Abstract

We study the drivers of increasing consumption after a government spending expansion—the “crowding-in puzzle”—using structural VARs and local-projections. While the marginal effect of the disposable-income-channel is small, there is evidence of a significant direct impact of public on private spending, consistent with useful-public-expenditures frameworks. Most importantly, monetary policy softens significantly and robustly conditional on a fiscal stimulus. This dis-inflation driven, systematic policy easing accounts for one-half of the consumption increase. As a further novel finding, we show the interest-rate-reaction to display pronounced state-dependencies. For initially low—but positive—rates, namely, monetary policy tightens paralleled by decreasing consumption.

Keywords: structural VAR, government spending shocks, impulse response decompositions, local-projections, state-dependencies.

1 Introduction

How and through which transmission channels are public expenditures propagated into private consumption spending in quarterly US data? With private consumption absorbing the largest fraction of aggregate demand, answering this question is key to understanding the macroeconomic repercussions of fiscal spending programs of any kind and, therefore, key to inform economic policy. In addition, revealing the underlying mechanisms of the impact of public on private spending helps to quantify the response of GDP, i.e., the size of the government spending multiplier, which has received renewed attention in the recent macroeconomic literature.

In Table 1, we analyze exogenous government spending innovations and calculate consumption multipliers for the sample 1954Q1 to 2007Q4.¹

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<td>[0.21 0.41]</td>
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<td>3 years</td>
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<td>0.72</td>
<td>0.71</td>
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<td></td>
<td>[0.41 0.94]</td>
<td>[0.47 0.95]</td>
<td>[0.45 0.99]</td>
<td>[0.43 1.00]</td>
<td>[0.45 0.97]</td>
<td>[0.51 1.41]</td>
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Notes: Consumption multipliers, $\partial c_{t+h}/\partial g_t$, defined as in Galí et al. (2007), for $h = 1, 4,$ and $12$ quarters. We furthermore find throughout positive coefficients when alternatively defining multipliers as $\partial c_{t+h}/\partial g_{t+h}$ or as cumulative $\sum_{h=0}^{H} \partial c_{t+h}/\sum_{h=0}^{H} \partial g_{t+h}$. We obtain the results from estimating their model—augmented by real interest rates, defined as in Gilchrist and Zakrajsek (2012)—over 1954Q1 to 2007Q4 using different identifications. To calculate consumption multipliers, we re-scale the IRFs by the sample average of the private-consumption-to-public-spending ratio to put them into dollar terms. The 95% confidence intervals in brackets are based on the recursive design wild-bootstrap procedure of Goncalves and Kilian (2004) for the VARs; and based on the procedure of Newey-West for the local-projections model.

We consider the variables-setting proposed in Galí et al. (2007), augmented by real interest rates: (1) with spending shocks alternatively VAR identified as in Blanchard and Perotti (2002); (2) recursively recovered by disturbing public expenditures excluding military spending; identified in the fiscal-foresight specification of, e.g., Bachmann and Sims (2012) by controlling for either (3) the narrative defense spending news of Ramey (2011); (4) the continuous defense news shock series proposed in Ben Zeev and Pappa (2017); (5) the accumulated excess-returns of US military contractors as in Fisher and Peters (2010); and (6) by relying on the Jordà (2005) local-projections framework and identifying spending shocks, again, recursively.

¹As in Galí et al. (2007), we focus on postwar US data and thus mainly on civilian government spending shocks. This focus is consistent with, e.g., Perotti (2014) and Nakamura and Steinsson (2014) who make the case that samples covering the Korean war or WWII may be subject to identification problems, due to confounding variations in price/product controls, rationing, patriotism, and new Fed regulations at the time (see recently Leeper et al., 2017, for a postwar data sample).
significant endogenous *increase of private consumption expenditures* appears to be a salient feature in postwar US data (Table 1).\(^2\)

The crowding-in of private consumption observed for public spending shocks in the data, however, is at odds with canonical RBC and New Keynesian models. In workhorse versions of these models, public spending induces negative wealth effects for households due to the anticipation of higher (lump-sum) taxes, leading households to substitute away from consumption to labour supply. These “throw-in-the-ocean” public expenditures do neither (directly) enter production nor utility (see also Baxter and King, 1993). Notably, in the New Keynesian framework, consumption is further depressed by a “leaning-against-the-wind” motive of a counter-cyclical monetary reaction function in the style of Taylor (1993), typically observed for, e.g., the Volcker-Greenspan episodes (Nakamura and Steinsson, 2014).

As a consequence and initiated by the contribution of Galí et al. (2007), a theoretical literature emerged studying possible modifications and additional transmission channels in rather standard DSGE models to account for the “conflicting”, empirically observed crowding-in effects.\(^3\) Many of these frameworks are capable of generating a co-movement between private consumption and government expenditures, conditional on a government spending surprise. Yet, while each of these theoretical contributions offers “one solution to a fiscal policy puzzle” (Bilbiie, 2011), some of the modelling devices may empirically be more promising than others, which leaves the question of the underlying sources of the crowding-in in the data unanswered.

In this regard, this paper attempts to make further headway by dissecting drivers of consumption crowding-in within a unified empirical framework, linking the discussed empirical and theoretical strands of literature and putting different transmission mechanisms to a test. While we find little support for the disposable-income-channel stressed in Galí et al. (2007), we document a significant direct effect of government spending impacting on private consumption in line with Leeper et al.\(^2\)

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\(^2\)See also the empirical literature surveyed in Lewis and Winkler (2017) clearly favoring consumption crowding-in relative to crowding-out, conditional on government spending shocks. Furthermore, Mountford and Uhlig (2009) document consumption crowding-in for an identification via sign-restrictions; and Ravn et al. (2012) find a co-movement of private and public spending after a fiscal stimulus by analyzing data from four industrialized countries. In addition, among more recent contributions that study news shocks on military spending, Fisher and Peters (2010), Forni and Gambetti (2016), and Ben Zeev and Pappa (2017) also document consumption crowding-in effects, whereas Ramey (2011) reports contractionary effects for (non-)durable consumption purchases.

\(^3\)See, inter alia, Christiano et al. (2011) and Woodford (2011) for a model with restricted monetary policy reaction (interest rate channel) in a zero-lower-bound environment, Galí et al. (2007) for an approach strengthening the disposable income channel by featuring “rule-of-thumb” consumers, Sims and Wolff (2017) and Lewis and Winkler (2017) for a useful public goods utility/production function, Ravn et al. (2012) for a deep-habit mechanism, and Ramey (2011) for a different approach of non-separable preferences over consumption and leisure.
Moreover, we link the empirical crowding-in effects to a systematic *easing of short-term (real) interest rates*. We show the latter to be a robust significant feature for government spending innovations—at the post-shock horizon of one year—in US data (Table 2). Further elaborating on this finding, this is the first empirical study featuring a systematic analysis of the observed reinforcing monetary policy stance following a fiscal stimulus. We thereby show the endogenous monetary policy response to explain 50 percent of the crowding-in on average. In addition, we characterize the softening of monetary policy as being responsive to dis-inflationary dynamics (Ravn et al., 2012) triggered by an endogenous improvement in total factor productivity (e.g., Cozzi and Impullitti, 2010; Bachmann and Sims, 2012; Sims and Wolff, 2017). Ultimately, we provide evidence that the monetary policy response displays pronounced state-dependencies, since for initially low—yet larger than zero—rates, we report a tightening of interest rates paralleled by consumption crowding-out.

**Table 2: Interest rate multipliers**

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</tr>
<tr>
<td>1 year</td>
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<td>-0.25</td>
<td>-0.33</td>
<td>-0.33</td>
<td>-0.38</td>
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</tr>
<tr>
<td>3 years</td>
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<td>0.12</td>
<td>0.04</td>
<td>0.05</td>
<td>0.04</td>
<td>0.07</td>
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<td>[-0.17 0.27]</td>
<td>[-0.16 0.24]</td>
<td>[-0.12 0.27]</td>
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*Notes:* Interest rate multipliers, \( \partial r_{t+h}/\partial g_t \), defined as in Galí et al. (2007), for \( h = 1, 4, \) and 12 quarters. For further notes see Table 1.

We proceed as follows. In a VAR framework following Galí et al. (2007), with the structural form recursively recovered as in Blanchard and Perotti (2002), we identify fiscal spending shocks and document significant crowding-in of private consumption spending. Then we, first, perform impulse response decompositions, as proposed in Kilian and Lewis (2011), to reveal what consumers are actually responding to in the VAR model. As the government spending shock causes the variables in the system to deviate from their conditional steady states, the impulse response decomposition reveals, to what extent the fluctuations in these variables *directly* contribute to the consumption response. In applying the IRF decomposition, we find that the short-run consumption response after a fiscal policy innovation can largely be characterized by the *direct impact of government spending*, while—to some extent—short-run consumption dynamics are also driven by triggered GDP gains. At longer horizons, consumers primarily respond to lags of the increasing consumption aggregate in the VAR itself, i.e., consumers essentially smooth-out the consumption surge, consistent with a habit formation or “keeping up with the Joneses” motive (Abel, 1990; Fuhrer, 2000; Krueger and Perri, 2005).
Second, we quantify the *marginal impact* of different endogenous transmission mechanisms in the propagation of government spending shocks into consumption. That is, we neutralize—one at a time—the income, sovereign deficit, and interest rate channels with counteracting exogenous surprises in disposable income, the fiscal deficit, and interest rates. For this statistical decomposition exercise, we calculate the respective surprises such as to zero-out the endogenous VAR responses under consideration, as in, e.g., Bernanke et al. (1997) or more recently in Bachmann and Sims (2012), Campbell et al. (2012), Bassetto et al. (2016), and Giannoni et al. (2016). We find little empirical support for the disposable income channel stressed in Galí et al. (2007) as the marginal effect of impacting disposable income in the propagation of the fiscal stimulus into consumption is virtually zero. When considering a fiscal spending shock with the public deficit path forced to zero, we still do not observe consumption crowding out. In this scenario, though, disposable income drops and the consumption response is muted by roughly one-third, yet still positive.

Most importantly, we show the *easing* of short-term (real) interest rates that we document following the government spending shock, in line with, e.g., Ramey (2011) and Perotti (2014), to add roughly one-half to the overall consumption increase. Specifically, we characterize this monetary policy response as being reflective of the *dis-inflationary dynamics* that the fiscal stimulus triggers and as being in line with the Taylor principle. Via Taylor rule estimations in the spirit of Orphanides (2003) and Coibion and Gorodnichenko (2011, 2012), we furthermore rule out a putative direct reaction of the Fed to the fiscal policy shock. The interest rate response hence mainly follows an inflation stabilization motive.

Consistent with empirical evidence in Bachmann and Sims (2012) or the productive public capital model in Sims and Wolff (2017), we document the observed dis-inflation fluctuations themselves to be consistent with increases of utilization-adjusted total factor productivity, which we measure along the lines of Fernald (2012). Given its marginal effect, the interest rate channel, i.e., the systematic monetary policy response, appears to be of first-order importance in the transmission of the public spending shock into consumption. In an environment, in which the Fed may tighten the policy instrument and by doing so may not accommodate the fiscal stimulus, crowding-out thus becomes more likely, in line with Ricardian consumers theory (see Christiano et al., 2011; Woodford, 2011). However, this is not what we find in the data on average.

4In the open-economy, deep-habit framework of Ravn et al. (2012), a government spending expansion provides incentives for domestic firms in the home market to sell at compressed mark-ups, thus causing *dis-inflationary pressure*, as well. Yet, this model only predicts consumption crowding-in in the absence of sticky prices (Jacob, 2015).
Overall, our findings suggest crowding-in to remain present when (i) analysing a shock without the support of increasing disposable income, (ii) considering a fully tax-financed spending shock, or (iii) shutting-down the empirically observed easing of policy rates. This evidence—along with the direct impact of public on private spending revealed by IRF decompositions—is in line with models predicting consumption crowding-in after a fiscal stimulus by featuring useful fiscal spending that directly enters households’ utility and serves as a complement to private consumption (Leeper et al., 2017). An additional channel through which public spending can positively affect private spending in such frameworks is productive public capital in the private sector’s production function (see Baxter and King, 1993) enhancing overall productivity (Sims and Wolff, 2017; Lewis and Winkler, 2017).

Against the backdrop of the pronounced interest rate sensitivity of private consumption that we document by a significant interaction of a systematic monetary policy accommodation with expansionary government expenditure shocks, we further test the hypothesis of crowding-in versus crowding-out effects being conditional on the overall level of monetary policy rates. Different levels of the policy instrument therefore may be associated with different systematic reactions of monetary policy rates, thus shaping the fiscal policy transmission differently. For instance, it is conceivable that monetary policy indeed eases in the face of a spending shock—just as in the state-independent model—when the initial level of the policy instrument is very restrictive, but does not behave in the same way, when the level of the latter is already particularly accommodative—yet larger than zero—potentially not leaving room for further easing. Testing state dependencies of the propagation of fiscal policy by conditioning on different levels of monetary policy rates during normal times, ultimately puts the study of Ramey and Zubairy (forthcoming) into perspective, which contrasts episodes of positive rates with near-zero interest rate regimes.

To explore this hypothesis of a state-dependent monetary policy reaction function being conditional on the prevailing level of interest rates, we re-estimate our empirical model by relying on the local-projections method developed in Jordà (2005). In particular, as in Born et al. (2015) and Bernardini and Peersman (2017), we recover structural government spending shocks in this framework in accordance to our recursive ordering assumption following Blanchard and Perotti (2002) in the benchmark

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Tenreyro and Thwaites (2016) report substantial interactions between fiscal and monetary policy by conditioning on economic expansions and contractions. In their empirical model, endogenous fiscal policy accommodations counteract restrictive, exogenous monetary policy innovations in recessions; the latter result does not hold, however, in business cycle booms, in which the fiscal policy stance becomes contractionary—thus reinforcing the initial monetary policy tightening. We contribute to this research by studying fiscal and monetary policy inter-dependencies conditional on a fiscal rather than a monetary policy shock.
model. The local-projections model allows to feature putative state-dependencies of the shock pass-through to the broader economy, while being less vulnerable to model mis-specifications relative to a non-linear VAR counterpart. Following Tenreyro and Thwaites (2016), we combine the local-projections approach of Jordà (2005) with the Granger and Teräsvirta (1993) smooth-transition regression framework to condition the macroeconomic consequences of fiscal expansions on the stance of monetary policy. We measure the latter as particularly high versus low levels of the nominal Federal funds rate; we further reveal that the growth rate of the policy instrument or levels of real interest rates do not signal different policy states as clearly.

In a regime of prevailing high levels of the Federal funds rate, the systematic component of policy rates eases significantly in a hump-shaped fashion for one year and more than doubles the output-effect of the spending innovation relative to a state-independent, linear model. More importantly, we find significant crowding-in of both, aggregate consumption expenditures and business investment. By contrast, we document pronounced crowding-out effects for investment and even for consumption, but in the latter case less significantly so, in an environment of low policy rates. We rationalise this finding by the systematic monetary policy reaction, which is characterised by a tightening for three quarters in this state of the economy, paralleled by inflationary dynamics; whereas in the high Federal funds rate regime, we report dis-inflationary effects. As a consequence of an endogenous interest rate tightening in the low Federal funds rate state, the output multiplier is considerably lower. In addition, the response of hours worked is counter-cyclical as opposed to pro-cyclical as in the high interest rate or linear regimes.

The remainder of the paper is as follows. Section 2 describes the data, the empirical set-up, and the identification strategy, while Section 3 presents the core findings derived from the linear VAR. Section 4 discusses the empirical evidence, whereas Section 5 adds a systematic analysis of the monetary policy reaction. Section 6 extends the results to a model specification that is non-linear in the level of interest rates. Section 7 explores disaggregated data and an additional state indicator before reviewing the results along several robustness dimensions. Section 8 concludes.

Clearly, state-dependencies associated with low levels of the policy rate may have different implications, when the latter hits the zero-lower-bound, eventually signalling a tight rather than accommodative monetary policy stance (Christiano et al., 2011; Woodford, 2011). Furthermore, it is conceivable that our state-indicator implicitly proxies for other state variables like the business cycle. We account for both ideas, first, by extending the data sample to 2013Q4 to include the US zero-lower-bound episode and, second, by modelling a smoothly-varying business cycle indicator (Auerbach and Gorodnichenko, 2012) as an additional state. Our results for low versus high interest rate regimes merely change in these extensions, which is fully consistent with Ramey and Zubairy (forthcoming), who do not find significant evidence that government spending multipliers vary with the amount of slack in the economy or during zero-lower-bound episodes.
2 Methodology

In this Section, we describe the linear VAR that we employ to study the propagation of government spending surprises to the broader economy. We present the data and identification strategy, before introducing impulse response decompositions and a statistical procedure to calculate marginal effects of endogenous impulse responses.

2.1 Structural VAR

We formulate a structural VAR representation for the variables of interest as follows:

\[
A_0 x_t = \sum_{l=1}^{p} A_l x_{t-l} + \varepsilon_t, \quad \text{with } E\{\varepsilon_t\} = 0 \text{ and } E\{\varepsilon_t \varepsilon_t'\} = \Sigma_{\varepsilon},
\]

abstracting from the intercept for notational convenience. At lag, \(l = 1, ..., p\), the \(n \times n\) matrix \(A_l\) comprises AR-parameters, and \(A_0\) captures contemporaneous relations. \(\varepsilon_t\) represents mutually uncorrelated innovations. We recursively identify a government spending shock by a Cholesky factorization of the reduced-form variance-covariance matrix, \(\Omega\), assuming government spending to be pre-determined with respect to within-quarter macroeconomic conditions, as in Blanchard and Perotti (2002).\(^7\) The vector \(x_t\) comprises the variables of the Gali et al. (2007) VAR, in this order: government spending (consumption plus investment), \(g_t\), GDP, \(y_t\), hours worked, \(h_t\), consumption (non-durables and services), \(c_t\), non-residential investment, \(i_t\), wages, \(w_t\), the budget deficit, \(d_t\), and personal disposable income, \(y_{dis}t\).\(^8\)

We further add short-term real interest rates, \(r_t\), calculated as the Federal funds rate (FFR) relative to realised core PCE-based inflation, as in Gilchrist and Zakrajsek (2012), to test the role of endogenously reacting interest rates in the propagation of government spending shocks—the interest rate channel (Christiano et al., 2011; Woodford, 2011). We model policy rates as real (versus nominal) interest rates, since, from a theoretical perspective, the basic consumption-Euler-equation can be formulated such that consumption is exclusively determined by the expected path

\(^7\)Ramey (2011) makes the case of professional forecasts and her measure of fiscal news Granger-causing recursively identified VAR shocks, hence constituting a potential caveat for the Blanchard and Perotti (2002) innovations. Due to their predictability, the latter may not be fully unanticipated and thus not structural. However, Mertens and Ravn (2010) and Perotti (2014) show that the innovations’ predictability leaves VAR dynamics virtually unaffected, and Auerbach and Gorodnichenko (2012) provide consistent findings when controlling for fiscal forecasts. We focus on a spending rather than a news shock, but control for news as in Ramey (2011), Ben Zeev and Pappa (2017), and Fisher and Peters (2010) in additional specifications, with similar results (Table 1).

\(^8\)Following Gali et al. (2007) the budget deficit enters as a ratio to trend GDP, which we proxy by lagged potential output; all measures enter at the quarterly frequency in real terms, quantity series are normalised by the total civilian population, and interest rates and the budget deficit are in percent, while the remaining time-series are in log levels.
of real interest rates. Results are, however, robust to using the nominal FFR or long-term interest rates, e.g., 10-year Treasury yields instead.

We estimate the VAR with four lags over the sample from 1954Q1 to 2007Q4. The beginning of the sample is motivated by, inter alia, Perotti (2014) who argues that including WWII data may cause identification problems as the influence of interfering factors like price and production controls, rationing, or the draft are hard to assess. Similarly during the Korean war, results may be driven and contaminated by new Fed regulations discouraging durables purchases. The impact of the latter event is particularly hard to gauge in the news approach of Ramey (2011), in which results are mainly driven by the defence spending shocks during the wars, whereas during the sample starting in 1954Q1 civilian spending shocks prevail. We end the sample in 2007Q4 to avoid non-linearities introduced by the zero-lower-bound (see also extensions including the zero-lower-bound episode in a non-linear model in Section 7.2).

2.2 Impulse response decompositions

In a first step, we are interested in empirically characterizing what consumers are actually responding to after a fiscal spending innovation, i.e., to understand, which variable-fluctuations directly trigger crowding-in in the structural VAR. For each quarter under consideration, the deviation of the consumption response from the baseline path of zero hereby can be formulated as the sum of a response to own lags of consumption and of the reaction to (lagged) realizations of other time-series in the VAR. Thus, to isolate the contribution of variable $j$ to the consumption reaction at horizon $h$ following a time $t = 0$ government spending surprise ($\Xi_{C,j,h}$), we apply an impulse response decomposition as proposed in Kilian and Lewis (2011). To do so, it is convenient to formulate the VAR as $x_t = Bx_t + A(L)x_{t-1} + \varepsilon_t$, where $B$ is strictly lower triangular, and $L$ is the lag operator. In addition, we collect the parameters in $\Theta = [B \ A_1 \ldots A_p]$. The impulse response decomposition of consumption then reads:

$$\Xi_{C,j,h} = \min(h, p) \sum_{m=0}^{\min(h, p)} \Theta_{C,mn+j} \Phi_{j,G,h-m},$$

with subscripts $C$ and $G$ denoting the position of consumption and government spending in the VAR, respectively. $h = 0, 1, \ldots, 20$ and $j = 1, 2, \ldots, n$. $\Phi_{j,G,h-m}$ is the $\{j,G\}$-element of the impulse response matrix, $\Phi_{h-m}$, following the definition of Lütkepohl (2005).
2.3 Marginal effects of endogenous impulse responses

In a second step, we aim to statistically single out the role, i.e., to quantify the marginal effect, of different endogenous transmission mechanisms that may influence the impact of exogenous government spending shocks on consumption and thereby may help to rationalise crowding-in effects. To do so, we use an approach of statistically decomposing the repercussions of the public spending shock into those effects arising from the endogenous response of another VAR-variable and those observed after fixing this particular variable to its pre-shock level. For instance, we quantify the effect of variable $\eta$ in the transmission of the public spending shock into consumption by positing hypothetical sequences of exogenous Cholesky factor innovations in variable $\eta$. We calculate these innovations to exactly neutralise the endogenous counterpart response of $\eta$, conditional on the initial government spending surprise (see also Bernanke et al., 1997; Bachmann and Sims, 2012; Campbell et al., 2012; Bassetto et al., 2016; Giannoni et al., 2016, using this approach).

By conditioning on a given path of the government spending trajectory, the impulse response decompositions from Section 2.2 already give some first-path guidance, which variables in the system directly affect the consumption reaction following a spending surprise. However, to quantify the marginal impact of an individual variable in the transmission process—and therefore the entire spectrum of indirectly operating effects emerging from this variable—the exercise proposed in this Section cancels out the endogenous response of an individual variable entirely. The absence of such a transmission variable yet potentially changes the trajectory of government spending itself (and of all other variables in the system) and hence the shock propagation as a whole, constituting an entirely different experiment.

In a recursive setting, we compute the innovations to variable $\eta$, necessary to force the respective endogenous response entirely to zero, as follows:

$$
\varepsilon_{\eta,h} = -\sum_{j=1}^{n} \Theta_{\eta,j} y_{j,h} - \sum_{m=1}^{\min(p,h)} \sum_{j=1}^{n} \Theta_{\eta,mn+j} z_{j,h-m}.
$$

(3)

$y_{j,0}$ denotes the $t = 0$ effect of a spending shock on variable $j$, whereas the same effect sans endogenous response of $\eta$ reads: $z_{j,0} = y_{j,0} + \Phi_{j,\eta,0} \varepsilon_{\eta,0}/\sigma_{\eta}$. The standard deviation of the disturbance of variable $\eta$ is $\sigma_{\eta}$ and for horizons $h > 0$ we calculate:

$$
y_{j,h} = \sum_{m=1}^{\min(p,h)} \sum_{i=1}^{n} \Theta_{j,mn+i} z_{j,h-m} + \sum_{i<j}^{n} \Theta_{j,i} y_{i,h} \text{ and } z_{j,h} = y_{j,h} + \frac{\Phi_{j,\eta,0} \varepsilon_{\eta,h}}{\sigma_{\eta}}.
$$

(4)
3 Results

For data from 1954Q1 to 2007Q4, Figure 1 traces VAR dynamics conditional on an expansionary government spending surprise sized one standard-deviation, over time.

Figure 1: Government spending shock

![Graphs showing VAR dynamics for various variables over time.](image)

**Notes:** We plot dynamics at the quarterly frequency. Solid lines represent point estimates of impulse response functions. Dark (light) shaded areas display one (two) standard deviations confidence intervals, which we obtain from 1,000 replications of the Goncalves and Kilian (2004) recursive-design wild bootstrap procedure.

Despite the more recent sample relative to Galí et al. (2007), we find very similar dynamics for most variables. Consumption rises sluggishly for two years, before slowly abating; and the response is significantly positive for more than two years. The budget deficit increases on impact and eventually passes through its conditional mean after eight quarters, before levelling off. After an initial drop, disposable
income builds-up, but does not turn significantly positive. In this case, Gali et al. (2007) reported a more pronounced response. The newly introduced real FFR eases by more than 30 basis points in a hump-shaped fashion and is significant for three quarters, consistent with, e.g., Ramey (2011) and Perotti (2014).

Figure 2 depicts the consumption response in more detail by means of an impulse response decomposition, intending to reveal what consumers are reacting to in the VAR. The short-run consumption response can largely be attributed to directly impacting government spending, while—to some extent—short-run consumption dynamics are also driven by triggered GDP gains. In subsequent quarters, consumers primarily follow a motive of smoothing-out the initial consumption surge, by responding to lags of consumption itself. It is thus the direct pass-through of the fiscal stimulus into consumption that mainly determines the overall consumption reaction, whereas shock propagations through, e.g., disposable income or the systematic interest rate reaction do not seem to explain consumption repercussions directly.

Figure 2: Impulse response decomposition: consumption

Notes: We plot the point estimates (solid lines) along with the contribution—as calculated via impulse response decompositions—to the overall consumption reaction of variable $j$.

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9In a specification in which we identify a government spending shock as in Fisher and Peters (2010), we even find a declining income response.

10While these studies do not include a detailed discussion or analysis of the systematic monetary policy reaction, we add such an analysis to the literature and, in particular, link the monetary policy response to the crowding-in puzzle. The result of an easing FFR after an expansionary spending shock also holds when identifying the latter in each of the five specifications from Table 2. In addition, we find a monetary policy accommodation for the original Gali et al. (2007) sample.
Nevertheless, the latter statement does not preclude that other variables in the system may matter for the shock propagation. The endogenous reaction of these variables, namely, may itself systematically feed back into government spending and thus shape the trajectory of the fiscal stimulus—with the latter appearing to dominate the direct consumption repercussions conditional on the spending innovation (in the short run). In the same vein, to the extent that GDP, which also appears to shape the consumption response at short horizons, can be independently effected by other transmission variables, these variables can still be relevant facets of the transmission mechanism. As a consequence, the impulse response decomposition as in Kilian and Lewis (2011) indeed provides a notion, which variables directly cause private spending to deviate from its conditional mean in the VAR. However, by assuming a fixed path of government spending (and real GDP), this exercise does not allow to infer the full marginal effects of individual transmission variables.

Figure 3: Marginal effects: disposable income, budget deficit, and interest rates

Notes: We present responses of key variables in the benchmark 9-variables VAR (full set available upon request), for which we shut down the endogenous response of the following variables, one at a time: disposable income (dotted line), budget deficit (dashed line), and the real FFR (line with nodes). The line with circles is the unrestricted response of consumption less the cumulative marginal effects of the three tested transmission variables. For further notes, see Figure 1.
In a next step, we therefore test the role of three transmission mechanisms that are potential candidates to influence the observed crowding-in (Figure 3). First, zeroing-out the disposable income response according to Section 2.3 virtually does not affect the shock transmission; the impulse responses of this scenario (dotted line) closely track the unrestricted point estimates (solid line). Second, absent a growing fiscal deficit, i.e., given a balanced budget stimulus, disposable income drops significantly and consumption reacts muted, yet still increasing—peaking at 0.2 percent after two years (dashed line). Third, in a fixed interest rate environment (line with nodes) the consumption increase is about half as pronounced relative to an accommodative monetary policy stance. In this case, the consumption response under hypothetically fixed interest rates even deviates from the 68% confidence interval of the original impulse response function.

4 Discussion

Our VAR evidence assigns little importance to the disposable income channel in the propagation of government spending shocks into consumption. First, the increase of real disposable income documented in Galí et al. (2007) appears not to be a robust feature in more recent data or in different model specifications and, second, the marginal effect of disposable income appears to be of second order. Against this backdrop, the minor role of the disposable income channel documented in this study raises, at least, some mis-specification concerns with respect to many medium to large-scale DSGE models that aim to give the fiscal sector a meaningful role by incorporating rule-of-thumb consumers that consume their disposable income in each period in the style of Galí et al. (2007). In fact, disposable income does not appear to be a relevant transmission variable to rationalise consumption crowding-in effects.

From a theoretical perspective, the observed consumption crowding-in may also be driven by the interaction of the deficit-financed character of the spending shock with consumers that do not internalise the fiscal budget constraint to be binding. For instance, consumers may not be fully aware of the negative wealth-effect introduced by the decrease in the expected value of their income (due to future tax increases). Such consumers may display positive consumption behaviour conditional on the shock. This, in turn, would repeal the irrelevance of the financing structure of the spending expansion that prevails in a Ricardian world of non-distortionary

---

11Beyond that, the result of a negligible marginal impact of real disposable income holds for the original Galí et al. (2007) sample, in which the income rise was somewhat more pronounced.

12This modelling approach was furthermore adapted by many central banks. See, for instance, the FRB/US model of the US economy representing a source that the Federal Reserve Board staff employs to forecast and structurally analyse both monetary and fiscal policy.
taxes and complete capital markets.

And indeed, the “balanced budget” experiment rejects the hypothesis of fully Ricardian consumption behaviour regarding the finance architecture of the fiscal stimulus; it predicts crowding-in to be less pronounced than in the unrestricted case, yet still taking place. Thus, the debt-financing of spending shocks magnifies the consumption response, but is not able to explain the crowding-in dynamics, i.e., to explain the sign of the consumption response by itself.

Moreover, the real interest rate channel—along the lines of consumption-Euler dynamics (see Christiano et al., 2011; Woodford, 2011)—contributes markedly to the consumption reaction; adding roughly one-half to the total reaction. However, for crowding-out to take place according to this channel, a tightening of the expected real interest rate path would be necessary to force private and public spending to reversely react conditional on a stimulating spending innovation. Empirically though, we document the opposite, i.e., an easing of interest rates in line with Ramey (2011) and Perotti (2014), ceteris paribus, predicting crowding-in effects. Given the quantitative importance of this channel we further study, first in Section 5, what the underlying drivers of the policy easing are and, second in Section 6, whether crowding-out effects may be observable in episodes of a systematic tightening of the monetary policy stance. To do the latter, we explicitly allow the monetary policy reaction function to be state-dependent, i.e., we allow the Federal funds rate to react differently across different monetary policy regimes.

Taken together, we reveal an increase in consumption independent from the explicitly tested theories, as consumption rises persistently after the fiscal policy shock even absent the cumulative marginal effects of the three tested transmission variables (line with circles in Figure 3). This evidence is in line with theories predicting consumption crowding-in after a fiscal stimulus, by incorporating useful fiscal spending that directly enters households’ utility. This finding is further corroborated by the direct reaction of consumption to a public spending shock, which we reveal by IRF decompositions in Section 2.2. Households in such a useful public spending framework immediately receive utility from public consumption, which in addition serves as a complement to private spending. Increases in public spending thus directly induce consumption to rise. Recent contributions that argue in this direction, such as Leeper et al. (2017), Sims and Wolff (2017), and Lewis and Winkler (2017), hence, find empirical support in our analysis.
5 Why does the Fed lower interest rates?

In this Section, we zoom-in in more detail into the systematic monetary policy response conditional on an expansion of public spending. In particular, we rationalise why the Fed actually reacts to the fiscal stimulus with an accommodation.

In this regard, two explanations are conceivable. Either the Fed may respond directly to the spending expansion, or the Fed might react to the macroeconomic dynamics that the fiscal stimulus unleashes. In line with the dual mandate of the Fed, an output or inflation stabilization motive may underlie the systematic policy response in the latter case. However, with GDP increasing in the VAR, only potential dis-inflationary effects are in line with the monetary accommodation. To test this proposal, we replace the real interest rate series in the benchmark VAR with the actual policy instrument of the Fed—the short-term nominal FFR, $r_t^{nom}$. In addition, we explicitly model inflation dynamics by introducing the core PCE inflation rate (see Gilchrist and Zakrjaszek, 2012) into the VAR in Figure 4.\(^\text{13}\)

In this augmented VAR setting, the nominal FFR eases by more than 30 basis points, similarly to the real interest rate counterpart in the benchmark VAR—despite the fact that the spending shock triggers an output boom. The inflation rate is initially sticky, but then declines significantly by more than 20 basis points in the first year after the shock. The Fed reaction is thus in line with the Taylor principle and may therefore rationalise the softening of the monetary policy stance. Still, it does not appear to be intuitive, why the fiscal stimulus is dis-inflationary. One potential explanation is a *productivity increase* following the spending expansion. A rise in the level of aggregate productivity may decrease marginal cost of firms and therefore result in dis-inflationary tendencies.\(^\text{14}\) Bachmann and Sims (2012) make the case that fiscal spending, in particular a shift toward public investment, may foreshadow productivity increments far in the future and may therefore amplify the output effects of fiscal spending during recessions. Furthermore, the approaches taken in Sims and Wolff (2017) or Lewis and Winkler (2017) model public investment to enter the private sector production functions, implicitly working like a shifter in total factor productivity relative to models that abstract from this feature.

To test whether the fiscal stimulus indeed triggers productivity gains, we replace the inflation rate in the VAR by rotating in the utilization-adjusted TFP series as in Fernald (2012). This series can be interpreted as a “cleaned-up” measure of TFP,

\(^\text{13}\)Results are robust to using aggregate PCE, CPI, or GDP deflator-based inflation rates.

\(^\text{14}\)In addition, the dis-inflationary effect of government spending is consistent with, inter alia, the deep-habits in consumption model proposed in Ravn et al. (2012), in which firms sell at compressed mark-ups after a fiscal stimulus.
as it is purified from potentially contaminating cyclical factors like the intensive and extensive margins of both, capital and labour inputs. We trace out the associated impulse response of TFP as the dashed line in Figure 4. In fact, we reveal an increase in total factor productivity, which peaks after four quarters, practically mirroring the inflation response. Thus overall government spending shocks appear to trigger productivity improvements on average in the data—not exclusively in particular episodes of the business cycle (Bachmann and Sims, 2012).

Figure 4: Monetary policy reaction function in the VAR

Notes: We present responses of key variables by using our nine-variables benchmark VAR and by rotating in—one at a time—the inflation rate (dashed line and (dashed-)dotted error bands) and total factor productivity (solid line, shaded error bands). As an interest rate proxy, we use the nominal instead of the real FFR. For further notes, see Figure 1.

To sum up, the fiscal stimulus induces dis-inflationary pressure—presumably caused by productivity gains—which causes the Fed to lower rates in accordance to the Taylor principle. Yet, this evidence is not sufficient to rule out a direct response of the Fed to the fiscal shock, which may potentially also drive the policy accommodation. In general, the Fed views fiscal policy through the prism of the economic outlook. Once the fiscal authority pushes the economy away from forecasted output and inflation targets, compensating interest rate policies are generally called upon. If the fiscal policy shock—in a hypothetical scenario—did not cause output or infla-

15We further analyse TFP dynamics in disaggregated government spending data, i.e., by conditioning on government consumption versus government investment shocks in Section 7.1.
tion to move, there would be no ex ante reason for the Fed to react with the policy instrument at all. However, Bernanke (2017) and Yellen (2016) argue that albeit fiscal policy programs may impact on the Fed’s objectives, the uncertainty about the likely macroeconomic repercussions and the specific configuration of individual fiscal packages may be hard to predict; so that a natural direct monetary policy response to the spending shock may be characterised as “wait-and-see”. Yet, viewed through the lens of a structural VAR model, this kind of behaviour is mechanically identified as a “lower than usual” path of interest rates, thus representing a negative deviation from the historical policy trend and therefore equivalent to a softening interest rate reaction that directly follows a spending shock.

Although we can interpret the interest rate equations in the benchmark VAR and the specifications from Table 2—for all of which we report a significant monetary policy softening—as a reaction function of the Fed, one may argue that the estimation of a reaction function based on realised historical time series does not sufficiently reflect the forward-looking behaviour and the information set of the central bank upon setting interest rates. In particular, the VAR evidence may not be able to clearly discriminate between the output/inflation versus direct-reaction-to-the-spending-shock motive underlying the interest rate easing. Consequently, as a specific test of the hypothesis of monetary policy directly reacting to spending shocks, we further reveal the Fed’s reaction function along the lines of Taylor (1993) and explicitly allow the Fed to react to changes in government spending.

While early generation Taylor rules were estimated on contemporaneous proxies for aggregate fluctuations, recent contributions favour fundamentals reflecting the real-time central bank expectations (e.g., Orphanides, 2003; Coibion and Gorodnichenko, 2011). In line with this literature, we follow Coibion and Gorodnichenko (2012), specify a Taylor rule, and add lagged changes of government spending:

\[
\begin{align*}
\text{r}_t^{nom} = c^* &+ \psi^*_\pi \mathbb{E}_{t-\{\pi_{t+h_\pi}\}} + \psi^*_y \mathbb{E}_{t-\{\hat{y}_{t+h_y}\}} + \psi^*_{\Delta y} \mathbb{E}_{t-\{\Delta y_{t+h_{\Delta y}}\}} \\
&+ \psi^*_{\Delta g} \Delta g_{t-1} + \eta^{TR}_t.
\end{align*}
\]

The policy rate responds to the expected realizations of inflation, \(\pi_t\), the output gap, \(\hat{y}_t\), and the quarterly change of GDP in percent, \(\Delta y_t\) (see Ireland, 2004, and subsequent studies for the inclusion of the latter term). The reaction coefficients are \(\psi^*_\pi\), \(\psi^*_y\), and \(\psi^*_{\Delta y}\). Coefficient \(c^*\) is an intercept capturing time-invariant central bank objectives and \(\eta^{TR}_t\) is a residual in the Taylor rule equation. Finally, we allow the Fed to respond to lagged changes of fiscal expenditures, \(\Delta g_{t-1}\), with coefficient \(\psi^*_{\Delta g}\).

\footnote{For the specification of \(\Delta g_{t-1}\), see Coibion and Gorodnichenko (2012) who include lagged changes of respective time series, when additionally modeling financial data.}
To condition the policy instrument of the Fed on the real-time information set shortly before FOMC meetings, $\mathbb{E}_{t-}\{\cdot\}$, we follow Coibion and Gorodnichenko (2012) and use the Board of Governors’ staff forecasts released in the Greenbook, which are exogenous to the subsequent meetings’ interest setting (e.g., Coibion and Gorodnichenko, 2011, 2012), where $h_{\pi}$, $h_{\tilde{y}}$, and $h_{\Delta y}$ denote the forecast horizons.

If we estimated Equation 5 directly, we would end up with strong serial correlation in the residuals, $\eta_{t}^{TR}$, i.e., this kind of Taylor rule is not capable of capturing the gradualism of monetary policy observed in the data. For accommodating the latter, two major empirical strategies are qualified: modelling the contemporaneous interest rate as a weighted average of the desired policy rate in period $t$ and formerly realised interest rates (interest rate smoothing) or accounting for auto-correlation directly in $\eta_{t}^{TR}$ (persistent monetary policy shocks). Rudebusch (2002) proposes a nested model to account for both modelling devices.

Based on that, we specify a generalised version of Equation 5, accommodating a flexible number $(K,J)$ of AR ($\rho_{r,k}$) and MA ($\rho_{\eta,j}$) terms as follows:

$$r_{t}^{nom} = c + \psi_{\pi}\mathbb{E}_{t-}\{\pi_{t+h_{\pi}}\} + \psi_{\tilde{y}}\mathbb{E}_{t-}\{\tilde{y}_{t+h_{\tilde{y}}}\} + \psi_{\Delta y}\mathbb{E}_{t-}\{\Delta y_{t+h_{\Delta y}}\} + \psi_{\Delta g}\Delta g_{t-1} + \sum_{k=1}^{K}\rho_{r,k}r_{t-k}^{nom} + \eta_{t}^{TR},$$

where $\psi_{i} \equiv (1 - \sum_{k=1}^{K}\rho_{r,k})\psi_{i}^{*}$ denote short-run coefficients.

For our benchmark Taylor rule, we closely follow the specifications of Coibion and Gorodnichenko (2012), who provide strong evidence for the interest rate smoothing hypothesis, in particular AR(1) smoothing. We set $h_{\pi} = 1,2$, $h_{\tilde{y}} = 0$, $h_{\Delta y} = 0$, $K = 1$, and $J = 0$, and estimate the equation, while additionally including lagged changes in government spending:\footnote{17Due to the fact that the Greenbook data are only available from 1969Q1, our sample runs from 1969Q1 to 2007Q4.}

$$r_{t} = -0.67^{***} + 0.36^{***}\mathbb{E}_{t-}\{\pi_{t+1,t+2}\} + 0.12^{***}\mathbb{E}_{t-}\{\tilde{y}_{t}\} + 0.16^{***}\mathbb{E}_{t-}\{\Delta y_{t}\} - 0.05\Delta g_{t-1} + 0.89^{***}r_{t-1} + \eta_{t}^{TR},\text{ with } \hat{R}^{2} = 0.94 \text{ and s.e.e. } = 0.84. \quad (7)$$

Our quantitative estimates closely coincide with the results reported in Coibion and Gorodnichenko (2012). We reveal highly significant reaction coefficients to inflation, the output gap, the growth rate of GDP, and to lagged interest rates. The long-run inflation coefficient is furthermore in line with the Taylor principle. Above all, we find a statistically insignificant response coefficient to lagged changes in government spending. In Table 3, we scrutinise this finding for several perturbations of the Taylor rule.
Table 3: Taylor rules including measures of (news on) government spending

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<td>$\psi_{\Delta y} : \eta_{t-{\Delta y_t}}$</td>
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<td>(0.08)</td>
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<td>$\psi_{\Delta g^{FP}} : \Delta g^{FP}_{t-1}$</td>
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Notes: The Table shows ordinary least squares estimates for the interest rate rule from Equation 6. $\psi_x$ denotes the central bank reaction to inflation expectations, $\psi_y$ is the response to the expected output gap, and $\psi_{\Delta y}$ is the coefficient for expected output growth. $\rho_{r,k}$ measures the degree of AR(k) interest rate smoothing, and $\rho_{\eta,j}$ defines the order (J) of serial correlation in $\eta_{\eta_{t}}^{TR}$. $\psi_{\Delta g}$ represents the monetary policy reaction to lagged changes in government spending. In Column (1) we set $K = 1, 2$ and $J = 0$, in Column (2) we set $K = 0$ and $J = 2$, in Column (3) we set $K = 1, 2$ and $J = 1, 2$. We further set $K = 1$ and use spending data excluding military spending, $\psi_{\Delta g^{ex}}$, in Column (4), Ramey (2011) news, $\psi_{\Delta g^{R}}$, in Column (5), Fisher and Peters (2010) news, $\psi_{\Delta g^{FP}}$ in Column (6) and data starting in 1979Q3 in Column (7). We present Newey-West standard errors in parentheses. $\bar{R}^2$ is the adjusted $R^2$ and s.e.e. represents the standard error of the regressions.

*** Significant: 1 percent, ** significant: 5 percent, and * significant: 10 percent level.
We do so by (1) allowing for AR(2) interest rate smoothing, (2) for MA(2) autocorrelated shocks, (3) for an ARMA(2,2) model, (4) including government spending less the contribution of military spending, (5) including fiscal news as in Ramey (2011), (6) including fiscal news as in Fisher and Peters (2010), or (7) by starting the benchmark AR(1) model in 1979Q3, i.e., by limiting the sample to post-Volcker data (see Clarida et al., 2000; Lubik and Schorfheide, 2004; Boivin and Giannoni, 2006, for this break date).\textsuperscript{18}

All estimations reveal the same finding, i.e., insignificant slopes for the coefficients that measure a putative immediate reaction of the Fed to fiscal spending. (News on) public expenditures, therefore, do not appear to enter the Fed’s reaction function \textit{directly}. To the extent, that we document movements in the monetary policy instrument conditional on a fiscal stimulus in the VAR, these dynamics should be therefore viewed as being responsive to the macroeconomic effects the shock has triggered; in particular, as being responsive to the productivity-induced, dis-inflationary dynamics that we document for fiscal policy shocks.

6 Non-linear fiscal and monetary policy interactions

The findings so far in this paper raise several follow-up questions. For instance, is crowding-out, despite our linear empirical evidence, still a relevant feature in US business cycle dynamics? Our study, particularly stresses the relevance of the interest rate channel, i.e., the quantitative—and perhaps even qualitative—behaviour of consumption is contingent on the systematic monetary policy reaction to the spending expansion. State-dependencies of crowding-out versus crowding-in with respect to the monetary policy stance are hereby conceivable. The correct question to ask regarding crowding-out effects thus may not start with \textit{whether}, but \textit{when}.\textsuperscript{18}

Perhaps closest to this idea is the study by Born et al. (2015) for Euro area data; the authors estimate a non-linear specification and interact public spending shocks with fiscal stress, measured by the sovereign bond premium. They report cuts in public consumption having larger output effects, when occurring in a state of a high sovereign bond premium. In this scenario, the bond premium systematically tightens and amplifies the shock’s impact on output. Related, Bernardini and Peersman (2017) document state-dependencies of the output reaction following a spending surprise by conditioning on private debt overhang. Auerbach and Gorodnichenko (2012) and Ramey (2011) interact public spending innovations with the state of the

\textsuperscript{18}Our results are furthermore fully consistent when estimating a MA(1) or ARMA(1,1) model, when including higher-order lags of the fiscal measures, when using government consumption or investment, and when starting the sample in 1984Q1, motivated by the Great Moderation episode.
business cycle, and Ramey and Zubairy (forthcoming) contrast zero-lower-bound with positive interest rate regimes. To the best of our knowledge, this is the first empirical study to analyse fiscal policy shocks in different regimes of the monetary policy instrument during normal times, i.e., during episodes of positive interest rates.

6.1 Local-projections framework and identification

In the following, we employ an empirical approach allowing us to test the hypothesis of a state-dependent monetary policy reaction function. To condition the dynamic effects of exogenous government spending innovations on the level of the monetary policy stance, we apply non-linear local-projections as in Jordà (2005) and allow switches between regimes to smoothly evolve following Granger and Teräsvirta (1993). We use a local-projections framework as it easily accommodates non-linearities, while being less vulnerable to model mis-specifications relative to a state-dependent VAR model. When we re-estimate the linear VAR model from Section 2.1 with local-projections, results are very similar. Consequentially, our statistical inference, at least in the linear case, is not sensitive to the choice of the time-series approach. The variables entering the local-projections are identical to the variables setting of the benchmark VAR from Section 2.1. In terms of model specifications, we closely follow Tenreyro and Thwaites (2016).

Specifically, we estimate the following regression for variable, $x_{t+s}$, measured for horizons $s \in \{0, S\}$ as a system of seemingly-unrelated-regression equations as follows:

$$x_{t+s} = (\alpha_s^h + \beta_s^h \varepsilon_t + \gamma_s(L_s) y_{t-1})\Lambda(z_t) + (\alpha_s^l + \beta_s^l \varepsilon_t + \gamma_s(L_s) y_{t-1})[1 - \Lambda(z_t)] + \delta_1 t + \delta_2 t^2 + u_{t+s}. \tag{8}$$

$\alpha_s^i$ are intercepts for the regimes $i \in \{h, l\}$, where $h$ characterises a high and $l$ a low level of the monetary policy instrument, which we measure as the quarterly average of the nominal Federal funds rate, $r_t^{nom}$, in percent. $\gamma_s^i$ and $\beta_s^i$ denote the slopes of a set of control variables at time $t - 1$, $y_{t-1}$, and a fiscal expenditure shock, $\varepsilon_t$, on $x_{t+s}$, i.e., the collection of the $\beta_s^i$ slopes for the sequence $s = 0, ..., S$ directly denotes state-dependent impulse response functions for horizons $t + s$ given a fiscal innovation at time $t$. $L$ is the lag operator and $\delta_1$ and $\delta_2$ represent the slopes of a linear and quadratic time trend, respectively (Bernardini and Peersman, 2017; 19

Indeed, a linear local-projections model closely tracks the state-independent VAR dynamics reported in Section 3, with local-projections impulses mostly remaining within the 68% confidence interval of the VAR.
Ramey and Zubairy, forthcoming).

We calculate the weights assigned to each regime by \( \Lambda(\cdot) \), which generates a smoothly shifting state indicator that alternates between 0 and 1 according to the state variable, \( z_t \), as follows:

\[
\Lambda(z_t) = \exp \left( \frac{\theta(z_t - \nu)}{\sigma_z} \right) \left[ 1 + \exp \left( \frac{\theta(z_t - \nu)}{\sigma_z} \right) \right]^{-1},
\]

where \( \sigma_z \) measures the standard deviation of the state variable \( z_t \). We define the latter as a lagged seven-quarter moving average (see, e.g., Auerbach and Gorodnichenko, 2012; Tenreyro and Thwaites, 2016) of the nominal Federal funds rate. The parameter \( \nu \) controls the share of quarters that are characterised by state \( i \in \{h, l\} \), and \( \theta \) is a scaling coefficient determining the propensity for shifts in the state of the economy, with \( \theta \to \infty \) forcing \( \Lambda(\cdot) \) toward a binary indicator. To draw inference, we take serial correlation within and across equations caused by sequential leads of \( x_{t+s} \) into account. We thus analytically adjust standard errors by, first, recovering the slopes in Equation 8, and, second, computing the average over moment conditions for lead \( s \) when computing Newey-West corrected variances.

In terms of the identification, the local-projections framework from Equation 8 closely relates to the VAR from Equation 1. In fact, it can be considered equivalent (see also Bernardini and Peersman, 2017; Born et al., 2015): The identification assumption following the seminal contribution of Blanchard and Perotti (2002), which we implemented in the VAR via a recursive Cholesky scheme, implies government spending to be pre-determined with respect to fluctuations in the broader economy. Thus, the working hypothesis is that government purchases—after agreed upon and implemented—need more than one quarter to effectively react to, among others, the state of the business cycle. This backward looking behaviour of policy makers can be expressed by a fiscal policy rule of the form:

\[
g_t = \kappa(L) y_{t-1} + \varepsilon_t,
\]

where \( y_{t-1} \) is the set of lagged controls from Equation 8. \( g_t \) measures public expenditures, and the government spending shock, \( \varepsilon_t \), is a generally unobservable variable. To incorporate the Blanchard and Perotti (2002) identification, we rearrange Equation 8 and substitute \( \varepsilon_t \) from Equation 10, leaving us with the following expression:

\[
x_{t+s} = (\alpha^h_s + \beta^h_s g_t + \tilde{\gamma}(L)^h_s y_{t-1}) \Lambda(z_t) + (\alpha^l_s + \beta^l_s g_t + \tilde{\gamma}(L)^l_s y_{t-1}) [1 - \Lambda(z_t)] + \delta_1 t + \delta_2 t^2 + u_{t+s},
\]

where we define \( \tilde{\gamma}(L)^h_s \equiv \gamma(L)^h_s - \beta^h_s \kappa(L) \) and \( \tilde{\gamma}(L)^l_s \equiv \gamma(L)^l_s - \beta^l_s \kappa(L) \). Given the fact
that the control variables, $y_{t-1}$, include the lagged variables of the fiscal spending rule from Equation 10, the Blanchard and Perotti (2002) identification scheme can be recovered by instrumenting the unobserved shock, $\varepsilon_t$, with the fiscal expenditure aggregate, $g_t$ in a final step.

6.2 Local-projections evidence

Figure 5 plots the nominal Federal funds rate, $r_{t}^{\text{nom}}$ (bold dashed line), along with the state indicator function (bold solid line), across time. We define the state variable as $z_t = \frac{1}{7}(r_{t}^{\text{nom}} - 6 + \ldots + r_{t}^{\text{nom}})$, set $\theta = 3$ as in Tenreyro and Thwaites (2016), and calibrate the parameter scaling the relative shares of regimes, $\nu$, such that 50 percent of our sample quarters are in a high and low interest rate environment, respectively. For robustness exercises regarding these specification choices, see Section 7.3.

Figure 5: Federal funds rate and state indicator function(s)

Notes: We plot dynamics at the quarterly frequency. Thick dashed lines represent the Federal Funds rate (left axis in percent), solid lines denote the state indicator function (right axis in probabilities), $\Lambda(z_t)$, for $\theta = 3$ (e.g., Tenreyro and Thwaites, 2016), and thin dashed lines represent the counterpart state indicator function for $\theta = 100$, i.e., for the case, in which we push the indicator toward a binary variable.

The state indicator function qualitatively closely tracks the Federal funds rate and does not switch in a binary fashion from 0 to 1. Consequently, many quarters in the sample contain information on both regimes, increasing the precision of the estimates (see Bernardini and Peersman, 2017). In addition, we calculate $\Lambda(z_t)$ by setting $\theta = 100$ (thin dashed line), giving rise to an almost binary regime indicator. We distribute the respective results of this specification to the robustness Section 7.3, where findings are fully consistent with the benchmark counterpart.
Figure 6 delineates the adjustment patterns after a—for comparability across regimes—normalised 1 percent government spending innovation for a low (line with nodes) and a high (dashed line) initial level of the Federal funds rate. In response to Ramey (2012), who makes the case that impulse response functions derived from local-projections are less reliable over medium to longer horizons, we restrict the presentation to 12 quarters in contrast to the 20 quarters depicted in the case of the VAR.

In a high FFR regime, GDP slowly builds up in a hump-shaped fashion in the second year after the shock; consumption resembles the output response qualitatively, but less so in terms of amplitude by peaking at roughly 0.4 percent, which is approximately half as pronounced as the GDP response. Notably, in this state of the economy, the fiscal expansion furthermore crowds-in private investment activity, which we cannot observe in the linear VAR model. Given the well-documented strong interest rate sensitivity of private investment, this response can be rationalised with the real FFR dynamics that we report. As in the linear case, short-term rates ease significantly in the first year after the shock, but substantially more in terms of magnitude. The response peaks at roughly -0.7 percent, which is more than twice as marked as in the linear model.

For the low FFR regime, we find notable differences. After a muted rise in the first year, GDP turns negative and significantly so in the second year after the shock; hours worked also decline, contrary to a rise in the counterpart state. Real wage dynamics are insignificant over the entire forecast horizon—indeed from the state of the monetary policy instrument. Most importantly, we report significant crowding-out for both, consumption and investment, when the spending impact on both aggregates primarily unfolds within the second year after the fiscal policy surprise.20 Conversely to the pronounced easing of policy rates in the high FFR regime, a hump-shaped and highly significant rise of real interest rates in the first three quarters in the low FFR regime may rationalise the crowding-out evidence, in line with Ricardian consumers theory (Christiano et al., 2011; Woodford, 2011).21

From a fiscal policy maker’s perspective, this evidence suggests fiscal packages, which are flexible in the time horizon of their implementation, not to pass through, when the monetary policy stance is particularly accommodative. Although tempting

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20 Consumption displays a short-lived uptick on impact, which is significant for one quarter. This is in line with the direct impact of government spending on consumption that primarily operates on impact (see the according results for the IRF decomposition from Section 2.2).

21 In a further specification, we add the rate of price inflation to the VAR. Inflation significantly declines in the high FFR regime, whereas we document significant increases for the low FFR state—consistent with the conditional real interest rate dynamics we uncover. Results are available upon request.
to do so in times of low rates—as longer-term refinancing cost for the government are most likely also low—a tightening of interest rate kicking-in may counteract or even reverse intended business cycle effects of fiscal spending in such a scenario.

Figure 6: Government spending shock: high versus low Federal funds rate

Notes: We plot dynamics at the quarterly frequency. Lines with crosses represent point estimates of impulse response functions in a low FFR regime. Dark (light) shaded areas display the respective one (two) standard deviations Newey-West confidence intervals, which we obtain from 1,000 replications. The dashed lines represent point estimates in a high FFR regime, and solid (dotted) lines denote the respective confidence intervals.
7 Disaggregated evidence and extensions

In this Section, we discuss possible extensions of our benchmark model for disaggregated data or additional state variables and, moreover, we provide a battery of robustness checks along several dimensions of the empirical model set-up.

7.1 Disaggregated data of government spending

Before discussing a number of robustness exercises, we aim to answer the question whether the effect of a fiscal stimulus on consumption and (real) interest rates varies with the type of public spending under consideration, that is, whether the macroeconomic repercussions are different for public investment versus public consumption innovations (see also Bachmann and Sims, 2012). This distinction is, inter alia, motivated by the theoretical literature on useful public spending in dynamic models that incorporates government consumption in the utility function of households, as in Leeper et al. (2017), and includes government investment to the private sector’s production function, as in Sims and Wolff (2017). To check the sensitivity of our findings regarding the definition of the public spending variable, we rely on disaggregated data from the BEA and re-run the VAR model from Equation 1, by replacing $g_t$, first, with public consumption expenditures and, second, with the public investment counterpart.

In depicting our results, we overlay the VAR responses (solid lines) with the linear local-projections responses (dashed lines) for a government consumption shock in Figure 7, and for a government investment shock in Figure 8, leading to similar results across the econometric model specifications for the respective shock.

Despite differences in the quantitative propagation of the shocks and in terms of significance for selected quarters, the qualitative adjustment patterns for both shocks are furthermore consistent across the disaggregated model specifications. Above all, adjustment patterns are in line with the benchmark case, in which we use the aggregate government spending measure to recover structural spending innovations.

Inspecting the impulse response dynamics in more detail reveals that the output effects of a government investment shock compared to the government consumption shock are stronger, statistically significant for more quarters, and of higher persistence, in line with the argument in Bachmann and Sims (2012). The same is true for the response of private consumption. Interestingly, this is the case despite the fact, that the government consumption shock is paralleled by more accommodative dynamics in the three transmission variables tested in Section 3. More specifically, we report significant deficit-financing and a significant monetary policy easing along
with a build-up in disposable income for a consumption spending shock. For the investment spending shock this is not the case; the deficit and real interest rate responses are insignificant and real disposable income declines. Still, the government investment shock displays stronger macroeconomic effects with respect to GDP and consumption.

Figure 7: Government consumption shock

Notes: We plot dynamics at the quarterly frequency. Solid lines represent point estimates of impulse response functions. Dashed lines represent point estimates from a local-projections model. Dark (light) shaded areas display one (two) standard deviations confidence intervals, which we obtain from 1,000 replications of the Goncalves and Kilian (2004) recursive-design wild bootstrap procedure.

This finding, again, supports the notion of public spending—in particular, shifts toward public investment—raising aggregate productivity in the economy and hereby
amplifying the repercussions of the initial shock and ultimately the consumption response. Furthermore, the hypothesis of endogenously triggered productivity improvements, most notably for the public investment shock, can be indirectly inferred by inspecting the impulse responses of hours worked. In our disaggregated framework, hours worked are significantly increasing in the case of the public consumption shock, but remain insignificant and rather flat for the public investment shock.

Figure 8: Government investment shock

Notes: We plot dynamics at the quarterly frequency. Solid lines represent point estimates of impulse response functions. Dashed lines represent point estimates from a local-projections model. Dark (light) shaded areas display one (two) standard deviations confidence intervals, which we obtain from 1,000 replications of the Goncalves and Kilian (2004) recursive-design wild bootstrap procedure.
In this context, Galí (1999, 2004) makes the case of positive, exogenous shocks in total factor productivity decreasing hours worked. To the extent that endogenous productivity increments can be viewed analogously to exogenous TFP shocks, these studies lend support to our interpretation of public investment shocks being particularly productivity enhancing. And indeed, when we add utilization-adjusted TFP as measured by Fernald (2012) to the VAR, we report a persistent increase in TFP for the government investment, and a short-lived and smaller increase in TFP for the government consumption shock. Against the backdrop of the more pronounced private consumption response in the former case, this evidence again supports the modelling devices of, e.g., Sims and Wolff (2017) or Lewis and Winkler (2017) as relevant features to induce consumption crowding-in.

7.2 Additional state-indicator and zero-lower-bound

In this Subsection, we formulate a more general version of our state-dependent local-projections model from Equation 8 allowing us to control for an additional regime indicator as, for instance, in Bernardini and Peersman (2017). Specifically, we want to test whether our regime indicator of high versus low policy rates implicitly proxies for other state variables, in particular the business cycle. In this scenario, the regime differences we reveal might be spuriously driven by a potentially co-moving state variable. As an additional state, we therefore control for a smoothly-varying indicator of business cycle fluctuations according to Auerbach and Gorodnichenko (2012) or Tenreyro and Thwaites (2016). Additionally, we extend our data sample to 2013Q4 to include the zero lower bound episode in the US into it. Clearly, state-dependencies associated with low levels of policy rates may have different implications, when the latter is stuck at its lower bound, eventually signalling a tight rather than an accommodative monetary policy stance (see Christiano et al., 2011; Woodford, 2011).

Via the extended sample, along with a proxy for the stance of the US business cycle, we therefore explicitly model the impact of the Great Recession in our framework.

For these model extensions—the longer sample including the zero-lower-bound, the additional state variable, or both extensions combined—our non-linear local-projection results for low and high FFR regimes are qualitatively fully consistent with the benchmark model. For the majority of impulse response horizons, the point estimates remain within the credible set of the benchmark time-varying model that are illustrated in Figure 6. For those quarters and variables showing impulse

\textsuperscript{22}Yet, Ramey and Zubairy (forthcoming) do not find significant empirical support for such non-linearities induced by the zero-lower-bound.
responses of high versus low FFR regimes that deviate from the confidence intervals of the benchmark case when additionally controlling for the business cycle and/or the zero-lower-bound, differences between the two interest rate regimes are even more pronounced relative to Figure 6.

7.3 Robustness

Finally, we perform a series of disturbances to the specification of our benchmark model to check how our results change given selected modifications.

First, we account for the following changes in the VAR model. We re-run the VAR using $p = 2, 3, 5,$ and $6$ lags, while the benchmark lag length is at 4. We further replace the consumption and investment aggregates that we applied in accordance with Galí et al. (2007) by the BEA aggregates that explicitly include durable consumption and investment items. Moreover, we use the nominal instead of the real Federal funds rate as the policy instrument and re-estimate the linear benchmark model by local-projections.

We perform all these changes to the VAR model one at a time.

Second, we analyse results for the following modifications in our non-linear local-projections model. We change the regime switching intensity parameter $\theta$ to $1, 2, 4, 10,$ and $100,$ and use a $3, 5, 9,$ and $11$ quarter moving-average of the nominal Federal Funds rate to create $z_t.$ In addition, we vary the proportion of quarters defined as high FFR regimes to $30, 40, 60$ and $70$ percent and change the model specifications one at a time as well, analogously to the VAR model robustness checks described above.

All of these changes to the benchmark model(s) do not change the qualitative results; and even quantitatively, the variations are minor, supporting the substantive robustness of our findings. To save space, we do not report these estimation results here, but provide them upon request.

8 Conclusion

Using structural VARs and local-projection models, we disentangle the drivers of the co-movement of consumption and public spending following a government spending surprise, the so-called “crowding-in puzzle”. Our empirical evidence assigns a minor role to the disposable-income-channel outlined in Galí et al. (2007). In addition, we show that crowding-in also takes place in a balanced budget scenario—with the fiscal deficit forced to zero—and in an environment of a fixed monetary policy response. In the data, a systematic easing of policy rates supports consumption crowding-in
by adding roughly one-half to the total consumption increase conditional on the fiscal stimulus. We furthermore report that government spending directly influences consumption in the short run, both in a statistically significant and economically meaningful way. Overall, our evidence aligns with theoretical contributions incorporating useful public spending to enter households’ utility. Ultimately, we also find crowding-in to be particularly pronounced in episodes of prevailing high policy rates, whereas in a regime of expansionary interest rates, crowding-out—for private consumption and investment expenditures—becomes more likely due to a systematic tightening of the monetary policy stance.

References


