Government Consumption and Investment Multipliers at the Zero Lower Bound: International Evidence using Local Projections[1]

Master Thesis in Policy Economics

Student: Ivan Ordoñez Martinez[2]

Thesis Supervisor: Lorenzo Pozzi[3]

Second Assessor: Anna Baiardi[4]

Final version: July 25, 2023

Abstract

This study estimates government consumption and government investment multipliers during normal times and at the zero lower bound (ZLB) by using a local projections methodology for a panel of 13 OECD countries. I find that the government consumption multiplier is higher —and larger than one— when the ZLB is binding, whereas the same does not apply to the government investment multiplier. A series of robustness exercises confirm these patterns. Further, I only find evidence consistent with the New Keynesian real interest rate channel hypothesis for government consumption, and not for government investment. Overall, these results suggest that, while fiscal policy acquires a more important role in stimulating the economy when the ZLB is binding, the fiscal effort may be even more effective if it concentrates on government consumption purchases instead of government investment programmes.

Keywords: Government spending multiplier, Zero lower bound, Government consumption, Government investment, Local projections

---

[1] I would like to thank Lorenzo Pozzi for supervising, guiding, and providing insightful feedback and suggestions on early drafts of my thesis. All errors are my own.

[2] Erasmus School of Economics; student number: 658273; ivanord182000@gmail.com.

[3] Erasmus School of Economics.

[4] Erasmus School of Economics.

Contents

List of Tables

List of Figures

1. Introduction

During the Great Recession, central banks of most developed countries were forced to reduce and keep nominal interest rates close to the zero lower bound (ZLB). In such juncture, the conventional monetary policy tools of these countries were no longer useful to provide stimulus to the real economy. As monetary policy increasingly ran out of steam due to the ZLB, several policymakers and academics stressed the importance of giving fiscal policy a more important role in stabilising the economy. But, in practice, how effective is fiscal policy —in particular, government spending— in stimulating the real economy when nominal interest rates have reached the ZLB? This is the question that was brought to the spotlight of policy debates back then.

On a theoretical level, standard New Keynesian (NK) models generally predict a rise in output following a government spending shock. However, the literature does not settle a consensus on the size of the government spending multiplier —defined as the percentage increase in output in response to a rise in government spending equivalent to a 1 percent of GDP— and how it may be affected by the ZLB. Furthermore, while most of the theoretical literature concentrates the analysis on total government spending, some studies such as Boehm (2020) emphasise the importance of separately considering government consumption and government investment to properly explore the size of government spending multipliers across different states of the economy. On the empirical domain, an increasing number of studies focus on analysing how government spending multipliers differ during ZLB periods with respect to normal times. The empirical findings are generally consistent with the idea of higher government spending multipliers when the ZLB is binding. Nevertheless, only a few empirical studies perform this analysis while separately accounting for government consumption and government investment, as Boehm (2020) claims.

This thesis contributes to the literature by providing new empirical evidence on the size of government spending multipliers at the ZLB when accounting for the following important aspects. First, given the importance of distinguishing between the components of the government spending shock, I separately estimate output multipliers for government consumption and government investment. Second, for the purpose of documenting the macroeconomic transmission mechanism underlying my findings, I also estimate the multipliers for inflation, real interest rates, private consumption, and private investment — all stemming from government consumption and investment shocks. Third, in order to identify exogenous government spending shocks, I follow a similar strategy as the one proposed by Blanchard and Perotti (2002). Fourth, in contrast with the bulk of empirical studies on government spending multipliers at the ZLB, which typically rely on a VAR approach, I perform my analysis by applying a state-of-the-art local projections methodology that allows me to directly estimate cumulative multipliers without depending on strong assumptions regarding variable dynamics.

I apply this local projections methodology to a panel of 13 advanced countries, covering a period that goes from 1990Q1 to 2022Q3. The reason I choose to work with quarterly data is twofold. On the one hand, it allows me to have more observations on ZLB episodes. On the other hand, the identifying assumption requires that fiscal policy does not respond to changes in economic conditions within the same period, and this is more likely to be true when using quarterly data. Additionally, since ZLB episodes are scarce, I consider periods of low nominal interest rates as a proxy for the ZLB. More specifically, I identify ZLB episodes when nominal policy interest rates are below 1%.

In the case of government consumption, I find an output multiplier of around 0.5 percent on impact during normal times. When the ZLB is binding, the output multiplier is significantly higher and reaches a value of 1.13 percent on impact, which is consistent with standard NK theoretical predictions. Moreover, I find that a government consumption shock increases real interest rates in normal times, though it significantly reduces them at the ZLB. This finding is in line with the NK hypothesis of the real interest rate channel of government spending. In the case of government investment, I find more dubious evidence on the NK predictions. During normal times I find an output multiplier of about 0.3 percent on impact, whereas it is barely distinguishable from zero during ZLB episodes. Further, I do not find any consistent evidence supporting the NK real interest rate channel hypothesis after a government investment shock. I conduct a series of robustness exercises that use different baseline specifications and definitions of ZLB episodes, and control for potential anticipation effects, the state of the business cycle and the exchange rate regime. I find that my main results remain roughly unchanged. Therefore, my findings suggest that when monetary policy is constrained by the ZLB, fiscal policy becomes vitally important to stimulate the economy. Most importantly, I show how the immediate impact of fiscal policy may be even more effective if the effort concentrates on government consumption purchases instead of government investment programmes.

The rest of the paper follows the next structure. Section 2 provides an overview of existing theoretical and empirical literature. Section 3 presents my definition of ZLB episodes and describes the empirical methodology used to perform the analysis. Section 4 explains and summarises the data used in this study. Section 5 presents the multiplier estimates and explores the robustness of my results. Lastly, Section 6 concludes.

2. Literature review

My work is related to a big body of literature on fiscal multipliers at the ZLB. This strand of the literature is generally classified into two broad groups, depending on whether the computation of fiscal multipliers is based on a theoretical or an empirical model. The following subsections survey the main contributions made by these two broad groups.

2.1. Theoretical mechanisms and predictions

Theoretical literature on government spending multipliers at the ZLB has generally relied on a New Keynesian (NK) framework, providing a wide range of predictions for the size of such multipliers. Like in many other economic theories, the most important element of each prediction are the assumptions governing the way in which economic agents behave.

2.1.1. Standard New Keynesian predictions

The main feature of the standard NK models generally used in the literature is the assumption of nominal rigidities and monopolistic competition (Hebous, 2011). In NK models, government spending multipliers at the ZLB range from negative to large positive values. Most of the contributions using a standard NK framework suggest that fiscal policy becomes considerably more effective when the economy is stuck at the ZLB. For instance, Christiano et al. (2011) show that the government spending multiplier is larger than one when the ZLB binds and becomes higher the longer the ZLB episode is. The underlying rationale is that an increase in government spending raises aggregate demand and inflation expectations. Under normal circumstances, the central bank reacts by following a Taylor rule, so it increases nominal interest rates by more than the rise in expected inflation (Taylor, 1993). This will be reflected in an increase of real interest rates which will "crowd out" private consumption and private investment. This crowding out effect implies that the final increase in output is lower than the initial increase in government spending, i.e., government spending multiplier is lower than unity. However, at the ZLB the central bank does not change nominal interest rates because they are temporarily fixed.[5]

[5] This relies on the assumption that under normal circumstances the central bank sets nominal interest rates according to a Taylor rule (Taylor, 1993), which implies that nominal interest rates rise in response to a government spending increase that exerts upward pressure on output and prices. However, when the ZLB is binding, nominal interest rates are stuck at zero and do not respond to a rise in government spending. This is because, at the ZLB, it is appropriate for monetary policy to be accommodative and keep nominal interest rates low during the period of fiscal expansion, even though inflation expectations begin to rise. By not acting to counteract the expansionary effects of fiscal policy, the central bank allows the fiscal stimulus to have substantially larger effects on the economy than if it acted according to its typical Taylor-type reaction function (Coenen et al., 2012).

Given the rise in inflation expectations, this leads to a decline in real interest rates which stimulates private consumption and investment. This “crowding in” effect may allow the government spending multiplier to exceed unity —meaning that per each dollar of increased government spending, aggregate output rises by more than one dollar. Similar predictions are held by Eggertson (2011) and Woodford (2011).

Other studies challenge this theoretical prediction by showing how some modifications in the assumptions of the standard model may lead to government spending multipliers being lower when the economy is at the ZLB. For instance, Mertens and Ravn (2014) and Aruoba et al. (2018) show that when the ZLB is caused by non-fundamental confidence shocks, government spending may have deflationary effects. This non-fundamental ZLB may occur when there is a severe pessimist shift in expectations that generates sufficient deflationary pressures to cause nominal interest rates to reach the ZLB. If pessimism of the public is so severe that inflation expectations are even lower than nominal interest rates, then real interest rates would rise and would crowd out private spending. This would limit the expansionary effect of a government spending shock, which would be reflected in lower multipliers during this confidence-driven ZLB than under normal circumstances. Roulleau-Pasdeloup (2018) shows that if the central bank is able to credibly promise that it will generate a boom in output and inflation as soon as nominal interest rates escape the ZLB, the inflationary effect of a government spending shock would be very mild. The intuition is that in such a situation, inflation expectations would be properly anchored by the central bank, which would prevent government spending shocks from significantly rising inflation expectations at the ZLB. This would limit the size of multipliers at the ZLB. In Kiley (2016), fiscal multipliers at the ZLB are strictly below one when price dynamics are driven by sticky information. This sticky-information framework builds on the notion that inflation may not significantly respond to a government spending shock since firms are slow in updating their information about the shock and its implications.

2.1.2. Predictions when accounting for the composition of the fiscal shock

Some studies note that the size of multipliers crucially hinges on the composition of the government spending shock. Accounting for this composition aspect implies distinguishing between two types of government spending: government consumption and government investment.

Predictions for government consumption

As explained by Bonam et al. (2020), the theoretical dynamics following a government consumption shock are roughly identical to those described by Christiano et al. (2011) after a government spending shock. The NK framework predicts that the output response to a government consumption shock is significantly higher when the ZLB is binding, and the multiplier can exceed unity due to the “real interest rate” (or “expected inflation”) channel described by Dupor and Li (2015). The intuition is the following.

An increase in government consumption raises aggregate demand and inflation expectations. The increase in aggregate demand induces a rise in labour demand, which raises real wages and marginal costs for firms. Furthermore, an increase in labour supply occurs due to a negative wealth effect on private consumption: since households foresee a rise in future taxes (necessary to finance the current fiscal expansion), they are willing to work more in the present to earn more and pay the higher future taxes while smoothing lifetime consumption. This leads to a fall in private consumption because households increase their marginal propensity to save in order to be able to face the expected rise in future taxes. Under normal circumstances, the central bank reacts by increasing nominal interest rates by more than the rise in expected inflation. This is reflected in an increase of real interest rates, which crowds out private investment and exacerbates the negative wealth effect on private consumption as saving becomes more attractive. Nevertheless, during ZLB episodes the central bank accommodates the fiscal expansion and temporarily holds nominal interest rates constant at a low level. Given the rise in inflation expectations, this translates into a decline in real interest rates, which crowds in private consumption and investment. Intuitively, this real interest rate effect allows the government consumption multiplier to exceed unity at the ZLB by 1) offsetting the negative wealth effect on private consumption since saving becomes less attractive, and 2) stimulating private investment since funding becomes cheaper (Bonam et al., 2020).

Predictions for government investment

The predictions that NK models hold for government investment shocks when the ZLB is binding are more ambiguous. Bouakez et al. (2017) show how the overall response of output to a government investment shock ultimately depends on the relative importance of two counteracting effects. On the one hand, an increase in government investment immediately raises aggregate demand, which raises labour demand and real wages. This implies a rise in firms' real marginal costs, thereby exerting upward pressure on inflation expectations. Given that nominal interest rates are kept constant at the ZLB, real interest rates will tend to decrease, thus stimulating private consumption and investment; this is the inflationary demand-side effect. On the other hand, public investment also directly reduces firms' real marginal costs once the public capital becomes productive, thereby exerting downward pressure on inflation expectations. Since nominal interests are stuck at the ZLB, real interest rates will tend to decrease, thus crowding out private consumption and investment; this is the deflationary supply-side effect. Which of these two offsetting effects dominates crucially depends on the time to build, i.e., the time that it takes for the government investment to become productive. When the time to build is sufficiently short, the deflationary supply-side effect takes hold quickly after the initial government investment shock hence mitigating the inflationary demand-side effect directly emerging from the increase in aggregate demand. As a result, real interest rates fall by less, which in turn implies a smaller government investment multiplier. However, when the time to build is relatively long, the deflationary supply-side effect is further pushed into the future, so the inflationary demand-side effect dominates in the short term. Hence, the fall in real interest rates is larger, so government investment multiplier will tend to be higher. In fact, Bouakez et al. (2017) state that if the time to build is sufficiently long, the government investment multiplier at the ZLB may be twice as large as the government consumption multiplier. Other studies such as Eggertson (2011), Albertini et al. (2014) and Bonam et al. (2020) present similar predictions.

2.2. Empirical results

When contemplating empirical methodologies to test the previous NK predictions, the main challenge always comes down to the separation of endogenous and exogenous fiscal shocks. Typically, fiscal policy and economic activity influence each other. Economic activity usually reacts to fiscal policy changes, while fiscal policy may also expand or constrict in response to changes in economic activity. The empirical literature has developed various methods to deal with this endogeneity problem, all of them relying on a plausible identification strategy in order to measure the aforementioned exogenous shocks. The next subsections present the identification strategies and empirical methodologies generally used by the literature, highlighting their main results when testing the NK predictions.

2.2.1. Identification strategies

The empirical literature commonly relies on two major approaches to identify exogenous government spending shocks. The first strategy follows from Blanchard and Perotti (2002) (BP) who assume that changes in output do not contemporaneously lead to changes in fiscal policy. The intuition is that, when responding to economic conditions, it takes time for policy makers to decide upon and implement changes in fiscal variables. This builds on the fact that fiscal policy measures need to be approved by parliament and may also be hampered by implementation lags. The second strategy is known as the narrative approach and consists of analysing historical data on government spending variations and argue qualitatively which spending shocks can be considered as exogenous. A ubiquitous example of exogenous government spending shock is military spending, as it is typically argued that military build-ups are highly dependent on geopolitical events, hence entirely uncorrelated with national macroeconomic conditions (Ramey and Shapiro, 1998; Nakamura and Steinsson, 2014).

2.2.2. Empirical methodologies

The study of fiscal multipliers entails analysing the impulse responses of economic variables of interest to shocks in the fiscal variables that are being examined. To this purpose, the empirical literature has typically relied on two main methodologies: vector autoregressions and local projections.

Vector autoregression models

Vector autoregression (VAR) models have been the most regularly used method to estimate how fiscal policy shocks affect the economy. This methodology generally uses quarterly data and relies on a BP-type assumption to identify exogenous fiscal shocks. The studies using this methodology provide mixed results on the effectiveness of government spending during ZLB periods. For instance, Morita (2015) implements a time-varying VAR model using quarterly Japan data covering from 1980Q1 to 2014Q4.[6] His model imposes a sign restriction on interest rates and finds that the effect of government spending is stronger during ZLB episodes —with cumulative multipliers exceeding one— due to the crowding in effect of consumption. Ramey (2011b) estimates a VAR using quarterly US data and finds a modest government spending multiplier of 0.7 at the ZLB. Note that the ZLB episode she identifies is reduced, only covering from 1939 to 1945.[7] Other contributions apply panel VAR models, such as Bonam et al. (2020), who use quarterly data to quantify government spending multipliers both during and outside the ZLB for a panel of 17 advanced countries during the 1970Q1–2017Q4 period. Importantly, they account for the composition of the fiscal shock by distinguishing between the government consumption and government investment multipliers and find that both are significantly higher and exceed unity when the ZLB is binding —being the former slightly higher than the latter.[8] Furthermore, they provide evidence supporting the existence of the NK real interest rate transmission channel for the case of government consumption. The IMF (2017) also finds evidence supporting this transmission channel by estimating a structural VAR for a panel of 55 advanced and emerging countries. According to their estimates, the government spending multiplier in an average major advanced country can be around four times larger when the economy is stuck at the ZLB than in normal times. Almunia et al. (2010) also estimate a panel VAR for 27 advanced and emerging countries using annual data from 1925 to 1939. Their results are consistent with the idea of higher government spending multipliers during periods of persistently low interest rates.

Local projections

A prominent methodology is the local projections (LP) method developed by Jordà (2005), which has become increasingly popular in the empirical literature due to its robust and flexible features to estimate

[6] Note that Japan traditionally represents an ideal case to study fiscal multipliers at the ZLB due to its protracted ZLB episode in which nominal interest rates have been near zero since 1995Q1.

[7] Note that this paper simply estimates the government spending multiplier over an episode of ZLB instead of estimating a state-dependent model.

[8] They further differentiate between equipment- and construction-related government investment and find that only the latter can have a significantly larger impact on output at the ZLB due to the longer time to build constraints associated with this type of investment.

state-dependent fiscal multipliers. However, the evidence on the effectiveness of government spending during ZLB episodes provided by this methodology is not fully conclusive. For instance, relying on a narrative strategy and using military news changes to identify exogenous shocks in government spending, Ramey and Zubairy (2018) apply a LP methodology and find little evidence on higher multipliers at the ZLB for the US in a prolonged period going from 1889 to 2013.[9] Similarly, Klein and Winkler (2021) use military spending to identify exogenous government spending shocks and proceed with a LP methodology for a panel of 13 advanced countries from 1917 to 2016. They estimate that government spending multipliers take values of around 1.5 at the ZLB, being considerably higher than during normal times.[10] Furthermore, they empirically investigate whether the NK real interest rate transmission channel is driving their results and find ambiguous evidence. Using a BP-type identification strategy, Miyamoto et al. (2018) implement a LP methodology for Japan. They use quarterly data covering from 1980Q1 to 2014Q1 and also find a multiplier of around 1.5 at the ZLB, whereas it only reaches 0.5 during normal periods.[11] Boehm (2020) applies a similar methodology for a quarterly panel from 2003 to 2016 for 17 OECD countries. He stresses the importance of estimating separate multipliers for government consumption and investment and finds evidence that both exceed unity at the ZLB, but the former is even higher than the latter. However, he does not document the transmission mechanism underlying his results. Neither do Bonam et al. (2020) when they implement a LP methodology to verify the robustness of their VAR results.[12]

Although these are the most widely used methodologies in the empirical literature on fiscal multipliers at the ZLB, there exist a few contributions using alternative methods. For example, Crafts and Mills (2013) directly regress output changes on defence expenditure changes and find low multipliers ranging between 0.3 and 0.8 for the UK during a ZLB episode identified from 1922 to 1938. Other papers propose alternative identification strategies such as Caldara and Kamps (2017), who use non-fiscal instruments —total factor productivity, oil shocks and monetary policy shocks— to identify exogenous government spending shocks and then compute the fiscal multipliers.

[9] The only case where they find a remarkably higher multiplier at the ZLB (of around 1.4 after 2 years) is when they exclude the rationing periods of WWII from the sample. However, the estimates they get are not robust.

[10] Their results are robust to relevant modifications in the empirical model, including changing the identification strategy to a BP-type assumption.

[11] Goode et al. (2021) extend the approach of Miyamoto et al. (2018) and find similar results for Japan.

[12] See Appendix A in Bonam et al. (2020).

3. Empirical methodology

Based on the previous discussion, I proceed to an empirical estimation of state-dependent government spending multipliers using the LP method introduced by Jordà (2005) and relying on a BP identification strategy. Importantly, I attend to the claim made by Boehm (2020) and distinguish between government consumption and government investment multipliers. I will aim at testing Bouakez et al.'s (2017) theoretical prediction that the multiplier associated with government investment may considerably exceed that associated with government consumption at the ZLB, on which empirical evidence is scarcely available. Moreover, not only will I examine output but also other aggregate variables to shed light on whether the NK real interest rate transmission channel might be underlying the results. This latter aspect is what mainly differentiates my paper from the work by Bonam et al. (2020) and Boehm (2020), who briefly provide LP estimates for government consumption and investment multipliers at the ZLB, but do not report the transmission mechanism driving their LP results. Furthermore, I present international evidence from a more recent and longer sample for ZLB periods.

In the next subsections, I describe my definition of ZLB episodes, my strategy to identify exogenous shocks in government spending, and the empirical specifications I use for estimating state-dependent government spending multipliers and documenting the underlying transmission mechanisms.

3.1. Definition of ZLB periods

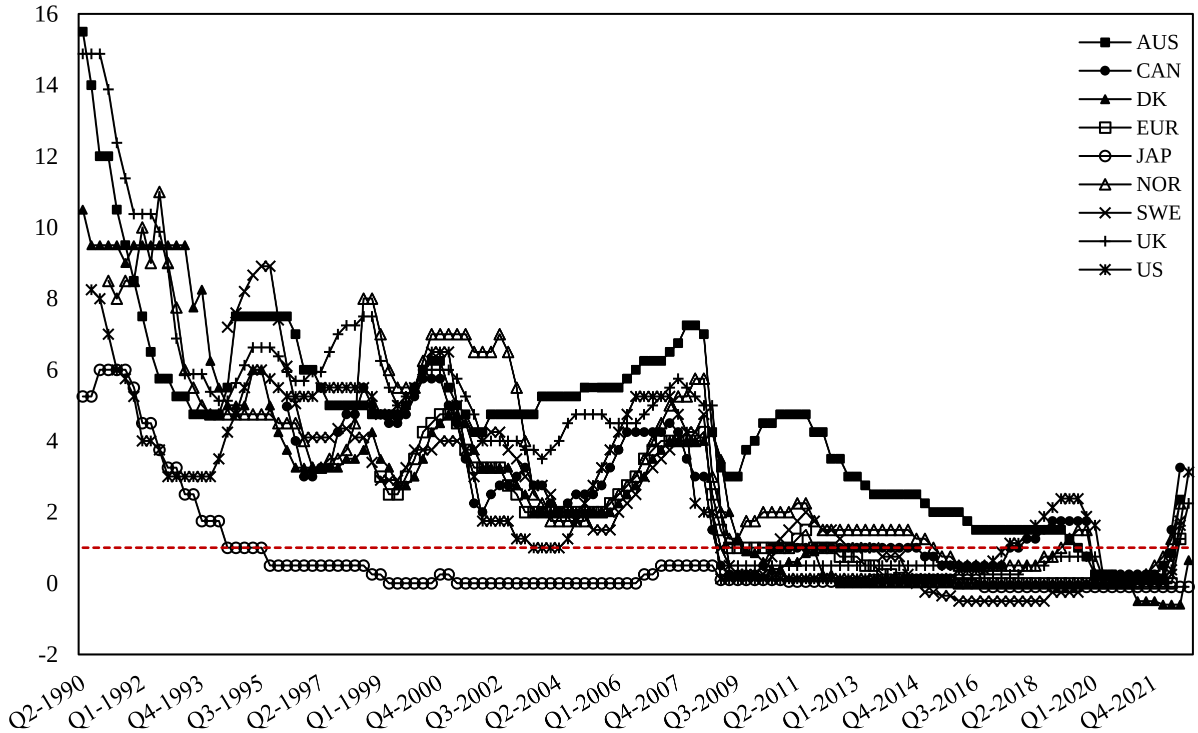
Following Bonam et al. (2020), I consider an economy to be at the ZLB when its nominal policy interest rate $R_{n,t}$ is lower than the threshold value τ of 1%. Hence, the proxy $Z_{n,t}$ used in my analysis to identify ZLB episodes is determined as follows:

$$Z_{n,t} = \begin{cases} 1 & \text{if} \quad R_{n,t-s} < 1\% \\ 0 & \text{otherwise} \end{cases}$$

This proxy $Z_{n,t}$ will split my sample into a subsample with ZLB periods and a subsample without ZLB periods. Note that this definition may identify periods during which nominal interest rates are not strictly zero but instead captures a low-interest-rate environment. According to Woodford (2011), what matters is that nominal interest rates are at a sufficiently low level that the monetary authority is unwilling to go below that level. Thus, this "effective lower bound" does not need to be zero.

My sample covers the period going from 1990Q1 to 2022Q3 for 13 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Japan, Netherlands, Norway, Sweden, the UK, and the US. Figure 1 provides a comprehensive picture of the ZLB episodes identified for this group of countries throughout my sample period. The horizontal red dashed line depicts the cut-off value of 1% that I use to define ZLB episodes. As seen in the figure, the identified ZLB episodes begin after 2009 for most countries, illustrating their strong monetary policy response to the Great Recession. The only exception is Japan, whose nominal policy interest rate has been stuck at the ZLB since 1995. Over the whole sample, I identify a total of 558 ZLB periods, which accounts for approximately a 33% of the sample. The remaining periods are considered as non-ZLB periods.

Figure 1. Nominal policy interest rates and ZLB periods.



Notes: The beginning of the series for some countries is restricted due to data availability on nominal policy interest rates. The Eurozone countries are depicted by the same line, reflecting the fact that these countries share a common monetary policy. *Source*: OECD Economic Outlook: Statistics and Projections database (edition 112) and own calculations.

3.2. Identification strategy

For the identification of exogenous government consumption —or alternatively, government investment— shocks I use the following specification:

$$\frac{G_{n,t} - G_{n,t-1}}{Y_{n,t-1}} = \lambda \frac{Y_{n,t} - Y_{n,t-1}}{Y_{n,t-1}} + \phi(L)W_{n,t} + v_n + \delta_t + u_{n,t}^G \quad (1)$$

where $\frac{G_{n,t} - G_{n,t-1}}{Y_{n,t-1}}$ is the change of real government consumption (investment) in country n at time t divided by real GDP in $t-1$;[13] $\lambda\frac{Y_{n,t}-Y_{n,t-1}}{Y_{n,t-1}}$ captures the systematic contemporaneous response (elasticity) of government consumption (investment) to changes in real output; $\phi(L)$ is a lag operator; $W_{n,t}$ is a vector of standard control variables that includes the change of real government investment (consumption) in country n at time t divided by real GDP in $t-1$, four lags of the changes in real GDP, real government consumption, real government investment, real private consumption, real private investment (all divided by real GDP in $t-1$), CPI inflation, the nominal policy interest rate and the unemployment rate; v_n and δ_t represent country and time fixed effects; and $u_{n,t}^{G}$ is an orthogonal shock capturing exogenous changes in real government consumption (investment).

From here, I follow Blanchard and Perotti (2002) and assume that government spending (both consumption and investment) is contemporaneously unaffected by changes in aggregate economic activity. The intuition is that, when responding to economic conditions, it takes time for policy makers to decide upon and implement changes in fiscal policy. Since I will use quarterly data, the assumption that governments do not respond to economic changes within the same quarter seems plausible. This assumption implies that $\lambda = 0$, so the term $\lambda\frac{Y_{n,t}-Y_{n,t-1}}{Y_{n,t-1}}$ gets washed out. Then I run specification (1) and recover the estimated residuals $\hat{u}_{n,t}^{G}$, which is the identified exogenous government consumption (investment) shock that I use as an instrument in the next estimation step.

3.3. Econometric specifications

In a second step, I perform the impulse response analysis by studying the dynamics of multipliers, which measure the change in a variable of interest relative to the change in government spending from the time of the government spending shock to a reported horizon of h quarters ahead. I estimate the multipliers using the local projections (LP) method introduced by Jordà (2005). This method estimates impulse responses by directly regressing a variable of interest on shocks as well as lags of variables typically entering a VAR. The reason I choose this method is because it presents various advantages over a VAR. For instance, the LP method does not impose linear constraints on impulse responses, so misspecification problems are less likely to occur than with VARs. Furthermore, it does not require all variables to be used in each equation, so specifications can be relatively simpler. Ramey and Zubairy

[13] The reason for the division by lagged real GDP follows from Ramey and Zubairy (2018), who argue that this avoids the potentially problematic ex-post conversion from elasticities to dollar units when computing the multipliers.

(2018) argue that these, among other aspects, allow for a more flexible and robust estimation of impulse responses than VARs.

Specifically, I focus my analysis on estimating two main specifications: a baseline specification for the output multiplier following government consumption and investment shocks;[14] and a secondary specification for the multipliers of other variables of interest in response to these shocks, which will shed light on the potential transmission mechanism driving my baseline results.

3.3.1. Baseline specification

For my base case, I follow Ramey and Zubairy (2018) and use the following specification for output multipliers at each horizon $h = 0, \ldots, 8$:

$$\frac{Y_{n,t+h} - Y_{n,t-1}}{Y_{n,t-1}} = M_h^G \, \hat{u}_{n,t}^G + \phi_h(L) W_{n,t} + v_{n,h} + \delta_{t,h} + \varepsilon_{n,t+h} \qquad (2)$$

where $\frac{Y_{n,t+h} - Y_{n,t-1}}{Y_{n,t-1}} \approx \ln Y_{n,t+h} - \ln Y_{n,t-1}$ is the change of real GDP in country *n* between quarter $t - 1$ and $t + h$; $\hat{u}_{n,t}^G$ is the identified exogenous government consumption (investment) shock from specification (1); M_h^G is the coefficient of interest and represents the government consumption (investment) multiplier;[15] $\phi_h(L)$ is a lag operator; $W_{n,t}$ is the vector of standard control variables; the parameters $v_{n,h}$ and $\delta_{t,h}$ capture country and time fixed effects; and $\varepsilon_{n,t+h}$ is the error term. Thus, the LP method computes the impulse responses as a sequence of the M_h^G's estimated in a series of single regressions for each horizon *h*.

3.3.2. Secondary specification

In order to document the transmission mechanism underlying my baseline results, I estimate the impulse responses of a set of macroeconomic variables of interest to a government consumption and investment shock. To do this, I run the following specification:

$$X_{n,t+h} = M_h^X \, \hat{u}_{n,t}^G + \phi_h(L) W_{n,t} + v_{n,h} + \delta_{t,h} + \varepsilon_{n,t+h} \qquad (3)$$

where the dependent variable $X_{n,t+h}$ is the variable of interest *X* for country *n* at quarter $t + h$. The variable of interest *X* can be CPI inflation, real interest rate, the growth rate of private consumption

[14] Note that I will refer to the output multiplier as "government consumption multiplier" or "government investment multiplier", depending on the government spending shock being examined.

[15] Therefore, the coefficient M_h^G is interpreted as the output response at time $t + h$ to the exogenous shock in government consumption (investment) at time *t*.

between $t + h$ and $t - 1$, and the growth rate of private investment between $t + h$ and $t - 1$. Hence, the coefficient M_h^X is interpreted as the multiplier of the variable of interest that is being studied. This specification includes all control variables presented above and four lags of the respective dependent variable.

Following this procedure, I estimate specifications (2) and (3) for each subsample —normal times and ZLB periods— and compare the resulting multipliers and impulse responses to assess the empirical validity of the NK theoretical predictions. Over the entire procedure, standard errors are calculated using the conventionally derived variance estimator for generalised least-squares regression.

4. Data description

I construct a quarterly panel covering from 1990Q1 to 2022Q3, for 13 advanced countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Japan, Netherlands, Norway, Sweden, the UK and the US. Data availability in some series restricts the beginning of the sample for some countries. Using quarterly data presents several advantages over annual data. As mentioned earlier, our BP identifying assumption of no contemporaneous response of fiscal policy to economic conditions is more plausible under quarterly data. Furthermore, quarterly data offer more observations than annual data, which is important given the scarcity of ZLB periods over time.

Regarding the variable construction, for real GDP, $Y_{n,t}$, I use GDP data in volumes at market prices. For real government consumption, $G_{n,t}^c$, I use government final consumption data in volumes. For real government investment, $G_{n,t}^i$, I use government gross fixed capital formation data in volumes. Inflation $\pi_{n,t}$ is constructed as the year-on-year percentage change in the CPI. The real interest rate $r_{n,t}$ is computed as the difference between the nominal policy interest rate and the inflation rate in the following period, i.e., $r_{n,t} = R_{n,t} - \pi_{n,t+1}$. All these time series are retrieved from either the OECD Data warehouse or the OECD Economic Outlook's Statistics and Projections database (edition 112). Further details on data definitions and variable construction can be found in Appendix A.

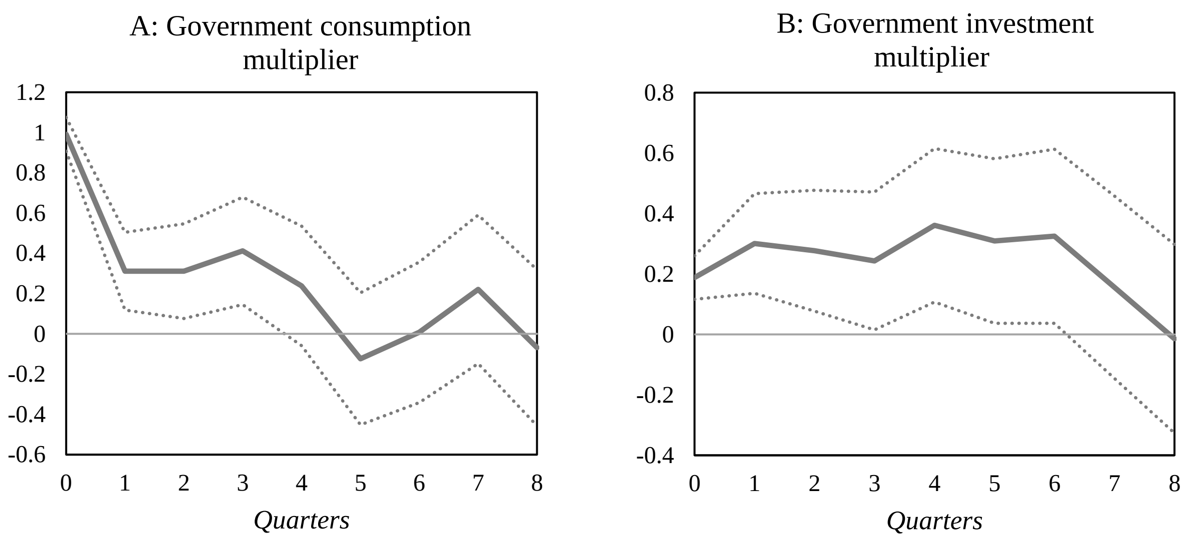
5. Results

This section presents the estimation results based on the empirical methodology described in Section 3. First, I show the output multiplier estimates for the full sample, i.e., without distinguishing between normal times and ZLB periods. Second, I present my baseline multiplier estimates and discuss how output responds to government consumption and investment shocks during normal times and at the ZLB. Third, I show the results of my secondary specification and analyse how other aggregate variables of interest respond to government spending shocks during normal times and at the ZLB. Reporting the response of these variables allows me to elucidate the economic transmission mechanism underlying my baseline results and assess the empirical validity of the NK predictions. Finally, I perform a series of robustness exercises.

5.1. Full sample multiplier estimates

Figure 2 plots the output multipliers for the full sample. As observed, the government consumption multiplier (Panel A) takes a statistically significant value of roughly 1 percent on impact. After this, it sharply declines over the remaining quarters but being no longer statistically significant. The government investment multiplier (Panel B) is considerably lower on impact, reaching a statistically significant value of around 0.2 percent. Nevertheless, the government investment multiplier remains between 0.3 and 0.4 percent up until the seventh quarter, though it is no longer statistically significant.

Figure 2. Government consumption and government investment output multipliers for the full sample.



Notes: These estimates are based on specification (2). Shocks are scaled to be equivalent to 1% of real GDP. The dotted lines are the 90% confidence bands. Units of the vertical axes are in percentages.

5.2. Baseline multiplier estimates

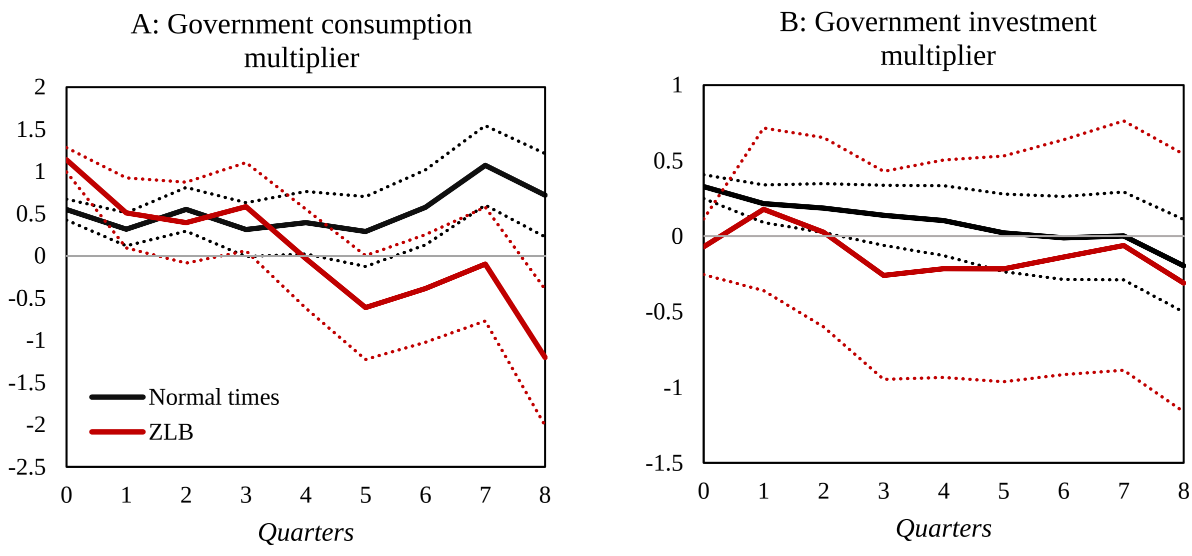
Figure 3 displays the impulse response functions of real GDP following government consumption and investment shocks during normal times (black solid line) and during ZLB episodes (red solid line). Panel A shows the response of real GDP to a government consumption shock. As can be observed, a shock in government consumption during normal times triggers a statistically significant increase in real GDP of around 0.5 percent on impact. This response of real GDP peaks at the seventh quarter with an increase of near 1 percent. However, this effect is no longer statistically significant from the third quarter onwards. In contrast, when the ZLB is binding, a government consumption shock brings about a statistically significant increase in real GDP by 1.13 percent on impact. After the first quarter, this effect progressively dies out and becomes no longer statistically significant. This is in line with the NK prediction of significantly higher —and larger than one— multipliers when the economy is at the ZLB than during normal times.

On the other hand, Panel B presents the response of real GDP to a government investment shock. Here, a shock in government investment during normal times leads to a more modest —but statistically significant— rise in real GDP of around 0.3 percent on impact. After the first quarter, this effect becomes statistically insignificant and starts to fade out. Finally, when the ZLB is binding, the response of real GDP to a government investment shock becomes less obvious. On impact, the response of real GDP is barely distinguishable from zero, then it becomes modesty positive for the next two quarters and drops to negative territory after the third quarter. At no horizons is this response statistically significant. This result is at odds with the theoretical prediction held by some authors such as Bouakez et al. (2017) which suggest that the government investment multiplier at the ZLB may be even larger than the government consumption multiplier.

5.3. Impulse response analysis

In order to shed light on the potential macroeconomic mechanism underlying my baseline results, I estimate specification (3) and examine the impulse response functions of CPI inflation, real interest rates, private consumption, and private investment in normal times and compare them with those at the ZLB. Figure 4 plots the impulse responses of these aggregate variables to a government consumption shock (left column) and government investment shock (right column).

Figure 3. Government consumption and government investment output multipliers.



Notes: These estimates are based on specification (2). Shocks are scaled to be equivalent to 1% of real GDP. The dotted lines are the 90% confidence bands. Units of the vertical axes are in percentages.

5.3.1. The effects of government consumption

As previously seen in Figure 3, the government consumption multiplier is significantly higher (and larger than one) during ZLB episodes than during normal times. Figure 4 shows that, during normal times, inflation responds negatively to a government consumption shock. This negative response of inflation may be explained by the behaviour of the monetary authority. As discussed in Section 2, under normal circumstances, a central bank that bases its monetary policy on a typical Taylor rule will react to a government consumption shock by rising nominal interest rates to counteract the inflationary pressures posed by the shock. Panel A suggests that this reaction of the central bank may be so strong that not only does it temper inflation pressures, but it even generates some extent of deflation. Given the rise in nominal interest rates and the decline in inflation, real interest rates increase (Panel C). This increase in real interest rates, in turn, leads to the crowding out of private consumption and investment as can be observed in Panels E and G, respectively. Note how, on impact, this crowding out effect is significantly stronger for private investment than for private consumption. These dynamics seem to be in line with NK theory, which predicts that this crowding out effect is the reason why the government consumption multiplier is lower than unity during normal times.

On the contrary, when the ZLB is binding, the response of inflation to a government consumption shock is positive and statistically significant up until the fifth quarter. From that moment onwards, the response of inflation starts to decline, eventually reaching negative territory but no longer being statistically significant (Panel A). This positive response of inflation is possible because, at the ZLB, the monetary authority changes its policy stance. As discussed in Section 2, when the economy is stuck at the ZLB, the appropriate monetary policy involves maintaining nominal interest rates constant at a low level to accommodate the fiscal expansion. Thus, the inflationary pressures posed by the government consumption shock are allowed to take hold. Given that the central bank holds nominal rates constant, and inflation increases, a decline in real interest rates occurs (Panel C).[16] This decline in real interest rates stimulates private consumption and investment, as reflected by panel E and G, respectively. The increase is sizable for both private consumption and investment on impact (reaching around 2.5 and 1.1 percent, respectively) but, in contrast with normal times, it is particularly stronger for the former. Again, these dynamics seem to be in line with NK theory, which predict that this crowding in effect is what allows government consumption multipliers to exceed unity during ZLB periods.

Therefore, these empirical results provide evidence supporting the NK real interest rate channel hypothesis and how it may be driving the differences in government consumption multipliers between normal times and ZLB periods.

5.3.2. The effects of government investment

As displayed in Figure 3, the values for the government investment multiplier are lower and more ambiguous during ZLB periods than during normal times. Now I focus on analysing the response of our variables of interest to a government investment shock with the intention of shedding light on the macroeconomic dynamics that could be explaining my less obvious baseline results for government investment. As can be observed in Figure 4, during normal times, the response of inflation to a government investment shock is positive but statistically insignificant at all horizons (Panel B). Contrary to what I found in the case of government consumption, real interest rates decline in response to a government investment shock (Panel D). This is at odds with the assumption that, during normal times, the monetary authority increases nominal interest rates more than the increase in inflation expectations in order to generate a rise in real interest rates and temper the inflationary pressures posed by the fiscal expansion. According to theory, this decrease in real interest rates should stimulate private spending. However, we observe that the response of private consumption is barely distinguishable from zero at all horizons (Panel F) and private investment responds negatively at all horizons (Panel H). This latter decline of private investment is particularly sizable —and statistically significant— on impact, reaching around −0.9 percent. Hence, while these responses of private consumption and investment might be

[16] Note that this decline in real interest rates is statistically significant up until the fourth quarter. From that moment onwards, the response of real interest rates starts to rise, eventually becoming positive but no longer being statistically significant.

behind the low values for the government investment multiplier during normal times, such responses do not seem to stem from the reaction of real interest rates, as standard NK theory would predict.

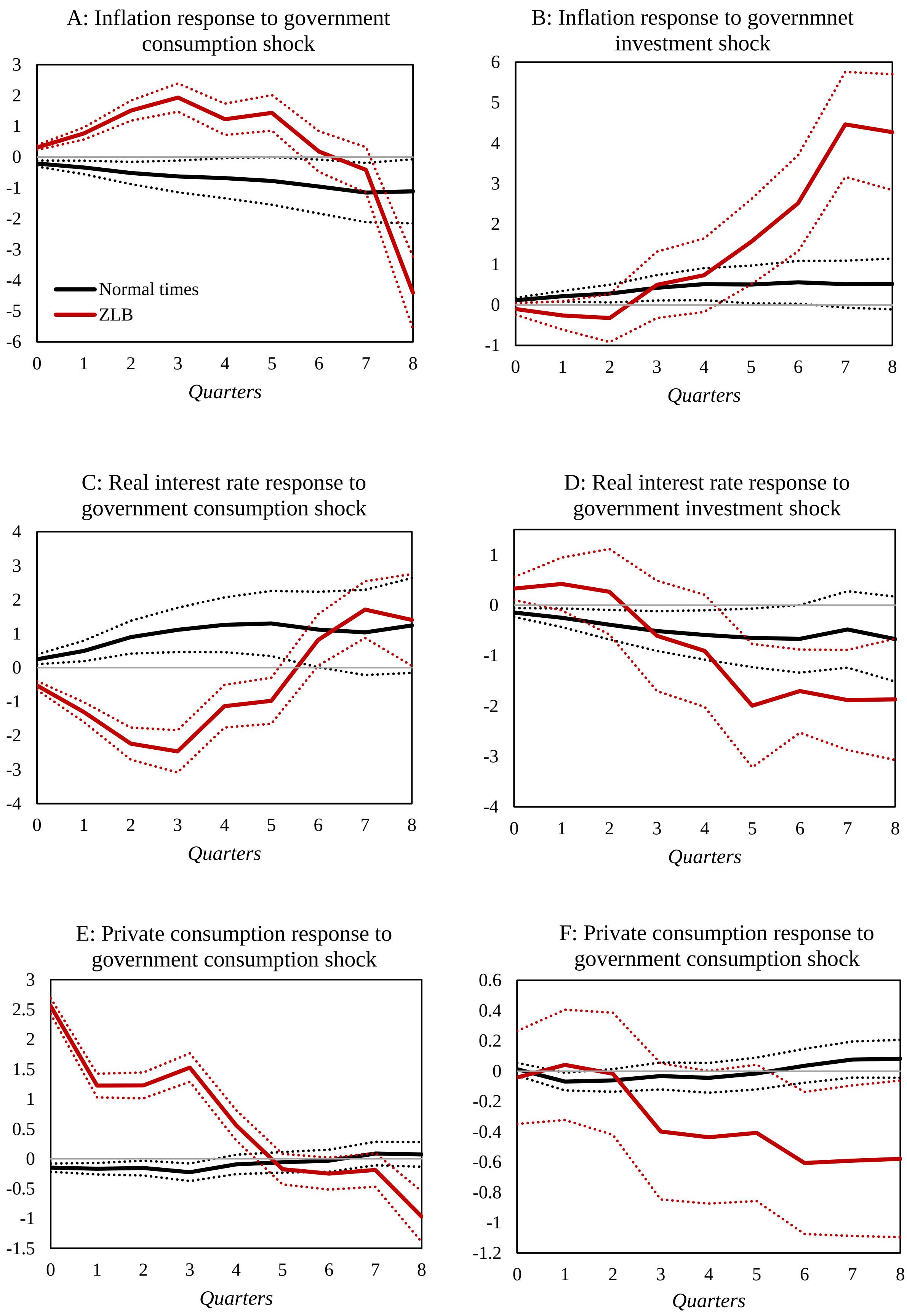
On the other hand, when the ZLB is binding, the response of inflation to a government investment shock is negative and statistically insignificant during the first three quarters. After the third quarter, this response becomes positive, reaching high —and statistically significant— values around 4 percent towards the seventh and eighth quarters (Panel B). Therefore, it could be argued that the inflationary demand-side effect proposed by NK theory for the case of government investment at the ZLB dominates, but this becomes noticeable only after the third quarter horizon. Given that the central bank keeps nominal interest rates constant at a low level during ZLB episodes, this behaviour of inflation is reflected in real interest rates, which show a positive reaction until the third quarter that then becomes negative, reaching statistically significant values of around -1.8 percent during the last two quarters (Panel D). Theoretically, this would imply that private spending is first crowded out and then stimulated (crowded in) once the response of real interest rates becomes negative. Nevertheless, we observe that the response of both private consumption and private investment is barely distinguishable from zero until the second quarter and then becomes negative (Panels F and H). Note that in the case of private investment, the response comes back to positive domain after the sixth quarter, though it remains statistically insignificant. Thus, in the case of private consumption I do not find evidence on the crowding in effect that the fall of real interest rates should imply from the third quarter onwards, according to NK theory. In the case of private investment, I do find some evidence of this crowding in effect, but it occurs with a lag of six quarters.

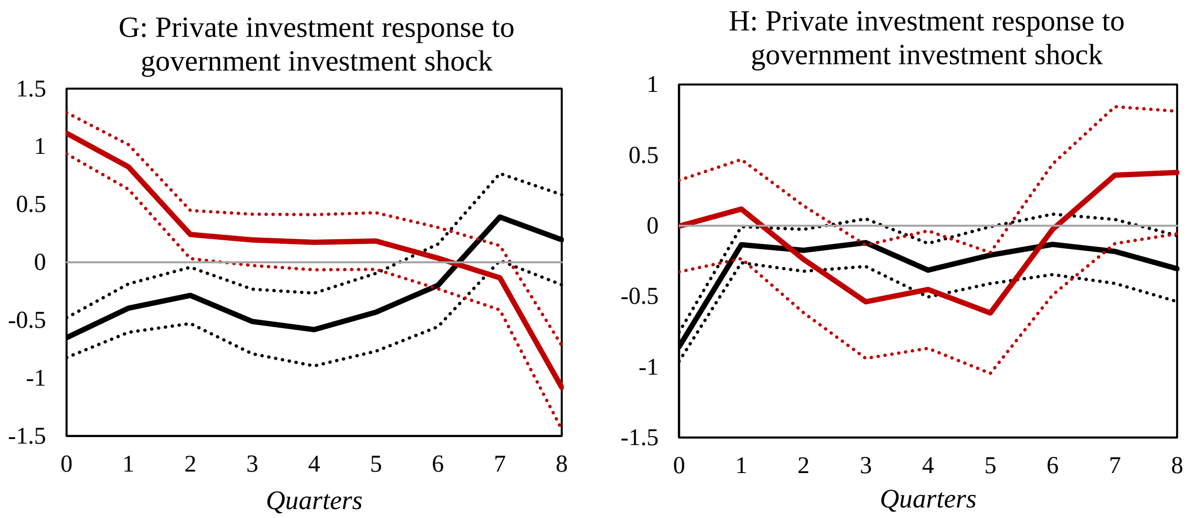
In sum, when it comes to government investment, I do not find evidence consistent with the real interest channel hypothesis proposed by NK theory. Table 1 summarises the multiplier estimates at different time horizons, for the two different categories of government spending, and across the two different states of the economy being analysed.

5.4. Robustness analysis

My baseline results suggest that government consumption multiplier is higher —and larger than one— when the ZLB is binding, whereas the same does not apply to the government investment multiplier. These results are potentially sensitive to several specification choices in the empirical model. Thus, in this section I assess the robustness of my baseline results when changing some of the specification choices underlying the model. First, I change the definition of the proxy used to identify ZLB periods in my sample. Second, I control for potential anticipation effects that might be biasing my results. Third, I control for the state of the business cycle. Fourth, I control for the influence of the exchange rate regime. Finally, I use an alternative state-dependent baseline specification to obtain the multipliers. The multiplier estimates derived from these robustness exercises can be found in Appendix B.

Figure 4. Impulse response functions of inflation, real interest rate, private consumption, and private investment.





Notes: These estimates are based on specification (3). Shocks are scaled to be equivalent to 1% of real GDP. The dotted lines are the 90% confidence bands. Units of the vertical axes are in percentages.

5.4.1. Changing the definition the ZLB proxy

The results presented in Figures 3 and 4 depend on my definition of ZLB episodes. As a means to explore whether my baseline results are robust, I reestimate the model using alternative definitions of the proxy $Z_{n,t}$ identifying ZLB periods in my sample. Specifically, I estimate government consumption and investment multipliers when the threshold value τ determining ZLB episodes is equal to 1.5%, 1.25%, 0.75%, 0.5%, and 0.25%. The sign and magnitude of the multipliers remain roughly the same as in the baseline model across all these different definitions of ZLB periods. The level of statistical significance also stays the same as in the baseline scenario. Hence, our main result of finding higher multipliers — and larger than one— when the ZLB is binding for the case of government consumption but not for government investment is robust to different definitions of the proxy $Z_{n,t}$ identifying ZLB episodes in my sample. The multiplier estimates resulting from these different definitions can be found in Table B1 in Appendix B.

5.4.2. Controlling for anticipation effects

A potential hurdle in estimating the effects of government spending shocks is the so-called fiscal foresight problem. This problem arises when private agents foresee future fiscal shocks and adjust their present behaviour accordingly. Failure in accounting for such foresight effect may lead to a downward bias in the estimates of output multipliers for government spending (Leeper et al., 2013; Ramey, 2011b). Furthermore, Ramey (2011b) argues that fiscal shocks identified with a BP-type scheme are more likely to be anticipated by economic agents, especially when using quarterly data. The argument goes that it is more likely that fiscal shocks will be anticipated one quarter in advance than one year in advance. To

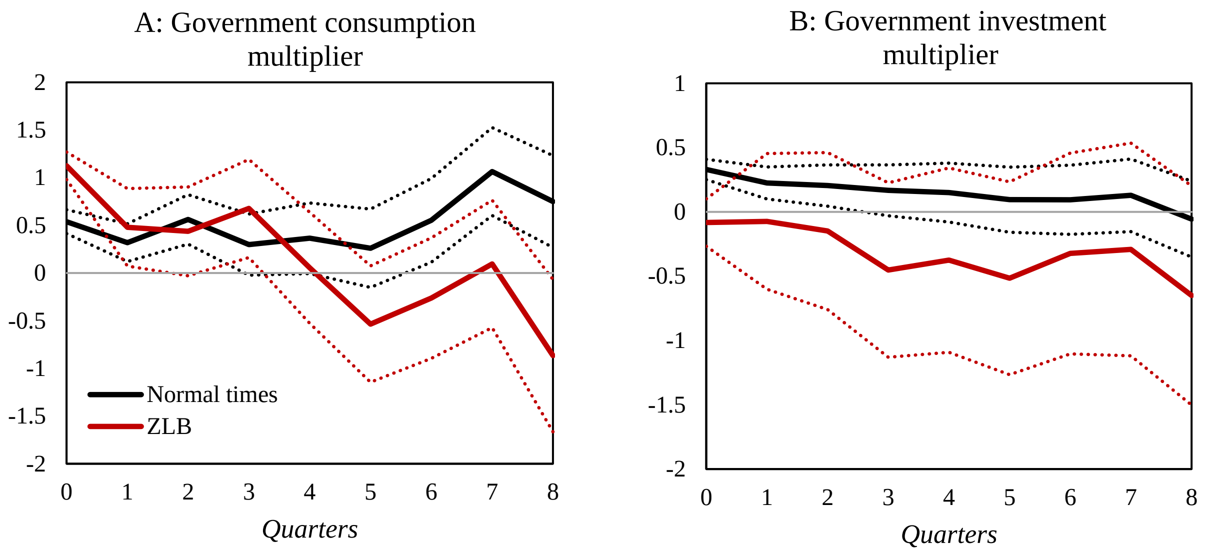
Table 1. Multiplier estimates after government consumption and government investment shocks.

	Government consumption shock		*Government investment shock*	
	Normal times	ZLB	Normal times	ZLB
Output				
Impact	0.549***	1.137***	0.328***	-0.069
4 quarters	0.393	-0.039	0.103	-0.215
8 quarters	0.719	-1.203	-0.196	-0.310
Inflation				
Impact	-0.210*	0.309***	0.117	-0.101
4 quarters	-0.658	1.227*	0.514	0.735
8 quarters	-1.111	-4.407	0.519	4.270***
Real interest rate				
Impact	0.246	-0.523***	-0.147	0.329
4 quarters	1.261	-1.134	-0.591	-0.907
8 quarters	1.242	1.405	-0.673	-1.868
Private consumption				
Impact	-0.148*	2.557***	0.013	-0.042
4 quarters	-0.094	0.561*	-0.044	-0.436
8 quarters	0.073	-0.969	0.082	-0.579
Private investment				
Impact	-0.651***	1.115***	-0.858***	-0.003
4 quarters	-0.581	0.173	-0.315	-0.452
8 quarters	0.195	-1.080	-0.304	0.377

Notes: Shocks are equivalent to 1% of real GDP. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

deal with these potential anticipation effects, one of the approaches put forward by the literature is to include forward-lookig variables as controls. The intuition is that such variables may encapsulate information about individuals' expectations regarding future fiscal policy developments. I follow this approach and augment the baseline model by including the long-term interest rate on government bonds in the vector of standard controls $W_{n,t}$. This follows from Forni and Gambetti (2010), who claim that including a financial market variable, due to its forward-looking nature, may help to account for additional information on the expected future path of fiscal variables. As displayed in Figure 5, the multipliers I obtain by estimating this augmented model have roughly the same size, sign, and statistical significance as those in the baseline scenario. Again, I find evidence on higher impact multipliers —and larger than one— when the ZLB is binding associated with governmnet consumption, but not with government investment. Therefore my baseline results are robust to the potential anticipation effects of fiscal policy.

Figure 5. Government consumption and government investment output multipliers when augmenting the model with long-term interest rates on government bonds.



Notes: These estimates are based on specification (2), augmented by including long-term interest rates on government bonds as an additional control. Shocks are scaled to be equivalent to 1% of real GDP. The dotted lines are the 90% confidence bands. Units of the vertical axes are in percentages.

5.4.3. Controlling for the state of the business cycle

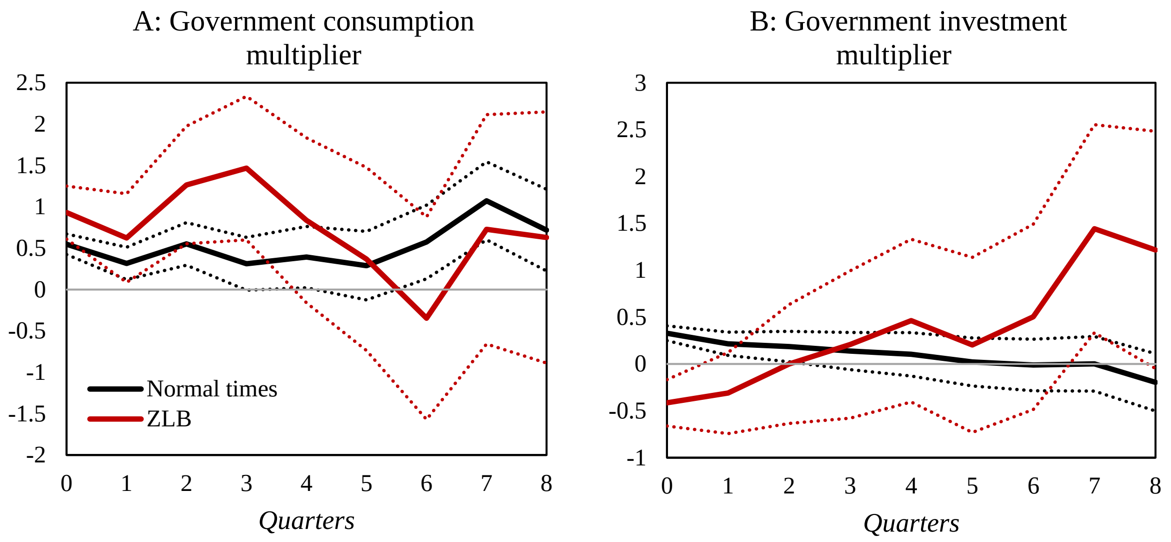
Some authors argue that the size of fiscal multipliers crucially depends on the state of the business cycle. The rationale behind this is that, during a recession, the private sector might be more credit constrained, which implies that their marginal propensity to consume is higher than in times of expansion. Consequently, the government spending multiplier is likely to be larger in times of recession than in more favourable economic circumstances (Bonam et al., 2020). For instance, Auerbach and Gorodnichenko (2012) find fiscal multipliers exceeding unity during crises, and between 0 and 0.5 during expansions. One could argue that ZLB episodes generally take place when the economy is going through bad times —i.e., when it faces a considerable economic slack—, since central banks would react to this by actively cutting nominal interest rates. Hence, this poses a potential identification issue since both the economic slack and the ZLB are predicted to drive government spending multipliers in the same direction. To control for this possibility, I now define ZLB periods as those when nominal policy interest rates $R_{n,t}$ are lower than the threshold value τ of 1% and, at the same time, the unemployment rate $\upsilon_{n,t}$ is above the country-specific median.[17] Thus, the ZLB proxy $Z_{n,t}$ now looks as follows:

$$Z_{n,t} = \begin{cases} 1 & \text{if} \quad R_{n,t-s} < 1\% \ and \ \upsilon_{n,t} > Med(\upsilon_{n,t}) \\ 0 & \text{otherwise} \end{cases}$$

Using this alternative definition of the ZLB proxy, I identify a total of 273 ZLB episodes and make sure that the size of government spending multipliers at the ZLB is estimated without being contaminated by the effects of the economic slack. Figure 6 shows the estimates for government consumption and investment multipliers obtained when using this alternative definition of ZLB episodes. Again, I find a statistically significant impact multiplier for government consumption which is still higher —and virtually equal to one— in the presence of the ZLB. Furthermore, note that the government consumption multiplier at the ZLB now peaks at about 1.5 towards the third quarter, which is considerably larger than under the baseline model where I did not control for the business cycle. In the case of government investment, I find no evidence on higher impact multipliers when the ZLB is binding. Nevertheless, note how the response of output to a government investment shock starts in negative territory but then becomes positive and exceeds unity towards the last two quarters, although at no horizons is it statistically significant. Therefore, broadly speaking, my baseline findings are robust to controlling for the state of the business cycle.

Figure 6. Government consumption and government investment output multipliers when using additional economic slack constraint.

[17] The fact of measuring the state of the business cycle by observing the deviation of the unemployment rate from its median value follows from Boehm (2020). Ramey and Zubairy (2018) also use a similar approach to gauge the amount of economic slack.



Notes: These estimates are based on specification (2), using the alternative definition for ZLB episodes. Shocks are scaled to be equivalent to 1% of real GDP. The dotted lines are the 90% confidence bands. Units of the vertical axes are in percentages.

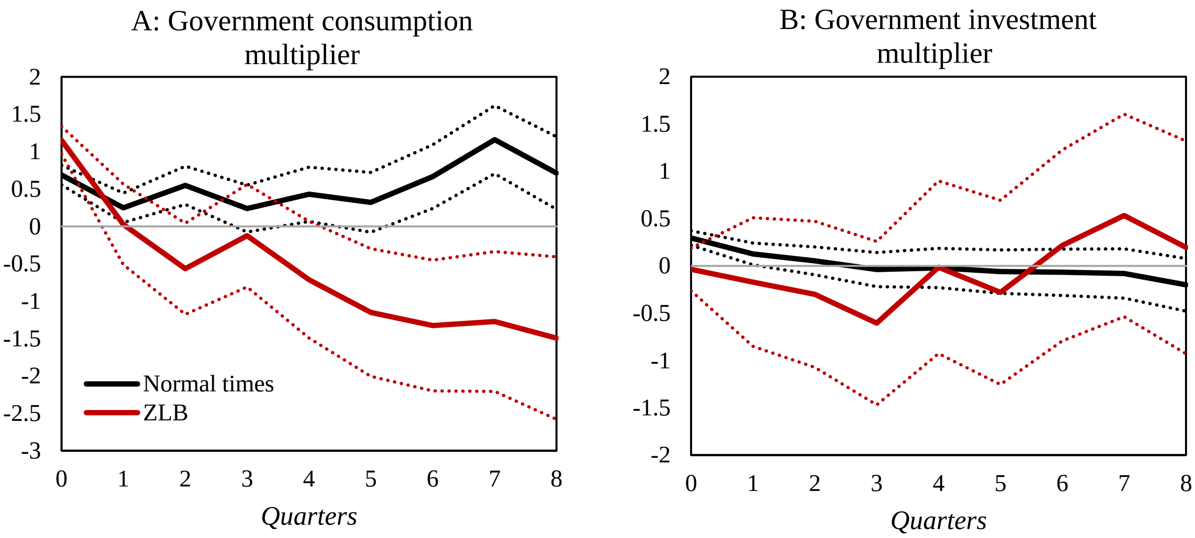
5.4.4. Excluding the eurozone countries from the sample

Another potential identification problem has to do with the inclusion of eurozone countries in my sample and the quasi-fixed exchange rate regime they hold within their borders.[18] The effects of a fixed exchange rate regime on fiscal multipliers have been argued to be similar to those of the ZLB (Corsetti et al., 2012; Ilzetzki et al., 2013). Intuitively, under a fixed exchange rate regime the central bank will not increase nominal interest rates to counteract a fiscal expansion because it is committed to maintain the fixed exchange rate. Therefore, under this scenario the crowding out effects of a government spending shock are likely to be smaller since —similarly to when the ZLB is binding— interest rates are less reactive. Given that the eurozone countries included in our baseline sample only experienced ZLB episodes when they were part of the eurozone, i.e., when they were facing a quasi-fixed exchange rate regime, the inclusion of these countries in our sample might be biasing our multiplier estimates. In order to address this potential identification problem, I rerun the baseline model excluding the eurozone members —except France— from the sample. The reason I keep France in the sample is because, given the relatively large size of the French economy within the eurozone, a government spending shock in France is likely to be large enough to induce a change in the common European Central Bank policy rate provided the economy is not at the ZLB. As shown in Figure 7, the multipliers I obtain have

[18] The term quasi-fixed exchange rate regime follows from Bonam et al. (2020) and illustrates the fact that the euro is allowed to fluctuate freely against other currencies but, at the same time, faces a fixed exchange rate regime within the eurozone borders.

approximately the same size, sign, and statistical significance as those in the baseline case. Again, I find evidence on higher impact multipliers —and larger than one— when the ZLB is binding after a government consumption shock, but not after a government investment shock. Therefore my baseline findings remain roughly unchanged after excluding most eurozone members from the sample.

Figure 7. Government consumption and government investment output multipliers when using a smaller country sample.



Notes: These estimates are based on specification (2), using a smaller country sample that excludes all the eurozone members, except for France. Shocks are scaled to be equivalent to 1% of real GDP. The dotted lines are the 90% confidence bands. Units of the vertical axes are in percentages.

5.4.5. Alternative state-dependent baseline specification

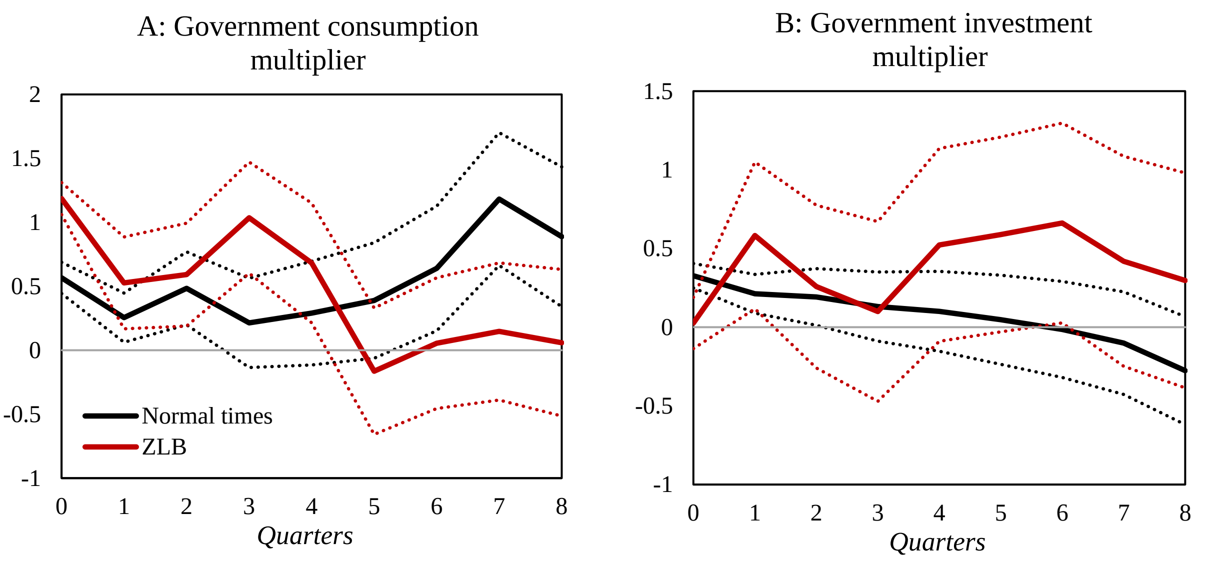
As a final robustness exercise, I estimate government consumption and investment multipliers using an alternative baseline specification. Contrary to what is done to obtain my baseline results, where I divide the sample into normal times and ZLB periods in advance and estimate specification (2) for each of the two subsamples separately, now I directly estimate a state-dependent specification in which the ZLB dummy indicator $Z_{n,t}$ is included within the regression. This alternative specification looks as follows:

$$\frac{Y_{n,t+h} - Y_{n,t-1}}{Y_{n,t-1}} = Z_{n,t}\,[M_h^{AG}\,\hat{u}_{n,t}^{G} + \phi_h(L)W_{n,t}] + (1 - Z_{n,t})\,[M_h^{BG}\,\hat{u}_{n,t}^{G} + \phi_h(L)W_{n,t}] + v_{n,h} + \delta_{t,h} + \varepsilon_{n,t+h} \quad (4)$$

where $Z_{n,t}$ is the dummy ZLB indicator that equals zero during normal times and one when the economy is constrained by the ZLB. Given this specification, M_h^{AG} represents the government consumption (investment) multiplier during normal times, whereas M_h^{BG} represents the government consumption (investment) multiplier when the ZLB is binding.

Figure 8 displays the output multipliers obtained by using this alternative specification. As can be observed, the impact multipliers I get are roughly identical in sign, size, and statistical significance as those stemming from the baseline specification (2). Again, I find higher impact multipliers —and larger than one— when the ZLB is binding after a government consumption shock, but not after a government investment shock. A noticeable difference with respect to the baseline multipliers shown in Figure 3 is that now output responds positively to a government investment shock at all horizons when the ZLB is binding, as can be seen in Panel B. With this exception, my baseline findings are robust to using the alternative state-dependent specification (4) to obtain the government consumption and government investment multipliers.

Figure 8. Government consumption and government investment output multipliers when using an alternative baseline specification.



Notes: These estimates are based on specification (4). Shocks are scaled to be equivalent to 1% of real GDP. The dotted lines are the 90% confidence bands. Units of the vertical axes are in percentages.

6. Conclusion

NK models typically predict that the response of GDP to a government spending shock is larger when the economy is at the ZLB due to the presence of the NK real interest rate channel and the crowding in effect that it generates in private spending. Some authors such as Boehm (2020) have stressed the importance of differentiating between government consumption and government investment shocks to properly document the impact and dynamics of fiscal policy on the economy. Despite this latter claim, there is only a limited amount of empirical studies testing the NK predictions for the ZLB when accounting for the composition of the government spending shock.

This thesis explores the effectiveness of the components of government spending —government consumption and government investment— in stimulating the economy when nominal interest rates are stuck at the ZLB. To do so, I apply a local projections methodology to a panel of 13 advanced countries and estimate the state-dependent government consumption and government investment output multipliers during normal times and during ZLB periods. Furthermore, I report how inflation, real interest rates, private consumption and private investment respond to government consumption and investment shcoks in order to shed light on the potential macroeconomic transmission channel underlying my baseline results.

In the case of government consumption, I find the output impact multiplier to be around 0.5 percent during normal times and 1.13 percent at the ZLB, which is in line with NK theoretical predictions. These results may be driven by the NK real interest rate channel since I find evidence on a crowding out effect of private spending during normal times and a crowding in effect when the ZLB is binding. However, this finding needs to be carefully interpreted since it might be that the distinct responses of inflation and real interest rates are caused by the difference in output multipliers during normal times and at the ZLB, and not necessarily the other way around. In the case of government investment, my results are less clear-cut. During normal times I obtain an output impact multiplier of about 0.3 percent, whereas it is roughly indistiguisable from zero during ZLB periods. Moreover, I do not find evidence supporting the NK real interest rate channel hypothesis following a government investment shock. All multiplier estimates are statistically significant on impact with the exception of the one after a government investment shock at the ZLB, which is statistically non-significant at all horizons.

These findings are robust to using alternative definitions of ZLB episodes in my sample and an alternative state-dependent baseline specification. My main conclusions also remain intact after controlling for anticipation effects, the state of the business cycle and the exchange rate regime. Therefore, from a policy perspective, my findings support the claim by policymakers and academics of giving fiscal policy a more important role in stimulating the economy when monetary policy is constrained by the ZLB. Most importantly, contrary to what some authors have argued (e.g. Bouakez et al., 2017; Albertini et al., 2014), my findings suggest that when the economy is at the ZLB, the fiscal effort would be even more effective in stimulating the economy if it concentrates on government consumption purchases instead of government investment programmes.

7. References

Albertini, Julien, Poirier, Arthur, and Roulleau-Pasdeloup, Jordan. 2014. “The Composition of Government Spending and the Multiplier at the Zero Lower Bound.” *Economics Letters* 122 (1): 31–35.

Almunia, Miguel, Benetrix, Agustín S., Eichengreen, Barry, O’Rourke, Kevin H., and Rua, Gisela. 2010. “From Great Depression to Great Credit Crisis: Similarities, Differences and Lessons.” *Economic Policy* 25 (62): 219–265.

Aruoba, S. Boragan, Cuba-Borda, Pablo, and Schorfheide, Frank. 2018. “Macroeconomic Dynamics Near the ZLB: A Tale of Two Countries.” *Review of Economic Studies* 85 (1): 87–118.

Auerbach, Alan, and Gorodnichenko, Yuriy. 2012. “Measuring the Output Responses to Fiscal Policy.” *American Economic Journal: Economic Policy* 4 (2): 1–27.

Blanchard, Olivier, and Perotti, Roberto. 2002. “An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output.” *Quarterly Journal of Economics* 117 (4): 1329–1368.

Boehm, Christoph. 2020. “Government Consumption and Investment: Does the Composition of Purchases Affect the Multiplier?” *Journal of Monetary Economics* 115: 80–93.

Bonam, Dennis, De Hann, Jakob, and Soederhuizen, Beau. 2020. “The Effects of Fiscal Policy at the Effective Lower Bound.” *Macroeconomic Dynamics* 26 (1): 1–37.

Bouakez, Hafedh, Guillard, Michel, and Roulleau-Pasdeloup, Jordan. 2017. “Public Investment, Time to Build, and the Zero Lower Bound.” *Review of Economic Dynamics* 23: 60–79.

Caldara, Dario, and Kamps, Christophe. 2017. “The Analytics of SVARs: A Unified Framework to Measure Fiscal Multipliers.” *Review of Economic Studies* 84 (3): 1015–1040.

Christiano, Lawrence, Eichenbaum, Martin, and Rebelo, Sergio. 2011. “When Is the Government Spending Multiplier Large?” *Journal of Political Economy* 119 (1): 78–121.

Coenen, Günter, Erceg, Christopher J., Freedman, Charles, Furceri, Davide, Kumhof, Michael, Lalonde, René, Laxton, Douglas, Lindé, Jasper, Mourougane, Annabelle, Muir, Dirk, Mursula, Susanna, De Resende, Carlos, Roberts, John, Roeger, Werner, Snudden, Stephen, Trabandt, Mathias, and in’t Veld, Jan. 2012. “Effects of Fiscal Stimulus in Structural Models.” *American Economic Journal: Macroeconomics* 4 (1): 22–68.

Corsetti, Giancarlo, Meier, Andre, and Müller, Gernot J. 2012. “What Determines Government Spending Multipliers?” *Economic Policy* 27 (72): 521–565.

Crafts, Nicholas, and Mills, Terence C. 2013. "Fiscal Policy in a Depressed Economy: Was there a 'Free Lunch' in 1930s' Britain?" *CEPR Discussion Papers* 9273.

Dupor, Bill, and Li, Rong. 2015. "The Expected Inflation Channel of Government Spending in the Postwar US." *European Economic Review* 74 (C): 36–56.

Eggertsson, Gauti B. 2011. "What Fiscal Policy Is Effective at Zero Interest Rates?" *NBER Macroecoenomics Annual 2010*, Vol. 25, edited by Daron Acemoglu and Michael Woodford, 59–112. Chicago: University of Chicago Press.

Forni, Mario, and Gambetti, Luca. 2010. "Fiscal Foresight and the Effects of Government Spending." *CEPR Discussion Papers* 7840.

Goode, Ethan, Liu, Zheng, and Lan Nguyen, Thuy. 2021. "Fiscal Multiplier at the Zero Bound: Evidence from Japan." *FRBSF Economic Letter* 2021 (14): 1–5.

Hebous, Shafik. 2011. "The Effects of Discretionary Fiscal Policy on Macroeconomic Aggregates: A Reappraisal." *Journal of Economic Surveys* 25 (4): 674–707.

IMF. 2017. "Seeking Sustainable Growth: Short-Term Recovery, Long-Term Challenges." World Economic Outlook, International Monetary Fund.

Ilzetzki, Ethan, Mendoza, Enrique G., and Végh, Carlos A. 2013. How Big (Small) Are Fiscal Multipliers?" *Journal of Monetary Economics* 60 (2): 239–254.

Jordà, Òscar. 2005. "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95 (1): 161–182.

Kiley, Michael. 2016. "Policy Paradoxes in the New Keynesian Model." *Review of Economic Dynamics* 21: 1–15.

Klein, Mathis, and Winkler, Roland. 2021. "The Government Spending Multiplier at the Zero Lower Bound: International Evidence from Historical Data." *Journal of Applied Econometrics* 36 (6): 744–759.

Leeper, Eric M., Walker, Todd B., and Yang, Shu-Chun Susan. 2013. "Fiscal Foresight and Information Flows." *Econometrica* 81 (3): 1115–1145.

Mertens, Karel, and Ravn, Morten. 2014. "Fiscal Policy in an Expectations-Driven Liquidity Trap." *Review of Economic Studies* 81 (4): 1637–1667.

Miyamoto, Wataru, Nguyen, Thuy L., and Sergeyev, Dmitriy. 2018. "Government Spending Multipliers under the Zero Lower Bound: Evidence from Japan." *American Economic Journal: Macroeconomics* 10 (3): 247–277.

Morita, Hiroshi. 2015. "Japanese Fiscal Policy under the Zero Lower Bound of Nominal Interest Rates: Time-Varying Parameters Vector Autoregression." *Discussion Paper Series* 627, Institute of Economic Research Hitotsubashi University.

Nakamura, Emi, and Steinsson, Jón. 2014. "Fiscal Stimulus in a Monetary Union: Evidence from US Regions." *American Economic Review* 104 (3): 753–792.

Ramey, Valerie A. 2011b. "Identifying Government Spending Shocks: It's All in the Timing." *The Quarterly Journal of Economics* 126 (1): 1–50.

Ramey, Valerie A., and Shapiro, Matthew D. 1998. "Costly Capital Reallocation and the Effects of Government Spending." *Carnegie-Rochester Conference Series on Public Policy* 48 (1): 145–194.

Ramey, Valerie A., and Zubairy, Sarah. 2018. "Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data." *Journal of Political Economy*, 126 (2): 850–901.

Roulleau-Pasdeloup, Jordan. 2018. "The Government Spending Multiplier in a (Mis)Managed Liquidity Trap." *Journal of Money, Credit and Banking* 50 (2–3): 293–315.

Taylor, John B. 1993. "Discretion versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy* 39: 195–214.

Woodford, Michael. 2011. "Simple Analytics of the Government Expenditure Multiplier." *American Economic Journal: Macroeconomics* 3 (1): 1–35.

Appendix A. Data definitions and variable construction

A.1. Main data

My sample covers 1990Q1-2022Q3 and the following 13 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Japan, Netherlands, Norway, Sweden, the UK, and the US. The quarterly time series are retrieved from the OECD Data warehouse and from edition 112 (November 2022) of the OECD Economic Outlook's Statistics and Projections database. This edition was downloaded on 04/05/2023. The variables are summarized in Table A1.

Table A1. Data from the OECD Economic Outlook: Statistics and Projections database

Variable	Variable code	OECD variable name
Real Gross Domestic Product	GDPV	Gross domestic product, volume, market prices
Real Private Consumption	CPV	Private consumption expenditure, volume
Real Private Investment	–	(See A2 for details on construction)
Real Total Investment	ITISKV	Gross capital formation, total, volume
Real Government Consumption	CGV	Government final consumption expenditure, volume
Real Government Investment	IGV	Government gross fixed capital formation, volume
Real Interest Rate	–	(See A2 for details on construction)
Nominal Policy Interest Rate	IRCB	Central bank key interest rate
Long Term Interest Rates	IRL	Long-term interest rate on government bonds
CPI Inflation Rate	–	Inflation (CPI), total
Unemployment Rate	UNR	Unemployment rate

Notes: All variables are in quarterly frequency. All variables come from the edition 112 of the OECD Economic Outlook's Statistics and Projections database, with the exception of CPI inflation rate, which is taken from the OECD Data warehouse at https://data.oecd.org/price/inflation-cpi.htm.

A.2. Notes on variable construction

Real interest rates

I construct real interest rates based on the Fisher equation. This is, by taking the difference between nominal interest rates and expected inflation for next period. In my case, I use the nominal policy interest rate (IRCB) in period t as a measure of nominal interest rates, and CPI inflation rate in period $t+1$ as a measure of expected inflation.

Real private investment

Real private investment is constructed by taking the difference between real total investment (ITISKV) and real government investment (IGV).

Appendix B. Robustness

Table B1. Government consumption and government investment output multipliers: Robustness.

	Government consumption shock		*Government investment shock*	
	Normal times	ZLB	Normal times	ZLB
Baseline				
Impact	0.549***	1.137***	0.328***	-0.069
4 quarters	0.393	-0.039	0.103	-0.215
8 quarters	0.719	-1.203	-0.196	-0.310
Alternative definitions	**of ZLB**			
$\tau = 1.5\%$				
Impact	0.633***	1.150***	0.316***	0.036
4 quarters	0.384	0.248	-0.160	0.633
8 quarters	0.557	-0.290	-0.108	0.393
$\tau = 1.25\%$				
Impact	0.644***	1.072***	0.319***	0.047
4 quarters	0.290	-0.082	-0.129	0.642
8 quarters	0.549	-1.266	-0.239	0.478
$\tau = 0.75\%$				
Impact	0.535***	1.191***	0.316***	-0.111
4 quarters	0.435	0.584	0.124	-0.469
8 quarters	0.868	-1.090	-0.203	-0.076
$\tau = 0.5\%$				
Impact	0.572***	1.202***	0.299***	-0.019
4 quarters	0.619	0.627	0.151	-0.503
8 quarters	1.104*	-1.134	-0.344	-0.099

Table B1. Continued.

	Government consumption shock		*Government investment shock*	
	Normal times	ZLB	Normal times	ZLB
$\tau = 0.25\%$				
Impact	0.704***	1.260***	0.317***	-0.034
4 quarters	0.063	0.536	0.176	-0.496
8 quarters	0.556	-1.436	-0.324	-0.079
Controlling for anticipation				
Impact	0.539***	1.125***	0.330***	-0.083
4 quarters	0.365	0.055	0.150	-0.375
8 quarters	0.750	-0.886	-0.056	0.650
Controlling for business cycle				
Impact	0.549***	0.931**	0.328***	-0.414
4 quarters	0.393	0.837	0.103	0.463
8 quarters	0.719	-0.346	0.002	1.217
Excluding eurozone, except France				
Impact	0.687***	1.152***	0.295***	-0.037
4 quarters	0.430	-0.713	-0.021	-0.014
8 quarters	0.714	-1.494	-0.200	0.196
Alternative state-dependent baseline specification				
Impact	0.566***	1.186***	0.372***	0.026
4 quarters	0.290	0.683	0.101	0.523
8 quarters	0.888	0.058	-0.276	0.297

Notes: Shocks are equivalent to 1% of real GDP. *, **, and *** denote stiatistical significance at the 10%, 5%, and 1% level, respectively.