Macroeconomic Dynamics, **19**, 2015, 1380–1399. Printed in the United States of America.
doi:10.1017/S1365100513000874

THE EFFECTS OF FISCAL SHOCKS IN A NEW KEYNESIAN MODEL WITH USEFUL GOVERNMENT SPENDING

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This paper develops a medium-scale New Keynesian model where consumer preferences depend on government expenditures and public capital is productivity-enhancing in order to account for recent evidence on the effects of government spending shocks. Under plausible assumptions on the degree of complementarity between private and public expenditures and on the output elasticity of public spending and considering alternative monetary policy rules, the effects of fiscal shocks delivered by the model are in line with the evidence.

Keywords: Useful Government Spending, New Keynesian Model, Taylor Rules

1. INTRODUCTION

New Keynesian (NK) models, also labeled new neoclassical synthesis (NNS) models, have recently imposed themselves as the benchmark model used by monetary policy decision makers. They add to the real business cycle (RBC) framework, characterized by optimizing agents and rational expectations, Keynesian features such as monopolistic competition and nominal rigidities. The latter imply that inflation is forward-looking, as firms and households are subject to limits on the frequency with which they are allowed to reset prices and wages and therefore need to plan ahead. If NK models have proved very useful in the analysis of monetary policy, more controversial is their ability to describe realistically the transmission mechanism of fiscal policy, in particular the consequences of changes in public spending.

The issue of the effects of increases in government spending on the economy has been widely debated in macroeconomics both from a theoretical and from an empirical point of view. RBC and Keynesian models reach different conclusions on the matter. In both classes of models, increases in public spending cause a rise in output. However, in RBC models, a fiscal shock yields a decline in consumption and real wages,[1] whereas in Keynesian models the same shock typically leads to an increase in the same variables. The difference is due to the fact that in the

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RBC framework an increase in government spending causes a negative wealth effect, whereas in the Keynesian setting consumption is crowded in because of the positive marginal propensity to consume.

Recent empirical studies seem to support the Keynesian view. Fatas and Mihov (2001), who analyze U.S. data in a vector autoregression framework, find that increases in government expenditure are followed by a rise in consumption and employment. The study by Blanchard and Perotti (2002) for the postwar U.S. economy reaches similar conclusions: a shock in government spending causes output and private consumption to increase, while private investment is crowded out. Marattin and Salotti (2011) apply a panel vector autoregression approach to European Union (EU) countries and find evidence of a positive effect of increases in government spending on both private consumption and investment. In Burnside et al. (2004), who build on Ramey and Shapiro (1998), focusing on changes in defence spending, public spending increases raise output and private investment, without having a significant effect on private consumption. Finally, Mountford and Uhlig (2009) find that both residential and nonresidential investment decrease following a positive fiscal shock and that private consumption does not change significantly. In conclusion, although results differ concerning the effects of government spending shocks on private investment, it is generally found that an increase in public investment or consumption either increases private consumption or leaves it almost unchanged.

The contribution of this paper is twofold. First, it aims to reconcile the predictions of New Keynesian models with the evidence on the effects of increases in government spending. The second contribution of the paper is an assessment of the importance of the monetary rule in determining the effects of government spending shocks under the assumption of nonwasteful government spending. A number of New Keynesian models have been developed to account for the evidence on the response of private consumption to public expenditure shocks. Galí et al. (2007) build a model with sticky prices and rule-of-thumb consumers (i.e., consumers who each period spend their entire labor income without borrowing or saving) and show that under certain conditions the framework is consistent with the data. Linnemann (2004) demonstrates that in a model with an unemployment insurance system accompanied by distortionary taxation, consumption increases after a positive fiscal shock. This paper considers an alternative departure from the standard New Keynesian model by assuming that government spending directly affect agents' behavior.

The standard New Keynesian model is augmented with two features: public capital enters the production function, thereby allowing for productive government spending, and government consumption can be a substitute or a complement for private consumption, affecting agents' utility. The implications of these assumptions have been analyzed in the context of growth and RBC models in a number of papers. For example, Turnovsky (2004) considers the effects of fiscal policy on the transitional dynamics of a growth model that includes productive public capital and utility-enhancing government consumption under different tax

financing modes, finding that, under lump-sum taxation, increases in government consumption have a gradual but mild positive effect on welfare over time, whereas increases in government investment involve a decline in welfare in the short run but a sharp improvement over time.[2] This paper differs from these contributions, in that it analyzes these issues within the the specificities of the New Keynesian framework, focusing on the implications of government spending shocks for consumption and investment and on their interactions with monetary policy. Linnemann and Schabert (2004) develop a New Keynesian model where public and private consumption are imperfect substitutes and show that for low values of the elasticity of substitution between the two, a government spending shock can be followed by a positive response of consumption. The present study adopts an alternative mechanism through which public consumption enters the utility function.

The empirical relevance of the assumption of productive government spending has been tested in a number of studies estimating the elasticity of output with respect to public capital, whose main motivation is to provide an assessment of the hypothesis that the productivity slowdown in the United States dating from the 1970s has been caused by underinvestment in public capital. Aschauer (1989) and Lynde and Richmond (1993) find evidence of a significant contribution of public capital to productivity. Ai and Cassou (1995) estimate lower values of public capital elasticity but, making use of a cost–benefit approach, conclude that the benefit of a marginal public capital expenditure is greater than its cost. From a theoretical point of view, Baxter and King (1993) analyze the impact of permanent and temporary changes in government spending within a RBC framework, finding that public investment increases both output and private investment dramatically.

Concerning the existence of a relationship of substitutability or complementarity between private and public consumption, Bailey (1971) and Barro (1981) first introduced the idea that government and private spending are imperfect substitutes. This view is supported by an empirical study by Aschauer (1985), who provides evidence in favor of the hypothesis of substitutability. However, more recent studies are more supportive of the hypothesis of complementarity. For instance, Karras (1994) argues that together with publicly provided goods and services that act as substitutes for private consumption, there are forms of government spending, e.g., public spending on transportation, that are complementary to private consumption and others that are both. His results suggest that public and private consumption must be regarded as complementary or unrelated. Evans and Karras (1996) and Obuko (2003) also support complementarity, whereas Amano and Wirjanto (1998) conclude that, given the weak degree of complementarity, the two variables are unrelated.

The main results of the paper are as follows. First of all, the dynamics of the response of output, consumption, and investment to a government spending shock in a standard New Keynesian model differs from that observed in RBC models because of the presence of nominal rigidities. However, the qualitative response of consumption and investment is unchanged. An increase in government spending

crowds out both private consumption and investment. Second, the introduction of nonwasteful government spending into an otherwise standard New Keynesian model generates a response of consumption to a government spending shock that is consistent with the evidence. The effects of the shock vary depending on whether public capital increases productivity or is utility-enhancing (or both). Which feature is crucial for the results depends on the composition of the government spending shock, in particular on whether the shock consists in an increase in government investment or consumption. When public capital is productive, the negative effect of an increase in public investment on consumption and investment is at least partially offset and turns positive when government spending is highly productive. On the other hand, a government consumption shock in the presence of a relationship of complementarity between private consumption and government spending has, for sufficiently high degrees of complementarity, a positive effect on consumption, but still implies a decrease in private investment. Finally, the role of monetary policy is crucial in determining the results, as the expansionary effect of a government spending shock observed when government spending is productive and/or private and public consumption are complementary disappears or is considerably smaller when the central banks aims to control output fluctuations in addition to inflation targeting.

The paper is organized as follows. Section 2 presents a NNS model with sticky prices and wages, in which government spending enters the production function and which allows for a degree of substitutability or complementarity between private consumption and public spending. Section 3 describes the equilibrium, Section 4 discusses the values given to the parameters, and Section 5 presents the results. Section 6 concludes.

2. THE MODEL

The model described in this section is a standard dynamic general equilibrium model with staggered prices and wages in which public capital can be productivity-enhancing and government spending affects utility. Firms produce differentiated goods and set prices according to the Calvo (1983)–Yun (1996) model and households offer differentiated labor services setting wages through the same mechanism adopted by firms. The government sector consists of a central bank and a fiscal authority. Lower-case letters denote real variables, whereas upper-case letters refer to nominal variables, with the exception of the nominal interest rate r_t. A circumflex on a lower-case letter denotes a logarithm of a variable or its deviation from steady state.

2.1. Firms

Firms are monopolistically competitive and produce differentiated goods denoted by $y_t(i)$, where $i \in [0, 1]$. The goods are combined into an output index making

use of a CES technology:

$$y_t = \left[\int_0^1 y_t(i)^{\frac{1}{1+\eta_p}} di\right]^{1+\eta_p},$$

where y_t is the output index and $\eta_p > 0$ the price markup rate. The output index is then sold at the price

$$P_t = \left[\int_0^1 P_t(i)^{-\frac{1}{\eta_p}} di\right]^{-\eta_p}. \tag{1}$$

The minimization of the production cost of y_t yields the demand function for the good produced by firm i, $y_t(i)$:

$$y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\frac{1+\eta_p}{\eta_p}} y_t. \tag{2}$$

Firms share the same level of technology x_t and produce goods according to the Cobb–Douglas production function

$$y_t(i) = x_t k_t(i)^{\alpha} l_t(i)^{1-\alpha} \left(k_t^g\right)^{\xi}, \tag{3}$$

where k_t^g represents public capital, $k_t(i)$ private capital, and $l_t(i)$ the labor services supplied by households. α, $(1-\alpha)$, and ξ are the shares of the three inputs in the production function, which exhibits constant returns to scale with respect to the private inputs. Firms minimize cost with respect to labor and private capital subject to (3) and take the nominal wage W_t and the rental cost of capital R_t^k as given. Public capital contributes to the production process, enhancing the productivity of both private capital and labor.[3] The producers have the same aggregate factor demand functions, given by

$$W_t = \mathrm{mc}_t(1-\alpha)x \left(k_t^g\right)^{\xi} k_t^{\alpha} l_t^{-\alpha} \tag{4}$$

and

$$R_t^k = \mathrm{mc}_t \alpha x_t \left(k_t^g\right)^{\xi} k_t^{-(1-\alpha)} l_t^{1-\alpha}.$$

The individual firm resets the price of the good produced with probability $(1-\chi)$, as in Calvo (1983). It is assumed that χ is independent of the state of nature and of the timing of the last price adjustment and that $0 \leq \chi < 1$, implying complete price flexibility when $\chi = 0$. Following Yun (1996), prices that are not reset are increased at the unconditional mean rate of gross inflation Π, such that

$$P_{t+k}(i) = \Pi^k P_t(i). \tag{5}$$

Consequently,

$$P_t = \left[(1-\chi)(P_t^*)^{-\frac{1}{\eta_p}} + \chi(\Pi P_{t-1})^{-\frac{1}{\eta_p}}\right]^{-\eta_p}, \tag{6}$$

where P_t^* is the price chosen by the firm. Whenever the firm cannot reset its price, the price of the good is equal to the price set in the previous period increased at the rate Π.[4] Therefore, the following profit function is maximized by firms:

$$E_t \sum_{k=0}^{\infty} \chi^k \vartheta_{t,t+k} \left[\Pi^k P_t(i) y_{t+k}(i) - \mathrm{mc}_{t+k} y_{t+k}(i) \right]. \tag{7}$$

The first-order condition is given by

$$E_t \sum_{k=0}^{\infty} \chi^k \vartheta_{t,t+k} \left[\left(\frac{1}{1+\eta_p} \Pi^k P_t(i) - \mathrm{mc}_{t+k} \right) \right] y_{t+k}(i) = 0. \tag{8}$$

2.2. Households

A continuum of households indexed by $j \in [0, 1]$ offer differentiated labor services, denoted by $n_t(j)$, to firms. The sum of firms' demands for labor is equal to the labor index

$$l_t = \left[\int_0^1 n_t(j)^{\frac{1}{1+\eta_w}} dj \right]^{1+\eta_w}. \tag{9}$$

with $\eta_w > 0$. The labor index is then bought by producers at the price

$$W_t = \left[\int_0^1 W_t(j)^{-\frac{1}{\eta_w}} dj \right]^{-\eta_w}. \tag{10}$$

The total demand for the individual household labor is then

$$n_t(j) = \left[\frac{W_t(j)}{W_t} \right]^{-\frac{1+\eta_w}{\eta_w}} l_t. \tag{11}$$

The utility function is separable in effective consumption, leisure, and real money balances and can be written as

$$E_t \sum_{k=0}^{\infty} \beta^k \left\{ U[c_{t+k}(j)^*] - V[n_{t+k}(j)] + Z\left[\frac{M_{t+k}(j)}{P_{t+k}} \right] + \Gamma[c_t^g] \right\}, \tag{12}$$

where E_t is the expectation operator at time t, β is the discount factor, M is the nominal money balances, and $c_t(j)^*$ denotes effective consumption, given by $c_t(j)^* = c_t(j) + \varrho c_t^g$ (where c_t^g is government consumption), according to the formulation first suggested by Bailey (1971). However, the assumption $0 < \varrho < 1$, stating the existence of a degree of substitutability between private and government consumption, is dropped. Following Karras (1994), ϱ is allowed to take negative values, implying that a rise in public consumption increases the marginal utility of private consumption and therefore that the two variables are complementary.[5] To avoid negative values of the marginal utility of government consumption, the term $\Gamma[c_t^g]$ has been added to the utility function. It is further assumed that $\partial\Gamma/\partial c_t^g$

is positive and that the consumers treat public expenditures as exogenous. The components of the utility function take the following forms:

$$U[c_t(j)] = \frac{1}{1-\sigma}[c_t(j) + \varrho c_t^g]^{1-\sigma}, \tag{13}$$

$$V[n_t(j)] = \frac{1}{1+\psi}[n_t(j)]^{1+\psi}, \tag{14}$$

$$F\left[\frac{M_t(j)}{P_t}\right] = \frac{\nu}{1-\mu}\left[\frac{M_t(j)}{P_t}\right]^{1-\mu}. \tag{15}$$

The constant ν measures the weight of real money balances in the utility function. Households spend their labor income and their share of profits to consume, to purchase bonds, and to increase their money holdings. The consumers' budget constraint is given by

$$\begin{aligned} P_t c_t(j) + P_t i_t(j) + M_t(j) + R_{t,t+1} B_t(j) &= M_{t-1}(j) + B_{t-1}(j) \\ &+ R_t^k k_t(j) + W_t(j) n_t(j) + \Lambda_t(j) - P_t t_t(j), \end{aligned} \tag{16}$$

where $k_t(j)$ is capital, $i_t(j)$ is investment, $B_t(j)$ the quantity of bonds held by household j, t_t lump-sum taxation, and $\Lambda_t(j)$ the dividends received by households. To rule out arbitrage opportunities, a stochastic discount factor $R_{t,t+1} = \frac{1}{1+r_t}$ is introduced, implying that $R_{t,t+1} B_t(j)$ is the current market price of a portfolio that will pay a nominal value of $B_t(j)$ at the end of time t. The household also earns labor income $W_t(j) n_t(j)$ and capital income $R_t^k k_t(j)$. Capital is accumulated according to the equation

$$k_{t+1} = \Phi\left(\frac{i_t}{k_t}\right) k_t + (1-\delta) k_t, \tag{17}$$

where δ is the depreciation rate and $\Phi(\frac{i_t}{k_t})$ is the adjustment cost function, with $\Phi'(i_t/k_t) > 0$ and $\Phi''(i_t/k_t) \leq 0$. Households maximize (12) with respect to consumption, private capital, investment, bonds, and money holdings subject to (11), (16), and (17). The first-order conditions with respect to k_{t+1} and i_t are given by

$$\begin{aligned} E_t \left\{ R_{t+1}^k + P_{t+1} q_{t+1} \left[\Phi\left(\frac{i_{t+1}}{k_{t+1}}\right) - \Phi'\left(\frac{i_{t+1}}{k_{t+1}}\right)\left(\frac{i_{t+1}}{k_{t+1}}\right) + (1-\delta) \right] \frac{1}{P_t q_t} \right\} \\ = E_t[R_{t,t+1}] \end{aligned} \tag{18}$$

and

$$q_t = \frac{1}{\Phi'(I_t/k_t)}. \tag{19}$$

The combination of the first-order conditions for consumption and bonds yields the Euler equation

$$(c_t + \varrho c_t^g)^{-\sigma} = E_t \left[\beta(1 + i_t)\left(c_{t+1} + \varrho c_t^g\right)^{-\sigma} \frac{P_t}{P_{t+1}} \right]. \tag{20}$$

The index j is omitted, because identical preferences and complete contingent claims markets are assumed, which implies that all households will choose the same path of consumption. The marginal rate of substitution is equal to

$$\text{mrs}_t = \frac{\left(c_t + \varrho c_t^g\right)^{-\sigma}}{n_t^{\psi}}. \tag{21}$$

Households reset their wages with probability $(1-\phi)$, on the basis of a mechanism analogous to the one through which firms set their prices.[6] Therefore, whenever a household is allowed to reset its wage, it maximizes the utility function (12) with respect to W_t. Assuming that whenever a household cannot reset its wage, which happens with probability ϕ, the wage is increased at the gross rate of inflation Π; the first-order condition is given by

$$E_t \sum_{k=0}^{\infty} \phi^k \beta^k \left[n_{t+k}(j)]^{\psi} + \frac{1}{1 + \eta_w} \frac{\Pi^k W_t(j)}{P_{t+k}} c_{t+k}^{-\sigma} \right] n_{t+k}(j) = 0. \tag{22}$$

2.3. Public Sector and Market Clearing

The central bank sets the interest rate following a variant of the Taylor (1993) rule (according to which the nominal interest rate r_t is a linear function of the gap between the inflation rate and the inflation target and of the gap between real output and trend output):

$$r_t = (1 - \rho)\gamma_\pi \pi_t + (1 - \rho)\gamma_y y_t + \rho r_{t-1} + \varepsilon_{t,m}, \tag{23}$$

where γ_π and γ_y are the coefficients on the inflation and output gaps, $\varepsilon_{t,m}$ is an i.i.d. monetary policy shock, and the parameter ρ is introduced to capture the tendency of central banks to adjust the interest rate only very slowly.[7]

The government budget constraint is given by[8]

$$R_{t+1,t} B_t + P_t t_t = B_{t-1} + P_t g_t, \tag{24}$$

where government spending is the sum of government investment and government consumption,

$$g_t = i_t^g + c_t^g, \tag{25}$$

which follow first-order autoregressive processes, which in log-linearized terms are

$$i_t^g = \rho_{i^g} i_{t-1}^g + \varepsilon_{t,i^g}, \tag{26}$$

$$c_t^g = \rho_{c^g} c_{t-1}^g + \varepsilon_{t,c^g}, \tag{27}$$

where ε_{t,i^g} and ε_{t,c^g} are i.i.d. shocks with constant variances $\sigma^2_{\varepsilon_{i^g}}$ and $\sigma^2_{\varepsilon_{c^g}}$. In addition, to ensure that the government budget constraint is satisfied at all times, a no-Ponzi condition is imposed:

$$\lim_{T\to\infty} \frac{B_{t+T}}{\prod_{j=0}^{T}(1+r_{t+j})} = 0. \tag{28}$$

The stock of public capital evolves according to

$$k_{t+1}^g = \Phi\left(\frac{i_t^g}{k_t^g}\right) k_t^g + (1-\delta_g) k_t^g, \tag{29}$$

where δ is the depreciation rate and $\Phi(\frac{i_t^g}{k_t^g})$ is the adjustment cost function. Finally, clearing of all markets requires

$$y_t = c_t + i_t + g_t. \tag{30}$$

3. EQUILIBRIUM

The equilibrium conditions are then log-linearized around the steady state, obtaining a system in the 13 endogenous variables $\{\hat{y}_t, \hat{c}_t, \hat{i}_t, \hat{k}_t, \hat{l}_t, \hat{r}_t, \hat{r_t^k}, \hat{\pi}_p, \hat{\pi_w}, \hat{w}_t, \widehat{\text{mrs}}_t, \widehat{\text{mc}}_t, \hat{q}_t\}$, where a circumflex over a lower case letter indicates the log-deviation of the variable from the steady state.

3.1. Firms

The log-linearization of the production function (3) and of the factor demand functions (4) yields

$$\hat{y}_t = \hat{x}_t + (1-\alpha)\hat{l}_t + \alpha\hat{k}_t + \xi\hat{k_t^g}, \tag{31}$$

$$\hat{w}_t - \hat{p}_t = \widehat{\text{mc}}_t + \hat{x}_t - \alpha\hat{l}_t + \alpha\hat{k}_t + \xi\hat{k_t^g}, \tag{32}$$

$$\hat{r_t^k} - \hat{p}_t = \widehat{\text{mc}}_t + \hat{x}_t + (1-\alpha)\hat{l}_t - (1-\alpha)\hat{k}_t + \xi\hat{k_t^g}. \tag{33}$$

Equation (6) is linearized around the steady state, giving

$$\hat{p}_t = (1-\chi)\hat{p_t^*} + \chi\hat{p_{t-1}}. \tag{34}$$

Considering that the relationship between nominal and real marginal cost, in log-linearized terms, is

$$\widehat{MC}_t = \widehat{\text{mc}}_t + \hat{p}_t, \tag{35}$$

and with a number of further substitutions, the following equation describing the dynamics of inflation is obtained:

$$\hat{\pi}_t = \beta E_t\widehat{\pi_{t+1}} + k_p\widehat{\text{mc}}_t, \tag{36}$$

where $k_p = (1-\beta\eta_p)(1-\eta_p)/\eta_p$. This is the New Keynesian Phillips curve, linking current inflation to expected inflation and to the marginal cost.

3.2. Households

In the steady state, the Euler equation reduces to $\beta(1+\overline{R}) = 1$. Using this result, the first-order condition is then linearized, yielding

$$\hat{c}_t = E_t[\widehat{c_{t+1}}] - \frac{1}{\sigma \bar{l}_c}(\hat{r}_t - \widehat{\pi_{t+1}}) + \varrho \frac{\bar{l}_{c^g}}{\bar{l}_c}\left(\widehat{c^g_{t+1}} - \hat{c^g_t}\right). \tag{37}$$

The log-linearization of the capital accumulation equation (17) yields

$$\widehat{k_{t+1}} = \delta \hat{i}_t + (1-\delta)\hat{k}_t. \tag{38}$$

Given that in the steady state $\frac{\overline{I}}{\overline{K}} = \delta$ and assuming that $\Phi(\delta) = \delta$ and $\Phi'(\delta) = 1$, the log-linearized first-order condition (18) is

$$\hat{q}_t = [1-\beta(1-\delta)]E_t\left[\widehat{r^k_{t+1}} - \widehat{p_{t+1}}\right] - \hat{r}_t + E_t\left[\widehat{\pi_{t+1}}\right] + \beta E_t[\widehat{q_{t+1}}], \tag{39}$$

whereas (19) becomes

$$\hat{i}_t = -\frac{\Phi'\left(\hat{i}_t/\hat{k}_t\right)}{\Phi''\left(\hat{i}_t/\hat{k}_t\right)}\frac{\overline{K}}{\overline{I}}\hat{q}_t + \hat{k}_t. \tag{40}$$

The log-linearized wage-setting rule is

$$\Delta\hat{w}_t = \beta E_t[\Delta\widehat{w_{t+1}}] + k_w[\widehat{\text{mrs}}_t - (\hat{w}_t - \hat{p}_t)], \tag{41}$$

and the marginal rate of substitution is

$$\widehat{\text{mrs}}_t = \sigma l_c \hat{c}_t + \sigma\varrho l_{c^g}\hat{c^g_t} + \psi\hat{l}_t, \tag{42}$$

with $l_c = \frac{\overline{C}}{\overline{C}+\varrho\overline{C^g}}$ and $l_g = \frac{\overline{C^g}}{\overline{C}+\varrho\overline{C^g}}$. The real wage changes over time according to

$$\hat{w}_t - \hat{p}_t = \widehat{w_{t-1}} - \widehat{p_{t-1}} + \Delta\hat{w}_t - \hat{\pi}_t. \tag{43}$$

3.3. Market Clearing and Technology Shock

The linearized market clearing relation is

$$\hat{y}_t = \frac{\bar{C}}{\bar{Y}}\hat{c}_t + \frac{\bar{I}}{\bar{Y}}\hat{i}_t + \frac{\bar{G}}{\bar{Y}}\hat{g}_t. \tag{44}$$

The technology shock evolves according to the first-order autoregressive process

$$\hat{x_t} = \rho_x \hat{x_{t-1}} + \varepsilon_{t,x}, \tag{45}$$

where $\varepsilon_{t,x}$ is an i.i.d. shock with variance σ_x^2.

4. CALIBRATION

In this section, the values assigned to the parameters will be briefly discussed. The calibration is to one quarter. Most values are taken from Erceg et al. (2000): the discount factor β is set equal to 0.99, σ is set equal to 1.5, and the capital share in the production function is $\alpha = 0.3$. The wage contract duration parameter is $\phi = 0.75$, implying that the average duration of a contract is 1 year. However, the parameter χ is set equal to 0.5, as in Benigno and Woodford (2004). The depreciation rate of capital is $\delta = 0.025$ and the persistence of the government spending shock is 0.9.

To assign a value to the parameter ξ, estimates of the output elasticity of public capital are used as a proxy. The empirical studies available provide a wide range of estimates: to cite a few, Eberts (1986) finds an estimated elasticity of 0.03, Ai and Cassou (1995) produce values ranging between 0.15 and 0.26, and Aschauer (1989) estimates a value of 0.39. On the basis of these studies, in Section 5 the effects of government investment shocks will be discussed for $\xi = 0.26$ (the highest value estimated by Ai and Cassou) and $\xi = 0.39$ (from the study by Aschauer).

The values taken by ϱ, which measures the degree of substitutability or complementarity between private and public spending, come from the estimates of Aschauer (1985) and Karras (1994). Aschauer (1985), using the full-information maximum likelihood method applied to U.S. data, gets estimates of the degree of substitutability of public expenditures for private consumption ranging between 0.23 and 0.42. Karras (1994), using a similar methodology for a sample of 30 countries, finds evidence of complementarity in almost all cases. In the next section, impulse responses will be plotted for $\varrho = 0.23$, $\varrho = 0.42$, $\varrho = -0.36$, and $\varrho = -1.34$. The latter are the estimates obtained by Karras (1994) for Germany and France and have been chosen to illustrate the implications of different degrees of complementarity.

Following the estimates of Clarida et al. (2000), ρ is given a value of 0.9,[9] whereas γ_π is equal to 1.5. The dynamics of the model are analyzed for two values of γ_y, $\gamma_y = 0.25$, which corresponds to an interest rule in which the central bank reacts to fluctuations in output and was originally suggested by Taylor (1993), and $\gamma_y = 0$. The second hypothesis is in line with recent evidence: for instance, Ireland (2000) runs a regression on the interest rate rule followed by the Fed since 1980 and finds that the coefficient on output is small (0.000372) and statistically insignificant.

Moreover, it is assumed that increases in government spending are fully financed by lump-sum taxes. Although the assessment of different forms of financing is beyond the scope of this paper, it must be noted that alternative assumptions concerning the mode of government expenditure financing can have different implications for the effects of fiscal shocks. For example, Turnovsky (2004) considers alternative forms of financing, finding that they lead to different dynamics of the variables impacted by the fiscal shocks and that in welfare terms lump-sum taxation dominates other financing modes.

5. RESULTS

This section discusses the effects of fiscal shocks on output, private consumption, and private investment for different calibrations of the parameters. It also shows the responses of labor and of the real wage to the shocks. The impulse responses are plotted against a benchmark model with price and wage rigidities in which public spending does not affect production ($\xi = 0$) and/or the utility function ($\varrho = 0$) and represent deviations from the steady state.

The implications of nominal rigidities for the consequences of government spending shocks are illustrated in Figure 1, which compares impulse responses to a 1% shock for the benchmark model and a version of the same model with flexible prices and wages (i.e., for $\chi = 0$ and $\phi = 0$). The figure shows that in both cases a fiscal shock is followed by an increase in output and a decline in consumption and investment. Overall, a higher proportion of the economy's output is absorbed by the public sector. In fact, a positive shock to government spending triggers a negative private wealth effect, as the increase in taxation needed to finance the additional government purchases reduces households' disposable income, which in turn leads to a decrease in consumption and leisure. The increase in labor supply is accompanied by a decline in the real wage. Interest rates also increase and investment declines. The presence of nominal rigidities implies a more gradual effect of the shock on consumption and investment, whereas the impact expansionary effect on output is accentuated. Nevertheless, price and wage stickiness alone is not sufficient to replicate the positive response of consumption to expansionary government spending shocks.

5.1. Fiscal Shocks and Productive Government Spending

Figure 2 shows the dynamic reaction of the five macroeconomic variables to a government investment shock for alternative values of the share of public capital in the production function, $\xi = 0.26$ and $\xi = 0.39$. Moreover, it is assumed that the monetary policy parameter γ_y is equal to 0: in other words, the central bank only targets inflation, setting the interest rate independent of output fluctuations.

An increase in productive public capital caused by a government investment shock enhances the productivity of private capital and therefore translates into an increase in its stock. The resulting increase in output also positively affects consumption. Setting the weight of public spending in the production function

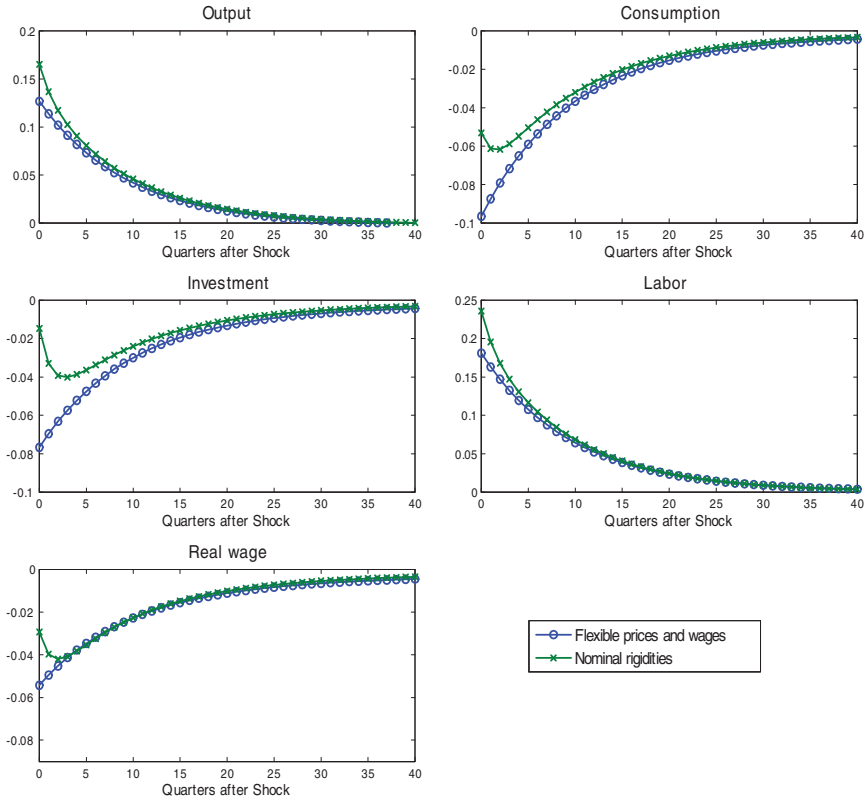

FIGURE 1. Government spending shock: Nominal rigidities vs. flexible prices.

equal to 0.26, the positive effect of a government spending shock on output is amplified and the magnitude of the effect grows over time as public capital accumulates, enhancing the productivity of private factors. Consumption and investment decline in the short run but increase above steady state over time as productivity increases. Higher values of the government spending share ξ (0.39), implying a strong contribution of public spending to productivity, strengthen the predicted effect of a positive fiscal shock on the components of output. The effect on private investment is positive even in the short run, whereas consumption declines slightly in the initial quarters and then gradually and persistently increases. Overall, an expansionary government investment shock generates a positive private wealth effect, increasing consumption and investment, if the productivity of public capital is high enough to offset the increased absorption of the economy's resources by the government.

5.2. Government Spending in the Utility Function

In this section, the implications of a relationship of substitutability or complementarity between private consumption and public spending are discussed.

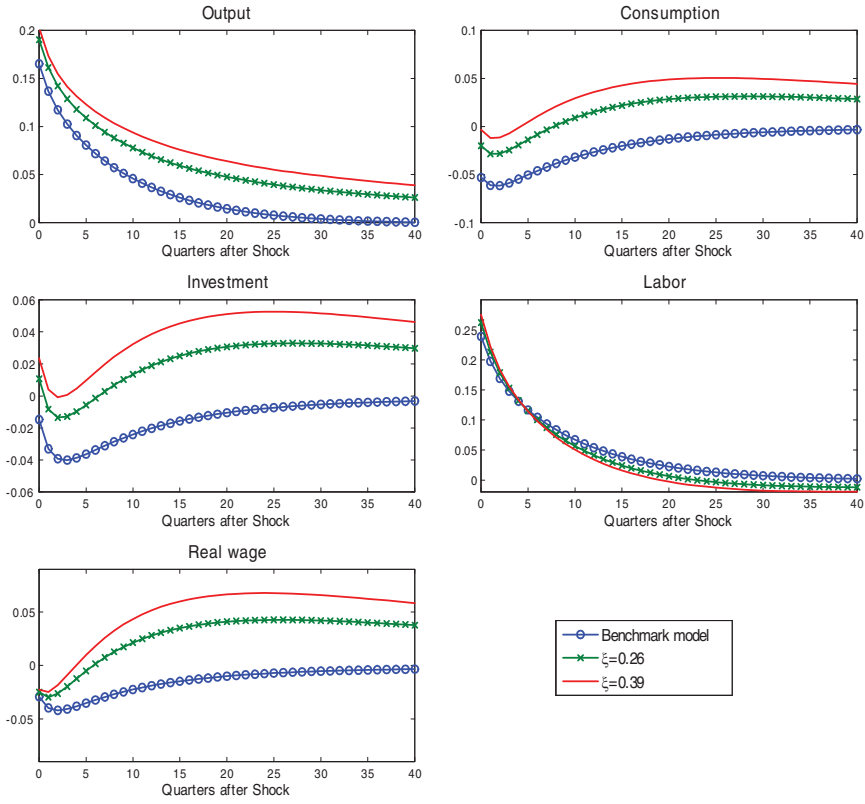

FIGURE 2. Government spending shock: Productive government spending vs. benchmark model.

Figure 3 shows the dynamic reactions of output, consumption, investment, labor, and the real wage to a positive government consumption shock when a relationship of substitutability between private and public consumption is assumed. To isolate the consequences of the assumption, the hypothesis of productive government spending is temporarily dropped. The impulse responses are displayed for $\varrho = 0.23$ and $\varrho = 0.42$, the lowest and highest values taken by the parameter in the empirical study by Aschauer (1985). Output still rises, but the negative effect on consumption is accentuated, whereas the negative effect on investment is lower than in the benchmark model. The relationship of substitutability between private and public consumption implies a larger reduction in private consumption and a smaller increase in labor supply. The effect on inflation is also smaller and, although the central bank increases the interest rate, the effect is smaller than in the benchmark model and the negative impact on investment is reduced.

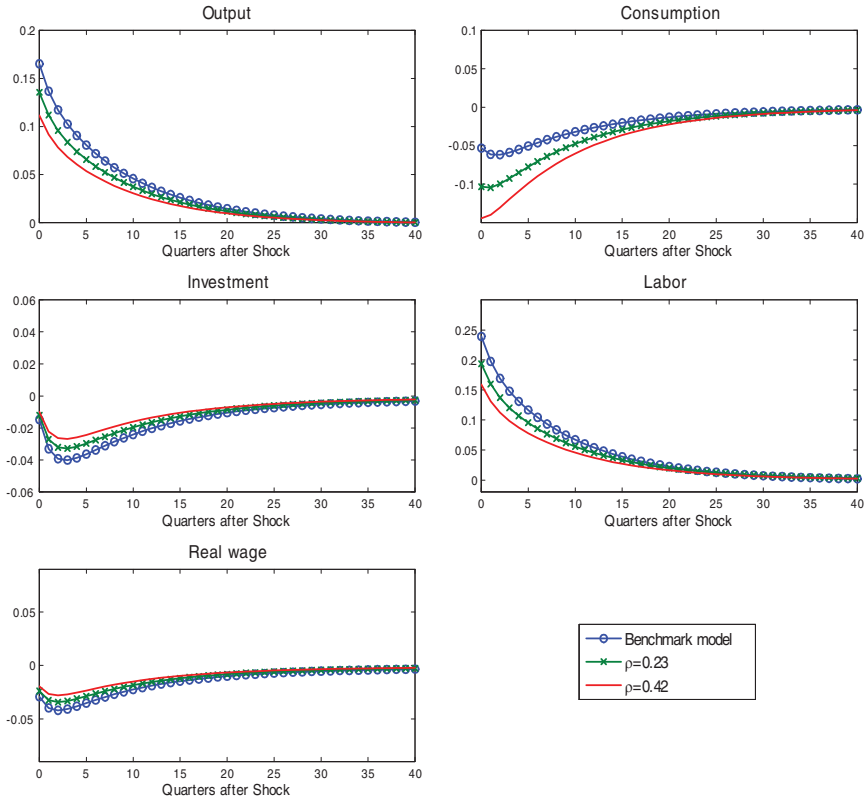

FIGURE 3. Government spending shock: Substitutability vs. benchmark model.

In Figure 4, the effects of a government consumption shock when private and government spending are complementary are shown for some of the values of ϱ found by Karras (1994). For all values of ϱ, the percentage deviation of output from steady state following an increase in government spending is higher than in the absence of complementarity. When the degree of complementarity is high ($\varrho = -1.34$), the positive effect of a fiscal shock on output is more than doubled. The presence of a certain degree of complementarity is also able to offset the negative wealth effect caused by an increase in government spending in the benchmark model, boosting consumption for high negative values of ϱ. The increase in government spending in the presence of complementarity is accompanied by a greater increase in labor supply and inflation than in the benchmark model, which in turn leads to a larger hike in the interest rate and a larger crowding-out effect for investment. The decrease in investment is in fact stronger the higher the degree of complementarity between private and public spending.

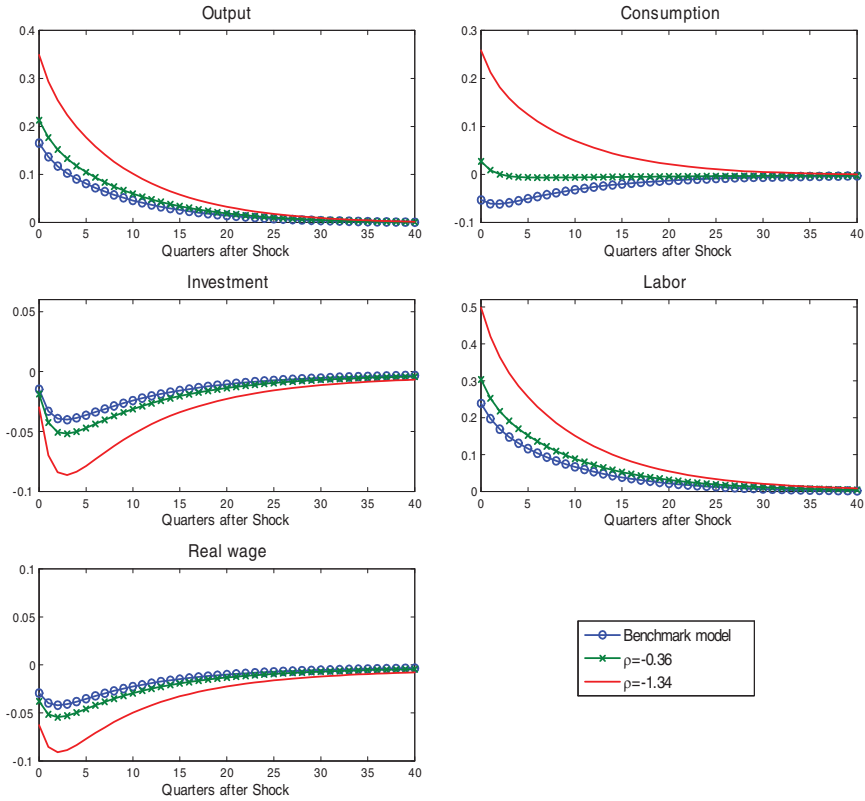

FIGURE 4. Government spending shock: Complementarity vs. benchmark model.

5.3. The Role of the Monetary Policy Rule

The dynamics described in the preceding sections refers to a situation in which the sole purpose of the monetary authority is to control inflation and therefore the interest rate is set without taking account of output fluctuations ($\gamma_y = 0$). However, the choice of the monetary policy rule has important implications for the way the economy reacts to a government spending shock.

Figure 5 illustrates this point, showing the impact response of output, consumption, and investment for $\gamma_y = 0$ and $\gamma_y = 0.25$. Two alternative simulations are considered: the effects of a government investment shock and the effects of a government consumption shock when public capital is highly productive ($\xi = 0.39$) and there is a high degree of complementarity between private and public consumption ($\varrho = -1.34$). For both simulations, the expansionary effect of a positive government spending shock on output is considerably weaker when the central bank reacts to variations in the real economy. In this case, a government investment shock has a relatively strong negative effect on private

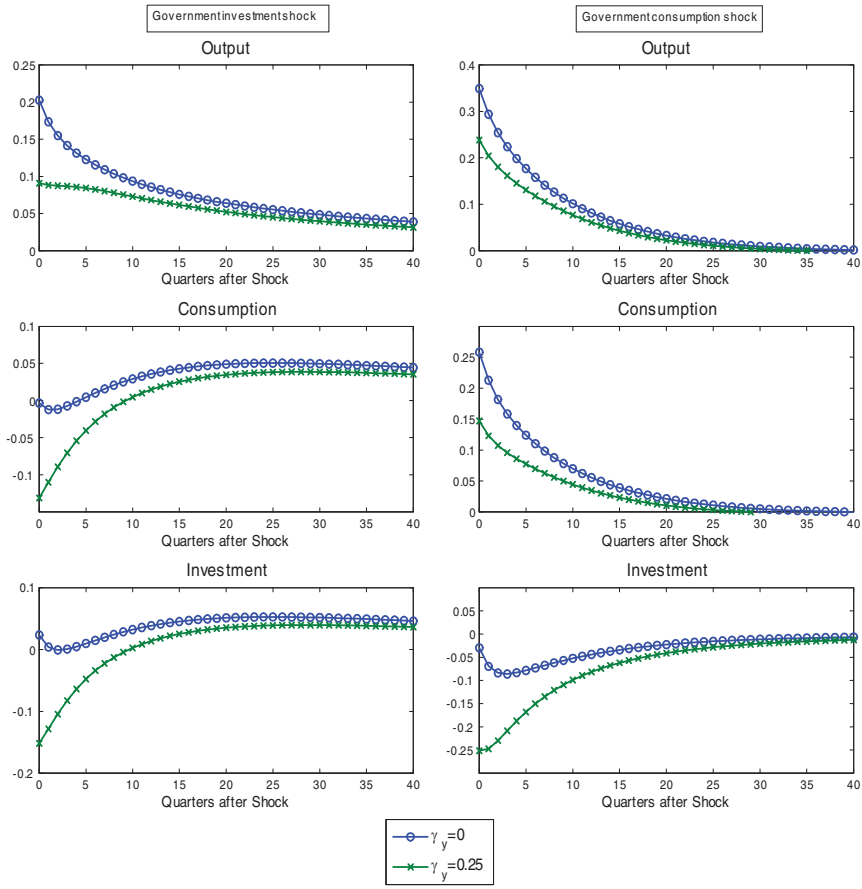

FIGURE 5. Government spending shock: $\gamma_y = 0$ vs. $\gamma_y = 0.25$.

consumption and investment on impact and the subsequent increase in private spending is smaller and takes longer to materialize. However, the impact of a government consumption shock on private consumption when the monetary authority responds to output fluctuations is smaller than when $\gamma_y = 0$, but still positive. Moreover, when $\gamma_y = 0.25$, private investment declines sharply in the short run in response to the government consumption shock. These results show that the positive effect of a government spending shock on private spending when public spending is nonwasteful is partially or fully offset if the central bank aims to control developments in the real economy.

6. CONCLUSIONS

This paper has examined the effects of government spending shocks on the economy, focusing on their impact on private spending, with the aim of developing a

model able to account for recent evidence in favor of a positive effect of increases in public spending on private consumption.

It is found that the introduction of both price and wage rigidities into the model does not substantially change the predicted effects of a fiscal shock from those in a model with flexible prices and wages. An increase in government spending has a positive effect on output and crowds out both private consumption and private investment. However, when public capital is assumed to be productive, government investment shocks are followed by a larger increase in output and the short-run negative effect on consumption and investment is at least partially offset. Moreover, as the stock of public capital accumulates, the positive effect of the shock on private investment and consumption becomes larger. In this case, private consumption and investment are boosted by a positive fiscal shock as a result of the increased productivity of the private factors.

The model also shows that the presence of a degree of complementarity between public and private consumption is capable of offsetting the negative effect of a government spending shock on consumer spending normally observed in RBC and NK models. More precisely, a rise in public spending in the presence of complementarity is followed by an increase in production and private consumption and by a decrease in private investment. It must also be emphasized that the choice of the monetary policy rule is not neutral. If the interest rate responds to variations in output, the expansionary effect of an increase in government spending is considerably reduced.

NOTES

1. See, for example, Baxter and King (1993), Ludvigson (1996), and Edelberg et al. (1999).
2. See also Turnovsky (1997).
3. This paper assumes that public spending affects either productivity or utility. It must be borne in mind, however, that several public goods have a dual nature; i.e., they provide both productivity and utility services to the private sector [see Chatterjee and Ghosh (2011)] and this can partially affect the implications of a government spending shock and in particular the efficacy of alternative modes of financing.
4. See, e.g., Yun (1996) and Erceg et al. (2000).
5. In the Auspitz–Lieben–Edgeworth–Pareto sense; see McCulloch (1977).
6. Wage rigidities are often included in New Keynesian models to improve the performance of the model in response to shocks, in particular the response of real wages [see, for example, Christiano et al. (1999)].
7. See Clarida et al. (2000).
8. Taxes evolve according to the following rule:

$$t_t = \theta_1 \frac{B_{t-1}}{P_t} + \theta_2 g_t,$$

where θ_1 is the fraction of public debt reimbursed every period and θ_2 is the proportion of government spending backed by taxes. Therefore, when $\theta_2 = 1$, public spending is entirely funded by new taxes, whereas if $\theta_2 = 0$, any increase in government purchases is totally deficit-financed. As the parameterization of the fiscal rule is not crucial for the results, for the rest of the paper it is assumed that government spending is fully financed by lump-sum taxes, i.e., $\theta_2 = 1$.

9. Experimenting with different values of interest rate smoothing did not affect the results significantly.

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