How do Different Government Spending Categories Impact on Private Consumption and the Real Exchange Rate?

Baldi, Guido

July 2013

How do Different Government Spending Categories Impact on Private Consumption and the Real Exchange Rate?

Guido Baldi*

July 2013

Abstract

The macroeconomic literature has found puzzling effects of government spending on private consumption, the real exchange rate and the terms of trade. Some authors find that private consumption increases after a shock to government spending, while others report a decrease. The same ambiguity can be found for the real exchange rate and the terms of trade. Our paper offers an intuitive explanation for these divergent results by distinguishing between productive and unproductive government spending. We show within a calibrated two-sector DSGE model that the two government spending categories have different effects on private consumption, the real exchange rate and the terms of trade. Hence, our findings suggest that the composition of government spending matters not only for long-run growth, but also impacts on the short-run.

JEL classification: E62, H31, H32, H41, F41
Keywords: Fiscal Policy, Productive Public Capital, Government Spending, Open Economy Macroeconomics

* Department of Macroeconomics and Forecasting, German Institute for Economic Research (DIW), Berlin, Germany. Address: DIW, Mohrenstr. 58, D-10117, Berlin, Germany. Email: guido.a.baldi@gmail.com.

1 Introduction

The severe recession following the financial crisis induced many governments to initiate large fiscal stimulus programs. These measures heavily relied on increases in government spending and less on tax reductions. Policymakers particularly advocated the increase of infrastructure spending in order to stimulate GDP, investment and private consumption. It is often argued that expenditures on infrastructure have more desirable effects on these macroeconomic variables than does an increase in ordinary government expenditures.

Does an increase in government spending have different effects on the economy than a shock to unproductive government spending? Can the distinction we make between these two spending categories even help to explain the ambiguous empirical results regarding the effect of fiscal policy on the real exchange rate and the terms of trade? The real exchange rate compares domestic and foreign output prices, while the terms of trade does a similar comparison between the prices of domestic and foreign tradable goods. In the literature, there seems to be a consensus regarding the positive short-run output effect of government spending, even though there is considerable disagreement on the size of this impact (for a good overview, see Hemming, Kell and Mahfouz (2002) and Spilimbergo, Symansky and Schindler (2009)). For other macroeconomic variables such the real exchange rate, the terms of trade and private consumption, there is no consensus even on the direction of the response of these variables to an increase in government spending. Associated with these disagreements are important methodological differences in terms of the estimation strategy.

For the real exchange rate, most empirical papers report a depreciation (e.g. Corsetti, Meier and Mueller (2009) and Monacelli and Perotti (2009)), which is at odds with the theoretical predictions of the standard neoclassical model. A few find an appreciation of the real exchange rate (e.g. Clarida and Prendergast (1999)), which is, however, reversed in the longer run. The evidence for the terms of trade is also mixed: while Monacelli and Perotti (2009) report a depreciation, Mueller (2006) finds an appreciation of the terms of trade. Besides, there is no agreement as to the effects of government spending on private consumption. A range of empirical studies, e.g. Blanchard and Perotti (2002) and Monacelli and Perotti (2009) report an increase in private consumption, while other studies find a negative effect (see e.g. Ramey and Shapiro (1999), Edelberg, Eichenbaum and Fisher (1999) and Ramey (2008)).

Our purpose in this paper is to investigate whether the puzzling empirical findings regarding the effects of government spending can be explained by distinguishing between productive and unproductive government spending. This is done by adding the stock of public capital to the production function of private firms. We study the effects of productive government spending in a small open two-sector economy. By distinguishing between a trading and a non-trading sector, we get useful insights into the different reactions of the real exchange rate and the terms of trade.

The general idea behind including productive government spending in the production function is that public and private inputs are not close substitutes. Examples of productivity enhancing government spending include - in a narrow sense - roads, railway infrastructure and airports. In a broader sense, one could also include spending categories such as education and health care. In this paper, however, we interpret productive public capital in a narrow sense to get a conservative idea of its theoretical short-run effects. An early theoretical contribution to the analysis of public infrastructure in the context of long-run economic growth stems from Arrow and Kurz (1969). The literature was further developed by Barro (1990) and Baxter and King (1993). The more recent literature includes, among others, Linnemann and Schabert (2006) and Leeper, Walker and Yang (2009), who analyze a closed economy. Empirically, an early influential study was conducted by Aschauer (1989), who estimated a log-linear production function and found an elasticity of 0.39 of output to nonmilitary public infrastructure. However, this high initial estimate of the productivity of public infrastructure was revised downwards by subsequent research and sometimes even estimated to be 0 (for a survey of the literature, see Romp and de Haan (2007)). A reasonable range for the elasticity seems to lie between 0.1 and 0.2.

If one adds the stock of public capital into the production function, what does standard macroeconomic theory predict will happen in the short-run after a shock to government investment? First, an increase in government demand for investment goods has the same effect on demand as a shock to non-productive spending. There is, however, an additional effect here, namely that government investment increases the productivity of private firms. This part of the impact of a shock to productive government spending should thus show similar effects as a technology shock, whose impacts have been studied extensively in the macroeconomic literature. A shock to productive government spending is therefore a combination of these two partial effects. While both kind of shocks can be expected to increase GDP, things are more complicated for private consumption.

Consumption increases after a technology shock, but decreases after a shock to unproductive government spending. The same ambiguity holds for private investment and the terms of trade. While a technology shock increases private investment and depreciates the terms of trade, the opposite holds for the demand shock, as it was discussed for unproductive government spending.

The remaining part of this paper is organized as follows. In section 2, we describe the model of a small open economy that is used to simulate the macroeconomic effects of fiscal policy instruments. This description is followed by section 3, which explains how the parameter values of the model are chosen. The simulation results of this model are presented and discussed in section 4. Finally, section 5 contains the conclusion.

2 The Model

The model used to analyze the macroeconomic effects of government spending categories is an extension of a standard DSGE model. The special features of the model in this paper is that it incorporates a detailed analysis of the government and two sectors of production. We call the first sector the manufacturing sector that produces tradable goods. The second sector is called the services sector comprising e.g. the majority of services, construction work and agriculture. The goods produced in the services sector are assumed to be non-tradable. Both sectors employ labor and capital, which makes it possible to study the sector specific behavior of the variables in these two sectors.

2.1 Production

2.1.1 Sector "M"

In this sector that can be interpreted as the manufacturing sector, the perfectly competitive firms produce output m_t according to:

$$m_t = z^m (k_t^g)^\gamma \, (k_t^m)^{\alpha_1} \, (l_t^m)^{1-\alpha_1} \tag{1}$$

Note that a subscript to identify an individual firm is suppressed because all firms are identical. k_t^m is capital used in this production sector and l_t^m is labor input. k_t^g is the stock of public capital, which is assumed to be non-rival. This means that public infrastructure is equally productive for all firms. α_1 and γ determine the elasticity of output with respect to the input factors. z^m stands for total factor productivity. Note that there are constant returns to scale in the privately provided inputs. One could also assume constant returns to scale in all three inputs, as it was done by Aschauer (1989) and Barro (1990). In fact, as pointed out by Turnovsky and Fisher (1995), it makes little difference to the result what specification is actually chosen, provided that one assumes $F_{kl} > 0$, which is given for the chosen production function.

The solution to the cost minimization problem implies that all intermediate goods firms equate their capital-labor ratio to a constant determined by α_1 times the ratio of nominal input prices, which are given by w_t^m for labor and r_t^m for capital.

$$\frac{k_t^m}{l_t^m} = \frac{1-\alpha_1}{\alpha_1}\frac{w_t^m}{r_t^m} \tag{2}$$

To keep the basic version of the model as simple as possible, prices are assumed to be flexible [1]. Output prices p_t^m, which are equal to nominal marginal costs are then given by:

$$p_t^m = mc_t^m = \frac{(r_t^m)^{\alpha_1}(w_t^m)^{1-\alpha_1}(1-\alpha_1)^{\alpha_1-1}\alpha_1^{-\alpha_1}}{(k_t^g)^{\gamma}} \tag{3}$$

From this expression, one can see that an increase in productive public capital has the same effects on output prices as a technology shock.

2.1.2 Sector "S"

This sector can be seen as comprising the services and the construction sector. Production in this relatively unproductive sector is given by:

$$s_t = z^s(k_t^g)^{\gamma}(k_t^s)^{\alpha_2}(l_t^s)^{1-\alpha_2} \tag{4}$$

k_t^s is capital and l_t^s is labor used in the inefficient sector. As for the manufacturing sector, k_t^g denotes the stock of productive public capital and is again assumed to be non-rival. α_2 and γ determine the elasticity of output with respect to the input factors and z^s denotes total factor productivity. It is assumed that $\alpha_1 > \alpha_2$, which implies that the services sector is more labor intensive than the manufacturing sector. Cost minimization implies for nominal output prices and marginal costs:

[1] In the appendix, a version of the model with sticky prices is discussed.

$$p_t^s = mc_t^s = \frac{(r_t^s)^{\alpha_2}(w_t^s)^{1-\alpha_2}(1-\alpha_2)^{\alpha_2-1}\alpha_2^{-\alpha_2}}{(k_t^g)^{\gamma}} \tag{5}$$

In addition, the optimal ratio between capital and labor is given by:

$$\frac{k_t^s}{l_t^s} = \frac{1-\alpha_2}{\alpha_2}\frac{w_t^s}{r_t^s} \tag{6}$$

2.1.3 Investment

In the preceding sections, we did not discuss the evolution of the capital stock. The inclusion of two production sectors into the model raises the issue of the composition of investment expenditures. According to empirical evidence, investment can be seen as a composite of manufacturing and services goods (see e.g. Bems (2008)). Following this reasoning, investment in the two sectors can be described by a CES-type function:

$$im_t = \left(a_1^{\frac{1}{\theta_1}}(im_t^m)^{\frac{\theta_1-1}{\theta_1}} + (1-a_1)^{\frac{1}{\theta_1}}(im_t^s)^{\frac{\theta_1-1}{\theta_1}}\right)^{\frac{\theta_1}{\theta_1-1}} \tag{7}$$

$$is_t = \left(a_2^{\frac{1}{\theta_2}}(is_t^m)^{\frac{\theta_2-1}{\theta_2}} + (1-a_2)^{\frac{1}{\theta_2}}(is_t^s)^{\frac{\theta_2-1}{\theta_2}}\right)^{\frac{\theta_2}{\theta_2-1}} \tag{8}$$

im_t and is_t denote demand for investment goods by the two sectors and a superscript m or s tells us the demand for goods produced by sector m and s. θ_1 and θ_2 determine the elasticities of substitutions between the two inputs. Concerning a_1 and a_2, we will assume that investment expenditures in a sector are biased towards goods from its own sector.

It is straightforward to derive the associated price indexes p_t^{im} for im_t and p_t^{is} for is_t:

$$p_t^{im} = \left(a_1(p_t^m)^{1-\theta_1} + (1-a_1)(p_t^s)^{1-\theta_1}\right)^{\frac{1}{1-\theta_1}}$$
$$p_t^{is} = \left(a_2(p_t^m)^{1-\theta_2} + (1-a_2)(p_t^s)^{1-\theta_2}\right)^{\frac{1}{1-\theta_2}}$$

The input demand functions can be written as:

$$im_t^m = a_1\left(\frac{p_t^m}{p_t^{im}}\right)^{-\theta_1} im_t$$
$$im_t^s = (1-a_1)\left(\frac{p_t^s}{p_t^{im}}\right)^{-\theta_1} im_t$$

$$is_t^m = a_2 \left(\frac{p_t^m}{p_t^{is}}\right)^{-\theta_2} is_t$$
$$is_t^s = (1-a_2) \left(\frac{p_t^s}{p_t^{is}}\right)^{-\theta_2} is_t$$

Finally, the evolution of the two capital stocks, which is driven by investment, can be written as:

$$k_{t+1}^m = (1-\delta)k_t^m + im_t$$
$$k_{t+1}^s = (1-\delta)k_t^s + is_t$$

As usual, the parameter δ is the rate of depreciation, which is assumed to be the same in both sectors.

2.2 The Representative Individual

The economy in this model is populated by a representative individual, whose utility function U is given by:

$$U = E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \frac{1}{1+\chi}\left(\phi_1 (l_t^m)^{1+\chi} + \phi_2 (l_t^s)^{1+\chi}\right)\right) \tag{9}$$

c_t is a consumption aggregate, l_t^m denotes hours worked in the more productive sector and l_t^s is hours worked in the less productive sector. σ is a parameter that determines the intertemporal substitution of consumption. χ is a parameter that determines the inverse of the Frisch elasticity of labor supply and the parameters ϕ_1 and ϕ_2 influence the disutility of work. This disutility is assumed to be higher for the productive sector, because work in this sector is supposed to be more stressful.

Given that the representative individual is the owner of the capital stocks described in the last section, she has to make investment decisions. Besides, the individual holds one-period government bonds (d_t) and pays lump-sum taxes. Following this description, the budget constraint can be written in nominal terms:

$$
\begin{aligned}
&(w_t^m l_t^m + w_t^s l_t^s) + r_t^m k_t^m + r_t^s k_t^s = \\
&p_t^c c_t + p_t^{im} im_t + p_t^{is} is_t \\
&-(1+r_{t-1}^d)d_{t-1} + d_t + t_t + (1+r_{t-1}^f)f_{t-1} - f_t + \frac{\varsigma}{2}(f_t - f_{t-1})^2
\end{aligned} \tag{10}
$$

p_t^c is the price for the consumption aggregate, i.e. the consumer price index (CPI). r_t^d is the nominal return for government bonds. In addition, the individual holds debt towards the rest of the world (f_t) and pays an interest rate r_t^f on this debt. The term $\frac{\varsigma}{2}(f_t - f_{t-1})^2$ stands for adjustment costs that a consumer has to pay when he changes his holdings of foreign debt. These costs are small and are solely included to make the model stationary (see Schmitt-Grohe and Uribe (2003)). The evolution of f_t is given by $f_t = -tb_t + (1+r_{t-1}^f)f_{t-1}$, where tb_t is the nominal trade balance given by: $tb_t = p_t^m ex_t - p_t^{imp} c_t^{imp}$. In steady-state, exports equal imports for each category of goods, which implies that the trade balance is zero. Exports are modeled in a way such that a one-percent increase in domestic prices leads to a one-percent decrease in exports. Note further that this paper considers a cashless economy and, therefore, consumers hold no money. The first-order conditions for the individual are given by:

$$
\begin{aligned}
&c_t^{-\sigma}\frac{p_t^{im}}{p_t^c} = \\
&\beta c_{t+1}^{-\sigma}\left((1-\delta)\frac{p_{t+1}^{im}}{p_{t+1}^c} + \frac{r_{t+1}^m}{p_{t+1}^c}\right)
\end{aligned} \tag{11}
$$

$$
\begin{aligned}
&c_t^{-\sigma}\frac{(p_t^{is})}{p_t^c} = \\
&\beta c_{t+1}^{-\sigma}\left((1-\delta)\frac{p_{t+1}^{is}}{p_{t+1}^c} + \frac{r_{t+1}^s}{p_{t+1}^c}\right)
\end{aligned} \tag{12}
$$

$$\frac{c_t^{-\sigma}}{p_t^c} = \beta\frac{c_{t+1}^{-\sigma}}{p_{t+1}^c}\left(1 + r_{t+1}^d\right) \tag{13}$$

$$\psi_1 p_t^c (l_t^m)^\chi = w_t^m c_t^{-\sigma} \tag{14}$$

$$\psi_2 p_t^c (l_t^s)^\chi = w_t^s c_t^{-\sigma} \tag{15}$$

The consumption aggregate c_t consists of tradable manufacturing goods c_t^{tr} and services c_t^s:

$$c_t = \left(a_3^{\frac{1}{\theta_3}}\left(c_t^{tr}\right)^{\frac{\theta_3-1}{\theta_3}} + (1-a_3)^{\frac{1}{\theta_3}}\left(c_t^s\right)^{\frac{\theta_3-1}{\theta_3}}\right)^{\frac{\theta_3}{\theta_3-1}} \tag{16}$$

a_3 is a weighting parameter that influences the expenditure shares of private consumption that go to the two sectors and θ_3 determines the elasticity of substitution between the two types of consumption. The associated demand functions are:

$$c_t^{tr} = a_3 \left(\frac{p_t^{tr}}{p_t^c}\right)^{-\theta_3} c_t$$
$$c_t^s = (1-a_3) \left(\frac{p_t^s}{p_t^c}\right)^{-\theta_3} c_t$$

The consumer price index (CPI) for the consumption aggregate is given by:

$$p_t^c = \left(a_3 (p_t^{tr})^{1-\theta_3} + (1-a_3)(p_t^s)^{1-\theta_3}\right)^{\frac{1}{1-\theta_3}}$$

Within the category of tradables (c_t^{tr}), the individual can choose between consuming domestically produced final manufactured goods (c_t^m) and an equivalent imported final good (c_t^{imp}):

$$c_t^m = a_4 \left(\frac{p_t^m}{p_t^{tr}}\right)^{-\theta_4} c_t^{tr} \tag{17}$$
$$c_t^{imp} = (1-a_4) \left(\frac{p_t^{imp}}{p_t^c}\right)^{-\theta_4} c_t \tag{18}$$

The associated price index for tradable consumer goods is given by:

$$p_t^{tr} = \left((1-a_4)(p_t^{imp})^{1-\theta_4} + a_4 (p_t^m)^{1-\theta_4}\right)^{\frac{1}{1-\theta_4}} \tag{19}$$

2.3 The Government

In this section, fiscal policy is studied in a detailed manner and takes more space than in other papers. We assume that the government collects lump-sum taxes that are used to finance productive government spending (ig_t), and to pay the government's non-productive expenditures (g_t), which includes payments to government employees and the consumption of goods and services. Thus, the government has the following budget constraint in nominal terms:

$$d_t + t_t = p_t^s ig_t + p_t^s g_t + (1 + r_{t-1}^d) d_{t-1}$$

It is assumed that the government buys its goods and services from the private sector. This incorporates the assumption that the production function of the government is the same as the production function of the private sector. More specifically, it is assumed that the government buys its goods from sector S. Given that sector S is meant to comprise services and construction work, this assumption can be seen as reasonable.

Since our objective is to study the effects of productive and unproductive government spending, two separate policy rules for these two spending instruments are set up. Formally, the rules for real productive and unproductive government spending are assumed to be given by:

$$\frac{p_t^s ig_t}{p_t^c} = \left(\frac{p_{t-1}^s ig_{t-1}}{p_{t-1}^c}\right)^{q_1} \left(\frac{p_{ss}^s ig_{ss}}{p_{ss}^c}\right)^{1-q_1} e^{\epsilon_3} \tag{20}$$

$$\frac{p_t^s g_t}{p_t^c} = \left(\frac{p_{t-1}^s g_{t-1}}{p_{t-1}^c}\right)^{q_2} \left(\frac{p_{ss}^s g_{ss}}{p_{ss}^c}\right)^{1-q_2} e^{\epsilon_4} \tag{21}$$

where q_i are parameters that measure the elasticity of the left-hand side variable with respect to the right-hand side variable. The subscript ss denotes steady-state values and ϵ_i are shocks to the two government spending categories.

In this model, government expenditures are initially financed by public debt. To ensure that the model eventually returns to its steady-state, it is usually necessary that a fiscal variable reacts to the debt-to-GDP ratio (see e.g. Leeper et al. (2009)), where real GDP is given by $gdp_t = \frac{p_t^m m_t + p_t^s s_t}{p_t^c}$. In our model, lump-sum taxes react to the debt-to-GDP ratio. This leads to a rule for real taxes similar to the one for the two spending categories without the shock term, but augmented with a term that reflects the reaction to the debt-to-GDP ratio:

$$\frac{t_t}{p_t^c} = \left(\frac{t_{t-1}}{p_{t-1}^c}\right)^{q_3} \left(\frac{t_{ss}}{p_{ss}^c}\right)^{1-q_3} \left(\frac{d_{t-1}/p_t^c gdp_{t-1}}{d_{ss}/p_{ss}^c gdp_{ss}}\right)^{q_4} \tag{22}$$

These government spending rules should not be interpreted as institutional rules restricting the government. Instead, one should see them as a description of fiscal policy (decided by a government that takes the evolution of public debt into account). Alternatively, one could assume that fiscal policy instruments relative to GDP are the variables of interest. However, at least in the short-run, it is unlikely that policy-makers target ratios of fiscal variables to GDP. Finally, the evolution of public capital is given by[2]:

$$k_{t+1}^g = ig_t + (1-\delta)k_t^g \tag{23}$$

Note that the rate of depreciation for public capital is assumed to be the same as for the private sector.

2.4 Resource Constraints

To close the model, the resource constraints need to be satisfied.

$$s_t = c_t^s + im_t^s + is_t^s + ig_t + g_t \tag{24}$$

$$m_t = c_t^m + ex_t^m + im_t^m + is_t^m \tag{25}$$

3 Choice of Parameter Values

The chosen parameter values of the model are listed in Table 1. As it is common in the literature, one period in the model corresponds to one quarter. Most parameters lie in the range of most papers in the DSGE literature on fiscal policy. The discount factor is set to 0.99. The coefficients that determine the intertemporal substitution of consumption and the inverse of the Frisch elasticity of labor supply are both equal to 1.

Table 1: Parameter Values

Parameter	Value	Parameter	Value
β	0.99	q_2	0.85
σ	1	q_3	0.85
δ	0.025	q_4	0.02
χ	1	a_1	0.6
ϕ_1	3	a_2	0.4
ϕ_2	2	a_3	0.4
α_1	0.4	a_4	0.4
α_2	0.3	θ_1	1
γ	0.1/0.2	θ_2	1
ς	0.01	θ_3	1
q_1	0.85	θ_4	1

α_1 is assumed to be bigger than α_2, which implies that the share of capital in the manufacturing sector is bigger than in the services sector. We experiment with two values

[2]In the appendix, the effects of longer implementation delays are discussed

of γ, 0.1 and 0.2, which implies that a one percent increase in k_t^g rises output by 0.1% resp. 0.2%. As has been discussed in section 1, these values correspond to a reasonable lower and upper bound of the empirical findings in the long-run growth literature. The parameters that determine the elasticities of substitution between consumption aggregates are set to 1, which implies that a constant share of a spending aggregate goes to the respective spending category. a_1, a_2, a_3 and a_4 are all chosen in a way to reflect the assumed biases discussed in section 2. In steady-state, the price of manufacturing output relative to the price of services is assumed to be equal to 1.

We calibrate fiscal policy in a similar way as in Davig and Leeper (2009). The size of government (excluding transfers), measured as the ratio of total expenditures to GDP is set to approximately 0.20. The steady-state ratio of productive government spending to GDP is roughly 0.04, and for non-productive government spending 0.15. Lump-sum taxes are chosen in a way such that the debt-to-(quarterly)GDP ratio is near 2.4. Since the variables are calibrated at a quarterly frequency, this implies a debt-to(-annual)-GDP ratio of roughly 0.6. This corresponds roughly to the average debt-to-GDP ratio for OECD countries before the financial crisis. The values of the parameters q_1 and q_2 are inspired by Corsetti et al. (2009) and both set to 0.85. As discussed in section 2, the parameter ς determines the adjustment costs of foreign debt.

4 Simulation Results

In this subsection, we present impulse response functions for shocks to productive (`reig`) and unproductive (`reg`) government spending.[3] We focus on the variables real GDP (`gdp`), real consumption (`cons`), real wages in the manufacturing (`wage_m`) and the services (`wage_s`) sector, the real interest rates in both these sectors (`int_m` and `int_s`),the relative price of manufacturing output relative to services (`pm_ps`), the real exchange rate (`rex`) and the terms of trade (`tot`) [4].

4.1 Shock to Unproductive Government Spending

This section looks at the behavior of the model after a shock to unproductive government spending. As one can see in figure 1, the reaction of the variables corresponds to the theoretical predictions of a standard macroeconomic model. There is a positive effect on GDP, which, however, disappears within roughly ten periods. As expected, the consumption aggregate decreases. Given that unproductive government spending goes

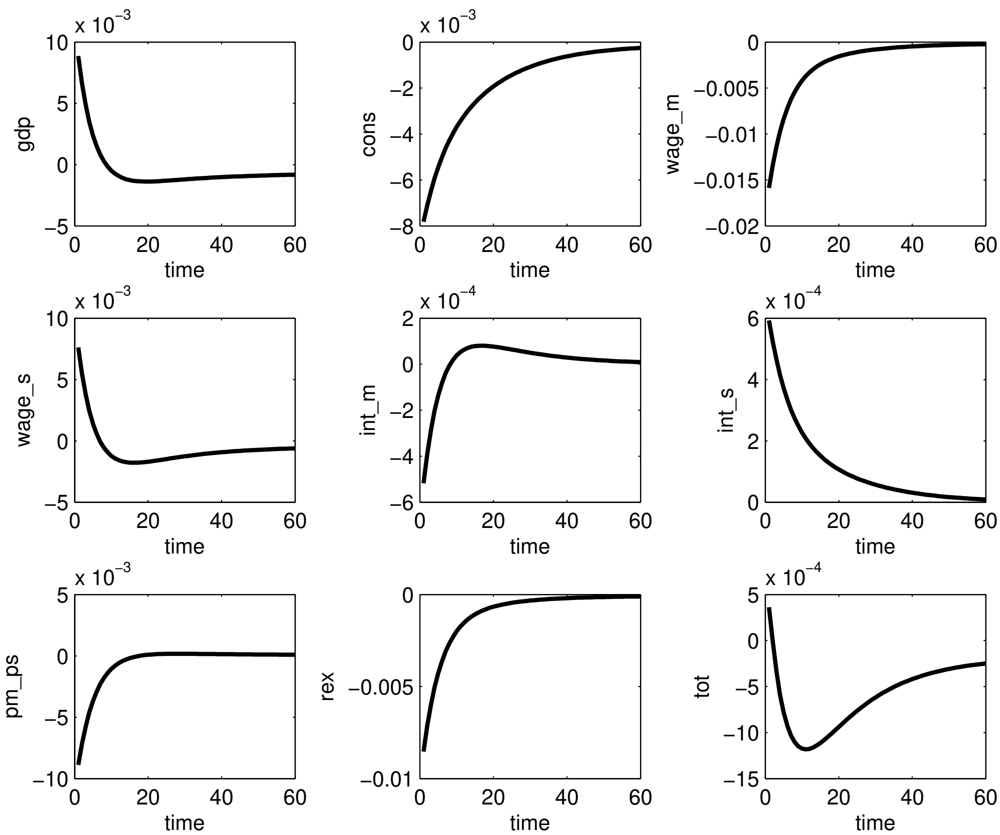
[3]For all simulations, the *Dynare* software version 4.1.0 is used.

[4]Formally, the real exchange rate is defined as $rex_t = (p_t^c)^*/p_t^c$ and $tot_t = (p_t^m)^*/p_t^m$

to the services sector, it is not surprising that real wages in this relatively unproductive sector increase, while real wages in the productive sector decrease. The same development can be observed for the real interest rates in the two sectors.

Concerning the real interest rate and the terms of trade, one can see that the real exchange rate appreciates because domestic output prices increase including the prices for tradables. The terms of trade initially depreciate before they appreciate. Why is this the case? This is due to the fact that higher unproductive government spending increases prices in the non-tradable sector, which therefore leads to a substitution of private consumption and investment towards the tradable good.

Figure 1: Shock to Unproductive Government Spending

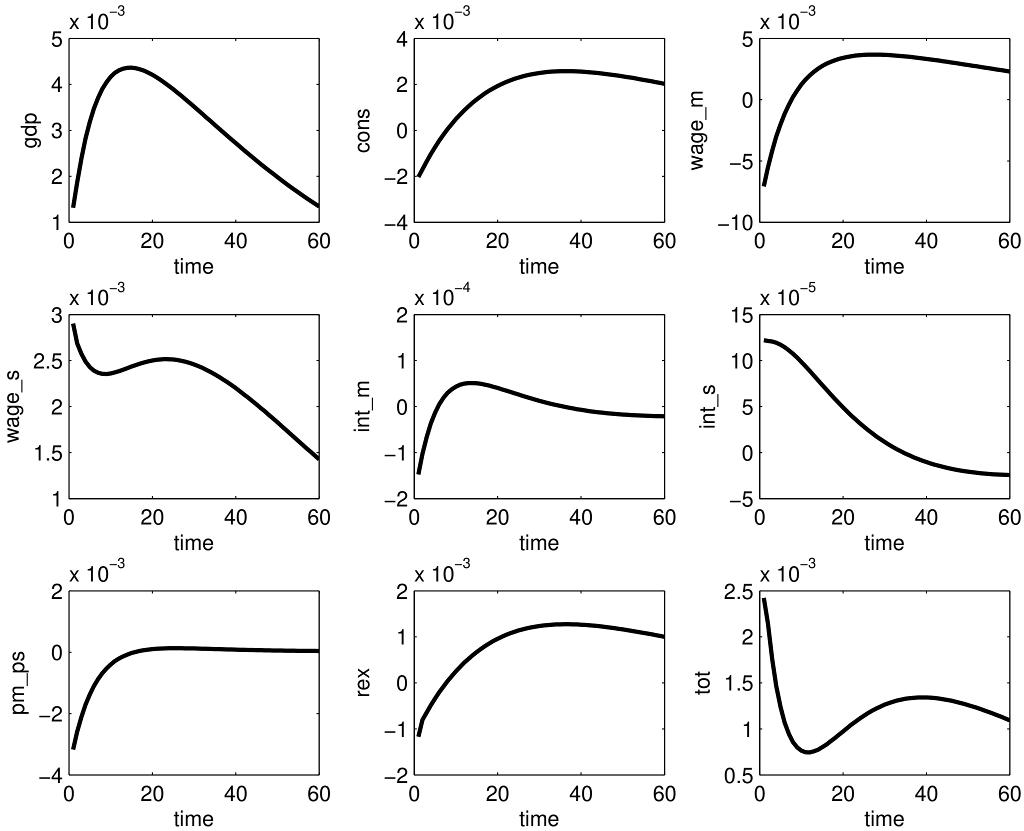


4.2 Shock to Productive Government Spending

The impulse response functions for a shock to productive government spending (figure 2) confirm the theoretical reasoning applied in section 1, namely that this shock can be seen as a combination of a technology shock and a nonproductive government spending shock. There is a persistent increase in GDP due to the productivity-enhancing effect of productive government spending. Consumption initially decreases, but becomes positive as soon as the productivity-enhancing part of the shock dominates the pure government demand shock. Real wages and interest rates show a divergent pattern in the short-run due to the demand side effect of government spending. After some periods, however, the increase in productivity dominates and leads to an increase in real income for factor inputs in both sectors. Compared with a shock to unproductive spending, it is in particular the real wage in the services sector, whose evolution changes and remains above its steady-state level. One can observe that the response of private consumption becomes positive roughly at the same time as the response of real wages in both sectors turns positive. Real interest rates show a pattern similar to that of real wages.

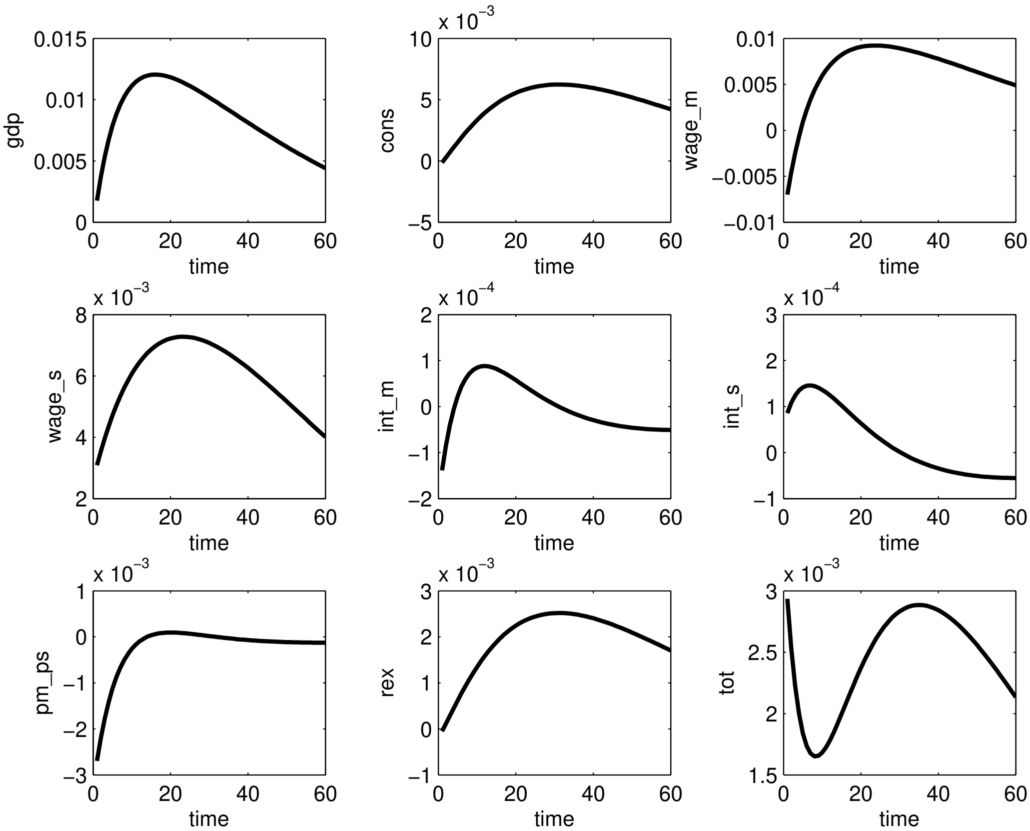
The real exchange rate appreciates in the short-run because increased government demand leads to a rise in the consumer price index. As soon as the productivity-enhancing effect dominates, the real exchange rate depreciates. The terms of trade, however, increase (i.e. depreciate) immediately because of the assumption that government demand goes to the non-tradable sector, while increasing productivity in both the tradable and nontradable sector.

Figure 2: Shock to Productive Government Spending when $\gamma = 0.1$



If one does the same exercise using a value of $\gamma = 0.2$, the observed effects can be expected to become more pronounced. Indeed, this is what can be seen from the impulse responses in figure 3. Interestingly, the responses of private consumption and the real exchange rate are now already positive in the first periods.

Figure 3: Shock to Productive Government Spending when $\gamma = 0.2$



5 Conclusion

In this paper, we have compared the short-run effects of productive and unproductive government spending on private consumption, the real exchange rate and the terms of trade. The simulation results show that the distinction between these two spending categories can contribute to explain why the empirical literature has found divergent impacts of government spending on these two macroeconomic variables.

The distinction between productive and unproductive government spending is somehow artificial and it is often difficult to make in practise. Furthermore, policymakers may be incited to declare a stimulus package as productivity enhancing when in reality, it is not. While the model in this paper has contributed to the theoretical basis to judge the potential impact of productive government spending, the practical relevance of these findings need to be examined by future research.

References

Arrow, K. J. and Kurz, M. (1969), 'Optimal public investment policy and controllability with fixed private savings ratio', *Journal of Economic Theory* **1**(2), 141–177.

Aschauer, D. A. (1989), 'Is public expenditure productive', *Journal of Monetary Economics* **24**(2), 177–200.

Barro, R. (1990), 'Government spending in a simple model of endogenous growth', *Journal of Political Economy* **98**(5), 103–125.

Baxter, M. and King, R. G. (1993), 'Fiscal policy in general equilibrium', *American Economic Review* **83**(3), 315–34.

Bems, R. (2008), 'Aggregate investment expenditures on tradable and nontradable goods', *Review of Economic Dynamics* **11**(4), 852–883.

Blanchard, O. J. and Perotti, R. (2002), 'An empirical characterization of the dynamic effects of changes in government spending and taxes on output', *Quarterly Journal of Economics* **117**(4), 1329–1368.

Calvo, G. A. (1983), 'Staggered prices in a utility-maximizing framework', *Journal of Monetary Economics* **12**(3), 383–398.

Clarida, R. and Prendergast, J. (1999), 'Fiscal stance and the real exchange: Some empirical estimates', *NBER Working Paper 7077* .

Corsetti, G., Meier, A. and Mueller, G. J. (2009), 'Fiscal stimulus with spending reversals', *mimeo* .

Davig, T. and Leeper, E. M. (2009), 'Monetary-fiscal policy interactions and fiscal stimulus', *NBER Working Paper 15133* .

Edelberg, W., Eichenbaum, M. and Fisher, J. D. (1999), 'Understanding the effects of a shock to government purchases', *Review of Economic Dynamics* **2**(1), 166–206.

Gali, J. (2008), *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*, Princeton University Press.

Hemming, R., Kell, M. and Mahfouz, S. (2002), 'The effectiveness of fiscal policy in stimulating economic activity–a review of the literature', *IMF Working Paper 208* .

Leeper, E. M., Walker, T. B. and Yang, S.-C. S. (2009), 'Government investment and fiscal stimulus in the short and long runs', *NBER Working Paper 15153* .

Linnemann, L. and Schabert, A. (2006), 'Productive government expenditure in monetary business cycle models', *Scotish Journal of Political Economy* **53**(1), 28–46.

Monacelli, T. and Perotti, R. (2009), 'Fiscal policy, the real exchange rate, and traded goods', *mimeo* .

Mueller, G. J. (2006), 'Understanding the dynamic effects of government spending on foreign trade', *mimeo* .

Ramey, V. A. (2008), 'Identifying government spending shocks: It's all in the timing', *mimeo, University of California San Diego* .

Ramey, V. A. and Shapiro, M. D. (1999), 'Costly capital reallocation and the effects of government spending', (NBER Working Paper 6283).

Romp, W. and de Haan, J. (2007), 'Public capital and economic growth: A critical survey', *Perspektiven der Wirtschaftspolitik* **8**(1), 6–52.

Schmitt-Grohe, S. and Uribe, M. (2003), 'Closing small open economy models', *Journal of International Economics* **61**(1), 163–185.

Spilimbergo, A., Symansky, S. and Schindler, M. (2009), 'Fiscal multipliers', *IMF Staff Position Note* .

Turnovsky, S. J. and Fisher, W. H. (1995), 'The composition of government expenditure and its consequences for macroeconomic performance', *Journal of Economic Dynamics and Control* **19**(4), 747–786.

A Implementation Delays

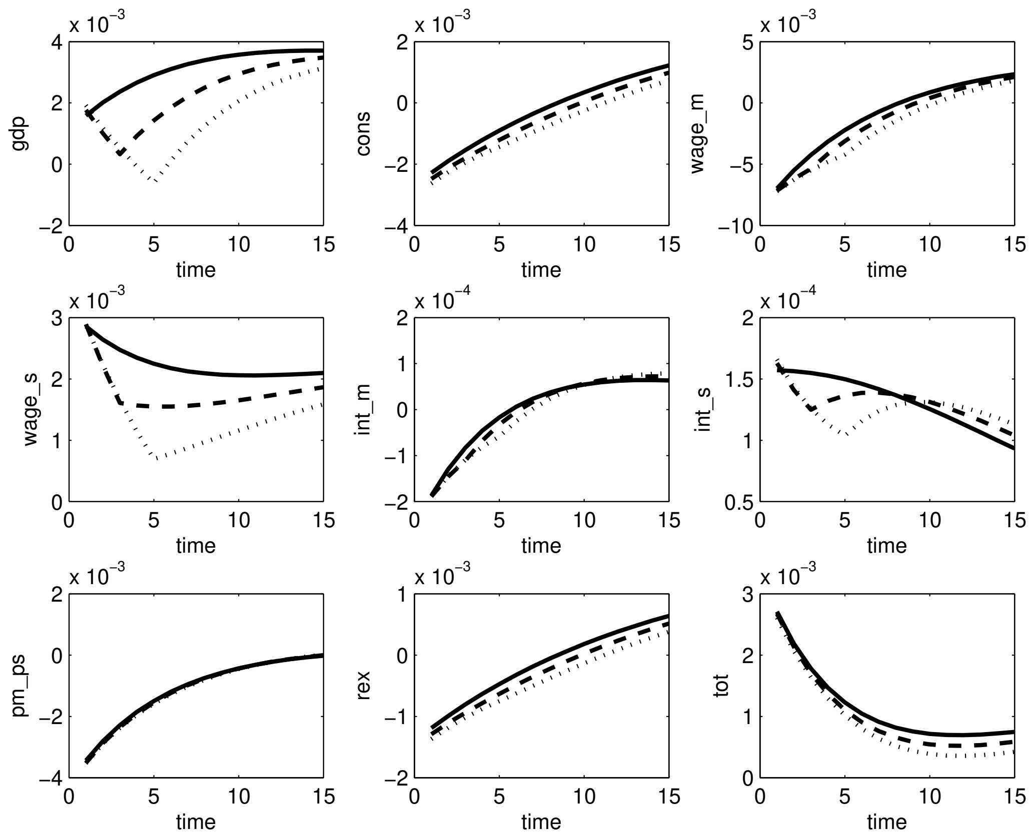
This section of the appendix considers the effects of implementation delays associated with building public capital. This modification tries to take into account that the provision of productive government spending may take more than one period (as in e.g. Leeper et al. (2009)). Thus, we vary n in the equation

$$k^g_{t+1} = ig_{t-n} + (1-\delta)k^g_t.$$

Figure 4 shows how implementation delays affect the impulse responses for our economy. We consider three cases to illustrate the effects of varying n: $n = 0$ as in the main part of this paper (solid lines), $n = 2$ (dashed lines) and $n = 4$ (dotted lines). The impulse response functions for the first 15 periods after the shock are depicted.

One can see that the qualitative pattern of most of the impulse response functions does not change. If there are implementation delays, the response of GDP is first very similar to the response for a shock to unproductive government spending. Due to this reason, the response of GDP even becomes negative after some periods when there are implementation delays. One can further observe that the effects on the terms of trade and the real exchange rate are only slightly modified.

Figure 4: Shock to Productive Government Spending with Implementation Delays: $n = 0$ (solid lines), $n = 2$ (dashed lines) and $n = 4$ (dotted lines)

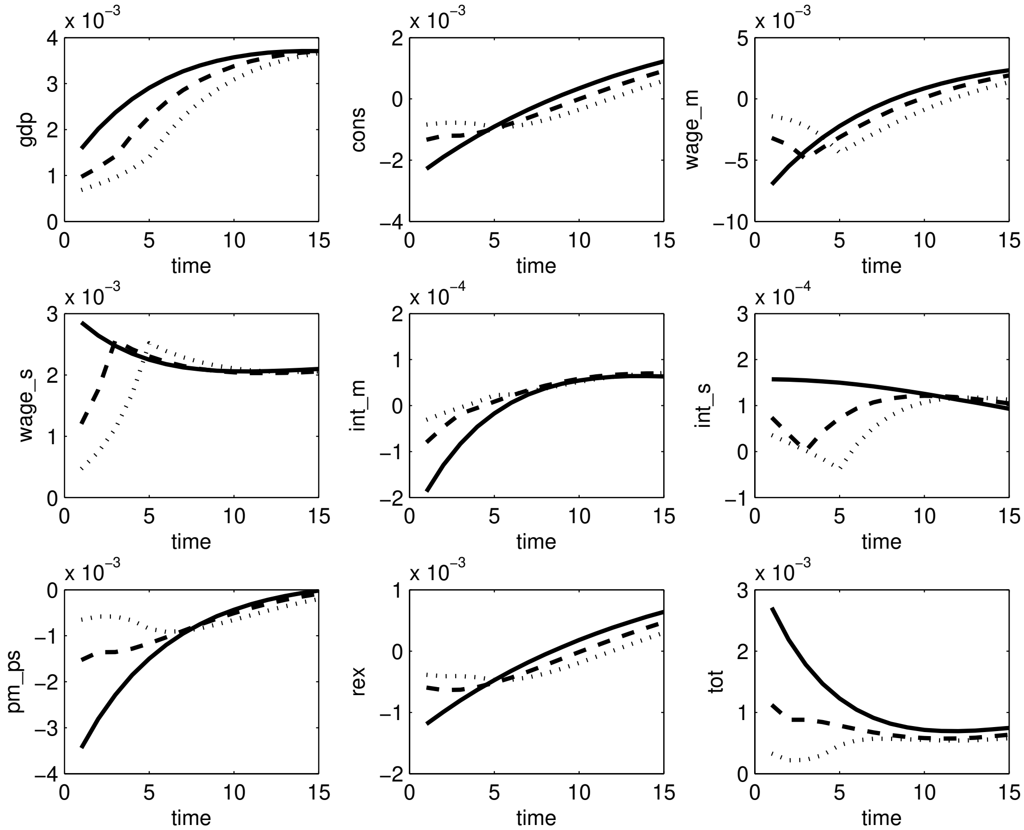


B Announcement Shocks

While implementation delays in a technological sense were analyzed in the last section, this section looks at implementation delays associated with the political and administrative process. What is meant by this is the period of time between the announcement of a project and its actual starting point. Thus, public investment ig_t at period t is determined by the announcement j_{t-n} of future investment by the government at period $t-n$. We thus have $ig_t = j_{t-n}$, which shows that we do not consider uncertainty about the completion of a project due to the political process. As in the last section, we consider three cases to illustrate the impacts of varying n: $n = 0$ (solid lines), $n = 2$ (dashed lines) and $n = 4$ (dotted lines).

One can observe in figure 5 that the response of GDP already differs in the first period, where the unexpected government demand shock immediately stimulates the economy for the case $n = 0$. Pure announcement shocks make individuals smooth their consumption. In the case of a delay between the announcement of a project and its provision, consumption falls less initially, but then increases less for the rest of the periods. Hence, we can observe an attenuation effect. An attenuation effect can also be observed for GDP. The longer the delay, the less pronounced is the increase in GDP when a project is actually realized.

Figure 5: Announcement Shock of an Increase of Productive Government Spending: $n = 0$ (solid lines), $n = 2$ (dashed lines) and $n = 4$ (dotted lines)



C The Effects of Sticky Prices

In this section, we analyze a version of the model that incorporates sticky prices. The modeling of sticky prices follows the formalism proposed by Calvo (1983) and explained in detail in e.g. Gali (2008). In this environment, there is a continuum of firms of measure 1 that produce intermediate products. Firm i produces $m_t(i)$ in sector M and $s_t(i)$ in sector S. A bundler firm puts the intermediate products together in order to provide the final good that can be used for consumption and investment. In each period, an individual firm can reset its price with probability $1-\mu$. When a firm can optimize its output price, it will take into account that it may not be able to repotimize this price in the future. Each firm maximizes the present value of profits weighting future profits by the probability that the price chosen now still applies in the future. Following this, each firm in sector M and sector S will then choose their optimal prices p_t^{mo} and p_t^{so} by solving the following maximization problems:

$$\max_{p_t^{mo}} \quad \sum_{t=0}^{\infty} \beta^t \mu^t E_t \left\{ p_t^{mo} m_t(i) - mc_t^m m_t(i) \right\}$$

subject to

$$m_t(i) = \left(\frac{p_t^{mo}}{p_t^m} \right)^{-\upsilon} m_t$$

and

$$\max_{p_t^{so}} \quad \sum_{t=0}^{\infty} \beta^t \mu^t E_t \left\{ p_t^{so} s_t(i) - mc_t^s s_t(i) \right\}$$

subject to

$$s_t(i) = \left(\frac{p_t^{so}}{p_t^s} \right)^{-\upsilon} s_t$$

The optimal prices are then given by:

$$p_t^{mo} = \frac{\upsilon}{\upsilon - 1} \frac{mc_0^m m_0 (p_0^m)^{\upsilon} + \sum_{t=1}^{\infty} \mu^t \beta^t m_t mc_t^m (p_t^m)^{\upsilon}}{m_0 (p_0^m)^{\upsilon} + \sum_{t=1}^{\infty} \mu^t \beta^t m_t (p_t^m)^{\upsilon}}$$

$$p_t^{so} = \frac{\upsilon}{\upsilon - 1} \frac{mc_0^s s_0 (p_0^s)^{\upsilon} + \sum_{t=1}^{\infty} \mu^t \beta^t s_t mc_t^s (p_t^s)^{\upsilon}}{s_0 (p_0^s)^{\upsilon} + \sum_{t=1}^{\infty} \mu^t \beta^t s_t (p_t^s)^{\upsilon}}$$

These two expression can be written in recursive forms that can then be embedded into our DSGE model. For sector M, we have:

$$x_t^m = m_t (p_t^m)^{\upsilon} mc_t^m + \beta\mu x_{t+1}^m$$
$$y_t^m = m_t (p_t^m)^{\upsilon} + \beta\mu y_{t+1}^m$$
$$p_t^{mo} = \frac{\upsilon}{\upsilon - 1} \frac{x_t^m}{y_t^m}$$

where x_t^m and y_t^m are two auxiliary variables. Similary, we have for sector S:

$$x_t^s = s_t (p_t^s)^{\upsilon} mc_t^s + \beta\mu x_{t+1}^s$$
$$y_t^s = s_t (p_t^s)^{\upsilon} + \beta\mu y_{t+1}^s$$
$$p_t^{so} = \frac{\upsilon}{\upsilon - 1} \frac{x_t^s}{y_t^s}$$

Every firm that can choose an optimal price in period t chooses the same optimal price. Hence, the aggregate price indices evolve as follows:

$$p_t^m = \left(\mu (p_{t-1}^m)^{1-\upsilon} + (1-\mu)(p_t^{mo})^{1-\upsilon}\right)^{\frac{1}{1-\upsilon}}$$

$$p_t^s = \left(\mu (p_{t-1}^s)^{1-\upsilon} + (1-\mu)(p_t^{so})^{1-\upsilon}\right)^{\frac{1}{1-\upsilon}}$$

Because of the markup over marginal costs, firms now make aggregate profits

$$\Pi_t^m = p_t^m m_t - w_t^m l_t^m - r_t^m k_t^m$$

and

$$\Pi_t^s = p_t^s s_t - w_t^s l_t^s - r_t^s k_t^s,$$

which are equally distributed among the individuals. Adding these profit shares to the budget constraint for an individual gives:

$$\begin{aligned} &(w_t^m l_t^m + w_t^s l_t^s) + (r_t^m k_t^m + r_t^s k_t^s) + (1 + r_{t-1}^d) d_{t-1} + \Pi_t^m + \Pi_t^s = \\ &p_t^c c_t + p_t^{im} im_t + p_t^{is} is_t + d_t + p_t^c \frac{\kappa}{2} \left(\left(k_{t+1}^m - k_t^m\right)^2 + \left(k_{t+1}^s - k_t^s\right)^2 \right) + t_t \end{aligned} \quad (26)$$

We have used two new parameters in this extension of the model, which need to be calibrated. For υ, we choose a value of 10 which is within the range of values usually used for this parameter. For μ, we consider three different cases that are depicted in figures 6: one where $\mu = 0.25$ (solid lines), one case with $\mu = 0.50$ (dashed lines) and one case with $\mu = 0.75$ (dotted lines).

The attenuation effect of sticky prices on the consumer price index (see figure 6) leads to a less pronounced impact on the real exchange rate and the terms of trade. Sticky prices in the tradable goods sector M prevent a strong immediate decrease of output prices in this sector. In all cases, foreign demand drives prices up and leads to a more negative impact on private consumption.

Figure 6: Shock to Productive Government Spending under Sticky Prices: $\mu = 0.25$ (solid lines); $\mu = 0.5$ (dashed lines); $\mu = 0.75$ (dotted lines)