes. The model equilibrium conditions log-linearized around a zero inflation steady state can be summarized by the IS and the Phillips curves:

$$\widehat{y}_t - \widehat{g}_t = \mathbb{E}_t \left(\widehat{y}_{t+1} - \widehat{g}_{t+1}\right) - \widetilde{\sigma} \left(i_t - \mathbb{E}_t \pi_{t+1} - \overline{r}\right), \tag{5}$$

$$\pi_t = \beta \mathbb{E} \pi_{t+1} + \kappa \left(\widehat{y}_t - \Gamma \widehat{g}_t\right), \tag{6}$$

where t indexes a model time period which corresponds to one quarter, $\widehat{y}_t$ denotes the log deviation of output from its steady state, $\widehat{g}_t$ denotes government spending deviation from its steady state over steady state output, π_t is inflation, i_t is a continuously compounded one-period riskless nominal interest rate, and $\overline{r}$ is the value of this rate in a steady state with zero inflation. The constant κ is the slope of the Phillips curve, Γ is the fiscal multiplier under flexible prices, and $\widetilde{\sigma}$ is the "effective" intertemporal elasticity of substitution.[43]

We characterize government spending policy by a steady state ratio of government spending over GDP, and by the path of government spending after a government spending shock. We assume that government spending after a spending shock equals the point estimate of the empirical impulse responses for the first sixteen quarters; then government spending reverts to steady state according to an $AR(1)$ process. Formally, $\widehat{g}_t = \widehat{g}_t^{emp}$ for $0 \le t \le 15$, and $\widehat{g}_t = \widehat{g}_{15}^{emp} \cdot \rho^{t-15}$ for $t > 15$, where $\widehat{g}_t^{emp}$ is our empirical point estimates. Because the empirical responses of government spending to a government spending shock are very close to each other in the normal and the ZLB periods, we use the normal period response as $\widehat{g}_t^{emp}$.

We define the output multiplier analogous to its empirical counterpart: $M_h^y = \sum_{t=0}^h \widehat{y}_t / \sum_{t=0}^h \widehat{g}_t$. We introduce the cumulative inflation multiplier and define it similarly to the output multiplier: $M_h^\pi = \sum_{t=0}^h \pi_t / \sum_{t=0}^h \widehat{g}_t$.

To examine the theoretical multipliers in the normal and in the ZLB periods, we consider three scenarios: (i) an unconstrained monetary policy that follows a "Taylor rule", (ii) the zero interest rate period caused by a fundamental shock to the spread between the monetary policy rate and the interest rate that the households face, (iii) the zero interest rate period caused by self-fulfilling periods of low confidence.

[43] These variables are expressed through the model's structural parameters in Appendix A.2.

7.1 Normal period

We model the normal period by assuming that monetary policy follows the Taylor rule of the following form

$$i_t = (1 - \rho_i)(\overline{r} + \phi_\pi \pi_t + \phi_y \widehat{y}_t) + \rho_i i_{t-1}, \tag{7}$$

where $\overline{r} \equiv -\log \beta$, $\phi_\pi > 1$, $\phi_y \geq 0$, and $0 < \rho_i < 1$. We assume that the economy never reaches the zero lower bound in this case. We solve the model for a unique bounded equilibrium. The details are in Appendix A.3.

7.2 ZLB due to Fundamental Shocks

One way to generate a zero nominal interest rate period is to assume the occurrence of a fundamental shock that requires the central bank to lower its policy rate to the lowest possible level. We follow Woodford (2010) and Eggertsson (2011) by allowing the policy interest rate to differ from the interest rate faced by the household. The Euler equation (5) becomes

$$\widehat{y}_t - \widehat{g}_t = \mathbb{E}_t \left(\widehat{y}_{t+1} - \widehat{g}_{t+1}\right) - \widetilde{\sigma} \left(i_t - \mathbb{E}_t \pi_{t+1} - r_t^{net}\right), \tag{8}$$

where $r_t^{net} \equiv \overline{r} - \Delta_t$, and Δ_t represents a spread between the policy rate and the interest rate that is relevant for the intertemporal consumption allocation of the households. Intuitively, a positive Δ_t may stand for a temporary disruption of the intermediation in the financial sector.

As in Woodford (2010), we consider a simple two-state Markov example in which r_t^{net} takes only two values: $\overline{r}$ and r_L, where $r_L < \overline{r}$. If the economy starts from a state with the elevated spread, i.e., $r_t^{net} = r_L$, then it stays in the same state next period with probability μ, otherwise it returns to a zero-spread state, i.e., $r_t = \overline{r}$, with probability $1 - \mu$. Once the spread returns to normal level it stays there forever. If the monetary policy follows the Taylor rule (7) a large enough spreads shock, i.e., small enough r_L, will imply negative i_t. As a result, the zero lower bound on the nominal rate starts to bind. Once the spreads normalize, the central bank follows the Taylor rule again.

We solve the model for a unique bounded equilibrium. This puts an upper bound on the persistence of interest rate spread shock μ.

7.3 ZLB due to Non-fundamental Shocks

Self-fulfilling variations in confidence provide an alternative explanation for the occurrence of the zero nominal rate periods in addition to the fundamental shocks discussed above. In a recent paper, Aruoba, Cuba-Borda, and Schorfheide (2016) estimate a New Keynesian model and conclude that Japan is more likely to be at the zero lower bound because it is experiencing low level of confidence rather than a liquidity trap caused by fundamental shocks. This provides a rational to investigate government spending multipliers in this situation.

Benhabib, Schmitt-Grohé, and Uribe (2001a,b) show that there are two steady states in the standard New Keynesian model when the policy rate actively responds to inflation but is also constrained by the zero lower bound. The first steady state is the standard targeted inflation steady state. The second steady state features zero nominal interest rate and deflation. We call this steady state "deflationary trap." Intuitively, if agents believe that there is permanent deflation, the central bank sets the nominal rate to zero. If the level of deflation equals the subjective discount factor, the economy can remain in this equilibrium forever. Thus, the economy may end up in a deflationary steady state with zero nominal interest rate because agents unexpectedly change their beliefs.

There are an infinite number of equilibrium paths to the deflationary steady state leading to infinitely many responses of the economy to government spending shocks. We follow Mertens and Ravn (2014) and Aruoba, Cuba-Borda, and Schorfheide (2016) and restrict our attention to Markov equilibria in which the only state variables are a non-fundamental random variable, called a sunspot, the current value of exogenous government spending, and a set of current news shocks about future government spending.[44] We add news shocks to replicate the empirically estimated government spending and to let agents to expect it in advance. This form of equilibrium restricts the solution to a single equilibrium: a sunspot determines a steady state to which the economy approaches, the Markovian structure with respect to exogenous fundamental shocks pins down a unique response of the economy to shocks.[45] We assume that government spending shocks do not affect sunspots.

Consider a sunspot, represented by ω_t, that can take on two values $\{\omega_P, \omega_O\}$. We call ω_O a state with "optimistic" expectations and ω_P a state with "pessimistic" expectations because, by

[44] In a non-linear solution to the model, the price dispersion will be an additional state variables.

[45] Cass and Shell (1983) show that sunspots matter in macroeconomic models. Benhabib and Farmer (1999) reviews the literature on sunspots in macroeconomic. Lubik and Schorfheide (2003) discuss the computation of sunspot equilibria in linear rational expectations models.

assumption, the economy converges to the desirable targeted inflation steady state when $\omega_t = \omega_O$ and to deflationary steady state when $\omega_t = \omega_P$. The optimistic expectations state is absorbing. Formally, $Pr\left(\omega_t = \omega_O | \omega_{t-1} = \omega_O\right) = 1$. If the economy starts in state with pessimistic expectations, the probability to remain in this state in the next period is $Pr\left(\omega_t = \omega_P | \omega_{t-1} = \omega_P\right) = \mu_\omega \in (0, 1)$. We solve the model by log-linearizing the equilibrium conditions around the zero inflation steady state.[46] See the appendix for the details.

7.4 Calibration

We set the values of the parameters as in Table 7. The Frisch elasticity of labor supply ν is 1, which is the standard value used in the macroeconomics literature. The elasticity of intertemporal substitution (IES) σ is set to 1.1, which is within the wide range of IES values used in the literature. The subjective discount factor β is 0.99. The elasticity of substitution across varieties θ is set to 7. The production function is $f(L_t(i)) = L_t(i)^a$, with $a = 1$. The probability of price adjustment $1 - \alpha$ is 0.25.

The Taylor rule parameters are $\phi_\pi = 1.67$, $\phi_y = 0.15$, and $\rho_i = 0.73$. These numbers are the estimated Taylor rule coefficients obtained by Aruoba, Cuba-Borda, and Schorfheide (2016) using Japanese data.[47] We set the continuation probability of high interest rate spread to $\mu = 0.87$. This number is slightly smaller than the upper bound on μ that insures unique equilibrium and hence it gives the fundamental ZLB the best chance to generate high output multiplier. The level of μ implies an average duration of the ZLB of about two years. We set the persistence of deflationary trap to $\mu_\omega = 0.95$, which corresponds to average duration of deflationary trap of five years.[48] The steady state ratio of government spending over output is 0.18. This number corresponds to the mean of government spending over GDP in Japan during the period $1980Q1$–$2014Q1$. We allow the parameter ρ governing the persistence of government spending after $t = 15$ to take on two values $\{0; 0.8\}$. We compute the output and inflation multipliers for each ρ.

[46] The approximation around the zero inflation steady state is valid as long as the values of endogenous variables are sufficiently close in the two steady states.

[47] The specification estimated in Aruoba, Cuba-Borda, and Schorfheide (2016) takes into account that the short-term nominal interest rate was zero in the last two decades in Japan.

[48] Imakubo, Nakajima et al. (2015) estimate a 10-year government bond yield net of term premium in Japan. The average value of this yield is about 0.8% in the ZLB period. Assuming that in the normal period the steady state policy rate is 4% and that confidence shocks follow a two-state Markov process that we assume, we can back out the probability of staying in deflationary trap of 0.8 a year or about 0.95 per quarter.

7.5 Model Multipliers

The model output multipliers and the empirical point estimates in the normal period are presented in the left panel of Figure 13. Both model output multipliers are below one at any horizon, they are decreasing for the first several horizons, and they go up at longer horizons. These features are qualitatively similar to the behavior of the empirical output multiplier, which is represented by the black bold line in the same figure. The numerical values of model multiplier are close to the empirical estimate at horizons up to four quarters; the model generates a higher output multiplier at longer horizons compared to the empirical estimates. The right panel of Figure 13 plots the model and empirical cumulative inflation multipliers in the normal period. We use the empirical CPI inflation impulse response to compute the empirical cumulative inflation multipliers.[49] For the values of ρ that we consider, the model inflation multipliers are negative which is qualitatively similar to the empirical estimate. The model generates negative inflation multipliers because of a negative wealth effect, which makes workers work more, reduces firms' marginal costs and inflation. The model inflation multiplier is smaller in absolute terms. However, this result is sensitive to the Taylor rule parametrization: higher ϕ_y leads to a more negative response of inflation in the model.

The left panel of Figure 14 presents the model output multipliers conditional on staying in the ZLB period in every quarter plotted. The ZLB period is caused by a fundamental spread shock in this plot. The model multipliers are below one; they first decline and then increase at longer horizons. These features stand in contrast to the behavior of empirical output multipliers in the ZLB period, the solid black line in the figure. Note also that the model generates a larger output multiplier during the ZLB period relative to the normal period. This is because the real interest rate falls after a government spending shock when the central bank does not change the interest rate and expected inflation increases. The right panel of Figure 14 compares the model cumulative inflation multiplier conditional on staying in the fundamental ZLB period in every quarter and empirical inflation multipliers in the ZLB period. The model cumulative inflation multipliers are sufficiently small relative to the empirical counterpart.

The left panel of Figure 15 presents the model output multipliers conditional on remaining in the ZLB period, where the ZLB period is caused by confidence shocks. The model multipliers are above one; they first increase and then decline at the longer horizons. These features are similar to the behavior of empirical output multipliers, the solid black line in the figure. For $\rho = 0.8$, the

[49] The cumulative inflation multiplier measured using the GDP deflator has large standard errors bounds that will always include theoretical inflation multipliers.

model output multipliers are close to the estimated output multipliers for various horizons. The right panel of Figure 15 compares the model and empirical cumulative inflation multipliers. For $\rho = 0.8$, the model inflation multipliers are reasonably close to the empirical counterparts. These results show that the model generates output and inflation multipliers close to the estimated ones.

Why are the model multipliers below one in the ZLB period driven by fundamental shocks? The value of the output multiplier depends on the persistence of spending shocks. When the persistence of spending shocks is high enough relative to the persistence of the ZLB period, which is the case in our calibration, the multiplier is small and can potentially be negative due to the fact that higher government spending after the ZLB period crowds out future consumption reducing incentives to consume now.

Why are the model multipliers above one in the ZLB period driven by self-fulfilling low confidence? The persistence of deflationary trap is higher than the persistence of government spending shock in our calibration. This results in a stronger positive effect of government spending compared to the case of the fundamental ZLB period. In particular, we obtain a multiplier which is higher than one. Note that this result is different from the low output multiplier in deflationary trap obtained by Mertens and Ravn (2014). The main difference between our and their calibrations is the persistence of government spending process. Mertens and Ravn (2014) assume that government spending is as persistent as deflationary trap. In this case, an increase in government spending is deflationary, which reduces output multiplier. In contrast, in our calibration, government spending process is less persistent than deflationary trap. In this case, an increase in government spending increases inflation, which stimulates the economy.

In this section, we presented two main findings. First, the output and inflation multipliers generated by a simple New Keynesian model are close to empirical estimates in the normal period for short horizons. Second, in the non-fundamental ZLB period, the model output and inflation multipliers are reasonably close to our estimates of the multipliers in the ZLB period. As a result, we can conclude that our empirical estimates for output and inflation multipliers are consistent with a simplest New Keynesian model.

8 Conclusion

We use information about the ZLB period in Japan to estimate the effects of government spending changes on output. We control for expected government spending to identify its unexpected changes. Our point estimate of the output multiplier is larger than one in the ZLB period, and this output multiplier is larger than that in the normal period. On impact, the output multiplier is 1.5 in the ZLB period and 0.6 in the normal period. The difference in the multipliers between the two periods is larger over longer horizons: while the multiplier increases to greater than two in the ZLB period, it becomes negative in the normal period. Furthermore, government spending crowds in private consumption and investment in the ZLB period, in contrast with the crowding-out effects in the normal period. We estimate a more positive response in the ZLB period for some measures of inflation. Additionally, the ex ante real interest rate decreases by more in the ZLB period than in the normal period.

We relate our empirical findings to a standard New Keynesian model calibrated with Japanese data. We find that this model can generate output multiplier close to our estimates in the ZLB period in Japan if the ZLB period is assumed to be driven by confidence shocks. The model also replicates empirical output multiplier at several horizons in the normal period. Because some of our measures of inflation does not show a significant response to government spending shocks, a New Keynesian model in which a higher multiplier can be generated without the expected inflation channel (Rendahl, 2014) may also be consistent with our empirical evidence.

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Appendices

A Model of Government Spending

A.1 Model Description

Households. The economy is populated by a continuum of households. Different households supply different types of labor indexed by i and there are an equal number of households supplying each type of labor. This is the heterogeneous labor supply assumption. A household supplying labor of type i maximizes its utility given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma^{-1}}}{1-\sigma^{-1}} - \chi \frac{L_t(i)^{1+\nu^{-1}}}{1+\nu^{-1}} \right), \tag{A.1}$$

where C_t is an index of the household's consumption, $L_t(i)$ is the quantity of labor of type i supplied, β denotes the subjective discount factor, ν is the Frisch elasticity of labor supply, and σ is the elasticity of intertemporal substitution.

Consumption C_t is an index given by

$$C_t = \left[\int_0^1 C_t(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}},$$

where $C_t(j)$ denotes consumption of variety j, $\theta > 1$ is the elasticity of substitution between varieties. There is a continuum of measure one of varieties. We denote $P_t(j)$ the price of variety j, and

$$P_t = \left[\int_0^1 P_t(j)^{1-\theta} dj \right]^{\frac{1}{1-\theta}}$$

is the corresponding price index.

Household of type i maximizes its utility subject to a flow budget constraint given by

$$\int_0^1 P_t(j)C_t(j)di + \mathbb{E}_t \left[Q_{t,t+1} B_{t+1}(i) \right] + T_t \leq B_t(i) + W_t(i)L_t(i) + \int_0^1 \Pi_t(j)dj, \tag{A.2}$$

together with a no-Ponzi condition. In this equation, $B_{t+1}(i)$ is a state-contingent payoff at the beginning of period $t+1$ of the financial portfolio of household i, $Q_{t,t+1}$ is the price of Arrow-Debreu securities divided by the conditional probability of the corresponding state, which equals the unique stochastic discount factor in equilibrium, $W_t(i)$ is the nominal wage received by labor type i in period t, $\Pi_t(j)$ is the nominal profit of the firm that produces variety j in period t, T_t is lump sum taxes.

Government. There is a government that conducts fiscal and monetary policy. Fiscal policy is represented by a government spending G_t and lump sum taxes T_t. Because the Ricardian equivalence holds, the timing of taxes is irrelevant. The government spending follows a process specified in the main text. Formally,

$$\widehat{g}_t = \begin{cases} \widehat{g}_t^{emp} & 0 \leq t \leq 15 \\ \widehat{g}_{15}^{emp} \cdot \rho^{t-15} & t > 15 \end{cases},$$

where $\widehat{g}_t \equiv (G_t - \overline{G})/\overline{Y}$, $\overline{G}$ is the steady state value of government spending, $\overline{Y}$ is the steady state value of output, ρ is the persistence parameter, $\widehat{g}_t^{emp}$ is the estimated empirical path of the reaction of government spending to a spending shock.

Government spending G_t has the same CES form as the index of household consumption:

$$G_t = \left[\int_0^1 G_t(j)^{\frac{\theta-1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}},$$

where $G_t(j)$ is government consumption of variety j. The government splits its expenditure $\int_0^1 P_t(j) G_t(j) di$ across varieties to minimize government spending.

The active monetary policy is represented by the following Taylor rule:

$$i_t = (1 - \rho_i)(\overline{r} + \phi_\pi \pi_t + \phi_y \widehat{y}_t) + \rho_i i_{t-1},$$

where $\widehat{y}_t$ denotes percentage deviations of output from its steady state, the policy instrument i_t is a one-period riskless nominal interest rate, and $\overline{r} = -\log \beta$ is the value of this rate in a steady state with zero inflation, and $\phi_\pi > 1, \phi_y \geq 0$ are the response coefficients, and $0 \leq \rho_i < 1$.

Firms. There is a continuum of firms, each of which specializes in the production of differentiated good j with labor using the technology given by

$$Y_t(j) = f\left(L_t(j)\right), \tag{A.3}$$

where $f\left(L_t(j)\right) = L_t(j)^a$ with $a \in (0,1)$. We follow Woodford (2003) and assume that firm j sets monopolistic price $P_t(j)$ for its output but acts as a price-taker on the market for labor of type

j.[50] We assume that firms pay a constant employment tax $1+\tau^L$ so that the nominal total cost of production is $(1+\tau^L)W_t(j)f^{-1}\left(Y_t(j)\right)$.

Firm j can re-optimize its price with probability $1-\alpha$. The firm maximizes its value,

$$\mathbb{E}_t \sum_{n=0}^{\infty} Q_{t,t+n}\alpha^j \left[P_t(j)Y_{t+n|t}(j) - (1+\tau^L)W_t(j)f^{-1}\left(Y_{t+n|t}(j)\right)\right],$$

where $Y_{t+n|t}(j) = (C_{t+n}+G_{t+n})\left(\frac{P_t(j)}{P_{t+n}}\right)^{-\theta}$, taking the sequences of $C_t, G_t, P_t, W_t(j), Q_{t,t+n}$ as given.

A.2 Equilibrium Conditions

A household's optimal choice of consumption, labor supply, and securities holdings leads to

$$\frac{u_L\left(C_t, L_t(i)\right)}{u_C\left(C_t, L_t(i)\right)} = \frac{W_t(i)}{P_t}, \tag{A.4}$$

$$\beta^n \frac{u_C\left(C_{t+n}, L_{t+n}(i)\right)}{u_C\left(C_t, L_t(i)\right)} = \frac{P_{t+n}}{P_t} Q_{t,t+n}, \tag{A.5}$$

$$C_t(j) = C_t\left(\frac{P_t(j)}{P_t}\right)^{-\theta}, \tag{A.6}$$

where $u_C\left(C_t, L_t(i)\right) = C_t^{-\sigma^{-1}}$ and $u_L\left(C_t, L_t(i)\right) = -\chi L_t(i)^{\nu^{-1}}$ are the derivatives of instantaneous utility function with respect to consumption and labor. Equation (A.4) represents the household labor supply, equation (A.5) is the consumption Euler equation, and equation (A.6) is the optimal choice of variety j.

Government demand for variety j is

$$G_t(j) = G_t\left(\frac{P_t(j)}{P_t}\right)^{-\theta}.$$

Firm j optimal price is

$$P_t(j) = \mathbb{E}_t \sum_{n=0}^{\infty} \frac{\alpha^n Q_{t,t+n} Y_{t+n|t}(j)}{\mathbb{E}_t \sum_{n=0}^{\infty} \alpha^n Q_{t,t+n} Y_{t+n|t}(j)} S_{t+n|n}(j),$$

where $S_{t+n|n}(j) = W_{t+n}(i)/f'\left(f^{-1}\left(Y_{t+n|t}(j)\right)\right)$ is the nominal marginal cost.

The log-linearized equilibrium conditions can be summarized by the New-Keynesian IS and the

[50] More specifically, firms belong to industries. There is a large number of firms in every industry. Each firm in industry x employs labor of type x. In addition, all firms in a particular industry reset their prices at the same time.

Phillips curves

$$\widehat{y}_t - \widehat{g}_t = \mathbb{E}_t\left(\widehat{y}_{t+1} - \widehat{g}_{t+1}\right) - \widetilde{\sigma}\left(i_t - \mathbb{E}_t\pi_{t+1} - \overline{r}\right), \tag{A.7}$$

$$\pi_t = \beta\mathbb{E}\pi_{t+1} + \kappa\left(\widehat{y}_t - \Gamma\widehat{g}_t\right), \tag{A.8}$$

where $\widetilde{\sigma} = \sigma\overline{C}/\overline{Y}$ is the "effective" intertemporal elasticity of substitution, $\overline{C}$ and $\overline{Y}$ are steady state consumption and output, $\kappa = (1-\alpha)(1-\alpha\beta)/\alpha \cdot \left(\widetilde{\sigma}^{-1} + \psi_\nu\right)/\left(1+\theta\psi_\nu\right)$ is the slope of the Phillips curve with $\psi_\nu = \left(1 - a + \nu^{-1}\right)/a$ being the elasticity of real marginal costs with respect to output, $\Gamma = \widetilde{\sigma}^{-1}/\left(\widetilde{\sigma}^{-1} + \psi_\nu\right) \in (0,1)$ is the fiscal multiplier under flexible prices. Observe that the results do not depend on disutility of labor parameter χ.

A.3 Solution

Normal period. Under the Taylor rule policy, we find the solution by using the Schmitt-Grohé and Uribe (2004) algorithm augmented with news shocks. Specifically, we introduce one contemporaneous shock and fifteen news shocks to government spending to mimic the estimated path of government spending for the first sixteen quarters. This procedure allows us to take into account that the agents expect the whole path of government spending after a government spending shock in advance. We denote the solution as $\{\widehat{y}_t^{norm}(T), \pi_t^{norm}(T)\}_{t=T}^{\infty}$ for every $T \geq 0$, which denotes the period when the economy permanently ends up in the normal period. This solution depends on T because the Taylor rule features lagged interest rate.

Fundamental ZLB period. When the economy finds itself in the ZLB due to fundamental shock to interest rate spreads, we solve for output and inflation that satisfy the following IS and Phillips curve equations

$$\begin{aligned}\widehat{y}_t - \widehat{g}_t = \mu\left(\widehat{y}_{t+1} - \widehat{g}_{t+1}\right) + (1-\mu)\left[\widehat{y}_{t+1}^{norm}(t+1) - \widehat{g}_{t+1}\right] \\ + \widetilde{\sigma}\left[\mu\pi_{t+1} + (1-\mu)\pi_{t+1}^{norm}(t+1) + r_L\right],\end{aligned} \tag{A.9}$$

$$\pi_t = \beta\left[\mu\pi_{t+1} + (1-\mu)\pi_{t+1}^{norm}(t+1)\right] + \kappa\left(\widehat{y}_t - \Gamma\widehat{g}_t\right). \tag{A.10}$$

We look for the unique bounded solution to these two equations. For example, if there is no lagged interest rate term in the Taylor rule in the normal period, the unique solution exists when $(1-\mu)(1-\beta\mu) - \widetilde{\sigma}\mu\kappa > 0$. This introduces the upped bound $\overline{\mu}$ on the duration of the ZLB. The condition for the existence of the unique bounded equilibrium in the case of lagged interest rate term in the Taylor rule is less tractable. We verify that it holds numerically.

For government spending shocks not to lift the economy out of the ZLB caused by fundamental shocks, the sequence $\{\widehat{g}_t\}$ has to be small relative to the shock that causes the ZLB. When we solve the model, we verify that a shock that increases government spending by 1% as a fraction of GDP on impact, does not increase output and inflation enough for the economy to exit the ZLB.

Non-Fundamental ZLB period. When the ZLB period is caused by a sunspot shock, we solve for output and inflation that satisfy the following equations

$$\widehat{y}_t - \widehat{g}_t = \mu_\omega \left(\widehat{y}_{t+1} - \widehat{g}_{t+1}\right) + (1-\mu_\omega)\left[\widehat{y}^{norm}_{t+1}(t+1) - \widehat{g}_{t+1}\right] + \widetilde{\sigma}\left[\mu_\omega \pi_{t+1} + (1-\mu_\omega)\pi^{norm}_{t+1}(t+1) + \overline{r}\right], \tag{A.11}$$

$$\pi_t = \beta\left[\mu_\omega \pi_{t+1} + (1-\mu_\omega)\pi^{norm}_{t+1}(t+1)\right] + \kappa\left(\widehat{y}_t - \Gamma \widehat{g}_t\right). \tag{A.12}$$

We assume that government spending changes do not affect sunspot shocks. The solution to this system is not unique. We pick a single solution as follows. If the economy still finds itself in the non-fundamental ZLB after 15 quarters after the shock, i.e, the government spending process follows an $AR(1)$ process, we look for solution of the form $\widehat{y}_t = \vartheta^y_{DT}\overline{r} + \gamma^y_{DT}\widehat{g}_t$ and $\pi_t = \vartheta^\pi_{DT}\overline{r} + \gamma^\pi_{DT}\widehat{g}_t$. By using the method of undetermined coefficients, one can verify that this type of solution is unique. After picking a single solution for $t > 15$, we then solve equations (A.11) and (A.12) backwards. This uniquely pins down output and inflation for $0 \leq t \leq 15$. This backward solution amounts to assuming that the solution not only depends on the current level of government spending but also on the information about future government spending represented by news shocks. After obtaining the solution, we verify that condition $(1-\rho_i)(\overline{r} + \phi_\pi \pi_t + \phi_y \widehat{y}_t) + \rho_i i_{t-1} < 0$ holds for all of the periods for which we assumed the economy is in the ZLB due to pessimistic sunspots.

B Data Sources

1. Output, consumption, investment, government spending, tax revenue, net exports, and GDP deflator are from *National Accounts of Japan* published on the Cabinet Office website:

   - http://www.esri.cao.go.jp/index-e.html (English)
   - http://www.esri.cao.go.jp/index.html (Japanese)

2. Forecasts of government spending, output and inflation are from the *Japan Center for Economic Research*:

   - http://www.jcer.or.jp/eng/

3. Unemployment rate, labor market tightness, population, and CPI are from *Statistics Japan*:

   - http://www.stat.go.jp/english/data/index.htm (English)
   - http://www.stat.go.jp/ (Japanese).

   The statistics website can be accessed through http://www.e-stat.go.jp/SG1/estat/eStatTopPortalE.do (English).

4. Nominal interest rates are from *the Bank of Japan*:

   - http://www.stat-search.boj.or.jp/index_en.html (English)
   - http://www.stat-search.boj.or.jp/index.html (Japanese)

5. The real effective exchange rate is from *the IMF International Financial Statistics database*:

   - http://www.imf.org/en/Data

6. The government budget outlook government spending forecast, leading indicators, public construction orders, public work orders, government budget (initial and final) are from *the Japanese NIKKEI NEEDS database*:

   - http://www.nikkei.co.jp/needs/ (Japanese)

7. The OECD and the IMF government spending forecasts are similar to those used in Auerbach and Gorodnichenko (2012b) and were obtained form the authors.

8. The construction sector stock price index is from *Haver Analytics*.

9. The fiscal packages and supplementary budget were collected from newspaper reports.

Tables and Figures

Table 1: Output Multipliers

	Normal	ZLB	p-value
On impact	0.61	1.54	HAC: 0.02
	(0.23)	(0.43)	AR: 0.09
1 quarter	0.53	1.93	HAC: 0.01
	(0.20)	(0.65)	AR: 0.06
4 quarter	0.12	2.67	HAC: 0.00
	(0.58)	(1.11)	AR: 0.06
8 quarter	-0.56	1.70	HAC: 0.00
	(0.34)	(0.94)	AR: 0.08

Notes: The table reports the results of the multipliers on impact and over four- and eight- quarter horizons in the normal period (Normal column) and in the ZLB period (ZLB column). The output multiplier is calculated as the cumulative change in output over the cumulative change in government spending over each horizon. The HAC robust and Anderson-Rubin p-values of the difference between the multiplier in the normal period and that in the ZLB period are reported in the "p-value" column. All numbers in parentheses are the HAC standard errors.

Table 2: Output Multipliers: Sources of real-time information

	On impact	4 quarter	8 quarter
No forecast			
Normal	0.38	-0.19	-0.49
	(0.18)	(0.44)	(0.38)
ZLB	1.49	2.43	1.53
	(0.42)	(1.01)	(0.86)
Add fiscal packages			
Normal	0.75	0.29	-0.29
	(0.27)	(0.65)	(0.35)
ZLB	1.63	2.53	1.52
	(0.47)	(1.09)	(1.06)
Add one-quarter ahead GDP forecast			
Normal	0.57	0.05	-0.57
	(0.23)	(0.56)	(0.40)
ZLB	1.45	2.57	1.58
	(0.43)	(1.11)	(0.95)
Add one to four quarter ahead of G			
Normal	0.54	0.29	-0.36
	(0.27)	(0.56)	(0.37)
ZLB	1.64	2.89	2.10
	(0.45)	(1.29)	(1.08)
Add four-quarter ahead annual G			
Normal	0.57	-0.06	-0.72
	(0.22)	(0.53)	(0.31)
ZLB	1.66	2.72	1.80
	(0.43)	(1.12)	(1.00)
Add four-quarter ahead annual GDP			
Normal	0.57	-0.16	-0.75
	(0.23)	(0.57)	(0.30)
ZLB	1.41	2.67	2.37
	(0.43)	(1.27)	(1.33)
Add OECD, IMF and Government Outlook forecast			
Normal	0.58	0.19	-0.41
	(0.21)	(0.54)	(0.30)
ZLB	1.66	3.42	2.47
	(0.60)	(1.81)	(1.35)

Notes: "No forecast" are the estimates without controlling for any real-time forecast. "Add fiscal packages" reports the results when we add the public investment component of the fiscal packages approved in Japan into the estimation. "Add one-quarter ahead output forecast" reports the results when we add a one-quarter-ahead forecast of output growth rate to identify spending shocks. "Add one to four quarter ahead of G" reports when forecasts of government spending from horizons one to four quarter ahead are included. "Add four-quarter ahead annual G" and "Add four-quarter ahead annual GDP" reports the case when we add four-quarter-ahead forecast of annual spending growth rate and GDP growth rate into the estimation, respectively. "Add OECD, IMF and Government Outlook"reports when we include a one-quarter-ahead forecast from different sources into the estimation. All numbers in parentheses are the standard errors.

Table 3: Output Multipliers: Different Specifications and Data

	On impact	4 quarter	8 quarter
Quadratic trend			
Normal	0.69	0.52	0.77
	(0.29)	(0.54)	(0.73)
ZLB	1.89	5.13	5.74
	(0.52)	(2.52)	(3.71)
Normalized by potential output			
Normal	0.61	0.11	-0.58
	(0.23)	(0.57)	(0.32)
ZLB	1.54	2.68	1.66
	(0.43)	(1.12)	(0.96)
One step estimation			
Normal	0.61	0.12	-0.56
	(0.23)	(0.52)	(0.33)
ZLB	1.54	2.53	1.72
	(0.41)	(1.06)	(0.83)

Notes: This table reports the output multipliers over several horizons in alternative specifications. 'Quadratic trend" reports the estimates when we add quadratic trend to the baseline specification. "Normalized by potential output" reports the estimates when the RHS variables in the baseline specification are converted to the same unit by dividing by potential output. "One step estimation" estimates the output multiplier in one regression by adding a one-quarter-ahead forecast of government spending to the control variables. "Unadjusted government spending" reports the multiplier when we use the published government spending data that include transfer of goods and services to estimate the baseline specification. "Actual final government spending" reports the multiplier when we use the published government spending data that exclude all transfer of goods and services to estimate the baseline specification. All numbers in parentheses are the standard errors.

Table 4: Multipliers of Other Variables

	Normal	ZLB	p-value
Consumption			
On impact	0.35	1.25	0.00
	(0.16)	(0.39)	
4 quarter	-0.54	2.83	0.00
	(0.56)	(0.83)	
8 quarter	-1.00	2.19	0.00
	(0.68)	(0.50)	
Investment			
On impact	-0.08	-0.13	0.84
	(0.16)	(0.13)	
4 quarter	-0.05	0.93	0.01
	(0.24)	(0.53)	
8 quarter	-0.17	0.93	0.01
	(0.22)	(0.49)	
Unemployment			
On impact	-0.03	-0.09	0.01
	(0.02)	(0.03)	
4 quarter	-0.05	-0.50	0.00
	(0.05)	(0.16)	
8 quarter	-0.06	-0.60)	0.00
	(0.05)	(0.27)	
Tax rate			
On impact	0.02	0.10	0.91
	(0.25)	(0.12)	
4 quarter	0.03	0.75	0.04
	(0.30)	(0.38)	
8 quarter	-0.34	0.56	0.00
	(0.18)	(0.42)	

Notes: The table reports the results of the multipliers on impact and over four- and eight- quarter horizons in the normal period (Normal column) and in the ZLB period (ZLB column). The consumption, investment and unemployment rate multipliers are defined analogously to the output multiplier. The HAC robust p-value of the difference between the multiplier in the normal period and that in the ZLB period is reported in the "p-value" column. All numbers in parentheses are the HAC standard errors.

Table 5: Multipliers of Inflation and Interest rates

	On impact	Horizon 4	Horizon 8
GDP deflator Inflation			
Normal	-0.02	-0.05	-0.22
	(0.08)	(0.13)	(0.15)
ZLB	-0.01	-0.01	0.10
	(0.22)	(0.11)	(0.09)
CPI			
Normal	-0.22	-0.32	-0.30
	(0.07)	(0.12)	(0.12)
ZLB	0.42	0.34	0.28
	(0.20)	(0.24)	(0.38)
GDP deflator Inflation expectation			
Normal	-0.02	-0.23	-0.99
	(0.25)	(0.18)	(0.25)
ZLB	-0.04	0.79	0.37
	(0.12)	(0.33)	(0.29)
CPI Inflation expectation			
Normal	-0.19	(0.25)	-0.21
	(0.20)	(0.08)	(0.19)
ZLB	0.10	0.40	0.44
	(0.13)	(0.21)	(0.47)
Short-term interest rate			
Normal	-0.10	0.37	0.12
	(0.16)	(0.26)	(0.59)
ZLB	-0.02	0.07	0.10
	(0.02)	(0.03)	(0.05)
Long-term interest rate			
Normal	-0.27	-0.10	-0.52
	(0,08)	(0.13)	(0.25)
ZLB	-0.14	0.03	-0.07
	(0.05)	(0.09)	(0.08)

Notes: This table reports the multipliers of inflation and inflation expectations, and the impulse responses of short-term and long-term nominal interest rates to an increase in government spending by one percent of output. All numbers in parentheses are the standard errors.

Table 6: Output Multipliers in Recession and Expansion

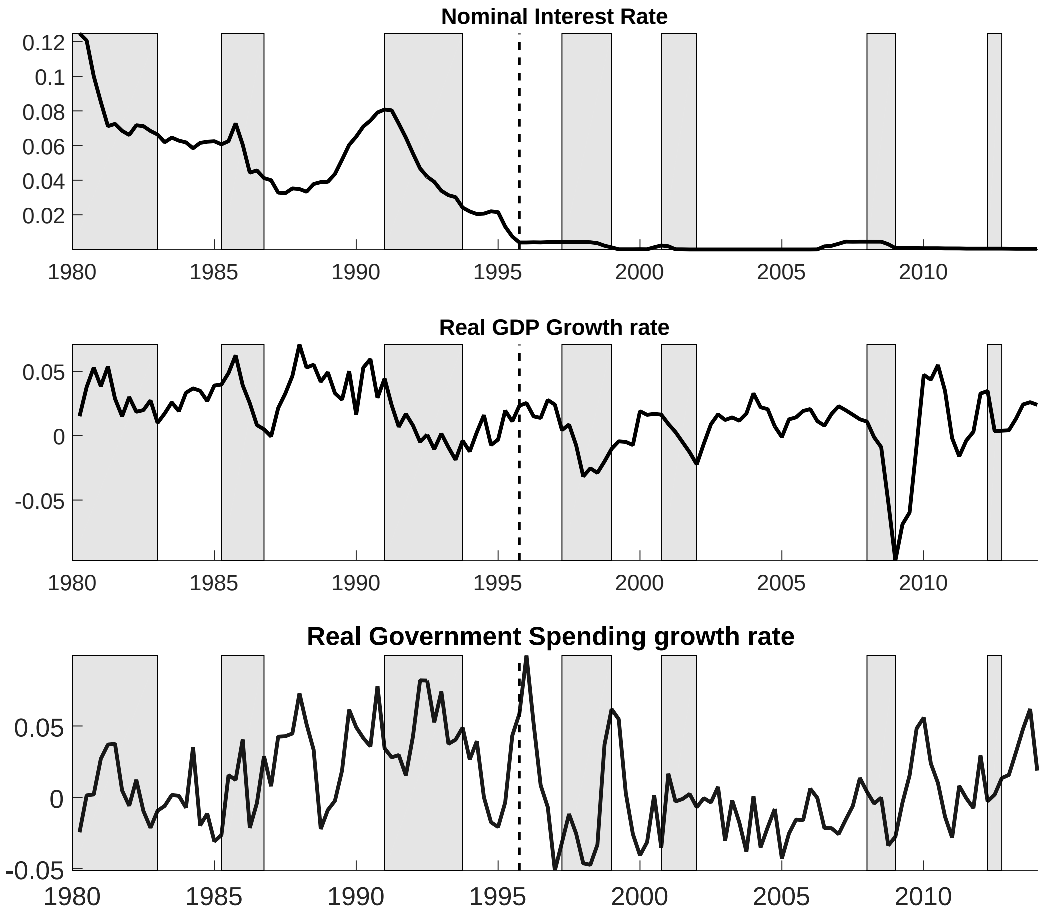
	On impact	4 quarter	8 quarter
Slackness			
Expansion	0.78	0.91	0.49
	(0.29)	(0.71)	(1.32)
Recession	1.97	2.53	0.86
	(0.60)	(0.72)	(1.39)
P-value of difference	0.09	0.27	0.83

Notes: This table reports the output multipliers over several horizons in alternative specifications. "Slackness" reports the multipliers in two regimes: recession and expansion, which are classified based on the Japanese Cabinet Office. All numbers in parentheses are the standard errors.

Table 7: Calibration

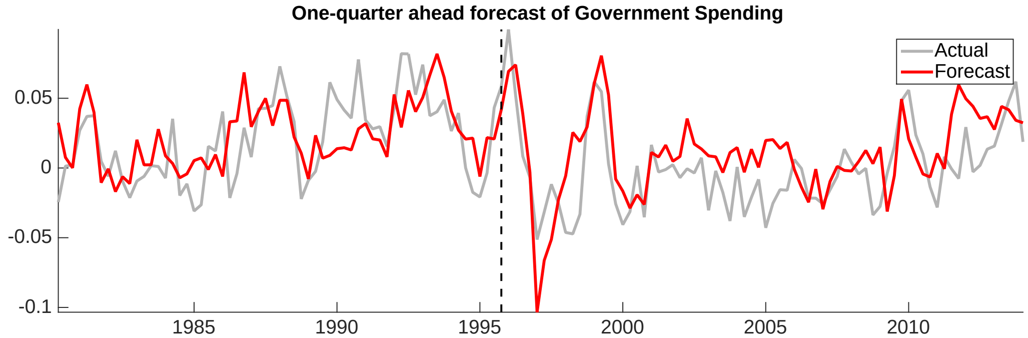
Discount factor	$\beta = 0.99$
Intertemporal elasticity of substitution	$\sigma = 1.1$
Elasticity of substitution	$\theta = 7$
Frisch elasticity of labor supply	$\nu = 1$
Steady state spending-GDP ratio	$\overline{G}/\overline{Y} = 0.18$
Production function	$a = 1$
Probability of price adjustment	$1 - \alpha = 0.25$
Taylor rule parameters	$\phi_\pi = 1.67$
	$\phi_y = 0.15$
	$\rho_i = 0.73$

Figure 1: Japan's Nominal Interest Rate and Real GDP and Government Spending Growth Rates between 1980Q2 and 2014Q1



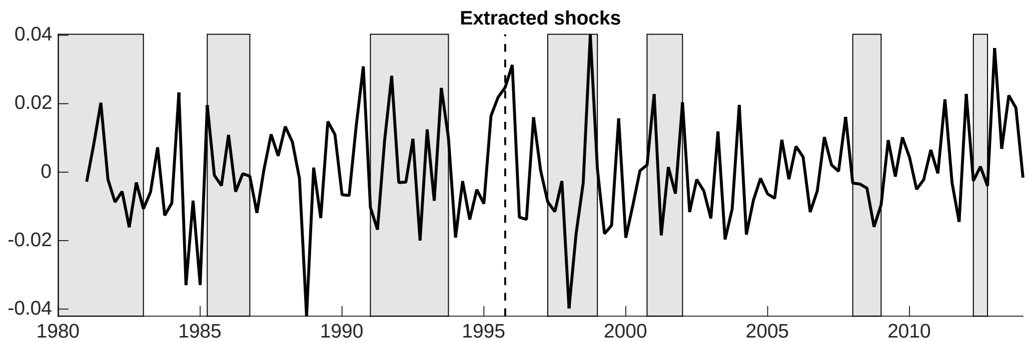
Notes: The shaded areas are Cabinet Office recession dates.

Figure 2: Government Spending Growth Rate: Actual and Forecast



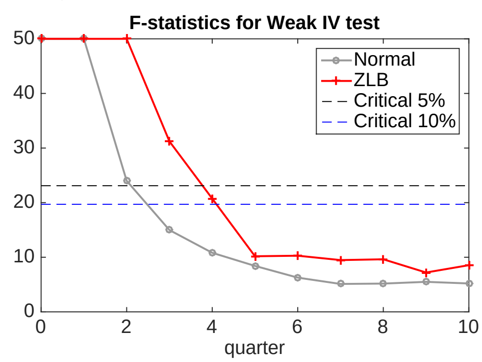
Notes: “Actual” denotes the realized government spending growth rate $\ln(G_t/G_{t-4})$ and “Forecast” denotes the one-quarter ahead forecast of government spending $F_{t-1}\ln(G_t/G_{t-4})$ from the JCER.

Figure 3: Extracted Government Spending shocks $\widehat{\epsilon}_t$



Notes: The extracted shocks series are estimated from equation (1).

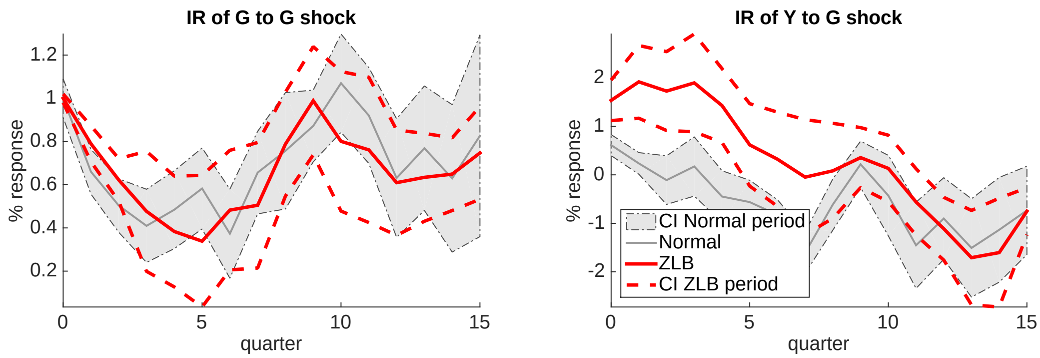
Figure 4: Test of Weak Instrument



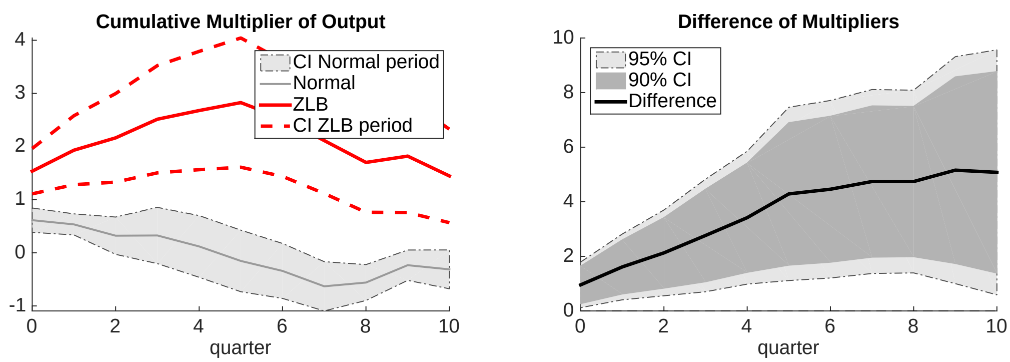
Notes: The graph reports the F-statistics, capped at 50, testing the weak instrument $\widehat{\epsilon}_t$ in the first stage estimation for equation (3). The threshold is 23.1 for one instrument for the 5 percent critical value for testing the null hypothesis that the two-stage least square bias exceeds 10 percent of the OLS bias, and 19.7 for 10 percent critical value. All statistics are robust to heteroskedasticity and serial correlation.

Figure 5: The Effects of Government Spending on Output in the Normal Period and the ZLB Period

(a) Impulse Responses of Output and Government Spending

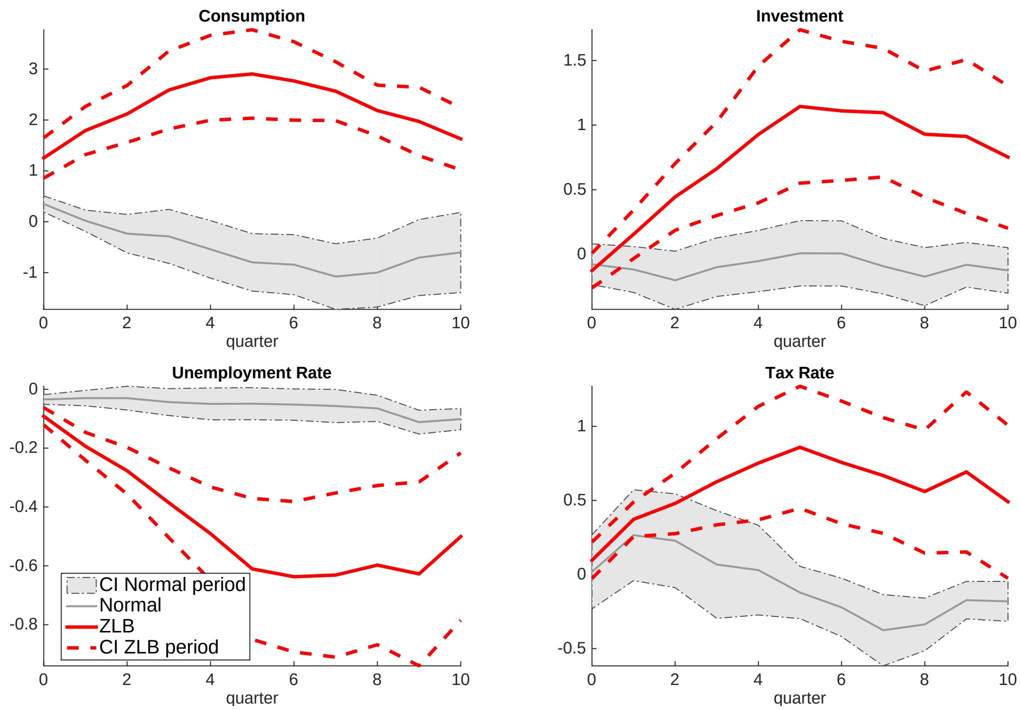


(b) Output Multipliers and the Difference in the Multipliers



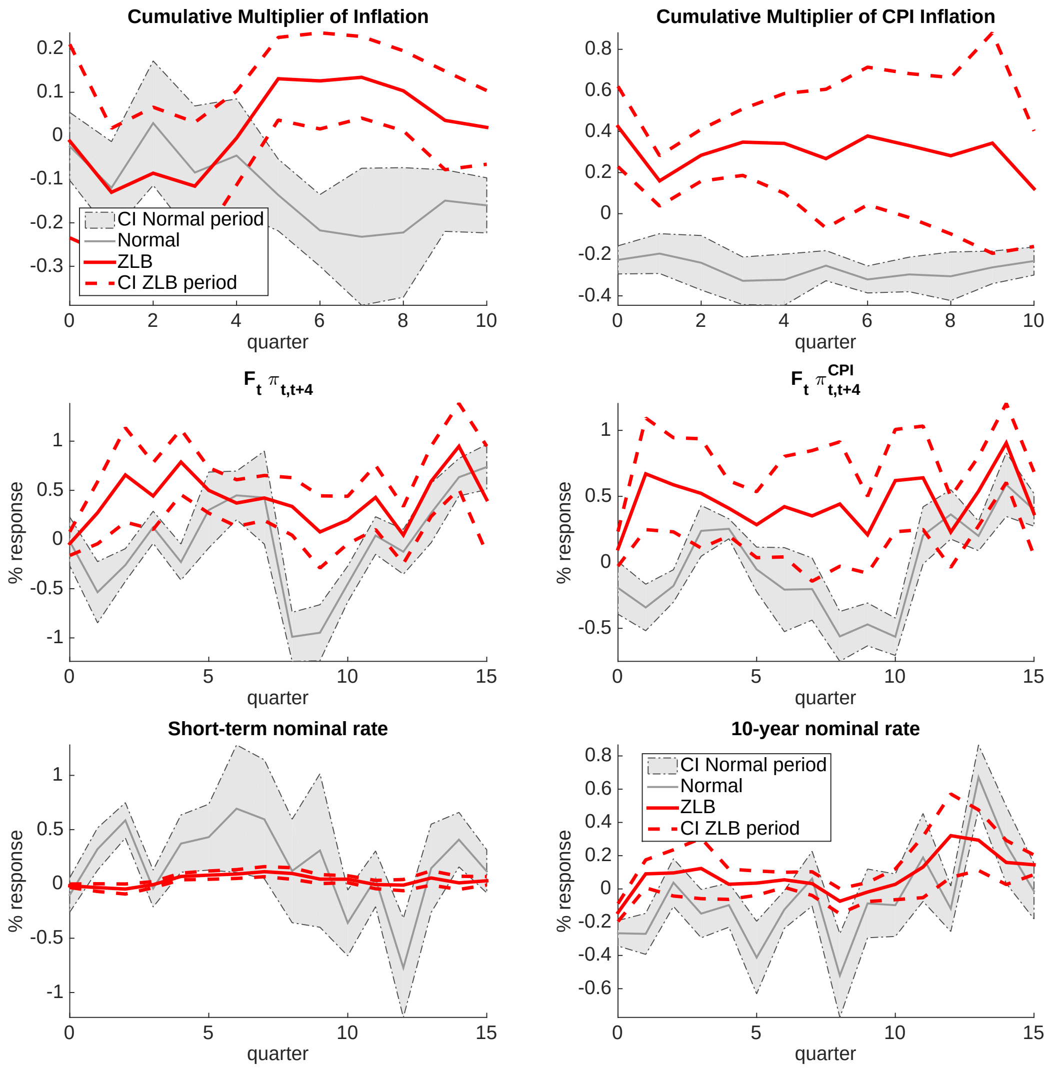
Notes: Impulse responses of output and government spending to an unexpected increase in government spending by one percent of output during normal and ZLB periods.

Figure 6: Other Multipliers



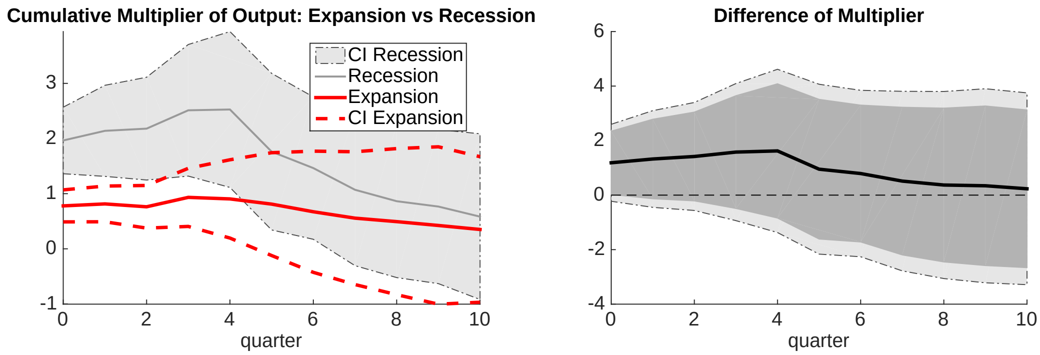
Notes: This figure plots the cumulative multipliers of consumption, investment, unemployment rate, and average tax rate in the normal period and in the ZLB period.

Figure 7: Inflation, Inflation Expectations and Nominal Interest Rates



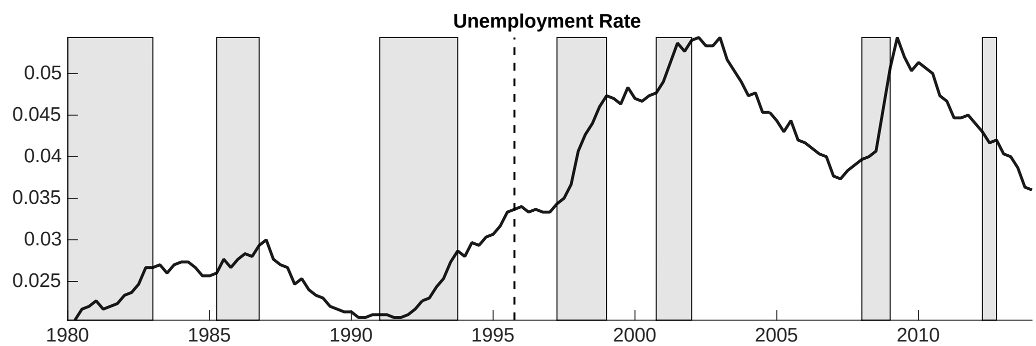
Notes: The first row of the figure plot the cumulative multipliers of inflation, the second row plots the impulse responses of one-year inflation expectations from the GDP deflator and CPI. The last row plots the impulse responses of expected inflation to an increase in government spending by one percent of output in normal and ZLB periods. $F_t\pi_{t,t+4}$ denotes the annual inflation expectation calculated from the GDP deflator forecast. $F_t\pi^{CPI}_{t,t+4}$ denotes the annual inflation expectation calculated from the CPI forecast.

Figure 8: Output Multiplier during Recessions and Expansions



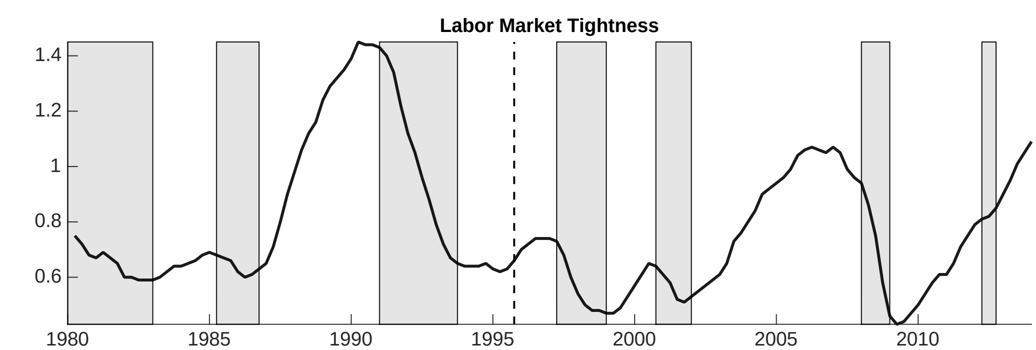
Notes: The left figure plots the output multipliers in recession and in expansion using Japanese data between 1980Q1 and 2014Q1; recessions are defined by the Japanese Cabinet Office. The figure on the right shows the difference in the output multipliers in recessions and in expansions; the 90% confidence interval is shown in dark grey and the one standard deviation confidence interval is shown in the light grey.

Figure 9: Unemployment Rate in Japan



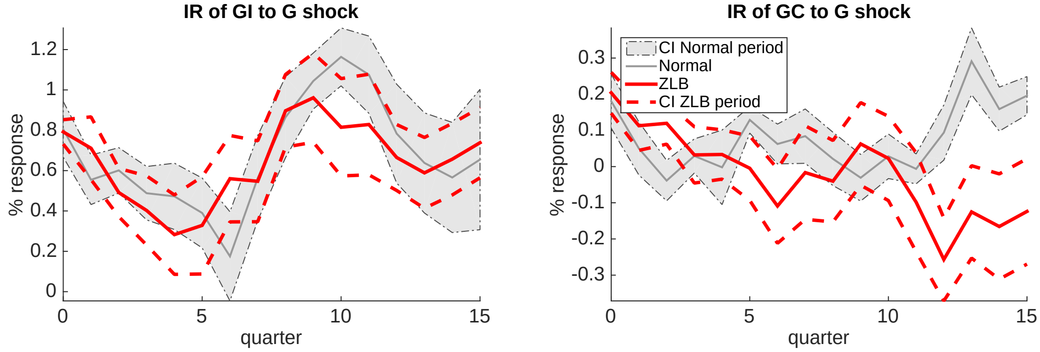
Notes: The shaded areas are Cabinet Office recession dates.

Figure 10: Labor Market Tightness in Japan



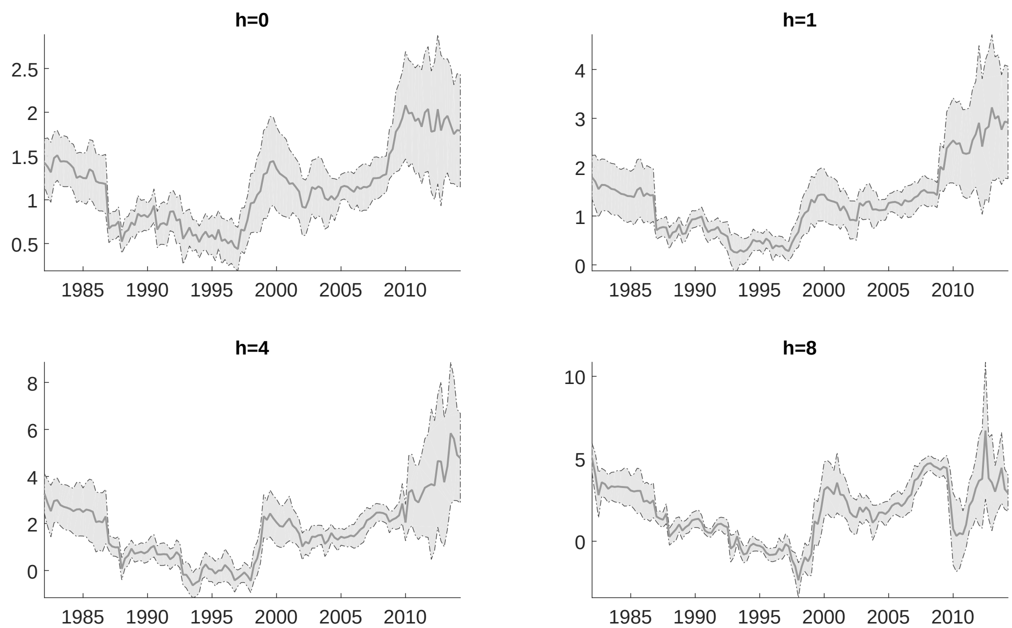
Notes: Labor market tightness is defined as the ratio of job openings to applicants. The shaded areas are Cabinet Office recession dates.

Figure 11: Impulse Responses of Components of Government Spending



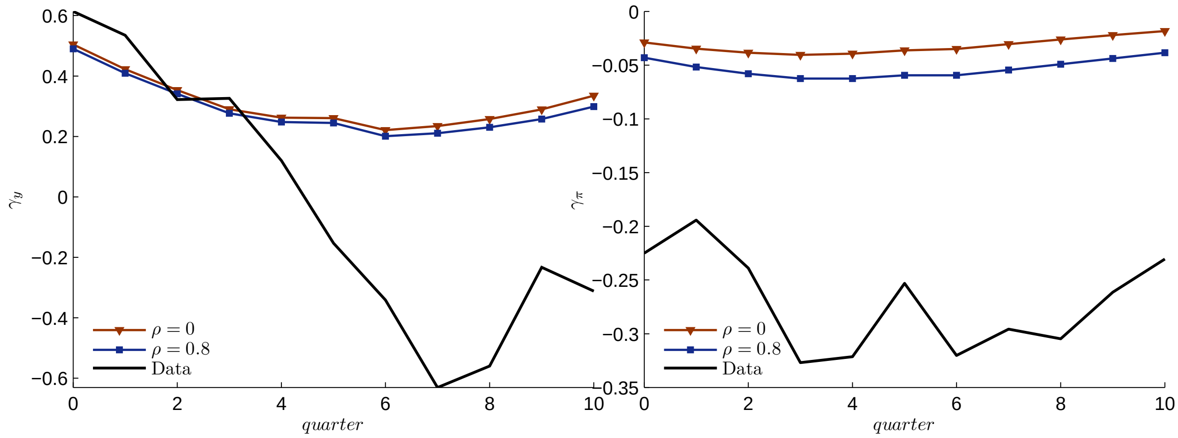
Notes: This figure plots the responses of government investment (left panel) and government consumption (right panel) to an increase in government spending by one percent of output. The responses for both government investment and consumption are measured as percent of output.

Figure 12: Output Multiplier: Rolling Estimation



Notes: The year of a reported multiplier corresponds to the last year of the 60 quarter window. For example, a multiplier reported for 1990Q1 is estimated over the period 1975Q1-1990Q1. Each plot corresponds to the output multiplier at different horizon h (in quarters). The grey areas are one standard deviation error bounds.

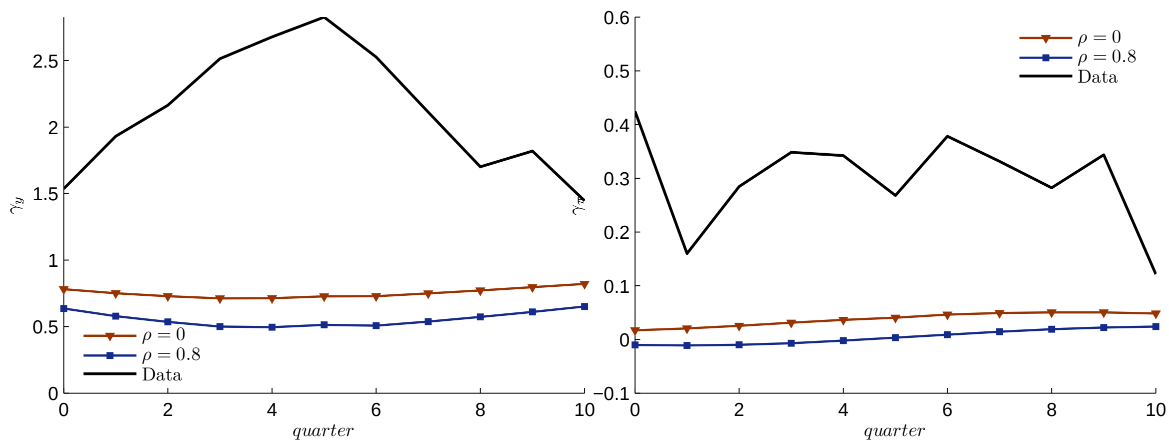
Figure 13: Estimated and Model Multipliers in the Normal Period



(a) Output Multipliers (b) Inflation Multipliers

Notes: This figure plots model and empirically estimated output (left panel) and cumulative inflation multipliers (right panel) in the normal period. We use the CPI to compute the empirical cumulative inflation multiplier in this plot. The model multipliers are computed assuming that during the first sixteen quarters government spending equals the estimated path of government spending after a government spending shock. ρ is the persistence of government spending after the estimated government spending path. The monetary policy follows a Taylor $i_t = (1-\rho_i)(\overline{r} + \phi_\pi \pi_t + \phi_y \widehat{y_t}) + \rho_i i_{t-1}$.

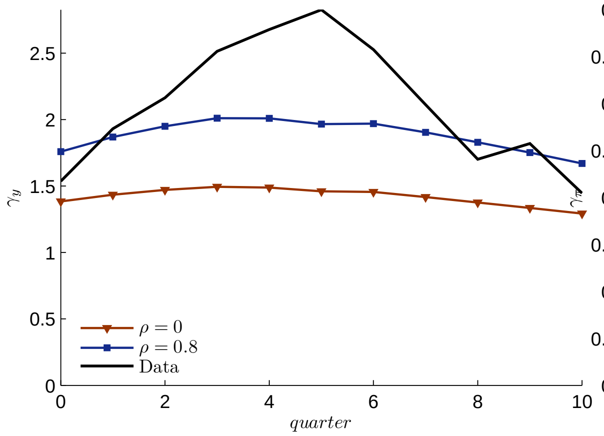
Figure 14: Estimated and Model Multipliers in the ZLB Period Driven by Fundamental Shocks



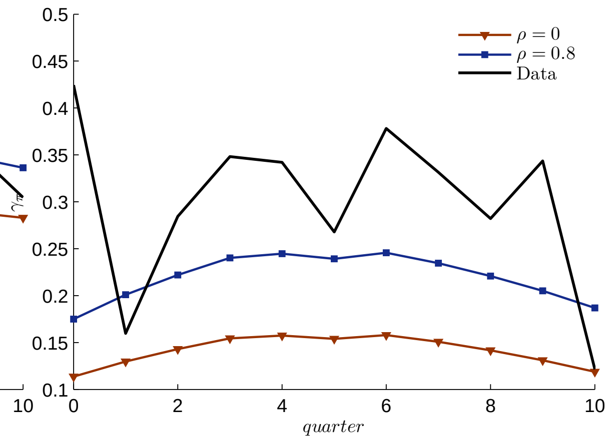
(a) Output Multipliers (b) Inflation Multipliers

Notes: This figure plots model and empirically estimated output (left panel) and cumulative inflation multipliers (right panel) when the monetary policy does not react to fiscal shocks because the economy is at the ZLB driven by a fundamental shock. The model multipliers are conditional on staying in the ZLB period in every quarter. We use the CPI to compute the empirical cumulative inflation multiplier. The model multipliers are computed assuming that during first sixteen quarters government spending equals the estimated path of government spending after a government spending shock. ρ is the persistence of government spending after the estimated government spending path.

Figure 15: Estimated and Model Multipliers in the ZLB Period Driven by Confidence Shocks



(a) Output Multipliers

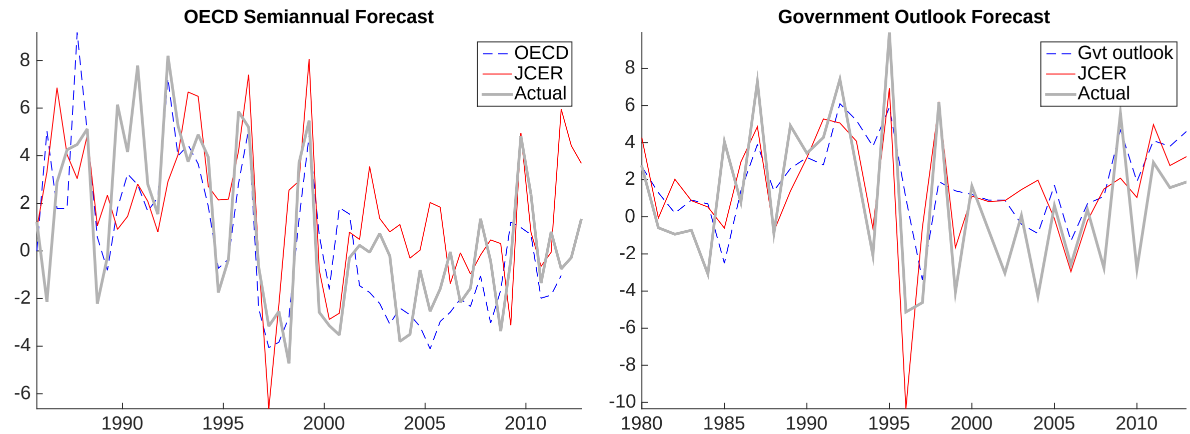


(b) Inflation Multipliers

Notes: This figure plots model and empirically estimated output (left panel) and cumulative inflation multipliers (right panel) when the monetary policy does not react to fiscal shocks because the economy is at the ZLB caused by deflationary trap. The model multipliers are conditional on staying in the ZLB period in every quarter. We use the GDP deflator to compute the empirical cumulative inflation multiplier. The model multipliers are computed assuming that during first sixteen quarters government spending equals the estimated path of government spending after a government spending shock. ρ is the persistence of government spending after the estimated government spending path.

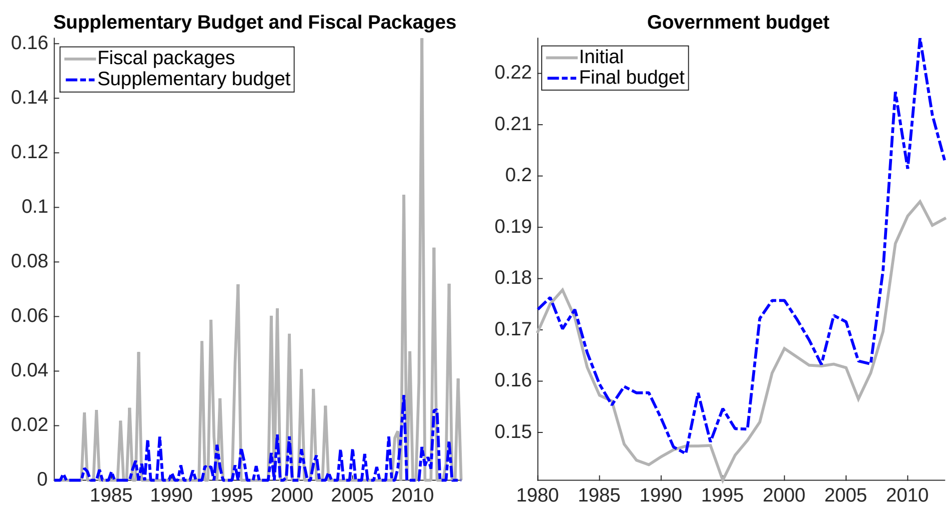
Online Appendix

Figure A1: Other Annual Forecasts of Government Spending



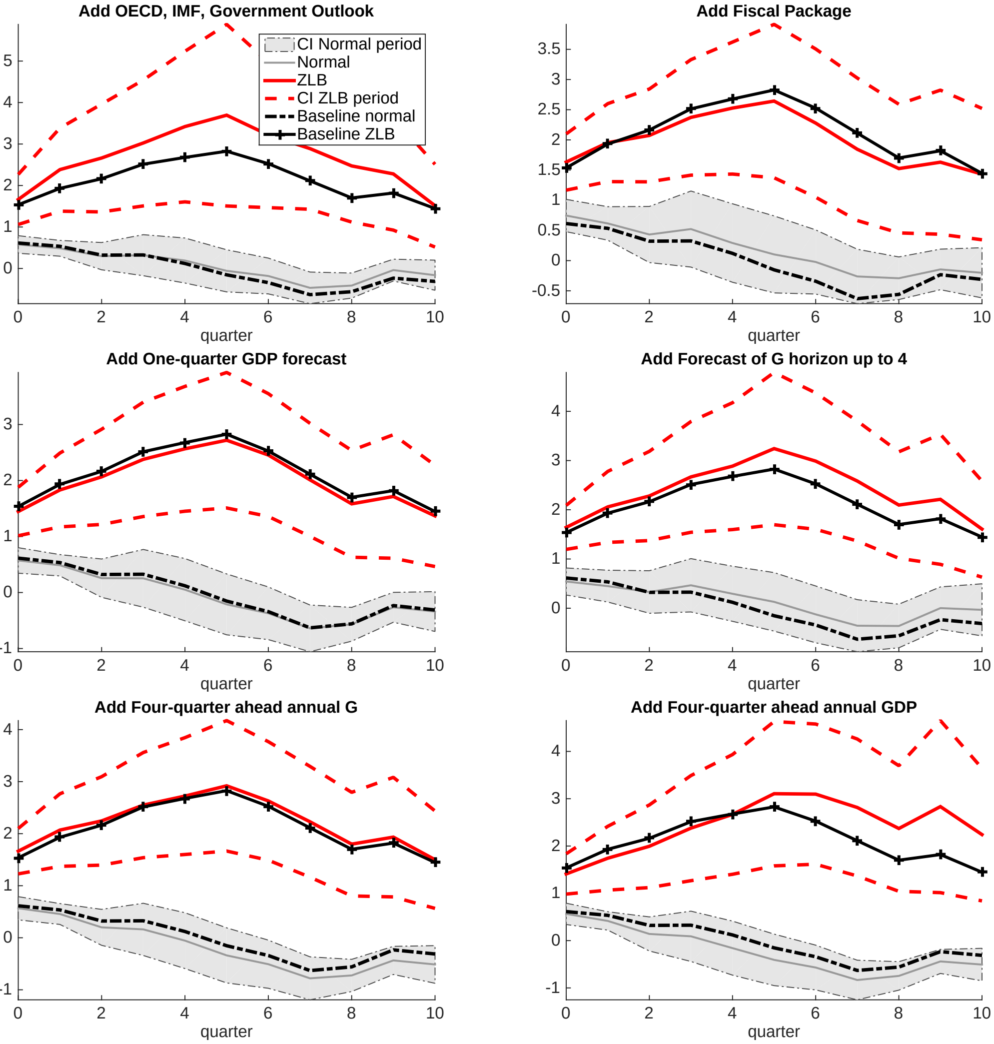
Notes: The figures plot the semiannual forecast of government spending from the OECD (in the left figure), and the annual forecast of government spending from the Government Outlook Forecast (in the right figure) against the same horizon JCER forecast and the actual government spending data.

Figure A2: Supplementary Budget, Fiscal Packages and Total Government Budget in Japan



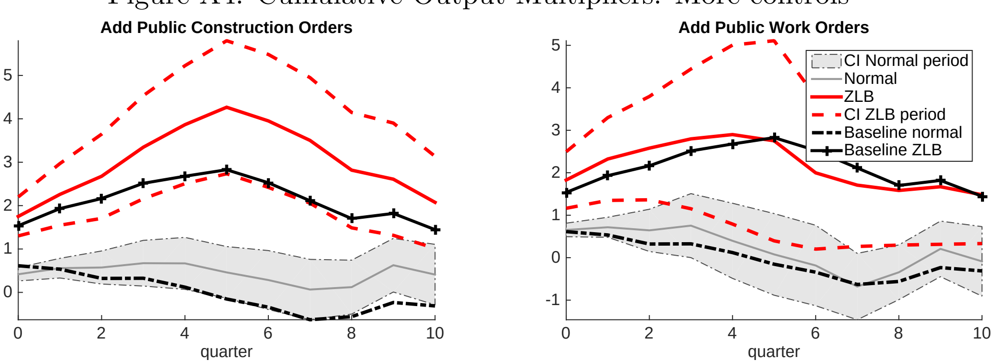
Notes: Supplementary budget for the central government, fiscal packages, and government budgets for the central government are calculated as a ratio of nominal GDP.

Figure A3: Output Multipliers: Adding Other Sources of Real-time Information



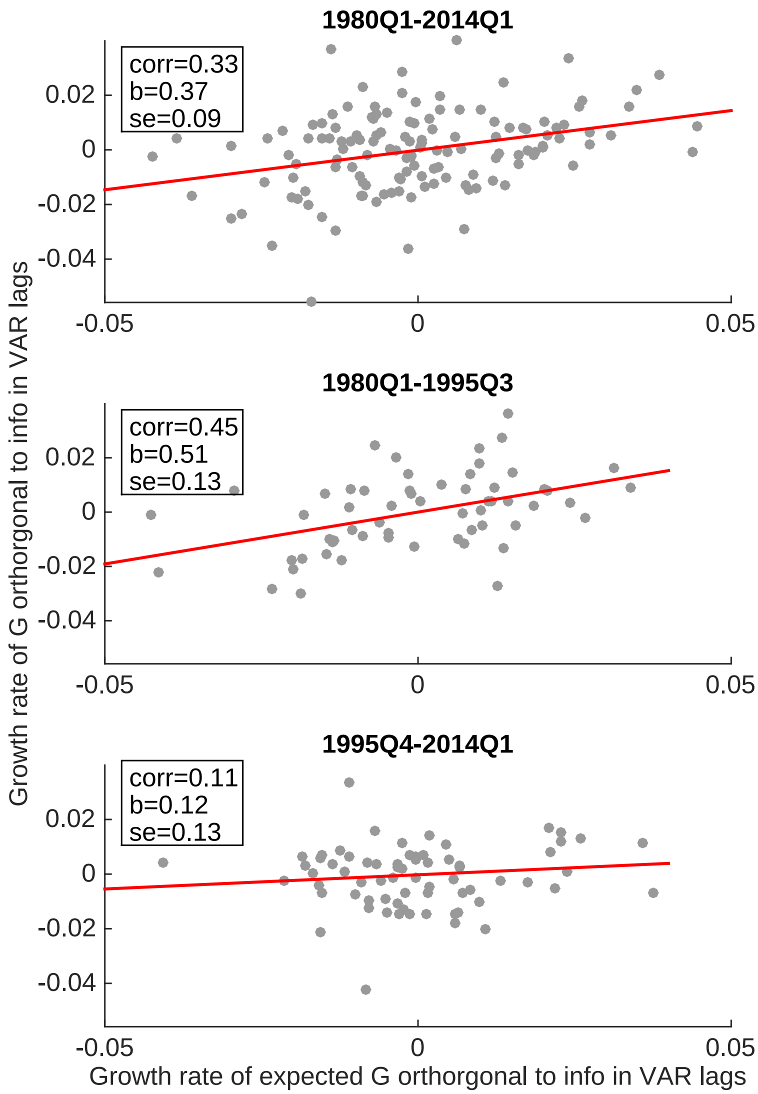
Notes: This figure plots the output multiplier when we add several series to the controls. The black lines are the estimates in the ZLB (with plus signs) and in the normal period (dotted) in the baseline.

Figure A4: Cumulative Output Multipliers: More controls



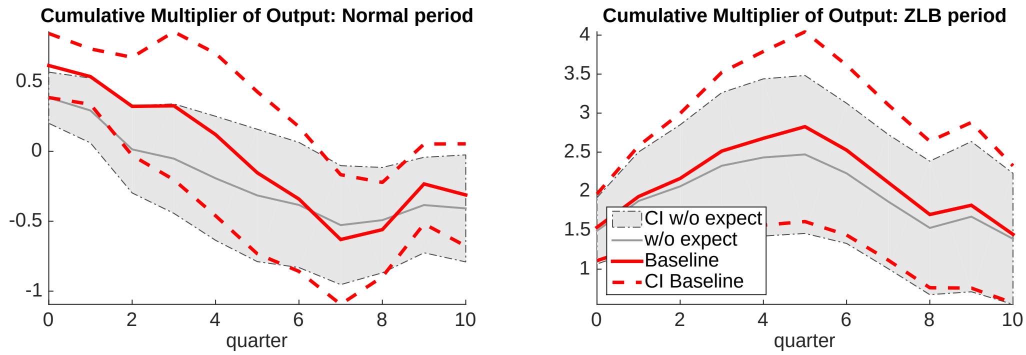
Notes: The figure plots the cumulative output multipliers when we add orders received for public construction (left panel) and contracted public work orders (right panel).

Figure A5: Predictability of Government Spending Shocks without Controlling for Expectations



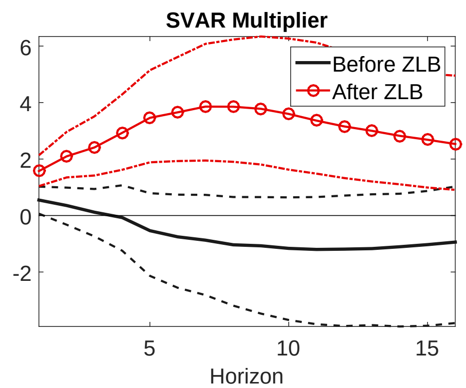
Notes: The figure plots residuals from projection of the growth rate of government spending predicted in JCER forecasts (horizontal axis) and actual growth rate of government spending (vertical axis) on the information contained in the lags of output, government spending and tax revenues. *corr* denotes the correlation between the two series, b is the regression coefficient and se is the standard errors of the regression coefficient. Specifically, we estimate the following specification: $x_t = \alpha^g + \psi^g(L)y_{t-1} + \epsilon_t^g$, for two cases. In the first case, the dependent variable x_t is the realized government spending growth rate, $\Delta \ln G_t$; we obtain the residuals, $\widehat{\epsilon}_{1,t}^g$. In the second case, the dependent variable x_t is the one-quarter ahead forecast of government spending, $F_{t-1}\Delta \ln G_t$; the residuals for this case are $\widehat{\epsilon}_{2,t}^g$. We then calculate the correlation between $\widehat{\epsilon}_{1,t}^g$ and $\widehat{\epsilon}_{2,t}^g$. A non-negative correlation implies that some of the government spending shocks identified without forecast data are predictable. For the entire sample 1980Q1-2014Q1, the correlation between the two residuals is 0.34 and statistically significant, suggesting that there is some forecastability of government spending shocks $\widehat{\epsilon}_{1,t}^g$ identified without forecast data. This correlation is 0.45 in the normal period but it is only 0.11 for the ZLB period between 1995Q4 and 2014Q1. This result suggests that the changes in government spending are less predictable in the ZLB period than in the normal period.

Figure A6: Output Multipliers with and without Forecast Data



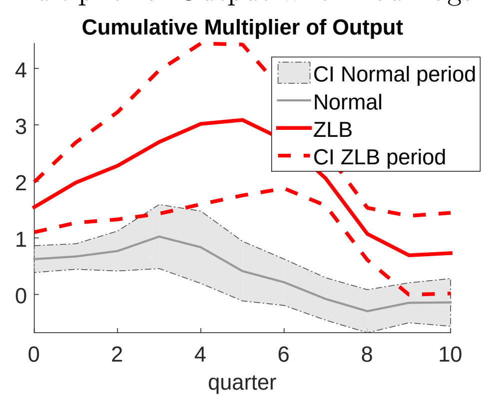
Notes: The left (right) figure plots the output multipliers in the normal (ZLB) period estimated in the baseline (the red lines) and estimated without forecast data (the grey lines), together with their one standard deviation confidence intervals.

Figure A7: Cumulative Multipliers for Output: SVAR



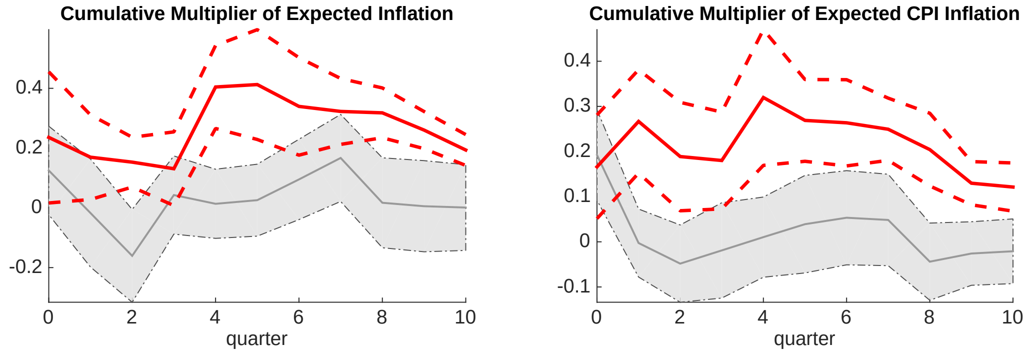
Notes: The figure plots the output multipliers in the ZLB period and the normal period estimated from a structural vector autoregression.

Figure A8: Cumulative Multiplier of Output when Four lags of $shock_t$ are included



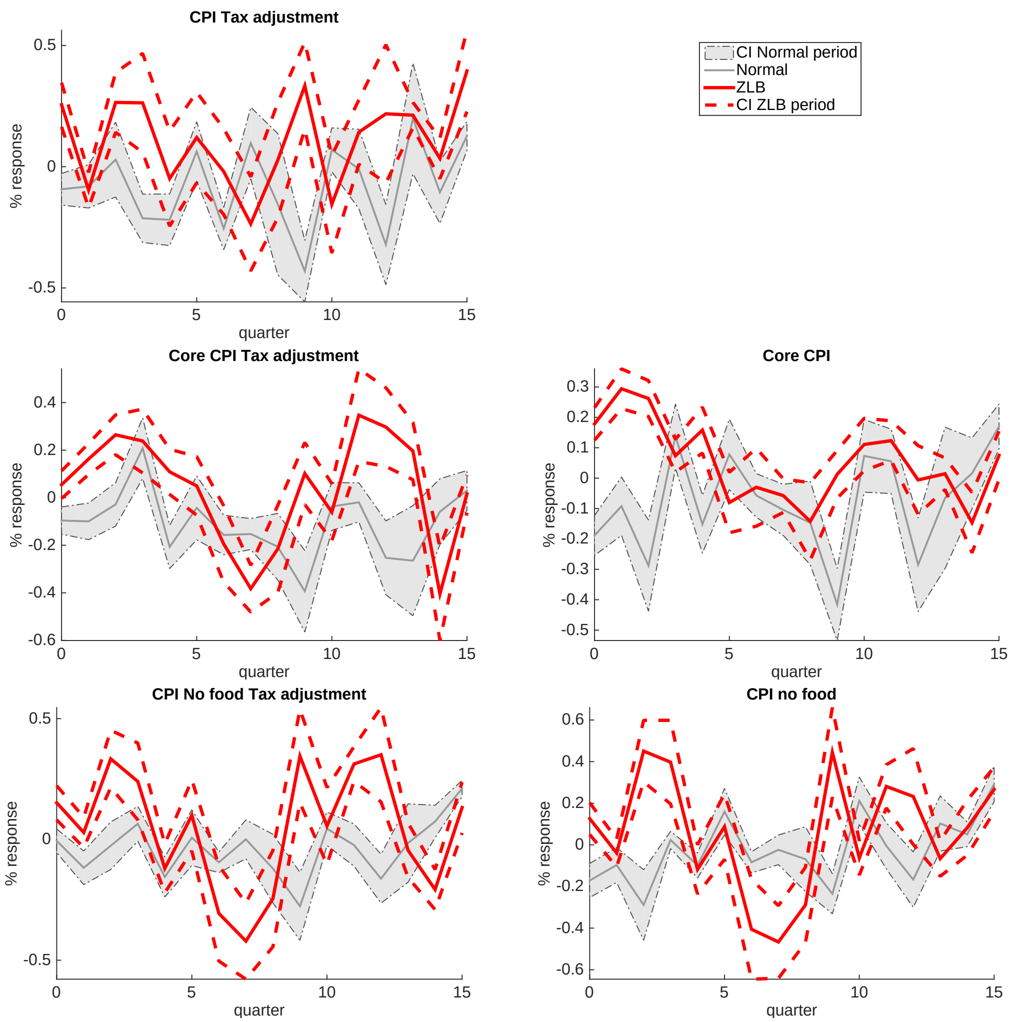
Notes: This figure plots the multiplier of output when we include four lags of $shock_t$ in the estimation.

Figure A9: One-quarter ahead Inflation Expectations Multiplier



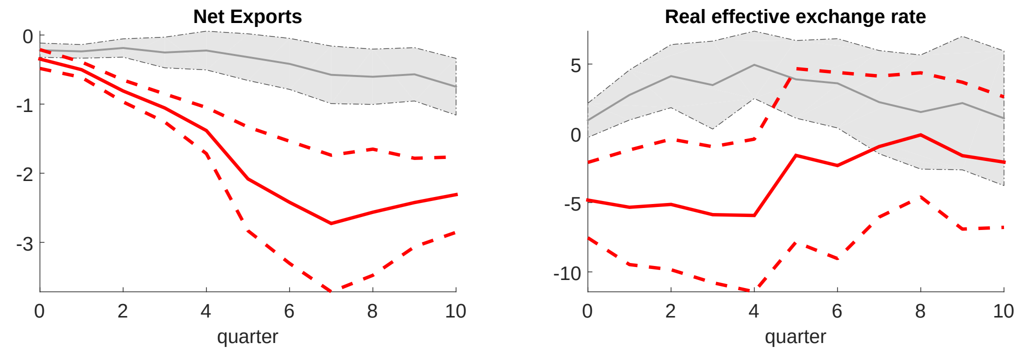
Notes: "One-quarter inflation expectation" is the inflation expectation from the GDP deflator forecast, $F_{t-1}\pi_t$, and "One-quarter CPI inflation expectation" is the inflation expectation from the CPI forecast, $F_{t-1}\pi_t^{CPI}$.

Figure A10: Different Inflation Data



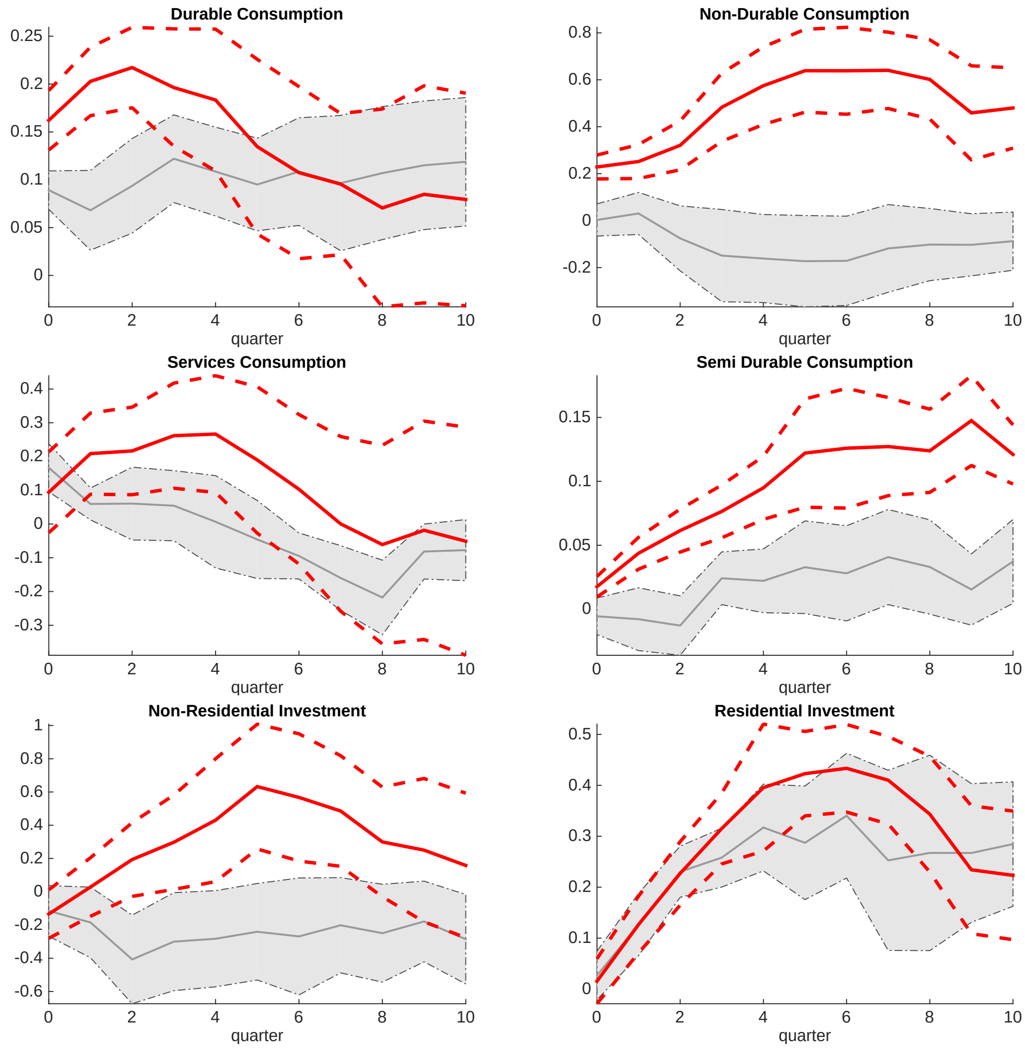
Notes: This figure plots the impulse responses of the inflation rate calculated from CPI, core CPI (excluding food and energy) and CPI no food (excluding fresh food) along with the measures of CPI inflation adjusted for consumption tax changes.

Figure A11: Net Exports and Real Exchange Rate Multipliers



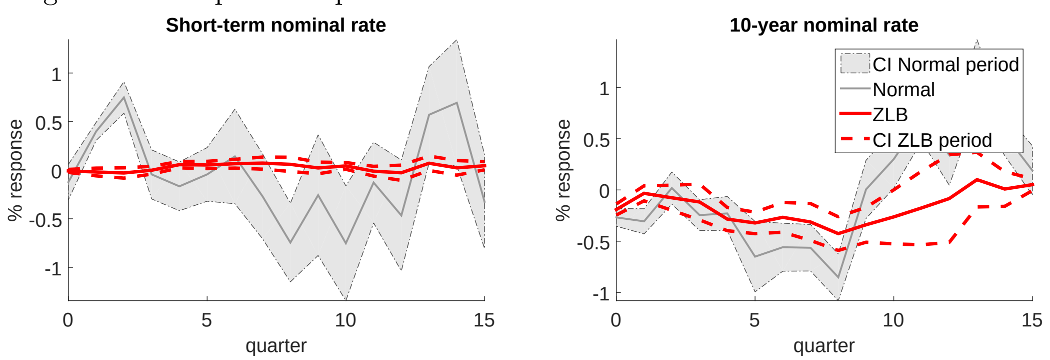
Notes: This figure plots the cumulative multipliers of Net Exports and Real Exchange Rate in the normal period and in the ZLB period.

Figure A12: Cumulative Multipliers for Components of Consumption and Investment



Notes: This figure plots the cumulative multipliers for the consumption of durables, non-durables, services, as well as residential and non-residential investment. The estimation specification is the same as consumption and investment in the baseline.

Figure A13: Impulse Responses of Interest Rate without trend in the estimation



Notes: This figure plots the responses of the nominal interest rate when there is no trend in the specification.