Investment and output effects of fiscal consolidations in a new-Keynesian DSGE model for the Euro Area: does composition matter?*

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Abstract

According to the Keynesian theory, fiscal consolidations are expected to generate short-term contractionary effects on output. However, both the theoretical and empirical literature on the fiscal multiplier have been far from consensual. In this paper we develop a new-Keynesian DSGE model in which the fiscal policy block is particularly detailed, in order to shed light on this issue. In addition to several taxes, we distinguish between public employment expenditures and government spending, which, in turn, may have different degrees of productivity. We calibrate the model for the Euro Area and use it to simulate alternative fiscal consolidations with changes in the budget composition. The main conclusions are that: (i) if conducted with a cut in weakly productive spending and a symmetric increase in highly-productive spending, fiscal consolidations may have expansionary effects that are mainly a result of the positive reaction of investment; (ii) if consolidation is pursued through a pure reduction in weakly-productive public employment, the negative effects on output decrease with the degree of labor market competition and turn out to be positive under perfect competition; (iii) the less productive the public expenditure is, and the more competitive the labor market is, the more favorable is the reaction of private investment and the more likely are expansionary effects of fiscal consolidations.

Keywords: fiscal policy, fiscal consolidation, DSGE model

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1 Introduction

After the fiscal profligacy of the 1970s and early 1980s, several OECD governments undertook large fiscal consolidations, aiming at sustainably reducing public deficits and debt. Despite these efforts of some countries, substantial fiscal adjustments cannot be avoided in most OECD countries in coming decades. In particular, the high levels of budget deficits and/or public debts, that resulted from the widespread fiscal stimulus against the 2007/08 financial crisis and the ensuing global depression, combined with the requirements of the Stability and Growth Pact (SGP), are currently requiring the consolidation of public finances in some European countries. Such need is further reinforced by the medium- and long-term spending pressures on public finances, related, inter alia, to population ageing, and the consequent increase in the demand for public spending on health and long-term care.

Fiscal consolidations are usually expected to imply short-term contractionary effects on output, given the Keynesian positive fiscal spending multiplier. However, there is a long standing debate about the macroeconomic effects of fiscal policy, with yet no consensus on the interaction between fiscal policy and short-term output growth.\(^1\)

At a theoretical level, the traditional Keynesian view of a larger than one fiscal multiplier, which was the conventional wisdom both in academic and in policy-making circles until then, has been challenged in the second half of the 1970s. On the one hand, new classical business cycle models, with wage and price flexibility and continuous market clearing, predict that fiscal policy can affect output only temporarily and if economic agents do not anticipate it. On the other hand, new Keynesian models, with intertemporal optimization and rational expectations, market imperfections and wage and price stickiness, raised the possibility of smaller or even negative fiscal multipliers.

At a policy level, the usefulness of fiscal policy for stabilization has been challenged by the environment of high inflation and unemployment, following the expansion of the modern welfare state during the 30 golden years, as budget deficits rose and there was a rapid accumulation of public debt. For the first time in decades there was a conflict between cyclical stabilization and the long-term sustainability of public finances.

At the empirical level, the extensive work on the output effects of fiscal consolidations in the last quarter of a century has failed to provide robust stylized facts on their short-run output effects.

\(^1\)For more detailed surveys of the literature see, for example, Hemming et al. (2002), European Commission (2003) and Briotti (2005).
Regarding spending versus tax multipliers, the literature has typically estimated tax revenue multipliers relatively large and persistent (Blanchard and Perotti (2002), Mountford and Uhlig (2009)) and spending positive but small fiscal multipliers (lower than one on impact and decreasing thereafter). More recently, Perotti (2005), Favero and Giavazzi (2007), Bilbiie et al. (2008) have found that the size of spending fiscal multipliers has fallen gradually after the 1980s.

Regarding the transmission of fiscal policy, while the results on the relation between fiscal policy and private consumption seem uncertain, although predominantly Keynesian (Perotti (1999), Giavazzi et al. (2000), Hogan (2004)), the evidence points to a large and persistent positive reaction of private investment to successful fiscal consolidations, which does not seem possible to justify only by simple textbook crowding-in effects (Blanchard and Perotti (2002), Burnside et al. (2004), Mountford and Uhlig (2009)).

Regarding the size of the fiscal multiplier, the evidence suggests that it is related to a set of critical conditions, namely the size and persistence of the fiscal consolidation, the initial state of public finances and, most especially, its composition in terms of fiscal instruments. With this respect, it is generally found that consolidations based on spending cuts lead to small or even negative fiscal multipliers (the so-called non-Keynesian effects), due to increases in private investment (especially in the case of government wage bills and welfare payments). As they directly affect the labor market, spending cuts induce market adjustments that reduce unit labor costs, increase profits and increase investment growth, with the structure and institutions of the labor market playing an important role in these effects (Alesina and Perotti (1995), Alesina et al. (2002)).

Against this background, this paper asks whether it is possible to conduct fiscal consolidations without relatively high short-term output losses. Or even, as some empirical evidence suggest, to reconcile fiscal consolidations with a short-term output expansion. This paper contributes to the debate by developing a new-Keynesian DSGE model with a fiscal policy block that allows for alternative budget compositions.

The paper is closely related to a recent new generation of new-Keynesian general equilibrium models that include a more developed fiscal policy block (Coenen and Straub (2005), Galí et al. (2007), Coenen et al. (2008)). Following modern sticky-prices new Keynesian DSGE models, as firstly suggested by Smets and Wouters (2003) and Christiano et al. (2005), this paper develops a medium-scale general equilibrium model, with a thorough set of fiscal budget components. We introduce government spending and public employment expenditures as variables with a direct relation with total pri-
vate factor productivity in the intermediate goods sector. Government spending is split into highly-productive, weakly and non-productive spending and public employment expenditure into a strong and a weak productivity component. The productivities of each class of expenditure are calibrated in line with the evidence in related empirical literature.

Motivated by a growing consensus in literature that the success of a fiscal consolidation depends on the "quality" of fiscal adjustments, i.e. on shifts in the budget decreasing less productive forms of expenditure (Romero-Ávila and Strauch (2008)), we simulate several experiments of fiscal consolidations with alternative changes in the budget composition. Studying the problem in the context of such experiments, should allow for a clear understanding of the transmission of the fiscal consolidation, thus solving the limitations of the empirical and historical studies.

Our main results may be summarized as follows: (i) The success – dimension and sustainability – of fiscal consolidations, either via public spending reductions or employment costs reduction, decreases with their degree of productivity; (ii) Consolidations through contractions of weakly-productive or, alternatively, non-productive public spending, generate short-run contractions of output; however, output falls twice as much in the case of weakly-productive spending consolidations, as investment falls, in contrast to what happens in the case of unproductive spending consolidations; (iii) If the consolidation is conducted with a structural change in the fiscal budget in favor of more productive spending – a cut in weakly (or non) productive spending together with a symmetric increase in highly-productive spending – the model predicts a positive short-run impact on output; there is a positive impact on output as long as highly-productive spending increases by 70 percent of the reduction in the weakly-productive spending (or 40 percent of the cut in non-productive spending); (iv) Consolidation through a reduction in weakly-productive public employment yields results similar to those of a reduction in weakly-productive public spending; however the negative effects on output decrease with the degree of labor market competition and can even turn out to be positive in a perfect competition scenario; (v) The less productive is the public expenditure that is cut, and the more competitive the labor market is, the more favorable is the reaction of private investment.

This paper is organized as follows. Section 2 discusses the composition and productivity of public expenditures. Section 3 develops our new-Keynesian DSGE model. Section 4, firstly, analyzes the impact on debt of shocks to each of the different fiscal spending components, in order to verify which may lead to a sizable and sustained fiscal
consolidation; then, it presents and discusses the general equilibrium effects of the fiscal shocks that have been identified as achieving a fiscal consolidation. Section 5 concludes.

2 Composition of Public Expenditure and Macroeconomic Productivity

The main distinctive feature of our analysis of fiscal consolidations is considering changes to the budget composition that impact on overall productivity, in a general equilibrium framework. To motivate our approach, in this section we briefly review the literature on the productivity of public expenditure.

Much of the literature focusing on the effects of fiscal policy treats government spending as consisting entirely of unproductive expenditure on goods, overlooking the productive and employment components of public spending. However, "In practice, government expenditure is on a variety of goods, some of which are intended to enhance the productive capacity in the economy" (Turnovsky (2000), p.255)

Macroeconomists have known for a long time that public spending is an important input in the production of total output, but only recently has this feature of public spending been explicitly modeled. To the best of our knowledge, Ratner (1983) has been the first to suggest an empirical model explicitly adding public spending to the neoclassical production function and to present econometric evidence consistent with that hypothesis. Barro (1990) has introduced government expenditure as an argument in the production function of a theoretical endogenous growth model.

This strand of literature received an important impulse with Aschauer’s (1989a, 1989b, 1990) empirical assessment of the effects of public inputs on output and productivity. Testing the hypothesis that the decrease in productive government services in the United States had been crucial for the productivity slowdown of the early 1970s, Aschauer (1989a) found a strong positive relation between the stock of non-military public structures and equipment and total output, estimating an elasticity of 0.39 for 1949-1985. Such a figure has been considered surprisingly high by several authors, as it implies that public inputs seem more productive than private capital. Aschauer’s controversial results stimulated a large body of empirical research testing their robustness, which has yielded mixed results.²

²For a comprehensive survey on this empirical literature see Gramlich (1994).
The criticism of Aschauer’s analysis has focused essentially on possible econometric problems such as non-stationarities, omitted variables and reverse causation. However, even when these econometric problems have been accounted for, the ambiguity remained, with several studies supporting Aschauer’s hypothesis, but others concluding against it. Subsequently, an alternative approach based on cost and profit functions and using co-integration techniques has delivered results quite in line with Aschauer’s (Berndt and Hansson (1992), Morrison and Schwartz (1996), Abdih and Joutz (2008)).

Overall, it can be argued that public inputs are indeed relevant in the production process – either by directly providing intermediate services to private sector firms, or by complementing private inputs in production – and thus raise marginal productivity of private capital and labor. The controversy lays on the magnitude of the contribution: "Government capital serves as an input into private-sector production, augmenting output and productivity. Here, there is conceptual agreement, but researchers disagree about the magnitudes involved." (Holtz-Eakin, 1993, p. 231).

The literature further suggests that different types of public expenditure have different impacts on the private factors productivity. Public capital stock, and especially non-military "core" infrastructures (highways, airports, electric and gas facilities, water systems, sewers, mass transit), directly raise the productive capacity of private firms, and are the most productive government expenditures. The output elasticity of this type of public capital stock may be higher than 0.3. In fact, several studies have found elasticities in the range 0.3 – 0.4 as, for example, Aschauer (1989a), Garcia-Milà et al. (1996), Fernald (1999) and Abdih and Joutz (2008), with an output elasticity of, respectively, 0.39, 0.37, 0.35 and 0.39.

Other types of government spending, generally seen as comprising a set of non capital expenditures (including, among others, education, health care, entertainment, culture, national defense and environment) provide a lower contribution to private production. While Aschauers’ estimated elasticities are insignificant, Garcia-Milà and McGuire (1992) found a positive correlation between these other types of government spending, especially education, and total output, estimating an elasticity in the range of 0.07 to 0.16 for the US (1969-1983).

Is should be noted that, at an aggregate level, the productive role of public inputs may also be neglected (output elasticity close to zero), as the positive effects from pro-

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3When output growth is high, incomes are rising rapidly and then the government can provide more public goods and services; i.e., the correlation can reflect a demand-side rather then a supply-side causal relationship.
ductive spending may be offset by the negative impact of the allocation of resources to other unproductive government spending, like the regulatory and bureaucratic processes and other current wasteful expenses.

The essence of the results and arguments reviewed in this section is that governments should be able to achieve productivity gains by altering the composition of government spending from weakly to highly productive expenses. Then, a criterious selection of the type of public expenditure cut in fiscal consolidations may minimize the possible negative impact of these cuts on the performance of the economy and may even generate a positive impact, as fiscal consolidation could be reconciled with an increase in global productivity. In the next sections we assess this conjecture. Our analysis will be based on model simulations, developed within a new-Keynesian DSGE model calibrated for the Euro Area, in which we intend to mimic some alternative spending cut fiscal consolidations.

3 The Model

Since the early 1980s, several studies have used dynamic general equilibrium (DSGE) models in order to analyze the macroeconomic effects of fiscal policy. Most of these models were variants of the neoclassical growth model with no market imperfections and have been used to analyze steady-state (or long run) impacts of different fiscal shocks (Barro (1989), Baxter and King (1993)). The last decade has witnessed the development of new-Keynesian DSGE models, built up from explicit microeconomic foundations with inter-temporally optimizing agents but in an environment of nominal rigidities (typically sticky prices). This class of models, which is presently the most-favoured framework for policy analysis, has been extensively used for monetary policy analysis. Yet, the use of new-Keynesian DSGE models for fiscal policy analysis has been far less usual, which explains the typical extreme simplicity of these models in their fiscal policy block. Recently, Smets and Wouters (2003) and Christiano et al. (2005) have developed a new generation of new-Keynesian DSGE models, by incorporating into the standard model various types of nominal and real frictions in an attempt to capture the high degree of persistence characterizing macroeconomic data. Following those works, and given our purposes, we will develop a version of these models that incorporates a further detailed fiscal policy block.

4For details on the standard new-Keynesian DSGE model see, for example, Clarida et al. (1999).
Our baseline model represents a closed economy with identical infinitely lived households, firms, a government and a monetary policy authority. Households form rational expectations and derive their lifetime utility from the consumption of privately produced goods as well as from leisure and use their disposable income to consume, to finance new investments and to purchase government bonds.

The wage dynamics is driven by a monopolistic competitive market, on the assumption that each household provides differentiated labor inputs, thus having some monopoly power over wages, which results in an explicit wage equation and allows for the introduction of sticky nominal wages as in the Calvo model (Calvo (1983)). Following Galí et al. (2007), we introduce, as an alternative specification of the labor market, a perfectly competitive market, with the main objective of comparing the results of the model simulations.

This economy produces a single final good and a continuum of intermediate goods. The final-good sector is perfectly competitive and the final good is used for consumption and investment. There is monopolistic competition in the market for intermediate goods, with firms producing differentiated goods and thus having some monopoly power over prices, with their price-setting following a dynamics a la Calvo. The model assumes that the monetary authority follows a generalized Taylor rule which includes inertia in the form of interest rate smoothing. Further sources of inertia include habit formation in consumption and capital adjustment costs.

As for the government, it purchases final goods from the private sector and finances its spending requirements with lump-sum taxes and with three different types of distortionary taxes, namely over consumption, over labor income and over capital income. The model also incorporates a fiscal rule that guarantees that the debt dynamics is non-explosive.

In this section we contribute to the literature by extending the baseline new-Keynesian DSGE model with a break up of public spending into three types of productive public expenditures: (i) highly productive spending; (ii) weakly productive spending; and (iii) public employment. When thinking of (i), highly productive spending, our first association is with expenditures with public capital; yet, there are items of current public spending that may also increase private factors productivity, like basic education, security and justice, and basic health care.

The introduction of government spending in the production function of the private sector follows the seminal work by Aschauer (1989a) admitting a direct relationship between government spending and the productivity of the private factors. This pro-
ductivity effect, outlined, for example, by Finn (1998), is one channel through which the government can influence the economic activity.

The literature is very scarce as regards inclusion of government expenditures in the production function within new-Keynesian DSGE models. More recently, Pappa (2009) has incorporated both productive government spending and public employment in a new-Keynesian DSGE model. Our exercise differs from hers’ in several respects: first, her model features less sources of nominal and real frictions and is thus less likely to be data-consistent; second, she explicitly identifies productive public spending with public investment; finally, her aim is to study the transmission of fiscal shocks to labor markets and not any fiscal consolidation.

3.1 Households

Households maximize an intertemporal utility function, separable in consumption ($C$) and labor ($l$), over an infinite life horizon. The function is given by:

$$\mathbb{E}_t \sum_{i=0}^{\infty} \beta^i U^\theta_t \left(C^\theta_t, l^\theta_t\right)$$

(1)

where the index $\theta$ represents a continuum of households that differ in that they supply a differentiated type of labor, $\beta$ is the discount factor and $U^\theta_t$ is the following instantaneous utility function:

$$U^\theta_t = e^{\varepsilon^\theta_t} \left[ \frac{1}{1 - \sigma_c} \left( C^\theta_t - H_t \right)^{1 - \sigma_c} - \frac{e^{\varepsilon^N_t}}{1 + \sigma_N} (l^\theta_t)^{1 + \sigma_N} \right].$$

(2)

Utility depends negatively on labor supply, $l^\theta_t$, and positively on consumption, $C^\theta_t$, relative to a time-varying external habit variable, $H_t$, that is assumed to be proportional to aggregate past consumption (habit formation in consumption):

$$H_t = hC_{t-1}.$$

(3)

In equation (2) the parameters $\sigma_c$ and $\sigma_N$ represent, respectively, the coefficient of relative risk aversion of households or the inverse of the intertemporal elasticity of substitution and the inverse of the elasticity of work effort with respect to the real wage.

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5Finn (1998) and Cavallo (2005) explicitly incorporate productive public spending and public employment but in a purely neoclassical DSGE model.
$\varepsilon^b_t$ and $\varepsilon^N_t$ are two preference shocks that affect the intertemporal substitution of households and the labor supply, and that are assumed to follow a first-order autoregressive process with i.i.d.-normal error terms:

$$\varepsilon^b_t = \rho_b \varepsilon^b_{t-1} + \eta^b_t; \quad (4)$$

$$\varepsilon^N_t = \rho_N \varepsilon^N_{t-1} + \eta^N_t. \quad (5)$$

Households face an intertemporal budget constraint given by:

$$Y^\theta_t + \frac{B^\theta_t - b_t B^\theta_{t+1}}{P_t} = (1 + \tau^\theta_t)C^\theta_t + I^\theta_t. \quad (6)$$

This constraint means that current real disposable income, $Y^\theta_t$, and real financial wealth$^6$, which is hold in the form of government bonds $B^\theta_t$, can be used for consumption, $C^\theta_t$, (including consumption taxes $\tau^\theta_t$), and investment in physical capital, $I^\theta_t$. Government bonds are one-period securities with price $b_t$, being $b_t B^\theta_{t+1}$ the current value of future holdings of government bonds$^7$.

Current disposable income, $Y^\theta_t$, consists of the sum of labor income with the return on the real capital stock and the dividends derived from the imperfect competitive intermediate firms, $Div^\theta_t$, deducted from the lump-sum taxes, $T^\theta_t$ and distortionary labor and capital income taxes, $\tau^\theta_n$ and $\tau^\theta_k$:

$$Y^\theta_t = (1 - \tau^\theta_n)w^\theta_t l^\theta_t + (1 - \tau^\theta_k)^tK^\theta_t + \delta \tau^\theta_k K^\theta_t + Div^\theta_t - T^\theta_t \quad (7)$$

where $w^\theta_t$ is the real wage, $r^\theta_k$ the real rental price of capital services and $\delta$ is the depreciation rate. It should be noted that capital income is not fully taxed because allowance is made for depreciation ($\delta$).

**Consumption and savings behavior**

Households maximize their objective function, given by equations (1) and (2), subject to the intertemporal budget constraint, given by equations (6) and (7):

$$\text{MAX } E_t \sum_{t=0}^{\infty} \beta^t \left\{ e^\theta_t \left[ \frac{1}{1 - \sigma_c} (C^\theta_t - H_t)^{1 - \sigma_c} - \frac{e^N_t}{1 + \sigma_N} (I^\theta_t)^{1 + \sigma_N} \right] \right\} \quad (8)$$

$^6$P is the price level.

$^7$As $b_t = \frac{1}{R_t}$, where $R_t$ is the nominal interest rate on bonds, $b_t B^\theta_{t+1} = \frac{P^\theta_{t+1}}{R_t}$. 
subject to,

\[(1 - \tau^t_t)\omega^t_t \theta^t_t + (1 - \tau^k_t)\tau^k_t K^0_t + \delta \tau^k_t K^0_t + Dw^t_t - T^t_t + \frac{B^0_t - b_t B^0_{t+1}}{P_t} = (1 + \tau^c_t) C^0_t + I^0_t. \quad (9)\]

Maximization with respect to consumption and bonds holdings yields the following first-order conditions:

\[\lambda_t = \frac{e^{\epsilon^t_t} (C_t - H_t)^{-\sigma_c}}{1 + \tau^c_t}; \quad (10)\]

\[E_t \left[ -\lambda_t \frac{b_t}{P_t} + \beta \lambda_{t+1} \frac{1}{P_{t+1}} \right] = 0 \implies E_t \left[ \beta \frac{\lambda_{t+1} R_t P_t}{\lambda_t P_{t+1}} \right] = 1 \quad (11)\]

where \(R_t = 1/b_t\) is the gross nominal rate of return on bonds and \(\lambda_t\) is the marginal utility of consumption.

Aggregating equations (10) and (11), and using equation (3) we have:

\[E_t \left[ \beta \frac{e^{\epsilon^t_{t+1}} (C_{t+1} - h C_{t+1})^{-\sigma_c}}{1 + \tau^c_{t+1}} \frac{R_t P_t}{P_{t+1}} \right] = 1. \quad (12)\]

**Investment and capital accumulation**

Households own the capital stock which they rent out to firms at a given rental rate of \(r^k_t\). They decide how much capital to accumulate in each period given the depreciation rate (\(\delta\)) and the costs (\(S(\cdot)\)) of adjusting the capital stock — which, following Smets and Wouters (2003), we model as a positive function of changes in investment,\(^8\)

\[K_t = K_{t-1}(1 - \delta) + \left[ 1 - S \left( \frac{e^{\epsilon^t_{t-1}} I_{t-1}}{I_{t-2}} \right) \right] I_{t-1} \quad (13)\]

where \(\epsilon^t_t\) represents a shock to the investment cost function, which is assumed to follow a first-order autoregressive process with an i.i.d.-normal error term:

\[\epsilon^t_t = \rho_t \epsilon^t_{t-1} + \eta^t_t. \quad (14)\]

Households choose the capital stock and investment in order to maximize their

\(^8\)It is assumed that, in the steady-state, \(S(\cdot)\) equals zero, and the first derivative, \(S'(\cdot)\), also equals zero around the equilibrium.
intertemporal objective function subject to the intertemporal budget constraint, as
described by (8) and (9), as well as subject to the capital accumulation equation (13).

After the maximization, the first-order conditions are the following equations for
the real current value of capital stock \( q_t \) and investment:

\[
q_t = E_t \left[ \beta \frac{\lambda_{t+1}}{\lambda_t} \left[ q_{t+1}(1 - \delta) + (1 - \tau_{t+1}^k) r_{t+1}^k + \delta r_{t+1}^k \right] \right] ; (15)
\]

\[
q_t \left[ 1 - S \left( \frac{e^{\xi I}_t}{I_{t-1}} \right) \right] = q_t S' \left( \frac{e^{\xi I}_t}{I_{t-1}} \right) \frac{e^{\xi I}_t}{I_{t-1}} - E_t \left[ \beta \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} S' \left( \frac{e^{\xi I_{t+1}}}{I_{t+1}} \right) \frac{e^{\xi I_{t+1}}}{I_{t+1}} \right] + 1. (16)
\]

**Labor supply decisions and wage setting**

Each household provides differentiated labor inputs, so that there is some monopoly
power over wages that results in an explicit wage equation. Nominal wages are assumed
to be sticky as in the Calvo model: households are allowed to optimally adjust their wage
each period with a constant probability equal to \( 1 - \xi_w \). Each household reoptimizing
his wage at a given period, will set a new wage \( \bar{w}_t^\theta \), taking into account the probability
that he will not be reoptimizing the wage in the near future. Following Smets and
Wouters (2003), we augment the Calvo model with the assumption that the fraction of
wages not reoptimized in a given period is partially indexed to past inflation:

\[
W_t^\theta = \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} W_{t-1}^\theta (17)
\]

where \( \gamma_w \) is the degree of wage indexation. When \( \gamma_w = 0 \) there is no indexation, and
the wages that cannot be reoptimized remain constant; when \( \gamma_w = 1 \) there is perfect
indexation to past inflation.

Households set their nominal wages in order to maximize their intertemporal objective
function subject to the intertemporal budget constraint, as described by (8) and
(9), as well as subject to the demand for labor, which is:

\[
l_t^\theta = \left( \frac{W_t^\theta}{W_t} \right)^{-\frac{1}{\lambda_{w,t}}} N_t \quad (18)
\]

where \( \lambda_{w,t} \) is a stochastic parameter that determines the time-varying wage markup. It
is assumed that $\lambda_{w,t} = \lambda_w + \eta_{w,t}$, with $\eta_{w,t}$ i.i.d.-normal. The aggregate labor demand, $N_t$, and the aggregate nominal wage, $W_t$, are given by the following Dixit-Stiglitz-type aggregator functions:

$$N_t = \left[ \int_0^1 \left( \frac{\theta}{\lambda_{w,t}} \right)^{1/(1+\lambda_{w,t})} d\theta \right]^{(1+\lambda_{w,t})} (1+\lambda_{w,t})$$

$$W_t = \left[ \int_0^1 (W_t)^{-1/(1+\lambda_{w,t})} d\theta \right]^{-1/(1+\lambda_{w,t})}$$

This maximization problem results in the following markup equation for the reoptimized wage:

$$E_t \sum_{i=0}^{\infty} \beta^i \xi_{w,i}^t N_{t+i}^\theta \left[ \frac{\tilde{w}_t}{P_t} \left( \frac{P_{t+i+1}}{P_{t+1}} \right)^{\gamma_w} \frac{U_{t+i}^C}{(1+\tau_{t+i}^C)} \right] - (1 + \lambda_{w,t+i}) \frac{U_{t+i}^l}{(1 - \tau_{t+i}^l)} = 0$$

where $U_{t+i}^C$ and $U_{t+i}^l$ are, respectively, the marginal utility of consumption and the marginal disutility of labor.

Following the Calvo model, and given equations (17) and (20), the law of motion of the aggregate wage index is given by:

$$(W_t)^{-1/(1+\lambda_{w,t})} = \xi_w \left[ W_{t-1} \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} \left( \frac{P_{t-1}}{P_{t-2}} \right)^{-1/(1+\lambda_{w,t})} \right]^{1/(1+\lambda_{w,t})}$$

**An alternative specification - a perfectly competitive labor market**

This variation to the baseline model could indeed prove to be interesting for the purposes of this paper. In fact, as the review in section 2 has shown, the literature on the short-term effects of fiscal consolidations suggests that an increase in the labor market efficiency and competitiveness may be crucial for the occurrence of a strong increase in private investment, that can lead to lower or even negative fiscal multipliers.

Assuming a perfectly competitive labor market, each household chooses the quantity of hours supplied given the market wage. This is done by maximizing, with respect to labor supply, the intertemporal objective function (8) subject to the intertemporal budget constraint (9). The first-order condition of this maximization yields the following equation for the real wage:
\[ \lambda_t(1 - \tau_t^N)w_t = e^{\varepsilon N} e^{\varepsilon N} N_t^\sigma N. \]  

(23)

Using (10) and rearranging, we obtain

\[ (C_t - hC_{t-1})^{-\sigma c}(1 - \tau_t^N)w_t = e^{\varepsilon N} N_t^\sigma N (1 + \tau_t^c). \]  

(24)

### 3.2 Firms

The model presents a closed economy that produces a single final good and a continuum of intermediate goods indexed by \( j \), with \( j \) distributed over the unit interval \([0, 1]\). The final-good sector is perfectly competitive, and the final good is used for consumption and investment, while there is monopolistic competition in the markets for intermediate goods.

**Final-good sector**

Following Galí et al. (2007), the final good is assumed to be produced using the intermediate goods with the following constant returns technology:

\[ Y_t = \left[ \int_0^1 (y^j_t)^{1 + \varepsilon} y^j_t \right]^{\frac{1}{\varepsilon + 1}} \]  

(25)

where \( y^j_t \) denotes quantity of intermediate good of type \( j \) at date \( t \) and \( \varepsilon \) is the constant elasticity of substitution.

At each period, the competitive final good producer maximizes its profit:

\[ \text{MAX} \left[ P_t Y_t - \int_0^1 p^j_t y^j_t \right] \]  

(26)

where \( P_t \) is the overall price index of the final good and \( p^j_t \) are the prices of the intermediate inputs. From (25) and (26), the demand for each intermediate input and the price index can be shown to be:

\[ y^j_t = \left( \frac{p^j_t}{P_t} \right)^{-\varepsilon} Y_t; \]  

(27)

\[ P_t = \left[ \int_0^1 (p^j_t)^{1-\varepsilon} y^j_t \right]^{\frac{1}{1-\varepsilon}}. \]  

(28)
Intermediate goods sector

In the intermediate goods sector each good \( j \) is produced by a firm \( j \) with the following technology:

\[
y_j^t = \varepsilon_a^t K_{j,t}^\alpha (N_{p,j,t})^{(1-\alpha)} (G_{lp}^t)^\gamma (G_{hp}^t)^\eta (N_{g,t})^\nu. \tag{29}
\]

The production function (29) features constant returns to scale with respect to private inputs, since the output elasticity of capital \((K)\), \(\alpha\) is a constant parameter, which can take values between 0 and 1, and the output elasticity of private employment \((N_{p})\) is \((1-\alpha)\). It differs from the standard production function in that public spending has three components, \(G_{lp}\), \(G_{hp}\) and \(N_{g}\), respectively, low productivity (or unproductive) spending, high productivity spending and public employment. The three types of public expenditures are incorporated in the production function as separate inputs enhancing the productivity of private factors. We assume that these public inputs are freely made available by the government at the beginning of each period.

The parameters \(\gamma\), \(\eta\) and \(\nu\), the output elasticities of each of the components of public spending, determine the interaction between public and private inputs in production. Depending on their value, an increase in government spending or employment has large, small or null effects on output (a value of zero means that the public input is unproductive).

\(\varepsilon_a^t\) is a productivity shock, assumed to follow a first-order autoregressive process with an i.i.d.-normal error term,

\[
\varepsilon_a^t = \rho_a \varepsilon_a^{t-1} + \eta_a^t. \tag{30}
\]

Labor demand by private firms is derived from the firms’ cost minimization for a given installed capital stock and a given stock of public inputs:

\[
\frac{w_t N_{p,j,t}}{r_t^K K_{j,t}} = \frac{1 - \alpha}{\alpha} \iff N_{p,j,t} = \frac{(1 - \alpha)}{\alpha w_t} \frac{r_t^K K_{j,t}}{1 - \alpha}. \tag{31}
\]

\(^9\)In the empirical literature there is no clear preference between constant returns to scale in all inputs or only in the two private inputs. Turnovsky and Fisher (1995, p.753) argue that "(...) our assumption of linear homogeneity in the two private factors views infrastructure as providing economies of scale in production. An alternative assumption discussed by Aschauer (1989) is to assume that the production function is linearly homogeneous in all three factors of production. It turns out that the choice between these two alternative formulations makes little difference, as long as one assumes \(F_{KL}>0\) in this alternative specification."
which implies that the capital-labor ratio will be identical across all intermediate
good producers and equal to the aggregate capital-labor ratio.

The production function implies that the firms’ marginal costs \( MC_t \) are given by,

\[
MC_t = \frac{1}{e^{\varepsilon_t}} w_t^{(1-\alpha)} r_t^{\kappa} (G_t^{dp})^{-\gamma} (G_t^{dp})^{-\eta} (N_t^p)^{-\nu} \left[ \alpha^{-\alpha} (1 - \alpha)^{-(1-\alpha)} \right].
\]  

(32)

which implies that the marginal costs are also independent of the intermediate good
produced. Real profits of firm \( j \) are then given by:

\[
profit_t^j = \left( \frac{p_t^j}{P_t} - MC_t \right) y_t = \left( \frac{p_t^j}{P_t} - MC_t \right) \left( \frac{p_t^j}{P_t} \right)^{-\varepsilon} Y_t.
\]

(33)

**Price setting**

Each firm produces a differentiated intermediate good and thus has some monopoly
power over prices. Nominal prices are sticky, by assumption, and their dynamics is
modelled as in the Calvo model, \( i.e., \) firms are allowed to optimally adjust their prices
each period with a constant probability equal to \( 1 - \xi_p \). In setting the new price, \( \tilde{p}_t^j \),
the reoptimizing firms take into account the probability that it will not reoptimize in
the near future. Following Smets and Wouters (2003), the Calvo model is augmented
with the assumption that prices that are not reoptimized in a given period are partially
indexed to past inflation:

\[
p_t^j = \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} p_t^{j-1}
\]

(34)

where \( \gamma_p \) is the degree of price indexation. When \( \gamma_p = 0 \) there is no indexation, and
the prices that cannot be reoptimized remain constant. When \( \gamma_p = 1 \) there is perfect
indexation to past inflation.

A firm resetting its price in period \( t \) will seek to maximize the discounted sum of
future profits (given by equation (33)), using the relevant stochastic discount factor
\( \Lambda_{t,t+i} \),

\[
\text{MAX}_{\tilde{p}_j^t} \sum_{i=0}^{\infty} \left\{ \xi_p^i \Lambda_{t,t+i} \left[ \left( \frac{\tilde{p}_t^j}{P_{t+i}} - MC_{t+i} \right) y_{t+i} \right] \right\}.
\]

(35)

Given equation (34), profit maximization by the producers that reoptimize their
prices at time $t$ results in the following first-order condition:

$$E_t \sum_{i=0}^{\infty} \left\{ \xi_p^i \Lambda_{t,t+i} \beta^j_{t+i} \left[ \tilde{P}^j_t \left( \frac{P_{t+i}}{P_{t+i-1}} \right)^{\gamma_p} - \mu MC_{t+i} \right] \right\} = 0$$

(36)

which shows that prices are set as a function of current and expected real marginal costs, with a markup $\mu$ over these weighted marginal costs. The gross "frictionless" price markup is,

$$\mu = \frac{\varepsilon}{\varepsilon - 1}$$

(37)

Following the Calvo model, and given equations (28) and (34), the law of motion of the aggregate price index is given by:

$$P_t^{(1-\varepsilon)} = \xi_p \left[ P_{t-1} \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} \right]^{(1-\varepsilon)} + (1 - \xi_p) (\tilde{P}^j_t)^{(1-\varepsilon)}.$$  

(38)

### 3.3 Policy and Market Clearing

**Monetary policy**

The monetary authority sets the nominal interest rate according to a simple rule which includes inertia in the form of interest rate smoothing:

$$R_t = R_{t-1}^\rho \left[ \left( \frac{P_t}{P_{t-1}} \right)^{\Phi_\pi} \right]^{1-\rho}$$

(39)

with $\Phi_\pi > 1$.

Following Galí et al. (2007) and Bilbiie et al. (2008), among others, our monetary policy-maker follows a simple interest rate rule corresponding to a strict inflation targeting regime – a particular case of the well-known Taylor rule, placing a zero coefficient on the output gap. It should be noted that this kind of rule is said to satisfy the Taylor principle if and only if $\Phi_\pi > 1$, which is, in the absence of non-Ricardian consumers, a necessary and sufficient condition to guarantee the uniqueness of equilibrium in this class of models.

We model the monetary policy-maker reacting purely to deviations of inflation from the target, and not to fluctuations in the output gap, for two main reasons. First, as we intend to isolate possible "purely fiscal" effects of a fiscal consolidation, we purposely assume the simplest possible monetary framework; in fact, alternative frameworks in-
cluding output or the output gap in the interest rate rule may suggest lower Keynesian
effects because of the immediate interest rate response to the initial decrease in output.
Second, as we are calibrating the model to the Euro Area case, our policy rule seems
more in line with the legal mandate of the European Central Bank (ECB) – maintaining
price stability in the medium-to-long-run – and is further justified by the apparent lack
of consensus on the relevance of the output gap in the actual preferences and reactions
of the ECB (Aguiar and Martins (2005)).

Fiscal policy

The fiscal authority purchases two types of final goods from the private sector \((G_{lp}^t \text{ and } G_{hp}^t)\), hires labor \((N_g^t)\), finances its spending requirements with lump-sum taxes
\((T_t)\) and distortionary taxes – over consumption \((\tau_c^t)\), labor income \((\tau_n^t)\) and capital
income \((\tau_k^t)\) – and issues debt \((B_{t+1})\), which consists of one-period nominal discounted
bonds, paying 1 unit at the beginning of next period.

Wages are equal in the public and private sector, as we assume that (i) working
hours can be moved costlessly across the two sectors, and (ii) the private and public
labor supply are perfect substitutes, as working for private firms or for the government
brings households exactly the same marginal disutility.\(^{10}\) Thus, the government budget
constraint is given by,

\[
G_{lp}^t + G_{hp}^t + w_t N_g^t + \frac{B_t}{P_t} = T_t + \frac{B_{t+1}}{P_t} b_t + \tau^n_t w_t N_t + \tau_k^t K_t - \delta \tau^k_t K_t + \tau_c^t C_t. \tag{40}
\]

All government spending variables and all tax rates are assumed to evolve exoge-
nously according to a first order autoregressive process with i.i.d.-normal errors,\(^{11}\)

\[
\hat{G}_{lp}^t = \varepsilon_{lp}^t = \rho_{lp} \varepsilon_{lp}^{t-1} + \eta_{lp}^t, \tag{41}
\]

\[
\hat{G}_{hp}^t = \varepsilon_{hp}^t = \rho_{hp} \varepsilon_{hp}^{t-1} + \eta_{hp}^t, \tag{42}
\]

\(^{10}\)Some recent literature shows that there is indeed a significative positive correlation between private
and public sector wages, even though their average levels differs (Afonso and Gomes (2008), Lamo et al.
(2008)).

\(^{11}\)In what follows a variable with a hat denotes its log deviation from its steady-state value, which
is denoted by the – above a variable.
\begin{align}
\hat{N}_t^g = \varepsilon_t^N = \rho_{N^g} \varepsilon_{t-1}^{N^g} + \eta_t^{N^g}. \\
\hat{\tau}_t^c = \rho_{\tau^c} \hat{\tau}_{t-1}^{c} + \eta_t^{\tau^c}, \\
\hat{\tau}_t^n = \rho_{\tau^n} \hat{\tau}_{t-1}^{n} + \eta_t^{\tau^n}, \\
\hat{\tau}_t^k = \rho_{\tau^k} \hat{\tau}_{t-1}^{k} + \eta_t^{\tau^k}.
\end{align}

Following Bilbiie and Straub (2004) and Galí et al. (2007), we assume a fiscal policy rule of the form,
\begin{equation}
\hat{T}_t = \phi_b \hat{B}_t + \phi_g \hat{G}_t
\end{equation}

where $\phi_b$ and $\phi_g$ are positive constants representing the elasticities of lump-sum taxes with respect to government debt and government spending, respectively. Under this fiscal rule, a necessary and sufficient condition for non-explosive debt dynamics is given by,
\begin{equation}
\beta^{-1}(1 - \phi_b) < 1.12
\end{equation}

Market clearing

Finally, the model is closed with two types of aggregate constraints. First, labor supply must equate labor employed by the private firms and by the public sector,
\begin{equation}
N_t = N_t^p + N_t^g.
\end{equation}

Second, aggregate production must equal the demand for goods by the private and public sector, and hence equation,
\begin{equation}
Y_t = C_t + I_t + G_{tp}^p + G_{hp}^p.
\end{equation}

The capital rental market is in equilibrium when the demand for capital by the intermediate goods producers equals the supply by the households, and the labor market is in equilibrium if firms’ demand for labor equals labor supply at the wage level set by

\footnotesize{12For more details see Galí et al. (2007).}
households. Finally, the capital market equilibrium means that the government debt is held by domestic investors at the market interest rate $R_t$.

**The Final Model**

In summary, the baseline model has fifteen equations (fourteen when assuming a perfectly competitive labor market): six for the households’ behavior – (12), (13), (15), (16), (21) and (22) (when assuming a perfectly competitive labor market these last two equations are replaced by (24) –, four for the firms’ behavior – (29), (31), (36) and (38) –, one for the monetary authority’s behavior – (39) –, two for the government’s behavior – (40) and (47) – and two market clearing equations – (49) and (50).

**3.4 Calibration**

In order to solve the model it is necessary to linearize the model’s equations around the nonstochastic steady state and to calibrate the model’s parameters.

After the linearization process (the full set of linear rational expectations equations are presented in appendix A.1) the model has thirteen equations and thirteen endogenous variables: consumption, interest rate, inflation, investment, real current value of capital stock, rental rate of capital, capital stock, real wage, labor demand, private labor demand, output, government bonds and lump-sum taxes. The stochastic behavior of the model is driven by fourteen exogenous shock variables: four shocks arising from technology and preferences ($\varepsilon^b$, $\varepsilon^l$, $\varepsilon^a$ and $\varepsilon^N$ ), three "cost-push" shocks ($\eta^p$, $\eta^q$ and $\eta^w$), a monetary policy shock ($\eta^R$) and six fiscal policy shocks ($\tilde{G}^p_t, \tilde{G}^h_t, \tilde{N}^g_t, \tilde{\tau}^c_t, \tilde{\tau}^p_t$ and $\tilde{\tau}^k_t$).

As for the numerical values assigned to the parameters of the linearized baseline model, each period is assumed to correspond to a quarter. Since our baseline model has been built upon Smets and Wouters (2003), with parameter values estimated for the Euro Area, we closely follow, when possible, their values.

We use Smets and Wouters (2003) values throughout concerning (i) the preferences and technology parameters and (ii) the inertia and price and wage setting parameters:

(i) regarding the preferences and technology parameters, the discount factor ($\beta$) is calibrated to 0.99 implying a annual steady-state real interest rate of 4%; the depreciation rate ($\delta$) is set to 0.025 (10% annual); the capital share ($\alpha$) is equal to 0.3 (which
implies a labor share of 0.7); and the inverse elasticity of substitution ($\sigma_c$) and of work effort ($\sigma_N$) are 1 and 2, respectively;

(ii) as for the inertia and price and wage setting parameters we have calibrated both the degree of price indexation ($\gamma_p$) and the degree of real wage indexation ($\gamma_w$) as 0.75; also the Calvo parameter on prices ($\xi_p$) and the Calvo parameter on wages ($\xi_w$) are both set to 0.75 in the baseline calibration; and the inertia parameters related with investment adjustment costs ($\varphi$) and consumption habit ($h$) are set to 4 and 0.7, respectively.

A difference between our parameter values and those used by Smets and Wouters (2003) concerns the steady-state values of the wage markup ($\lambda_w$) and of the price markup ($\mu$). Smets and Wouters (2003) set those values equal to 1.5, by increasing the values estimated by Griffin (1996) for the United States. Our values are set at, respectively, 1.3 and 1.35, following the values used by Bayoumi et al. (2004) and Jonsson (2007), which have been estimated for the Euro Area.

Another difference regards the baseline policy parameters since, in view of the purposes of the paper, our monetary policy framework has been simplified, while the fiscal policy block is much more detailed. The parameter values are as follows: we set the degree of interest rate smoothing ($\rho$) and the size of the response of the monetary authority to inflation ($\phi_\pi$) equal to, respectively, 0.8 and 1.5, values commonly used in empirical Taylor rules; as regards the parameters describing the fiscal policy rule ($\phi_g$ and $\phi_b$), following Coenen and Straub (2005), we have calibrated both to 0.1, which satisfies the necessary and sufficient condition for non-explosive debt dynamics given by equation (48); the autoregressive parameters of the fiscal policy shocks are set to 0.9, while the autoregressive parameters of all other shocks are set to 0.85.

In what regards the steady-state values, we set the ratios of private consumption and private investment relative to GDP equal to, respectively, 0.6 and 0.2, which corresponds more or less to their average value in the Euro Area over the period 1981Q1:2005Q413. The quarterly value of the ratio of real government debt relative to GDP is set to 2.4, which is in accordance to the Stability and Growth Pact reference value of a government debt ratio parameter of 60% at the annual steady-state. Finally, as regards distortionary taxation, following the average values for Euro Area calculated by Coenen et al. (2007), we set the steady-state values of the consumption tax rate ($\tau_c$) and the labor income

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13European Central Bank’s Area-wide Model database, update 6 (September 2006), which has been originally published in Fagan et al. (2005).
tax rate \((\tau^n)\) equal to a reasonable value of 0.2.\(^{14}\) As for capital income tax rate \((\tau^k)\), we found a widely range of values in the literature, going from 0 (Coenen et al. (2007)) to 40\% (Cavallo (2005)). Hence, we set the steady-state value of capital tax rate in an average value of 20\%.\(^{15}\)

As for the government spending productivity parameters, from the literature reviewed in the last section, we conjecture that a value between 0.15 and 0.2 for the highly productive components of government spending would not risk any overvaluation of the possible productive role of public spending; we have furthermore chosen to be conservative and so we have calibrated parameter \(\eta\) with the value 0.15. As regards the low productivity spending we have calibrated parameter \(\gamma\) with two alternative values (0.05 and 0) and have assessed both parameterizations subsequently. Regarding the public employment parameter \((\nu)\), we have considered it as productive as the high productive government spending (0.15) and as the weakly productive government spending (0.05), in alternative calibrations. These alternative calibrations are also important to test the model’s sensitivity to these central parameters.

Finally, following Cavallo (2005), Ardagna (2007) and Afonso and Gomes (2008), we calibrate the steady-state ratios of private and public employment to total employment as, respectively, 0.84 and 0.16. Following Finn (1998) and Pappa (2009), the steady-state ratios of the low productivity government spending, high productivity government spending and public wage bill to output \((\gamma_{g^l}, \gamma_{g^h} \text{ and } \gamma_{wn})\) are calibrated as, respectively, 0.07, 0.03 and 0.1. This last value is roughly in accordance with the value presented by the European Commission for the European Union for 2007, which was around 11\% (see Afonso and Gomes (2008)).

Table 1 in appendix A.2 summarizes the calibrated values of the parameters of the model.

\(^{14}\)Coenen et al. (2007) found, for Euro Area, average values for consumption and labor income tax rates of, respectively, 18.3\% and 24\%. The labor income tax rate includes social security contributions by employees.

\(^{15}\)We have done some sensitivity tests, and we have found that the results are robust to a reasonable variation in the tax rate values. Hence, the choice of these values does not seem to be relevant, since we obtain very similar results with different calibrations.

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4 Dynamic Effects of Fiscal Consolidations With Changes in the Budget Composition

In this section we inspect the impact of fiscal consolidations, achieved through changes in qualitatively different items of fiscal expenditure, on output. In order to do so, we disaggregate the composition of public spending into three types of productive public expenditures: (i) highly productive spending; (ii) weakly productive spending; and (iii) public employment.

4.1 Fiscal Consolidations

There is a growing consensus in the literature that the success of a fiscal consolidation, i.e. the size and the sustainability (persistence) of debt reduction, clearly depends on the "quality" of fiscal adjustments (von Hagen et al. (2002), Guichard et al. (2007)). "Quality" concerns to the relative contribution of different public budget components, i.e., to the composition of the fiscal adjustment. In the literature, "good quality" fiscal adjustments are defined as those with a strong emphasis on government spending cuts rather than on raising taxes, and particularly on the reduction of current expenditures (public consumption and social transfers) and some politically sensitive items of the budget, such as public employment and public sector wages.

Typically, the association between cuts in politically sensitive expenditures and a higher probability of success of fiscal consolidations is seen as the result of the fact that such cuts signal a stronger commitment to public finances sustainability. In our model there are no comparable credibility effects but rather the general equilibrium effects of fiscal shocks (leading to fiscal consolidation) that have different roles in the production of intermediate goods and income.

We now analyze the impact of shocks to each of the different fiscal components on debt, in order to verify which may lead to a sizable and persistent fiscal consolidation. Our fiscal policy shocks mimic a fiscal consolidation in the sense that they are modelled with high persistence, as AR processes with a root close to 1 (0.9), and are thus expected to have a gradual and persistent impact on public debt. As usual we base the analysis on the inspection of the impulse response functions to the shock.

In figure 1 in appendix A.3 we show the dynamic path of the deviation of the public debt ($\hat{B}_t$) as a result of a unitary shock to government spending, both non-productive and weakly productive. In figure 2 (appendix A.3) we show the path of $\hat{B}_t$ as a response
to a unitary shock to both highly and weakly productive public employment. In both figures we show the results of simulations under the baseline labor market and the alternative perfectly competitive market.

Figures 1 and 2 show results that are in line with the literature: (i) cuts in the less productive government spending and public employment (\(i.e.\) unproductive spending and weakly productive employment) are more likely to generate strong and persistent fiscal consolidations; (ii) cuts in productive public spending, even if weakly productive, generate a rather limited and not sustained response of debt;\(^{16}\) (iii) cuts in highly productive public employment also generate a rather timid and less persistent response of debt and may even induce a medium- to long-term increasing path for debt.

There are two additional results that are worth mentioning. First, as a rule, shocks to all budget spending components generate a larger fiscal consolidation the more competitive is the labor market. This rule knows only one exception: when the fiscal consolidation is achieved through a persistent shock in non-productive government spending, the debt dynamics is independent of the degree of competition in the labor market. Second, fiscal consolidations appear gradually and, in the case of the most effective shocks, take between 40 and 60 quarters to fully develop.

4.2 Government Spending Shocks

In this subsection we present and discuss the general equilibrium effects of the fiscal shocks on types of government spending that have been identified as achieving a fiscal consolidation, in the previous subsection.

Non-productive government spending (negative) shock (\(\gamma=0\))

Figure 3 (appendix A.3) shows the results from a non-productive government spending negative shock. While there is a small increase in private consumption, a marked crowding-in effect on private investment occurs, but is insufficient to offset the direct negative impact of the spending cut on output.

The decrease in non-productive government spending generates a wealth effect which is caused by the decrease in the present value of future taxes. By anticipating the lower

\(^{16}\)We did not consider a fiscal consolidation entirely based on cuts in the highly-productive government spending because, on the one hand, it seems economically unsustainable, from a long-term output growth view, to reduce the most productive expenditures, and, on the other hand, our preliminary results show an rather insignificant short-run impact on debt, followed by an clear medium- to long-run increase in debt path.
tax burden, households increase consumption and leisure, thus reducing labor supply. In an environment of monopolistic competition and sticky prices, there is also a labor demand effect: in response to the decline of aggregate demand, only a few firms are able to lower prices; all other firms necessarily react by lowering production, which leads to a decrease in labor demand. Hence, these two opposite forces that drive a decrease in labor generate a undefined effect on the real wage. Given the real wage stickiness, real wages are not much affected. Our results show that there is a real wage increase, although of a very small magnitude.

Paralleling the wealth effect, there is an intertemporal substitution effect. Given the monetary policy framework, the decrease in prices and inflation leads to a fall in the real interest rate, leading households to anticipate consumption. At the same time, the real interest rate reduction induces an increase in private investment, which is also triggered by the decrease in the marginal productivity of capital (due to the decrease in labor), and consequently on the rental price of capital.

In sum, a cut in non-productive government spending is followed by a rather small increase in private consumption and a relatively strong increase in private investment: the impact on investment is about 5 to 6 times higher than the impact on consumption. Combined with the direct negative effect of the cut in government spending, these impacts on private demand do not hinder a relatively small decrease of output.

These results are generally in line with those obtained by Smets and Wouters (2003), with one major difference: Smets and Wouters (2003) found a strong crowding-in effect on investment (just like us) and also on consumption (the effects on consumption and investment are of similar magnitude). These difference may be explained by two main reasons, related with both our fiscal and monetary policy framework: (i) in order to avoid an explosive path for the public debt, our model includes a fiscal policy rule that generates a decrease in current lump-sum taxes in response to a lower government spending and debt; this decrease in current taxes, induces a lower decrease in future tax burden, and thus reduces the wealth effect; since it is the present value of future taxes that matters for inter-temporally optimizing households (Bilbiie and Straub (2004)), than there is a lower increase in private consumption; (ii) our interest rate rule attaches a zero coefficient to the output gap; therefore there is not an interest rate reaction to the output decrease, which reduces the intertemporal substitution effect.

Hence, the model indicates that there is a positive, although small effect of non-productive government spending on economic activity, because the effects over consumption and investment are insufficient to compensate the direct negative effect of the
cut in public spending.

It should be noted that, results are within the alternative scenario of a perfectly competitive labor market. While the response of private consumption is identical, the crowding-in effect on investment is slightly higher on impact and, thus, the overall impact on output is slightly lower. The main reason for this difference is the decline of the now flexible real wage, that induces a reduction in firms’ marginal costs and, hence, an increase in profits, generating an upward pressure on investment. Within a perfectly competitive labor market, real wages clearly decline upon the impact of the shock, in contrast to what happens in figure 3. Hence, as competition increases in labor market, real wages tend to decrease in response to a government spending reduction. This is a result already documented in the theoretical literature on short-term effects of fiscal consolidations (Alesina and Perotti (1995), Alesina and Perotti (1997), Alesina et al. (2002), Ardagna (2007)). Its main origin is the moderation of wage claims by households (unions) induced by the government spending cut, resulting from the fact that these cuts generate a labor demand reduction and thus increase the probability of unemployment.

**Weakly-productive government spending (negative) shock ($\gamma = 0.05$)**

The reaction of the relevant macroeconomic variables to a weakly-productive government spending shock is quite different (figure 4 in appendix A.3). Although the effect on private consumption remains small (albeit with a different sign), the reduction of public spending crowds-out investment. This leads to a stronger negative impact on output when compared to the shock analyzed in the previous sub-section.

The differences to the case of a shock to non-productive public spending are caused by a direct negative impact of the government spending cut on the productivity of private factors, which generates a negative effect on wealth, that offsets the positive wealth effect that derives from a lower present value of taxes. Hence the strong negative direct impact on capital demand (and so on investment) and on labor demand, and the corresponding fall in wages (relatively small due to the stickiness in wages) and in the rental price of capital.

In the alternative labor market scenario (perfect competition, figures not reported), the main difference concerns a smaller negative impact on investment and, hence, a lower contraction of output. Again, the explanation lies on the higher decline of the

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17 Due to this similarity, we have decided not to present the figures concerning the perfectly competitive labor market. This will also occur in the case of the weakly-productive government spending cut. All these impulse response functions are available on request.
flexible real wage, which induces a reduction in firms’ marginal costs and, hence, an increase in profits, generating an upward pressure on investment.

In sum, comparing the dynamic effects of the non-productive and weakly-productive government spending cuts, follows for three main conclusions: (i) the decrease in output is almost twice as large when government cuts the weakly-productive spending; (ii) the final effect on private consumption is small in both cases, although with a different sign; (iii) the reaction of investment is opposite, as it increases when unproductive government spending is reduced and decreases when the cut is on weakly-productive public spending. Overall, we conclude, on the one hand, that the direct effect of the weakly productive spending shock on the productivity of the private inputs clearly prevails over the indirect effects, pushing down private consumption and, mostly, investment. One the other hand, we conclude that the smaller size and persistence of the fiscal consolidation generated by the weakly-productive government spending cut, induces a lower positive wealth effect and, hence, a smaller crowding-in effect on private consumption and investment.

4.3 Switching government spending productivity

The simulations performed so far with the developed model have focused on the reduction of a single component of government spending. The reductions have, irrespectively of the class of spending cut, generated contractionary fiscal consolidations, i.e., consolidation with no evidence of non-Keynesian expansionary effects. However, it is well known that, in an environment of limited public resources and binding fiscal constraints, fiscal policy makers may redirect spending towards more productive activities. Although this kind of switching can induce, in the short-run, a smaller and less intensive fiscal consolidation, in the medium- to long-run they may generate a stronger and, possibly, more persistent consolidation, due to a positive impact on growth.

We now use our developed model in simulations in which there is a switching from non- or weakly- to highly-productive public spending. Such simulations are, on the one hand, devised to account for realistic features of fiscal consolidations in the real world, when policy makers try to minimize the social costs of consolidations; on the other hand, our simulations will aim at uncovering thresholds for combinations of shocks that may, in our model, generate expansionary effects driven by a strong increase in private investment. Actually, it seems that a fiscal consolidation may be successful and yet generate non-Keynesian effects if the government reduces their non- or weakly-
productive expenses while it increases the highly-productive.

We have performed four different experiments of a switching from low productivity spending to high productivity spending, always with the decrease in the low productivity spending fully compensating the increase in the high productivity spending ($\tilde{G}_t^{lp} = -\tilde{G}_t^{hp}$): (i) $\gamma = 0$ within a perfectly competitive labor market (figure 5 in appendix A.3); (ii) $\gamma = 0$ with monopolistic competition in labor market (figure 6 in appendix A.3); (iii) $\gamma = 0.05$ within a perfectly competitive labor market (figure 7 in appendix A.3); and, (iv) $\gamma = 0.05$ with monopolistic competition in labor market (figure 8 in appendix A.3).

Overall, the main conclusion is that replacing less productive public spending with highly productive spending can generate a decrease in public debt and positive effects on output (i.e., non-Keynesian expansionary effects), driven by a strong increase in private investment. Two notes are in order regarding these results. First, although there is no overall reduction of public expenditures, in all cases the fiscal deficit improves because of the increase in taxes generated by higher output. Second, as before, the main transmission mechanism leading to the non-Keynesian expansionary effects is the wealth effect over investment, crucially associated with the credibility of the consolidation process.

We have further analyzed whether non-Keynesian expansionary effects arise in cases in which the increase in the highly productive government spending is smaller than the decrease in the weakly productive spending. Such combinations would improve the budget balance more rapidly and thus enhance the fiscal consolidation credibility. In particular, we aim at finding the threshold for the percentage of the low productivity spending cut that needs to be compensated by an high productivity spending increase in order to generate non-Keynesian expansionary effects. Four experiments have been made, and results are summarized in table 2 in appendix A.2.

Quantitatively, the results show that, with our developed model and our calibration, short-term expansionary effects appear when the highly productive spending is increased by about 40% of the reduction in the non-productive spending and 70% of the reduction in the weakly-productive spending. Hence, if the government reduces the non-productive (weakly-productive) spending by 10% of its steady-state level, he should increase the highly productive spending by about 4% (7%) of its steady-state level. These values are rather similar in the two analyzed scenarios (perfectly competi-
4.4 Public Employment Shocks

In this subsection, we report the main results of simulating a negative shock to public employment, which can be thought of as a reduction in the number of public employees and/or in public wages. As we have seen in subsection 4.1, a cut in the highly productive public employment only generates a fiscal consolidation in the perfect competition labor market scenario (figure 2 in appendix A.3). That consolidation is, yet, rather small and unsustained. Hence, we will only analyze the case of a consolidation via a reduction of the weakly-productive government employment.\footnote{The thresholds presented allow for visible non-Keynesian expansionary effects. Some inferior values may also allow for medium-term expansionary effects, but with a negative short-run impact on output.}

The results concerning the monopolistic competition scenario are qualitatively similar to the results obtained with the weakly-productive government spending cut (figure 9 in appendix A.3). The reduction in public employment generates two contradictory wealth effects: on the one hand, the decrease in public spending increases wealth by decreasing the present expected value of the tax burden, generating an upward pressure on both private consumption and investment; on the other hand, the direct negative impact on private factors productivity induces a negative effect on wealth, leading to a decrease in investment and, though to a lesser extent, in consumption. Since the direct effect is stronger, the final result is a small decline in private consumption and a strong contraction of investment, inducing a contractionary effect on output.

In contrast, in a version of our model with perfect competition in the labor market, results differ substantially (figure 10 in appendix A.3). There is now clear evidence of non-Keynesian expansionary effects, driven by an increase in private investment. The strong crowding-out effect on investment in the monopolistic competition scenario, becomes a strong crowding-in effect in the perfect competition scenario.

This can be explained essentially by two reasons.

First, the reduction in public employment tends to put a marked downward pressure on real wages via two mechanisms: (i) the negative impact on private factors productivity tends to generate a decrease in labor demand and, hence, in wages; (ii) lower public employment decreases the probability of being employed in the public sector, inducing a lower reservation utility for private sector workers and, hence, lower pressure on wage

\footnote{These simulations are available upon request.}
bargaining. Following these dynamics, the decline in real wages is now visibly larger in a flexible labor market: the impact decrease in real wages is more than three times that of the monopolistic competition. Lower real wage means lower marginal costs, higher profits and, hence, higher investment.

Second, the fiscal consolidation tends to be stronger and more persistent in the perfect competition scenario (figure 2), which tends to generate a larger positive effect on wealth, and thus an upward pressure on private investment.

In sum, these results suggest that a contraction of (weakly-productive) public employment may induce a fiscal consolidation and promote non-Keynesian expansionary effects, provided that the labor market features a high degree of competition. Hence, the advantages of combining fiscal policy consolidations with some structural reforms in the labor market.

5 Summary and Final Remarks

This paper has developed a medium-scale new-Keynesian general equilibrium model, with a thorough set of fiscal budget components, which was calibrated for the Euro Area. Following a growing consensus in literature that the success and the short-term effects of a fiscal consolidation depends the budget composition, we had simulated several policy experiments of fiscal consolidations, allowing for the change in the budget composition during the fiscal adjustment.

In order to motivate the paper, we firstly reviewed the theoretical and empirical literature that considers how and which items of government expenditure may be directly related to total factor productivity; and secondly tried to ascertain literature studying how cuts in those items of expenditure could generate different patterns of fiscal consolidation and of the dynamic response of the main macroeconomic variables.

This paper then contributes to the literature by incorporating into the standard new-Keynesian DSGE model some classes of public expenditure. Specifically, the standard model has been enhanced with the introduction of government spending and public employment expenditures as variables with a direct relation with total private factor productivity in the intermediate goods sector. Such relation has been allowed to be important or unimportant, as public spending has been split into highly-productive and weakly or non-productive spending, and public employment has been alternatively calibrated with a strong and a weak productivity effect. The production elasticity
of each class of public spending and employment have been calibrated according to evidence in the literature.

Our analysis has been laid down in successive steps, all replicated, as a rule, for models with monopolistic and, alternatively, perfect competition in the labor market.

First, we have assessed the ability of cuts in public spending and employment, for a realistic range of their impact on productivity, to generate fiscal consolidations – \textit{i.e.} sizeable and sustained deviations from the debt-ratio from its starting level.

Second, we have studied the general equilibrium effects of fiscal consolidations based on the reduction of weakly-productive and non-productive spending; and further studied consolidations based on the switching from less to more productive public spending.

Third, we have studied the general equilibrium effects of fiscal consolidations based on the reduction of weakly-productive public employment.

The main conclusions are the following.

The success – dimension and sustainability – of fiscal consolidations, either via public spending reductions or employment costs reduction, decreases with the degree of their productivity.

So long as consolidation involves the contraction of expenditures with some productivity, its success increases with the degree of competition in the labor market.

Consolidations through pure contractions of weakly-productive or, alternatively, non-productive public spending, generate short-run contractions of output and as such do not generate non-Keynesian effects. However, the effects on investment are opposite in these alternative routes for consolidation. Cuts in unproductive spending generate the wealth effect associated to the fall in the discounted value of future taxes and a fall in the price of capital that visibly stimulate investment in the short-run, albeit by less than would be necessary to compensate the negative impact of the reduction in public demand. Cuts in weakly-productive spending generate a negative wealth effect due to the reduction of overall productivity that surpass the standard wealth effect associated to the fall in future taxes (which is, by itself, smaller as the consolidation is weaker); as a result, investment crowds-out and output falls twice as much as does in the case of unproductive spending consolidations.

If the consolidation is conducted simultaneously with a structural change in the fiscal budget in favor of more productive spending – a cut in weakly (or non) productive spending together with a symmetric increase in highly-productive spending – then our model predicts the existence of non-Keynesian expansionary effects. The spending switch generates the standard wealth effect associated to expected future taxes as well
as a direct increase in productivity, which both stimulate investment (and, although
to a lesser extent, consumption) and create a net short-run increase of output. This
increase expands taxes and triggers an improvement in the fiscal deficit and a sustained
decrease in public debt. The non-Keynesian expansionary effects are larger when the
labor market features monopolistic competition, because the increase in labor demand
due to the rise in productivity leads to a smaller rise in the real wage than in a perfectly
competitive market, and thus to a larger net increase in profits and investment. A
thorough sensitivity analysis has allowed the detection of thresholds for the spending
switch: fiscal consolidation and non-Keynesian effects exist as long as highly-productive
spending increases by 70 percent of the reduction in the weakly-productive spending
(or 40 percent of the cut in non-productive spending).

Consolidation through a reduction in weakly-productive public employment (cuts in
highly-productive employment have been disregarded, as the model does not predict
a proper consolidation in such case) yields results similar to those of a reduction in
weakly-productive public spending in our baseline model. Actually, output falls more
markedly in this case because the increase in inflation triggers an increase in the interest
rate that further depresses investment. However, in a version of the model with perfect
competition in the labor market, such a route for consolidation does generate some
short-run increase in output, as a large positive reaction of investment arises. The
change in the behavior of investment and in the overall dynamics is associated to a
larger fall in real wages: in a perfect competition labor market, the fall in the demand
for labor by the government decreases real wages throughout the market, reducing
marginal costs, increasing profits and consequently private investment. Additionally,
the consolidation develops quicker and the wealth effect further stimulates investment.
Appendix

A.1 The Linearized Model

In this appendix we present the full set of linear rational expectations equations. In what follows a variable with a hat denotes its log deviation from steady-state. The full linearization process is available upon request.

Consumption equation

The consumption equation results from the linearization of equation (12):

$$
\hat{C}_t = \frac{1}{1 + h} E_t \hat{C}_{t+1} + \frac{h}{1 + h} \hat{C}_{t-1} - \frac{1 - h}{\sigma_c(1 + h)} \left( \hat{R}_t - E_t \hat{\pi}_{t+1} \right) \\
- \frac{(1 - h) \tau_c (1 - \rho_{\tau_c})}{\sigma_c(1 + h)(1 + \tau_c)} \hat{\varepsilon}_t - \frac{(1 - h)(1 - \rho_{\tau_c})}{\sigma_c(1 + h)} \hat{\varepsilon}_t.
$$

(51)

Thus, current consumption depends (i) positively on a weighted average of past and expected future consumption, with the corresponding elasticity depending on the habit persistence parameter \( h \); and (ii) negatively on the ex-ante real interest rate, with the interest rate elasticity of consumption depending on the habit persistence parameter and on the inverse of the intertemporal elasticity of substitution \( \sigma_c \). Preferences shocks have also a positive impact on current consumption and, as expected, the consumption tax shock has a negative impact.

Investment equation

The investment equation results from the linearization of equation (16):

$$
\hat{I}_t = \frac{1}{1 + \beta} \hat{I}_{t-1} + \frac{\beta}{1 + \beta} E_t \hat{I}_{t+1} + \frac{\varphi}{(1 + \beta)} \hat{q}_t - \frac{(1 - \beta \rho_I)}{1 + \beta} \hat{\varepsilon}_t^I.
$$

(52)

where \( \varphi = 1/S''(\tau) \).

Thus, current investment depends positively (i) on past and expected future investment, with elasticities that depend on the rate of time preference \( \beta \), and (ii) on the value of installed capital, with an elasticity that is a function of \( \beta \) and \( \varphi \), a parameter summarizing the investment adjustment costs. A positive shock to the adjustment cost function temporarily reduces investment.
Value of capital stock equation

The value of capital stock equation results from the linearization of equation (15):

\[
\hat{q}_t = \beta(1 - \delta)E_t\hat{q}_{t+1} - \left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) + \beta(1 - \tilde{\pi}^k)E_t\hat{r}_{t+1}^k + \rho_{\tau^k}(\delta - \beta\tilde{\pi}^k)\hat{r}_t^k + \eta_t^q, \tag{53}
\]

It is easy to conclude that, around the steady-state,

\[
\tilde{\pi}^k = \frac{\frac{1}{\beta} - \delta\tilde{\pi}^k + \delta - 1}{1 - \tilde{\pi}^k}. \tag{54}
\]

Thus, the current value of the capital stock depends positively on its expected future value and on the expected rental rate, and negatively on the ex-ante real interest rate. As expected, it depends negatively on the capital income tax rate as \((\delta - \beta\tilde{\pi}^k)\) is always negative.\(^{20}\) In equation (53) we have considered an equity premium shock \((\eta_t^q)\) that affects positively the value of installed capital, which is meant to capture changes in the cost of capital that may be due to stochastic variations in the external finance premium, and is assumed to follow an i.i.d.-normal process.

Capital accumulation equation

The capital accumulation equation results from the linearization of equation (13):

\[
\hat{K}_t = (1 - \delta)\hat{K}_{t-1} + \frac{T}{K}\hat{l}_{t-1} \Leftrightarrow \hat{K}_t = (1 - \delta)\hat{K}_{t-1} + \delta\hat{l}_{t-1}. \tag{55}
\]

Inflation equation

The inflation equation derives from the linearization and aggregation of equations (36) and (38):

\[
\hat{\pi}_t = \frac{\gamma_p}{1 + \beta\gamma_p}\hat{\pi}_{t-1} + \frac{\beta}{1 + \beta\gamma_p}E_t\hat{\pi}_{t+1} + \frac{(1 - \beta\xi_p)(1 - \xi_p)}{(1 + \beta\gamma_p)\xi_p} \times \left[ (1 - \alpha)\hat{w}_t + \alpha\hat{r}_t^k - \gamma\hat{G}_t^{hp} - \eta\hat{G}_t^{hp} - \nu\hat{N}_t^{g} - \varepsilon_t^a \right] + \eta_t^p, \tag{56}
\]

\(^{20}\)It can be easily be proven that, \((\delta - \beta\tilde{\pi}^k) = \frac{(1 - \beta)[\delta(1 - \tilde{\pi}^k) - 1]}{1 - \tilde{\pi}^k} < 0.\)
Current inflation depends positively on past and expected future inflation and on current real marginal costs, which are a positive function of real wages and the rental cost of capital. The elasticity with respect to changes in past inflation is essentially dependent on the degree of price indexation \( (\gamma_p) \) while the elasticity with respect to changes in marginal costs depends crucially on the degree of price stickiness \( (\xi_p) \). The productivity process \( (\varepsilon_\alpha t) \) impacts negatively on inflation. There is also a negative impact on inflation from the government spending processes \( (\hat{G}_t^p, \eta \hat{G}_t^{hp}, \hat{N}_t^p) \) due to the enhancing of the productivity of private factors. Following Smets and Wouters (2003), we have introduced a "cost push" shock \( (\eta_p t) \) in the inflation equation (56), which affects positively the price markup, and thus inflation. This shock is assumed to follow an i.i.d.-normal process.

**Real wage equation**

The real wage equation derives from the linearization and aggregation of equations (21) and (22):

\[
\hat{w}_t = \frac{\beta}{1 + \beta} E_t \hat{w}_{t+1} + \frac{1}{1 + \beta} \hat{w}_{t-1} + \frac{\beta}{1 + \beta} E_t \hat{\pi}_{t+1} - \frac{1 + \beta \gamma_w \hat{\pi}_t}{1 + \beta} \\
+ \frac{\gamma_w}{1 + \beta} \hat{\pi}_{t-1} - \frac{(1 - \beta \xi_w)(1 - \xi_w)}{(1 + \beta) \xi_w \left(1 + \frac{(1 + \lambda_w) \sigma_N}{\lambda_w}\right)} \times \\
\times \left[ \hat{w}_t - \sigma_N \hat{N}_t - \frac{\sigma_c}{1 - h} (\hat{C}_t - h \hat{C}_{t-1}) - \frac{\pi^c}{1 + \pi^c} \hat{\tau}_t - \frac{\pi^N}{1 - \pi^N} \hat{\tau}_t - \hat{\pi}_t \right] + \eta_w t.
\]

The real wage is (i) positively related to past and future expected real wage, past and future expected inflation, labor demand, current consumption and tax rates (consumption and labor income); and (ii) negatively related to current inflation and past consumption. The elasticities of real wage with respect to inflation are dependent on the degree of indexation of the non-optimized wages \( (\gamma_w) \). In turn, the elasticities with respect to labor demand and consumption are intrinsically related to the degree of wage stickiness \( (\xi_w) \). There is also a positive effect on the current real wage from a labor supply preference shock \( (\hat{\xi}_N^{w}) \). We have introduced a shock to the wage markup \( (\eta_w^w) \) that affects positively the real wage, which is assumed to follow an i.i.d.-normal process.

**Alternative real wage equation - perfectly competitive labor market**
An alternative real wage equation is derived from the linearization of equation (24):

$$\hat{w}_t = \sigma_N \hat{N}_t + \frac{\sigma_c}{1 - h} (\hat{C}_t - h \hat{C}_{t-1}) + \frac{\tau^c}{1 + \tau^c} \hat{\tau}_t^c + \frac{\tau^n}{1 - \tau^n} \hat{\tau}_t^n + \varepsilon_t^N. \quad (58)$$

The real wage is (i) positively related to the quantity of labor, current consumption and tax rates (consumption and labor income); and (ii) negatively related to past consumption. There is also a positive effect on the current real wage from a labor supply preference shock ($\varepsilon_t^N$).

**Labor demand function**

The labor demand function results from the linearization of equation (31):

$$\hat{N}_t = -\hat{w}_t + \hat{\tau}_t^k + \hat{K}_t, \quad (59)$$

Labor demand depends negatively on the real wage, with a unit elasticity, and positively on the real rental price of capital and on the capital stock.

**Production function**

The production function is deduced from the linearization of equation (29):

$$\hat{Y}_t = \varepsilon_t^a + \alpha \hat{K}_t + (1 - \alpha) \hat{N}_t^p + \gamma \hat{G}_t^{hp} + \eta \hat{G}_t^{hp} + \nu \hat{N}_t^g, \quad (60)$$

**Monetary policy rule**

The model assumes that the monetary authority follows a simple interest rate rule as expressed by equation (39). If we linearize that equation around the steady-state we get:

$$\hat{R}_t = \rho \hat{R}_{t-1} + (1 - \rho) \phi_x \hat{\pi}_t + \eta_t^R. \quad (61)$$

The interest rate reacts to current inflation but exhibits persistence, with a degree of smoothing $\rho$. It is also assumed that there is a monetary policy shock which is a temporary i.i.d. normal interest rate shock ($\eta_t^R$).

**Government budget constraint and fiscal policy rule**

Linearization of the government budget constraint (equation (40)) around a steady-state yields:
\[
\hat{B}_t = \frac{1}{\beta} \hat{B}_{t-1} + \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} \hat{G}^t + \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} \hat{G}^t - \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} \hat{T}_t + \hat{R}_t - \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} (\hat{\tau}_t^p + \hat{N}_t) - \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} \hat{\tau}_t^k + \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} (\delta - \tau^k) (\hat{\tau}_t^k + \hat{K}_t) - \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} (\hat{\tau}_t^c + \hat{C}_t) + \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} \hat{N}_t^g + \frac{1}{\beta} \frac{\gamma\gamma}{\gamma_b} \hat{N}_t^g \]

where, $\gamma_{g\gamma} = \frac{\gamma}{\gamma_b}$, $\gamma_{g\gamma'} = \frac{\gamma_{g\gamma'}}{\gamma_b}$, $\gamma_t = \frac{\gamma}{\gamma_b}$, $\gamma_b = \frac{\gamma}{\gamma_b}$, $\gamma_{wn} = \frac{\gamma_{wn}}{\gamma_b}$, $\gamma_{k} = \frac{\gamma_{k}}{\gamma_b}$, $\gamma_{c} = \frac{\gamma_{c}}{\gamma_b}$ and $\gamma_{wn}^g = \frac{\gamma_{wn}^g}{\gamma_b}$.

As expected, debt depends positively on government spending and on the debt service (past debt and real interest rate), and negatively on taxes.

As regards fiscal policy, recall that we have allowed a fiscal policy rule of the form,

\[
\hat{T}_t = \phi_t \hat{B}_t + \phi_g \hat{G}_t.
\]

**Market clearing conditions**

The goods market equilibrium condition results from the linearization of equation (50):

\[
\hat{Y}_t = \gamma_c \hat{C}_t + \delta \gamma_k \hat{T}_t + \gamma_{g\gamma} \hat{G}^t + \gamma_{g\gamma'} \hat{G}^t,
\]

Finally, from the linearization of equation (49):

\[
\hat{N}_t = \theta_{n,p} \hat{N}_t^p + \theta_{n,g} \hat{N}_t^g
\]

where, $\theta_{n,p} = \frac{\gamma}{\gamma_b}$ and $\theta_{n,g} = \frac{\gamma}{\gamma_b}$, are the steady-state ratios of private and public employment to total employment.
A.2 Tables

Table 1 - Parameters values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor - $\beta$</td>
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<td>Consumption habit - $h$</td>
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<td>Calvo's parameter on prices - $\xi_p$</td>
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<td>Elasticity of taxes to debt - $\phi_b$</td>
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Table 2 - Thresholds for spending switching

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<th>weakly-productive spending</th>
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<tr>
<td>monopolistic competition</td>
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<td>0.65</td>
</tr>
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</table>
A.3 Figures

**FIGURE 1 - Impact of government spending cut on debt**

**FIGURE 2 - Impact of public employment reduction on debt**
FIGURE 3 - Non-productive government spending
(monopolistic competition in labor market)
FIGURE 4 - Weakly-productive government spending
(monopolistic competition in labor market)
FIGURE 5 - Switching from non-productive to highly productive spending  
(perfectly competitive labor market)

FIGURE 6 - Switching from non-productive to highly productive spending  
(monopolistic competition in labor market)
FIGURE 7 - Switching from weakly-productive to highly productive spending
(perfectly competitive labor market)

FIGURE 8 - Switching from weakly-productive to highly productive spending
(monopolistic competition in labor market)
FIGURE 9 - Weakly-productive public employment
(monopolistic competition in labor market)
FIGURE 10 - Weakly-productive public employment
(perfectly competitive labor market)
References


