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## (Not) Dancing Together: Monetary Policy Stance and the Government Spending Multiplier[1]

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## Abstract

This paper provides estimates of the government spending multiplier over the monetary policy cycle. We identify government spending shocks as forecast errors of the growth rate of government spending from the Survey of Professional Forecasters (SPF) and from the Greenbook record. The state of monetary policy is inferred from the deviation of the U.S. Fed funds rate from the target rate, using a smooth transition function. Applying the local projections method to quarterly U.S. data, we find that the federal government spending multiplier is substantially higher under accommodative than non-accommodative monetary policy. Our estimations also suggest that federal government spending may crowd-in or crowd-out private consumption, depending on the extent of monetary policy accommodation. The latter result reconciles—in a unified framework—apparently contradictory findings in the literature. We discuss the implications of our findings for the ongoing normalization of monetary conditions in advanced economies.

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# I. Introduction

The Great Recession has highlighted the role of fiscal policy as a counter-cyclical tool that can be deployed alongside monetary policy when the economy is hit by a particularly large shock. In the aftermath of the crisis, fiscal policy in advanced economies went from an expansionary phase (through a wave of stimulus packages) to a consolidation phase, the latter with a view to restoring fiscal sustainability. Monetary policy, however, was thought to have remained mostly "accommodative" until the Fed's "Taper Talk" in May 2013 and early signs of monetary policy normalization in United Kingdom. Although the exit from unconventional monetary policy is likely to be highly asynchronous across countries (with "Abenomics"[1] still unfolding in Japan and the Euro area maintaining monetary policy accommodation to support the recovery), fiscal policy will eventually confront the old monetary policy normal. Understanding how the stance of monetary policy affects the size of the government spending multiplier can therefore help inform our assessment of the effectiveness of fiscal policy in advanced economies going forward.

The strong interplay between monetary and fiscal policy poses a challenge to both policymakers and researchers as they try to disentangle the contribution of each type of policy shock on the economy. Traditional models of monetary and fiscal policy interaction, however, have focused mainly on policy coordination to provide a stable nominal anchor, in a non-cooperative game between a government and its central bank. More recently, however, a few papers have built on the new Keynesian Dynamic Stochastic General Equilibrium framework to examine the size of the fiscal multiplier when the Zero Lower Bound (ZLB) on the nominal interest rate binds. The equilibrium outcome of the interaction between active/passive monetary and fiscal policy has also been examined in the literature, also using the new Keynesian set-up.

Despite the above recent theoretical contributions, the empirics of how the response of output to government spending shocks varies with the stance of monetary policy remain limited at best. This paper is an attempt to fill that gap. We provide estimates of the government spending multiplier under accommodative and non-accommodative monetary policy.

Central to our analysis is the identification of the state of monetary policy, capturing the extent to which the Central Bank leans against the wind. More explicitly, we approximate the reaction function of the U.S. Fed to the output gap and inflation using a simple Taylor-type rule.[2] The extent of monetary policy accommodation is then inferred from the deviation of the actual Fed funds rate from the Taylor rule-implied rate, using a (smooth) transition distri-

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[1]Abenomics, the economic plan put forward by the Japanese Prime Minister, Shinzō Abe, since his re-election in December 2012, entails three (complementary) "arrows": (i) fiscal expansion (in the short-run); (ii) monetary easing (QE); and (iii) structural reforms.

[2]This is broadly consistent with the "dual mandate" of the Fed, as articulated in Section 2A (on monetary policy objectives) of the 1977 amendment of the Federal Reserve Act: "The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long run growth of the monetary and

bution, calibrated to reflect the average historical frequency of monetary policy accommodation.

Following Auerbach and Gorodnichenko (2013), government spending shocks are identified as forecast errors of the growth rate of government spending from the Survey of Professional Forecasters (SPF) and from the Greenbook, further stripped from their predictable components.[3] We also identify government spending shocks using the Cholesky decomposition as in Blanchard and Perotti (2002), as a way to benchmarking our results, given the popularity of that approach in the empirical literature.

To estimate the fiscal multiplier across states of monetary policy, we apply the local projections method, pioneered by Jordà (2005) and applied recently by Auerbach and Gorodnichenko (2013) and Owyang, Ramey, and Zubairy (2013), to U.S. quarterly data. The local projections method, among many other desirable features, does not impose the implicit dynamic restrictions inherent to Structural Vector Autoregressions (SVARs).

Our estimations suggest that the federal government spending multiplier is substantially higher under accommodative than non-accommodative monetary policy. Furthermore, our paper reconciles, within a unified framework, apparently contradictory findings in the literature: federal government spending may crowd-in or crowd-out private consumption, depending on the extent of monetary policy accommodation. Our results are robust to alternative identification of the spending shock and of the state of monetary policy, and to more disaggregated categories of consumption expenditures. We explore two channels through which the stance of monetary policy may impact the effectiveness of fiscal policy: the "substitution effect" (via the real interest rate path) and the "wealth effect" (through the funding scheme for government spending).

The remainder of the paper proceeds as follows. We end this section with a brief review of the literature. Section II delineates our empirical strategy, including the local projections method and our identification of the state of monetary policy. Section III presents the estimation results on a sample ending 2008Q4 and explores transmission channels. Section IV presents estimation results on an extended sample to cover the ZLB episode and the recent period where output has been below potential. Section V performs some sensitivity analyses. Section VI concludes, draws policy implications, and explores possible extensions.

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credit aggregates commensurate with the economy's long run potential to increase production, so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates."

[3]The Greenbook—officially entitled "Current Economic and Financial Conditions"—provides an analysis of the U.S. and international economy. It is produced by the staff of the Federal Reserve Board (FRB) and distributed to Federal Open Market Committee (FOMC) meeting's participants one week prior to the meeting. We focus in this paper on federal government spending, in line with the fact that monetary policy (characterizing the state of the world in our framework) is conducted at the federal level.

## A. Related Literature

This paper is at the intersection of two strands of the literature: the theoretical literature that studies the interaction between fiscal and monetary policy, including when the ZLB on nominal interest rates binds; and the empirical literature that examines the effects of fiscal policy, including state-dependent fiscal multipliers.

Related to the theoretical strand of the literature, Davig and Leeper (2007) estimate regime-switching rules for monetary policy and tax policy—assumed to behave either actively or passively—over the post-war period in the United States and integrate the estimated policy process into a calibrated DSGE model with nominal rigidities. An active authority in the model pays no attention to the level of government debt while passive authority responds to shocks to government debt and is therefore constrained by the actions of the active authority. The authors then simulate the effects of a tax-cut on the U.S. economy across monetary and tax policy regimes. Davig and Leeper (2011) use Davig and Leeper (2007)'s setting to simulate the macroeconomic impact of changes in government spending when monetary and fiscal policies interact. They find that an increase in government purchases induces a stronger rise in consumption, output and inflation under a regime combining passive monetary policy and active tax policy than a regime combining active monetary policy and passive tax policy regime.

A few theoretical studies, building on the New Keynesian DSGE framework, examine the effects of government spending when the ZLB on the nominal interest rate binds (see, e.g., Christiano, Eichenbaum, and Rebelo (2011), Woodford (2011), Mertens and Ravn (2014), among others). Simulations from these studies exhibit larger output multipliers from government spending when the ZLB on the nominal rates binds. The transmission channel, like in the case of passive monetary policy, is the real interest rate. Expansionary fiscal policy induces higher expectations for future inflation. Since the nominal interest rate is stuck at zero, the real rate declines, inducing an expansion of the aggregate demand.[4] This expansion of aggregate demand leads to a further increase in inflation expectations and depresses the real rate further. Increased government spending therefore breaks the deflationary spiral associated with the ZLB. More recently, Gaspar (2015) finds that monetary policy transmission is more uncertain when the interest rate is constrained by the ZLB (and unconventional monetary policy used), suggesting a potentially supportive role for fiscal policy.[5]

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[4]The fact that the rate is stuck at zero of course does not prevent the monetary authority from raising it. The constraint comes from the fact that the "notional" target rate before the fiscal shock is already very negative and cannot be reached in practice because the nominal rate is bounded from below by zero. The monetary authority may therefore not be able to bring the rate up to the positive territory without running the risk of plunging the economy into a deep recession.

[5]These findings, focused particularly on the Euro area, are based on simulations from the Global Integrated Monetary and Fiscal model (GIMF)—a multi-region DSGE model developed at the IMF (see Anderson and others (2013))—and its subsequent extensions.

In connection with the empirical strand of the literature, an impressive volume of papers, using linear SVARs models have investigated the effects of fiscal policy changes on macroeconomic outcomes, output in particular. These studies mainly identify fiscal shocks either by the Cholesky decomposition complemented with institutional information (see the seminal paper by Blanchard and Perotti (2002), and Perotti (2004)), by the sign restrictions (see Mountford and Uhlig (2009)), or using the narrative approach pioneered by Romer and Romer (1989).[6] While most papers find that government spending increases output and crowd-out private investment, the response of private consumption remains mixed. Some authors find that government spending crowds-in private consumption (see, e.g., Blanchard and Perotti (2002), Bouakez and Rebei (2007), Mountford and Uhlig (2009)), while others, using the narrative approach to identifying exogenous changes in government spending, find the opposite result (see, e.g., Ramey and Shapiro (1998), Ramey (2011)).

Some authors have considered the non-linear effects of government spending. Choi and Devereux (2006) investigate how changes in government purchases affect the U.S. economy at different levels of real interest rates. They find that expansionary government spending is more conductive to short-term growth when real rates are low. Indeed, the Ricardian effect is smaller at lower financing costs of fiscal policy. More recently, a number of papers have investigated how the fiscal multiplier varies with the state of the economy (see Auerbach and Gorodnichenko (2012), Auerbach and Gorodnichenko (2013), and Baum, Poplawski-Ribeiro, and Weber (2012), among others). They generally find that an increase in government spending has a substantially higher impact on output during recessions than expansions. Recently, however, Owyang, Ramey, and Zubairy (2013), using newly constructed historical data for the US and Canada, find evidence of higher multipliers during times of slack in Canada, but find no such evidence for the United States.

Our paper contributes to the existing literature along several important dimensions: First, the state of the world in our non-linear model is characterized by the stance of monetary policy, and not by the level of economic activity (recessions or expansions), which has been the focus of many recent papers on state-dependent fiscal multipliers. In fact, recessions and expansions may themselves be the outcome of combined monetary and fiscal policy actions—earlier findings that fiscal multipliers are higher in recessions might well reflect the fact that monetary policy is likely to be accommodative in recessions. Some papers have admittedly controlled for the level of the interest rate (e.g., Belinga (2013) and Canova and Pappa (2011)), but we argue that the level of the interest rate considered solely could be a poor proxy of the state of monetary policy, which should ultimately be defined in light of macroeconomic conditions. In fact, a relatively low interest rate, otherwise accommodative (in normal times), could be deemed non-accommodative if the economy is in a deep recession and inflation expectations

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[6]The authors use historical records to identify episodes during which large monetary disturbances were not caused by output fluctuations. The method has since been adapted to the fiscal realm to identify exogenous changes in tax policy and military spending based on news reports (see, e.g., Romer and Romer (2010), Ramey and Shapiro (1998), and Owyang, Ramey, and Zubairy (2013), among others).

well-anchored. The reverse could hold for a relatively high interest rate in an overheating economy. We account for the behavior of the interest rate over the business cycle, and explicitly characterize monetary policy by two states (accommodative and non-accommodative). Moreover, we ensure a smooth transition between the two states. More specifically, we infer the state of monetary policy from the deviation of the actual Fed funds rate from the target rate. The likelihood of being in either of the two states is higher in a given period if the actual nominal rate deviates "enough" from the rate implied by the "traditional" reaction function of the Fed to macroeconomic conditions. This approach captures high frequency changes in monetary policy, which is desirable, given the quite frequent occurrence of fiscal shocks (we use quarterly data).

Second, we provide evidence that the existing tension over the crowding-in/crowding-out effect of government spending on private consumption in the literature may stem from previous studies not controlling for the state of monetary policy. Also, we find that fiscal policy is more effective in the United States at times of slack when monetary policy accommodates. The latter result shades some light on Owyang, Ramey, and Zubairy (2013) who, not controlling for the state of monetary policy, find no evidence that fiscal policy is more effective at times of slack in the United States.

Last but not least, the use of the local projections method allows us to relax the implicit dynamic restrictions on the Impulse Response Functions (IRFs) inherent to the alternative Structural Vector Autoregressions (SVARs) method.

## II. ECONOMETRIC MODEL

### A. Model Specification

We estimate the impulse response functions (IRFs) of macroeconomic variables (and output in particular) to a government spending shock across monetary policy states, using the local projections method developed by Jordà (2005) and applied recently by Auerbach and Gorodnichenko (2013).

The (state-dependent) response of a variable (e.g., output) to a government spending shock ($Gshock_t$), $h$ periods ahead, is given by $\beta_A^h$ in the accommodative state and by $\beta_N^h$ in the non-accommodative state. These responses are estimated directly for each horizon $h$ ($h = 0, 1, 2, ..., H$) from the following sequence of regressions:

$$y_{j,t+h} = F(z_{t-1}) \left[ \psi_A^h(L)X_{t-1} + \beta_A^h Gshock_t \right] + (1 - F(z_{t-1})) \left[ \psi_N^h(L)X_{t-1} + \beta_N^h Gshock_t \right] + u_t, \tag{1}$$

$$u_t \sim N(0, \sigma_t^2), \tag{2}$$

$$F(z_t) = \frac{\exp(-\gamma z_t)}{1 + \exp(-\gamma z_t)}, \quad \gamma > 0, \tag{3}$$

$$E(z_t) = 0, \text{var}(z_t) = 1, \tag{4}$$

where $y_{jt}$ is our variable of interest, $X_t = [G_t, T_t, Y_t]'$ is a set of controls, and $L$ is the lag operator. $z_t$ is an indicator of the stance of monetary policy, normalized to have unit variance, making $\gamma$ scale-invariant. There is no clear-cut theoretical guidance in defining the index $z$. We compute $z$ as the deviation of the actual Fed funds rate from the target rate, with large negative values (higher values of $F(z)$) signaling a higher likelihood of monetary policy accommodation.

$F(z)$ takes values between $0$ and $1$ and is decreasing in $z$. $\beta_A$ represents the fiscal multiplier in a (sufficiently) deep monetary policy accommodation (i.e., $F(z_t) \approx 1$) and $\beta_N$ represents the multiplier under non-accommodative monetary policy (i.e., $F(z_t) \approx 0$ or equivalently $1 - F(z_t) \approx 1$). Interestingly, $F(0) = 1/2$, which captures well the fact that it is equally likely to be in the accommodative or non-accommodative state when the Fed funds rate exactly matches the target rate. The parameter $\gamma$ captures the speed at which one (smoothly) moves from the accommodative to the non-accommodative monetary policy state as $z$ increases from large and negative values to positive ones. It is calibrated to match the frequency of monetary policy accommodation in the data (see below). Following Auerbach and Gorodnichenko (2013), we date the index $z$ by $t-1$ in Equation (1) to avoid contemporaneous feedbacks from fiscal policy actions into the state of monetary policy.[7]

The local projections approach has a number of advantages: First, it easily accommodates state dependence and does not impose the implicit dynamic restrictions on the IRFs inherent to SVARs. The fact that the response of each endogenous variable is estimated separately allows one to economize on the number of parameters to be pinned-down simultaneously, therefore increasing the available degrees of freedom. In fact, unlike the VAR model which requires several variables and lags to control for the effects of non-exogenous shocks,[8] and therefore a significant loss of degrees of freedom, one loses only up to $H$ observations for the left-hand side variable in estimating Equation (1).[9] In addition, contrary to VARs, the lagged

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[7]This is not too restrictive given that the state of monetary could adjust over the next quarter.

[8]Including a large number of lags under the VAR allows the error term to be orthogonal to information contained in the past values of variables included in the VAR.

[9]In fact, one loses no observation in estimating the impact multiplier and loses $h$ ($h = 1, 2, ..., H$) observations in estimating the $h$-periods ahead multiplier.

explanatory variables are not needed to describe the dynamics of the dependent variable conditional on the shock.[10] The parameters $\beta_i^h$, $i \in \{A, N\}$ describe the behavior of a variable at time $t + h$ in response to an exogenous government spending shock that occurred at time $t$. In fact, the response of each endogenous variable is estimated in isolation to other endogenous variable. The lag structure $\psi_A(L)X_{t-1}$ in Equation (1) does not represent an internal dynamic of the system, but is included simply to strip *Gshock* from predictable components that would have been wiped-out had the professional Forecaster run a VAR.[11]

Second, the induced IRFs in a state-dependent VAR model implicitly assume no change in the state variable. For instance, monetary policy could remain accommodative even after a massive fiscal expansion. This assumption is difficult to reconcile with a shock which may push output above potential, overheating the economy. The local projections method does not constraint monetary policy to be stuck in a given state forever, given that IRFs are estimated directly at each horizon, rather than obtained recursively from an estimated system. The coefficient $\beta_i^h$, $i \in \{A, N\}$, directly captures the average effect of a government spending shock at horizon $h$ when monetary policy is in the state $i$.

Third, one limit associated with the VAR model is the way spending multipliers are computed. Real GDP and real government spending in the VAR-system are usually expressed in the log-form. Therefore, the computed IRFs give rise to elasticities but not spending multipliers *per se*. To convert the percent changes to dollar equivalents, the IRFs are scaled by the inverse of the sample average ratio of $G/Y$. This approach may bias the size of the spending multiplier since the ratio $G/Y$ tends to move substantially over the sample period (see Figure A1 in the appendix). To allow the computed multiplier to be consistent with the variability in $G/Y$ over time and following Barro and Redlick (2011) and Owyang, Ramey, and Zubairy (2013) we define the dependent variable $y_t$ as

$$y_{t+h} = \frac{Y_{t+h} - Y_{t-1}}{Y_{t-1}},$$

where $Y$ is real GDP and

$$g_{t+h} = \frac{G_{t+h} - G_{t-1}}{Y_{t-1}} = \left( \frac{G_{t+h} - G_{t-1}}{G_{t-1}} \right) \times \frac{G_{t-1}}{Y_{t-1}},$$

where $G$ is a measure of government spending. The multipliers are then derived directly from the estimates of $\beta_i^h$, $i \in \{A, N\}$ for government spending and real GDP, using Equation (1).

Furthermore, the function $F(z)$ induces a smooth transition between the two states of monetary policy. This approach has a number of advantages. First it allows one to control for

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[10]In VARs, the IRF that describes the dynamic of a variable following a shock is a combination of the estimated parameters of lagged endogenous variables and the parameters of the VAR-COV matrix of residuals.

[11]The lag structure is indeed not indexed by $h$ and therefore does not move with the estimation horizon of the impact of the shock that occurs at time $t$ on output $h$-period ahead.

the uncertainty surrounding an otherwise (arbitrary) cut-off value of $z$ for defining monetary policy accommodation. Second, by discriminating across different values of the index $z$, the (smooth) transition function captures the extent of monetary policy accommodation in a continuous way—a minor deviation from the Taylor-rule implied rate would be associated with a very low likelihood of being in either of the two states; a large negative (positive) deviation would send a strong signal of monetary policy accommodation (non-accommodation). Third, it limits the risk of mis-classifying monetary policy states that may be brought about, e.g., by a mis-specified Taylor rule. The smooth transition method is indeed a sharp departure from the alternative of estimating the fiscal multiplier separately for each regime, which would reduce the number of degrees of freedom if the number of realizations of the accommodative state is limited. The threshold regression approach does not suffer from the latter drawback, but fails to capture the uncertainty surrounding the turning point associated with the non-linear effects of fiscal policy across the states of monetary policy.

The smooth transition method, however, delivers estimates for extreme accommodation and non-accommodation, while the extent of monetary policy accommodation is likely to be somewhere in-between these two polar cases in reality. Also, the local projections approach requires that the shock be identified exogenously.

## B.  Data

We estimate the model using U.S. quarterly data over the period 1965Q4–2012Q4. Our sample does not go further back in time because our identification of (unanticipated) government spending shocks relies on data from the Survey of Professional Forecasters (SPF) and the Greenbook, which starts only in 1965.

The state of monetary policy in our baseline estimations is identified only through 2008Q4 because the Fed funds rate used in the identification has been constrained by the ZLB since December 2008 and therefore has (temporally) ceased to be an appropriate indicator of the Fed's monetary policy stance. Unconventional Monetary Policy (UMP) tools have since included assets purchases, with effects on the long end of the yield curve, and not on the Fed funds rate itself.[12] Also, the level of the potential output is currently surrounded by lot of uncertainty.[13] To account for these recent developments, we first run estimations on a sample through 2008Q4. We then present results on an extended sample that nests the ZLB episode. Because the ZLB constraint indeed became active only post-2008Q4, the sample is extended

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[12]Our estimations, however, do include the contemporaneous impact of a government spending shock that occurred in 2009Q1 (e.g., the American Recovery and Reinvestment Act), conditional on the state of monetary policy in 2008Q4 (see Equation (1) above).

[13]This is because our estimation of the Taylor-rule uses the output gap, obtained as the deviation of actual output from its potential level. There is indeed an extensive debate about whether the global financial crisis has had a permanent effect on output.

through 2012Q4, using estimates of the shadow Fed funds rate—the effective policy rate when UMP is accounted for (see sub-Section IV)—over 2009Q1–2012Q4.

The estimation of Equation (1) uses real GDP, a measure of real government purchases[14] and real tax revenues (direct and indirect tax receipts and social security contributions) net of transfers payment, all expressed in log-form. Aggregate real GDP, aggregate real consumption and its components, real private fixed investment, and real federal government spending (all in billions of chained 2009 dollars) are from the historical database maintained by the Federal Reserve Bank of Philadelphia. Military spending, tax revenues net of transfers, and federal debt are from the National Income and Product Accounts (NIPA) or the Federal Reserve Economic Data (FRED) at the Federal Reserve Bank of St. Louis. Real net tax revenues and real federal debt are obtained by dividing their nominal values by the GDP deflator, expressed in the base year 2009. The Real value of each spending component is obtained by dividing the nominal value from NIPA by the (specific) price index of that component, expressed in the base year 2009.[15] The output gap—used in the estimation of the Taylor-type rule—is the deviation of the actual output from its potential, obtained from the Congressional Budget Office (CBO). Finally, the unemployment rate and the civilian employment-population ratio are from the FRED.

## C. Determining the State of Monetary Policy

We qualify monetary policy as being accommodative when the Fed does not raise the policy rate more than it "traditionally" does in response to macroeconomic developments, based on its estimated (historical) reaction function. We capture the reaction function of the Fed to macroeconomic conditions by means of a Taylor-type rule (see Taylor (1993)), following Clarida, Gali, and Gertler (1998). These authors assume that within each period, the Central Bank has a target for the nominal short term interest rate, $i_t^*$, which depends on both the expected inflation and the deviation of output from potential.

$$i_t^\star = \bar{i} + \beta(E_t \pi_{t+n} - \pi^\star) + \gamma(E_t y_t - y_t^\star), \tag{5}$$

where $\bar{i}$ is the steady-state short term nominal interest rate, $\pi^\star$ is the inflation target of monetary authorities and $y_t^\star$ is the potential output.

To account for the observed autocorrelation in interest rates, it is assumed that the nominal rate adjusts to its target level only gradually. Abrupt policy reversals could indeed disrupt capital markets or undermine credibility. The adjustment equation reads:

$$i_t = (1 - \rho)i_t^\star + \rho i_{t-1} + \varepsilon_t, \tag{6}$$

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[14]We use government purchases and government spending interchangeably in the paper.

[15]We proceed this way because spending components expressed in real terms are available only since 1999Q1 in the NIPA or FRED database.

where $\rho \in (0,1)$ is the smoothing parameter.

From (5) and (7) and after some arrangements, one gets:

$$i_t = (1-\rho)(\bar{i} - \beta \pi^\star) + (1-\rho)\beta E_t \pi_{t+n} + (1-\rho)\gamma(E_t y_t - y_t^\star) + \rho i_{t-1} + \varepsilon_t \qquad (7)$$

For the empirical specification we use the Federal Funds Rate (FFR) as a measure of the short-term nominal interest rate, the one-quarter ahead projection of inflation $\pi_t^a$ obtained from the SPF,[16] and a measure of the output-gap. It is standard practice in the literature to use the Fed funds rate as the monetary policy indicator, although the sample may include periods in which the Fed was not explicitly targeting the funds rate. This concern is mitigated by the fact that alternative monetary policy targets would arguably be correlated with the Fed funds rate.

We estimate the following reduced-from Taylor-rule equation:

$$FFR_t = \alpha + \rho FFR_{t-1} + \gamma_\pi \pi_t^a + \gamma_y (y_t - y_t^\star) + \varepsilon_t, \qquad (8)$$

with $\alpha = (1-\rho)(\bar{i} - \beta \pi^\star)$, $\gamma_\pi = (1-\rho)\beta$ and $\gamma_y = (1-\rho)\gamma$.

We then compute an index of the monetary policy stance, $z$, as the deviation of the actual Fed funds rate from its estimated level obtained from fitting the reaction function of the Fed to the expected inflation and the actual output gap:

$$z_t = (FFR_t - \widehat{FFR_t}) \qquad (9)$$

$z$ averages $0$ by construction (estimation residual) and is normalized to have unit variance.[17]

Although the approximation of the Fed's reaction function by a Taylor-type rule is consistent with the Fed mandate under the Federal Reserve Act, the value of z could in principle also capture, in some instances, omitted variables (e.g., if the Fed did shift its focus to other aggregates than the output gap and inflation at a given point in time). For instance, unemployment became a major focus of policymaking in the aftermath of the great recession, on account of the jobless recovery. Also, the policy rate is unlikely to be orthogonal to (now) increased financial stability concerns. The risk that z may not reflect the stance of monetary policy is, however, mitigated by a number of factors: (i) we estimated the Fed's reaction function over a relatively long period of time (and the sample is limited to the pre-crisis episode); and (ii)

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[16]We also use alternative measures of inflation, including the actual inflation rate, to estimate the Taylor rule and our results remain unaltered.

[17]The estimated Taylor-type rule over 1965Q4–2008Q4 is given by the below equation, where standards errors are in parentheses:

$$\widehat{FFR_t} = \underset{(0.167)}{-0.012} + \underset{(0.032)}{0.897} FFR_{t-1} + \underset{(0.080)}{0.179} \pi_t^a + \underset{(0.031)}{0.138} (y_t - y_t^*).$$

These estimates suggest that the Fed tends to put more emphasis on inflation, and there is quite some interest rate smoothing, both consistent with the existing literature.

our identification of the state of monetary policy during the crisis and post-crisis episodes, over which unemployment and financial stability concerns became more prominent, accounts for the zero lower bound on the nominal interest rate and the ensuing deployment of unconventional monetary policies tools (see Section IV). In addition, smooth transition between the two states of monetary policy (see below) further limits the risk that the stance of monetary policy be poorly identified—the value of z (simply) informs the likelihood of being in a given state.

It is worth emphasizing that our approach for identifying the state of monetary policy—unlike some existing studies on the non-linear effects of fiscal policy in relation to monetary policy—accounts for prevailing macroeconomic conditions. For instance, Freedman and others (2010) define monetary accommodation as instances in which the interest rate is kept constant for one or two years. Our approach is consistent with Morgan (1993)'s who identifies monetary policy tightening/easing using residuals from the regression of the level of the Fed funds rate on its own lags, current and lagged values of output growth and inflation, in testing for the asymmetric effects of monetary policy in the U.S. economy.

Although the extent of monetary policy accommodation ($z$) is defined here in reference to macroeconomic conditions, $z$ may also reflect the extent of monetary policy accommodation with respect to the fiscal shock, given that the Fed would arguably increase the interest rate following an increase in government spending only to the extend that the fiscal action feeds inflation expectations or push output above potential (see Romer and Romer (2014) for a similar issue). This conjecture is confirmed ex-post: we find that the Fed funds rate falls following a positive federal spending shock under accommodative monetary policy, though inflation rises. As a consequence, the real interest rate falls even sharper (see Section III.C).

$F(z)$ denotes the probability of being in the accommodative state for a given value of $z$.[18] With this characterization, we can easily incorporate the fact that fiscal policy shocks, by affecting output, can alter the monetary policy stance.[19] We calibrate the parameter $\gamma$ so that monetary policy remains accommodative for about 30 percent of time in our sample and perform some sensitivity analyses with respect to that frequency. Assuming that monetary policy is accommodative if $F(z_t) > 0.8$, $\gamma$ is obtained as solution to the equation: $Pr(F(z) > 0.8) = 0.3$. Solving this equation—using the cumulative distribution of $F$—yields $\gamma = 5$. We choose this parametrisation because we are particularly interested in episodes which are very sharp and clearly indicative of a change in the Fed's monetary policy stance. Auerbach and Gorodnichenko (2012) obtained a smaller value for $\gamma$ of 1.5, reflecting the fact that recessions (their

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[18]Monetary policy is supposed to be in either of the accommodative or non-accommodative state at any point in time.

[19]As an alternative to our approach, one could be tempted to define monetary policy accommodation as instances in which the deviation of the federal funds rate from the target rate is below a given threshold $z_0$ (i.e., $z_t \leq z_0$), with non-accommodation corresponding to the opposite case. We explore this approach by estimating $z_0$ by mean of a threshold regression. The results, however, tend to be highly sensitive to small perturbations to the estimated threshold, undermining confidence to that approach.

focus) are less frequent in the data (they occur 20 percent of the time, based on NBER recession dating). Our higher value of $\gamma$ is conservative as it implies a faster move from the accommodative to the non-accommodative monetary state. This would result in a smaller scope for discriminating between the two states—too "close" to each other—when it comes to the effectiveness of fiscal policy (the sensitivity analyses around the parametrization of $\gamma$ is discussed in Section V).

The estimated Taylor-rule delivers expected coefficients, with the Fed being more aggressive vis-a-vis inflation than towards the output gap. We also find strong evidence of interest rate smoothing, typical in the estimated of the Fed's reaction function—not surprisingly, the policy rate does not jump around. Figure 1 portrays the Fed funds rate and $F(z)$ over our sample period. The shared areas correspond to recessions, as identified by the NBER Business Cycles Dating Committee.

A number of observations can be drawn from Figure 1: (i) The post-war dynamics of the Fed funds rate display two broad phases: an episode of rising Fed funds rate through 1981, and an episode of declining rate post-1981. As such, controlling for the level of the interest rate as done in previous studies may not capture the full extent of changes that occurred in the U.S. monetary policy stance over time (first panel chart); (ii) Our identification scheme suggests a high likelihood of monetary policy being accommodative in some episodes of rising interest rate (second panel chart), a fact that would not be captured if one simply considers the level of the interest rate; and (iii) $F(z)$ is greater than 0.8 over the sample period in almost all the recession dates, indicating an overall accommodative stance during recessions. Our identification may therefore nest the framework that examines the size of the fiscal multiplier over the business cycle. In fact, Robert Hall in his comments on Auerbach and Gorodnichenko (2013) (see Alesina and Giavazzi (2013)) notes that the state of the economy as identified by the authors may simply reflect various phases in US monetary policy. Interestingly, our identification suggests that monetary policy was at times accommodative outside recession episodes, making our framework broader in scope.

One challenge associated with our identification strategy is the treatment of the ZLB episode. In fact the index $z$ is, by construction, biased upward when the nominal interest rate hits the ZLB. This is because the estimated Taylor-rule rate ($\widehat{FRR_t}$) is unbounded, while the actual interest rate is bounded from below. We extend the identification of the monetary policy state to the ZLB episode, using alternative methods in Section IV.

**Figure 1. The Fed Funds Rate and the Likelihood of Being in the Accommodative State**
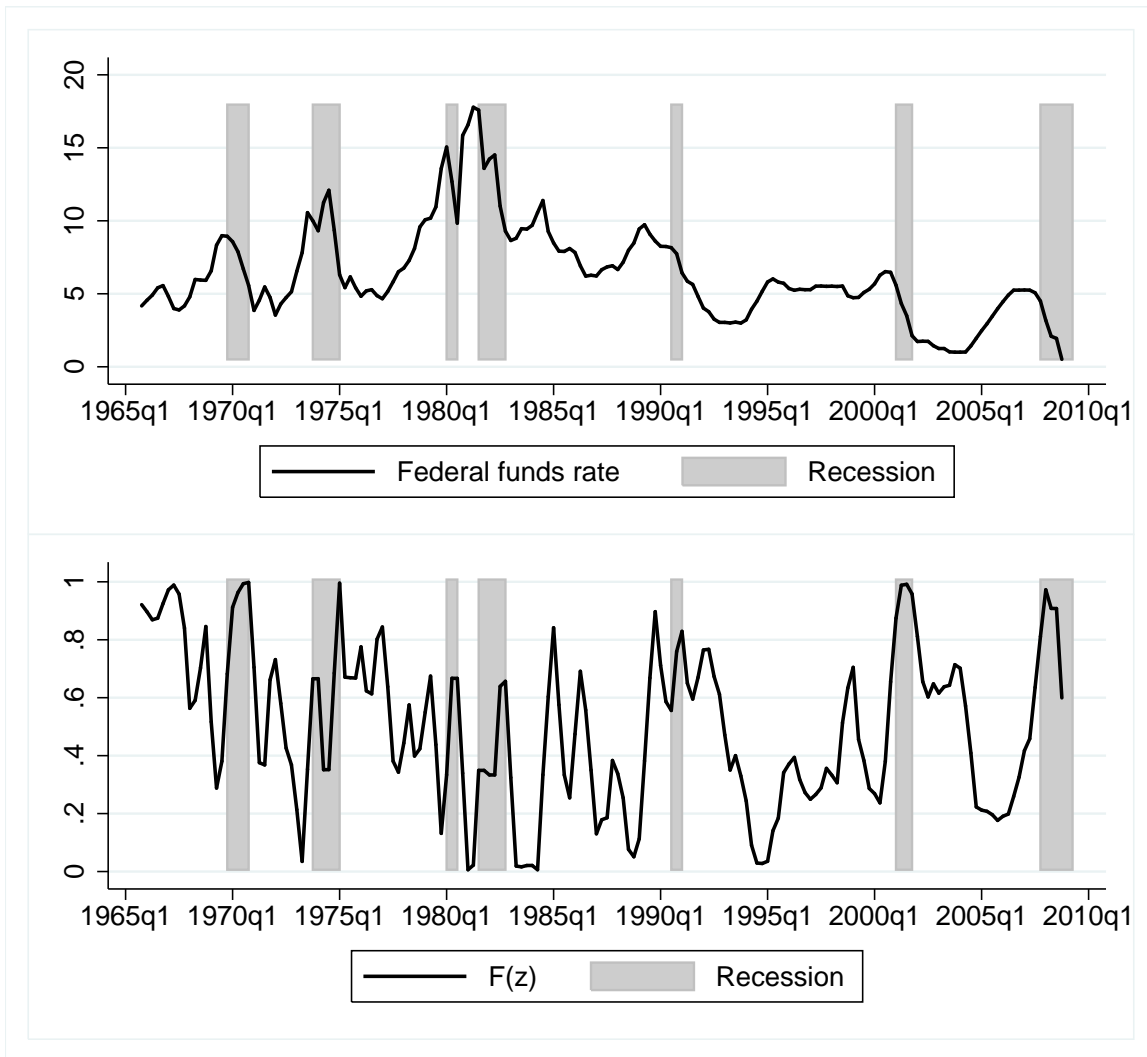


Notes: The first panel chart portrays the Federal funds rate and the second panel chart displays the probability of being in the accommodative state of monetary policy (moving average). Shaded bars represent NBER recession dates.

## III.   ESTIMATION RESULTS (SAMPLE ENDING IN 2008Q4)

For each regression $h$ ($h = 0, 1, 2, ..., H$) of Equation (1), we use 4 lags of **X**, and following Owyang, Ramey, and Zubairy (2013), we add a quartic trend.[20] Government spending shocks (*Gshock*) are identified using two approaches. We first examine the case in which government spending shocks are identified using the Cholesky decomposition (quite standard in the VAR-

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[20]The coefficients of the trend are not state-dependent.

like approach). We subsequently turn to a measure of unanticipated government spending shocks which controls for expectations.

## A. Government Spending Shocks Identified Using the Cholesky Decomposition

As a starting point, we identify shocks to government spending ($Gshock_t$) as residuals of the projection of log of $G_t$ on the lagged values of log of $\mathbf{X_t} = [\mathbf{G_t}, \mathbf{T_t}, \mathbf{Y_t}]'$, common in the literature. Innovations from this projection are equivalent to those that would be generated by a SVAR in which shocks are identified using the Cholesky decomposition whereby the government spending variable is ranked first. Delays in adopting/implementating government spending measures (e.g., due to the parliamentarian process) are indeed such that they may not affect output within a quarter (see the seminal paper by Blanchard and Perotti (2002)). Equation (1) is then estimated using the resulting series $Gshock_t$.

Estimation results suggest that federal government purchases are expansionary and have a highly persistent impact, with output increasing for many quarters after the shocks (see appendix, Figure A3). It is worth noting that our linear model generates government spending multipliers that are well within the range of those found in the literature: the impact multiplier of U.S. federal government spending is around 1.7 upon impact (one-year cumulative). For comparison purposes, we also use military spending, and find that they tend to be more expansionary (the induced multiplier is around 2), consistent with earlier findings in the literature. The peak output multiplier is also the largest for military spending.[21] Our non-linear estimations also suggest that the response of output to the federal government spending shock depends on the state of monetary policy that prevails at the time of the shock—the increase in output is higher when monetary policy is accommodative and for many quarters after the shock (see detailed discussion below).[22]

## B. Government Spending Shocks Identified as Forecast Errors

One criticism associated with the above identification strategy is that these shocks might be forecastable because fiscal policy changes are anticipated in advance due to the time lag between their adoption by the Legislative and their implementation—see Ramey (2011) on the critical role of the timing of fiscal shocks in pinning-down the effect of fiscal shocks. Even including a large number of lags could fail to capture these anticipated future changes in fiscal

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[21]detailed results associated with defense spending shocks are available upon request.

[22]This result is consistent with Freedman and others (2010) who find, using simulations from a multi-region DSGE model (see Anderson and others (2013)), that multipliers of two-year fiscal stimulus are higher when the interest rate is kept constant for one or two years. It is also consistent with simulations in Coenen and others (2010). But our analysis differs from those studies in that it is empirical in nature and our identification of the state of monetary policy accounts for macroeconomic conditions (see discussion above).

policy. For this reason, we use a measure of a surprise government spending shock. Following Auerbach and Gorodnichenko (2012), we identify unanticipated government spending shocks as forecasts errors of the growth rate of government purchases:

$$FE_t^G = \Delta logG_t - E_{t-1}\Delta logG_t$$

We construct our forecast series of real government spending growth from two sources: the Survey of Professional Forecasters (SPF) and the Greenbook record. SPF data is only available since 1981. We complement that source with the Greenbook record prepared by the staff of the Federal Reserve Board ahead of the meetings of the Federal Open Market Committee (FOMC) since 1965. Our series of government spending shocks therefore cover the period from 1965 to 2012. Because of many revisions in national accounts data, we follow Auerbach and Gorodnichenko (2012) in using growth rates (rather than levels) of real federal spending. More specifically, we first constitute series of forecasts of real federal spending from one-quarter-ahead projections available from the Greenbook up to 1984. We then take the one-quarter ahead forecast of federal spending from the SPF, available since 1981, from which we back out the real growth rate. Finally, to have a complete series of expected real growth of federal spending, we splice both series of expected growth of real spending. The series of forecast errors are then obtained as the difference between actual real growth of federal spending and their one-quarter ahead projection made in the previous quarter. Finally, to purify our series of government spending shocks from predictable changes in the growth rate of government spending that would have been foreseen by professional forecasters, we include lagged values of government spending, net taxes, and output to the local projections (Equation (1)).

Is there any empirical case for using SPF/Greenbook as sources of identification of government spending shocks rather than relying on the (traditional) Cholesky decomposition? To provide an answer to that question, we project actual real federal spending growth and their forecasts on the lags of real federal spending, real GDP and real tax revenues expressed in log-term. As shown in Figure 2, the two series of residuals obtained from those projections are correlated, with a coefficient of correlation of about 0.3. When we regress the series of residuals from actual federal spending growth equation on the series of residuals from the forecasts of federal spending growth equation, we find a coefficient of 0.5, significant at 5 percent significance level.

These findings suggest that innovations from the VAR-like approach are predictable (Auerbach and Gorodnichenko (2012) present a similar evidence). Our preferred approach is therefore one in which government spending shocks are identified as forecast errors of the growth rate of government spending from SPF/Greenbook. This is the approach adopted in all the estimations presented below.

**Figure 2. Predictability of Innovations from the Cholesky Decomposition**
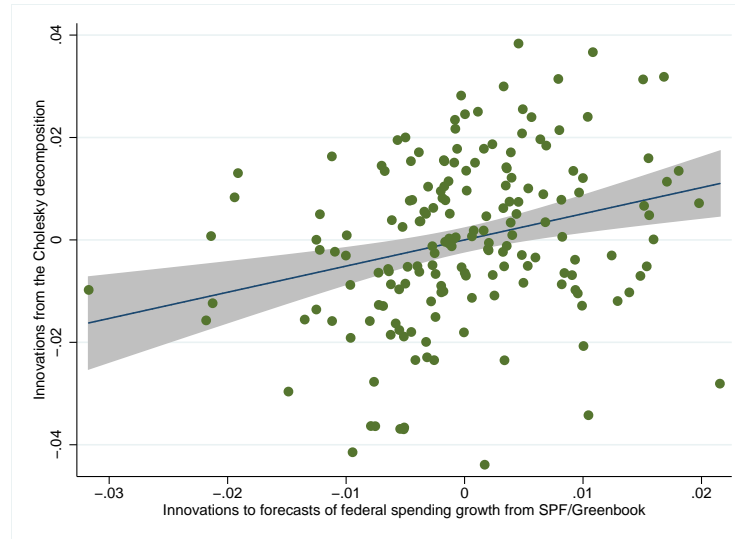


Notes: This figure shows residuals of projecting actual real federal growth spending on lags of real federal spending, real GDP and real tax revenues expressed in log (vertical-axis) and residuals of the projection of forecasts of real federal spending growth on the same variables. The correlation between the two series of residuals is 0.3. The projection of the first series on the second delivers a coefficient of 0.5 with a standard error of 0.13. The grid area is the 95 percent confidence interval around the fitted values.

## Results for aggregate output

Figure 3 displays the IRFs of output and federal spending to a "surprise" federal spending shock (as identified in sub-Section III.B), in the linear case (first Column) and across the two states of monetary policy: accommodative state (second Column) and non-accommodative state (third Column). Gray shaded regions represent the 95 percent confidence bands around the estimates. Given the relatively small number of observations in the accommodative state (about 30 percent of the sample), the associated confidence bands are slightly wider than in the non-accommodative state.

Clearly, the response of output is conditional on the state of monetary policy: output increases to a large extent following a federal spending shock when monetary policy accommodates, while it falls, albeit not significantly, when monetary policy does not accommodate. This result holds over time and is consistent with the findings in Auerbach and Gorodnichenko (2012). The authors find that government spending tend to be slightly recessionary during expansions when expectations are controlled for.

Because the response of output (and other aggregates) depends on the persistence of the response of government spending (different across the two states of monetary policy), we report in Table 1 and subsequent tables two measures of "normalized" spending multipliers: (i) the

"cumulative multiplier" (one-year, two-year, and four-year integral), defined as the ratio of the sum of the response of output over the sum of the response of government spending through that period; and (ii) the "peak multiplier" defined as the ratio of the response of output and government spending at their respective peaks. These measures of spending multipliers are common in the literature (see Owyang, Ramey, and Zubairy (2013) and Auerbach and Gorodnichenko (2013)).

Estimation results suggest that output increases by 2.5 dollars within a year for a dollar increase in federal spending when monetary policy is accommodative and decreases by 1.6 dollars when monetary policy is non-accommodative. The peak multiplier when the accommodative state prevails is equal 5.5 and only equals 2.8 under non-accommodative monetary policy.

The magnitude of our estimated multipliers under monetary policy accommodation are consistent with Christiano, Eichenbaum, and Rebelo (2011) who, using a DSGE framework, finds an output multiplier of 3.7 at the ZLB under their benchmark specification. We note that one should interpret the multipliers obtained here for the two states of monetary policy as polar values—they correspond to sufficiently deep monetary policy accommodation and non-accommodation. The extent of monetary policy accommodation is likely to be in-between these two extremes in reality.

Although the patterns of the results are broadly similar across the two approaches to identifying fiscal shocks (see Table 1), two notable differences emerge: (i) The multiplier upon impact is much lower using our preferred measure of government spending shock (derived from forecast errors from SPF/Greenbook), estimated at 0.6, against 1.5 with the Cholesky decomposition, a result that is revert overtime; and (ii) controlling for the role of anticipations seems to increase the discriminatory role of monetary policy (fiscal multipliers across the accommodative and non-accommodative states are more apart with the measure of unanticipated shocks). These two elements highlight the need to control for anticipations in estimating fiscal multipliers.

**Results for disaggregated output**

Figure 4 portrays the response of total private consumption to a (surprise) federal government spending shock. Under accommodative monetary policy, federal government spending significantly and persistently crowds-in private consumption, while private consumption is somewhat crowded-out when monetary policy is non-accommodative. Surprisingly, the state of monetary policy does not seem to discriminate the response of private investment (see appendix, Figure A4). This result might be driven by the composition of federal government spending and how it is financed. It may also reflect the response of inventories over the business cycle.

**Figure 3. IRFs of Federal Government Spending and Output to Federal Government Spending Shocks**
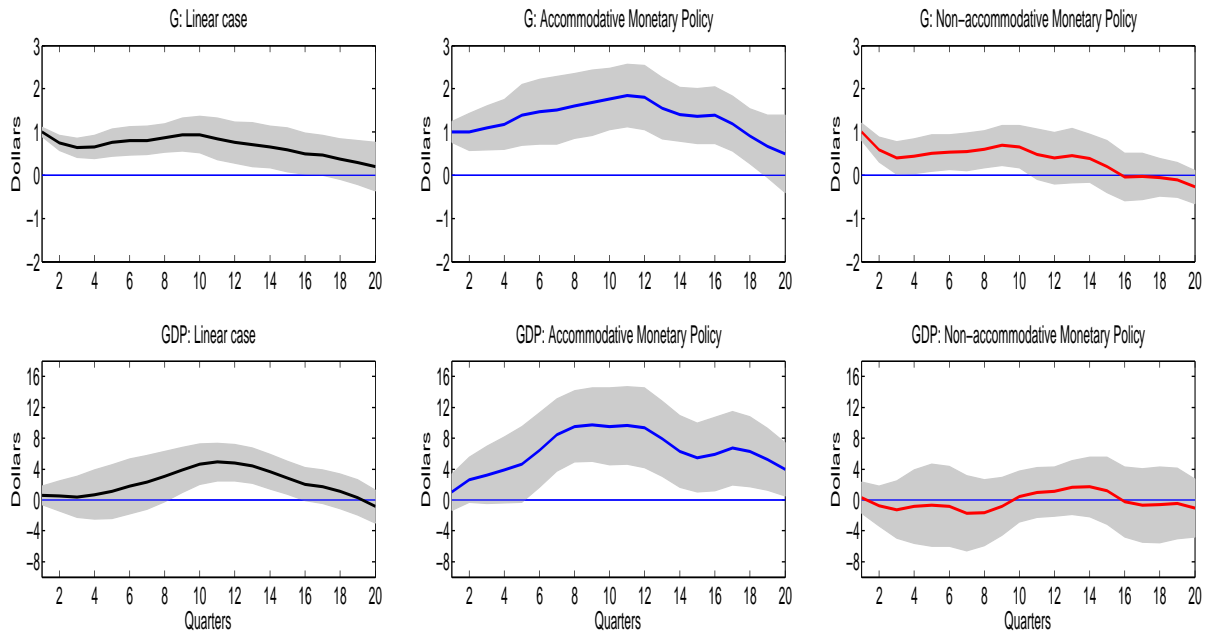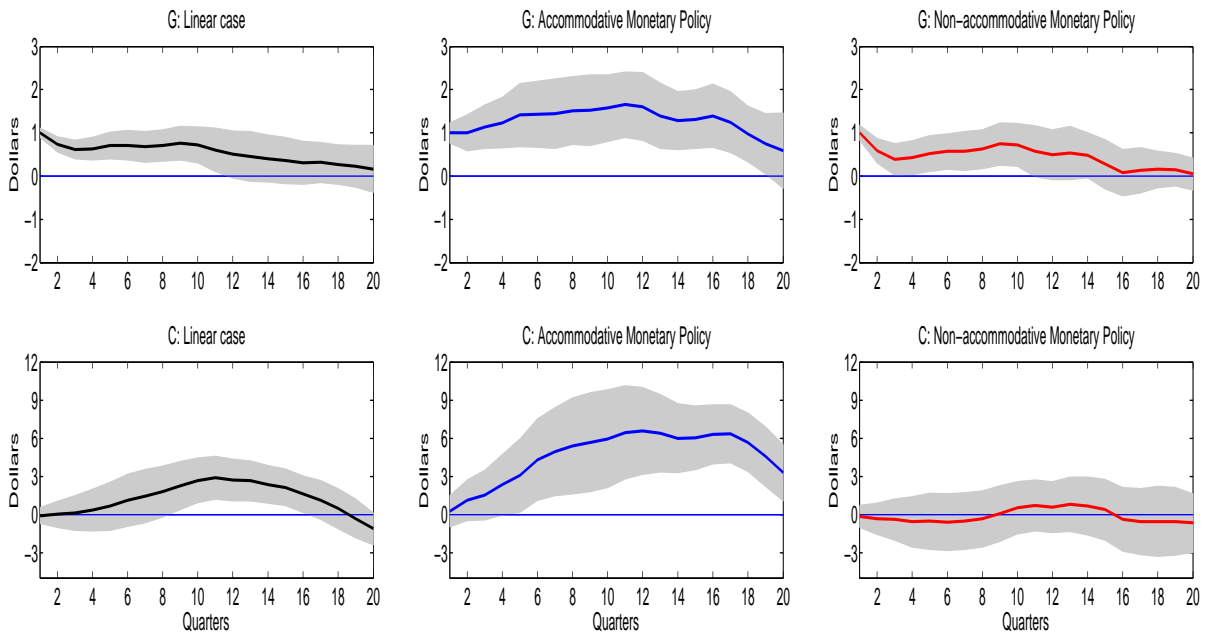


Notes: Shaded areas represent the 95 percent confidence bands around the estimates.

**Table 1. GDP Cumulative and Peak Multipliers: "Anticipated" versus "Non-anticipated" Federal Spending Shocks**

|  | 1-year integral | 2-year integral | 4-year integral | Ratio of peak responses |
|---|---|---|---|---|
| **"Anticipated" shocks (Cholesky decomposition)** | | | | |
| Linear | 1.53 | 2.07 | 2.83 | 3.27 |
| Non accommodative | 0.60 | 1.46 | 2.12 | 2.59 |
| Accommodative | 2.46 | 2.79 | 3.41 | 4.19 |
|  | | | | |
| **"Non-anticipated" shocks (SPF/Greenbook)** | | | | |
| Linear | 0.60 | 1.63 | 3.44 | 5.04 |
| Non accommodative | -1.55 | -1.97 | -0.22 | 2.76 |
| Accommodative | 2.50 | 3.96 | 4.48 | 5.51 |

Notes: Cumulative multipliers are computed as the ratio of the sum of responses of GDP and government spending. The peak measure is the ratio of the IRFs at their respective peaks.

We also examine the response of disaggregated private consumption into durable goods, and non-durable goods and services and the above finding on aggregate private consumption

**Figure 4. IRFs of Private Consumption**



Notes: Shaded areas represent the 95 percent confidence regions around the estimates.

holds across its major components: federal government spending significantly and persistently crowds-in consumption of durable goods and non-durables goods and services under accommodative monetary policy, while these consumption components tend to be crowded-out under non-accommodative monetary policy. Table A3 in appendix presents the multipliers for aggregate and disaggregated private consumption and private investment at various horizons (cumulative multipliers) and at their maximum (peak multiplier).

## C.  Transmission Channels

We explore two channels that might explain our findings: (i) the "substitution effect" through the real interest rate path; and (ii) the "wealth effect" through the funding scheme for federal government spending.

The path of the real interest rate conceptually matters for the effectiveness of fiscal policy. For instance, when the nominal interest rate hits the ZLB in New Keynesian models, an increase in government spending induces a decline in the real interest rate, as inflation rises and the nominal rate remains constant. The decline in the real rate in turns boosts private spending and aggregate demand. Even beyond the ZLB, the response of the short term nominal rate to inflation, reflecting the stance of monetary policy would affect the effectiveness of fiscal policy. Accommodative monetary authorities may for instance not necessarily increase the short

term rate in response to the spending shock, which would prompt inflation to rise more than otherwise. As a consequence, the real interest rate declines, boosting aggregate demand. To test this conjecture, we compute the response to federal government spending shock of the Feds fund rate, inflation, and two measures of the real interest rate across our monetary policy states (accommodative and non-accommodative): (i) the ex-ante real interest defined as the difference between actual nominal rate and the one-quarter ahead projection of inflation (from SPF): $rr_t^a = FFR_t - \pi_t^a$; and (ii) the ex-post real interest rate defined as the measure between actual nominal rate and the realized inflation rate $rr_t^p = FFR_t - \pi_{t+1}$. In this context, we estimate the local projections equation (see Equation (1)), adding the interest rate or inflation to the set of variables $X_t$. We find that the nominal interest declines in response to the spending shock while inflation rises, under accommodative monetary policy. The opposite holds under non-accommodative monetary stance. As a consequence, the two measures of real interest rate decline in response to a federal spending shock under accommodative monetary and increase under non-accommodative monetary policy (see Figure 5 for the response of the (nominal) Fed funds rate and Figure 6 for the response of the ex-ante real rate). This, we believe, is a nice feature of our monetary policy states. In fact, although identified with respect to macroeconomic conditions (output gap and inflation) ex-ante, our monetary states mimic a direct reaction of monetary authorities to fiscal shocks ex-post—the nominal and real interest rates decline (increase) following a government spending shock under the accommodative (non-accommodative) state. The monetary and fiscal authorities may therefore dance together or not in practice.

Figure A5 in the Appendix displays the response of real federal debt to a shock to federal government spending. Real debt increases under accommodative monetary policy and decreases when monetary policy is not accommodative. Interestingly, we find that the response of real tax (not reported) does not depend on the state of monetary policy. These two results seem to suggest that federal spending are financed mostly with debt at lower financing costs (under accommodative monetary policy). The decline in real interest rate, coupled with debt financing of spending may therefore explain the stronger response of output and private consumption under accommodative monetary policy.

## IV. ESTIMATION RESULTS (SAMPLE COVERING THE RECENT ZLB EPISODE)

### A. Identification of the State of Monetary Policy at the ZLB and Estimated Multipliers

In a recent paper, Christiano, Eichenbaum, and Trabandt (2014) emphasize the critical role of the zero lower bound (interacting with financial frictions) in accounting for movements in

**Figure 5. IRFs of the (Nominal) Fed Funds Rate**
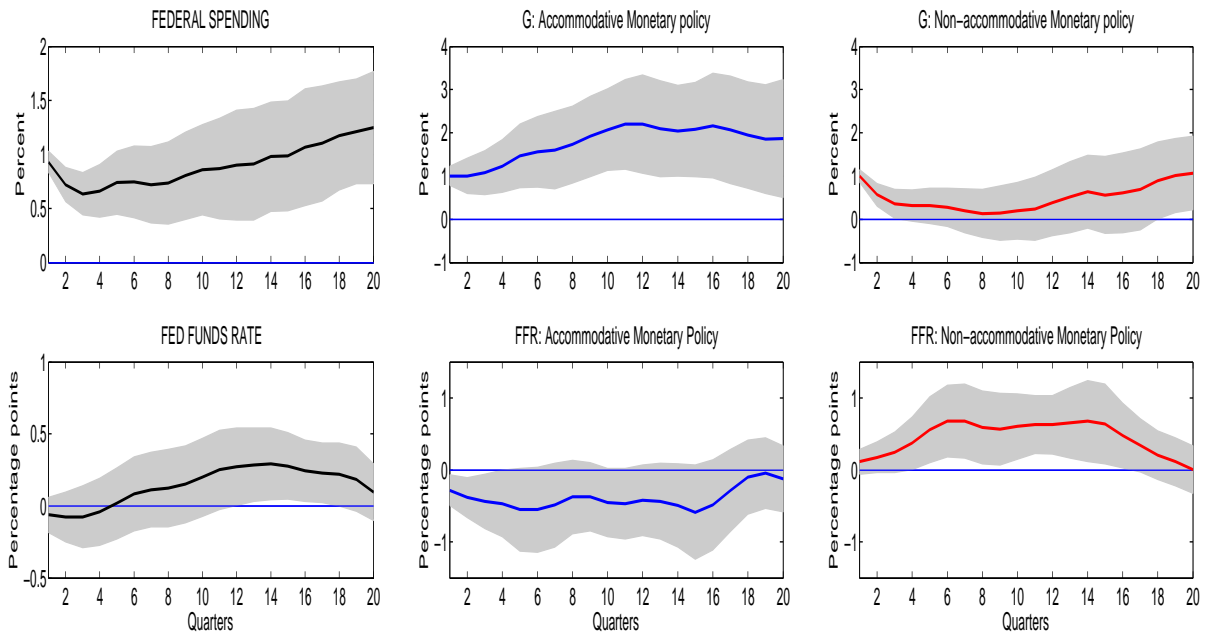


Notes: Shaded areas represent the 95 percent confidence bands around the estimates.

**Figure 6. IRFs of the Real Fed Funds Rate**
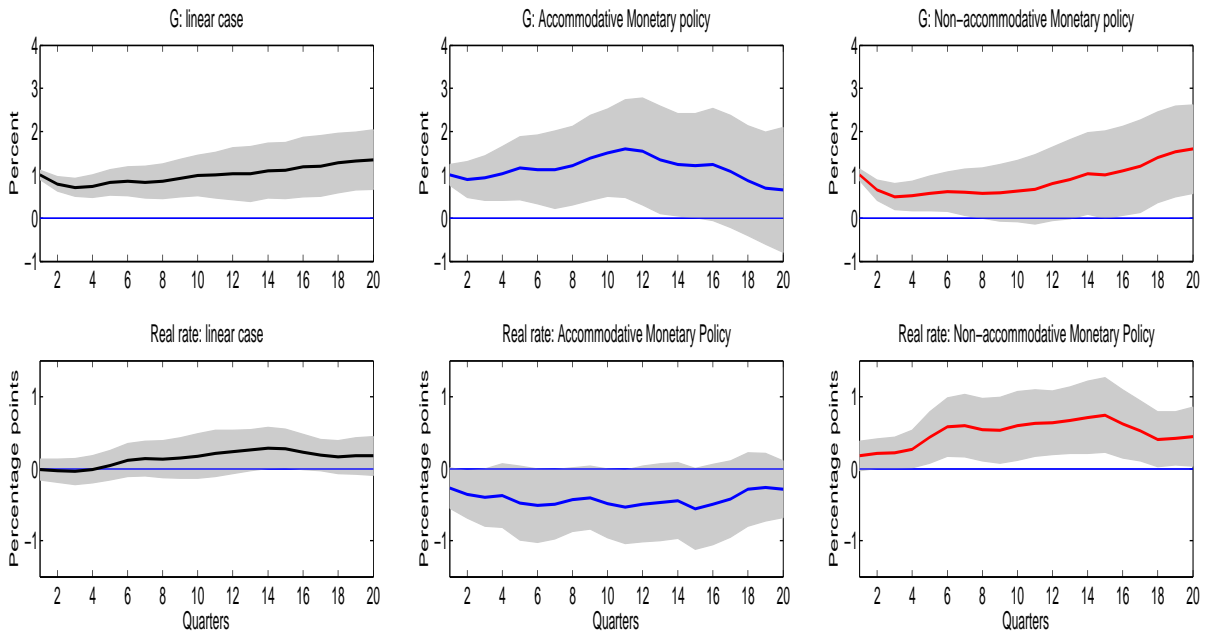


Notes: Shaded areas represent the 95 percent confidence bands around the estimates.

aggregate real economic activity during the Great Recession. Because of the uncertainty surrounding the state of monetary policy at the ZLB, our above estimations covered a sample ending in 2008Q4. We examine in this section how our results change when the sample is extended through 2012Q4, using alternative approaches. One challenge is indeed that our index of monetary policy accommodation (defined as the difference between the actual Fed funds rate and the target rate) is biased upward when the Fed funds rate is stuck at 0. In fact, at 16 basis points in December 2008, the Fed funds rate *de facto* reached the zero lower bound on the nominal interest rate and was no longer an appropriate indicator to assessing the Fed's monetary policy stance.[23] In an attempt to relax financing conditions in the U.S. economy further, as the short-term rate was stuck at zero, the Federal Reserve has deployed a number of unconventional monetary policy tools. These included large-scale asset purchase programs (QE), and forward guidance, a new communication toolkit aims at signaling the future course of monetary policy to the public.[24] These policy measures have essentially affected the long end of the yield curve—long term interest rates have (temporarily) become the Fed's intermediate targets. Many researchers have since tried to assess the effectiveness of these unconventional monetary policy tools, an uncharted territory. One related question—of particular interest for the identification of the state of monetary policy adopted in this paper—is the level of the Fed funds rate that would generate the observed yield curve if the rate was not constrained (i.e could take negative values).

In that context, Wu and Xia (2014) develop a nonlinear term structure model to summarize the macroeconomic effects of unconventional monetary policy at the ZLB. In particular the authors generate series of a "shadow" Fed funds rate from 2009Q1 to date.[25] Interestingly, the shadow rate coincides with the actual rate prior to 2008Q4. We first use these series to extend our sample of monetary policy state. More explicitly, we generate the target rate for the period from 2009Q1 to 2012Q4 during which the ZLB was binding in our sample, by fitting the actual values of the expected inflation and the output gap to our estimated Taylor rule. We then compute the index $z$ of monetary policy accommodation as in Equation (9), and the function $F(z)$ capturing the likelihood of being in the accommodative state. Finally, we re-estimate the (monetary policy state-dependent) government spending multiplier on the extended sample.

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[23]The nominal interest rate is bounded by 0 from below because holding cash is always a better (available) alternative option than borrowing at 0 or negative interest rate.

[24]Forward guidance has recently consisted for the Fed in stating that the policy rate will be kept low as long as some amount of slack remains in the economy (unemployment rate below 6.5 percent) or the recovery remains fragile.

[25]The series, including their description, are available on the web site of the Federal Reserve Bank of Atlanta: www.frbatlanta.org/cqer/researchcq/shadow_rate.cfm.

**Table 2. GDP Cumulative and Peak Multipliers (extended sample through 2012Q4)**

|  | 1 year integral | 2 years integral | 4 years integral | Ratio of peak responses |
|---|---|---|---|---|
| **ZLB: Wu and Xia (2014)** |  |  |  |  |
| Linear | -0.58 | -0.29 | 1.61 | 2.79 |
| Non accommodative | -2.89 | -3.97 | -1.16 | 1.63 |
| Accommodative | 1.72 | 2.52 | 2.97 | 3.68 |
|  |  |  |  |  |
| **ZLB: Own calculations** |  |  |  |  |
| Linear | -0.58 | -0.29 | 1.61 | 2.79 |
| Non accommodative | -2.00 | -3.09 | -0.86 | 1.54 |
| Accommodative | 1.47 | 2.45 | 3.01 | 3.77 |
|  |  |  |  |  |
| **ZLB: Lombardi and Zhu (2014)** |  |  |  |  |
| Linear | -0.58 | -0.29 | 1.61 | 2.79 |
| Non accommodative | -1.71 | -2.13 | -0.40 | 1.67 |
| Accommodative | 1.01 | 1.84 | 2.76 | 3.57 |

Notes: Cumulative multipliers are computed as the ratio of the sum of responses of GDP and government spending. The peak measure is the ratio of the IRFs at their respective peaks.

As robustness check of our identification of the state of monetary policy at the ZLB, we also use the shadow rate series generated by Lombardi and Zhu (2014).[26] We also construct an alternative measure, assuming (naively) that changes in the 10-year US rate reflect change that would have affected the Fed funds rate if the latter was unconstrained. Although the three methods deliver estimates of the shadow rate that are quite different quantitatively, they all suggest a shadow Fed funds rate that is broadly in the negative territory during the ZLB episode (see Figure A2 in appendix). Interestingly, our main qualitative result that the federal spending multiplier is higher under accommodative than under non-accommodative monetary policy is unaltered in all the three cases. Table 2 portrays our estimation results for the (surprise) federal government spending shock from SPF/Greenbook. The corresponding IRFs under accommodative and non-accommodative states, using Wu and Xia (2014)'s measure of the shadow rate, are displayed in Figure A6 in appendix.[27] To put these results in perspective, Figure A8 in appendix portrays our characterization of the state of monetary policy overtime, including under the recent UMP. It suggests that monetary policy became accommodative only progressively after the zero lower bound on the nominal interest rate had become bind-

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[26]Our preferred series of the shadow rate are those from Wu and Xia (2014), partly because of the high volatility of the series in Lombardi and Zhu (2014), which seems at odd with interest rate smoothing. Christiano, Eichenbaum, and Trabandt (2014) also provide a specification for the shadow Fed funds rate in a DSGE set-up.
[27]The IRFs corresponding to the two other measures of the shadow rate are available upon request.

ing.[28] Also, Figure A9 in appendix traces the cumulative fiscal multiplier overtime, along with the dating of our (extreme) monetary policy accommodation ($F(z) > 0.8$). As in Auerbach and Gorodnichenko (2012), there is quite some variability in state-dependent fiscal multipliers overtime with, in our case, usually higher multipliers when monetary policy accommodates.

Our estimations also indicate that the federal government spending multiplier is lower at all horizons (linear model) when the sample is extended through 2012Q4. Also, although still much higher compare to the case of non-accommodative monetary policy, the fiscal multiplier in the accommodative state of monetary policy is lower on the extended sample that covers the recent ZLB episode. These findings are consistent with recent contributions in the theoretical literature on the size of the fiscal multiplier at the ZLB. In fact, while Christiano, Eichenbaum, and Rebelo (2011) find an output multiplier of 3.7 in the benchmark specification of their DSGE model, Mertens and Ravn (2014) show that the size of the fiscal multiplier when the zero lower bound binds is reduced in a liquidity trap caused by a self-fulfilling state of low confidence.

## B. What Happens at Times of Slack?

As a bridge between our analysis and former studies that examine how the fiscal multiplier varies with the state of the economy, we re-estimate Equation (1), distinguishing between periods of "slack" and periods of "non-slack". The amount of slack in the economy is captured by the unemployment rate. Following Owyang, Ramey, and Zubairy (2013), we use 6.5 percent as the threshold, which is also in line with the recent Fed's forward guidance. This value of the threshold implies that the U.S. economy spends about one-third of the time in slack. This is higher than the 20 percent time proportion that the U.S. economy spends in recession, as implied by the information from the NBER Business Cycle Dating Committee (see Auerbach and Gorodnichenko (2012)). The relatively high frequency of slack is consistent with the fact that some economic recoveries are "jobless".[29]

We generally do no find broad support to higher government spending multiplier at times of slack in the U.S. economy when the state of monetary policy is not accounted for (see Table

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[28]Interestingly, the extent of monetary policy accommodation increases when we use a former vintage (Fall 2013) of the output gap from CBO to evaluating the Taylor-rule implied rate. The identification of the state of monetary policy for the remainder of the sample period, however, is robust across vintages of the output gap data. This heterogeneity stems from the fat that, while the output gap had been underestimated across the board, the underestimation was more pronounced for the post-crisis episode for which the output potential was recently marked-down significantly.

[29]Assuming the same 20 percent share for slack as for recessions would imply a cut-off unemployment rate of 7.3 percent. Some sensitivity analyses on the value of the threshold for characterizing the slack leave our qualitative results unaltered.

**Table 3. GDP Cumulative and Peak Multipliers at Time of Slack and Non-slack (extended sample through 2012Q4)**

|  | 1 year integral | 2 years integral | 4 years integral | Ratio of peak responses |
|---|---|---|---|---|
| Linear | -0.58 | -0.29 | 1.61 | 2.79 |
| Non-slack | -1.04 | -0.46 | 1.51 | 3.63 |
| Slack | -0.15 | -0.26 | 1.83 | 2.55 |

Notes: Cumulative multipliers are computed as the ratio of the sum of responses of GDP and government spending. The peak measure is the ratio of the IRFs at their respective peaks.

3). This is consistent with recent findings by Owyang, Ramey, and Zubairy (2013), using newly constructed historical U.S. quarterly data from 1890 to 2010. Our estimations suggest, however, that federal government spending are highly effective at times of slack if monetary policy is accommodative, but are contractionary otherwise. Figure 7 clearly highlights the sharp contraction of output when monetary policy does not accommodate during slack. We also compute the response of employment and unemployment to a federal spending shock at times of slack and the non-linear effects with respect to the state of monetary policy are similar to those of output (see Figure A7 in appendix for the response of the employment).

**Figure 7. IRFs of Output at Times of Slack (extended sample, including the ZLB episode)**
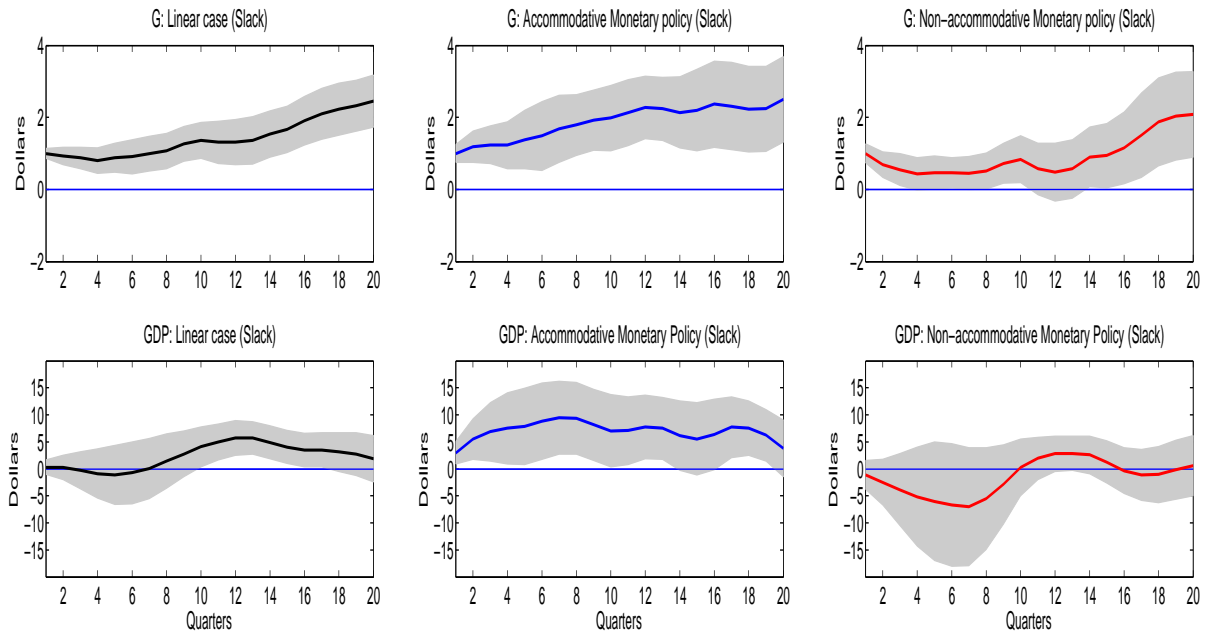


Notes: Shaded areas represent the 95 percent confidence regions around the estimates.

## V.  SENSITIVITY ANALYSIS

We investigate the robustness of our results along two dimensions: the function characterizing the transition from the accommodative to the non-accommodative state of monetary policy and the measure of inflation used in estimating the Taylor rule. The first sensitivity analysis is important because it captures how far apart the two states are, while the second is relevant for determining the real interest rate, one of our transmission channels.

### A.  Model Parametrization: Smoothing Parameter

The smoothing parameter $\gamma$ (see Equation (3)) dictates the speed at which monetary policy moves from the accommodative to the non-accommodative state as $z$ increases (e.g., moving from the negative to the positive territory) is relevant for our empirical analysis. That speed is decreasing in $\gamma$, given that $F$ is an increasing function of $\gamma$. Table A2 in appendix displays output multipliers across different values of $\gamma$, with government spending shocks identified by forecast errors of federal spending. Our results are robust to the frequency of monetary accommodation. Regardless the value of $\gamma$, GDP multipliers remain positive and larger under accommodative monetary policy while fiscal stimulus are at times recessionary when monetary policy is not accommodative. Note that, when $\gamma$ increases, the difference in the size of the multipliers between the accommodative and the non accommodative state diminishes. Indeed, higher values of $\gamma$ are associated with small deviations of the interest rate from the target, inducing less expansionary fiscal stimuli.

### B.  Measure of Inflation Used in the Estimation of the Taylor Rule

The measure of the inflation target used in the empirical analysis is potentially relevant. We estimate different specifications of the Taylor rule using respectively our benchmark measure of inflation (the one-quarter ahead forecast of inflation from the SPF), the quarterly CPI inflation, the quarterly Personal Consumption Expenditures (PCE) inflation, the year-on-year CPI inflation, and the year-on-year lead CPI inflation. The latter is used as inflation forecast. Our results (displayed in Table A1 in appendix) remain robust across different measures of inflation. Whatever the specification, output multipliers are larger under accommodative than non-accommodative monetary policy.

## VI. CONCLUSION, POLICY IMPLICATIONS, AND POSSIBLE EXTENSIONS

This paper examines how the stance of monetary policy affects the aggregate and sectoral response of output to government spending shocks. We apply the local projections method to quarterly U.S. data and provide estimates of the government spending multiplier over the monetary policy cycle. Government spending shocks are identified as forecast errors of the growth rate of federal government spending from the Survey of Professional Forecasters and the Greenbook, further stripped from their predictable components. The state of monetary policy is inferred from deviations of the Fed funds rate from the target rate, using a smooth transition distribution, calibrated to reflect the average frequency of monetary policy accommodation in Fed's history.

We find that the federal government spending multiplier is substantially higher under accommodative than under non-accommodative monetary policy. Moreover, by examining the response of various components of output, including disaggregated consumption expenditure, we are able to reconcile, within a unified framework, apparently contradictory findings in the existing literature: federal government spending may crowd-in or crowd-out private consumption, depending on the extent of monetary policy accommodation. Controlling for predictable components of government spending increases the estimated effectiveness of fiscal policy under accommodative monetary policy. The paper documents two channels through which monetary policy accommodation increases the effectiveness of fiscal policy: the real interest rate channel and the funding channel for federal government spending.

Our findings have important policy implications. They broadly suggest that fiscal policy is more effective when needed the most (e.g., at times of slack), if supported by monetary policy. Our results also have implications for the normalization of monetary conditions in advanced economies: the exit from UMP would lead to much lower federal government spending multipliers than otherwise, even if some amount of slack was to remain in the economy. This further highlights the need for a careful calibration of the timing of exit from unconventional monetary policy.

Our analysis can be extended along several dimensions. First, a more ambitious avenue to identifying the response of the monetary authority to macroeconomic developments, including fiscal policy, could be the narrative approach based on historical record. This would consist in exploiting information contained in the minutes of the meetings of the FOMC at the U.S. Federal Reserve, available electronically on a quarterly basis since 1936. Monetary policy could be deemed non-accommodative if the need to counter-act the effects of government actions was explicitly mentioned in the minutes of the FOMC meeting that took place around the time when the fiscal measure was legislated or in anticipation to its adoption. Another natural extension would be to apply the framework developed in this paper to examine the effects of tax policy changes. The (traditional) associated challenge would be the identification

of exogenous variations in tax policy, given their distorsionary impact (e.g., on labor supply). Last, but not least, extending our empirical framework to other OECD countries, and to Euro area countries in particular (given their common central bank) would provide supplementary evidence on how fiscal and monetary policy interact.

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**APPENDIX**

**Tables**

**Table A1. GDP Cumulative and Peak Multipliers with Alternative Measures of Inflation in the Taylor Rule**

|  | Measure of inflation | 1 year integral | 2 years integral | 4 years integral | Ratio of peak responses |
|---|---|---|---|---|---|
| Non accommodative | SPF forecast Infl. | -1.55 | -1.97 | -0.22 | 2.76 |
| Accommodative |  | 2.50 | 3.96 | 4.48 | 5.51 |
| Non accommodative | Quarterly CPI Infl. | -1.28 | -1.73 | 0.72 | 2.88 |
| Accommodative |  | 2.47 | 3.90 | 4.15 | 5.25 |
| Non accommodative | Quarterly PCE Infl. | -2.19 | -2.93 | -0.39 | 2.20 |
| Accommodative |  | 2.78 | 4.09 | 4.22 | 5.21 |
| Non accommodative | Year/year CPI infl. | -1.21 | -1.62 | 0.54 | 3.47 |
| Accommodative |  | 2.49 | 4.02 | 4.53 | 5.33 |
| Non accommodative | Year/year lead CPI Infl. | -1.35 | -2.10 | -0.54 | 2.33 |
| Accommodative |  | 2.73 | 4.36 | 4.60 | 5.87 |

Notes: This table provides GDP multipliers from a surprise federal spending shock across alternative measures of inflation in the Taylor-rule. The benchmark corresponds to one-quarter ahead inflation forecast from SPF.

**Table A2. GDP Cumulative and Peak Multipliers with Different Values of the Smoothing Parameter, $\gamma$**

|  | $\gamma$ | 1 year integral | 2 years integral | 4 years integral | Ratio of peak responses |
|---|---|---|---|---|---|
| Non accommodative | 2.5 | -2.78 | -4.95 | -4.39 | 2.07 |
| Accommodative |  | 3.00 | 4.60 | 4.75 | 5.55 |
| Non accommodative | 3.5 | -2.12 | -3.24 | -1.77 | 2.42 |
| Accommodative |  | 2.77 | 4.29 | 4.62 | 5.52 |
| Non accommodative | 5 | -1.55 | -1.97 | -0.22 | 2.76 |
| Accommodative |  | 2.50 | 3.96 | 4.48 | 5.51 |
| Non accommodative | 6.5 | -1.21 | -1.28 | 0.52 | 2.97 |
| Accommodative |  | 2.32 | 3.74 | 4.39 | 5.51 |
| Non accommodative | 7.5 | -1.06 | -0.99 | 0.82 | 3.07 |
| Accommodative |  | 2.24 | 3.64 | 4.35 | 5.52 |
| Non accommodative | 10 | -0.82 | -0.53 | 1.27 | 3.22 |
| Accommodative |  | 2.10 | 3.47 | 4.28 | 5.53 |

Notes: This table provides GDP multipliers from a surprise federal spending shock across different values of the smoothing parameter $\gamma$. Note that the lower $\gamma$ is the more far apart are the two states of monetary policy. $\gamma = 5$ corresponds to the benchmark case where monetary policy remains accommodative for about $30$ of the time in our sample period.

**Table A3. Cumulative and Peak Sectoral Multipliers (surprise federal government spending)**

|  | 1-year integral | 2-year integral | 4-year integral | Ratio of peak responses |
|---|---|---|---|---|
| **Total Consumption** | | | | |
| Linear | 0.09 | 0.93 | 2.53 | 2.98 |
| Non accommodative | -0.64 | -0.82 | -0.01 | 1.63 |
| Accommodative | 1.09 | 2.27 | 3.29 | 3.87 |
| | | | | |
| **Cons. of durables** | | | | |
| Linear | 0.10 | 0.32 | 0.71 | 0.85 |
| Non accommodative | -0.16 | -0.21 | -0.04 | 0.49 |
| Accommodative | 0.43 | 0.76 | 0.85 | 0.99 |
| | | | | |
| **Cons. of non durables & serv.** | | | | |
| Linear | -0.11 | 0.22 | 1.27 | 1.71 |
| Non accommodative | -0.57 | -0.60 | -0.00 | 0.79 |
| Accommodative | 0.47 | 0.91 | 1.69 | 2.43 |
| | | | | |
| **Private fixed investment** | | | | |
| Linear | -0.26 | -0.42 | 0.96 | 0.65 |
| Non accommodative | 0.11 | -0.86 | -1.11 | 2.30 |
| Accommodative | -0.17 | 0.02 | 0.22 | 0.91 |

Cumulative multipliers are computed as the ratio of the sum of responses of GDP and government spending. The peak measure is the ratio of the IRFs at their respective peaks.

# Figures

**Figure A1. Federal Spending-to-GDP Ratio (in percent) Over the Sample Period**
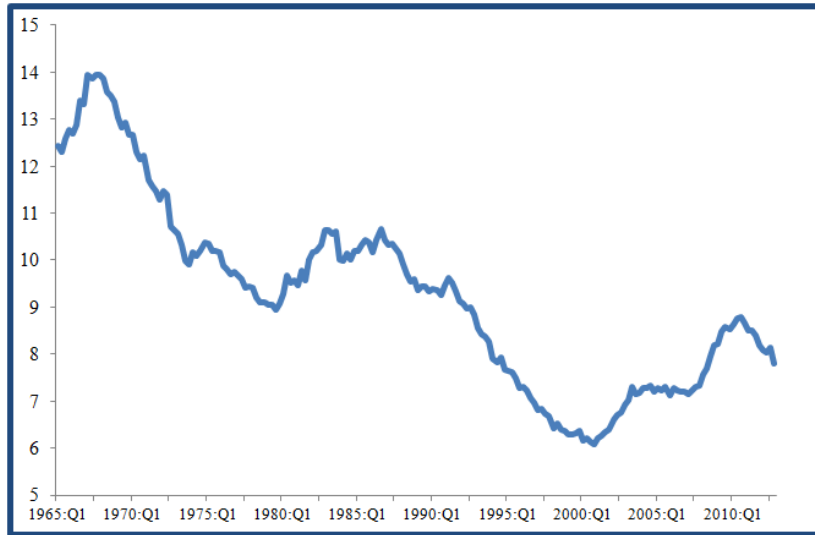


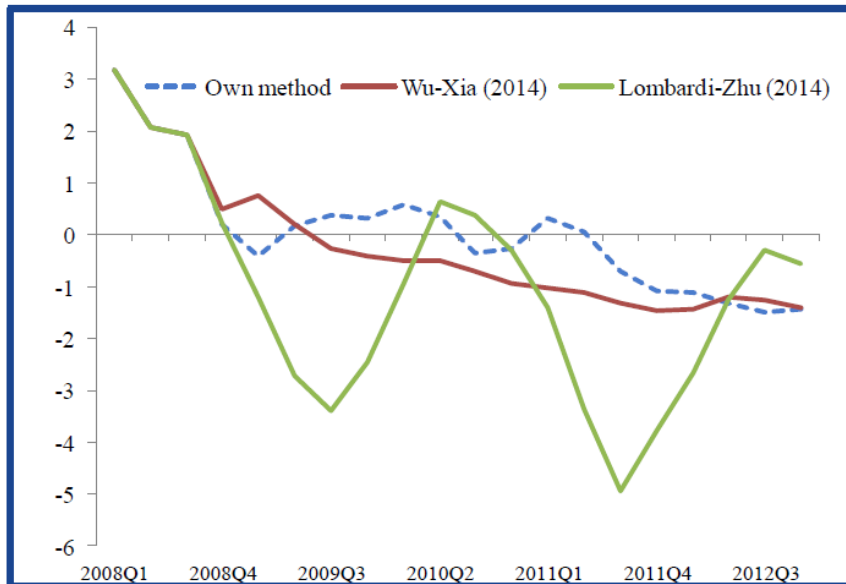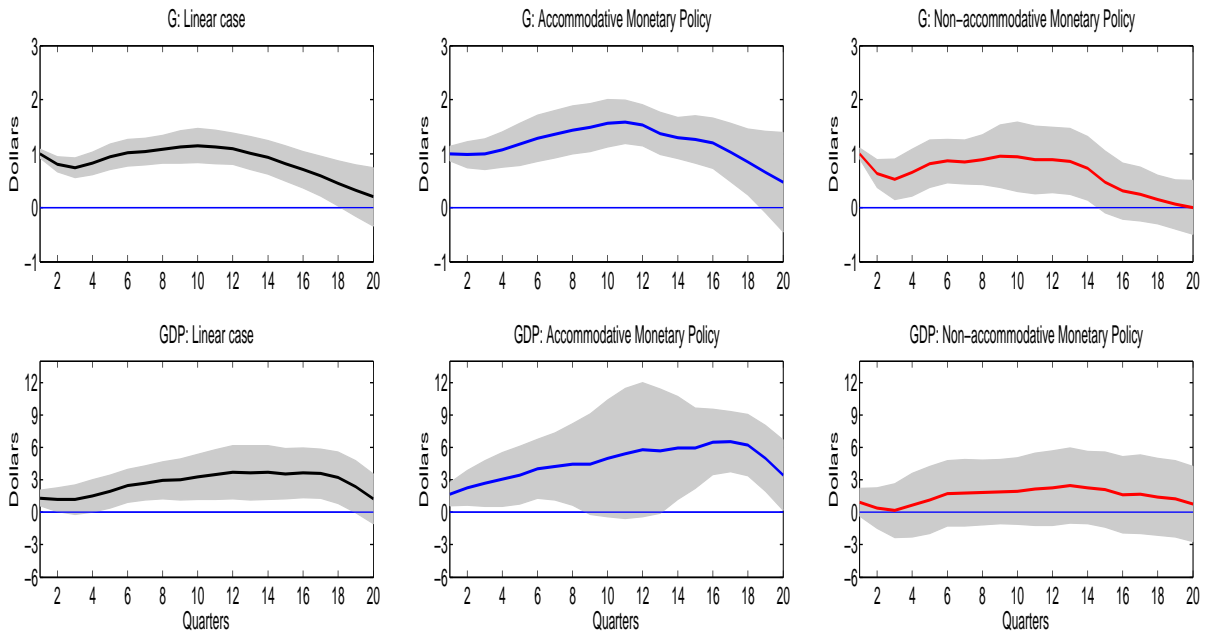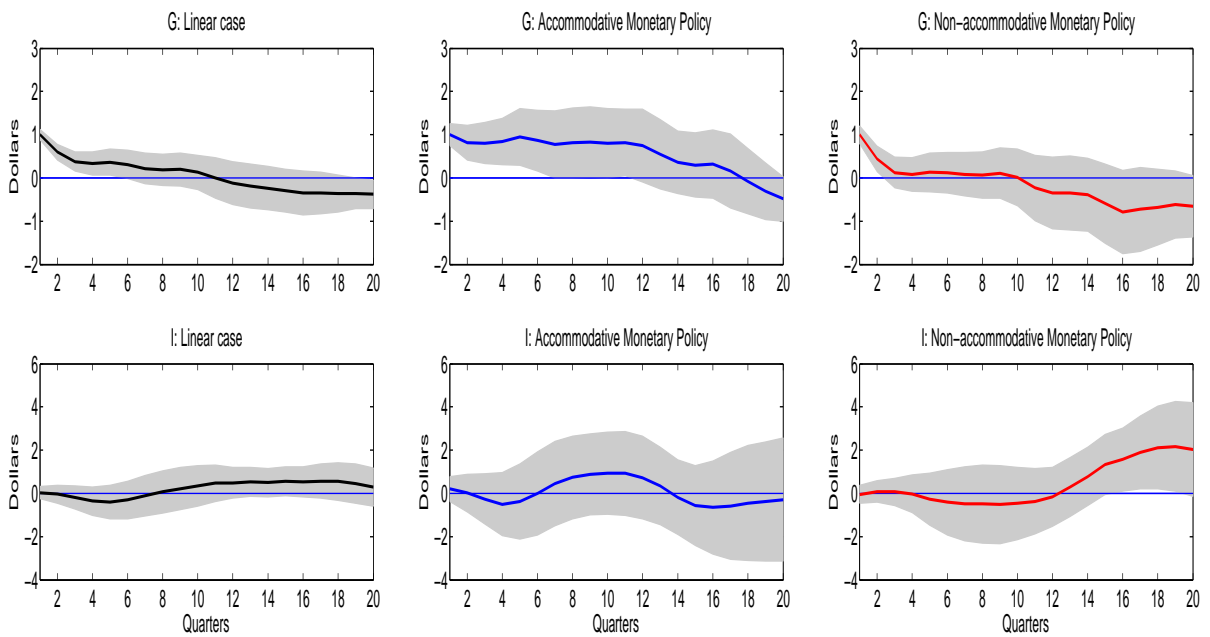**Figure A2. Shadow Fed Funds Rate Near the ZLB (2008Q1–2012Q4)**

**Figure A3. IRFs of Federal Government Spending and Output to Federal Government Spending Shocks Using the Cholesky Decomposition**



Notes: Shaded areas represent the 95 percent confidence bands around the estimates.

**Figure A4. IRFs of Private Investment (SPF/Greenbook)**



Notes: Shaded areas represent the 95 percent confidence bands around estimates.

**Figure A5. IRFs of Federal Debt (SPF/Greenbook)**
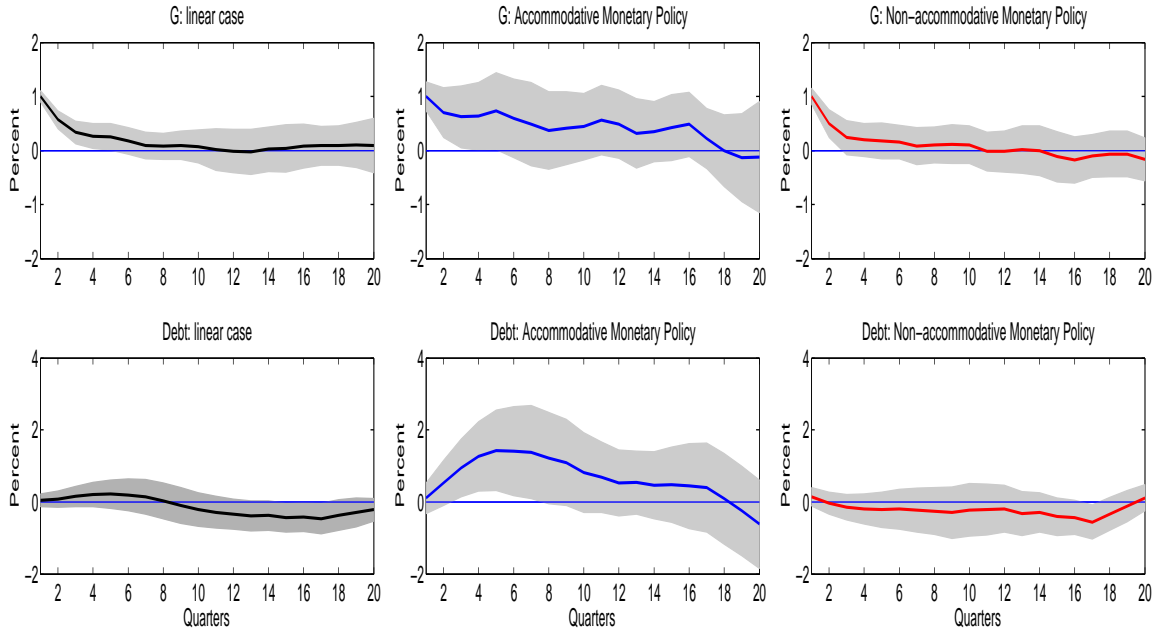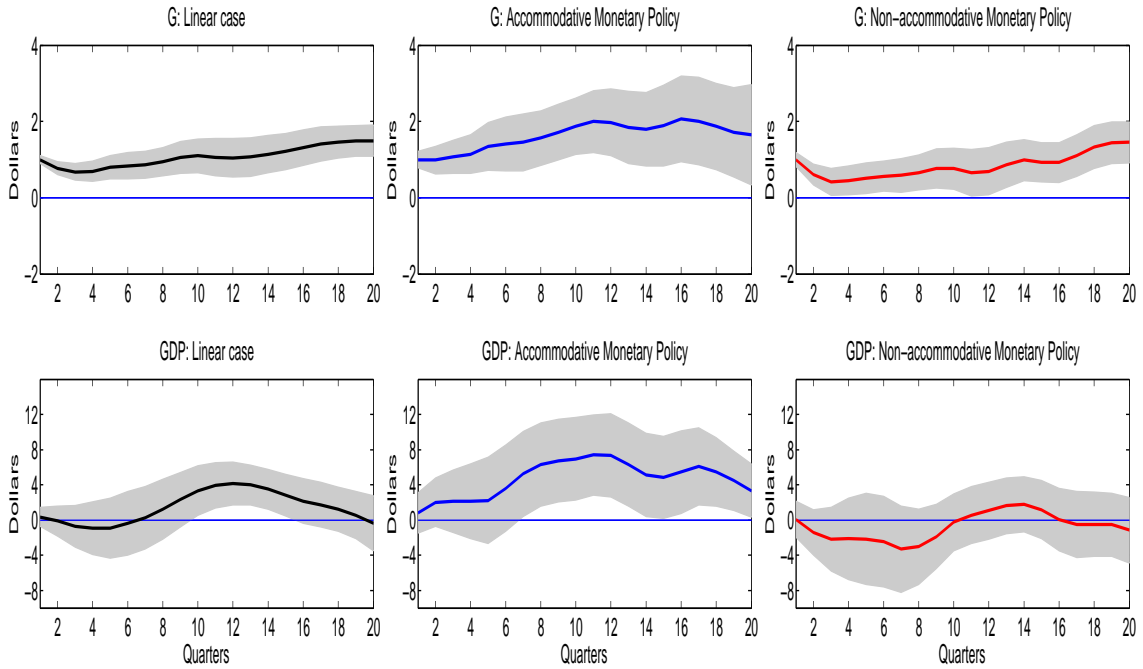


**Figure A6. IRFs of Output (SPF/Greenbook): Extended Sample Through 2012Q4**

**Figure A7. IRFs of Employment at Times of Slack (SPF/Greenbook): Extended Sample, Including the ZLB Episode**
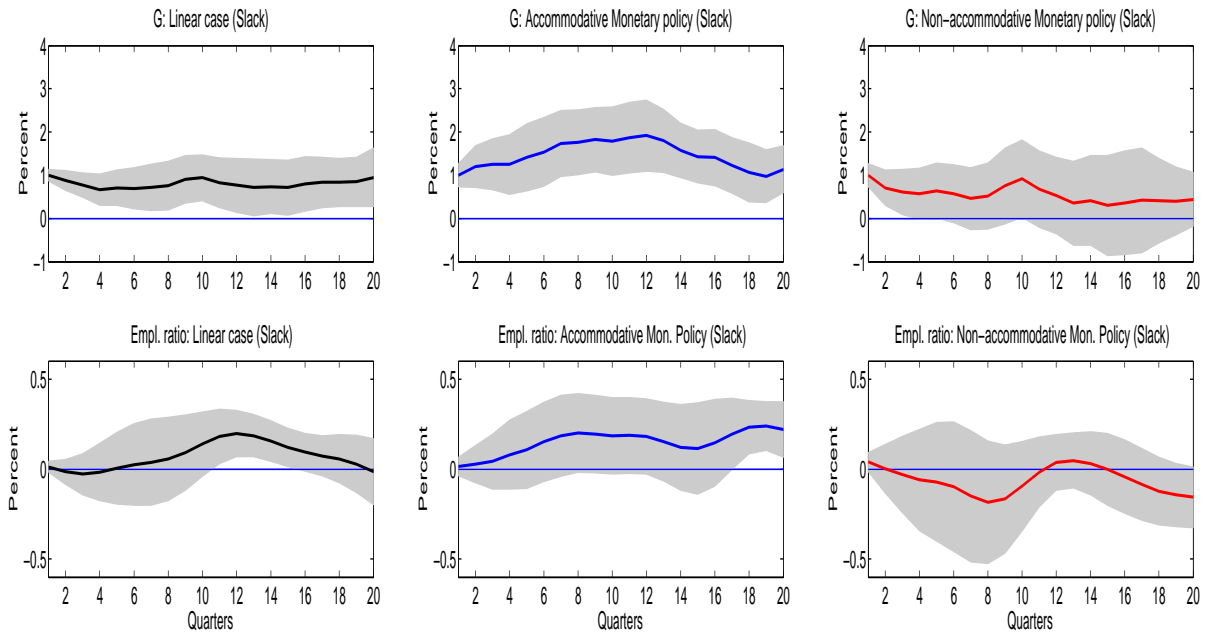
**Figure A8. The Fed Funds Rate, the Shadow Fed Funds Rate, and the Likelihood of Being in the Accommodative State (extended sample, including the recent ZLB episode)**
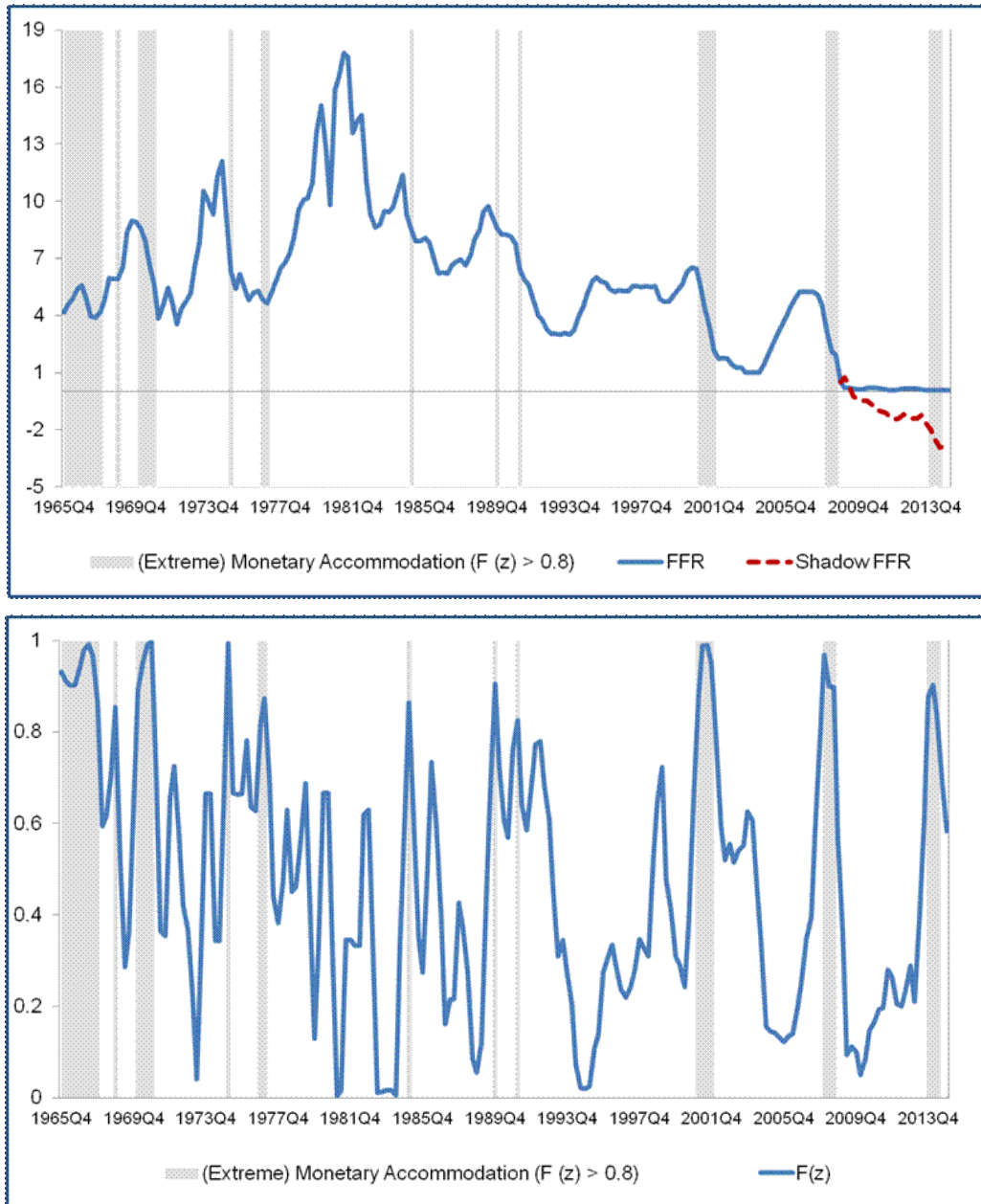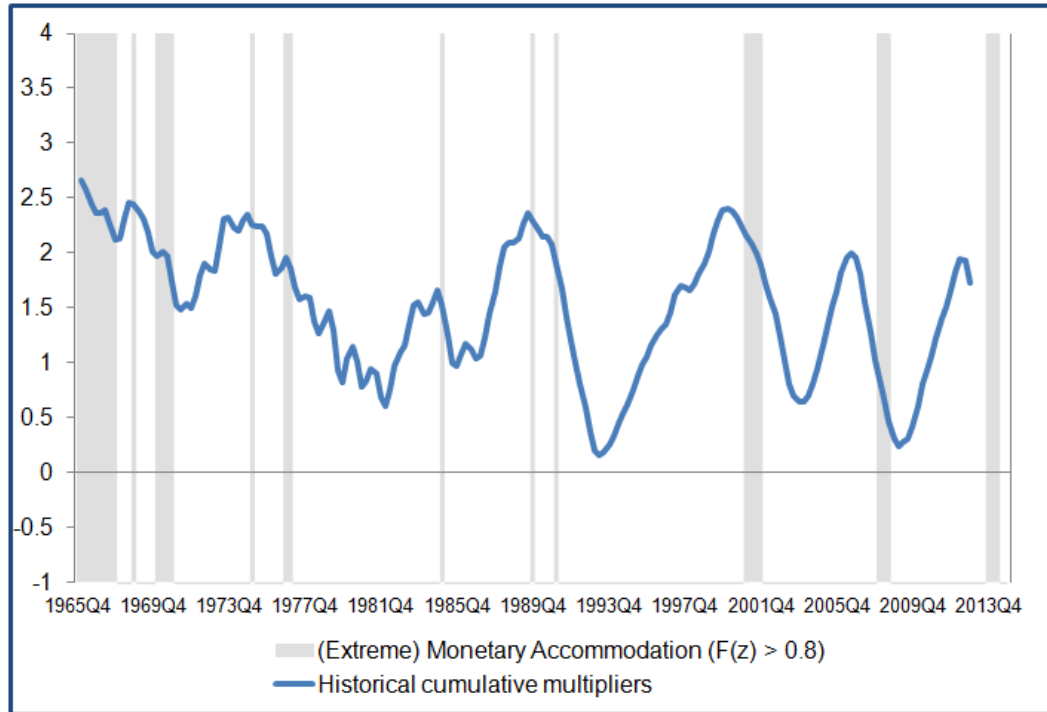
**Figure A9. Historical Cumulative Fiscal Multipliers Over the Sample Period**



Notes: The multiplier in each quarter is cumulative over 16 quarters ahead (4-year integral).