Optimal Fiscal Policy in a Liquidity Trap at the Zero Lower Bound

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Abstract

We show that in an economy with nominal interest rates at the zero lower bound, monetary policy does not provide the appropriate stimulus. In this setting, we build a New Keynesian dynamic stochastic general equilibrium (DSGE) model to explore the macroeconomic consequences of fiscal expansionary shocks and consolidations during the recent financial crisis of 2008 in Eurozone. We provide novel empirical evidence that fiscal spending in recessions is more efficient from a zero nominal interest rate policy. We also find that in a liquidity trap, the optimal monetary policy with the long-term zero bound commitment proposed by Krugman (1998), becomes effective when associated with an expansionary government spending program to stimulate demand.

JEL classification: E62; E63; E12

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1. Introduction

"*It would be extremely helpful if central banks could count on other policymakers, particularly fiscal policymakers, to take on some of the burden of stabilizing the economy during the next recession*".

Ben Bernanke, 13 September 2016.[1]
Brookings Institute

The financial crisis of 2008 led to a global recession and to an intense debate about the limitations of monetary policy and the efficacy of fiscal stimulus. After years of massive stimulus policies with nominal interest rates at the zero lower bound from the major central banks in the US, Europe, and Japan, inflation remains stubbornly low while the economies have not recovered as much as expected. As explained by the former Federal Reserve Chair Ben Bernanke at the Brookings Institute, and was highlighted a few weeks later by the European Central Bank (ECB) Chair Mario Draghi, central banks are close to the limits of what their stimulus policies (also known as quantitative easing) can achieve, and therefore fiscal policy makers have to take actions and to complement these policies.[2] This is especially the case in Europe where quite recently, though without success since growth remains anaemic, the ECB ramped up its stimulus program repeatedly, cutting deposit interest rates even below zero and accelerating its monthly bond purchase program to about $90 billion.[3] This zero bound nominal interest constraint when expansionary monetary policy fails to stimulate demand, gives rise to a macroeconomic paradox known as a "liquidity trap" that was first considered as a theoretical possibility by Keynes (1936).

For decades the question of what is the appropriate policy when the zero bound constraint is reached, was long considered to be of doubtful practical importance. However, the economic crisis in Japan where the overnight rate has been at zero for most of the time since 1999, along with the global economic recession of 2008 brought renewed interest, and triggered

[1] "Modifying the Fed's policy framework: Does a higher inflation target beat negative interest rates?". Source: https://www.brookings.edu/blog/ben-bernanke/2016/09/13/modifying-the-feds-policy-framework-does-a-higher-inflation-target-beat-negative-interest-rates/
[2] Mario Draghi's speech in the European Parliament, Brussels, 25 September 2016. Source: https://www.ecb.europa.eu/press/key/date/2016/html/sp160926_2.en.html
[3] See, Eser and Schwaab (2016) for a detailed discussion on the Securities Market Program employed by the ECB.

debates about the appropriate policy at the "zero bound constraint". The standard Keynesian prescription, as described by Hicks (1937) in the work that introduced the IS–LM model along with the liquidity trap, is to launch expansionary fiscal measures to stimulate the economy. However, recently Japan applied large fiscal expansions in an attempt to stimulate demand and to escape its liquidity trap without success. Therefore its validity has been challenged and questioned. We address this critical issue, by comparing the effectiveness of a "zero bound policy" and an expansionary fiscal policy in stimulating the four largest Eurozone economies, namely Germany, France, Italy and Spain.

There is an emerging New Keynesian literature which suggests that in a liquidity trap the optimal policy is to change expectations about the future monetary policy (Eggertsson and Woodford, 2003 and 2004). Particularly, Krugman (1998) suggests that policy commitments to keeping the interest rate at zero for longer period compared to the no-commitment policy, is the optimal solution to stimulating an economy. However, this view has recently been challenged by works which show that the best response would be to reduce the government by reducing taxes and spending (Caggiano et al., 2015, Blanchard and Perotti, 2002) and studies which propose an increase in government spending (Beetsma and Giuliodori, 2011; Gemmel et al., 2011; *inter alia*).

To identify the optimal policy for the Eurozone economies to escape from the liquidity trap, we examine how large is the fiscal multiplier in a recession at the zero lower bound under three different policies: (i) An expansionary fiscal policy with increased government spending to stimulate demand; (ii) a fiscal policy with tax cuts to expand supply; and (iii) an optimal monetary policy framework where implementing the proposition made by Krugman (1998) that there is a long-term commitment for zero lower bound interest rates. In doing so, we introduce a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model with short-term nominal interest rate at the zero lower bound constraint, with the four Eurozone economies in a recession and in a liquidity trap. We also employ a Structural Vector Autoregressive (SVAR)

model to empirically calibrate the theoretical model, to quantify and identify the optimal policy under these conditions.

Building on the works of Eggertsson and Woodford (2004) and Eggertsson (2009), the New Keynesian model suggests that the main problem in the liquidity trap is insufficient demand. The results from the fiscal shocks show a significant positive effect on the economies, with the stronger effect observed for the government spending program, implying that the use of fiscal expansion can significantly stimulate an economy at the liquidity trap. More precisely, the implementation of a government spending program (i.e., an increase in consumption and investment) can perfectly stabilize an economy in a time-consistent way, contributing to the works of Beetsma and Giuliodori (2011), Gemmel et al. (2011), Bi et al. (2013), and Caggiano et al. (2015). Importantly, short-term effects on the budget balance can be offset and ameliorated five years after the implementation of this policy.

Additionally, the results imply that this policy has a disadvantage on the inflationary pressures provoked by government spending. Therefore, the model suggests that interest rates must be raised significantly within five years of the implementation of the fiscal expansion, to control for inflationary pressures. Further investigation shows that the optimal monetary policy with the long-term zero bound commitment proposed by Krugman (1998) is more effective, when associated with a government spending program to stimulate demand, hence contributing to the work of Correia et al. (2013). Therefore, the first and foremost policy should be on ways by which a government can increase spending. Alternative policies with tax cuts that expand supply do not have the same power at zero interest rates, contrary to the findings of Blanchard and Perotti (2002).

The remainder of this paper proceeds as follows. Section 2 describes the literature review. Section 3 presents the methodological approach. Section 4 depicts the dataset and analyses the results. Section 5 concludes.

2. Literature review

Eggertsson (2001) pioneers the study of the effect of government spending at a zero interest rate in a New Keynesian DSGE model. That paper characterizes the optimal policy under commitment and discretion, where the government has as policy instruments the short-term nominal interest rate and real government spending and assumes taxes are lump sum. Our paper studies a much more general menu of fiscal instruments, such as the effect of various distortionary taxes and gives more attention to the quantitative effect of fiscal policy. Moreover, the present paper does not take a direct stance on the optimality of fiscal policy but instead focuses on "policy multipliers", that is, the effect of policy at the margin as in Christiano (2004). This allows us to obtain clean closed form solutions and illuminate the general forces at work.

Earlier work on the implications of the zero bound for monetary and fiscal policy was motivated by the prolonged recession in Japan, where overnight rates have been close to zero for the last 15 years, as well as by the low targets for the federal funds rate in the United States in 2003 and 2004. Krugman (1998) and Eggertsson and Woodford (2003, 2004) show that there may be downturns that could (and should) be avoided if it were not for the zero bound. They also show how monetary policy can be adjusted so that the costs of those downturns may be reduced. In particular, they propose policies that keep the interest rate for a longer period at zero to generate inflation. Eggertsson and Woodford (2006) consider both monetary and fiscal policy in a Ramsey taxation model with no capital, with consumption taxes assuming that the prices are sticky inclusive of those taxes. Those taxes can be used to partially offset the effects of the zero bound, and additional taxes, such as labor income taxes, are redundant. They also point out that if there were to be two consumption taxes, such that prices are set after one and before the other, then it would be possible to implement the same allocation as if the zero bound did not bind. They find the use of those taxes to be unrealistic.

This paper also builds upon a large literature on optimal monetary policy at the zero bound, such as Summers (1991), Fuhrer and Madigan (1997), Krugman (1998), Reifschneider

and Williams (2000), Svensson (2001, 2003), Eggertsson and Woodford (2003, 2004), Christiano (2004), Jung, Terenishi, and Watanabe (2005), Wolman (2005), Adam and Billi (2006), and Eggertsson (2006a). The analysis of the variations in labor taxes builds on Eggertsson and Woodford (2004), who study value added taxes (VAT) that show up in a similar manner. One difference is that while they focus mostly on commitment equilibrium (in which fiscal policy plays a small role because optimal monetary commitment does away with most of the problems) the assumption here is that the central bank is unable to commit to future inflation, an extreme assumption, but a useful benchmark.

Neoclassical and New Keynesian models, grounded in intertemporal consumption smoothing behaviour, also tend to suggest that temporary public expenditure cuts and distortionary tax increases reduce output, although with some crowding in of private sector consumption in the case of spending cuts. Giavazzi and Pagano's (1990) analysis of fiscal consolidations in Denmark and Ireland in the 1980s, however, suggests that such fiscal actions could be expansionary, as output growth actually accelerated after these particular fiscal tightening. Briotti's (2005) survey of empirical work considers a wider set of countries over a wider time period and also finds some evidence that fiscal consolidations can be expansionary. The persistence and composition of the consolidation often matter, with government spending cuts being thought to be pro-growth relative to tax increases.

With standard theory unable to produce expansionary consolidations, emphasis has shifted to the role of expectations. Bertola and Drazen (1993) develop a model in which government spending is inherently unsustainable but the government periodically cuts spending to make policy sustainable. These consolidations may occur at a low threshold, but if not, they will definitely occur at a second, higher threshold. A worsening fiscal position raises the probability of soon entering a period of fiscal correction and, therefore, can lead to an expansion. While Bertola and Drazen' (1993) are often cited as an example of the importance of expectations when considering the impact of fiscal policy, it cannot address questions relating to

the composition of consolidations that the empirical literature often finds important. There is now an emerging New Keynesian view of liquidity traps. Krugman (1998) and Eggertsson and Woodford (2003), and more recently Werning (2012) have characterized optimal monetary policy at the zero bound. Their work emphasizes the role of policy commitments. They show that it is optimal to commit to keeping the interest rate at zero for longer than under the no-commitment solution. This increases output and inflation both in the present and in the future—optimally trading off the mitigation of a recession in the present and the creation of a boom in the future. This literature has also emphasized the beneficial effects of fiscal policy.

There is also recent work on public spending multipliers, showing that these can be very large at the zero bound (see, e.g., Christiano, Eichenbaum, and Rebelo 2011). Christiano, Eichenbaum, and Rebelo (2009), building on Christiano (2004), calculate the size of the multiplier of government spending in a much more sophisticated empirically estimated model than previous studies, taking the zero bound explicitly into account. Eggertsson (2009) also considers different alternative taxes and assesses which one is the most desirable to deal with the zero bound. The zero bound is also a key component in the numerical work presented in the evaluation of the American Recovery and Reinvestment Plan by Blanchard, Dell'Ariccia, and Mauro (2010), who argue for a better integration between monetary and fiscal policy.

3. The Model

3.1 The Normal Economy Model

Consider a normal economy where the liquidity wedge is small and leverage is high, similar to Fostel and Geanakoplos (2008). The economy is in an infinite-horizon, comprised of a continuous set of a government (with aggregate consumption), and a central bank which can supply capital to firms, and a firm with internal capital (H), distributed over the support $[0, I]$. The firm is endowed with a pre-existing asset (w) and an opportunity to undertake a new project. The project requires an initial outlay of I at date–0 with an expected payoff or cash flow

(P) at the end of the project in date–2, with $H < I$ and $H + w = I$. As a result, to invest in this project, the firm must borrow capital from banks. To achieve this, the firm can pledge their asset (w) as collateral.

With the economy in this setting, good news and the credit boom correspond to an increase to the price of assets. Building on Gorton and Ordoñez (2014) with the information produced in the normal economy "more and more firms borrow with debt backed by collateral of unknown type (but high perceived quality)", and therefore, the perceived quality of collateral w is high enough. Consequently, in a normal economy, any uncertainty (U) for the quality of the collateral (w) is resolved, even when information is not produced for this asset. The firm has a demand to borrow L, such that the supply of intermediation facing the firm, is at most,

$L = w$, where $w > 0$ (1)

and

$H + L = I$ (2)

while the bank is unwilling to lend more than the amount in Equation (1). If either H or w is small, the firm's ability to participate in the project will be restricted with equilibrium effects on risk premia and asset prices. The project is expected to return a dividend of D_t per unit time at date–1, with $\{D_t\}$ following a geometric Brownian motion (GBM):

$\frac{dD_t}{D_t} = gdt + \sigma dZ_t$, given D_0 (3)

where $g > 0$ and $\sigma > 0$ are constants. Also, $\{Z_t\}$ follows a standard Brownian motion on a complete probability space (Ω, F, P), where P_t is the cash flow generated by the project at date–2. Therefore, the total return at date–2 on the new project is expected to be

$dR_t = \frac{D_t dt + dP_t}{P_t}$ (4)

and

$dR_t > L(1 + r_t)$ (5)

where $\{r_t\}$ is the interest rate process.

The firm takes into account the conditions to borrow as described in Equation (1), and therefore, it is unwilling to invest for a return which is lower than the return expected in Equation (5).

3.2 The cashless economy

In the next stage, the economy is cashless and therefore the uncertainty in period t ≥ 0 is described by the random variable $s_t \epsilon S_t$, where S_t is the crisis economy at t. At this setting, the firm has a set of preferences described over aggregate consumption C_t and leisure L_t., so that:

$$E_0 \sum_{t=0}^{\infty} \beta^t \, u(C_t, L_t, \psi_t) \tag{6}$$

with consumption on:

$$C_t = [\int_0^1 c_{it}^{\frac{\theta-1}{\theta}} di \,]^{\frac{\theta}{\theta-1}} \tag{7}$$

where c_{it} is private consumption of variety $i \in [0,1]$, ψ_t represents a shock, and θ > 1 is the elasticity of substitution between the varieties. Building on Eggertsson and Woodford (2004) and Eggertsson (2009), we introduce a New Keynesian model by providing the following assumptions for the aggregate government consumption in a Dixit-Stiglitz aggregator of public consumption:

$$G_t = \left[\int_0^1 g_{it}^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}} \tag{8}$$

with the following production function for each good i which needs labor n_{it} to be produced:

$$c_{it} + g_{it} = A_t n_{it} \tag{9}$$

and where A_t is the aggregate productivity shock.

We define total labor $N_t$to produce the good as:

$$N_t = \int_0^1 n_{it} \, di \tag{10}$$

The government minimizes the expenditure of the individual goods when:

$$P_t = \left[\int_0^1 P_{it}^{1-\theta}\, di\right]^{\frac{1}{1-\theta}} \tag{11}$$

where P_{it} is the price of variety i.

The continuum household of measure 1 on the other hand minimizes spending on aggregate C_t by choosing the consumption of different varieties so that:

$$\frac{C_{it}}{C_t} = (P_{it}/P_t\ )^{-\theta} \tag{12}$$

Therefore, the aggregate budget constraint becomes:

$$\frac{1}{1+i_i}\bar{B}_t + E_t Q_{t,t+1} B_{t,t+1} = \bar{B}_{t-1} + B_{t-1,t} + (1-\tau_t^n) W_t N_t + \left(1-\tau_t^d\right)\Pi_t - (1+\tau_t^c) P_t C_t -$$

$$T_t,\ t \geq 0 \tag{13}$$

Following the New Keynesian literature, a stimulus plan is introduced where a combination of temporary government spending increases, temporary investment tax credits, and a temporary elimination of sales taxes, all of which can be financed by a temporary increase in capital taxes. Temporarily cutting sales taxes and implementing an investment tax credit are both examples of effective fiscal policy. These tax cuts are helpful not because of their effect on aggregate supply but because they directly stimulate aggregate spending. Similarly, a temporary increase in government spending is effective because it directly increases overall spending in the economy. For government spending to be effective in increasing demand, however, it has to be directed at goods that are imperfect substitutes with private consumption (such as infrastructure spending). Otherwise, government spending will be offset by cuts in private spending, leaving aggregate spending unchanged.

The aggregate demand (AD) is given by two relationships. First, there is the "IS" equation derived from the optimal consumption decision of the household as described above and the resource constraint:

$$\widehat{Y}_t = E_t \widehat{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e) + (\hat{G}_t^N - E_t \hat{G}_{t+1}) + \sigma x^s E_t(\uparrow_{t+1}^s - \uparrow_t^s) + \sigma x^A \uparrow_t^A \tag{14}$$

The monetary policy rule at the zero lower bound is approximated by:

$$i_t = \max\left(0, r_t^e + \varphi_\pi \pi_t + \varphi_y \bar{Y}_t\right) \quad (15)$$

When combining these relationships in next sections, we will simply refer to the result as aggregate demand (AD) as it determines the overall level of spending in the economy given the monetary policy rule. The aggregate supply (AS) is derived from the optimal pricing decision:

$$\pi_t = \kappa \bar{Y}_t \kappa \psi\left(\chi^\omega \uparrow_t^s - \sigma^{-1} \hat{G}_t^N\right) + \beta E_t \pi_{t+1} \quad (16)$$

For a given policy rule for taxes and spending equations (14)–(16) close the model. An approximate equilibrium can now be defined as a collection of stochastic processes for $\{\hat{Y}_t, \pi_t\}$ that satisfy (14) and (16), given an exogenous path for $\{r_t^e\}$, a monetary policy specifying the process $\{i\}$ that satisfies Equation (15) and fiscal policy rules that determine the path for $\{\uparrow_t^s, \uparrow_t^A, \hat{G}_t^N\}$ which are the increase in government spending, and the tax expansionary incentives (tax investment credits, and tax consumer cuts), in a government intervention fiscal policy. Notably, in the short-run period, the economy is subject to the disturbance and the fiscal intervention which is defined as $r_t^e = r_s^e$.

The household maximises the utility subject to the budget constraint, taking the wage rate as given. The model is solved by an approximation around a steady state and we linearize it around a constant solution with positive government debt $\bar{b} > 0$ and zero inflation. The consumption Euler equation of the representative household combined with the resource constraint can be approximated to yield:

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e) + \left(\hat{G}_t - E_t \hat{G}_{t+1}\right) + \sigma \chi^s E_t(\hat{\tau}_{t+1}^s - \hat{\tau}_t^s) \quad (17)$$

where i_t is the one period risk-free nominal interest rate, π_t is inflation, E_t is an expectation operator, and the coefficients are $\sigma, \chi^s > 0$, $\hat{Y}_t \equiv \log \frac{Y_t}{\hat{Y}}$, $G_t \equiv \log \frac{G_t}{\hat{Y}}$, while $\hat{\tau}_t^s \equiv \tau_t^s - \hat{\tau}^s$.

Firms maximize prices similar to Calvo (1983), Correia et al. (2008), and Correia et al. (2013):

$$E_t \sum_{j=0}^{\infty} \alpha^j Q_{t,t+j}\left(1 - \tau_{t+j}^d\right)[p_t y_{t+j} - W_{t+j} - W_{t+j} n_{t+j}] \quad (18)$$

where the output $y_{t+j} = c_{t+j} + g_{t+j}$ must satisfy the production function in Equation (9) and the following demand function:

$$y_{t+j} = \left(\frac{P_t}{P_{t+j}}\right)^{-\theta} Y_{t+j}$$

and the optimal price set is:

$$p_t = \frac{\theta}{\theta-1} E_t \sum_{j=0}^{\infty} \eta_{t,j} \frac{W_{t+j}}{A_{t+j}} \tag{19}$$

where

$$\eta_{t,j} = \frac{(\alpha\beta)^j \frac{1-\tau^d_{t+j} u_c(t+j)}{(1+\tau^C_{t+j})} (P_{t+j})^{\theta-1} Y_{t+j}}{E_t \sum_{j=0}^{\infty} (\alpha\beta)^j \frac{1-\tau^d_{t+j} u_c(t+j)}{(1+\tau^C_{t+j})} (P_{t+j})^{\theta-1} Y_{t+j}} \tag{20}$$

Using the demand functions, the equilibrium for $[C_t, L_t, N_t]$ is characterized by the conditions described in equations (17), (18), (19) and (20) and can be written as:

$$C_t + G_t = \left[\sum_{j=0}^{t+1} \overline{\omega}_j \left(\frac{P_{t-j}}{P_t}\right)^{-\Theta}\right]^{-1} A_t, N_t \tag{21}$$

where $\overline{\omega}_j$ is the share of firms that have set prices j periods before.

Away from the zero bound, monetary policy can implement the first-best allocation with constant taxes on consumption τ_c and labor τ_η. In order for private and public consumption to be the same across varieties, all firms must charge the same price (Equation 21). That can be the case only if firms start at time zero with a common price, p_{-1}.

To solve the model and take the zero bound explicitly into account, we make use of a simple assumption:

Assumption 1: In period 0 there is a shock $r_s^e < \bar{r}$ which reverts to a steady state with a probability 1–μ in every period. We call the stochastic period in which the shock reverts to steady state t_s and assume that (1–μ)(1–βμ)–μσκ > 0.

For the fiscal policy we assume:

Assumption 2: $\hat{\tau}_t^I = \hat{\tau}_t^s = G_t = 0$ forÆ so that the government budget constraint is satisfied

For the monetary policy we assume:

Assumption 3: Short-term nominal interest rates are set so that $\pi_t = 0$. *If this results in* $i_t < 0$ *we assume* $i_t = 0$ *and* π_t *is endogenously determined.*

Given *Assumptions 1* and *2*, the policy commitment in *Assumption 3* this implies that $\pi_t = \hat{Y}_t = 0$ for $t \geq t_s$. In the short run either $\pi_t = \hat{Y}_t = 0$ when the zero bound is not binding and hence $i_t = r_t^e > 0$, or π_t and $\hat{Y}_t$ are determined by the following two equations:

$$\pi_t^s = \kappa \hat{Y}_t^s + \beta\mu E_t \pi_{t+1}^s \tag{22}$$

$$\hat{Y}_t^s = (\mu) E_t \hat{Y}_{t+1}^s + \sigma(\mu) E_t \pi_{t+1}^s + \sigma r_s^e \tag{23}$$

where S denotes the short run and we have substituted for $i_t^s = 0$. Solving these equations we derive our first proposition:

Proposition 1: Suppose assumptions 1, 2, and 3 hold and that $r_t^e < 0$, *then there is a unique bounded solution for output and inflation at the zero short-term interest rates given by:*

$$\pi_t = \pi_s = \frac{1}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa} \kappa\sigma r_s^e < 0 \; for \; 0 \; \leq t \leq t_s \tag{24}$$

$$\hat{Y}_t = \hat{Y}_s = \frac{1-\beta\mu}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa} \sigma r_s^e < 0 \; for \; 0 \leq t \leq t_s \tag{25}$$

The proof of this proposition follows from the fact that one eigenvalue of the equations (22)–(23) has to be outside of the unit circle and the other inside it so the proof follows from Blanchard and Kahn (1980). With this bounded solution we can also derive a short-run evolution of the deficit from *Assumption 2*:

Proposition 2: Suppose assumptions 1, 2, and 3 hold. Then, the deficit in the short run is given by

$$\widehat{D}_s = \frac{\bar{b}}{Y}\hat{b}_t - \frac{\bar{b}}{Y}(1+\bar{\imath})\hat{b}_{t-1} = \frac{\bar{b}}{\bar{Y}}(1+\bar{\imath})(\bar{\imath}_s - \pi_s) - (\bar{\tau}^I + \bar{\tau}^s)\hat{Y}_s =$$

$$\begin{cases} 0 & if \; r_s^e < 0 \\ -\frac{\bar{b}}{Y} r - \frac{\left[\left[\frac{\bar{b}}{Y}\right](1+\bar{\imath})\kappa + (\bar{\tau}^I + \bar{\tau}^s)(1-\beta\mu)\right]}{(1-\mu)(1-\beta\mu)-\mu\sigma\kappa} \sigma r_s^e < 0 & otherwise \end{cases} \tag{26}$$

where $\widehat{D}_s$ *is the deficit.*

4. Empirical findings

4.1 Data analysis

For the empirical investigation, as explained by Beetsma and Giuliodori (2011) the Structural Vector Autoregressive (SVAR) method is the most suitable approach to estimate fiscal shocks on an economy. Building on Romer and Romer (2010) approach on the effects of tax changes –fiscal shocks on the US, we use a comparable dataset among the four largest Eurozone economies which is based on official documents provided by Eurostat, the European Central Bank and Datastream. In particular, we use quarterly data from 03/2002 till 12/2015 of the Gross Domestic Product (GDP), Government Debt, the budget balance, discretionary government spending and investments, private and household consumption, as well as for tax revenue collections.

Figure 1 depicts the fiscal position of the four largest Eurozone economies from 2012 till 2015. The fiscal position is annually re-adjusted to reflect the real deficit or surplus reported by the countries. We observe that the best performing country is Germany, with the highest deficit being at about 4% in the aftermath of the financial crisis of 2008 (i.e. 2008–2010). Notably, since 2012 onwards Germany achieved a marginal fiscal surplus. We also observe that Spain had a fiscal surplus till the crisis of 2008 when government interventions caused an initial deficit of 10% which is now at about 4.5%. Italy and France have a deficit in the area of 3% and 5% respectively.

"Please insert Figure 1 about here"

4.2 Impulse responses

The set of endogenous variables in the baseline structural VAR consists of government purchases g (the sum of government consumption and government investment), cyclically-adjusted net taxes (with country-specific cyclical adjustment) n_t, output (GDP) y, and the long-run nominal interest rate i_l. All the variables are real and in natural logarithms, except for the long-run interest rate, which is in percentage. The variables are entered into the vector

$[g, n_t, y, i_l]0$ while the identification is based on a lower-triangular Cholesky decomposition according to this particular ordering. Hence, the main identifying assumption is that government purchases are not contemporaneously affected by the other variables, and especially they are not affected by GDP. Notably, the cyclically-sensitive spending items (in particular, social benefits and other transfers) are included in net taxes, which are then cyclically adjusted. Further, changes in government purchases are usually contained in the budget law for the coming year, while adjustments during that year tend to be of less importance. Since we focus on impulse responses to government purchases shocks only, the relative ordering of the other variables does not affect the impulse responses, as these variables are all ordered after government purchases (Christiano et al., 1999). We include cyclically-adjusted net taxes (Alesina et al., 2002) rather than unadjusted net taxes to take account of the cross-country heterogeneity in the response of net taxes to changes in output. If there is such heterogeneity, then not accounting for it may jeopardise the correct inferences on the dynamics of the VAR. An additional benefit of including cyclically-adjusted net taxes is that we get a direct insight into the reaction of the fiscal authorities to a spending shock, because it is cyclically-adjusted net taxes that are directly under the government's control.

Our results reveal that the strongest effect on the economy during the recessionary period is achieved by an expansionary fiscal policy driven by an increase in government spending. For example, Figure 2 exhibits the baseline impulse responses from a 1% of GDP increase in government purchases (i.e. consumption + investments) to the output (GDP). The blue lines represent the confidence bands, while the red line shows the effect on the economies of the four Eurozone countries. The linear dashed trend line exhibits the trend caused by the fiscal shock.

"Please insert Figure 2 about here"

Table 1 provides specific results caused in different sectors from the fiscal shock. For all the economies the output increases significantly by at least 3.57% and peaks at 4.67% for Germany, just one year after the fiscal shock. Accordingly, government purchases and the private consumption are positively affected for all the economies. Furthermore, the long-run interest rate has an upward trend, implying that interest rates must be increased soon after the fiscal shock to control for significant inflationary pressures. The higher increase is found to be implemented for Germany. As expected, the budget balance (i.e. fiscal deficit-surplus) is negatively affected in the short-run for all the economies. On the contrary, in the long-run the benefits of the fiscal expansion ameliorate the effect on the budget. Notably, an interesting picture is uncovered for the effect on the cyclically-adjusted net taxes. More precisely, initially net taxes are negatively affected, whilst in the long run they have a positive trend, indicating an increase in the collection of taxes due to the government spending fiscal shock.

"Please insert Table 1 about here"

Figure 3 exhibits the baseline impulse responses from a 1% increase of GDP on government spending to private consumption. Again, there is a significant effect for all the four Eurozone countries. Private consumption rises significantly (red line) at the first years after the shock, when it peaks at about 4%, but it follows a downward trend over the years. The linear dashed trend line exhibits the trend caused by the fiscal shock.

"Please insert Figure 3 about here"

Table 2 shows the findings from the fiscal shock which is caused by a 1% decrease of GDP in taxes. For all the economies the GDP increases, though in a lower level compared to the increase caused by government spending. The stronger impact is found for the German economy with an increase of about 1.5%. Accordingly, government purchases and private consumption are positively affected, but in a lower magnitude compared with the fiscal shock caused by government spending. Importantly, the long-run interest rate does not indicate a

strong response from the fiscal shock, implying that inflationary pressures caused by the tax consolidation fiscal shock are significantly lower. Importantly, small effect is also observed on the budget balance. Surprisingly, we find that there is a positive effect on the effect on the cyclically-adjusted net taxes, indicating that tax consolidations in the short run to stimulate the economy create higher tax revenues in the long run.

"Please insert Table 2 about here"

Figure 4 shows the baseline impulse responses from a 1% increase of GDP on government spending to the budget balance. Notably, the initial negative effect on the budget balance (red line) disappears in the long run, indicating that an increase in government spending stimulates the economy effectively.

"Please insert Figure 4 about here"

Table 3 provides the results motivated by the optimal monetary policy with a long-term commitment as proposed by Krugman (1998). For all the economies the output increases significantly by at least 1.84% (i.e. Germany) and peaks at 2.52% (i.e. France) one year after the implementation of the long-term commitment. We observe that the effect is stronger from a tax-oriented fiscal shock. However, the effect on the economy is smaller compared to the effect triggered by government spending, just one year after the fiscal shock. Accordingly, government purchases, the cyclically adjusted net taxes and private consumption are positively affected for all the economies. Notably, the long-run interest rate has a significant upward trend, implying the existence of meaningful inflationary pressures. Therefore, interest rates must increase from the first year after the implementation of the optimal monetary policy. The higher increase is found to be implemented for Germany, where interest rates must rise up to about 3.5% in the long-run to control inflationary pressures. Interestingly, the budget balance (i.e. fiscal deficit-surplus) is positively affected for all the economies, indicating that this policy might not be ideal to stimulate an economy but it supports the fiscal balance.

"Please insert Table 3 about here"

4.3 Anticipation of time and trend effects

In Table 4 we have adjusted the fiscal shock caused by government spending on the quadratic time and trend effects. By using this adjustment, the model takes into consideration the trend of the economy over the last five years. For all the economies the output increases significantly by at least 3.30% (i.e. Spain) and peaks at 4.37% (for Germany), just one year after the fiscal shock. Accordingly, government purchases and the private consumption are positively affected for all the economies. Furthermore, the long-run interest rate has a moderate upward trend, implying that under this scenario the inflationary pressures are not significant. The higher increase is found again to be implemented for Germany at 1.90%, five years after the fiscal shock. As expected, the budget balance (i.e. fiscal deficit-surplus) is negatively affected in the short-run for all the economies. On the contrary, in the long-run the benefits of the fiscal expansion ameliorate the effect on the budget. Finally, the effect is initially negative on the cyclically-adjusted net taxes, but in the long run there is a positive trend, indicating an increase in the collection of taxes.

"Please insert Table 4 about here"

In Table 5 we adjust the fiscal shock caused by the consolidation in taxes on the quadratic time and trend effects. For all the economies the GDP increases, though in a lower level compared to the increase caused by the adjusted government spending. The stronger impact is found for the German economy with an increase of about 1.3%. Accordingly, the cyclically adjusted net taxes. government purchases and private consumption are positively affected, but in a lower magnitude compared with the fiscal shock caused by government spending. Notably, the long-run interest rate does not follow an upward trend, implying that under this scenario there are no inflationary pressures. Importantly, small effect is also observed on the budget balance.

"Please insert Table 5 about here"

In Table 6 we have adjusted the optimal monetary policy with the long-term commitment on the quadratic time and trend effects. For all the economies the output increases significantly by at least 1.71% (i.e. Germany) and peaks at 2.44% (i.e. Spain) one year after the implementation of the long-term commitment. We observe that the effect is stronger from the adjusted tax-oriented fiscal shock. However, the effect on the economy is smaller compared to the effect triggered by the adjusted government spending policy. Accordingly, government purchases, the cyclically adjusted net taxes and private consumption are positively affected for all the economies. Notably, the long-run interest rate implies the existence of meaningful inflationary pressures. Therefore, interest rates must increase from the first year after the implementation of the optimal monetary policy. The higher increase is found to be implemented for France, where interest rates must rise up to about 2.59% in the long-run to control inflationary pressures. Interestingly, the budget balance (i.e. fiscal deficit-surplus) is positively affected for all the economies, indicating that this policy supports a disciplined fiscal budget.

"Please insert Table 6 about here"

4.4 The effect of high debt

In Table 7 we adjust the fiscal shock caused by government spending on the scenario of high Debt/GDP ratio (i.e. >120%). For all the economies the output increases significantly by at least 2.37% (i.e. Spain) and peaks at 3.41% for Germany, just one year after the fiscal shock. Compared to the results provided in Table 1 where the debt levels were not affecting the fiscal shock, we observe that the effect in the economies is smaller in magnitude. Accordingly, government purchases and the private consumption are positively affected in a smaller magnitude for all the economies. However, the long-run interest rate has a small upward trend, implying that inflationary pressures caused by government spending the fiscal shocks are small. As expected, the budget balance (i.e. fiscal deficit-surplus) is negatively affected in the short-run for all the economies.

"Please insert Table 7 about here"

In Table 8 we adjust the fiscal shock caused by the consolidation in taxes on the scenario of high Debt/GDP ratio (i.e. >120%). For all the economies the GDP increases, though in a lower level compared to the increase caused by government spending even for the scenario of high Debt/GDP ratio. The stronger impact is found to exist for the German economy with an increase of about 0.73%, just one year after the fiscal shock. Accordingly, the cyclically adjusted net taxes, government purchases and private consumption are positively affected, but in a lower magnitude compared with the fiscal shock caused by government spending. Notably, the long-run interest rate does not follow an upward trend, implying that under this scenario there are no inflationary pressures.

"Please insert Table 8 about here"

In Table 9 we adjust the optimal monetary policy with the long-term commitment on the scenario of high Debt/GDP ratio (i.e. >120%). For all the economies the output increases significantly by at least 0.98% (i.e. Germany) and peaks at 1.62% (i.e. Italy), one year after the implementation of the long-term commitment. We observe that the effect is stronger than the tax-oriented fiscal shock. However, the effect on the economy is smaller compared to the effect triggered by the government spending policy. Accordingly, government purchases, the cyclically adjusted net taxes and private consumption are positively affected for all the economies. Notably, the long-run interest rate implies the existence of meaningful inflationary pressures. Therefore, interest rates must increase from the first year after the implementation of the optimal monetary policy. The higher increase is found to be implemented for France and Spain, where interest rates must rise up to about 2.28% and 2.29% accordingly, in the long-run to control inflationary pressures. Interestingly, the budget balance (i.e. fiscal deficit-surplus) is positively affected for all the economies, indicating that this policy supports a disciplined fiscal budget.

"Please insert Table 9 about here"

4.5 Fiscal versus Monetary Policy: The Multiplier

In Table we compare the effectiveness of the fiscal and the monetary multiplier on the economy (ΔY). In particular, we use two scenarios. The first scenario is with positive nominal interest rates in the economy and the second scenario is with zero nominal interest rates. Based on these scenarios we quantify the effect of two fiscal multipliers (i.e. government spending fiscal shock (ΔG) and tax reduction fiscal shock (Δt) with the effects of the interest rates (Δi) as implemented by the monetary policy. The results show that the government spending fiscal multiplier has the strongest impact on the economy. Particularly, in the positive interest rate area the multiplier is at least 1.09 (i.e. France). When this fiscal policy is associated with the zero bound policy, the multiplier increases significantly to 1.98 (i.e. Spain). The smaller multiplier, and hence the less effective policy, is the fiscal shock with tax reductions. In this case, the multiplier is always lower than 1. Importantly, the results imply that the effectiveness of the zero lower bound policy increases significantly when it is associated with a government spending fiscal expansion policy.

"Please insert Table 10 about here"

Figure 5 exhibits the comparison between the three multipliers. The government spending fiscal shock multiplier (red line) has the strongest effect on stimulating the economy, followed by the zero bound policy multiplier (green line), whilst the tax reduction fiscal shock (solid purple line) has the smallest effect. The blue line represents the trend on the economy when using these policies.

"Please insert Figure 5 about here"

5. Conclusion

In this article we study the optimal policy in a financial crisis and at the zero lower bound for the four largest Eurozone economies, by introducing a New Keynesian Dynamic Stochastic Gerneral Equilibrium (DSGE) model. The main problem identified in the liquidity trap is

insufficient demand. Therefore, we implement two policies that stimulate demand: A government spending program and a tax cut program. The fiscal shocks show a significant positive effect on the economies, with the stronger effect observed for the government spending program.

Overall, the results imply that the use of fiscal expansion can significantly stimulate an economy at the liquidity trap. More precisely, the implementation of a government spending program (i.e. an increase in consumption and investment) can perfectly stabilize an economy in a time-consistent (maximum three years from the implementation) with a positive long-run effect on the revenues. Importantly, the short-term effect on the budget balance can be offset and improved five years after the implementation of this policy. The results also revealed that this policy has a disadvantage on the inflationary pressures caused by government spending. Indeed, we find that interest rates must be increased significantly within five years of the implementation of fiscal expansion to control inflation. Further investigation shows that the optimal monetary policy with the long-term zero bound commitment proposed by Krugman (1998) is more effective, when associated with a government spending program, to stimulate demand. Therefore, the first and foremost policy should be on ways in which a government can increase spending. Alternative policies with tax cuts that expand supply do not have the same power at zero interest rates.

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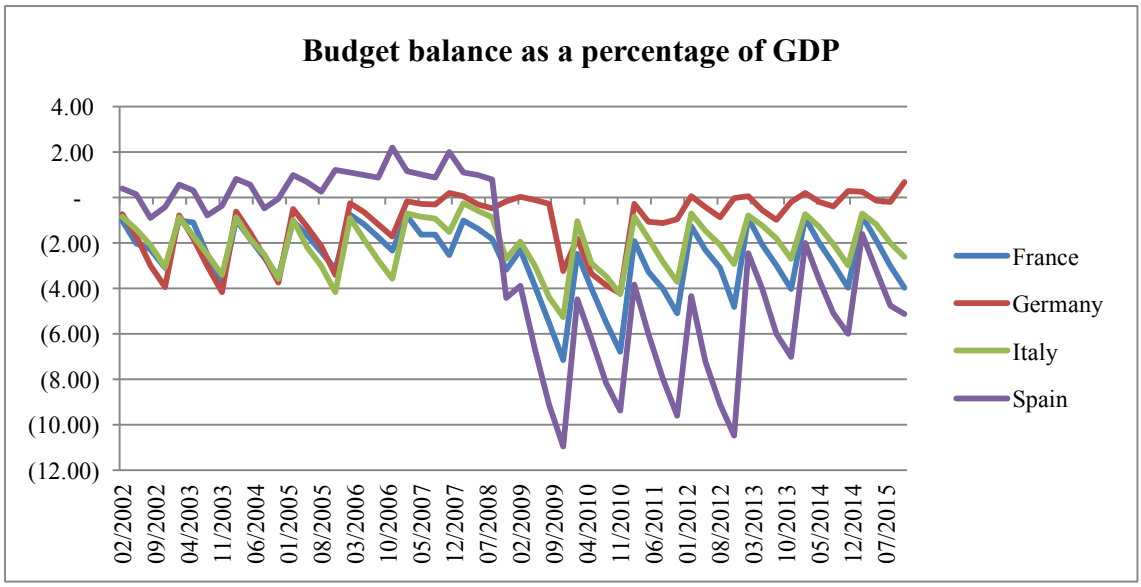

Figure 1. Budget balance as a percentage of GDP.
Note: The figure exhibits quarterly changes on the budget balance for the four large Eurozone economies, from 2002 till 2015.

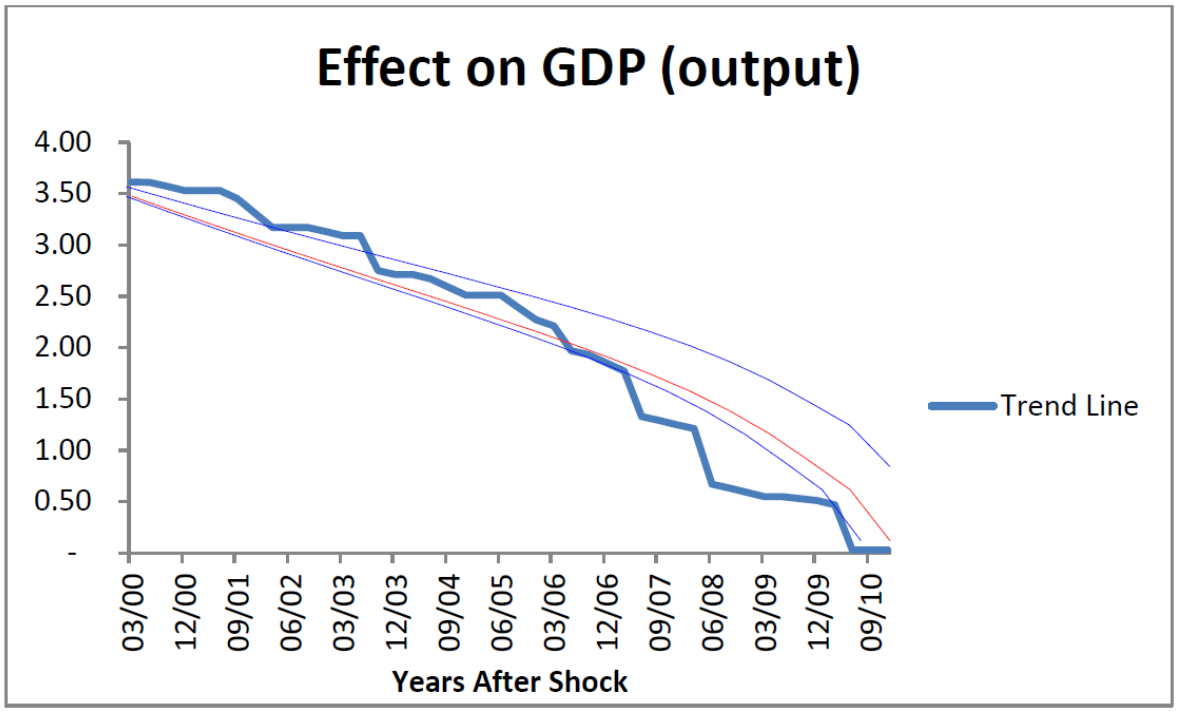

Figure 2. Responses after a government purchases shock of 1% of GDP on the output.
Note: Confidence bands (the light blue lines) are the 5th and the 95th percentiles from Monte Carlo simulations based on 5,000 replications. The red line provides the median estimation over the replications. The solid blue line shows the trend caused on the GDP from the fiscal shock.

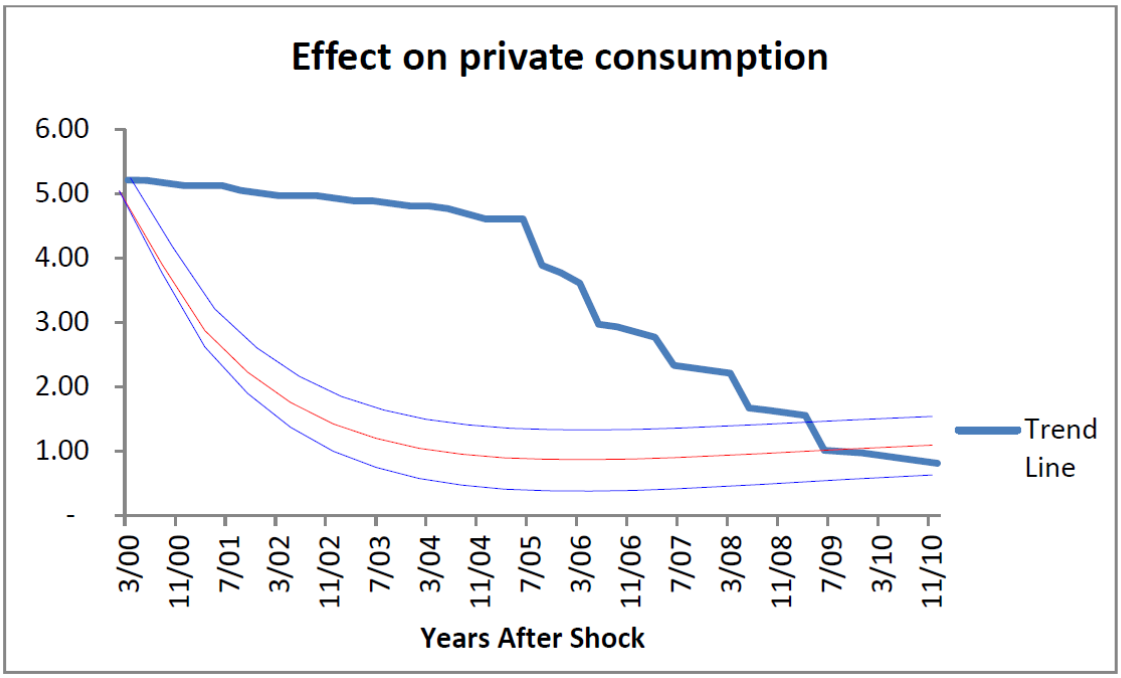

Figure 3. Responses after a government purchases shock of 1% of GDP on private consumption.
Note: Confidence bands (the light blue lines) are the 5th and the 95th percentiles from Monte Carlo simulations based on 5,000 replications. The red line provides the median estimation over the replications. The solid blue line shows the trend caused on private consumption from the fiscal shock.

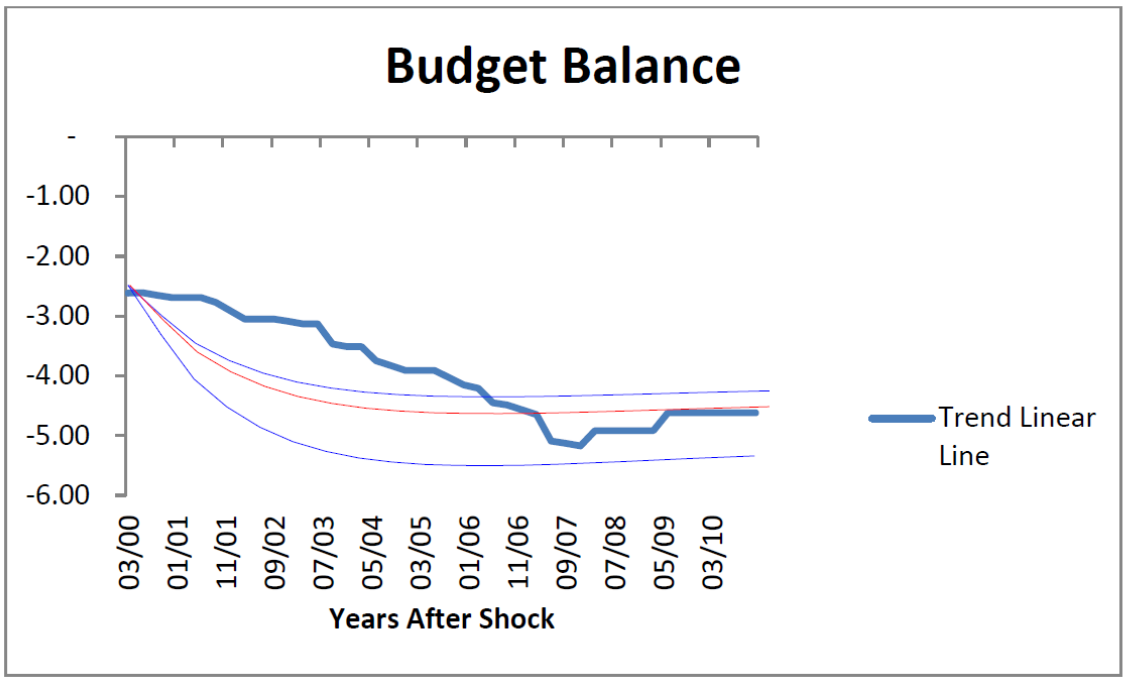

Figure 4. Responses after a government purchases shock of 1% of GDP on the budget balance.
Note: Confidence bands (the light blue lines) are the 5th and the 95th percentiles from Monte Carlo simulations based on 5,000 replications. The red line provides the median estimation over the replications. The solid blue line shows the trend caused on the budget balance from the fiscal shock.

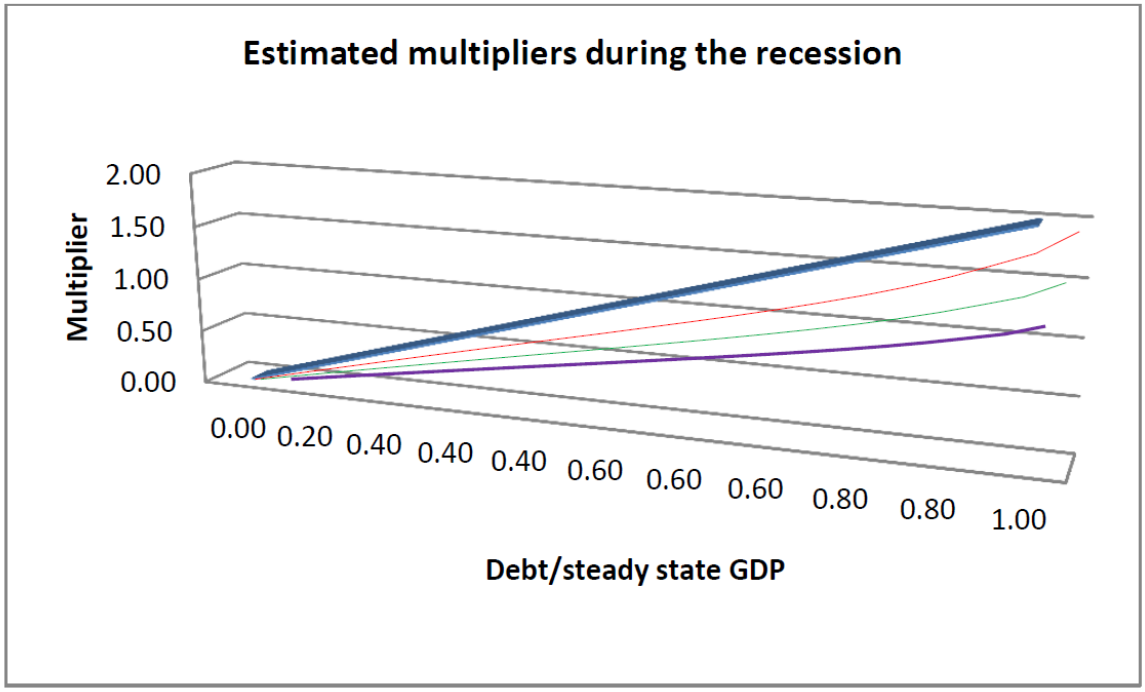

Figure 5. Cumulative estimation of the fiscal and monetary multipliers.

Table 1. Responses to a government purchases increase – Fiscal spending shock of 1% of GDP.

	Impact effect	After one year	After three years	After five years
Baseline – France				
Output	4.01*	4.39*	3.75*	2.43*
Net taxes	–0.53*	–0.48	0.26	0.30
Government purchases	1.64*	1.96*	1.35*	0.47*
Private consumption	1.28*	1.59*	0.94*	0.38*
Long-run interest rate	1.95*	0.46	2.08*	2.61*
Budget balance/GDP	–0.73*	–0.62*	–0.47*	–0.28*
Baseline – Germany				
Output	4.11*	4.67*	3.92*	2.86*
Net taxes	0.29*	–0.05	0.36	0.41
Government purchases	2.01*	2.42*	1.80*	0.93*
Private consumption	1.43*	1.70*	0.97*	0.45*
Long-run interest rate	2.37*	0.94	2.40*	3.36*
Budget balance/GDP	–0.46*	–0.58*	–0.39*	–0.24*
Baseline – Italy				
Output	3.89*	4.24*	3.56*	1.94*
Net taxes	–1.20*	–0.67	–0.21	0.11
Government purchases	1.48*	1.72*	1.18*	0.30*
Private consumption	1.12*	1.36*	0.72*	0.31*
Long-run interest rate	1.97*	0.29	1.56	3.00*
Budget balance/GDP	–1.03*	–1.14*	–0.72*	–0.36*
Baseline – Spain				
Output	3.57*	4.08*	3.10*	1.53*
Net taxes	–1.48*	–1.02	–0.44	–0.26
Government purchases	1.10*	1.46*	0.95*	0.20*
Private consumption	1.03*	1.20*	0.62*	0.28*
Long-run interest rate	1.88*	0.21	1.14	2.76*
Budget balance/GDP	–1.28*	–1.33*	–0.92*	–0.55*

Note: The shock is an increase in government purchases equal to 1% of GDP. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 2. Responses to a Tax consolidation– Fiscal shock of 1% of GDP

	Impact effect	After one year	After three years	After five years
Baseline – France				
Output	1.24*	1.35*	0.66*	0.18*
Net taxes	–0.78*	–0.51	0.07	0.22
Government purchases	0.81*	0.94*	0.35*	0.10*
Private consumption	0.43*	0.51*	0.11*	0.07*
Long-run interest rate	0.03*	0.04	0.02	0.00*
Budget balance/GDP	–0.26*	–0.34*	–0.13*	–0.05*
Baseline – Germany				
Output	1.47*	1.83*	0.70*	0.24*
Net taxes	–0.85*	–0.74	0.02	0.30
Government purchases	1.02*	1.20*	0.52*	0.24*
Private consumption	0.46*	0.55*	0.18*	0.08*
Long-run interest rate	0.05*	0.07	0.03*	0.02
Budget balance/GDP	–0.31*	–0.42*	–0.18*	–0.10*
Baseline – Italy				
Output	1.02*	1.26*	0.51*	0.04*
Net taxes	–0.59*	–0.45	0.06	0.23
Government purchases	0.70*	0.76*	0.25*	0.08*
Private consumption	0.22*	0.30*	0.08*	0.02*
Long-run interest rate	0.02*	0.03	0.01	0.01
Budget balance/GDP	–0.24*	–0.33*	–0.12*	–0.03*
Baseline – Spain				
Output	0.77*	0.91*	0.33*	0.01*
Net taxes	–0.52*	–0.40	0.06	0.24
Government purchases	0.53*	0.62*	0.11*	0.02*
Private consumption	0.18*	0.24*	0.05*	0.01*
Long-run interest rate	0.01*	0.02	0.00	0.00
Budget balance/GDP	–0.22*	–0.28*	–0.07*	–0.01*

Note: The shock is a tax cut equal to 1% of GDP. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 3. Responses to the zero bound policy with long-term commitment (Krugman, 1998)

	Impact effect	After one year	After three years	After five years
Baseline – France				
Output	2.06*	2.52*	1.83*	0.61*
Net taxes	0.47*	0.66	0.37	0.19
Government purchases	0.90*	1.08*	0.30*	0.09*
Private consumption	0.58*	0.82*	0.31*	0.14*
Long-run interest rate	2.47*	0.84	2.32*	2.98*
Budget balance/GDP	0.26*	0.12*	0.34*	0.72*
Baseline – Germany				
Output	1.84*	2.13*	1.66*	0.57*
Net taxes	0.36*	0.52	0.28	0.10
Government purchases	0.96*	1.10*	0.42*	0.10*
Private consumption	0.54*	0.79*	0.35*	0.18*
Long-run interest rate	2.78*	0.91	2.75*	3.51*
Budget balance/GDP	0.40*	0.27*	0.50*	0.81*
Baseline – Italy				
Output	2.14*	2.47*	1.92*	0.71*
Net taxes	0.49*	0.68	0.37	0.21
Government purchases	0.92*	1.19*	0.35*	0.11*
Private consumption	0.66*	0.90*	0.37*	0.15*
Long-run interest rate	2.33*	0.52	2.00	3.16*
Budget balance/GDP	0.25*	0.09*	0.38*	0.78*
Baseline – Spain				
Output	2.18*	2.48*	1.97*	0.79*
Net taxes	0.48*	0.71	0.40	0.14
Government purchases	0.93*	1.24*	0.36*	0.09*
Private consumption	0.68*	0.94*	0.41*	0.19*
Long-run interest rate	2.37*	0.61	2.19	3.11*
Budget balance/GDP	0.30*	0.13*	0.40*	0.80*

Note: The change is commitment for a long-term zero bound policy. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 4. Responses to a government purchases increase – Fiscal spending shock of 1% of GDP

	Impact effect	After one year	After three years	After five years
Quadratic time effects and trends – France				
Output	3.92*	4.19*	3.61*	2.20*
Net taxes	–0.59*	–0.52	0.21	0.27
Government purchases	1.58*	1.89*	1.31*	0.34*
Private consumption	1.15*	1.42*	0.86*	0.30*
Long-run interest rate	1.19*	0.21	0.90*	1.75*
Budget balance/GDP	–0.76*	–0.68*	–0.53*	–0.34*
Quadratic time effects and trends – Germany				
Output	4.02*	4.38*	3.76*	2.29*
Net taxes	0.23*	–0.09	0.21	0.38
Government purchases	1.75*	2.10*	1.54*	0.76*
Private consumption	1.23*	1.50*	0.92*	0.36*
Long-run interest rate	1.20*	0.23	0.97*	1.90*
Budget balance/GDP	–0.41*	–0.44*	–0.31*	–0.13*
Quadratic time effects and trends – Italy				
Output	3.61*	4.02*	3.37*	1.70*
Net taxes	–1.39*	–0.74	–0.28	0.02
Government purchases	1.32*	1.48*	0.88*	0.19*
Private consumption	0.90*	1.06*	0.63*	0.27*
Long-run interest rate	1.12*	0.16	0.67	1.28*
Budget balance/GDP	–1.48*	–1.82*	–0.95*	–0.61*
Quadratic time effects and trends – Spain				
Output	3.30*	3.87*	2.96*	1.11*
Net taxes	–1.82*	–1.45	–0.78	–0.44
Government purchases	0.91*	1.20*	0.76*	0.17*
Private consumption	0.82*	1.01*	0.53*	0.20*
Long-run interest rate	1.06*	0.12	0.61	1.23*
Budget balance/GDP	–1.53*	–1.89*	–0.98*	–0.72*

Note: The shock is an increase in government purchases equal to 1% of GDP. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 5. Responses to a Tax consolidation – Fiscal shock of 1% of GDP

	Impact effect	After one year	After three years	After five years
Quadratic time effects and trends – France				
Output	1.06*	1.12*	0.60*	0.13*
Net taxes	–0.86*	–0.59	0.01	0.20
Government purchases	0.74*	0.90*	0.31*	0.08*
Private consumption	0.38*	0.43*	0.09*	0.05*
Long-run interest rate	0.03*	0.03	0.02	0.00*
Budget balance/GDP	–0.34*	–0.45*	–0.18*	–0.09*
Quadratic time effects and trends – Germany				
Output	1.30*	1.57*	0.61*	0.22*
Net taxes	–0.89*	–0.75	0.01	0.24
Government purchases	0.95*	1.12*	0.48*	0.21*
Private consumption	0.42*	0.50*	0.12*	0.03*
Long-run interest rate	0.03*	0.03	0.02*	0.01
Budget balance/GDP	–0.35*	–0.48*	–0.19*	–0.12*
Quadratic time effects and trends – Italy				
Output	0.94*	1.10*	0.45*	0.03*
Net taxes	–0.62*	–0.47	0.01	0.20
Government purchases	0.63*	0.71*	0.20*	0.04*
Private consumption	0.18*	0.25*	0.04*	0.01*
Long-run interest rate	0.02*	0.02	0.01	0.01
Budget balance/GDP	–0.29*	–0.38*	–0.16*	–0.09*
Quadratic time effects and trends – Spain				
Output	0.68*	0.80*	0.27*	0.00*
Net taxes	–0.59*	–0.51	0.01	0.10
Government purchases	0.48*	0.55*	0.07*	0.01*
Private consumption	0.14*	0.19*	0.03*	0.01*
Long-run interest rate	0.01*	0.01	0.00	0.00
Budget balance/GDP	–0.29*	–0.36*	–0.04*	–0.01*

Note: The shock is a tax cut equal to 1% of GDP. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance/GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 6. Responses to the zero bound policy with long-term commitment (Krugman, 1998)

	Impact effect	After one year	After three years	After five years
Quadratic time effects and trends – France				
Government purchases	1.97*	2.28*	1.70*	0.54*
Net taxes	0.42*	0.61	0.33	0.15
Output	0.82*	1.00*	0.27*	0.08*
Private consumption	0.51*	0.76*	0.26*	0.11*
Long-run interest rate	1.85*	0.51	1.70*	2.59*
Budget balance/GDP	0.20*	0.07*	0.29*	0.41*
Quadratic time effects and trends – Germany				
Government purchases	1.71*	2.01*	1.62*	0.54*
Net taxes	0.34*	0.50	0.27	0.10
Output	0.93*	1.08*	0.40*	0.09*
Private consumption	0.52*	0.77*	0.31*	0.16*
Long-run interest rate	2.00*	0.68	1.84*	2.21
Budget balance/GDP	0.37*	0.24*	0.45*	0.76*
Quadratic time effects and trends – Italy				
Government purchases	2.02*	2.40*	1.88*	0.63*
Net taxes	0.44*	0.61	0.34	0.17
Output	0.88*	1.07*	0.30*	0.08*
Private consumption	0.61*	0.80*	0.33*	0.11*
Long-run interest rate	1.98*	0.36	1.59	2.48*
Budget balance/GDP	0.22*	0.02*	0.30*	0.71*
Quadratic time effects and trends – Spain				
Government purchases	2.04*	2.44*	1.91*	0.65*
Net taxes	0.46*	0.67	0.36	0.12
Output	0.91*	1.20*	0.33*	0.06*
Private consumption	0.62*	0.90*	0.37*	0.16*
Long-run interest rate	2.01*	0.42	1.65	2.53*
Budget balance/GDP	0.25*	0.01*	0.26*	0.51*

Note: The change is commitment for a long-term zero bound policy. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 7. Responses to a government purchases increase – Fiscal spending shock of 1% of GDP

	Impact effect	After one year	After three years	After five years
Anticipated effects – Debt/GDP>120% – France				
Government purchases	3.11*	3.25*	2.40*	1.03*
Net taxes	–0.68*	–0.59	0.03	0.21
Output	1.40*	1.61*	1.14*	0.27*
Private consumption	1.00*	1.34*	0.69*	0.23*
Long-run interest rate	1.12*	0.17	0.80*	1.68*
Budget balance/GDP	–0.81*	–0.73*	–0.59*	–0.41*
Anticipated effects – Debt/GDP>120% – Germany				
Government purchases	3.12*	3.41*	2.60*	1.07*
Net taxes	0.19*	–0.15	0.18	0.32
Output	1.60*	1.78*	1.33*	0.51*
Private consumption	1.01*	1.22*	0.79*	0.28*
Long-run interest rate	1.02*	0.12	0.83*	1.66*
Budget balance/GDP	–0.48*	–0.51*	–0.35*	–0.17*
Anticipated effects – Italy				
Government purchases	2.70*	3.19*	2.21*	0.58*
Net taxes	–1.47*	–0.92	–0.39	–0.10
Output	1.16*	1.27*	0.72*	0.15*
Private consumption	0.75*	0.89*	0.58*	0.22*
Long-run interest rate	0.97*	0.10	0.48	1.17*
Budget balance/GDP	–1.59*	–1.91*	–1.06*	–0.78*
Anticipated effects – Spain				
Government purchases	2.37*	2.74*	1.51*	0.27*
Net taxes	–1.97*	–1.68	–0.92	–0.63
Output	0.75*	0.98*	0.59*	0.11*
Private consumption	0.60*	0.81*	0.40*	0.12*
Long-run interest rate	0.92*	0.07	0.42	1.01*
Budget balance/GDP	–1.78*	–2.01*	–1.44*	–0.96*

Note: The shock is an increase in government purchases equal to 1% of GDP. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 8. Responses to a Tax consolidation – Fiscal shock of 1% of GDP

	Impact effect	After one year	After three years	After five years
Anticipated effects – France				
Government purchases	0.39*	0.46*	0.22*	0.11*
Net taxes	–0.93*	–0.67	–0.19	0.02
Output	0.65*	0.83*	0.20*	0.05*
Private consumption	0.30*	0.36*	0.07*	0.03*
Long-run interest rate	0.02*	0.02	0.01	0.00*
Budget balance/GDP	–0.45*	–0.58*	–0.31*	–0.20*
Anticipated effects – Germany				
Government purchases	0.47*	0.73*	0.50*	0.17*
Net taxes	–0.97*	–0.89	–0.34	–0.07
Output	0.82*	0.99*	0.41*	0.19*
Private consumption	0.35*	0.40*	0.08*	0.01*
Long-run interest rate	0.03*	0.03	0.02*	0.01
Budget balance/GDP	–0.44*	–0.56*	–0.28*	–0.15*
Anticipated effects – Italy				
Government purchases	0.29*	0.41*	0.25*	0.01*
Net taxes	–0.73*	–0.55	–0.27	0.02
Output	0.55*	0.62*	0.13*	0.02*
Private consumption	0.14*	0.20*	0.03*	0.00
Long-run interest rate	0.01*	0.01	0.00	0.00
Budget balance/GDP	–0.47*	–0.59*	–0.38*	–0.25*
Anticipated effects – Spain				
Government purchases	0.14*	0.53*	0.18*	0.00*
Net taxes	–0.74*	–0.69	–0.30	–0.06
Output	0.41*	0.48*	0.04*	0.01*
Private consumption	0.11*	0.16*	0.01*	0.00
Long-run interest rate	0.01*	0.01	0.00	0.00
Budget balance/GDP	–0.52*	–0.65*	–0.43*	–0.27*

Note: The shock is a tax cut equal to 1% of GDP. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 9. Responses to the zero bound policy with long-term commitment (Krugman, 1998)

	Impact effect	After one year	After three years	After five years
Anticipated effects – France				
Government purchases	1.12*	1.36*	0.62*	0.10*
Net taxes	0.34*	0.52	0.21	0.11
Output	0.76*	0.93*	0.23*	0.06*
Private consumption	0.45*	0.70*	0.22*	0.09*
Long-run interest rate	1.76*	0.40	1.52*	2.28*
Budget balance/GDP	0.07*	–0.23*	0.01*	0.30*
Anticipated effects – Germany				
Government purchases	0.98*	1.17*	0.60*	0.14*
Net taxes	0.29*	0.42	0.23	0.08
Output	0.87*	0.98*	0.34*	0.07*
Private consumption	0.48*	0.72*	0.25*	0.12*
Long-run interest rate	1.83*	0.44	1.52*	2.01
Budget balance/GDP	0.30*	0.20*	0.41*	0.72*
Anticipated effects – Italy				
Government purchases	1.23*	1.62*	0.85*	0.19*
Net taxes	0.34*	0.51	0.24	0.13
Output	0.81*	0.92*	0.27*	0.06*
Private consumption	0.58*	0.74*	0.29*	0.09*
Long-run interest rate	1.64*	0.28	1.33	2.18*
Budget balance/GDP	0.10*	–0.19*	0.22*	0.47*
Anticipated effects – Spain				
Government purchases	1.20*	1.57*	0.94*	0.18*
Net taxes	0.40*	0.59	0.31	0.08
Output	0.83*	0.93*	0.29*	0.07*
Private consumption	0.56*	0.72*	0.24*	0.08*
Long-run interest rate	1.71*	0.31	1.40	2.29*
Budget balance/GDP	0.06*	–0.30*	–0.04*	0.32*

Note: The change is commitment for a long-term zero bound policy. Further, * denotes statistical significance at the 10% level. The impulse responses are expressed in percentage of the underlying variable, except for the long-run interest rate, which is in basis points, and the budget balance / GDP ratio, which is in percentage of GDP. The model in first differences displays the cumulative responses.

Table 10. The multiplier on Fiscal expansion versus Zero lower bound policy.

	i>0 (positive interest rate)	i=0 (zero lower bound)
	GDP effect	GDP effect
France		
ΔY/ΔGs	1.090	1.843
ΔY/Δtc	0.482	0.619
ΔY/Δi	0.288	0.856
Germany		
ΔY/ΔGs	1.173	1.829
ΔY/Δtc	0.639	0.850
ΔY/Δi	0.424	1.048
Italy		
ΔY/ΔGs	1.135	1.973
ΔY/Δtc	0.267	0.451
ΔY/Δi	0.204	0.918
Spain		
ΔY/ΔGs	1.124	1.986
ΔY/Δtc	0.201	0.373
ΔY/Δi	0.115	0.839

Note: The Table compares the effect of the three policies on the Eurozone economies (ΔY) via quantifying the three multipliers: (i) government purchases fiscal expansion multiplier (i.e. ΔGs); (ii) tax cuts fiscal multiplier (Δtc); and (iii) the effect of interest rates on stimulating the Eurozone economies (Δi). i>0 implies that the economy is in a positive nominal interest rate territory, while i=0 exists when the zero lower bound policy is in effect.