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Seminar Paper in "Recent Research in Macroeconomics"

Replication of Erceg & Lindé (2012):

Is there a Fiscal Free Lunch in a Liquidity Trap?

Denis Maciel & Tobias Müller

supervised by
Prof. Dr. Mathias Trabandt

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I Introduction

The financial crisis in 2007/08 and the following worldwide recession marked a turning point in the economic and public debate about optimal fiscal and monetary policy. In the aftermath of the great recession, economists discussed about the effectiveness of expansionary fiscal policy to stabilize the economy and stimulate the private sector. In this debate the fiscal multiplier has received special attention.
In the the aftermath of the crisis, governments and central banks launched unconventional and in part uncharted measures to mitigate the harmful consequences of a prolonged recession. The strong reduction in the nominal interest rate was very preeminent among those measures because many central banks reduced the interest rates down to zero. Since the zero lower bound was hit and monetary policy exhausted one of its main tools, fiscal policy became more relevant. This new state of affairs gave birth to a literature increasingly concerned with fiscal policy and the government spending multiplier. This literature stresses the effectiveness of government spending in cases where monetary policy has already brought interest rates to zero and the economy finds itself in a liquidity trap.

In this context, the authors Christopher Erceg and Jesper Lindé address in the paper *"Is there a Fiscal Free Lunch in a liquidity trap?"* the question whether policymakers should limit the size of the government spending. They do so by writing a model in which the liquidity trap is endogenously determined and then by calculating the multiplier schedule for different calibrations. They also draw the very important distinction between marginal and average spending multiplier, which is crucial for policymakers to better understand the effects of changes in government spending. Finally, the paper provides new insights into how fiscal spending and austerity impact the government budget in a liquidity trap.

In our paper, we try to replicate the basic results of Erceg and Lindé (2014) using Dynare. It is organized as follows. In Section II, we discuss briefly the current literature about the government spending multiplier and explain the main results of the analyzed paper. In Section III, we concentrate on the key equations of the paper, explain the structure of the model and the underlying microeconomics of the simple New Keynesian model. In Section IV, we present the results of the impulse response functions to show how the model reacts to an exogenous consumption taste shock and a government spending hike. We also analyze how the results vary if we change the slope of the Phillips curve or the parameters of the monetary rule. In Section V, we dive deeper into the concept of multiplier and explain the distinction between *marginal* and *average* multiplier. We show that the variation of the fiscal multiplier depends highly on the size of the government response and on the average contract duration (the Calvo parameter). In Section VI, we analyze the impacts of an increase in government spending on the government budget and answer the question wether there is a fiscal free lunch in a liquidity trap. In Section VII, we provide some additional information on our workflow that could be useful for future participants of this seminar. In Section VIII, we conclude with final remarks.

II Fiscal Policy and the Spending Multiplier

Before the financial crisis in 2007/08, fiscal policy was often seen as inefficient and costly. In particular, the time-lag of the implementation of the fiscal spending and the crowding-out effect on the private sector were seen as great obstacles to the use of public spending programs. Besides the theoretical economic arguments, different models have delivered contrasting results on the effects of fiscal policy. Coenen et al. (2010b) and Afonso et al. (2010) compare various state-of-the-art macroeconomic models and show the wide range of different frameworks in which the spending multiplier can be analyzed. The type, design, duration and funding of the fiscal stimulus are as important as the circumstances of the economic meltdown, the interaction with monetary policy and the scope for public finance. Coenen et al. (2010a) mention that an economic crisis normally has negative consequences for the current debt position of a country, as we could observe during the euro crisis, and thus the budgetary room for maneuver can be highly at risk in a situation when fiscal packages can normally be extraordinary effective.

New evidence on recent model-based economic research provide some new understanding on whether fiscal policy can be an adequate response in a deep recession. Eggertsson (2011) suggests that stimulating short run aggregate demand, rather than the supply side of the economy, has particularly positive effects at the zero lower bound. **?** and Christiano et al. (2011) show that an increase in government spending can outsize the effect on output in a deep recession, especially in prolonged liquidity traps. Once the nominal interest rate hits the lower bound, there can be a strong case for a fiscal stimulus on a temporary basis to jump-start the economy and push it out of an economic downward spiral.

The key question of the paper "Is there a fiscal free lunch in a liquidity trap?" concentrates on the magnitude of the government spending multiplier, the distinction between marginal and average effects and the impact of the fiscal policy on the government budget. The paper uses a simple New Keynesian model to analyze the impulse response of two different exogenous shocks. It shows that fiscal policy can play a crucial role in stabilizing the economy during an economic crisis. One important result of the paper is that the marginal multiplier is high in a liquidity trap, but decreases quickly when the size of the government spending increases. We replicate the concept of the marginal spending multiplier, which is a step function depending on the level of government spending. We also show that under certain conditions, an expansionary fiscal policy can in fact reduce government debt and thus be self-financing, the case in which there is a fiscal free lunch. Finally, we point out the risks of fiscal austerity measures while the economy faces a liquidity trap.

III The Model

In this section we describe and summarize the baseline illustration of the New Keynesian dynamic stochastic general equilibrium (DSGE) model Erceg and Lindé (2014) use in their paper.[1] The New Keynesian DSGE model has a RBC-core, but allows for two inefficiencies, so that shocks can cause deviations from the "natural level": monopolistic competition among firms and the Calvo model of firms' price setting. Therefore, the New Keynesian model addresses the deficits of the RBC-models and makes the more realistic assumptions that prices do not adjust instantaneously and markets are not perfectly competitive. Consequently, monetary policy can affect the real interest rate and have real effects on the economy. The microfoundation permits a normative policy analysis.

Households

The representative household makes the intertemporal consumption decision by maximizing

$$E_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1-\frac{1}{\sigma}} \left(C_{t+j} - C\nu_{t+j}\right)^{1-\frac{1}{\sigma}} - \frac{N_{t+j}^{1+\chi}}{1+\chi} + \mu_0 F\left(\frac{MB_{t+j+1}(h)}{P_{t+j}}\right)\right\}$$

under the constraint

$$P_t(1+\tau_{C,t})C_t + B_{G,t} + MB_{t+1} = (1-\tau_{N,t})W_t N_t + (1+i_{t-1})B_{G,t-1} + MB_t - T_t + \Gamma_t,$$

where $0 < \beta < 1$ is the discount factor and E_t the rational expectations operator. The utility function depends on the households current consumption C_t as deviation from a "reference level" $C\nu_{t+j}$, where the negative taste shock ν_t reduces this steady-state level. The taste shock, which is responsible for triggering the liquidity trap, enters the model in the household's utility function and affects the consumption decision of the household. The shock changes the marginal utility of consumption and so the willingness of the household to consume.

The utility function also depends inversely on hours worked N_t. By assuming that μ_0 is arbitrarily small, changes in real money balances have negligible implications for seignorage in the model. The household's budget constraint implies that the expenditure on goods and net purchases of government bonds $B_{G,t}$ equals the after-tax labor income $(1-\tau_{N,t})\,W_t N_t$, minus a lump-sum tax T_t, plus a proportional share of the profits Γ_t of

[1] Additional information and a more detailed derivation of the standard log-linearized version of the New Keynesian model can be found in the Online Appendix of the original paper.

all intermediate firms. The household's optimal plan needs to satisfy the first order conditions, so that we get

$$(C_t - C\nu_t)^{-\frac{1}{\sigma}} - \lambda_t P_t (1 + \tau_{C,t}) = 0,$$

$$-N_t^{\chi} + \lambda_t (1 - \tau_{N,t}) W_t = 0,$$

$$-\lambda_t + \beta (1 + i_t) E_t \lambda_{t+1} = 0,$$

and finally the Euler equation

$$\frac{(C_t - C\nu_t)^{-\frac{1}{\sigma}}}{(1 + \tau_{C,t})} = \beta E_t \frac{(1 + i_t)}{1 + \pi_{t+1}} \frac{(C_{t+1} - C\nu_{t+1})^{-\frac{1}{\sigma}}}{(1 + \tau_{C,t+1})}, \tag{1}$$

and the aggregate labor supply relation

$$mrs_t \equiv \frac{N_t^{\chi}}{(C_t - C\nu_t)^{-\frac{1}{\sigma}}} = \frac{(1 - \tau_{N,t})}{(1 + \tau_{C,t})} \frac{W_t}{P_t}. \tag{2}$$

The last equation shows that the marginal rate of substitution between consumption and labor must equal the after-tax real wage. In our simple New Keynesian Model we set the sales tax $\tau_{C,t}$ equal to zero to get the same results as in the paper.

Firms

The production function of the firms is described by

$$Y_t = K^{\alpha} N_t^{1-\alpha},$$

where aggregate capital is fixed, but shares of the aggregate capital stock can be allocated across the firms. All firms choose the factor demand such that costs are minimized. The real factor costs per marginal product therefore are

$$\frac{MC_t}{P_t} = \frac{W_t / P_t}{(1 - \alpha) K^{\alpha} N_t^{-\alpha}}. \tag{3}$$

The firm, which can reset its price in period t, chooses a price $\left(P_t^{opt}\right)$ and maximizes

$$\max_{P_t^{opt}(f)} E_t \sum_{j=0}^{\infty} \xi_p^j \psi_{t,t+j} \left[(1 + \pi)^j P_t^{opt}(f) - MC_{t+j} \right] Y_{t+j}(f),$$

where $\psi_{t,t+j}$ is the discount factor and ξ the probability that the firm's price set in t will still be the same in period t+1. The demand function for the good (f) faced by the firm is given by

$$Y_{t+j}(f) = \left[\frac{P_t(f)}{P_t} \right]^{\frac{-(1+\theta_p)}{\theta_p}} Y_t,$$

which varies with the relative price of the good, the substitution elasticity θ and the aggregate demand Y_t. The first order condition with optimal price $\left(P_t^{opt}\right)$ is

$$E_t \sum_{j=0}^{\infty} \xi_p^j \psi_{t,t+j} \left[\frac{(1+\pi)^j P_t^{opt}(f)}{1+\theta_p} - MC_{t+j} \right] Y_{t+j}(f) = 0. \tag{4}$$

To derive the New Keynesian Phillips curve, we also need the average price of the final goods

$$P_t = \left[(1-\xi_p) \left(P_t^{opt}\right)^{\frac{-1}{\theta_p}} + \xi_p \left((1+\pi) P_{t-1}\right)^{\frac{-1}{\theta_p}} \right]^{-\theta_p}. \tag{5}$$

Finally, we have to derive the aggregate resource constraint

$$C_t + G_t \leq \left(\frac{P_t^*}{P_t} \right)^{\frac{(1+\theta_p)}{\theta_p}} K^{\alpha} N_t^{1-\alpha}, \tag{6}$$

where actual output Y_t can be divided into private consumption and government spending ($Y_t \equiv C_t + G_t$).

By log-linearizing the equations (1) to (7) around the steady-state and after some rearranging, we get the key equations of the model used in the Erceg and Lindé (2014).

The Government

The government budget constraint is given by

$$B_{G,t} = (1+i_{t-1}) B_{G,t-1} + P_t G_t - \tau_{C,t} P_t C_t - \tau_{N,t} W_t N_t - T_t - MB_{t+1} + MB_t,$$

where after scaling with $1/P_t Y_t$, the left side of the equation defines the end-of-period real government debt. In the model the government can issue bonds to finance the budget. As mentioned before, we set the consumption tax $\tau_{C,t}$ in our simplified model for all t equal to zero. The government charges the labor income with a constant tax rate τ_N according to the equation

$$\tau_N = \frac{g_y}{s_N}$$

with g_y as the government share of steady-state output ($g_y = 0.2$) and s_N as the steady-state labor share ($s_N = 0.7$). The government also collects a lump-sum tax ($\tau_t \equiv T_t / P_t Y$)), which varies in time and adjusts according to the evolution of the debt stock ($\tau_t = \varphi_b b_{G,t-1}$). Therefore, the fiscal policy specifies that taxes respond to government debt, but does not affect other macro variables in the model. We set the tax rule parameter φ_b equal to 0.01. Consequently, the evolution of the tax base depends

mostly on the variation in labor tax revenues the first years after a negative taste shock. The government budget is zero in steady-state in the simple benchmark model.
Monetary policy follows a Taylor rule which is subject to the zero lower bound

$$i_t = max\left(-i, \gamma_\pi \pi_t + \gamma_x x_t\right).$$

By setting the parameters γ_π and γ_x arbitrarily large, we assume that the monetary policy would completely stabilizes inflation and the output gap in absence of the the zero lower bound. In the next section, we also consider the alternative case where the parameters of the monetary policy rules are lower.
Table 1 provides an overview over the parameter values, we use in our benchmark calculation.

IV Impulse Response Functions

First, we focus on the impulse response of a large negative taste shock and a positive government spending shock to counteract the fall in output. The main steps to replicate the results of Erceg and Lindé (2014) are the following:

1. Write up the model equations in Dynare and set the parameter values provided in the paper
2. Solve the model without baseline shock, so that the nominal interest rate does not hit the zero lower bound and compute then impulse to government spending and consumption taste shock
3. Impose the ZLB on monetary policy and simulate effects of a large negative consumption demand shock, so that the economy hits the zero lower bound
4. Find the right parameter and shock values for an eight quarter liquidity trap in an environment of an positive government spending shock equal to one percentage point of steady-state output
5. Calculate the difference between the impulse responses of both shocks and the taste shock only to get the effects of the government spending shock

The large taste shock leads to a fall of the potential real interest rate r^{pot}. The length of the liquidity trap is defined by how long r^{pot} remains below $-i$. Figure 1 gives the first impression of how the negative taste shock affects the key variables of the model: the real interest rate, the output gap, inflation and government debt to GDP. We set here the Taylor rule parameter on output γ_x equal to 15 for approximately receiving the closest result to the original paper.

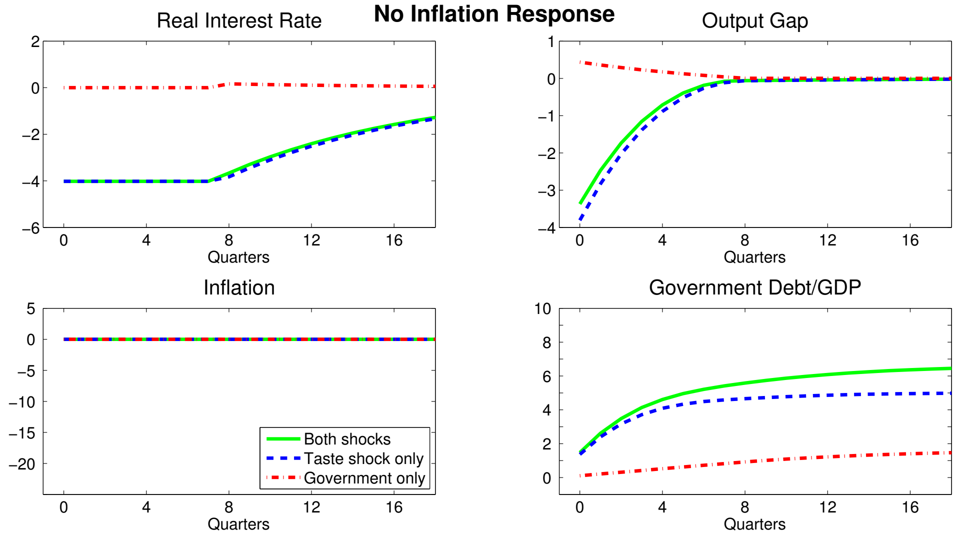

Figure 1: Immediate Rise in Government Spending (No Inflation Response)

In the following subsections we explain the cruxes to get the right results. We explain more in detail the shock parameters, emphasize the role of the price rigidity and the policy responses to the negative taste shock.

The Shock Parameter

The model consists of two different types of exogenous shocks: the consumption taste shock and the government spending shock. The adverse consumption shock triggers the fall of the potential real interest rate. We begin the analysis by setting the Calvo parameter equal to one and thus eliminating changes in inflation. For the following calculations and figures, it is important to find the exact values for an eight quarter liquidity trap. The nominal and real interest rate fall simultaneously to the zero lower bound when the adverse consumption shock is large enough. Both interest rates stay at the zero lower bound for eight quarters and return gradually to the steady state.

The negative shock also leads to a fall in output and to a rise in government debt. In Figure 1 to 10 we simulate the model with a negative taste shock of 29.2. The taste shock is scaled in the model by the scale parameter ν_c and $(1 - g_y)$, which can be seen as the private sector's share of the steady-state output. Therefore, the negative taste shock can be interpreted as $0.01 * (1 - 0.2) * 29.2 = 0.2336$ or a 23.36% fall in output of steady-state GDP.

To counteract the negative effects on output, the government increases spending by one percentage point of total GDP. The interpretation of the government spending shock is similar to the taste shock. The government shock is scaled by the government share of total output g_v. We simulate the model with a government shock of 0.05. This means that government spending is increased by 5%. Given that government spending accounts for 0.2 of total GDP, the government shock can also be expressed in terms of total GDP. This means that a 0.05 government shock leads to a increase in government spending of 1% of total GDP ($0.2 * 0.05 = 0.01$). In Figure 1 the solid green line shows the dynamic effects of both shocks. The blue dashed line shows the result of the negative taste shock without the rise in spending. And the red dash-dotted line shows the isolated effects of the government shock in the scenario with both shocks. The red line is calculated by subtracting the results of the simulation with the taste shock only from the results of the simulation with both shocks to isolate the effects of the government spending rise.

Figure 2 shows the effects of different values of taste shocks on the potential real interest rate. The step function implies that a slightly larger adverse shock does not change the liquidity trap duration. Only when the adverse taste shock is big enough and the potential real interest rate falls beyond a certain threshold, the liquidity trap duration increases. We did the calculations necessary to plot Figure 2 by simulating the model with 501 different values of the taste shock. We started with the shock at 0 and increased its value each time by 0.1 until we reached 50. For each different value of the shock we calculated the potential real interest rate and the corresponding duration of the liquidity trap. Figure 3 gives a better a idea of how small the increases in the adverse taste shock were, since it plots each simulation as a single point.

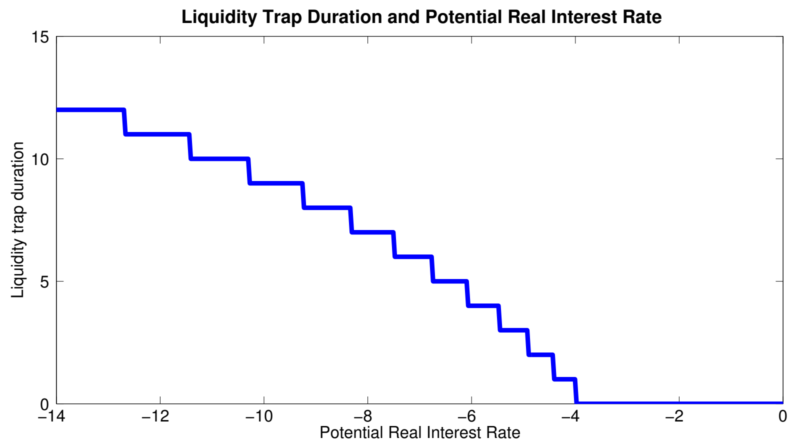

Figure 2: Potential Real Interest Rate and Variation of Taste Shock

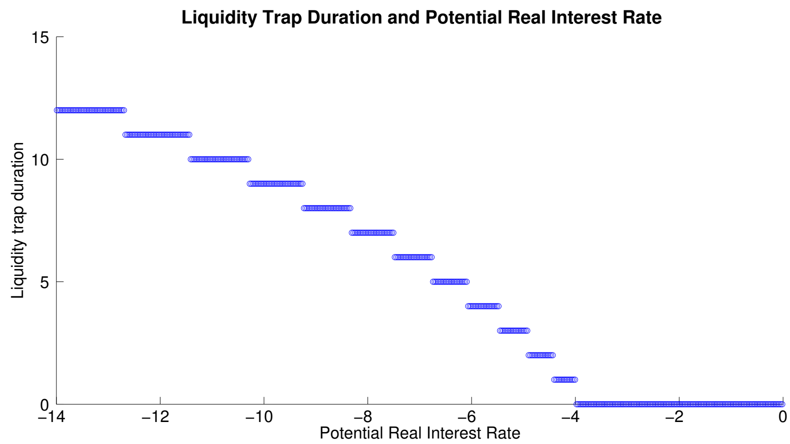

Figure 3: Potential Real Interest Rate and Variation of Taste Shock (Scatter plot)

The Calvo Price Setting

The slope of the Phillips curve is a important factor in the analysis of the government spending multiplier and the impact of fiscal spending on government debt. In Figure 1 we begin with an environment of zero inflation. As the inflation is kept to zero, the annualized real interest rate falls to -4% and follows the path of the nominal interest rate ($r_t = i_t$). We change the Calvo parameter to 0.8 to get a 5 quarter price contract duration in the model and thereby allow for inflation. When the economy now hits the zero lower bound and inflation is responsive, the fall in output is very large. The exogenous shock leads to a fall in marginal costs and a decline in prices, which changes the inflation expectations of the agents. Real interest rates have then to rise when the nominal interest rate is stuck at the zero lower bound. Consequently, households change their consumption behavior by increasing their savings, which reduces the output even further.

Monetary policy cannot cut the nominal interest rate as much as it would in the absence of the zero lower bound. With falling inflation the real interest rate rises, triggering an large fall in output. When the nominal interest rate hits the lower bound, the central bank does not have any further options to react in our simple model. We see therefore that the real interest rate plays the key role at the ZLB in the NK model. In this framework fiscal policy becomes crucial to stabilize the economy and counteract the negative taste shock. Figure 4 illustrates these results.

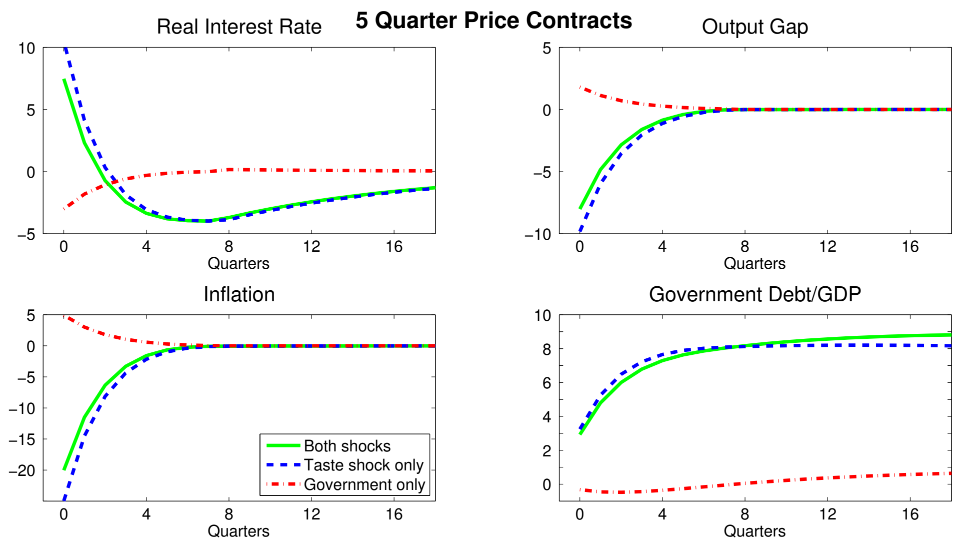

Figure 4: Immediate Rise in Government Spending (5 Quarter Price Contracts)

Policy Rules

In the following, we shift the focus to the monetary rule and fiscal policy. After setting the parameters of the monetary rule in Figure 4 arbitrarily large, we change the monetary policy rule to values that are more *usual* in standard New Keynesian models. We set the Taylor rule parameter on output γ_x to 0.2 and inflation γ_π to 1.5. As a result the negative taste shock leads to an explosive behavior of the impulse response. The amplitude of the impulse response reaches boundaries that are unrealistic and not useful for further economic analysis. The careful calibration of the Taylor rule parameter is essential to our model and part of an optimal monetary policy analysis.

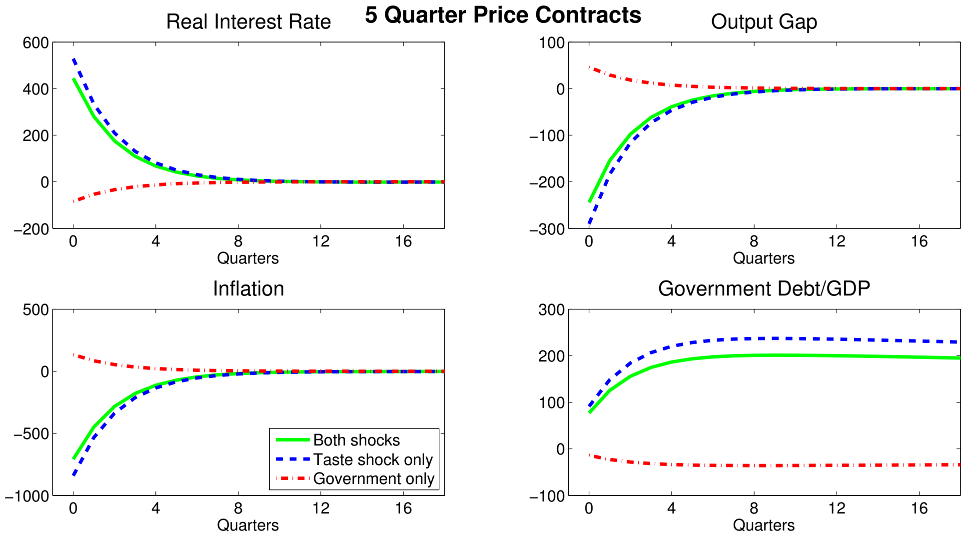

Figure 5: Immediate Rise in Government Spending (Alternative Taylor Rule Values)

We turn the focus now to the fiscal response. Figure 6 shows how the rise in government spending helps to shorten the liquidity trap duration. The negative taste shock leads to a fall in the potential real interest rate and keeps r^{pot} below the nominal interest rate for eight quarters. Fiscal policy partly offsets this drop and pushes the potential real interest rate upwards. Nevertheless, the spending increase of 1% of total GDP is still not high enough to shorten the liquidity trap duration. As the fiscal response exceeds a certain threshold, the liquidity trap duration decreases to seven quarters. That is exactly the case with the 2% spending hike. It is big enough to reduce the duration of the liquidity trap by one period, which enables the central bank to raise the nominal interest rate after seven quarters.

V The Government Spending Multiplier

Definition of Government Spending Multiplier

A key figure to decide whether a fiscal intervention by the government is desirable or not is the multiplier. We need to know (or at least estimate) what are the effects

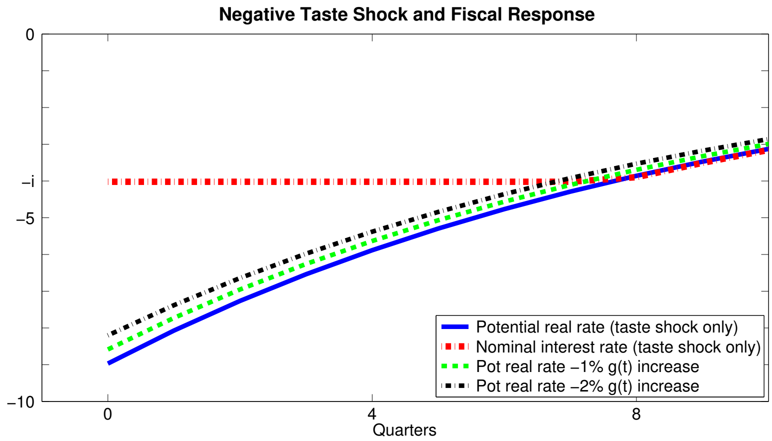

Figure 6: Potential Real Interest Rate and Fiscal Response

of a spending hike in the economy and the multiplier delivers important information about this question. The multiplier measures the impact that marginal variations of government spending has on output. It is defined as the increase in GDP generated by a marginal increase in government spending. If government steps in and spends one extra euro, it is not clear a priori how agents will react to that. It can be argued that this euro will be further spent by its recipient generating a virtuous circle that will ultimately boost the economy. On the other hand, spending increases also put pressure on government budget, which might trigger uncertainty about government's ability to pay its debt back. This in turn could lead agents to cut back on spending foreseeing hard times. In this case, an increase in government could trigger a fall on GDP. In general lines, it is not clear what are the implications of government intervention in a crisis. Understanding the mechanism behind the multiplier and how it works can shed light on this question, because the multiplier is this one number that states whether an increase in government spending will ultimately boost or depress an economy and by how much. The multiplier m_t can be expressed formally as

$$m_t = \frac{dY_t}{dG_t} = \frac{1}{g_y}\frac{dy_t}{dg_t}$$

where capital letters stand for variables in levels and lowercase letters for variables expressed in deviations from steady state.

The Multiplier in the Model

In the model, the multiplier has a stairway format. The multiplier is constant as long as the duration of the liquidity trap remains unchanged. This means that each extra euro spent by the government will have the same effect on output if the liquidity trap duration is not affected. Once the increase in government spending is big enough to shorten the duration of the liquidity trap by one period, the multiplier declines. Government spending becomes then less effective in boosting the economy.

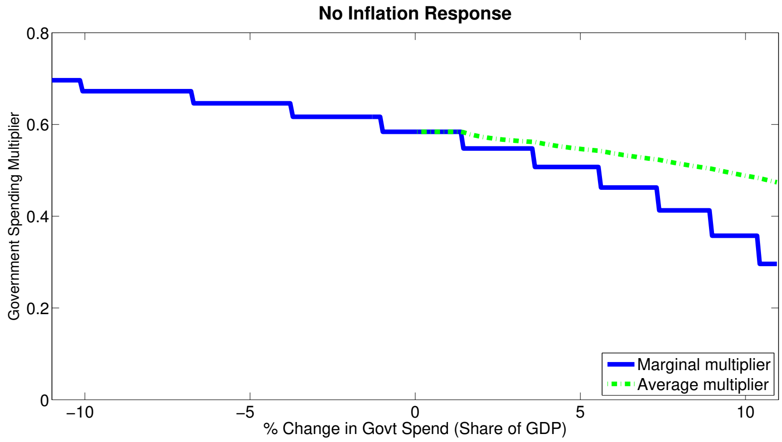

Figure 7: Average and Marginal Spending Multiplier with No Inflation

In Figure 7, which depicts a model with no inflation, the multiplier is 0.584 by 0% change in government spending. If policy makers decide to step in and increase spending, the multiplier remains constant at 0.584 until the increase in spending surpasses the threshold of 1.46% of GDP. At this point, the liquidity trap becomes one period shorter, which makes the multiplier decrease to 0.548. This mechanism works in this fashion (big enough government spending hike leads to shorter liquidity trap and smaller multiplier) until the increase in government spending is so high that the economy gets out of the liquidity trap. After that, the multiplier is constant in the model irrespective of the size of the government in the economy. The case we have been considering, in which prices do not vary at all, displays a relatively low multiplier. In fact, it is smaller than unity. Once we allow for the more realistic scenario with sticky but not completely fixed prices, the multiplier increases by a considerable amount. Figure 8 shows the multiplier schedule for three different average price durations. The more flexible the prices, the higher the multiplier for a given level of government spending. With four-quarter contracts (Calvo parameter set to 0.75), the multiplier reaches a far greater value of 3.828. This means that each euro spent by the government will increase GDP by 3.828 euros (as long, of course, as the spending hike is not too big to shorten the liquidity trap).

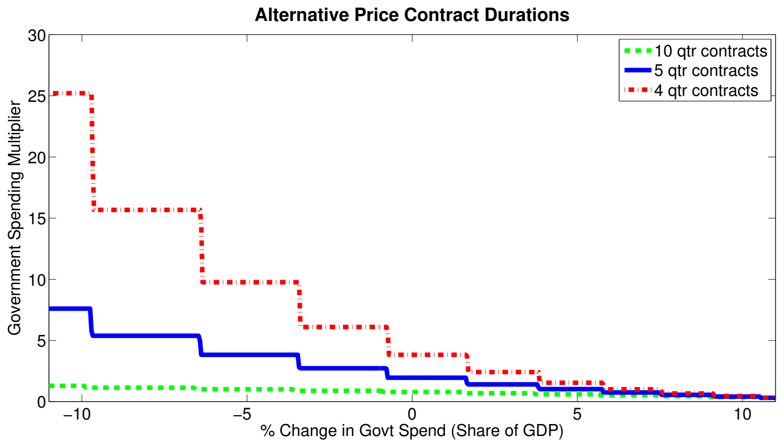

Figure 8: Spending Multiplier under Alternative Contract Duration

A large multiplier makes a strong case for government intervention. Figure 8 tells, however, also another story and a word of caution is necessary here. Although we have a higher multiplier the more flexible the prices are, the drop in the multiplier caused by the shortening of the liquidity trap is also stronger in this case. The multiplier falls sharply with the level of government spending when prices are not very sticky. This observation leads to the important distinction between average and marginal multiplier, which is central for the paper we are analyzing.

Marginal vs. Average Multiplier

The multiplier itself is a marginal concept. It tells by how much GDP grows if government increases spending by one percent. More important for policy making, however, is what Erceg and Lindé (2014) have called the *average multiplier*. Governments, while intervening in an economy, never do so by increasing spending only by a little amount. Rather, in face of an economic slow down, they often introduce stimulus packages of many millions of euros. In such a scenario, the marginal interpretation offered by the multiplier may not be very useful, especially if the multiplier varies significantly with the level of government spending. In face of a given-sized spending hike, the average multiplier tells us by how much *on average* each extra euro spent by the government contributed to the increase in GDP. For the policy maker, it is of greater interest to know the average impact of higher spending (average multiplier) than the impact of the first euro spent (marginal multiplier), especially when the increase is considerable and the multiplier varies a lot with the size of government spending. This is exactly the case with the model of Erceg and Lindé (2014). In rough lines, the marginal multiplier is certainly higher in a liquidity trap, but it decreases at a fast rate once the government intervenes and through increases in government spending, shortens the duration of the liquidity trap.

Thus, an important message from the model is the following: although it may seem attractive to increase government spending in a liquidity trap because of the higher marginal multiplier, the overall effect on the economy might not be as pronounced as one is led to believe by analyzing the snapshot of the marginal multiplier when the crisis hit. This is so because the marginal multiplier decreases rapidly as the duration of the liquidity trap becomes shorter. It turns out that the average multiplier, i.e. the average contribution of each extra euro spent to GDP, is usually not as large as the marginal multiplier when government spending is at its steady state levels.

How to Calculate the Multiplier

It turns out that the multiplier cannot be calculated analytically in the model. For that reason, we used a numerical approach to determine the multiplier schedule. For that, we used the Dynare loop to simulate the model with 551 different values for the government shock. We started with the scenario in which government *cuts* spending by 11% of GDP and went through increasing the government shock each time by 0.2% until we reached the situation in which government *increases* spending also by 11% of GDP.

We then calculated the marginal multiplier as following. For each shock $i \in \{2, \cdots, 551\}$

we computed:

$$m_i = \frac{1}{g_y}\frac{(y_i - y_{i-1})}{(g_i - g_{i-1})}$$

This ensured that the marginal interpretation of the multiplier is still valid, since the difference between g_i and g_{i-1} is very small. Also because of this small difference, we succeeded in plotting the multiplier schedule with the format of a stairway. Given that the distance between every two points in the graph is so small, the line linking values of multiplier values in two different liquidity traps appear to be perfectly vertical, even though strictly speaking this is not the case.

For the average multiplier we proceeded similarly. We found the government shock that roughly corresponds to the case in which there is no change in government spending or, in other words, the shock closest to zero. This shock turned out to be the 275th iteration of the loop. From that point we computed for each $i \in \{276, \cdots, 551\}$:

$$m_i^{avg} = \frac{1}{g_y}\frac{(y_i - y_{275})}{(g_i - g_{275})}.$$

VI Fiscal Free Lunch

We have seen that in the case where prices are more flexible, the multiplier can become very large with each extra euro spent by government boosting GDP by almost 4%. Given that the multiplier is so high, would it be the case of a fiscal free lunch? A fiscal free lunch would occur if the extra economic activity generated by the fiscal stimulus is so high that the taxes collected over it are greater than the stimulus itself. Contrary to common-sense, an increase in spending would in fact reduce overall public debt compared to the case in which government does not intervene.

This question is best answered by analyzing Figure 10. It depicts the marginal effect that government spending has on government debt. The striking conclusion of the model is that for four-quarter contracts, a spending hike of one percent of GDP causes the debt to fall by roughly 0.7 percentage points. In this very scenario, even increases in spending in amounts greater than 7% of GDP would not only be self-financing but it would in fact decrease government debt. The fiscal free lunch is also observed

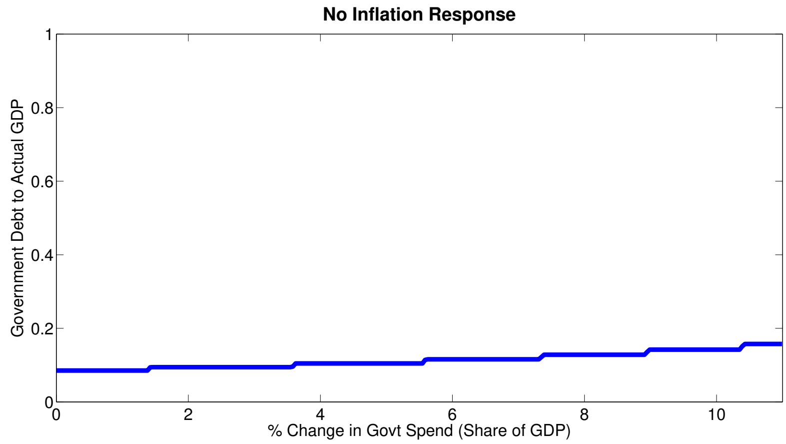

Figure 9: Government Debt Response with No Inflation

for five-quarter contracts although not as pronounced as in the previous case. For more sticky prices (average contract duration of ten quarters and with no inflation in Figure 9), there is no fall in debt but still in this case the government stimulus comes at moderate budgetary costs. The rate at which debt increases with government spending is not so high.

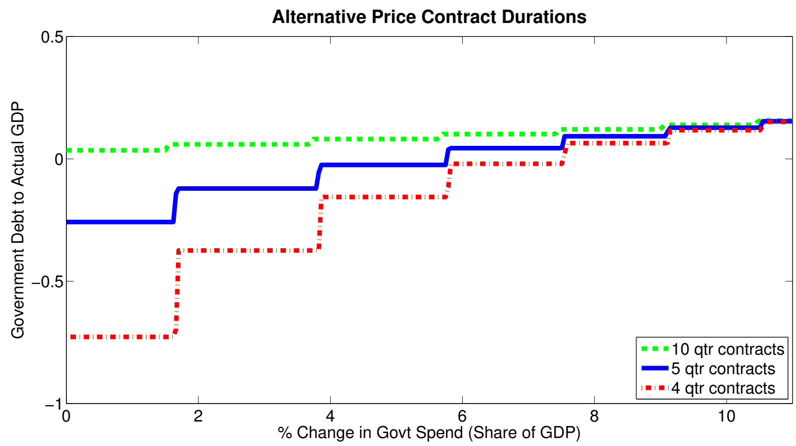

Figure 10: Government Debt Response under Alternative Contract Duration

The existence of a fiscal free lunch has an important flipside. If it is true that government can stimulate the economy at low or no costs while in a liquidity trap, it is also true – and maybe even more important to notice – that austerity measures in such a scenario can have very detrimental effects to the economy. A high multiplier means not only that increases in spending boosts GDP but also that cuts in spending when the economy is already depressed will deepen the recession even further.

VII Workflow

GitHub

To coordinate and control our coding, we have used GitHub.[2] GitHub is a version control software based on the git system. It allows its users to keep track of all the changes made to a specific project and provides an overview of the development of the project. GitHub has a variety of features and it is mostly used by software engineers who work simultaneously with many other people in big projects.

GitHub was particularly useful to us because it forced us to document all the changes we made to the project. This way it was much easier for us two to work remotely without losing track of what each other had already done. Alongside with the documentation function, the git system offers the possibility to reload previous versions of the project and undo changes that turn out to be undesired. GitHub displays a timeline in which the user can follow the development of the project from its beginning until its current state. This allows the user to go back in time and recover old versions of project or only parts of it. This was particularly useful for us too. It happened more than once that one of us two has mistakenly changed the code and Dynare could no longer simulate the model. Instead of spending hours debugging and trying to find the error, we simply opted to go back to a previous version and start again from there.

Although the git system is primarily designed to be used from the command line (Terminal for macOS or Command Line for Windows), GitHub offers a very user-friendly desktop application, which makes possible for not-so-advanced user to profit from its features. GitHub is free as long as you are willing to make your project public. The code for this project, for example, is available online.[3]

[2] https://github.com

[3] https://github.com/denismaciel/fiscalfreelunch

Syntax Highlighting

Another tip worth mentioning is to use syntax highlighting while coding. It is not only much more comfortable to read a code whose parts have different colors according to its function, but the task of spotting errors becomes much easier when the code is highlighted. Even though we could not find a specific syntax highlighting package for Dynare, it turns out that Java highlighting works well with it. For example, % is used to comment the code and the single feature of being able to quickly tell the difference between actual code and comments makes it worth trying.

VIII Conclusion

The paper makes a strong case for the effectiveness of government spending in a liquidity trap, even if it warns against the fact that this effectiveness, measured by the marginal multiplier, may decline at a fast rate. It is important, however, not to forget the assumptions the model rests on. The taste shock that pushes the economy down to the zero lower bound, for example, implies a decrease of 23% of GDP. Such a decline in output does not occur very often in real economies. For that reason, a very thorough assessment of the real economy should be done to check if the model can adequately inform policy-making for it.

In general lines, we have been able to replicate the most important results of Erceg and Lindé (2014). Even when we could not get the exact values, our simulations behaved qualitatively in the same way as in the original paper. The results from the paper and from our replication are most different in the scenario with no inflation. For example, we got a multiplier that is roughly 0.1 smaller. In scenarios with Calvo parameter different than one, it seems we managed to get the exact same results of the paper (judging from the plots).

The results of the model are very interesting and point to new research questions that could well be answered by refining the baseline model. Due to the importance of the Calvo parameter and the price setting framework in the model, alternative analysis with prices adjustments according to sticky information, rational inattention or state-dependent price settings are interesting for further research. Moreover, the simple New Keynesian model can be expanded to include a negative debt position in the steady-state, an open economy framework, the distinction between tax and debt financed government spending and an empirical comparison between the US and the euro area.

References

Afonso, Attinasi, Catz, Checherita, Nickel, Leiner-Killinger, Maurer, Rother, Slavik, Valenta, Riet, Warmedinger, and Trabandt. Euro area fiscal policies and the crisis. *ECB Occasional Paper*, (No. 109), 2010.

L. Christiano, M. Eichenbaum, and S. Rebelo. When is the government spending multiplier large? *Journal of Political Economy*, 119(No. 1):78–121, 2011.

G. Coenen, C. Erceg, C. Freedman, D. Furceri, M. Kumhof, R. Lalonde, D. Laxton, J. Lindé, A. Mourougane, D. Muir, S. Mursula, C. Resende, J. Roberts, W. Roeger, S. Snudden, M. Trabandt, and J. Veld. Effects of fiscal stimulus in structural models. *IMF Working Paper*, 2010a.

G. Coenen, J. Kilponen, and M. Trabandt. When does fiscal stimulus work? *ECB Research Bulletin*, (No. 10), 2010b.

G. B. Eggertsson. What fiscal policy is effective at zero interest rates? In Daron Acemoglu and Michael Woodford, editors, *NBER macroeconomics annual 2010*, volume 25, pages 59–112. Univ. of Chicago Pr, Chicago, 2011. ISBN 0-226-00213-6.

C. Erceg and J. Lindé. Is there a fiscal free lunch in a liquidity trap? *Journal of the European Economic Association*, 12(1):73–107, 2014.

Table 1: Parameter Values Benchmark Calibration

	Description	*Value*
α	Capital Share	0.3
β	Discount Factor	0.995
σ	Intertemporal Substitution Elasticity	1
χ	Inverse of Frisch-Elasticity	2.5
g_y	Government Share on Output	0.2
φ_b	Tax Rule Parameter	0.01
ν_c	Scale Parameter on the Taste Shock	0.01
ρ	AR(1) Natural Rate for both Shocks	0.1
ξ_p	Calvo Parameter (No Inflation)	1
	Calvo Parameter (10 quarter price contracts)	0.9
	Calvo Parameter (5 quarter price contracts)	0.8
	Calvo Parameter (4 quarter price contracts)	0.75
γ_π	Taylor Rule Coefficient on Inflation	66.15
γ_x	Taylor Rule Coefficient on Output Gap	66.15
	Taylor Rule Coefficient on Output Gap (Figure 1)	15