연세대학교 상경대학
경제연구소
Economic Research Institute
Yonsei Universit

서울시 서대문구 연세로 50
50 Yonsei-ro, Seodaemun-gu, Seoul, Korea
TEL: (+82-2) 2123-4065 FAX: (+82-2) 364-9149
E-mail: yeri4065@yonsei.ac.kr
http://yeri.yonsei.ac.kr/new

Are Government Spending Shocks Inflationary at the Zero Lower Bound? New Evidence from Daily Data

Sangyup Choi
Yonsei Univ
Junhyeok Shin
Johns Hopkins University
Seung Yong Yoo
Yonsei Univ

December 2021
2021RWP-189

Economic Research Institute

Yonsei University

Are Government Spending Shocks Inflationary at the Zero Lower Bound? New Evidence from Daily Data*

Sangyup Choi† Yonsei University

Junhyeok Shin‡ Johns Hopkins University

Seung Yong Yoo◊ Yonsei University

December 2021

Abstract

Are government spending shocks inflationary at the zero lower bound (ZLB)? Despite the importance of the inflation channel in amplifying a government spending multiplier at the ZLB, empirical evidence has not provided a clear answer to this question. Exploiting newly constructed high-frequency data on government spending and the price index of the U.S. economy, we find that prices decline persistently in response to a positive government spending shock at the ZLB. When compared to normal times, government spending shocks are less inflationary and less expansionary at the ZLB. Our finding is difficult to reconcile with the larger fiscal multiplier at the binding ZLB often predicted by standard New Keynesian models via rising inflation and a falling real interest rate. High-frequency developments in consumer confidence, economic policy uncertainty, and oil prices, as well as changes in the component of military spending during the ZLB period, do not explain this anomaly.

JEL Classification: E31; E32; E62; F31; F41

Keywords: Zero lower bound; Government spending; Online price index; High-frequency data; New Keynesian model; COVID-19

---

* We are thankful to Wongi Kim (discussant), Gillian Brunet, Daeha Cho, Lawrence Christiano, Jeongmin Ha, Joonyoung Hur, Eunseong Ma, Kwang Hwan Kim, Ryan Kim, Kwangyong Park, Dongling Su, and participants at the HenU/INFER Workshop on Applied Macroeconomics 5.5, 2021 KER International Conference, and the Conference on "The Effects and Limitations of Fiscal Policy in the New Normal" for their helpful comments. We appreciate Alberto Cavallo for helping with daily data on the Online Price Index. This research was (in part) supported by the Yonsei Signature Research Cluster Program of 2021 (2021-22-0011). This paper was written when Junheok Shin was a graduate student at Yonsei University. Any errors are the authors' responsibility.

† School of Economics, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, South Korea. Email address: sangyupchoi@yonsei.ac.kr.

‡ Department of Economics, Johns Hopkins University 3400 N. Charles Street Baltimore, MD 21218. Email address: jshin77@jhu.edu.

◊ School of Economics, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, South Korea. Email address: 14syoo@yonsei.ac.kr.

I. Introduction

Are government spending shocks inflationary? Despite the rapid progress in identifying these shocks and understanding their macroeconomic effects (e.g., Blanchard and Perotti, 2002; Mountford and Uhlig, 2009; Ramey, 2011), the literature has not reached a consensus on this matter. For example, Jørgensen and Ravn's (2018) review noted that almost equal numbers of studies have found disinflationary (or deflationary), inflationary, and null (i.e., insignificant) responses to government spending shocks.[1] The conventional wisdom is that increases in government spending are inflationary via the positive aggregate demand effect. This idea plays a crucial role in transmitting fiscal policy shocks in many theoretical models, including textbook New Keynesian models.

Understanding the effect of government spending shocks on inflation has become particularly important since the Great Recession, as the size of the fiscal multiplier hinges on the ability of higher government spending to drive up inflation and therefore reduce the real interest rate when the nominal interest rate is at the zero lower bound (ZLB) (e.g., Christiano et al., 2011; Eggertsson, 2011; Woodford, 2011).[2] However, related research has been greatly constrained in this context because only a handful of low-frequency observations are available when the economy is at the ZLB (2009–2015). Although alternative approaches have been adopted to resolve this constraint, only a few time-series observations do not allow for sufficient statistical power to obtain a definite answer to the question.[3]

[1] See Jørgensen and Ravn (2018) for a comprehensive review of empirical studies on the price response to government spending shocks in the U.S. economy.

[2] Under nominal rigidities, the upward shift in its expected real wage path following fiscal expansion leads businesses to increase prices today, resulting in higher inflation, which reduces the real interest rate; such a reduction also leads households to shift consumption toward the present, increasing the size of the fiscal multiplier. This effect is particularly strong when monetary policy is not responsive due to the ZLB.

[3] To circumvent the lack of sufficient time-series data in studying the effect of government spending shocks at the ZLB, some authors have estimated the time-varying parameter model (Klein and Linnemann, 2019), relied on a historical sample

We circumvent this challenge in identifying a causal relationship between government spending and inflation by exploiting the high-frequency (daily) data on both U.S. defense spending (announcement and actual payments) constructed by Auerbach and Gorodnichenko (2016) and the online price index (OPI) constructed by Cavallo and Rigobon (2016). To the best of our knowledge, this is the first attempt to identify the effect of government spending shocks on inflation using high-frequency data, which are largely immune to the potential misspecification problem in Vector Autoregressions (VARs) when imposing timing restrictions on low-frequency data.[4] Moreover, using daily-frequency spending proxies alleviates the concern made in Brunet (2020) when using the National Income ProductAccounts (NIPA) to measure government spending.[5] Online prices also provide additional insights because price stickiness is less relevant in online markets than in traditional brick-and-mortar stores (Gorodnichenko et al., 2018).

We estimate the effect of government spending using local projections as in Jordà (2005) and Auerbach and Gorodnichenko (2016) and confirm the main finding of Auerbach and Gorodnichenko (2016) that the U.S. dollar appreciation in response to fiscal expansion largely holds in the binding ZLB subsample. Importantly, we find robust evidence that prices decline significantly and persistently after a positive government spending shock. We further find that inflation expectations over the medium to long term—measured by daily financial market data—decline mildly in response to government spending shocks. Therefore, both ex-ante and ex-post real interest

---

covering more than 100 years (Ramey and Zubairy, 2018), or focused on a particular country (Japan), where the chronic ZLB since the 1990s allow for a rather standard time-series analysis (Miyamoto et al., 2018).

[4] An alternative approach is using inflation expectations extracted from financial market data, readily available at a high frequency. However, as explained in Gürkaynak et al. (2010), this so-called “break-even” inflation measure can be affected by inflation risk premium or liquidity premium, resulting in a distorted measure of inflation expectations. Such distortion magnifies at a higher frequency. We still use a break-even inflation measure for robustness checks.

[5] Brunet (2020) argues that NIPA measures government spending too late in the process, which is problematic when measuring the influence of government spending on economic activity. While a significant fraction of government payments are often delayed until final goods are delivered to the government, firms often hire workers and purchase materials in advance of such payments. Thus government spending may be recorded in NIPA after its direct effects on the economy have already begun, and sometimes after the direct effects have concluded.

rates increase after positive government spending shocks, suggesting that the conventional expansionary effect of government spending may not work. Indeed, by employing the Aruoba-Diebold-Scotti Business Conditions Index (ADS Index) from Aruoba et al. (2009) that captures daily economic conditions, we find that government spending shocks fail to increase economic activity at the ZLB.

However, when we incorporate additional data from outside the ZLB period, we find that the same shock becomes inflationary and results in a decline in the real interest rate and an improvement in economic conditions, all consistent with standard theoretical predictions. To the extent that the high-frequency data used in this study provide more reliable identification of a fiscal shock, our finding contributes to settling the so-called "fiscal price puzzle" examined by Jørgensen and Ravn (2018) in the context of normal times but creates another anomaly in the context of the ZLB.

From a theoretical perspective, it is even more puzzling that the inflation response is stronger when the economy is no longer constrained by the ZLB since we expect a less inflationary response when active monetary policy is allowed, translating into an increase in the real interest rate and a stronger crowd-out effect compared to the ZLB. Overall, our findings suggest that the stimulating effect of fiscal expansion at the ZLB is unlikely to operate via the inflation channel and, therefore, suggest a potential explanation for the finding in Ramey and Zubairy (2018) that the government spending multiplier is not larger during the ZLB than normal times when using military news shocks and similar methodology.

From the open economy perspective, the deflationary effect of fiscal expansion might be induced by a decline in import prices via the nominal appreciation of the U.S. dollar. Then, the indirect effect on inflation via appreciation might dominate the direct demand effect of fiscal expansion. However, accounting for the open economy nature (by controlling for fluctuations in the nominal effective exchange rate), which hardly affects the estimated deflationary response to the spending shock, still does not provide a definite answer to this anomaly.

The literature has also recognized the role of confidence or uncertainty in governing the effectiveness of government spending policies (e.g., Bloom, 2009; Bachmann and Sims, 2012; Mertens and Ravn, 2014; Berg, 2019).[6] For example, it is possible that government spending during the ZLB period failed to create inflation because agents remained pessimistic about the future course of the U.S. economy and postponed their spending decisions. To the extent that consumer confidence affects aggregate demand independently of economic fundamentals, the deflationary effect of government spending at the ZLB can be attributed to prevalent consumer pessimism during the sample period.

There is also a long-standing idea that uncertainty about the economy reduces the effectiveness of economic policies (e.g., Brainard, 1967; Bloom, 2009; Baker et al., 2016). According to the uncertainty channel of fiscal policy, heightened uncertainty about the state of the economy or future economic policies might have prevented an inflationary effect of government spending shocks at the ZLB: households and firms take a "wait-and-see" approach under higher uncertainty, weakening the stimulating effect of government spending shocks.

We further use novel daily measures of consumer confidence and economic policy uncertainty to test the empirical relevance of these channels. Our finding largely disputes consumer confidence and uncertainty as a potential explanation for the deflationary effect of government spending shocks at the ZLB. There is no evidence that government spending shocks induced a decline in consumer confidence or rising uncertainty at the ZLB compared to normal times. As a result, controlling for these variables hardly affects our conclusion, making it even more puzzling from the theoretical perspective.

---

[6] For example, Bachmann and Sims (2012) show that consumer confidence is an important channel of U.S. government spending shocks using a structural VAR model. See Bloom (2009) for a discussion of how heightened uncertainty reduces the effectiveness of government policies by increasing the region of the inaction of private agents.

The remainder of the paper is organized as follows. Section II illustrates the effect of a government spending shock on inflation during the ZLB using a simplified New Keynesian model. Section III introduces novel daily data on the key variables, including government spending and the price index, and explains the empirical model. Section IV presents the main findings and provides a series of robustness checks. Section V discusses how the empirical findings can be potentially reconciled with recently developed theoretical models and concludes.

II. Simple Analytical Illustration

Using a simplified theoretical framework, we illustrate how the binding ZLB strengthens the inflationary response to government spending shocks, further stimulating consumption and output compared to normal times. Although the model is highly stylized, it provides analytical solutions, enabling straightforward comparative statistics. Moreover, this study shares its theoretical predictions with more sophisticated medium-scale New Keynesian models (e.g., Smets and Wouters, 2003).

Considering the standard dynamic New Keynesian model characterized by Calvo pricing, linear labor-only production technology, and separable consumption and leisure in the utility function (e.g., Carlstrom et al., 2014; Dupor and Li, 2015), the linearized model is given by

$$i_t - E_t\pi_{t+1} = -\sigma(c_t - E_t c_{t+1}), \tag{1}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa mc_t, \tag{2}$$

$$mc_t = \sigma c_t + \nu y_t, \tag{3}$$

$$y_t = (1-s)c_t + s g_t, \tag{4}$$

where $\pi_t, y_t, c_t, g_t, mc_t$, and i_t denote inflation, output, consumption, government spending, marginal cost, and the nominal interest rate, respectively, all measured as deviations from the steady state. Additionally, for simplicity, we assume that steady-state inflation is zero. The constant s is the share of government spending in the steady state.[7] Substituting Equations (3) and (4) into Equation (2), we have

$$\pi_t = \beta E_t \pi_{t+1} + \kappa(\sigma + \nu(1-s))c_t + \kappa\nu s g_t. \tag{5}$$

The simple dynamic New Keynesian model is given by the dynamic IS curve (1), New Keynesian Phillips curve (5), the monetary policy rule (6), and the fiscal policy rule (7). Following Dupor and Li (2015), the monetary and fiscal policies are set according to the following:

$$i_t = \psi E_t \pi_{t+1}, \tag{6}$$

$$g_t = \rho g_{t-1} + \varepsilon_t, \tag{7}$$

where ε_t is the mean zero white noise. The monetary policy is considered active when the responsiveness parameter $\psi > 1$, and passive otherwise.

Given Equations (1), (5), and (6) and the endogenous variables c_t, i_t, and π_t, one can solve for the model's rational expectations equilibria around its steady state. The equilibrium is typically unique under an active monetary policy, whereas multiple equilibria exist under a passive monetary policy. Following Boivin and Giannoni (2006) and Dupor and Li (2015), we only focus on the bubble-free equilibrium to rule out multiple equilibria. Regardless of monetary policy, inflation and consumption in equilibrium are given by

$$\pi_t = \Lambda g_t = \frac{\kappa s \nu(1-\rho)}{\beta(\rho^2 + \Theta\rho + \frac{1}{\beta})} g_t, \tag{8}$$

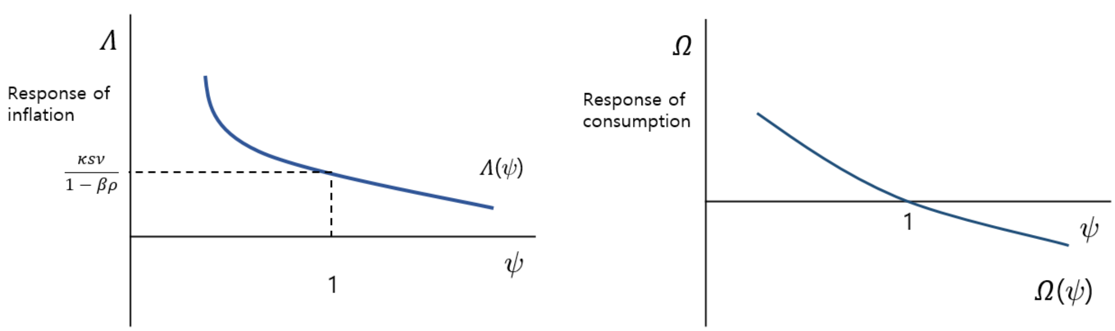
$$c_t = \Omega g_t = \frac{(1-\beta\rho)\Lambda - \kappa s \nu}{\kappa(\sigma + \nu(1-s))} g_t, \tag{9}$$

[7] As in Dupor and Li (2015), Equations (1) to (5) do not include a government budget constraint because we assume that fiscal policy is Ricardian. Thus, the government's present value budget condition holds for any sequence of prices and quantities as long as the fiscal rule is followed. This assumption allows us to focus on the inflation channel of government spending shocks amplified by the ZLB.

where $\Theta = \frac{\sigma^{-1}\kappa(\sigma+\nu(1-s))(\psi-1)-\beta-1}{\beta}$. It can be clearly seen that when $\psi = 1$, $\Lambda = \frac{\kappa s \nu}{1-\beta\rho} > 0$.[8] When the monetary authority raises the nominal interest rate one for one with expected inflation, a government spending shock increases inflation. Given this value of Λ, we can easily confirm that $\Omega = 0$. Government spending shocks do not crowd out nor crowd in private consumption when ψ equals one. For a reasonable value of ψ, we have $\frac{\partial \pi_t}{\partial g_t} > 0$. Moreover, when $\psi < 1$, $\frac{\partial c_t}{\partial g_t} > 0$, and when $\psi > 1$, $\frac{\partial c_t}{\partial g_t} < 0$.

Our research interest is observing how the binding ZLB amplifies the inflation response and, therefore, the consumption (and output) response to government spending shocks. At binding ZLB, $\psi \to 0$ so that the monetary authority keeps the nominal interest rate at zero regardless of inflation. Although this simple model does not consider the binding ZLB in the strict sense, the following mechanism generating a higher multiplier via an increase in (expected) inflation is shared by theoretical models considering the ZLB explicitly (e.g., Christiano et al., 2011; Eggertsson, 2011; Woodford, 2011).

Figure 1. Equilibrium impact responses of inflation and consumption to a government spending shock under active and passive monetary policy rules



Note: This graph plots the equilibrium impact responses of inflation (left) and consumption (right) to a government spending shock in terms of the parameter ψ.

[8] Because σ, κ, $\nu \geq 0$ and $1 > \beta$, $\rho \geq 0$, Λ must be positive.

As ψ only affects Λ via changes in Θ, it is clear that $\frac{\partial}{\partial\psi}\left(\frac{\partial\pi_t}{\partial g_t}\right) < 0$, and therefore, $\frac{\partial}{\partial\psi}\left(\frac{\partial c_t}{\partial g_t}\right) < 0$. The inflationary response to government spending shocks is maximized at the ZLB, which also maximizes the size of the fiscal multiplier. Figure 1, taken from Dupor and Li (2015), plots the equilibrium impact responses of inflation and consumption to a government spending shock under the active and passive monetary policy, depending on the value of ψ.

This simple theoretical illustration clarifies the crucial role of inflation in characterizing the transmission channel of government spending at the ZLB. Equipped with a novel dataset spanning the ZLB at a daily frequency (2,460 observations), we now have the exogeneity of fiscal policy and enough statistical power to test the empirical relevance of this theoretical channel.

III. Empirical Analysis

A. Data

This section presents the five primary datasets available at a daily frequency: the government spending, price index series, economic activity index, consumer confidence index, and uncertainty index. First, we use two daily government defense spending series constructed by Auerbach and Gorodnichenko (2016). The first series is the announced volume of contracts awarded daily by the U.S. Department of Defense (DoD). As modifications to existing contracts are anticipated, the series extracts information on the announcement of new contracts only–first-time contracts on the DoD website. The second series is payments to defense contractors reported in the daily statements of the U.S. Treasury.

Using defense spending as a representative for government spending is justifiable for several reasons. Compared to other types of spending, defense spending i) is less likely to be determined by current economic conditions, ii) is much less predictable, iii) takes a large domestic component, and iv) is a major source of variation in government spending. Auerbach and Gorodnichenko (2016) confirm the validity of these measures by showing that i) the announced volume of contracts are closely related to major military developments and ii) the payment series closely tracks the standard government spending data available at a quarterly frequency.

Following Auerbach and Gorodnichenko (2016), we use the novel framework introduced by De Livera et al. (2011) to deseasonalize and detrend both series, alleviating any existing seasonal variation and other predictable components. Auerbach and Gorodnichenko (2016) asserted that using these two series helps underscore the key role of fiscal foresight for timing government spending shocks and their responses. While these data series are mostly available throughout the ZLB, we extend the second series—payments to defense contractors—until 2018 to investigate the inflation response to government spending shocks after the ZLB is lifted. Figure A.1 in the appendix plots both series at a daily frequency.

Second, we obtain the daily OPI from Cavallo and Rigobon (2016), calculated using price data from numerous websites. While they mimic the construction of the conventional price index, the price index is updated daily by replacing the usual data collection process with an automated "web-scraping" program. Therefore, this index is conceptually consistent with the consumer price index (CPI) and closely tracks fluctuations in the CPI during the sample period at a higher frequency (see Figure A.2 in the appendix). Moreover, new and disappearing products are easily detected and reflected in the index as the data collected are comprehensive. However, the daily OPI is available only from July 2008, which is chosen as the starting period of our empirical analysis.

Third, we use the ADS index from Aruoba et al. (2009). The ADS Index tracks real business conditions at high observation frequency (i.e., daily) and fully covers our sample period (see Figure A.3 in the appendix). Its underlying economic indicators (e.g., weekly initial jobless claims, monthly payroll employment, etc.) combine high- and low-frequency data. Our baseline specification includes the ADS Index as a daily proxy for overall economic conditions to eliminate any remaining concern for endogeneity in daily defense spending.

Lastly, we also use a daily measure of consumer confidence and economic policy uncertainty to shed further light on the transmission of government spending shocks at a high frequency. For consumer confidence, we use the Gallup Economic Confidence Index (ECI), which is based on the questions from Gallup's U.S. Daily Survey Poll about national economic conditions posed daily to approximately 500 respondents between January 2008 and December 2017. This index is calculated by adding the percentage of respondents who rate current economic conditions ((‘Excellent’ + ‘Good’) – ‘Poor’) to the percentage who say the economy is (‘Getting better’ – ‘Getting worse’) and dividing the sum by 2. Weighting adjustments are used for aggregation to make the index representative of the U.S. population. See Lewis et al. (2019) for a detailed description of this index and a discussion of its sensitivity to various macroeconomic news.

For economic policy uncertainty, we use the daily news-based Economic Policy Uncertainty (EPU) Index drawn from Baker et al. (2016), which is based on newspaper archives from Access World New's NewsBank service. The primary measure for this index is the number of news articles in the U.S. that contain at least one term from each of the three sets of terms: (i) ‘economic’ or ‘economy’; (ii) ‘uncertain’ or ‘uncertainty’; (iii) ‘legislation’ or ‘deficit’ or ‘regulation’ or ‘congress’ or ‘federal reserve’ or ‘white house.’ Both series are plotted in Figure A.4 in the appendix. To reduce excessive volatility at a daily frequency, we plot the three-day moving average of the daily index.

Other daily-frequency variables used in the analysis are standard in the literature, including the trade-weighted (i.e., effective) nominal exchange rate, nominal interest rates at different maturities, and real interest rates at different maturities measured by yields on Treasury Inflation-Protected Securities (TIPS). We also analyze the response of inflation expectations, measured by the difference between the nominal treasury yields and TIPS yields at the corresponding maturities (i.e., break-even inflation). We use the Treasury yields with five (twenty)-years maturity for the medium (long)-term interest rates. These variables are plotted in Figure A.5 in the appendix.

B. Local projection method

We now briefly describe the main empirical framework used in the analysis. We employ Jórda's (2005) methodology for estimating the response of various macroeconomic and financial variables to government spending shocks. The local projection method has been widely adopted in macroeconomic studies as a flexible alternative to VAR specifications without imposing the pattern generated by structural VARs. We iteratively estimate the following regression to calculate Jórda's impulse response function:

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h shock_t + \Phi_h(L) X_t + \varepsilon_{t+h},\ \ for\ h = 0, 1, 2, \cdots, \tag{10}$$

where y_t is the dependent variable; our interest is its response. $shock_t$ is the daily government spending shock; $\Phi_h(L)$ is a lag polynomial; and X_t is a set of control variables. We always include the lags of the dependent variable, the shock variable, and a proxy for economic conditions (i.e., the ADS Index) in X_t to deal with any possible serial correlation of the variables and the omitted variable bias (Montiel Olea and Plagborg-Møller, 2021).

This specification also corresponds to the standard VAR approach in identifying a government spending shock (Blanchard and Perotti, 2002), where government spending appears before other macroeconomic variables in the Cholesky decomposition. This order reflects the identifying assumption that a measure of government spending $shock_t$ does not respond contemporaneously to innovations in y_t. Given that we address $shock_t$ at a daily frequency, this assumption is likely to hold. Following Auerbach and Gorodnichencko (2016), we include 20 lags of every variable in X_t.

In Equation (10), β_h shows the response of the dependent variable h days after the shock. Therefore, a series of β_h illustrates the dependent variable's impulse response function to a shock. In our analysis, β_h indicates the cumulative impact of military spending changes on the dependent variable after h days. One potential problem in Jórda's method is the serial correlation of the error terms, and in our case, the extent of persistence of the dependent variable. To address this challenge, we adopt Newey-West (1987) heteroskedasticity and autocorrelation-corrected standard errors.

State-dependent local projections. While our baseline analysis focuses on the period characterized by the binding ZLB based on the availability of daily data, we extend our analysis by incorporating more recent data on the second measure of government spending (i.e., payments to defense contractors). Local projections are particularly useful in this context. The above model can be conveniently transformed into a state-dependent model, which allows for testing, within a single equation framework, whether the effects of government spending shocks differ between normal times and the ZLB period. Compared to the subsample analysis, this method facilitates more efficient estimation by increasing the effective sample size and has been used in ZLB studies (see, for a similar application, Auerbach and Gorodnichenko, 2016; Ramey and Zubairy, 2018; Miyamoto et al., 2018; Choi and Yoon, forthcoming).

We closely follow the state-dependent local projection model used by Auerbach and Gorodnichenko (2016) and Ramey and Zubairy (2018). Therefore, the nonlinear version of the regression model can be specified as follows:

$$y_{t+h} - y_{t-1} = I_{t-1}[\alpha_{Z,h} + \beta_{Z,h} shock_t + \mathit{\Phi}_{Z,h}(L)X_t] + (1 - I_{t-1})[\alpha_{N,h} + \beta_{N,h} shock_t + \Phi_{N,h}(L)X_t] + \varepsilon_{t+h}. \quad (11)$$

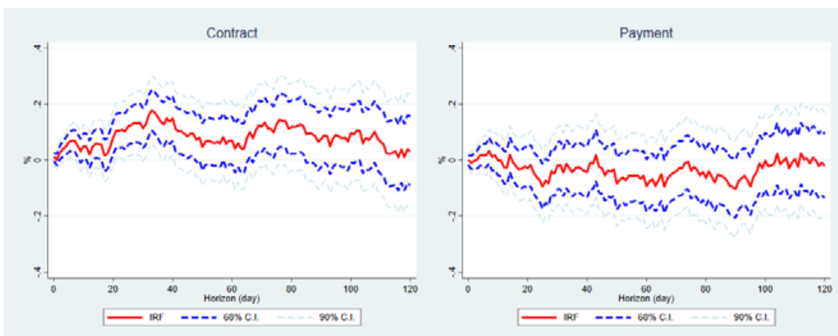
Here, we allow variation in coefficients according to whether the ZLB is binding to acquire a state-dependent impulse response function. Specifically, the first part of Equation (11) accounts for the binding ZLB, and the second part corresponds to the period without the ZLB, where I_t is a binary indicator denoting whether the economy falls in the ZLB period. Thus, a series of $\beta_{Z,h}$ for $h = 1, 2, ...$ denotes the impulse response to government spending shocks at the ZLB, whereas a series of $\beta_{N,h}$ describes the same during normal times.

IV. Empirical Analysis

A. Main results

Response of the nominal exchange rate. To check whether the main finding of Auerbach and Gorodnichencko (2016) still holds in our subsample at the ZLB, we first plot the response of the nominal effective exchange rate to a one standard deviation shock in the DoD announcements (daily log volume of awarded contracts, deseasonalized and detrended). Given the relatively short sample in our analysis compared to Auerbach and Gorodnichencko's (2016), we report both the 68% and 90% confidence bands. The baseline analysis is from December 1, 2008, to March 28, 2014. Although the ZLB has persisted until December 2015, the ending period is constrained by the availability of daily government spending data.

Figure 2. Nominal exchange rate response to government spending shocks



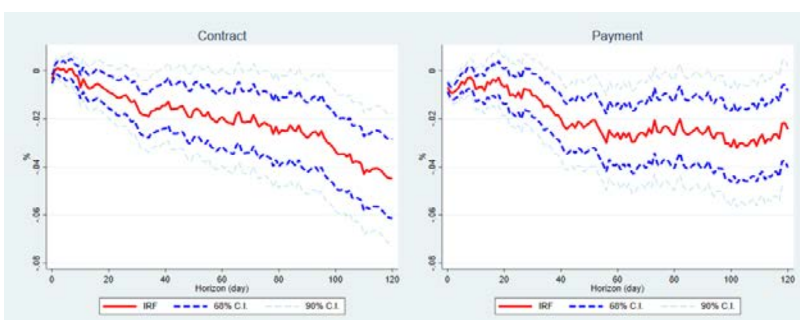
Note: This figure shows the impulse response of the nominal effective exchange rate, using the trade-weighted exchange rate of the dollar. An increase denotes the appreciation of the dollar vis-à-vis its trading partners. The left panel shows the response to one standard deviation shock of the DoD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

As shown in Panel A of Figure 2, 20 business days (corresponding to about a one-month response) after the announced spending, the dollar appreciates by 0.08%, consistent with the original finding of Auerbach and Gorodnichencko (2016), who used data between 1994 and 2014. Additionally, in Panel B, we present the daily responses of the exchange rate to actual spending (daily payments to defense contractors) to demonstrate the difference between announced and actual spending shocks. The results are both qualitatively and quantitatively consistent with Auerbach and Gorodnichencko (2016), although statistical significance is somewhat reduced due to the smaller sample size.

While this finding does not align with that of empirical studies reporting nominal depreciation in response to fiscal expansion in advanced economies (e.g., Ravn et al., 2012; Ilzetzki et al., 2013; Kim, 2015; Miyamoto et al., 2019), it is in line with the prediction of standard open economy models, such as the Mundell–Fleming model, as well as more recent DSGE models (e.g., Erceg et al., 2010). Moreover, to the extent that fiscal expansion is often followed by monetary easing, the stronger appreciation of USD at the ZLB period can be understood by the absence of further interest rate cuts. As high-frequency data alleviates identification concerns when fast-moving financial variables such as the exchange rate are involved, we view the nominal appreciation following fiscal expansion news as a credible description of the U.S. economy during the recent ZLB period.

Response of prices. Figure 3 summarizes the main finding of this study: the response of the daily log OPI to government spending shocks during the ZLB. Prices decline persistently after fiscal expansion, regardless of whether government spending shocks are identified by announcements (Panel A) or actual payments (Panel B).

Figure 3. Inflation response to government spending shocks



Note: This figure shows the impulse response of the price level using the daily online price index. The left panel shows the response to one standard deviation shock of the DOD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

The inflation response is marginally statistically significant for announcements and strongly statistically significant for payments. The effects are also economically significant in both cases. Three months later, prices declined by 0.019% in response to the announcement shock and by 0.025% in response to the actual payment shock. The magnitude of the effects is translated into annualized inflation of -0.08% for the announcement shock (-0.1% for the actual payment shock). In Figure A.6 in the appendix, we present the response of daily prices to government spending shocks without controlling for the daily economic activity index. The results are nearly identical to those in Figure 3, confirming the assumed exogeneity of daily defense spending to economic conditions at such a high frequency.

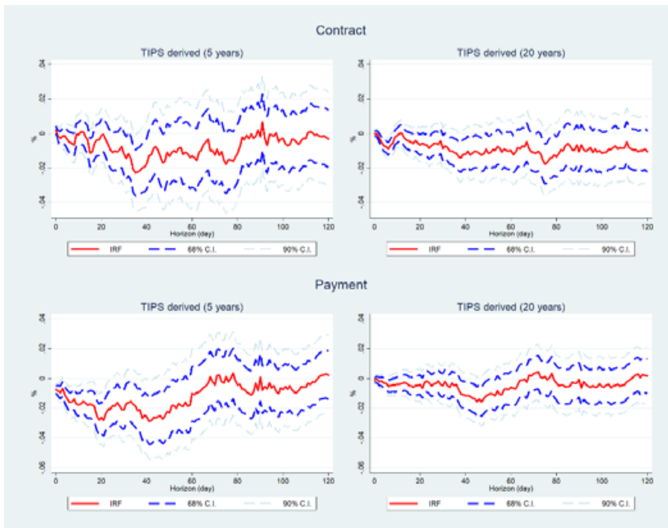
The deflationary response to government spending shocks in Figure 3 identified via the newly constructed daily data during the ZLB contributes to the literature on the fiscal price puzzle. Despite a straightforward theoretical prediction of the standard New Keynesian model, empirical studies have often found contrasting evidence on the sign of the effect of government spending shocks on inflation.[9] To the extent that high-frequency data alleviates the endogeneity issue in identifying a causal relationship between macroeconomic variables, our novel finding using daily data provides a credible description of the effects of fiscal shocks at the ZLB. At the same time, it casts doubt on the well-known theoretical prediction that government spending shocks are more expansionary at the ZLB via the inflation channel (e.g., Christiano et al., 2011; Eggertsson, 2011; Woodford, 2011), thereby providing a potential explanation for Ramey and Zubairy's (2018) main finding that the size of the government spending multiplier is not greater at the ZLB.

Response of inflation expectations. Despite the strong evidence presented in Figure 3, it is still possible that fiscal expansion increases future expected inflation without increasing current inflation. To the extent that consumption and investment decisions are affected by both the current and

[9] For example, Edelberg et al. (1999), Caldara and Kamps (2008), Ben Zeev and Pappa (2017), and Ferrara et al. (2021) found an inflationary response to a government spending shock, whereas Fatás and Mihov (2001), Mountford and Uhlig (2009), Ricco et al. (2016), Jørgensen and Ravn (2018), and d'Alessandro et al. (2019) found a disinflationary response to the same shock.

expected real interest rate, investigating the response of inflation expectations has its merits. Figure 4 plots the responses of inflation expectations inferred from financial market data (i.e., the difference between nominal Treasury yields and TIPS yields for the same maturity) at two different horizons (five and twenty years ahead).

Figure 4. Inflation expectation response to government spending shocks

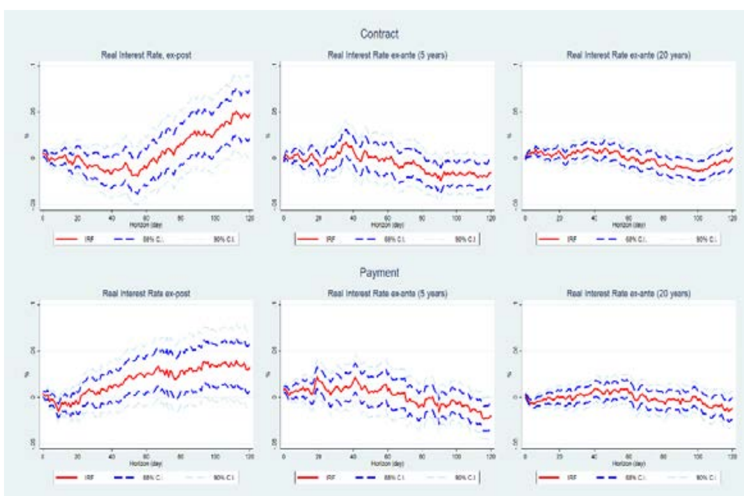


Note: This figure shows the impulse response of the inflation expectation derived by subtracting yields of the TIPS with a maturity of 5 years (left) and 20 years (right) from treasury yields of the corresponding maturities. The upper panel shows the response to one standard deviation change in the DoD contract, and the bottom panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

The left panel corresponds to the five-year-ahead inflation expectations and the right panel to the twenty-year-ahead expectations. Although the results are less clear-cut than in the OPI case, they highlight a decline in inflation expectations, especially for the five-year-ahead period. The finding that the expected disinflationary effect is weaker in the long term is consistent with the notion that long-run inflation expectations were still anchored at the ZLB (Ascari and Sbordone, 2014; Choi et al., forthcoming). However, caution is required when interpreting these results because the variation in TIPS yields can be affected by inflation risk premium or liquidity premium apart from inflation expectations of financial market participants (Gürkaynak et al., 2010), and the bias can be substantial (Fleckenstein et al., 2014).[10] This explains why we prefer using the realized inflation response using the OPI, which is free of such confounding factors.

Response of real interest rates. While the U.S. economy falls into the binding ZLB state during the sample period, this holds only in the absolute sense. The response of the nominal interest rate conditional on other structural shocks, including government spending shocks, might not entirely be null in the econometric model. This is especially true in the case of the long-term interest rate. In this case, a deflationary response conditional on government spending shocks may not necessarily translate into a rise in the real interest rate even at the ZLB. We investigate three types of real interest rates to guard against this possibility: (i) the difference between the effective Federal Funds rate and realized annualized inflation using OPI, (ii) yields on five-year TIPS, and (iii) yields on twenty-year TIPS. However, caution is required in interpreting the results because of the inflation risk premium or liquidity premium in the TIPS.

Figure 5. Real interest rate response to government spending shocks



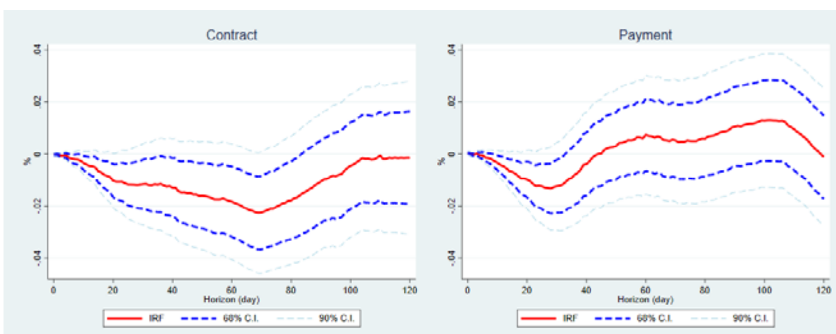
Note: This figure shows the impulse response of different types of real interest rates: ex-post real interest rate using the difference between effective Federal Funds rate and realized OPI inflation (left), TIPS with 5- and 20-year maturities (center, right), The upper panels show the response to one standard deviation change in the DoD contract and the lower panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

[10] The direction of bias created from inflation risk premium or liquidity premium is theoretically unclear, though.

The first column of Figure 5 shows that the response of the realized interest rate is generally positive, especially toward the end of the forecasting horizon. This is not surprising given the strong deflationary effect three months after the shock, shown in Figure 3, and the absence of fluctuations in the nominal policy rate at the ZLB. The second and third columns report the response of the ex-ante real interest rate implied from the TIPS yields. The responses are statistically insignificant in general. However, we do not observe a decline in the real interest rate as predicted by standard New Keynesian models, regardless of how it is measured.

Response of economic activity. The lack of inflationary response (Figure 4) and the lack of a decline in the real interest rate (Figure 5) suggest that government spending shocks at the ZLB are not necessarily more expansionary, in contrast to the standard prediction in the recent stream of theoretical literature (Christiano et al., 2011; Eggertsson, 2011; Woodford, 2011). We directly test this hypothesis by employing the ADS index as a new dependent variable.

Figure 6. Economic activity response to government spending shocks



Note: This figure shows the impulse response of the economic conditions using the daily ADS index. The left panel shows the response to one standard deviation shock of the DOD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

Figure 6 confirms that government spending shocks fail to expand economic activity when the economy is at the ZLB.[11] However, these results alone cannot reject the hypothesis that fiscal

[11] One should take these results with caution. Since the ADS index is constructed from a variety of stock and flow data capturing different dimensions of economic conditions, it does not directly correspond to consumption or output in the theoretical model, which is always maximized at the ZLB.

policy is more effective at the ZLB. In the following section, we shed further light on this issue by comparing the responses of key variables to government spending shocks at the ZLB and during normal times.

B. Additional exercises and robustness checks

Additional exercises covering the non-ZLB period. While the theoretical prediction of a standard New Keynesian model provides a definite answer regarding the inflation response to government spending shocks at the ZLB, we can conclude that our findings are puzzling from the standard New Keynesian framework only if is the inflationary response during the ZLB weaker than that during normal times.

Thus, we use additional observations before the Federal Reserve lowered its policy rate in December 2008 and after the Federal Reserve lifted it in December 2015 to investigate whether the inflation response differs between normal times and the ZLB period. The following analysis is somewhat constrained by data availability, as we can extend the payment series only. Both the beginning (July 2008) and the ending period (April 2018) are chosen based on the availability of the daily OPI series. As a first exercise, we analyze the effects of the shock to payments to defense contractors using the observations from the post-ZLB period only (January 2016 to April 2018). Figure 7 presents the responses to the payment shock of the nominal effective exchange rate, price level, five-year-ahead inflation expectations, actual real interest rate, expected real interest rate (five-year-ahead), and economic conditions measured by the ADS index.

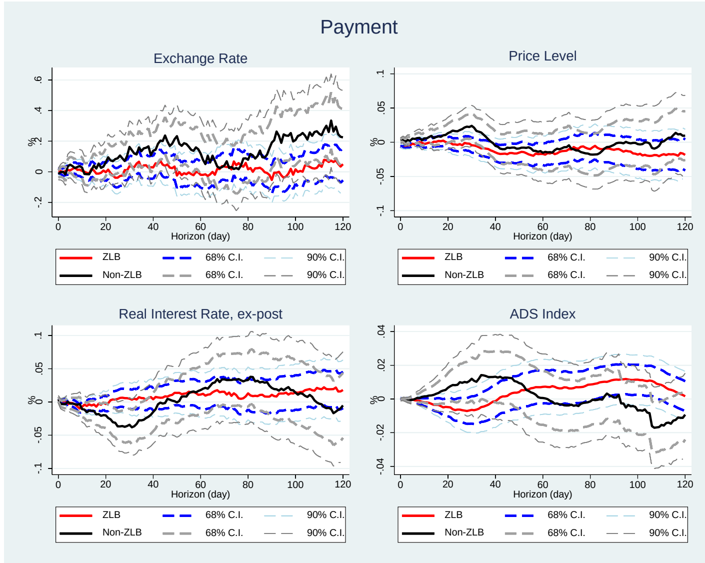
We find different responses for every variable. Unlike the response during the ZLB period, the nominal exchange rate does not appreciate in the short run and exhibits delayed appreciation. However, the inflation response is striking. Unlike during the ZLB, the response becomes inflationary and highly statistically significant for the first two months. The response of inflation expectations is less clear-cut but points toward a mild increase. Therefore, we find a decline in the real interest rates, although it is not statistically significant. Importantly, we find an expansionary effect of government shocks from the positive response of daily business conditions. The response of economic activity is not statistically significant, probably because of the shorter sample period.

Figure 7. Response to government spending shocks: post-ZLB period (January 2016 – April 2018)

Note: This figure shows the impulse response of the six variables of interest (nominal interest rate, price level, expected inflation, ex-post and ex-ante real interest rate, and business conditions) to one standard deviation change in treasury payment, but using a subsample that covers normal times. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from January 4, 2016, to April 13, 2018.

As noted, this subsample analysis might suffer from insufficient statistical power despite the use of daily data. Thus, as a second exercise, we exploit the state-dependent local projection method, enhancing estimation efficiency by using an effectively larger sample to address this issue. The effects of the government spending shock between normal times and the ZLB period in Figure 8 largely confirm the results in Figure 7. Outside the ZLB period, we find a strong inflationary response and a significant decline in the real interest rate, especially in the short run. Consistent with the real interest rate decline, government spending shocks are more expansionary in normal times than in the ZLB period. From a theoretical perspective, it is puzzling that the inflationary response is greater when the economy is no longer constrained by the ZLB since we expect a less inflationary response when active monetary policy is allowed. We call it the deflation anomaly of government spending at the ZLB.

Figure 8. State-dependent response to government spending shocks: ZLB vs. non-ZLB

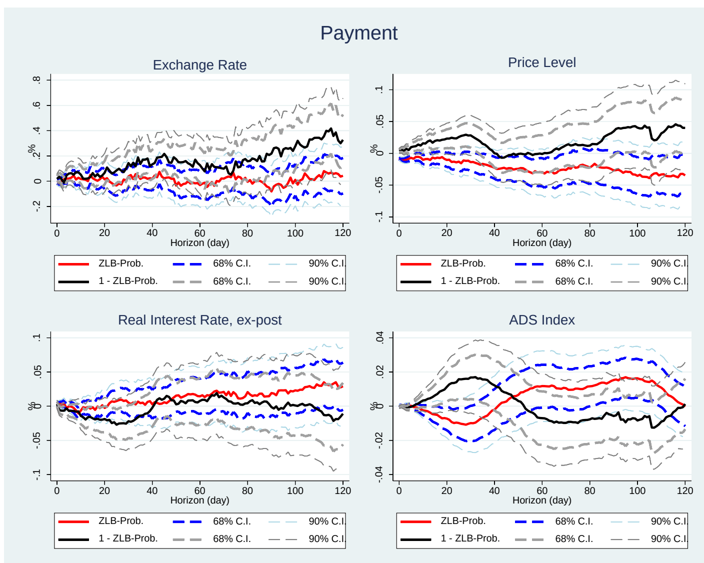


Note: This figure shows the state-dependent impulse response of the four variables of interest (nominal interest rate, price level, ex-post real interest rate, and business conditions) to one standard deviation change in treasury payment. The red line illustrates the impulse response at the ZLB, and the black line denotes the response during normal times. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from July 1, 2008, to April 13, 2018.

While we have used a binary indicator to differentiate the ZLB period from normal times, economic agents did not necessarily have the same expected duration of the binding ZLB throughout the sample. For example, it is possible that agents in 2009, shortly after the aggressive rate cut by the Fed, might have initially thought that monetary policy would have normalized soon. After multi-rounds of Large Scale Asset Purchases (LSAPs) or forward guidance, agents could have switched their belief that the Fed would keep the policy rate at the lower bound for an extended period. Indeed, the expected duration of the binding ZLB is crucial in determining the size of the government spending multiplier in many theoretical models of the ZLB. However, using a binary indicator treats all the ZLB period the same, ignoring the degree to which these constraints actually bind.

To guard against this possibility, we use a measure of the market-implied probability of being at the ZLB based on the overnight index swap (OIS) market from Moessner and Rungcharoenkitkul (2019). The OIS-implied ZLB probability is obtained via rate decision tree calculations from Bloomberg based on OIS forward rates below 50 basis points the FOMC meeting date around nine months ahead. The accounting of this de-facto ZLB episode extends the methodology in Swanson and Williams (2014), which computed the sensitivity of government yields at different maturities to macroeconomic news to measure the degree to which monetary policy is constrained. They found that 1- and 2-year Treasury yields were surprisingly unconstrained throughout 2009 to 2010, although the effective Federal Funds rate already reached the ZLB. Figure A.7 in the appendix plots the implied probability of the binding ZLB constraint (P_t) during the sample period.

Figure 9. State-dependent response to government spending shocks: ZLB vs. non-ZLB using the implied ZLB probability



Note: This figure shows the state-dependent impulse response of the four variables of interest (nominal interest rate, price level, ex-post real interest rate, and business conditions) to one standard deviation change in treasury payment. The red line illustrates the impulse response at the ZLB, and the black line denotes the response during normal times. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from July 1, 2008, to April 13, 2018.

We replace the binary indicator I_t in Equation (11) with the implied probability P_t that allows for utilizing the intensity of the ZLB and re-estimate Equation (11). The patterns of state-dependent responses to government shocks in Figure 9 are similar to the results in Figure 8, suggesting that accounting for the intensity of the ZLB constraint does not overturn our main findings. In particular, we still find a stronger inflationary response during normal times, resulting in a decline in the real interest rate. This finding suggests that the binding ZLB is unlikely to produce a larger fiscal multiplier via the inflation channel compared to normal times.

Robustness checks. We provide several robustness checks for the main finding that government spending shocks are deflationary at the ZLB. First, unlike most studies that identified a depreciation of the domestic currency in response to a positive government spending shock (e.g., Ravn et al., 2012; Ilzetzki et al., 2013; Kim, 2015; Miyamoto et al., 2019), Auerbach and Gorodnichenko (2016) found a robust appreciation using the same daily fiscal spending data. We also confirmed that this finding still holds when limiting the analysis to the ZLB. Given the downward pressure of domestic appreciation on import prices, the deflationary response we report might be easily explained by the appreciation of the U.S. dollar presented in Figure 2.

We plot the response of prices to government spending shocks after controlling for 20 lags of the nominal effective exchange rate. Figure A.8 in the appendix shows that controlling for the exchange rate movements hardly affects the inflation response to the government spending shock.[12] The inability of the nominal exchange movements to account for the documented response is consistent with the lower exchange rate pass-through documented for the U.S. (Campa and Goldberg, 2005) and for the average good priced in U.S. dollars among U.S. imports (Gopinath et al., 2010).[13]

Third, given the large open economy nature of the U.S. economy, it is possible that domestic fiscal expansion influences commodity prices such as oil prices worldwide, feeding back into U.S. consumer prices. Despite the decreasing oil price pass-through over time (Chen, 2009; Choi et al., 2018), this transmission channel is distinct from the exchange rate pass-through and is worth investigating. We, therefore, control for 20 lags of the log of crude oil prices (West Texas Intermediate) in addition to the nominal effective exchange rate. Figure A.9 in the appendix shows

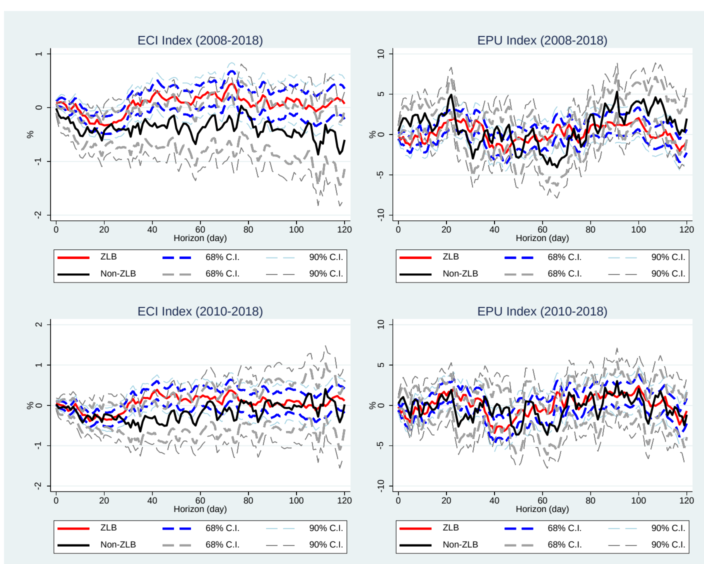
[12] Controlling for the growth of the nominal effective exchange rate leads to the same result.

[13] In a recent study, Forbes et al. (2020) found that exchange rate movements caused by demand shocks such as government spending shocks consistently correspond to significantly lower pass-through than those caused by monetary policy shocks.

that this additional control hardly changes the inflation response to the government spending shock, suggesting that incorporating the open economy nature into the estimation framework cannot fully account for the deflationary response to the government spending shock at the ZLB.

Fourth, the deflationary effect of government spending shocks during the ZLB period we documented might have been driven by consumer pessimism or heightened uncertainty at the same time. As explained earlier, ample theoretical literature emphasizes the role of consumer confidence and uncertainty in the transmission of government spending shocks. If government spending shocks significantly lower consumer confidence or increase economic uncertainty at the ZLB—suppressing demand and inflationary pressure, thereby offsetting the traditional inflation channel—, the deflationary effect we observed is no longer puzzling. We test this possibility by using the daily Gallup ECI and EPU index as a dependent variable.

Figure 10. State-dependent response of consumer confidence and policy uncertainty to government spending shocks: ZLB vs. non-ZLB



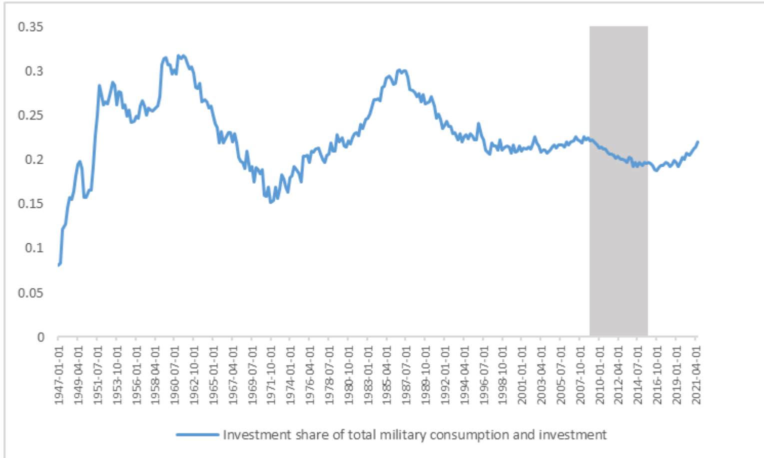
Note: This figure shows the impulse responses of the Economic Confidence Index (ECI) and Economic Policy Uncertainty Index (EPU Index) after controlling for 20 lags of the Aruoba-Diebold-Scotti Business Conditions Index (ADS Index). For the top panels, the estimation sample is from July 1, 2008, to March 28, 2014. For the bottom panels, the estimation sample is from January 1, 2010, to March 28, 2014, which is the period after dropping the Great Recession period (2008-09). Each panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals.

As shown in Figure 10, we do not find any evidence that government spending shocks at the ZLB are followed by a decline in consumer confidence or an increase in policy uncertainty compared to normal times. If anything, we found the opposite, especially for consumer confidence, suggesting that the confidence or uncertainty channel of fiscal policy is unlikely to explain our findings. Taking out the Great Recession observations, which are associated with a sharp decline in consumer confidence and heightened uncertainty, does not change this narrative. As a result, controlling for these variables in addition to the daily ADS index hardly affects the baseline finding (see Figures A.10 and A.11 in the appendix), making it even more puzzling from the theoretical perspective.

Fifth, given the ample theoretical and empirical evidence on the asymmetric effects of government spending shocks on the output between expansions and recessions (Auerbach and Gorodnichenko, 2012; Biolsi, 2017), the deflationary response in this study might have been driven by a recession, not by the ZLB. This concern is especially valid because the Great Recession accounts for a nontrivial share of the total sample used in the baseline estimation. Moreover, as shown in the figures in the appendix, the Great Recession is characterized by the unusual behavior of most variables considered, which is particularly visible when using daily data. To test this possibility, we re-estimate the inflation response by using the observations since 2010. Figure A.12 in the appendix confirms that the Great Recession does not simply drive the deflationary response to the government spending shock at the ZLB.

Lastly, the deflationary response during the ZLB period might not be entirely puzzling if the component of military spending at the ZLB is systematically different from normal times given the potentially different effects on inflation of each component of government spending (Bouakez et al., 2017; Boehm, 2020). In other words, government consumption shocks and investment shocks could reflect different types (aggregate demand vs. aggregate supply) of shocks, naturally leading to different responses of inflation.

Figure 11. The share of investment in total federal national defense spending



Note: This figure shows the share of investment in total federal national defense spending (i.e., the sum of the consumption expenditures and gross investment) from 1947Q1 to 2021Q2. The shaded area denotes the ZLB period.

However, as shown in Figure 11, the share of investment in total federal national defense spending (i.e., the sum of the consumption expenditures and gross investment) is fairly stable, around 0.2 during the sample period under investigation. If anything, the share of investment somewhat decreased during this period, suggesting that the expansionary effect of military spending shocks should have been larger via the composition changes, according to the theoretical prediction of Boehm (2020).[14] Thus, the composition effect goes against finding our results.

V. Discussion and Concluding Remark

The deflationary response to government spending shocks at the recent ZLB of the U.S. economy we documented using daily data corroborates Dupor and Li's (2015) finding. They found that the inflation response during the recent ZLB period (or during the earlier period characterized by passive monetary policy) does not align with the prediction of the textbook New Keynesian model. In a related study, Garín et al. (2019), using a local projection, also found that the effects of

[14] Boehm (2020) shows both theoretically and empirically that government consumption shocks are more expansionary than the same size of government investment shocks.

supply shocks on output and inflation at the ZLB were inconsistent with the predictions of a standard New Keynesian model.

In both studies, the inflation channel plays an important role in determining the size of the fiscal multiplier at the ZLB. The robust evidence on the deflationary response to the government spending shock at the ZLB can help understand the main finding of Ramey and Zubairy (2018) that the government spending multiplier is not larger during the historical ZLB episodes. Therefore, it must be considered in the design of theoretical models to analyze the interaction of fiscal policy and the ZLB. Instead of proposing a new theoretical framework, we discuss relevant recent works that, in our view, offer promising extensions to the basic New Keynesian framework that might help make the model more consistent with our empirical findings and understand the root of the fiscal price puzzle.

A promising avenue is to introduce deep habit formation (Zubairy, 2014) or variable technology utilization (Jørgensen and Ravn, 2018) into an otherwise standard medium-scale New Keynesian model, assume monetary policy inertia at the ZLB (Hills and Nakata, 2018), and consider realistic substitutability between private and government consumption (Ercolani and e Azevedo, 2019). Zubairy (2014) highlights the role of countercyclical markups—endogenously generated by deep habits—in propagating fiscal shocks. Since markups are countercyclical, a government spending shock can lead to a decline in inflation. Jørgensen and Ravn (2018) show that variable technology utilization allows firms to accommodate increased demand by adopting new technology into the production process. The resulting increase in measured productivity leads to a decline in prices.

Hills and Nakata (2018) show that the economy with policy inertia can bring the prediction of the New Keynesian model more closely to our empirical findings. Policy inertia reduces the government spending multiplier by reducing the effects of government spending shocks on expected inflation. Ercolani and e Azevedo (2019) showed that using recent estimates of the degree of substitutability between private and government consumption in an otherwise standard New

Keynesian model can make government spending less inflationary, thereby reducing the size of government spending multipliers obtained when the nominal interest rate is zero.

Our work fits broadly into a growing literature that empirically tests predictions of the textbook New Keynesian model when the ZLB is binding. The inflationary response to government spending shocks during normal times, identified using novel daily data, is consistent with standard textbook models, thereby resolving the fiscal price puzzle discussed in Jørgensen and Ravn (2018). However, the novel finding of the deflationary response at the ZLB creates another anomaly that cannot be easily squared with existing theoretical models or alternative explanations resorting to consumer confidence or uncertainty. Thus, caution is required when using the standard model to predict the economic consequences of fiscal policies at the binding ZLB. Further research into alternative model specifications and searching for the root of this empirical anomaly will be fruitful.

Lastly, our novel findings contribute to the recent debate on the effectiveness of fiscal stimulus and ultra-accommodative monetary policy in response to the COVID-19 pandemic (e.g., Chetty et al., 2020; Guerrieri et al., 2020). Although the U.S. economy has again fallen into the realm of ZLB since March 2020, it does not necessarily guarantee a larger fiscal multiplier from fiscal expansion as often claimed if it fails to increase inflation. Indeed, despite the massive increase in government spending after the pandemic, core inflation has remained low throughout 2020. Thus, more careful analysis, possibly using a real-time tracker, should be conducted before drawing any pre-emptive justification of the unprecedented level of fiscal stimulus.

References

d'Alessandro, Antonello, Giulio Fella, and Leonardo Melosi. "Fiscal stimulus with learning-by-doing." International Economic Review 60, no. 3 (2019): 1413-1432.

Ascari, Guido, and Argia M. Sbordone. "The macroeconomics of trend inflation." Journal of Economic Literature 52, no. 3 (2014): 679-739.

Auerbach, Alan J., and Yuriy Gorodnichenko. "Measuring the output responses to fiscal policy." American Economic Journal: Economic Policy 4, no. 2 (2012): 1-27.

Auerbach, Alan J., and Yuriy Gorodnichenko. "Effects of fiscal shocks in a globalized world." IMF Economic Review 64, no. 1 (2016): 177-215.

Aruoba, S.B., Diebold, F.X. and Scotti, C. "Real-Time Measurement of Business Conditions." Journal of Business and Economic Statistics 27, no. 4 (2009): 417-427.

Baker, Scott R., Nicholas Bloom, and Steven J. Davis. "Measuring economic policy uncertainty." Quarterly Journal of Economics 131, no. 4 (2016): 1593-1636.

Ben Zeev, Nadav, and Evi Pappa. "Chronicle of a war foretold: The macroeconomic effects of anticipated defence spending shocks." Economic Journal 127, no. 603 (2017): 1568-1597.

Berg, Tim Oliver. "Business uncertainty and the effectiveness of fiscal policy in Germany." Macroeconomic Dynamics 23, no. 4 (2019): 1442-1470.

Biolsi, Christopher. "Nonlinear effects of fiscal policy over the business cycle." Journal of Economic Dynamics and Control 78 (2017): 54-87.

Blanchard, Olivier, and Roberto Perotti. "An empirical characterization of the dynamic effects of changes in government spending and taxes on output." Quarterly Journal of Economics 117, no. 4 (2002): 1329-1368.

Boehm, Christoph E. "Government consumption and investment: Does the composition of purchases affect the multiplier?" Journal of Monetary Economics 115 (2020): 80-93.

Boivin, Jean, and Marc P. Giannoni. "Has monetary policy become more effective?" Review of Economics and Statistics 88, no. 3 (2006): 445-462.

Bouakez, Hafedh, Michel Guillard, and Jordan Roulleau-Pasdeloup. "Public investment, time to build, and the zero lower bound." Review of Economic Dynamics 23 (2017): 60-79.

Brainard, William C. “Uncertainty and the Effectiveness of Policy.” American Economic Review 57, no. 2 (1967): 411-425.

Brunet, Gillian. “When Does Government Spending Matter? Evidence from a New Measure of Spending.”, Mimeo (2020).

Caldara, D., and C. Kamps, 2008, “What Are the Effects of Fiscal Shocks? A VAR-based Comparative Analysis.” European Central Bank Working Paper 877.

Campa, Jose Manuel, and Linda S. Goldberg. “Exchange rate pass-through into import prices.” Review of Economics and Statistics 87, no. 4 (2005): 679-690.

Carlstrom, Charles T., Timothy S. Fuerst, and Matthias Paustian. “Fiscal multipliers under an interest rate peg of deterministic versus stochastic duration.” Journal of Money, Credit and Banking 46, no. 6 (2014): 1293-1312.

Cavallo, Alberto, and Roberto Rigobon. “The billion prices project: Using online prices for measurement and research.” Journal of Economic Perspectives 30.2 (2016): 151-78.

Chen, Shiu-Sheng. “Oil price pass-through into inflation.” Energy Economics 31, no. 1 (2009): 126-133.

Chetty, Raj, John Friedman, Nathaniel Hendren, and Michael Stepner. “How did covid-19 and stabilization policies affect spending and employment? a new real-time economic tracker based on private sector data.” NBER working paper w27431 (2020).

Choi, Sangyup, Davide Furceri, Prakash Loungani, Saurabh Mishra, and Marcos Poplawski-Ribeiro. “Oil prices and inflation dynamics: Evidence from advanced and developing economies.” Journal of International Money and Finance 82 (2018): 71-96.

Choi, Sangyup, Davide Furceri, and Prakash Loungani. Inflation anchoring and growth: evidence from sectoral data. Journal of Economic Dynamics and Control (forthcoming)

Choi, Sangyup, and Chansik Yoon. “Uncertainty, Financial Markets, and Monetary Policy over the Last Century.” B.E. Journal of Macroeconomics: Advances (forthcoming).

Christiano, Lawrence, Martin Eichenbaum, and Sergio Rebelo. “When is the government spending multiplier large?” Journal of Political Economy 119, no. 1 (2011): 78-121.

De Livera, Alysha M., Rob J. Hyndman, and Ralph D. Snyder. “Forecasting time series with complex seasonal patterns using exponential smoothing.” Journal of the American Statistical Association 106, no. 496 (2011): 1513-1527.

Dupor, Bill, and Rong Li. "The expected inflation channel of government spending in the postwar US." European Economic Review 74 (2015): 36-56.

Edelberg, Wendy, Martin Eichenbaum, and Jonas DM Fisher. "Understanding the effects of a shock to government purchases." Review of Economic Dynamics 2, no. 1 (1999): 166-206.

Eggertsson, Gauti B. "What fiscal policy is effective at zero interest rates?" NBER Macroeconomics Annual 25, no. 1 (2011): 59-112.

Erceg, Christopher, Christopher Gust, David López-Salido, and Malin Adolfson. "The Transmission of Domestic Shocks in Open Economies." University of Chicago Press, (2010): 89-156.

Ercolani, Valerio, and João Valle e Azevedo. "How can the government spending multiplier be small at the zero lower bound?" Macroeconomic Dynamics 23, no. 8 (2019): 3457-3482.

Fatás, Antonio, and Ilian Mihov. "The effects of fiscal policy on consumption and employment: theory and evidence." CEPR Discussion Paper 2760 (2001).

Ferrara, Laurent, Luca Metelli, Filippo Natoli, and Daniele Siena. "Questioning the puzzle: fiscal policy, real exchange rate and inflation." Journal of International Economics (2021): 103524.

Fleckenstein, Matthias, Francis A. Longstaff, and Hanno Lustig. "The TIPS-treasury bond puzzle." Journal of Finance 69, no. 5 (2014): 2151-2197.

Forbes, Kristin, Ida Hjortsoe, and Tsvetelina Nenova. "International Evidence on Shock-Dependent Exchange Rate Pass-Through." IMF Economic Review 68, no. 4 (2020): 721-763.

Garín, Julio, Robert Lester, and Eric Sims. "Are supply shocks contractionary at the ZLB? Evidence from utilization-adjusted TFP data." Review of Economics and Statistics 101, no. 1 (2019): 160-175.

Gopinath, Gita, Oleg Itskhoki, and Roberto Rigobon. "Currency choice and exchange rate pass-through." American Economic Review 100, no. 1 (2010): 304-36.

Gorodnichenko, Yuriy, Viacheslav Sheremirov, and Oleksandr Talavera. "Price setting in online markets: Does IT click?" Journal of the European Economic Association 16, no. 6 (2018): 1764-1811.

Guerrieri, Veronica, Guido Lorenzoni, Ludwig Straub, and Iván Werning. "Macroeconomic implications of COVID-19: Can negative supply shocks cause demand shortages?" No. w26918. National Bureau of Economic Research, 2020.

Gürkaynak, Refet S., Brian Sack, and Jonathan H. Wright. "The TIPS yield curve and inflation compensation." American Economic Journal: Macroeconomics 2, no. 1 (2010): 70-92.

Hills, Timothy S., and Taisuke Nakata. “Fiscal multipliers at the zero lower bound: the role of policy inertia.” Journal of Money, Credit and Banking 50, no. 1 (2018): 155-172.

Ilzetzki, Ethan, Enrique G. Mendoza, and Carlos A. Végh. “How big (small?) are fiscal multipliers?” Journal of Monetary Economics 60, no. 2 (2013): 239-254.

Jordà, Òscar. “Estimation and inference of impulse responses by local projections.” American Economic Review 95, no. 1 (2005): 161-182.

Jørgensen, Peter Lihn, and Søren Hove Ravn. “The inflation response to government spending shocks: a fiscal price puzzle?” Mimeo (2018).

Kim, Soyoung. “Country characteristics and the effects of government consumption shocks on the current account and real exchange rate.” Journal of International Economics 97, no. 2 (2015): 436-447.

Klein, Mathias, and Ludger Linnemann. “Macroeconomic effects of government spending: The great recession was (really) different.” Journal of Money, Credit and Banking 51, no. 5 (2019): 1237-1264.

Lewis, Daniel J., Christos Makridis, and Karel Mertens. “Do Monetary Policy Announcements Shift Household Expectations?” FRB of New York Staff Report 897 (2019).

Mertens, Karel RSM, and Morten O. Ravn. “Fiscal policy in an expectations-driven liquidity trap.” Review of Economic Studies 81, no. 4 (2014): 1637-1667.

Miyamoto, Wataru, Thuy Lan Nguyen, and Dmitriy Sergeyev. “Government spending multipliers under the zero lower bound: Evidence from Japan.” American Economic Journal: Macroeconomics 10, no. 3 (2018): 247-77.

Miyamoto, Wataru, Thuy Lan Nguyen, and Viacheslav Sheremirov. “The effects of government spending on real exchange rates: Evidence from military spending panel data.” Journal of International Economics 116 (2019): 144-157.

Moessner, Richhild, and Phurichai Rungcharoenkitkul. “The zero lower bound, forward guidance and how markets respond to news.” BIS Quarterly Review, March (2019).

Montiel Olea, José Luis, and Mikkel Plagborg-Møller. “Local projection inference is simpler and more robust than you think.” Econometrica 89, no. 4 (2021): 1789-1823.

Mountford, Andrew, and Harald Uhlig. “What are the effects of fiscal policy shocks?” Journal of Applied Econometrics 24, no. 6 (2009): 960-992.

Newey, Whitney K., and Kenneth D. West. "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation." Econometrica 55, no. 3 (1987): 703-708.

Ramey, Valerie A. "Identifying government spending shocks: It's all in the timing." Quarterly Journal of Economics 126, no. 1 (2011): 1-50.

Ramey, Valerie A., and Sarah Zubairy. "Government spending multipliers in good times and in bad: evidence from US historical data." Journal of Political Economy 126, no. 2 (2018): 850-901.

Ravn, Morten O., Stephanie Schmitt-Grohé, and Martín Uribe. "Consumption, government spending, and the real exchange rate." Journal of Monetary Economics 59, no. 3 (2012): 215-234.

Ricco, Giovanni, Giovanni Callegari, and Jacopo Cimadomo. "Signals from the government: Policy disagreement and the transmission of fiscal shocks." Journal of Monetary Economics 82 (2016): 107-118.

Smets, Frank, and Raf Wouters. "An estimated dynamic stochastic general equilibrium model of the euro area." Journal of the European Economic Association 1, no. 5 (2003): 1123-1175.

Swanson, Eric T., and John C. Williams. "Measuring the effect of the zero lower bound on medium- and longer-term interest rates." American Economic Review 104, no. 10 (2014): 3154-85.

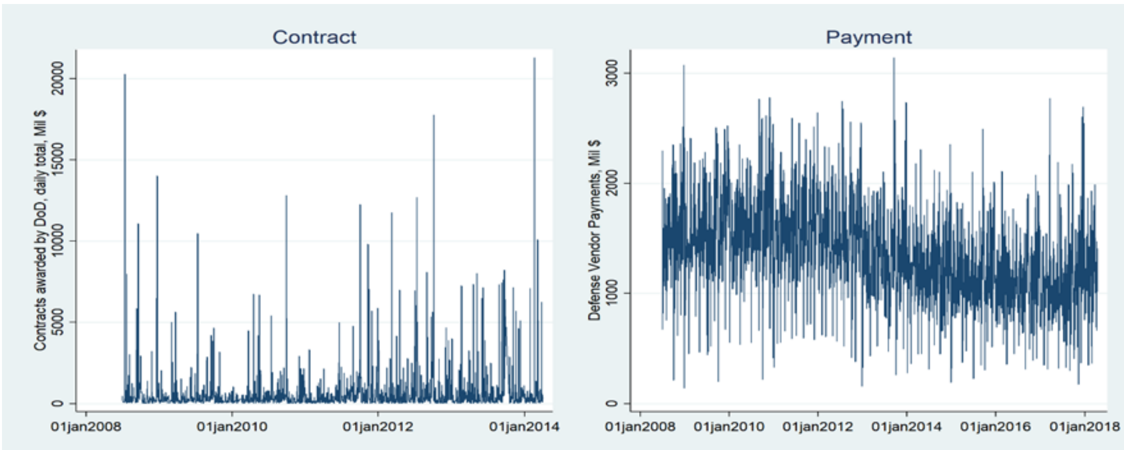
Woodford, Michael. "Simple analytics of the government expenditure multiplier." American Economic Journal: Macroeconomics 3, no. 1 (2011): 1-35.

Zubairy, Sarah. "On fiscal multipliers: Estimates from a medium scale DSGE model." International Economic Review 55, no. 1 (2014): 169-195.

Appendix

A. Additional figures and tables

Figure A.1. Daily measure of government spending (left panel: announced volume of contracts, right panel: payments to defense contracts)

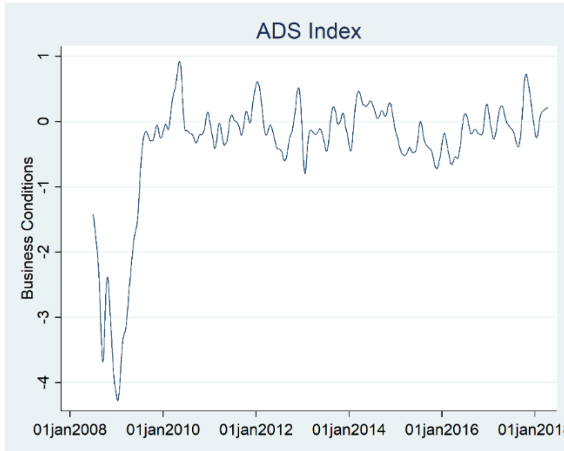


Note: This figure plots two daily series of government spending constructed by Auerbach and Gorodnichenko (2016). The left panel shows the first series—announced volume of contracts awarded daily by DoD—that covers the sample period from July 1, 2008, to March 28, 2014, and the right panel presents the extended second series—payments to defense contracts—that covers the sample period from July 1, 2008, to April 13, 2018.

Figure A.2. Online price index (OPI) and consumer price index (CPI) at a daily frequency

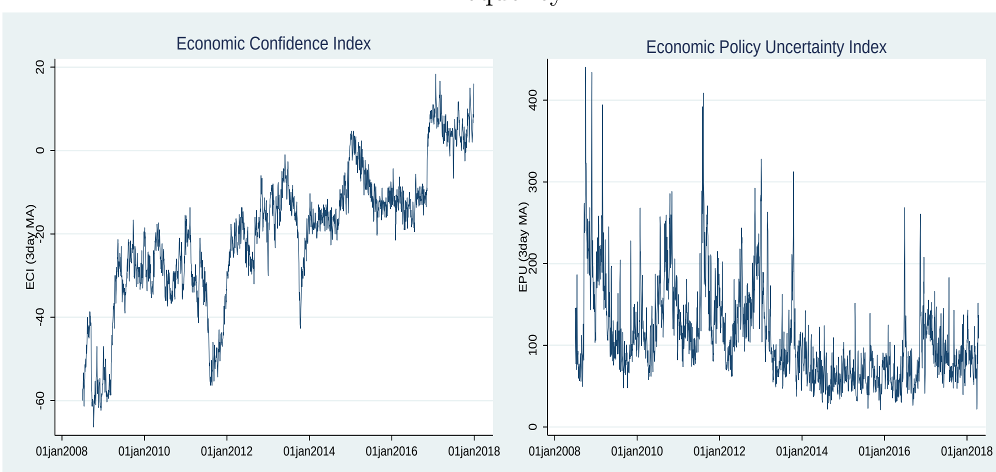
Note: This figure plots the daily time series of the U.S. daily online price index and the consumer price index released by the Bureau of Labor Statistics for the sample period between July 1, 2008, and April 13, 2018. The indices are normalized by the first observation of each series.

Figure A.3. Business conditions (ADS index) at a daily frequency



Note: This figure plots the daily time series of the Aruoba-Diebold-Scotti business conditions index (ADS Index) from Aruoba et al. (2009) for the sample period between July 1, 2008, and April 13, 2018.

Figure A.4. Consumer confidence (Gallup ICS) and economic policy uncertainty at a daily frequency



Note: This figure plots the daily time series of the Economic Confidence Index (ECI) and Economic Policy Uncertainty Index (EPU Index) for the sample period between July 1, 2008, and April 13, 2018.

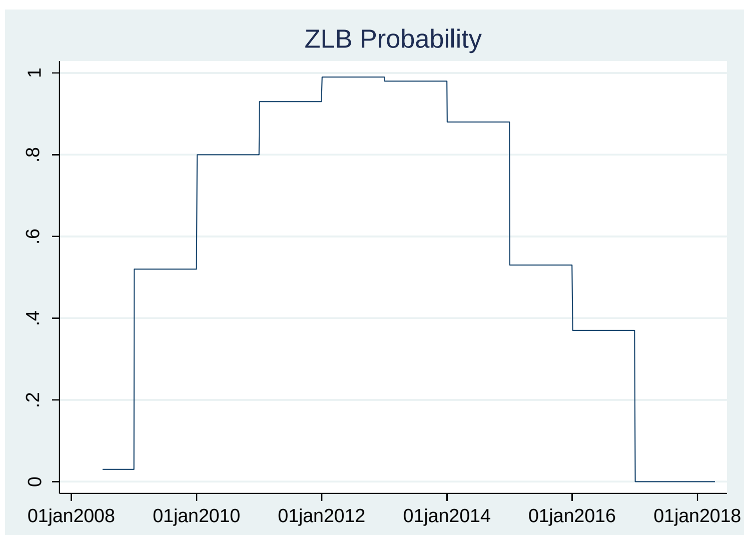
Figure A.5. Evolution of the main variables used in the analysis

Note: This figure presents time series graphs for nine variables of our interest (nominal effective exchange rate, effective Federal Funds rate, 5-year Treasury yield, 20-year Treasury yield, ex-post and two ex-ante real interest rates, and two inflation expectation measures). The sample period is between July 1, 2008, and April 13, 2018.

Figure A.6. Inflation response to government spending shocks: without controlling for the ADS index

Note: This figure shows the impulse response of the price level using the daily online price index without controlling for 20 lags of the ADS index. The left panel shows the response to one standard deviation change in the DoD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

Figure A.7. The implied probability of the ZLB

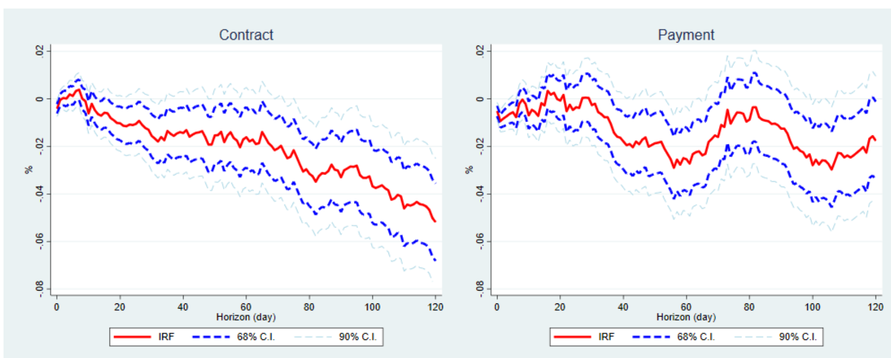


Note: This figure presents a time-series graph for the OIS-Implied ZLB probability, which is the probability of U.S. OIS rates below 50 bp around nine months ahead. The sample period is between July 1, 2008, and April 13, 2018.

Figure A.8. Inflation response to government spending shocks: controlling for the nominal exchange rate

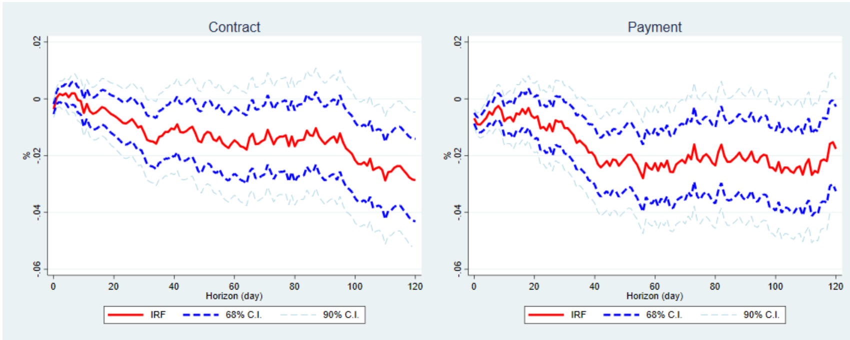
Note: This figure shows the impulse response of the price level using the daily online price index after controlling for 20 lags of the nominal effective exchange rate. The left panel shows the response to one standard deviation change in the DoD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

Figure A.9. Inflation response to government spending shocks: controlling for the nominal exchange rate and oil prices



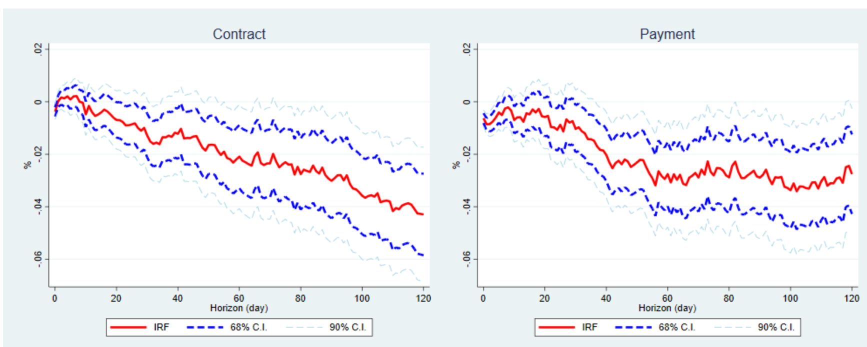
Note: This figure shows the impulse response of the price level using the daily online price index after controlling for 20 lags of the nominal effective exchange rate and crude oil prices. The left panel shows the response to one standard deviation change in the DoD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

Figure A.10. Inflation response to government spending shocks: controlling for the ADS Index and ECI Index



Note: This figure shows the impulse response of the price level using the daily online price index after controlling for 20 lags of the Aruoba-Diebold-Scotti Business Conditions Index (ADS Index) and Economic Confidence Index (ECI). The left panel shows the response to one standard deviation change in the DoD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

Figure A.11. Inflation response to government spending shocks: controlling for the ADS Index and EPU Index



Note: This figure shows the impulse response of the price level using the daily online price index after controlling for 20 lags of the Aruoba-Diebold-Scotti Business Conditions Index (ADS Index) and Economic Policy Uncertainty Index (EPU Index). The left panel shows the response to one standard deviation change in the DoD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from December 1, 2008, to March 28, 2014.

Figure A.12. Inflation response to government spending shocks: excluding the Great Recession

Note: This figure shows the impulse response of the price level using the daily online price index after dropping the Great Recession period (2008-09) from the estimation. The left panel shows the response to one standard deviation change in the DoD contract, and the right panel shows the response to one standard deviation change in treasury payment. The dashed lines denote 68% and 90% confidence intervals. The estimation sample is from January 1, 2010, to March 28, 2014.