The Government Spending Multiplier in a Model with the Cost Channel

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Abstract
This paper studies the government spending multiplier in the presence of the cost channel of the nominal interest rate. I find that the spending multiplier of normal times declines markedly when this channel is introduced. The rise in government spending leads to a rise in the nominal interest rate and, with the cost channel, to a rise in the marginal cost and inflation. In turn, this leads to a bigger rise in the nominal interest rate and the expected real interest rate, hence a lower multiplier, than in a model that abstracts from the cost channel. On the other hand, in a liquidity trap, the cost channel makes the spending multiplier larger than in a model that does not account for this channel. Therefore, by ignoring the cost channel, the spending multiplier is overestimated in normal times and underestimated during liquidity-trap episodes. Since liquidity traps are rare, however, the spending multiplier is mostly lower than in previous estimates.

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1. Introduction
The main goal of this paper is to study the government spending multiplier in a model with the cost channel of monetary policy, whereby changes in the nominal interest rate affect inflation through their direct effects on firms’ costs. The study extends an otherwise standard New Keynesian (NK) model by assuming that the wage bills of firms is paid before production takes place, thus giving rise to borrowing by firms and, consequently, supply-side effects of the nominal interest rate on inflation. It is found that in normal times, during which the nominal interest rate is not fixed, the cost channel reduces the multiplier. On the other hand, when the nominal interest rate is fixed, as may happen because of the zero lower bound (ZLB) constraint, the cost channel makes the spending multiplier larger. This effect is stronger when prices are more flexible and the responses of the loan interest rates to government spending shocks are stronger.

Intuitively, when the nominal interest rate is free to adjust, the rise in government spending raises this interest rate and, as a result, the marginal costs of firms. In turn, this leads a larger increase in inflation and inflation expectations than in a model that abstracts from the cost channel. And, since the nominal interest rate increases by more than one-for-one with inflation (and the expected inflation rate), the rise in inflation triggers even a larger increase in the nominal interest
rate. The result is a larger increase in the expected real interest rate, which induces a bigger decline (or a muted rise) in consumer spending. In turn, the spending multiplier is smaller than in an model without the cost channel.

In liquidity traps, the opposite occurs. Higher borrowing costs of firms raise the marginal costs, and thus the expected inflation by more than in the absence of the cost channel. Since the nominal interest rate that is relevant for consumer spending remains unchanged (and it is unaffected by the cost channel), the decline in the expected real interest rate is larger than in the absence of this channel, which implies a larger spending multiplier during this type of episodes. Therefore, the response of monetary policy to government spending shocks matters for how the cost channel affects the spending multiplier. In addition, previous quantitative estimates of the multiplier that did not account for the cost channel underestimated the multiplier of liquidity traps and overestimated the multiplier of normal times.

The empirical analyses of this paper also establish that firms’ borrowing costs are responsive to government spending shocks; in particular, the credit spread rises following positive government spending shocks. This finding supports the choice of a model that distinguishes between the policy interest rate and the borrowing interest rates of firms as a platform for studying the implications of the cost channel for the government spending multiplier.

The paper adds to the recent quantitative literature on the government spending multiplier. Christiano et al. (2011) show that the multiplier is slightly above 1 when the nominal interest rate is governed by a standard Taylor rule, but can be considerably larger if the nominal interest rate does not respond to a rise in government spending. The rise in government spending raises output and inflation expectations. When the nominal interest rate is fixed, that leads to a decline in the expected real interest rate and to a further rise in consumption, output and expected inflation, leading to a loop of rising inflation expectations and output. The spending multiplier, thus, can be large. Using a NK framework, Carlstrom et al. (2014) compare the results when the monetary-fiscal expansion lasts for a certain number of periods (“deterministic duration”) to the results when the expansion is stochastic. They find that the size of the stochastic multiplier is considerably larger than the deterministic multiplier. Dupor and Li (2015) distinguish between “passive” monetary policy, which occurs when the central bank increases the nominal interest rate by less than one-for-one with the change in the expected inflation rate, and “active” monetary policy, when the opposite occurs. It is found that under a passive monetary policy the spending multiplier exceeds one, and under an active policy it is less than one. Bouakez et al. (2017) study the multiplier in a model with public investment and suggest that ignoring the investment component of the 2009 Stimulus Package leads to underestimation of the multiplier by roughly a half. Leeper et al. (2017) study the fiscal multipliers in four nested models and under two distinct monetary-fiscal policy regimes, and find that the averages of short-run output multipliers are similar across regimes but are considerably larger after 10 years under the passive money/active fiscal regime than under the active money/passive fiscal regime.

The size of the fiscal multiplier at the ZLB has also been empirically studied. Ramey and Zubairy (2018) construct quarterly U.S. data for 1889-2013 to test whether government spending multipliers differ according to the amount of slack in the economy and being near the ZLB. They find that the amount of slack in the economy does not affect the size of the multiplier and that the results for ZLB periods are mixed. Caggiano et al. (2015) show that the fiscal multipliers are
larger than one in recessions, but they are not higher than the multipliers of expansions. On the other hand, Auerbach and Gorodnichenko (2012) use U.S. data for 1947:Q1-2008:Q4 and find that government spending is considerably more effective in recessions than in expansions. For the period 1949:Q1-2006:Q4, Arin et al. (2015) find that the spending multipliers are larger during periods of low economic activity. The findings of the current study align with the findings of the latter two studies.

Barth and Ramey (2001) present aggregate and industry-level evidence to demonstrate that monetary policy has supply-side effects on real variables; the responses of aggregate economic variables to a monetary contraction is similar to their responses to a negative productivity shock than a negative demand shock. In addition, for key manufacturing industries, relative prices rise and output falls in response to a an unanticipated monetary contraction. Ravenna and Walsh (2006) uses a NK model with working capital to characterize optimal monetary policy with the cost channel. Using U.S. data, the authors provide strong evidence in support of the cost channel. Chowdhury et al. (2006) use data for the G7 countries and find that changes in short-run nominal interest rates significantly affect the short-run behavior of of inflation rates in Canada, France, Italy, the UK and the US (implying that the cost channel exist in these countries), but no evidence to support this channel in Germany and Japan. Tillmann (2008) uses an otherwise NK model with the cost channel and shows that the cost channel significantly improves the explanation of inflation dynamics for the US, the UK and the Euro area. In addition, the cost channel can explain certain inflation episodes that cannot be accounted for by the standard NK model that abstracts from this channel. Gaiotti and Secchi (2006) use micro-level data from Italian manufacturing firms and provide evidence in favor of the existence of the cost channel.

The remainder of the paper proceeds as follows. Section 2 outlines the model economy. Section 3 presents the government spending multiplier of normal times and liquidity traps. The main numerical results are outlined in Section 4. Section 5 presents robustness analyses using alternative parameter values, preferences and a monetary policy rule. A medium-scale dynamic stochastic general equilibrium (DSGE) model with capital, distortionary taxes and habit persistence is also presented in this section. Section 6 provides empirical evidence on the relationship between the spending multiplier and the cost channel as well as the response of firms’ borrowing costs to government spending shocks. Section 7 concludes.

2. The Model Economy

The economy is populated by a continuum of infinitely-lived households who derive utility from consumption and leisure. Households also hold cash and they are engaged in the intermediation sector by holding some of their assets in the form of interest-earning deposits. Intermediate-good firms operate in an environment of monopolistic competition. They hire labor as the only input to produce differentiated products, set prices in a staggered fashion and borrow from intermediaries to finance part of their wage bills as in a standard model with the “working capital” requirement. The products of these firms are sold to final-good firms (retailers) who package them into final goods using a one-to-one technology. The basic setup through which the cost channel is introduced follows Ravenna and Walsh (2006) and Christiano et al. (2005), and the reader may refer to these studies for more details.
2.1. Households

The problem of the representative household is to choose consumption \((c_t)\), labor supply \((n_t)\), deposits \((D_t)\) and cash \((M_t)\) to maximize:

\[
E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{c_t^\gamma (1 - n_t)^{1-\gamma}}{1 - \sigma} \right) 
\]

where \(\beta\) is the subjective discount factor, \(E_0\) is the expectation operator, \(\sigma > 0\) and \(\gamma \in (0,1)\). The assumption of non-separable utility function follows Christiano et al. (2011). At the beginning of the period, households make deposits at the financial intermediary and the remaining amount \(M_t + W_t n_t - D_t\), with \(W_t\) being the nominal wage, is used for consumption. At the end of the period, households receive profits from the financial intermediary and intermediate-good firms as well as the principle and interest on their deposits. The corresponding constraints that households face are then given by the sequence of budget constraints:

\[
P_t c_t + D_t + M_{t+1} = M_t + R_t D_t + W_t n_t + T_t + \Pi_t \tag{2}
\]

and the cash-in-advance (CIA) constraints:

\[
P_t c_t = M_t + W_t n_t - D_t \tag{3}
\]

where \(P_t\) is the price level, \(R_t\) is the gross nominal policy (or market) interest rate, \(T_t\) are nominal net transfers and \(\Pi_t\) are nominal profits from the ownership of firms and the financial intermediary. The full description of the households’ problem is presented in Appendix A.1.

The optimization by households leads to the following standard consumption Euler equation and the labor supply condition, respectively, expressed in log deviations from the steady state:

\[
\frac{\gamma (1-\sigma) - 1}{\gamma (1-\sigma)} \tau_t - (1-\gamma) (1-\sigma) \tau_t + \frac{\pi_t}{1-\tau_t} = R_t - E_t \left[ \frac{\pi_{t+1}}{1-\tau_{t+1}} - \frac{\gamma (1-\sigma) - 1}{\gamma (1-\sigma)} \tau_{t+1} + (1-\gamma) (1-\sigma) \frac{\pi_{t+1}}{1-\tau_{t+1}} \right] \tag{4}
\]

\[
\bar{c}_t + \frac{\pi_t}{1-\tau_t} \bar{n}_t = \bar{w}_t \tag{5}
\]

where, in what follows, \(\overline{\tau}\) denotes the non-stochastic steady state and \(\overline{\tau}_t\) is the log deviation from this steady state for any variable \(x_t\), \(\pi_t\) is the inflation rate and \(w_t\) is the real wage. As expected, these conditions hold regardless of the cost channel and they are similar to the corresponding conditions in Christiano et al. (2011).

2.2. The Production Sector

As is standard in the literature, two types of firms operate in this sector: monopolistically competitive intermediate-good firms that produce differentiated products, and perfectly competitive firms that transform intermediate goods into final goods using a constant return to scale technology.

2.2.1. Final-Good Firms

Firms in this sector purchase a continuum of intermediate goods from intermediate-good producers, indexed by \(j \in (0,1)\), and assemble them into final goods using the following technology:
\[ y_t = \left( \int_0^1 \frac{\varepsilon - 1}{y_{j,t}} \, dj \right)^{\frac{\varepsilon}{\varepsilon - 1}} \] (6)

with \( y_{j,t} \) being the quantity of intermediate-good \( j \) that is purchased by a final-good firm and \( \varepsilon > 1 \) is the elasticity of substitution between two differentiated types of intermediate goods.

Profit maximization by intermediate-good producers gives the following downward-sloping demand function for the product variety \( j \):

\[ y_{j,t} = \left( \frac{P_{j,t}}{P_t} \right)^{-\varepsilon} y_t \] (7)

where \( P_t = \left( \int_0^1 P_{1-j,t}^{1-\varepsilon} \, dj \right)^{\frac{1}{1-\varepsilon}} \) is the Dixit-Stiglitz aggregate price level.

### 2.2.2 Intermediate-Good Firms

Each firm \( j \) hires labor as the only input to produce a differentiated product using the following technology:

\[ y_{j,t} = n_{j,t} \] (8)

Firms in this sector borrow from the intermediary at the beginning of each period at an interest rate of \( R_{L,t} \) in order to pay a fraction \( \alpha \) of their wage bills. Additionally, I let the loan interest rate be different from the policy interest rate, with the deviations between these two interest rates being a result from market power in the intermediation sector and the costs of managing loans (see discussions in Elyasiani et al. (1995), Freixas and Rochet (1997) and Kopecky and VanHoose (2012), among others). In addition, each period, a firm \( j \) has the probability \( 1 - \phi \) of changing its price as in Calvo (1983).

With this characterization of the intermediate-good sector, the time \( t \) real profit function of firm \( j \) is given by:

\[ \Pi_{j,t}^f = y_{j,t} - \alpha R_{L,t} \tilde{w}_t n_{j,t} - (1 - \alpha) \tilde{w}_t n_{j,t}. \] (9)

Maximization by firm \( j \) is subject to conditions (7)-(8). As is standard in the NK literature, optimization and imposing symmetry across firms lead to the following forward-looking Phillips curve:

\[ \pi_t = \beta E_t \pi_{t+1} + \kappa \tilde{m}_t \] (10)

with \( \kappa = \frac{(1-\phi)(1-\beta \phi)}{\phi} \). In addition, the labor demand condition reads:

\[ \tilde{m}_t = \tilde{w}_t + \delta R_{L,t} \] (11)

with \( \delta = \frac{\alpha R_L}{1 - \alpha + \alpha R_L} \). Therefore, the loan interest rate affects the marginal cost and, via condition (10), the inflation rate too. Furthermore, if no part of the wage payment is paid ahead of production (\( \alpha = 0 \)), then the cost channel is not operative (\( \delta = 0 \)). On the other extreme, if the firm pays all wages ahead of production (\( \alpha = 1 \)), then \( \delta = 1 \). For any intermediate value of \( \alpha \), we have \( 0 < \delta < 1 \).

By combining conditions (10) and (11), the Phillips curve be re-written as:

\[ \pi_t = \beta E_t \pi_{t+1} + \kappa \left( \tilde{w}_t + \delta R_{L,t} \right) \] (12)

and, thus, the nominal loan interest rate has supply-side effects on the inflation rate.
2.3. The Financial Intermediary

The full details of the financial intermediary are presented in Appendix A.2. The solution to the problem of the financial intermediary yields:

\[ R_{L,t} = \frac{\xi}{\xi - 1} R_t + \theta \frac{\xi}{\xi - 1} l_t \]  

(13)

with \( l_t = \alpha w_t n_t \) being the real value of loans, \( \theta \) is the parameter that governs the cost of managing loans and \( \xi \) governs the degree of market power in the loan market.\(^1\) When \( \xi \to \infty \), the loan market is perfectly competitive, and deviations between the loan rate and the policy rate occur only due to the cost of managing loans. According to condition (13), the loan rate is increasing in the policy rate and the amount of loans that are extended to firms. In particular, for a finite value of \( \xi \), a rise in the policy rate leads to more than one-for-one rise in the loan rate. In log deviations, this condition may be written as:

\[ \frac{\hat{R}_{L,t}}{\hat{R}_t} = \Psi_r \frac{\hat{R}_t}{\hat{s}} + \Psi_l \frac{\hat{l}_t}{\hat{s}} \]  

(14)

with \( \Psi_r = \frac{\xi R}{(\xi - 1) R_{L,t}} \) and \( \Psi_l = \theta \frac{q}{(\xi - 1) R_{L,t}} \). One can then substitute condition (14) into condition (12) to obtain an equation that directly relates the inflation rate to the nominal policy interest rate (and the coefficient of \( \hat{R}_t \) would be \( \kappa \delta \Psi_r \)).

Finally, it is useful to express the credit spread between the loan rate and the policy rate \( (s_t) \) as:

\[ s_t = R_{L,t} - R_t \]  

(15)

Then, in log deviations, the credit spread can be written as:

\[ \hat{s}_t = \frac{1}{\xi} \left(1 + \frac{\hat{R}_t}{\hat{s}}\right) \Psi_r \hat{R}_t + \left(1 + \frac{\hat{R}_t}{\hat{s}}\right) \Psi_l \hat{l}_t \]  

(16)

This spread is an increasing function of the policy rate (a similar result is shown in Gerali et al., 2010) and the amount of loans.\(^2\) Consider first the case in which the policy rate is time varying: an increase in government spending raises inflation and output and, in itself, the policy rate. Loans also rise in response to a positive government spending shock (as firms expand their production to meet the rise in demand), which constitutes another factor in raising the credit spread. When the nominal policy interest rate is constant \( (\hat{R}_t = 0) \), the credit spread will rise due to the rise in the amount of loans. Therefore, even if the policy rate is fixed, the loan rate is not fixed and the credit spread will fluctuate. For this reason, the cost channel remains operative in periods with constant nominal policy interest rates.

2.4. Market Clearing, Fiscal Policy and Monetary Policy

Government spending is financed via lump-sum taxes \( (g_t = T_t) \). In equilibrium, the resource constraint of the economy reads:

\( ^1 \)The real cost of managing loans could result from a need for further hiring and training (e.g. of loan officers) by banks to expand the size loans, increasing advertisements and possibly constructing new branches to cope with the rise in the scale of operation.

\( ^2 \)Gertler and Karadi (2015) show that the credit spread rises following a tightening of monetary policy. Their result is consistent with condition (16): other things equal, a rise in the policy rate raises the credit spread.
\[ y_t = c_t + g_t \]  

Log linearization of the resource constraint yields:

\[ \hat{y}_t = (1 - g)\hat{c}_t + g\hat{g}_t \]  

where \( g = \frac{\hat{g}_t}{\hat{c}_t} \) is the steady-state government spending-output ratio.

Government spending evolves according to the following AR(1) process:

\[ \hat{g}_t = \rho\hat{g}_{t-1} + u_t \]  

with \( \rho \) being the persistence parameter and \( u_t \sim N(0, \sigma_u^2) \).

In addition, monetary policy is governed by the following interest-rate rule:

\[ \overline{R}_t = \phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t \]  

In what follows, I check the robustness of the results with an alternative interest-rate rule, and show results when government spending is financed via bonds and distortionary taxes on labor income and capital income. The advantage of the current setup is that it allows for good comparisons with previous studies as well as for obtaining analytical results.

3. The Government Spending Multiplier- Analytical Analyses

The main analytical analyses regarding the government spending multiplier are presented in this section. Following the literature (e.g. Christiano et al., 2011 and Carlstrom et al., 2014), the model is solved using the Method of Undetermined Coefficients. Specifically, define the change in output following a change in government spending as \( \hat{y}_t = A_y \hat{g}_t \). Then, the government spending multiplier is given by:

\[ M \equiv \frac{dy_t}{dg_t} = \frac{A_y}{g} \]  

or, alternatively:

\[ M = 1 + \frac{1 - g}{g} \frac{\hat{c}_t}{\hat{g}_t} \]  

The size of government spending multiplier depends on the response of consumption to changes in government spending \( (\hat{c}_t = A_c \hat{g}_t) \). In particular, the response of consumption to spending shocks determines whether the multiplier is larger than, less than or equal to one.

3.1. The Government Spending Multiplier of Normal Times

In normal times, the nominal policy interest rate \( (\overline{R}_t) \) follows a Taylor-type rule. Under the assumption that \( \phi_\pi > 1 \), the solution yields:

\[ M^{NT} = \frac{(1 - \rho)(1 - \beta \rho - \delta \kappa \phi_\pi \Psi_r)[\gamma(\sigma - 1) + 1] + \kappa(\phi_\pi - \rho)(1 + \delta \Psi_l)}{(1 - \beta \rho - \delta \kappa \phi_\pi \Psi_r)[1 - \rho + (1 - g)\phi_y] + (1 - g)(\phi_\pi - \rho)[\frac{1 + \delta \Psi_l}{1 - g} + \frac{\pi + \delta \Psi_l}{1 - \pi} + \delta \Psi_r \phi_y]} \]

with \( NT \) denoting “normal times”. By setting \( \delta = 0 \), we obtain the exact spending multiplier as in Christiano et al. (2011). The multiplier is affected by the cost channel, but the exact effect is not
possible to tell without further information, and it may depend on the size of $\delta$ as well as other parameters. There is one case, however, when the role of the cost channel is easy to see: if prices approach full stickiness ($\phi \to 1$), $\kappa$ approaches zero, and the cost channel will not affect the size of the multiplier. This result is as expected since, according to condition (12), the interest rate does not affect the behavior of the marginal cost (hence, inflation), and the cost channel is immaterial. As will be outlined below, the size of $\kappa$ is very important for the size of the spending multiplier and for the role of the cost channel.

3.2. The Government Spending Multiplier of Liquidity Trap

This subsection presents the liquidity-trap government spending multiplier, which occurs when the nominal interest rate is fixed ($\bar{R}_t = 0$). With a probability $p$, the nominal interest rate remains fixed next period, and with a probability $1 - p$ the shock expires and the system reverts back to normal. The system of equations that we use has no endogenous state variables, and thus all endogenous control variables jump on impact, but they revert back to their steady-state values once the shock expires. For this reason, we can write $E_t \bar{\pi}_{t+1} = p \bar{\pi}_t$ and $E_t \bar{c}_{t+1} = p \bar{c}_t$.\footnote{With probability $p$, and for any variable $x_t$, we have $\bar{x}_t \neq 0$. With probability $(1 - p)$, the shock expires and the system reverts back to the steady state: $\bar{x}_t = 0$. Therefore, the expected value is given by $E_t \bar{x}_{t+1} = p \bar{x}_t + (1 - p) \cdot 0 = p \bar{x}_t$.}

The solution then yields the following liquidity-trap spending multiplier:

$$M^{LT} = \frac{(1 - \beta p)(1 - p)[\gamma(\sigma - 1) + 1] - p\kappa(1 + \delta \Psi_t)}{(1 - \beta p)(1 - p) - p\kappa [1 + \delta \Psi_t + (1 - g) \frac{\pi_t + \delta \Psi_t}{1 - \pi}]}$$

where $LT$ denotes “liquidity trap”. For $\delta = 0$ or when the borrowing costs of firms do not respond to government spending shocks ($\Psi_t = 0$), the constant interest-rate government spending multiplier restores that of Christiano et al. (2011).

With a fixed nominal interest rate, the denominator of condition (24), which will be referred to as $\Delta$, might be negative. As has been discussed in Christiano et al. (2011) and Carlstrom et al. (2014), when the denominator is negative, we enter the “indeterminacy” region and multiple equilibria are possible. To ensure the existence of a unique stationary equilibrium, our analysis will thus be conducted under the standard assumption that the denominator is positive. On this basis, the parameter $\kappa$ is set so that this goal is achieved. Also, following Christiano et al. (2011) and subsequent studies, we let $p = \rho$ so that the probability that the nominal interest will not change next period equals the persistence parameter of government spending, which enables better comparisons between the liquidity-trap multiplier and the normal-times multiplier.

The cost channel appears both in the numerator and the denominator of condition (24). When $\delta$ rises (say from zero to a positive value), the denominator falls by more than the numerator, thus leading to a larger government spending multiplier. As such, for liquidity traps, the effect of the cost channel on the spending multiplier is clearer than in normal times; the cost channel raises the liquidity-trap multiplier.

3.3. The Cost Channel, Expected Real Interest Rate and the Government Spending Multiplier

The key intuition behind the effects of the cost channel on the spending multiplier can be seen through the response of the expected real interest rate to government spending shocks. In normal times, the expected real interest rate is given by:
\[ E_t \tilde{r}_{t+1} = (\phi_\pi - \rho) A_\pi \tilde{g}_t \]  

(25)

with \( A_\pi \) being the response of inflation to a government spending shock \( (\tilde{\pi}_t = A_\pi \tilde{g}_t) \). Since the response of inflation to spending shocks is bigger in the model with the cost channel and \( \phi_\pi > \rho \), the expected real interest rate will rise by more than in the model that abstracts from the cost channel. Also, the rise in the actual real interest rate is bigger when the cost channel is operative. The actual real interest rate will rise provided that \( \phi_\pi > 1 \), which is the standard assumption in this class of models. This results from the fact that the nominal interest rate rises by more than one-for-one with the inflation rate.

When the nominal policy interest rate is fixed, the expected real interest rate can be expressed as:

\[ E_t \tilde{r}_{t+1} = -pA_\pi \tilde{g}_t, \]  

(26)

which indicates that the decline in the expected real interest rate following a government spending shock is bigger with a stronger response of the inflation rate to this shock (i.e. with a larger \( A_\pi \)). With the cost channel, the response of inflation is stronger and the corresponding decline in the expected real interest rate is bigger, leading to a larger multiplier when the cost channel is present.\(^4\)

4. Numerical Analysis

This section first discusses the parameterization of the model and then presents the benchmark numerical results regarding the government spending multiplier in the model with the cost channel.

4.1. Parameterization

Table 1 summarizes the parameter values that are used in the benchmark analyses. To allow for comparisons with the seminal work of Christiano et al. (2011), all of the parameter values in this table are set as in their study. To obtain the value of \( \delta \), I iterate on the value of \( \alpha \) between 0 and 1 and then use the relationship between both parameters that is shown in Subsection 2.2; namely \( \delta = \frac{\alpha R_L}{1 - \alpha + \alpha R_L} \). The values of the parameters \( \Psi_r \) and \( \Psi_l \) are set based on empirical analyses that are presented in Appendix B.1, where I distinguish between normal times and liquidity traps.\(^5\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( \beta )</th>
<th>( \sigma )</th>
<th>( \gamma )</th>
<th>( \rho )</th>
<th>( \kappa )</th>
<th>( g )</th>
<th>( \phi_\pi )</th>
<th>( \phi_y )</th>
<th>( \pi )</th>
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<td>0.80</td>
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<td>0.20</td>
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</tr>
</tbody>
</table>

Table 1: Values of the parameters. Note: \( p = \rho \). \( \Psi_r = 1.0010 \), \( \Psi_l = 0.0139 \) for 1984:Q1-2008:Q3 and \( \Psi_r = 1.1004 \), \( \Psi_l = 0.0382 \) for 2008:Q4-2015:Q4. The values of loan rate are \( R_L = 1.0210 \) for the first sub-period and \( R_L = 1.0139 \) for the second.

\(^4\)When the nominal policy interest rate responds to output alongside inflation \( (\phi_y > 0) \), the same arguments hold. In this case, the expected real interest rate is given by: \( E_t \tilde{r}_{t+1} = [(\phi_\pi - \rho) A_\pi + \phi_y A_y] \tilde{g}_t \), which, other things equal, shows a larger increase in the expected real interest rate than in the model with response to inflation only. Therefore, the government spending multiplier in this case is lower than in the model with \( \phi_y = 0 \), with or without the cost channel, which is in line with the findings of Christiano et al. (2011). In addition, when the nominal interest rate is fixed, we have \( \tilde{\pi}_t = A^{LT}_\pi \tilde{g}_t \), and the expected inflation rate is given by \( E_t \tilde{\pi}_{t+1} = p A^{LT}_\pi \tilde{g}_t \), implying that the response of the expected inflation rate to government spending shocks is proportional to the response of the actual inflation rate to government spending shocks. The same applies to the real interest rate \( (\tilde{r}_t) \) and the expected real interest rate \( (E_t \tilde{r}_{t+1}) \).

\(^5\)The Federal Reserve System started raising the Federal Funds Rate in January 2016 after it has essentially been at the ZLB since the fourth quarter of 2008.
4.2. Numerical Results- Benchmark

The top panels of Figure 1 show the government spending multiplier for values of $\delta$ between 0 and 1. Without the cost channel, the spending multiplier of normal times is slightly above one (as in Christiano et al., 2011), but it declines as the significance of the cost channel rises. The overall effect on the normal-times multiplier, however, is relatively modest, which aligns with the above analysis.

![Figure 1: The government spending multiplier and the response of the expected real interest rate to government spending shocks for various values of $\delta$.](image)

In liquidity traps, the multiplier starts from a value of 3.7, which is exactly the value in Christiano et al. (2011), and then significantly rises in $\delta$. Therefore, the effects of the cost channel are quite clear and they support the expectations: the cost channel plays a significant role in strengthening the “expected inflation channel” and renders the liquidity-trap multiplier considerably larger than the normal-times counterpart.

The behavior of the expected real interest rate helps with understanding these results: in normal times, the expected real interest rate rises with the strength of the cost channel, which constitutes a stronger crowding out effect on consumption, and hence a smaller spending multiplier. In liquidity traps, the expected real interest rate falls with the cost channel, thus generating a bigger stimulative effect of government spending.\(^6\) An important take away of these findings is that the response of monetary policy to spending shocks matters for how the cost channel affects the spending multiplier.

4.3. The Government Spending Multiplier and the Credit Spread

In this subsection, I briefly discuss an alternative representation of the government spending multiplier, which shows the effects of the cost channel on the government spending multiplier of liquidity

\(^6\)The numerical results when the policy interest rate responds to output ($\phi_y > 0$) are very similar to the results of Figure 1. On this basis, I proceed with the assumption that the nominal interest rate responds to inflation only.
traps in a clearer manner. Let \( \tilde{s}_t = A_s \tilde{g}_t \), then in normal times we have:

\[
M_{NT}^{\gamma} = \frac{(1 - \beta \rho - \delta \eta \phi \pi)(1 - \rho) [\gamma (\sigma - 1) + 1] + \kappa (\phi \pi - \rho) - (1 - g)(\phi \pi - \rho) \kappa \delta \lambda A_s}{(1 - \beta \rho - \delta \eta \phi \pi)(1 - \rho + (1 - g) \phi \pi) + (1 - g) \kappa (\phi \pi - \rho) \left[ \frac{1}{1 - g} + \frac{\pi}{1 - \pi} + \delta \phi \pi \right]}
\]

(27)

with \( \delta = \frac{\pi}{g(R + \pi)} \) and \( \lambda = \frac{\pi}{g(R + \pi)} \). The last term in the numerator clearly shows that, other things equal, a rise in the spread following a government spending shock \( A_s > 0 \) leads to a decline in the government spending multiplier. This effect is magnified by the strength of the cost channel. The total effect of the cost channel, however, is a-priori unclear as \( \delta \) appears in multiple terms both in the numerator and denominator of this equation.

Similarly, in liquidity traps:

\[
M_{LT}^{\gamma} = \frac{(1 - \beta p)(1 - p) [\gamma (\sigma - 1) + 1] - p \kappa + (1 - g)p \kappa \delta \lambda A_s}{(1 - \beta p)(1 - p) - p \kappa (1 - g) \left[ \frac{1}{1 - g} + \frac{\pi}{1 - \pi} \right]}
\]

(28)

Under the assumption that the denominator of this expression is positive, the response of the spread to a government spending shock is positive \( A_s > 0 \); see Appendix A.3 for a proof. In addition, the cost channel appears only in the numerator of condition (28); therefore, the cost channel raises the spending multiplier of liquidity traps. Intuitively, a rise in government spending raises the credit spread and, as result, the firms’ borrowing costs. Firms respond by raising prices by more than they would in the absence of the cost channel, implying that the expected inflation channel is stronger; as result, the government spending multiplier of liquidity traps is larger than in the model of Christiano et al. (2011).

Figure B.1 presents the response of the spread to a government spending shock when \( \delta \) is varied. The key observation is that the \( A_s \) is positive for normal times and liquidity-trap periods. Consequently, the cost channel reduces the spending multiplier of normal times (per condition (27)), but raises the spending multiplier of liquidity traps (condition (28)). These numerical results support the analyses that are discussed in Section 2.3 regarding the behavior of the credit spread.

While this paper explains the behavior of the credit spread by focusing on the market power and real costs of intermediaries, the literature suggests other mechanisms that can lead to a similar outcome. For example, in the standard Costly State Verification (CSV) model of Carlstrom and Fuerst (1997), the rise in the risk premium (the loan rate in excess of the rate on a safe asset) rises following positive shocks. In the online appendix, I provide analysis to illustrate this result using a simplified version of the CSV model.

5. Robustness Analysis

This section first considers alternative parameter values, and then shows the results with an alternative interest-rate rule as well as separable preferences. The section is concluded by presenting a medium-scale DSGE model.

5.1. Alternative Parameter Values

Figure B.2 provides the results of two robustness analyses. First, the size of \( \Psi_l \) is twice its benchmark value. This modification has a small effect on the spending multiplier of normal times, but a
profound effect on the spending multiplier of liquidity traps. Second, I set $\kappa = 0.033$, which corresponds to less rigid prices (this value of $\kappa$ guarantees that the denominator of condition (24) is still positive). This small modification has a very strong effect on the size of the liquidity-trap multiplier and a small effect on the normal-times multiplier. Therefore, with more flexible prices, the cost channel has considerably stronger effects on the government spending multiplier of liquidity-trap periods.7

5.2. An Alternative Interest-Rate Rule: Active vs. Passive Monetary Policy

Following Dupor and Li (2015), the nominal interest rate is governed by the following rule:

$$\bar{R}_t = (1 + \psi) E_t \pi_{t+1}. \quad (29)$$

and the expected real interest rate is then given by $E_t \bar{R}_{t+1} = \psi E_t \pi_{t+1}$. Monetary policy is “active” if the nominal policy interest rate rises by more than one-for-one with the expected inflation rate (which occurs when $\psi > 0$), “passive” if the nominal policy interest rate rises by less than one-for-one ($\psi < 0$), and “neutral” if this interest rate rises by exactly one-for-one ($\psi = 0$). This specification directly addresses the expected inflation rate channel that has been frequently mentioned in the fiscal multiplier literature. Also, $\psi = -1$ is the lower bound on this parameter, otherwise the nominal interest rate will decline following a rise in inflation expectations, which is implausible. These observations hold whether or not the cost channel exists.8 The government spending multiplier of normal times is then given by:

$$M^{NT} = \frac{(1 - \rho)(1 - \beta \rho - \delta \kappa p \psi_r (1 + \psi)) [\gamma (\sigma - 1) + 1] + \kappa p \psi (1 + \delta \Psi_T)}{(1 - \rho)(1 - \beta \rho - \delta \kappa p \psi_r (1 + \psi)) + \kappa p \psi (1 + \delta \Psi_T) + (1 - g) \kappa p \psi \left[ \frac{\pi_{t+1} + \delta \Psi_T}{1 - \pi} \right]} \quad (30)$$

In liquidity traps, $\bar{R}_t = 0$, implying $\psi = -1$. Then, we get:

$$M^{LT} = \frac{(1 - p)(1 - \beta p) [\gamma (\sigma - 1) + 1] - \kappa p (1 + \delta \Psi_T)}{(1 - \rho)(1 - \beta \rho) - \rho \kappa \left[ 1 + \delta \Psi_T + (1 - g) \frac{\pi_{t+1} + \delta \Psi_T}{1 - \pi} \right]} \quad (31)$$

which is exactly as in the benchmark model (condition (24)). For this reason, the change in the monetary policy rule has no effects on the spending multiplier of liquidity traps, and the above analyses regarding the liquidity-trap multiplier hold.

On the other hand, changing the interest-rate rule could have implications for the spending multiplier of normal times. In order to examine the effects of the cost channel on the spending multiplier with this interest-rate rule, I calculate the normal-times spending multiplier for various values of $\delta$ under both active and passive central banks. The results are reported in Figure B.3. For the active central bank, the rise in the expected real interest rate with the cost channel is larger.

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7It is well known in the literature that changing $\kappa$ may have a large impact on the spending multiplier of liquidity traps. See, for example, Carlstrom et al. (2014).

8As noted by Dupor and Li (2015), with $\psi < 0$, the equilibrium is not unique (as the coefficient of inflation in the interest-rate rule is $\rho (1 + \psi) < 1$). In this case, the minimum-state-variable (MSV) equilibrium, which has been frequently used in rational expectations models since McCallum (1983), is analyzed. The MSV limits solutions to those that are linear functions of the minimum set of “state variables”, which are either predetermined or exogenous determinants of current endogenous variables. McCallum (1999) argues that the MSV approach generally identifies a single solution that can “reasonably be interpreted as the unique solution that is free of bubble components”.

12
than otherwise, which makes the cost-channel spending multiplier smaller. Moreover, the impact of the cost channel on the size of the multiplier is more significant for a passive policy than for an active policy. This observation may reflect the fact that the government spending multiplier with the active central bank is already (relatively) low. The opposite holds for a passive central bank; the cost channel strengthens the impact of government spending shocks on consumption and thus raises the multiplier.

The reason for this finding is the following: the cost channel increases the expected inflation rate beyond the corresponding increase in the expected inflation rate that would materialize when this channel is absent. With a passive central bank, the nominal interest rate rises by less than one-for-one with the rise in the expected inflation rate, leading to larger drop in the expected real interest rate in the model with the cost channel; in turn, the government spending multiplier is larger. Therefore, the degree to which the central accommodates fiscal policy shocks matters for the effects of the cost channel on the effectiveness of fiscal policy; the more accommodative the central bank, the larger the spending multiplier. In this respect, the “passive” monetary policy can be seen as an intermediate case between normal times and liquidity traps; monetary policy reacts to changes in the expected inflation rate, but by less than one-for-one, while in normal times the central bank is essentially active.

5.3. Separable Utility Function

The period utility function in this setup is given by:

$$u(c_t, n_t) = \frac{c_1^{1-\sigma} - \sigma^t}{1 - \sigma} - \chi n_1^{1+\nu}$$

(32)

with $\sigma$ being the consumption curvature parameter and $\nu$ the inverse of the labor supply elasticity. The corresponding Euler and labor supply conditions are given by:

$$\overline{R_t} - E_t \overline{\pi_{t+1}} = \sigma (E_t \overline{c_{t+1}} - \overline{c_t})$$

(33)

$$\nu \overline{n_t} + \sigma \overline{c_t} = \overline{w_t}.$$  

(34)

Under the assumption $\phi > 1$, the spending multiplier of normal times:

$$M^{NT} = \frac{\kappa(\phi - \rho)\sigma(1 + \delta \Psi_t) + (1 - \rho)(1 - \beta \rho - \delta \Psi_t, \kappa \phi)}{\kappa(\phi - \rho)[(1 + \delta \Psi_t)(\sigma + \nu(1 - g)) + \delta \Psi_t(1 - g)] + \sigma(1 - \rho)(1 - \beta \rho - \delta \Psi_t, \kappa \phi)\phi}$$

(35)

And, in liquidity traps:

$$M^{LT} = \frac{\sigma[(1 - \beta \rho)(1 - \rho) - p\kappa(1 + \delta \Psi_t)]}{\sigma(1 - \beta \rho)(1 - \rho) - p\kappa[(1 + \delta \Psi_t)(\sigma + \nu(1 - g)) + (1 - g)\delta \Psi_t]}$$

(36)

With $\delta = 0$, the liquidity-trap spending multiplier restores that of Carlstrom et al. (2014). Once more, the spending multiplier is affected by the cost channel, $\kappa$ matters markedly, and the

9When the utility function is separable in consumption and labor ($\sigma = 1$), the spending multiplier is 1 when the central bank is neutral ($\psi = 0$) and less than 1 for an active monetary policy ($\psi > 0$). The multiplier is larger than 1 if monetary policy is passive ($\psi < 0$) provided that the denominator is positive.
cost channel will not affect the size of the multiplier when $\kappa = 0$. Figure B.4 provides numerical evaluation; in normal times, the introduction of the cost channel has a slight negative effect on the spending multiplier, while in liquidity traps the cost channel induces a rise in the spending multiplier. These findings confirm the findings with the non-separable utility function, albeit the effects of the cost channel are smaller than in the former case.

5.4. A Medium-Scale DSGE Model and the Cost Channel

This section presents a medium-scale DSGE model that features multiple nominal and real frictions as well as physical capital. Differently from the baseline setup, I assume that the government issues bonds and uses distortionary taxes (on labor and capital) to finance its spending. Household preferences exhibit habit persistence whereby current utility depends on the previous-period level of consumption. Households hold cash, government bonds and make deposits at the intermediary. The full details of the model and the parameterization of the model are outlined in Appendix A.4.

The model is solved numerically to evaluate the size of the government spending multiplier. Figure B.5 displays the response of the economy to a government spending shock under the assumption that the nominal interest rate is free to adjust. For each variable, the response of that variable is normalized to the change in government spending (i.e. the vertical axes display $\frac{\Delta x_{t+h}}{\Delta g_t}$ for each variable $x$); therefore, for output, the figure essentially displays the impact spending multiplier. The rise in government spending induces a rise in inflation and consequently the real interest rate. In this case, investment responds strongly and consumption displays a small decline (but remains mostly unchanged due to habit persistence). This effect is magnified by the cost channel. The behavior of output mostly follows the behavior of investment and the government spending multiplier with the cost channel is smaller than in the alternative model.

For liquidity traps, the drop in the real interest rate is magnified by the cost channel (as inflation rises more), which induces a larger increase in investment and a smaller drop in consumption relative to a model without the cost channel (Figure B.6). As a result, the government spending multiplier is larger on impact. This result reaffirms the findings from the benchmark model.

In the baseline model, the size of the multiplier is determined by the behavior of consumption: the multiplier is larger than one if consumption rises after a spending shock, less than one if the opposite occurs and exactly one if consumption is irresponsive to spending shocks. In the expanded model, however, the spending multiplier depends also on the behavior of investment and on the habit persistence. The latter reduces the response of consumption to spending shocks. In fact, the response of consumption in this model is very small and does not drive the dynamics of output. Investment reacts very sharply to a spending shock, which reflects the sharp decline in the real interest rate (in liquidity traps) or the sharp rise in the real interest rate (in normal times). Clearly, the behavior of output on impact resembles the behavior of investment.

The goal of this subsection is to study the effectiveness of fiscal policy when the nominal interest rate is fixed. Therefore, unlike in subsection 4, we do not impose that the probability that the nominal interest rate is fixed ($p$) to equal the persistence of government spending ($\rho$). Instead, we let $p \to 1$ in this experiment so that $R_t$ is essentially irreversible to spending shocks. By letting the nominal interest rate be virtually constant, we can focus on the effects of the cost channel on the effectiveness of fiscal policy without being concerned about the degree to which monetary policy is accommodative.
6. Empirical Analysis

6.1. The Credit Spread, Excess Bond Premium and Government Spending Shocks

Standard economic theory suggests that government spending crowds out the private sector by, among other channels, increasing the cost of borrowing of firms. This subsection provides some empirical evidence regarding the effects of changes in government spending on the credit spread. For government spending I use the “Real Government Consumption Expenditures and Gross Investment”. The credit spread is measured as the difference between Moody’s Seasoned Baa Corporate Bond Yield and a 3-Month Treasury Bill Rate. Unless otherwise stated, the data are available in the FRED database of the Federal Reserve Bank of St. Louis. I use Baa rated corporate bonds as they represent well rated bonds (i.e. not the best or worst rated corporate bonds).

I use local projection as in Jorda (2005) based on a Victor Auto-Regression (VAR) that includes the credit spread, output gap, tax receipts-GDP ratio, the 10-year minus 3-month U.S. government bond spread and a government spending shock. Cholesky Decomposition is used where the shock to government spending is ordered first. For identification, I use four different fiscal policy shocks: 1) the stock returns approach of Fisher and Peters (2010); 2) the dummy variable of military news of Ramey and Shapiro (1998); 3) the narrative approach of military news of Ramey (2011), and 4) the errors of fiscal policy as obtained from the Survey of Professional Forecasters (SPF). These errors are calculated for the current quarter, and then for 1-4 quarters in the future. In what follows, I show the results for the current quarter, 1 quarter in the future and 4 quarters in the future, but the results hold also for a horizon of 2-3 quarters.

Figure B.7 shows the results for the period 1984:Q1-2008:Q3. In all cases, the credit spread rises after a shock to government spending. This effect typically lasts for roughly two years before becoming statistically insignificant at the 95% confidence level. For the second sub-period (2008:Q4-2015:Q4), the shock that is based on stock returns is not available. In addition, since the dummy variable takes a value of zero for every quarter since 2001:Q3, I do not use for it this sub-sample either. As such, I present results that are based on the narrative military news variable and the SPF forecast errors (Figure B.8). Overall, these results suggest that the credit spread rises following a government spending shock; this is clearly the case with the military news shock. As for the SPF forecast errors, the effects tend to be significant for nearly 6 quarters, but the responses to a government spending shock are not as smooth as in the first sub-sample (which could reflect the relatively short sub-period.

To experiment on the results for the first sub-sample, I show the results using the excess bond premium, which is available for the period 1973:Q1-2010:Q3. The advantage of this measure is that it accounts for the cost of financial frictions rather than just the compensation for risk (put differently, the excess bond premium captures the additional spread that is not directly attributable to firm-specific expected default risk.). Overall, the results confirm the findings with the credit spread, and the effects seem to persist for an extended period of time (Figure B.9).

6.2. Cross-Country Evidence: The Cost Channel and Spending Multiplier

The goal of this subsection is twofold. First, to check if the cost channel holds for a panel of 16 advanced nations. Second, to estimate the government spending multiplier for these countries and

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then examine if any systematic relationship exists between the strength of the cost channel and the spending multiplier. Specifically, I examine whether countries with stronger cost channel tend to have lower spending multipliers (as this paper finds in normal times). The analysis is based on the quarterly data that have been collected by Ilzetzki et al. (2013), which cover the period between 1960:Q1-2007:Q4 (with some variation between countries due to the availability of data). To calculate the spending multipliers, I follow Ilzetzki et al. (2013) by employing the SVAR approach of Blanchard and Perotti (2002). The sample includes Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, the UK and the US.

Due to sample limitations, formal regression analyses are not feasible and, thus, I only show simple analyses (Figure B.10). The main findings can be summarized as follows. First, as the figure indicates, the cost channel exists in almost all industrial countries. Second, on average, a stronger cost channel is associated with a lower government spending multiplier. Countries with nearly zero (or even negative multipliers) are mostly nations with very strong cost channel. Indeed, the correlation coefficient between the strength of the cost channel and the impact government spending multiplier is sizeable (-36%). These findings are mostly consistent with the analysis using U.S. data.\textsuperscript{12}

Ilzetzki et al. (2013) discuss the impact of multiple factors on the government spending multiplier and find that it is affected by the level of development (the multiplier is relatively large in advanced than in developing economies), exchange rate regime (the multiplier is larger in economies with predetermined exchange rates and zero in economies that operate under flexible exchange rates), openness to trade (more open economies have smaller multipliers), and public indebtedness (high-debt countries have negative multipliers). My findings indicate that the strength of the cost channel of monetary policy can be viewed as another reason for the differences in the size of the government spending multiplier across countries. Since I use data for advanced countries only, the findings cannot be attributed to substantial differences in the levels of development or the quality of institutions.

7. Conclusions

The government spending multiplier in a model with the cost channel of the nominal interest rate is studied in this paper. It is found that the cost channel matters a great deal for the size of the spending multiplier. In normal times, where the nominal interest rate is free to adjust, the cost channel reduces the multiplier considerably as it induces a bigger rise in the expected real interest rate following a rise in government spending, which crowds out consumption. When the nominal policy interest rate is fixed and the costs of borrowing of firms rise following a spending shock, the cost channel leads to a bigger drop in the expected real interest rate and, consequently, to a larger government spending multiplier. Empirically, The paper provides evidence about the response of a corporate credit spread to government spending shocks, suggesting that firms’ borrowing costs are not fixed during zero lower-bound episodes. In turn, this allows the cost channel to be operative even when the nominal policy interest rate is fixed.

\textsuperscript{12}Two comment are in order. First, the correlation coefficient between the cost channel and the cumulative government spending multiplier for this sample period is -30\%. Second, due to differences across countries regarding the ZLB since 2008:Q4, I focus on the first sub-sample only.
This study adds to the voluminous literature on the government spending multiplier and to the literature on the cost channel. By so doing, the paper provides first analysis regarding the implications of the cost channel for the effectiveness of fiscal policy as previous literature on the cost channel naturally focused on monetary policy and the dynamics of inflation. The debates about the 2009 American Recovery and Reinvestment Act as well as the size of the government spending multiplier, particulary during liquidity traps, make this topic very important to investigate.

References


A. Mathematical Appendix

I start by presenting the households’ problem and then move to presenting the expected real interest rate and the response of inflation to spending shocks with both fixed and non-fixed nominal policy interest rates. I also show the problem of the intermediation sector and an alternative approach to introducing the cost channel in the model.

A.1. The Households’ Problem

The problem of the households is to

\[
\max_{\{c_t, D_t, M_t, n_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{[c_t^\gamma (1 - n_t)^{1-\gamma}]^{1-\sigma} - 1}{1 - \sigma} \right) \quad (A.1)
\]

subject to the sequence of budget constraints

\[
P_t c_t + D_t + M_{t+1} = M_t + R_t D_t + W_t n_t + T_t + \Pi_t \quad (A.2)
\]

and the cash-in-advance (CIA) constraint:

\[
P_t c_t = M_t + W_t n_t - D_t \quad (A.3)
\]

where \( W_t \) denotes the nominal wage, \( P_t \) is the price level, \( R_t \) is the gross nominal policy (or market) interest rate, \( T_t \) are nominal net transfers and \( \Pi_t \) are nominal profits from the ownership of firms and the financial intermediary.

Denote the Lagrange multipliers on conditions (A.2) and (A.3) by \( \lambda_t \) and \( \mu_t \), respectively. Then, the first-order conditions with respect to \( c_t, D_t, M_t \) and \( n_t \) are, respectively, given by:

\[
[c_t^\gamma (1 - n_t)^{1-\gamma}]^{-\sigma} \gamma c_t^{\gamma-1} (1 - n_t)^{1-\gamma} = P_t (\lambda_t + \mu_t) \quad (A.4)
\]

\[
\lambda_t R_t = \lambda_t + \mu_t \quad (A.5)
\]

\[
\lambda_t = \beta \mathbb{E}_t (\lambda_{t+1} + \mu_{t+1}) \quad (A.6)
\]

\[
[c_t^\gamma (1 - n_t)^{1-\gamma}]^{-\sigma} (1 - \gamma) c_t^\gamma (1 - n_t)^{-\gamma} = W_t (\lambda_t + \mu_t) \quad (A.7)
\]

Combining conditions (A.4)-(A.6) gives the Euler equation:

\[
[c_t^\gamma (1 - n_t)^{1-\gamma}]^{-\sigma} \gamma c_t^{\gamma-1} (1 - n_t)^{1-\gamma} = \beta R_t \mathbb{E}_t \left( \frac{[c_{t+1}^\gamma (1 - n_{t+1})^{1-\gamma}]^{-\sigma} \gamma c_{t+1}^{\gamma-1} (1 - n_{t+1})^{1-\gamma}}{\pi_{t+1}} \right) \quad (A.8)
\]

Similarly, combining (A.4) and (A.7) gives the labor supply condition:

\[
\frac{(1 - \gamma) c_t}{\gamma (1 - n_t)} = w_t \quad (A.9)
\]

Log Linearization of conditions (A.8) and (A.9) around the deterministic steady state yields conditions (4) and (5) in the text, respectively.
A.2. The Intermediation Sector

There is a continuum of measure 1 of identical intermediaries (banks). Let $D_{i,t}$ and $L_{i,t}$ denote the time-$t$ amounts of deposits at bank $i$ and the amount of loans that are extended by this bank, respectively. Let also $D_{-i,t}$ and $L_{-i,t}$ be the amounts of deposits and loans of all other banks. The total amount of deposits and loans are then given by: $D_t = D_{i,t} + D_{-i,t}$ and $L_t = L_{i,t} + L_{-i,t}$. Banks operate in an environment with Cournot competition in the loan market with each bank taking $D_{-i,t}$ and $L_{-i,t}$ as given. The loan rate $R_{L,t}$ is determined by the total demand for loans. Formally, $R_{L,t} = R_L(L_t)$. The loan interest rate and the total amount of loans are negatively related: $\frac{\partial R_{L,t}}{\partial L_t} < 0$.

Let lower case variables denote the corresponding real values of each variable, then the problem of bank $i$ is to choose $d_{i,t}$ and $l_{i,t}$ to maximize its expected present discounted stream of real profits, with time-$t$ profits given by:

$$\Pi^b_{i,t} = R_{L,t} l_{i,t} - R_D d_{i,t} - R_h h_{i,t} - \Gamma_{i,t}$$

(A.10)

with $\Gamma_{i,t} = \Gamma(l_{i,t})$ being the cost of managing loans and $h_{i,t}$ being the real balance (position) of bank $i$ in the interbank market. The latter can be either positive (if bank $i$ is a net lender), negative (if the bank is a net borrower) or zero. The nominal policy interest $R_t$ is the interest rate at which interbank lending takes place, which similar to the Federal Funds Rate in the U.S. Furthermore, $\frac{\partial \Gamma_{i,t}}{\partial L_{i,t}} > 0$.

Profit maximization by bank $i$ is subject to its balance sheet:

$$l_{i,t} = d_{i,t} + h_{i,t}$$

(A.11)

where, for simplicity, I abstract from reserve requirements. In addition, since all banks are symmetric in equilibrium, the interbank lending of each bank is zero; therefore, $h_{i,t} = 0$ for all $i$ and $t$. Substituting condition (A.11) into the present discounted stream of profits and taking first-order conditions with respect to $l_{i,t}$ yields:

$$R_{L,t} = R_t - \frac{\partial R_{L,t}}{\partial l_t} \frac{\partial l_t}{\partial l_{i,t}} l_{i,t} + \frac{\partial \Gamma_{i,t}}{\partial l_{i,t}}.$$  

(A.12)

Condition (A.12) suggests that the loan interest rate is higher than the market interest rate due to the market power of banks and the cost of managing loans. As a result, we have $R_{L,t} > R_t$, and thus banks generate profits by charging above-market interest rates on the loans that they extend. This condition then gives condition (15) in the text:

$$R_{L,t} = R_t + s_t$$  

(A.13)

where $s_t = -\frac{\partial R_{L,t}}{\partial l_t} \frac{\partial l_t}{\partial l_{i,t}} l_{i,t} + \frac{\partial \Gamma_{i,t}}{\partial l_{i,t}}$ measures the spread, driven in this analyses by market power in the loan market and the cost of managing loans.

Following Kopecky and VanHoose (2012), we assume that the cost of managing the current amount of loans is quadratic:

$$\Gamma_{i,t} = \frac{\theta}{2} l_{i,t}^2$$  

(A.14)

and the demand for total loans is given by:
\[ l_t = \left( \frac{R_t}{R_{L,t}} \right)^\xi \]  

(A.15)

with \( \theta \) being the parameter that governs the cost of managing loans and \( \xi \) governs the degree of market power in the loan market. After imposing symmetry across intermediaries, the first-order condition with respect to loans (A.12) can be re-written as:

\[ R_{L,t} = \frac{\xi}{\xi - 1} R_t + \theta \frac{\xi}{\xi - 1} l_t \]  

(A.16)

which is condition (13) in the text.

Notice that in the benchmark setup, we have the special case of the deposit rate being equal to the policy rate (\( R_{D,t} = R_t \)), which can be obtained by taking a first-order condition with respect to \( d_{t,t} \). In the real world, the spread between the loan rate and the policy rate may result from other factors that are not accounted for in this illustrative case. The key goal of this analysis is to demonstrate how the loan rate can differ from the policy interest rate, implying that even at the ZLB, the loan rate is not zero (and/or not constant).

In addition, loans equal the part of the wage bill that is paid in advance:

\[ l_t = \alpha w_t n_t. \]  

(A.17)

Substituting this condition in condition (A.11) and imposing symmetry gives \( d_t = \alpha w_t n_t \), which is the clearing condition of the intermediation sector.

A.3. The Response of the Credit Spread to a Government Spending Shock
Log-linearizing condition (A.17) around the deterministic steady state gives:

\[ \ln_t = \ln_t + \n_t = \ln_t + \n_t + \n_t \]  

(A.18)

which suggests that the amount of loans rises proportionately with labor income. Using the production function, (A.18) can also be re-written as:

\[ \ln_t = \ln_t + \n_t + \n_t \]  

(A.19)

Furthermore, using the log-linearized labor supply condition and condition (A.19), gives:

\[ \ln_t = \ln_t + \n_t + \n_t + \n_t \]  

(A.20)

Next, substituting the log-linearized resource constraint and the log-linearized production function into (A.20), and re-arranging give:

\[ \ln_t = \left( \frac{(1 - g) + (1 - \n)}{(1 - g)(1 - \n)} \right) \n_t - \frac{g}{1 - g} \n_t \]  

(A.21)
Recall that the spread is given by:

\[ s_t = \frac{1}{\xi} \left( 1 + \frac{R}{\psi_r} \right) \psi_r \hat{R}_t + \left( 1 + \frac{R}{\psi_l} \right) \psi_l \hat{l}_t \]  
(A.22)

Therefore, letting \( \hat{l}_t = A_l \hat{g}_t \) and using the interest-rate rule, condition (A.22) can be re-written as:

\[ A_{sNT}^N = \frac{1}{\xi} \left( 1 + \frac{R}{\psi_r} \right) \psi_r \phi_{\pi} A_{\pi}^{NT} + \phi_y A_y^{NT} + \left( 1 + \frac{R}{\psi_l} \right) \psi_l A_l^{NT} \]  
(A.23)

Therefore, in normal times, to the extent that output and the inflation rate rise following a rise in government spending (\( A_{\pi}^{NT}, A_y^{NT} > 0 \)) and labor income rises (\( A_l^{NT} > 0 \)), the credit spread rises.

In liquidity traps:

\[ A_s^{LT} = \left( 1 + \frac{R}{\psi_l} \right) \psi_l A_l^{LT} \]  
(A.24)

and, thus, the spread rises with the rise in loans (or labor income). Therefore, the proof that, in liquidity traps, the credit spread rises following a spending shock amounts to proving that \( A_l > 0 \).

To do, so, first write (A.21) as:

\[ A_l^{LT} = \left( \frac{(1-g) + (1-\pi)}{(1-g)(1-\pi)} \right) A_y^{LT} - \frac{g}{1-g} \]  
(A.25)

then substitute the expression for \( A_y^{LT} \) to get:

\[ A_l^{LT} = \frac{(1-\beta p)(1-p)\gamma(\sigma-1)[(1-g) + (1-\pi)]g + (1-g)[(1-\beta p)(1-p) - p\kappa(1-\pi)]g}{(1-g)(1-\pi)\Delta} \]  
(A.26)

where \( \Delta = (1-\beta p)(1-p) - p\kappa [1 + \delta \psi_r + (1-g) \frac{\pi + \delta \psi_l}{1-\pi}] \) is positive as assumed in the text. But since \( \Delta > 0 \), the second expression in the numerator, \( (1-\beta p)(1-p) - p\kappa(1-\pi) \), is surely positive. Therefore, \( A_l^{LT} > 0 \). As a result, \( A_s^{LT} > 0 \).
A.4. A Medium-Scale DSGE Model

In this appendix, I outline a model that includes capital, habit persistence in consumption, labor taxation, capital taxation and government bonds. The model is then solved numerically and the results are presented in Section 5.4 of the paper.

1. Households: the problem of the representative household is to:

\[
\max_{\{c_t, B_t, D_t, M_t, n_t, k_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, c_{t-1}, n_t) \tag{A.27}
\]

The utility function satisfies: \(\frac{\partial u}{\partial c} > 0\), \(\frac{\partial^2 u}{\partial c^2} < 0\) and \(\frac{\partial u}{\partial n} < 0\) and \(\frac{\partial^2 u}{\partial n^2} < 0\).

Maximization is subject to the sequence of households’ budget constraints is given by:

\[
P_t c_t + M_{t+1} + B_{t+1} + D_t + P_t i_t = M_t + R_{D,t} D_t + R_t B_t + (1 - \tau^n_t) W_t n_t + T_t + \Pi_t \tag{A.28}
\]

and the CIA constraint:

\[
P_t c_t = M_t + (1 - \tau^n_t) W_t n_t - D_t \tag{A.29}
\]

and the law of motion of capital:

\[
k_{t+1} = i_t + [r_t + 1 - \delta^k - \tau^k_t (r_t - \delta^k)] k_t - \frac{\phi^k}{2} \left( \frac{k_{t+1}}{k_t} - 1 \right)^2 \tag{A.30}
\]

where \(B_t\) denotes nominal bonds, \(i_t\) is investment in physical capital, \(k_t\) is capital, \(R_t\) is the gross nominal interest rate on bonds, \(R_{D,t}\) is the gross nominal interest rate on deposits, \(\tau^n_t\) is the labor income tax rate, \(\tau^k_t\) is the capital-income tax rate, \(\delta^k\) is the depreciation rate of capital and \(\phi^k\) is the parameter that governs the adjustment cost of capital. All other variables are as defined in the text.

Optimization by households leads to the following first-order conditions:

\[
u_{c,t} = \beta R_{D,t} \mathbb{E}_t \left( \frac{u_{c,t+1}}{\pi_{t+1}} \right) \tag{A.31}
\]

\[
-\frac{u_{n,t}}{u_{c,t}} = (1 - \tau^n_t) w_t \tag{A.32}
\]

\[
u_{c,t} = \beta \mathbb{E}_t \left( \frac{R_{t+1}}{R_{D,t}} \frac{u_{c,t+1}}{\pi_{t+1}} \frac{R_{D,t}}{R_{D,t+1}} \right) \tag{A.33}
\]

\[
u_{c,t} \left[ 1 + \phi^k \left( \frac{k_{t+1}}{k_t} - 1 \right) \right] = \beta \mathbb{E}_t \left[ u_{c,t+1} \frac{R_{D,t}}{R_{D,t+1}} \left[ r_{t+1} + 1 - \delta^k - \tau^k_{t+1} (r_{t+1} - \delta^k) + \phi^k \left( \frac{k_{t+1}}{k_t} - 1 \right) \left( \frac{k_{t+1}}{k_t^2} \right) \right] \right] \tag{A.34}
\]

where \(u_{c,t}\) is the marginal utility of consumption and \(u_{c,t}\) is the marginal utility of labor.

Furthermore, I use the following period utility function:

\[
u(c_t, c_{t-1}, n_t) = \frac{(c_t - hc_{t-1})^{1-\sigma}}{1-\sigma} - \chi \frac{n_t^{1+\nu}}{1+\nu} \tag{A.35}
\]

with \(h\) being the parameter that governs the strength of the habit persistence in consumption.
With this functional form, the marginal utility of consumption is given by:

$$u_{c,t} = (c_t - hc_{t-1})^{-\sigma} - \beta h E_t (c_{t+1} - hc_t)^{-\sigma}$$  \hspace{1cm} (A.36)

Clearly, with $h = 0$, we obtain the standard marginal utility in consumption of separable preferences.

2. Production sector: each intermediate-good firm hires labor and rents capital to produce output using the following technology:

$$y_{j,t} = k_{j,t}^{\varsigma} n_{j,t}^{1-\varsigma}$$  \hspace{1cm} (A.37)

with $\varsigma$ being the elasticity of output with respect to capital.

Since I solve a non-linear version of the model (with which Calvo price rigidity is not tractable), I assume that firms face a quadratic adjustment cost as in Rotemberg (1982), expressed in units of the final good. Then, the problem of the firm it then to choose $k_{j,t}, n_{j,t}$ and $P_{j,t}$ to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{u_{c,t}}{u_{c,0}} \right) \left[ \frac{P_{j,t}}{P_t} y_{j,t} - R_{L,t} \alpha w_t n_{j,t} - (1 - \alpha) w_t n_{j,t} - r_t k_{j,t} - \frac{\varphi}{2} \left( \frac{P_{j,t}}{P_{j,t-1}} - \bar{\pi} \right)^2 y_t \right]$$  \hspace{1cm} (A.38)

with $\beta \frac{u_{c,t}}{u_{c,0}}$ being the stochastic discount factor, $\varphi$ being the price adjustment cost parameter and $\bar{\pi}$ is the steady-state gross inflation rate. Maximization is subject to the demand curve for the firm’s product and the production technology. Taking first-order conditions and imposing symmetry across firms then gives the following factor demands:

$$(1 - \varsigma) k_t^{\varsigma} n_t^{1-\varsigma} m_c = (1 - \alpha + \alpha R_{L,t}) w_t$$  \hspace{1cm} (A.39)

$$\varsigma k_t^{\varsigma-1} n_t^{1-\varsigma} m_c = r_t$$  \hspace{1cm} (A.40)

where $m_c$ is the real marginal cost. As expected, each firm hires labor and rents capital so that the marginal product of each input is a markup over its factor price.

In a symmetric equilibrium, in which all firms set the same price, Rotemberg pricing leads to the following forward-looking Phillips curve:

$$\varepsilon(1 - m_{c_t}) = 1 - \varphi(\pi_t - \bar{\pi}) \pi_t + \beta \varphi E_t \left[ \left( \frac{u_{c,t+1}}{u_{c,t}} \right) (\pi_{t+1} - \bar{\pi}) \pi_{t+1} \frac{y_{t+1}}{y_t} \right]$$  \hspace{1cm} (A.41)

The final-good firm sector remains unchanged.

3. Government Budget Constraint and Marking Clearing: Government expenditures are financed by taxation on labor and capital and the issuance of bonds:

$$P_t g_t + R_{t-1} B_t = B_{t+1} + P_t \tau^n w_t n_t + P_t \tau^k (r_t - \delta^k)$$  \hspace{1cm} (A.42)

and government spending evolves according to:

$$\ln \left( \frac{g_t}{g} \right) = \rho \ln \left( \frac{g_{t-1}}{g} \right) + \zeta_t$$  \hspace{1cm} (A.43)
The resource constraint of the economy is given by:

\[ y_t + (1 - \delta^k)k_t = c_t + k_{t+1} + g_t + \frac{\varphi}{2} (\pi_t - \overline{\pi})^2 y_t + \frac{\phi^k}{2} \left( \frac{k_{t+1}}{k_t} - 1 \right)^2 \]  

(A.44)

4. **Intermediation sector**: The intermediation sector is described in Appendix A.2. In the extended model, I allow for deviations between the nominal policy interest rate, nominal deposit interest rate and the nominal loan rate. Important for this paper, we have:

\[ R_{L,t} = R_t + s_t \]  

(A.45)

with \(s_t\) being a credit spread between the nominal loan rate and the nominal policy rate.

5. **Fiscal Policy Rules**: The tax rates are assumed to respond to deviations of output and the public debt from their steady state values, as follows:

\[
\ln \left( \frac{\tau^n_t}{\overline{\tau}^n} \right) = \rho_n \ln \left( \frac{\tau^n_t}{\overline{\tau}^n} \right) + (1 - \rho_n) \lambda_n \ln \left( \frac{y_t}{\overline{y}} \right) + (1 - \rho_n) \delta_n \ln \left( \frac{b_t^{-1}}{\overline{b}} \right) \]

(A.46)

\[
\ln \left( \frac{\tau^k_t}{\overline{\tau}^k} \right) = \rho_k \ln \left( \frac{\tau^k_t}{\overline{\tau}^k} \right) + (1 - \rho_k) \lambda_k \ln \left( \frac{y_t}{\overline{y}} \right) + (1 - \rho_k) \delta_k \ln \left( \frac{b_t^{-1}}{\overline{b}} \right) \]

(A.47)

This concludes the description of the model.

6. **Parameterization of the Model**: The parameter values that I use in the DSGE model are as follows: \(\varsigma = 0.33, \beta = 0.99, \alpha = 0.50, \sigma = 2.00, \varphi = 18.47, \delta^k = 0.026, \overline{\pi} = 1.005, \overline{\tau}^n = 0.20, \overline{\tau}^k = 0.30, \phi_\pi = 1.50, \phi_y = 0.00, h = 0.80, \rho = 0.80, g = 0.20, \phi^k = 95\) and \(\epsilon = 6.00\). The coefficients of the tax rate rule rules are set to: \(\rho_k = 0.82, \rho_n = 0.82, \lambda_k = 0.66, \lambda_n = 0.65, \delta_k = 0.39\) and \(\delta_n = 0.18\). Some of these parameter values are as in the text. The value of \(\overline{\pi}\) implies an annual inflation rate of 2%, \(\epsilon\) suggests a steady-state price markup of 20% in line with the literature, \(\delta^k\) is set so that the annual depreciation rate of capital is roughly 11%, \(h\) is in line with most studies with habit persistence and the value of \(\varphi\) is consistent with a price duration of 2.5 quarters. Following Faia and Monacelli (2007), this value of \(\varphi\) is obtained by letting the slope of the Phillips curve under Calvo price rigidity be equal to the slope of the Phillips curve under Rotemberg price rigidity. The coefficients of the tax rate rules are obtained from Abo-Zaid et al. (2017), and they are based on empirical evidence.
B. Quantitative Appendix

B.1. Parameters

To calibrate the parameters $\Psi_r$ and $\Psi_l$, I estimate condition (14) using Moody’s Seasoned Baa Corporate Bond Yield for $R_{L,t}$, the 3-Month Treasury Bill Rate for $R_t$, and Commercial and Industrial Loans for $l_t$. To distinguish between normal times and liquidity traps, I conduct analysis for the period before the ZLB became binding (1984:Q1-2008:Q3) and for the U.S. ZLB episode (2008:Q4-2015:Q4). I start with the first quarter of 1984 because of two reasons. First, it is well known that many macroeconomic series have changed since 1984. Second, in Section 6, I provide more empirical evidence where some of the shocks to government spending are available only since the early 1980s. For consistency, I chose 1984:Q1 as the starting point. Furthermore, the U.S. reached the zero-lower bound in 2008:Q4 and the Federal Reserve did not raise the Federal Funds Rate until 2016:Q1. On this basis, my second sub-sample covers 2008:Q4-2015:Q4.

I conduct Ordinary Least Square (OLS) and Generalized Method of Moments (GMM) estimation. The results are summarized in Table B.1. Overall, the results are similar, but to be conservative with the benchmark analyses, I set $\Psi_r$ and $\Psi_l$ as the mid point values that are implied by both methods of estimation. These are the values that are reported in Subsection 4.1. Finally, the values of $\bar{R}_L$ that are reported in Subsection 4.1 correspond to the averages of the Baa series for each sub-periods. In addition, the goal of these analyses is to estimate these two key parameters with no intention to necessarily establish causality.

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<tr>
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<td>$\Psi_r$</td>
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<td>(0.0055)</td>
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<tr>
<td>$\Psi_l$</td>
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<td>0.0157***</td>
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<td>(0.0047)</td>
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<tr>
<td>Obs.</td>
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Table B.1: OLS and GMM estimation of condition (14). Standard errors in parentheses. * Denotes significance at the 10% level. ** Denotes significance at the 5% level. *** Denotes significance at the 1% level. The original series are not stationary while the log-deviations in the model are stationary. To make the series stationary, I calculate the year-over-year for each series.
B.2. Tables and Figures

Figure B.1: The response of the credit spread to government spending shocks ($A_s$) for various values of $\delta$. Following Christiano et al. (2011), I assume a zero steady-state inflation rate ($\pi = 1$). Then, from the Euler equation, $R = 1/\beta$, and the steady-state value of spread is given by $\bar{s} = \bar{R}_L - \bar{R}$. The values of $\bar{R}_L$ for normal times and liquidity traps are provided in the text.

Figure B.2: The government spending multiplier for various values of $\delta$ with alternative parameter values. Top panel: the results with $\Psi_l$ being twice its benchmark value. Middle panel: the results with $\kappa = 0.033$. Bottom Panel: the results with different values of $\beta$ for normal times and liquidity traps. In each case, all other parameter values are as in the text.
Figure B.3: The government spending multiplier and the cost channel: active vs. passive monetary policy for various values of $\delta$. Following Dupor and Li (2015), I set $\psi = -0.5$ for a passive central bank and $\psi = 0.5$ for an active central bank. All other parameter values are as in the text.

Figure B.4: The government spending multiplier for various values of $\delta$ with separable utility function. Notes: $\nu = 0.50$. All other parameter values are as in the text.
Figure B.5: Impulse responses to a positive shock to government spending. Notes: normal times, where the nominal policy interest rate follows an interest-rate rule. The response of each variable is normalized to the change in government spending. With the cost channel, the estimated value of $A^{NT}_t$ on impact is 0.013 (and the peak is 0.027). Time unit: quarters.

Figure B.6: Impulse responses to a positive shock to government spending. Notes: liquidity traps. The response of each variable is normalized to the change in government spending. With the cost channel, the estimated value of $A^{LT}_t$ on impact is 0.24. Time unit: quarters.
Figure B.7: Impulse responses of the corporate credit spread to a positive government spending shock using local projections. Sample period: 1984:Q1-2008:Q3. Notes: shaded areas indicate the 95% confidence intervals. I include a fiscal policy shock, government spending, credit spread, output, tax receipts-GDP ratio and the 10-year minus 3-month U.S. government bond spread. Government spending series: Real Government Consumption Expenditures and Gross Investment.

Figure B.8: Impulse responses of the corporate credit spread to a positive government spending shock using local projections. Sample period: 2008:Q4-2015:Q4. Notes: see figure B.7 for more details.
Figure B.9: Impulse responses of the excess bond premium to a positive government spending shock using local projections. Sample period: 1984:Q1-2008:Q3. Notes: the data on the excess bond premium are obtained from Gilchrist and Zakrajšek (2012), who decompose their credit spread index into two components: one that captures the systematic movements in default risk of individual firms, and a residual component that represents the cyclical changes in the relationship between the measured default risk and credit spreads (which is the excess bond premium). See figure B.7 for more details.

Figure B.10: Cross-country analysis: the impact government spending multiplier vs. the response of inflation to changes in the nominal policy interest rate (the equivalent to $\kappa \delta \Psi_r$ in the model economy). Sample period: 1984:Q1-2007:Q4. For identification, I follow Ilzetzki et al. (2013) by employing the SVAR approach of Blanchard and Perotti (2002) as using local projections for the entire list of countries is not practical due to the lack of the fiscal policy shocks (that are discussed in the text) for this panel of nations.