Optimal Monetary and Fiscal Policy: The Role of Substitutability between Private and Public Consumption*

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Abstract

We show that the degree of substitutability between private and public consumption can have important effects on the effectiveness of fiscal stabilization policy at the zero lower bound on the nominal interest rate. Specifically, we study optimal monetary and fiscal policy under discretion within a simple stochastic New Keynesian model. We find that relatively less government intervention is needed to stabilize the economy if public and private spending are complements. Furthermore, the improved stabilization performance of government spending under complementarity results in a relatively lower variance of inflation, the output gap and the government spending gap.

JEL Classification: E31, E52, E62, E63, D11

Keywords: Monetary Policy, Fiscal Policy, Discretion, Edgeworth complementarity, Zero nominal interest rate bound, New Keynesian model

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1 Introduction

The recent financial crisis and the ensuing academic debate on the size of the fiscal multiplier has renewed the interest in the effectiveness of fiscal stabilization policy. The literature has shown (see e.g. Linnemann and Schabert, 2004, or Ganelli and Tervala, 2009) that a lower degree of substitutability[1] between private and public consumption would lead to less crowding out of private consumption or even to a stimulating effect of public on private consumption. Assuming an additively separable utility specification in private and public consumption as is usually done in the New Keynesian model setup might lead to a misinterpretation of the effects of government spending on economic activity.

In the aftermath of the first wave of the financial crisis, large fiscal stimulus packages were coinciding with a low interest rate environment. Inspired by this, the academic literature has started to study optimal monetary and fiscal policy allowing for a zero bound on the nominal interest rate. It is shown that fiscal policy can have a welfare improving stabilizing effect on economic activity in the presence of a lower bound (see e.g. Schmidt, 2012). This stabilizing effect, however, is not observed in situations in which the lower bound of zero on the nominal interest rate does not constitute a constraint.

In this paper, we are particularly interested in how the degree of substitutability between public and private consumption affects optimal monetary and fiscal policy when allowing for a zero lower bound on the nominal interest rate. We study optimal monetary and fiscal policy under discretion within the framework of a simple stochastic New Keynesian model economy à la Woodford (2003) assuming non-separability in household utility between public and private consumption. We find that relatively less government intervention is needed to stabilize the economy if public and private spending are complements. Furthermore, the improved stabilization performance of government spending under complementarity results in relatively lower variances in the key macroeconomic variables.

The earlier literature on optimal monetary and fiscal policy has assumed an additively separable utility specification for public and private consumption. Schmidt (2012) finds that in the presence of a zero lower bound on the nominal interest rate actively using government spending as a stabilization tool is welfare improving compared to a situation in which fiscal policy is assumed to be inactive. Fiscal policy helps to mitigate the well established defla-

[1]It is here assumed that a high degree of substitutability implies the two goods to be substitutes, whereas a low and negative degree of substitutability implies that the two goods are complements. A formal definition of Edgeworth substitutability and complementarity will follow in section 2.

tionary bias in private sector expectations arising from the presence of the zero lower bound on interest rates and thereby improves welfare outcomes.

Earlier empirical studies on the degree of substitutability find evidence for non-separability between public and private consumption. For a sample of 30 countries (ranging from the 1950s to the 1980s) Karras (1994) estimates the sensitivity of total consumption with respect to government consumption departing from a simple Euler equation representation of aggregate consumption (public + private consumption) and finds that government and private consumption are complements in most of the countries rather than substitutes. Ni (1995) finds that for the United States estimation results for the degree of substitutability are sensitive to the choice of the aggregation technique of public and private consumption. When aggregate consumption is specified as a linear function of public and private consumption, public and private consumption tend to be substitutes. When aggregated by a Cobb-Douglas type function, both forms of consumption tend to be complements.

Bouakez and Rebei (2007) develop a real business cycle model with non-separable preferences in public and private consumption and persistence in habits. Maximum-likelihood estimation on U.S. data points to a strong Edgeworth complementarity between public and private consumption. Coenen, Straub, and Trabandt (2013) estimate an extended version of the ECB's New Area-Wide Model explicitly allowing for non-separability between public and private consumption. Aggregate consumption is defined by a CES aggregate of public and private consumption. Results for the euro area also point to rather strong complementarity between the two goods. Fève, Matheron, and Sahuc (2012) examine sources of bias in the estimation of the government spending multiplier originating from the combination of Edgeworth complementarity and endogenous government expenditures.

The rest of the paper is organized as follows: Section 2 provides a brief introduction to the model and discusses the specification of the utility function. Section 3 describes optimal monetary and fiscal policy under discretion. Section 4 describes optimal monetary and fiscal policy under commitment. In section 5, we investigate the robustness of our results. The last section concludes.

2 Model

We consider a standard small scale New Keynesian economy: households maximize lifetime utility derived from aggregate consumption (a composite of public and private consumption) and minimize disutility from providing labor services to firms. Firms which act under monopolistic competition use the labor services as input in the production process which yields differentiated output that can be used for public and private consumption. Nominal rigidities in the price setting process originate from staggered price setting à la Calvo (1983). Government expenditures are financed by non-distortionary lump-sum taxes. In this section we first discuss the specificities of household preferences in our setup. We then give a brief introduction to the behavioral constraints of the private sector. Before providing an overview on the calibration, we derive and discuss the welfare criterion.

2.1 Specification of Household Preferences

Household preferences differ from those usually assumed in the literature (see e.g. Woodford, 2011) in that we do not assume additive separability between public and private consumption. Expected lifetime utility is given by:

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t V_t, \text{ with } V_t = U(\bar{C}_t, \xi_t) - \int_0^1 v(n_t(i), \xi_t) di + g(G_t, \xi_t)$$

β is the discount factor, $n_t(i)$ is the labor supply of household i, ξ_t denotes a vector of preference shocks and G_t is government spending. $\bar{C}_t$ is aggregate consumption composed of private consumption and public consumption. We assume the following aggregation technology:

$$\bar{C}_t = C_t + \theta G_t$$

The two goods are considered to be Edgeworth complements (substitutes) if an increase in government consumption increases (decreases) the marginal utility of private consumption. The two goods are complements (substitutes) if $\theta < (>) 0$. For $\theta = 0$, we have the special case of additive separability as for example studied in Schmidt (2012) or Woodford (2011). Furthermore, it is assumed that the function $g(G_t, \xi_t)$ is of such nature that $\frac{\partial V_t}{\partial G_t} > 0$ holds for all possible values of θ.

2.2 Behavioral Constraints of the Private Sector

Optimization problems of the representative household and firm yield the New Keynesian Phillips curve and the dynamic IS equation:

$$\hat{\pi}_t = \kappa \left(\hat{Y}_t^{gap} - (1-\theta)\Gamma \hat{G}_t^{gap} \right) + \beta \mathrm{E}_t \hat{\pi}_{t+1} + u_t \quad (1)$$

$$\hat{Y}_t^{gap} = (1-\theta)\hat{G}_t^{gap} + \mathrm{E}_t \hat{Y}_{t+1}^{gap} - (1-\theta)\mathrm{E}_t \hat{G}_{t+1}^{gap} - \sigma \left(\hat{R}_t - \mathrm{E}_t \hat{\pi}_{t+1} \right) + d_t \quad (2)$$

Equations are log-linearized around the non-stochastic steady state. The gross steady state inflation rate is set equal to 1. Hat variables are percentage deviations from their steady state. $\hat{R}_t$ is the nominal interest rate between t and $t+1$. $\hat{\pi}_t$ is the inflation rate. $\hat{Y}_t^{gap}$ is the output gap which is defined as the difference between the actual level of output and the level of output which is consistent with the efficient equilibrium. $\hat{G}_t^{gap}$ is the government spending gap which is defined as the difference between the actual level of government spending and the level of government spending which is consistent with the efficient equilibrium. σ denotes the inverse of the intertemporal elasticity of substitution of aggregate consumption with respect to total output. Γ and κ are functions of structural parameters.

$$\Gamma = \frac{\sigma^{-1}}{\sigma^{-1} + \eta}$$

$$\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha(1+\eta\Theta)(\sigma^{-1}+\eta)}$$

η denotes inverse of the elasticity of labor supply, α denotes the share of firms that do not receive a signal to optimally set prices in every period, Θ represents the steady state of the price elasticity of demand for differentiated goods.

Both equations feature an exogenous disturbance:

$$u_t = \rho^u u_{t-1} + \epsilon_t^u \quad (3)$$

$$d_t = \rho^d d_{t-1} + \epsilon_t^d \quad (4)$$

u_t is the cost-push shock process with AR parameter ρ^u and iid innovation ϵ_t^u. d_t is the demand shock process with AR parameter ρ^d and iid innovation ϵ_t^d. The demand shock is structurally driven by variations in the real interest rate consistent with the efficient equilibrium. In what follows, we will refer to this shock as the efficient real rate of interest.

2.3 Policy Objective

The second order approximation to the representative household's utility can be expressed as follows[2]:

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t V_t \approx -\frac{1}{2} U_C (\sigma^{-1} + \eta) \kappa^{-1} \Theta \left[\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \{ \hat{\pi}_t^2 + \lambda (\hat{Y}_t^{gap} - (1-\theta)\Gamma \hat{G}_t^{gap})^2 + (1-\theta)\lambda_G (\hat{G}_t^{gap})^2 \} \right]$$

The relative weights in the loss function are given by:

$$\begin{aligned} \lambda &= \frac{\kappa}{\Theta} \\ \lambda_G &= \frac{\kappa}{\Theta} \Gamma \left((1-\theta)(1-\Gamma) + \frac{\sigma}{\omega} \right) \end{aligned}$$

From this follows the monetary and fiscal policy makers' objective function, the loss function:

$$\mathrm{L}_0 = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left[\hat{\pi}_t^2 + \lambda \left(\hat{Y}_t^{gap} - (1-\theta)\Gamma \hat{G}_t^{gap} \right)^2 + (1-\theta)\lambda_G \left(\hat{G}_t^{gap} \right)^2 \right]$$

The policy maker's loss function depends on the degree of non-separability θ.

2.4 Calibration

The model is calibrated to the US economy and we adopt the same calibration as Schmidt (2012) who mainly follows Woodford (2003) and Adam and Billi (2007). Table 1 provides an overview on parameter values and recalls the economic interpretation for all parameters.

3 Optimal Policy under Discretion

Under discretion the policy maker cannot affect beliefs about future policy as he is not able to credibly commit to future policy actions. Policy actions are time-consistent. The policy maker therefore minimizes the expected lifetime loss subject to the behavioral constraints of the private sector and the lower bound on the nominal interest rate by setting $\hat{\pi}_t$, $\hat{Y}_t^{gap}$,

[2] For a detailed description of the derivation see Woodford (2003), chapter 6, or Schmidt (2012).

Table 1: Calibration

Parameter	Value	Interpretation
r^*	3.5/4	Steady state efficient rate of interest (in %)
β	0.9913	Discount factor
G/Y	0.2	Steady state share of government spending in total output
α	0.66	Share of firms per period that keep prices unchanged
Θ	7.66	Price elasticity of demand in the steady state
η	0.47	Elasticity of real marginal costs with respect to firm's own output level
σ	6.25	Inverse elasticity of marginal utility of aggregate consumption w.r.t. total output
ω	1.56	Inverse elasticity of marginal utility of public consumption w.r.t. total output
κ	0.0244	Slope parameter in New Keynesian Phillips curve
ρ^u	0	AR-coefficient cost-push shock
ρ^d	0.8	AR-coefficient efficient real rate shock
$Sd(\epsilon_t^u)$	0.154	Standard deviation cost-push shock innovation (in %)
$Sd(\epsilon_t^d)$	1.542	Standard deviation efficient rate shock innovation (in %)
λ	0.0032	Loss function weight I
λ_G	0.0038	Loss function weight II

$\hat{G}_t^{gap}$ and $\hat{R}_t$ in each period t. The minimization problem is formulated as follows:

$$\begin{aligned}
\underset{\hat{\pi}_t,\hat{Y}_t^{gap},\hat{G}_t^{gap},\hat{R}_t}{\text{minimize}} \quad & \mathrm{E}_t \sum_{j=0}^{\infty} \beta^j \frac{1}{2}\left[\hat{\pi}_{t+j}^2 + \lambda\left(\hat{Y}_{t+j}^{gap} - (1-\theta)\Gamma\hat{G}_{t+j}^{gap}\right)^2 + (1-\theta)\lambda_G\left(\hat{G}_{t+j}^{gap}\right)^2\right] \\
\text{subject to} \quad & \hat{R}_t \geq -r^* \\
& \text{equations (1), (2), (3) and (4)} \\
& u_t,\ d_t \text{ given} \\
& \{\hat{\pi}_{t+j}, \hat{Y}_{t+j}^{gap}, \hat{G}_{t+j}^{gap}, \hat{R}_{t+j} \geq -r^*\} \text{ given for } j \geq 1.
\end{aligned}$$

The first-order conditions of the above minimization problem can be summarized as follows:

$$(1-\Gamma)\left(\kappa\hat{\pi}_t + \lambda\left(\hat{Y}_t^{gap} - (1-\theta)\Gamma\hat{G}_t^{gap}\right)\right) + \lambda_G\hat{G}_t^{gap} = 0 \qquad (5)$$

$$\left(\kappa\hat{\pi}_t + \lambda\left(\hat{Y}_t^{gap} - (1-\theta)\Gamma\hat{G}_t^{gap}\right)\right)(\hat{R}_t + r^*) = 0 \qquad (6)$$

$$\kappa\hat{\pi}_t + \lambda\left(\hat{Y}_t^{gap} - (1-\theta)\Gamma\hat{G}_t^{gap}\right) \leq 0 \qquad (7)$$

$$\hat{R}_t \geq -r^* \qquad (8)$$

When the zero lower bound on the nominal interest rate is not binding, the strict inequality in (8) implies that the expression in the first parenthesis in (6) is equal to zero. From (5) it then follows that $\hat{G}_t^{gap} = 0$. In normal times, when the zero lower bound on the nominal interest rate is not binding, the government spending gap is closed and monetary policy is therefore the preferred policy tool. One reason for this is that monetary policy itself does not cause welfare costs as variations in the interest rate only have an indirect effect on the loss function through the other model variables, whereas variations in government spending directly impact welfare.

When the zero lower bound on the nominal interest rate is binding, fiscal policy is actively used to stabilize the economy. Equations (5) and (7) yield the following expression:

$$\hat{G}_t^{gap} = -\frac{1-\Gamma}{\lambda\Gamma\frac{\sigma}{\omega}}[\kappa\hat{\pi}_t + \lambda\hat{Y}_t^{gap}] \geq 0$$

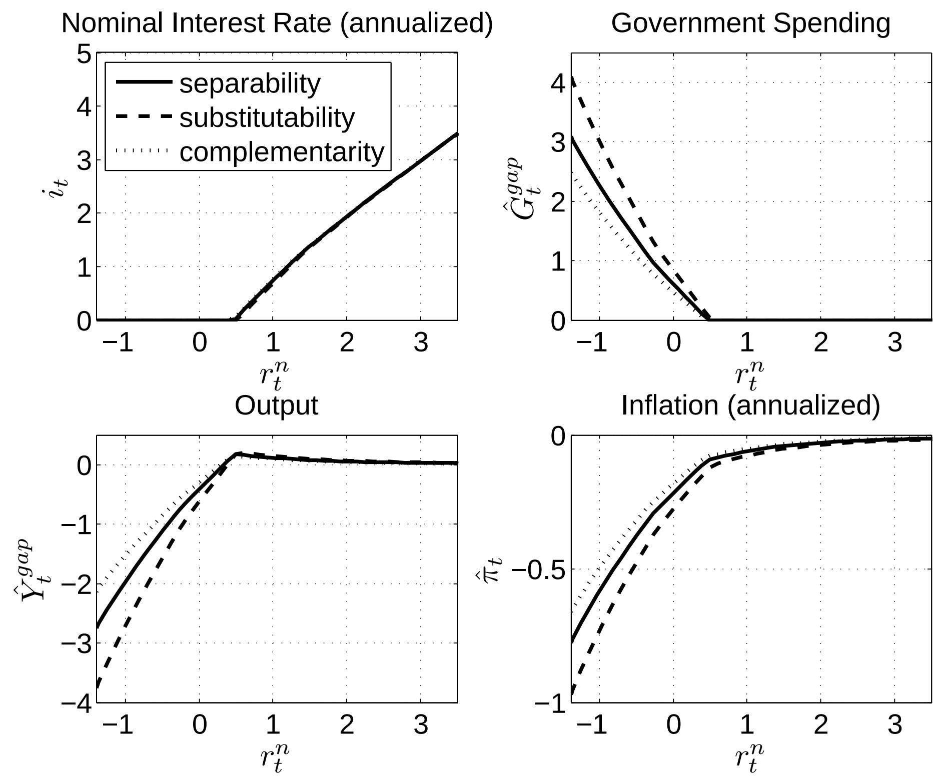
Interestingly, this optimality condition does not depend on the degree of substitutability. The interaction between public spending and inflation or output under optimal discretionary monetary and fiscal policy therefore remains unaffected by the degree of separability.

The rational expectations solution under optimal discretionary monetary and fiscal policy can be characterized by the policy functions of $\hat{\pi}_t$, $\hat{G}_t^{gap}$, $\hat{Y}_t^{gap}$ and $\hat{R}_t$, which are all functions of the two shock processes u_t and d_t. We approximate the policy funtions by applying the collocation method to the set of equations (1), (2) and (5)-(8)[3]. Figure 1 displays equilibrium responses to the efficient real rate of interest under discretion. The horizontal axis represents realizations of the efficient real rate of interest, r_t^*. The vertical axes represent the responses of the corresponding variables to the realizations of r_t^*. Despite the fact that we use linearized constraints for the private sector, the zero lower bound on the nominal interest rate constitutes the major non-linearity which translates into a non linear relationship between r_t^* and each of the endogenous model variables. We display equilibrium responses for three different values of θ: 0 - separability (solid line); 0.4 - substitutability (dashed line); -0.4 - complementarity (dotted line).

In periods in which the zero lower bound on the nominal interest is not binding, fiscal policy is not used as a policy instrument but monetary policy instead. The converse is true when the zero lower bound is binding. We make four observations regarding the degree of non-separability: First, when sufficiently far away from the zero lower bound, the distinction between the different degrees of non-separability appears to have little effect. This observation does not stand in contrast with what we expected, as fiscal policy does not constitute an optimal policy tool when the lower bound is not binding. Second, under substitutability a stronger reaction of government spending is needed to optimally stabilize the economy against the adverse shock. Third, the higher the degree of complementarity, the larger the

[3]For a detailed description of the algorithm, see for example Appendix A in Adam and Billi (2007)

Figure 1: Equilibrium responses to the efficient real rate of interest under discretion



Notes: The horizontal axis represents the efficient real rate of interest (annualized). Solid line: separability ($\theta = 0$). Dashed line: substitutability ($\theta = 0.4$). Dotted line: complementarity ($\theta = -0.4$). Inflation and interest rates are expressed in annualized percentage points. The value of the cost-push shock is set equal to zero.

(adverse) shock has to be to drive the economy to the zero lower bound on nominal interest rate and therefore the longer monetary policy remains active. This result is also reflected in the frequency of zero lower bound episodes (see Table 2). Under complementarity, the zero lower bound is hit in only 2.8 % of the periods in our calibration. Assuming substitutability, the zero lower bound is hit in 3% of the periods. Fourth, variations in all four variables considered are higher the higher the degree of substitutability at the zero lower bound. Put differently, when public and private consumption are complements, a smoother reaction in government spending is enough to more efficiently stabilize the economy to an adverse shock as it would be the case of separability or both goods being substitutes.

Table 2: Welfare equivalent consumption losses and frequency of ZLB episodes - Discretion

	Substitutes $\theta = 0.3$	Separability $\theta = 0$	Complements $\theta = -0.3$
Std Output Gap	1.010	1.000	0.995
Std Government Spending Gap	0.294	0.236	0.202
Std Inflation	0.132	0.131	0.131
Frequency of ZLB episodes (in percent)	2.997	2.875	2.793
Average duration of ZLB events	1.540	1.523	1.521

Values are obtained from 2000 repetitions of a simulation of the model across 1050 periods, where the first 50 periods are discarded. The underlying shocks are the cost-push shock and the natural real rate shock calibrated as indicated in Table 1.

4 Optimal Monetary and Fiscal Policy under Commitment

In this section, we study optimal monetary and fiscal policy under commitment. The benevolent policy maker is able to credibly commit to future policy actions. Precisely, the policy maker minimizes societal loss subject to the zero lower bound on the nominal interest rate and the behavioral constraints by choosing state contingent paths for inflation, the output gap, the government spending gap and the nominal interest rate at time t.

$$\underset{\hat{\pi}_t, \hat{Y}_t^{gap}, \hat{G}_t^{gap}, \hat{R}_t}{\text{minimize}} \quad \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left[\hat{\pi}_t^2 + \lambda \left(\hat{Y}_t^{gap} - (1-\theta)\Gamma \hat{G}_t^{gap} \right)^2 + (1-\theta)\lambda_G \left(\hat{G}_t^{gap} \right)^2 \right]$$

$$\begin{aligned} \text{subject to} \quad & \hat{R}_t \geq -r^* \\ & \text{equations (1), (2), (3) and (4)} \\ & u_0,\ d_0 \text{ given,} \\ & \text{for all } t = 0, 1, \ldots, \infty. \end{aligned}$$

The first-order conditions of the above minimization problem can be summarized as follows:

$$\hat{\pi}_t - \phi_t + \phi_{t-1} - \frac{\sigma}{\beta}\mu_{t-1} = 0 \tag{9}$$

$$\lambda \left(\hat{Y}_t^{gap} - (1-\theta)\Gamma \hat{G}_t^{gap} \right) + \kappa\phi_t + \mu_t - \frac{1}{\beta}\mu_{t-1} = 0 \tag{10}$$

$$\frac{1-\Gamma}{\lambda_G} \left(\mu_t - \frac{1}{\beta}\mu_{t-1} \right) = \hat{G}_t^{gap} \tag{11}$$

$$\mu_t \geq 0 \tag{12}$$

$$\hat{R}_t \geq -r^* \tag{13}$$

$$\mu_t(\hat{R}_t + r^*) = 0 \tag{14}$$

$$\tag{15}$$

where ϕ_t and μ_t denote the lagrange multipliers with equations (1) and (2). The presence of lagged lagrange multipliers in equations (9) through (11) introduces history dependence in the conduct of monetary and fiscal policy. Whenever the lower bound on interest rates is not binding, (12) has to hold with equality. From equation (11) it then follows that government spending is not used as a stabilization tool as long as interest rate policy remains effective. In episodes of a binding lower bound, μ_t enters positive territory and therefore optimal policy urges the policy maker to make use of the stabilizing potential of government spending. From (11) the connection between the degree of substitutability and the extent to which government spending is used as a stabilization tool in episodes of a binding zero lower bound becomes visible. As the inverse of λ_G depends positively on the degree of substitutability, we infer that under complementarity government spending is used less aggressively for stabilization as under additive separability or substitutability.

In Figure 2 we display impulse-response functions to an efficient real interest rate shock of magnitude -3 unconditional standard deviations. Lagrange multipliers in the period before realization of the shock are assumed to be 0. For the different degrees of substitutability, we observe qualitatively identical effects. Even though the quantitative effects appear to be small in our baseline calibration, we observe somewhat milder responses of government spending, the ouput gap and inflation to the efficient real rate shock when private and public consumption are complements. This conclusion is also reflected in Table 3 where the standard deviations of output gap and the government spending gap are lower if private and public goods are complements.

Table 3: Welfare equivalent consumption losses and frequency of ZLB episodes - Commitment

	Substitutes $\theta = 0.3$	Separability $\theta = 0$	Complements $\theta = -0.3$
Std Output Gap	1.022	1.021	1.019
Std Government Spending Gap	0.074	0.066	0.059
Std Inflation	0.111	0.111	0.111
Frequency of ZLB episodes (in percent)	0.558	0.530	0.530
Average duration of ZLB events	1.468	1.418	1.420

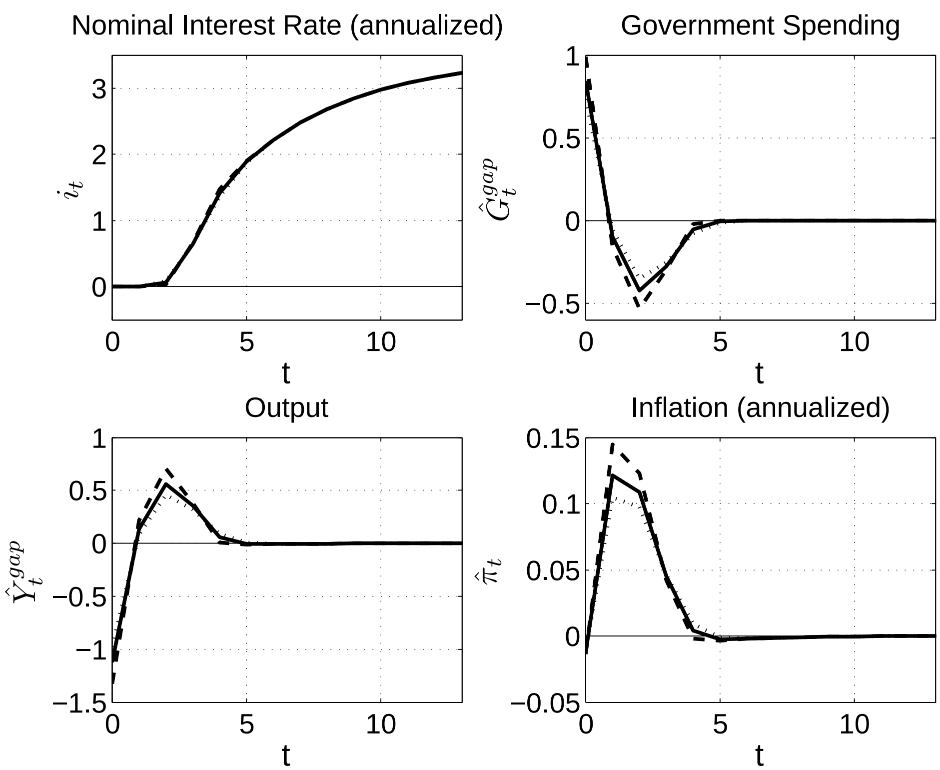
Values are obtained from 2000 repetitions of a simulation of the model across 1050 periods, where the first 50 periods are discarded. The underlying shocks are the cost-push shock and the natural real rate shock calibrated as indicated in Table 1.

5 Robustness Analyis

6 Conclusion

In this paper, we have studied the impact the degree of substitutability between public and private consumption has on optimal policy when allowing for a zero lower bound on the nominal interest rate. In a simple New Keynesian model economy we conduct an optimal monetary and fiscal policy analysis under discretion and commitment allowing for the presence of the zero lower bound on the nominal interest rate. We find that relatively less government intervention is needed to stabilize the economy if public and private spending are complements. Furthermore, the improved stabilization performance of government spending under complementarity results in a relatively lower variance of key variables like output and inflation. We have shown that the degree of substitutability between public and private consumption has important implications for the conduct of optimal monetary and especially fiscal policy at or close to the zero lower bound on the nominal interest rates. Assuming an additively separable utility specification in private and public consumption as is done often

Figure 2: Impulse responses to an efficient real rate shock under commitment



Notes: Impulse responses to an efficient real rate shock of -3 unconditional standard deviations. The horizontal axis represents quarters after the realization of the shock. Solid line: separability ($\theta = 0$). Dashed line: substitutability ($\theta = 0.3$). Dotted line: complementarity ($\theta = -0.4$). Inflation and interest rates are expressed in annualized percentage points.

in the New Keynesian model setup leads to a misinterpretation not only of the size of the effects of government spending on economic activity but also of the design of an optimal policy response to adverse shocks.

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