Macroeconomic Effects of Fiscal Consolidation: 
A General Equilibrium Approach.

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Abstract
In contrast to many (partial) econometric studies, only a few papers have analyzed the effects of fiscal consolidation within a general equilibrium model. This paper uses a computable overlapping-generations model to analyze how different fiscal consolidation policies contribute to public debt reduction, taking into account these policies’ influence on the employment rate of different age groups, the schooling decision of young people, and aggregate per capita output and growth. We model eight different consolidation scenarios; three of them resort to capital, labor or consumption tax hikes, while the other implement cuts in different public expenditures (wage consumption, nonwage consumption, non-employment benefits, and investment and education expenditures). We contribute to the literature in two important ways: (i) we endogenously explain individual decisions of time allocation between education, working and leisure and (ii) we model two ability groups. The first extension is crucial given the importance of education for growth (and of growth for a reduction of the debt ratio). The second extension allows to assess the (possibly different) impact of fiscal tightening on welfare of low- and high-skilled individuals.

Our simulations show that consolidation is most harmful for medium-run output when it resorts to hikes in the labor or capital tax or when efficiently used public employment is reduced. Lowering non-employment benefits, on the other hand, has the opposite effects. In the long run, per capita growth benefits more from fiscal consolidation when budgetary savings are used to increase productive expenditures; labor supply increases most when labor taxes are reduced. Higher public employment also stimulates growth and labor supply. Our results underscore the importance of modeling the individual’s education decision; something which is often neglected in this literature. Finally, our model confirms earlier findings that inter- rather than intra-generational equity is most likely to pose the greatest obstacle to fiscal tightening.

Key words: employment by age, endogenous growth, fiscal consolidation, overlapping generations

JEL Classification: E62, H63, J22, 041

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1. Introduction

In the aftermath of the financial crisis of 2008, automatic fiscal stabilization and massive fiscal stimulus plans in many European economies have led to drastic increases in public debt-to-GDP ratio’s. As concerns over fiscal sustainability are at the forefront of current debates, fiscal consolidation has become of paramount importance for many European countries. Moreover, the fiscal pressure coming from health and pension costs will imply an explosion of public debt if policy remains unchanged. A large literature acknowledges the magnitude of the challenge and provides estimates of the required adjustments (see e.g. IMF, 2010). We contribute to this debate by simulating the medium- and long-run macroeconomic and welfare effects of different fiscal consolidation scenarios for Europe.

Many countries have gained experience with fiscal consolidation programmes in the past two or three decades. Analysis of the determinants of the success or failure of fiscal consolidation has also been high on the agenda of many researchers since seminal work by Giavazzi and Pagano (1990) and Alesina and Perotti (1995). The range of existing empirical studies is extremely wide. Whereas some studies focus on individual countries or fiscal episodes, most studies have a cross-country or panel setup. As dependent variable, many studies try to explain the probability of success in debt or deficit reduction. Others focus on the evolution of economic growth, private consumption, or private investment during and after consolidation periods. Still others directly study the evolution of fiscal deficits. Explanatory variables may relate narrowly to the characteristics of the consolidation programme, e.g. its composition or size, the economic context within which consolidation takes place, or the institutional environment within which it takes place. As to institutions, some studies focus on fiscal institutions, others on labor and product market institutions, still others on the ideology of ruling political parties. A large deal of the empirical literature has investigated the possibility of short-run expansionary influences of fiscal consolidations on consumption and/or output. They are based on theoretical arguments explaining non-Keynesian effects of fiscal policy. In a companion paper (Heylen, Hoebeeck and Buyse, 2011), we give an overview of many of these econometric studies.

In contrast to the empirical literature, however, the current paper is more related to studies of the general equilibrium effects of fiscal tightening. The range of studies with this focus is much smaller. Most research in this context makes use of stochastic non-Keynesian models which are orientated towards the short- to medium-run. By contrast, our goal is to shed light on the medium- to long-run effects of fiscal consolidation. In this sense, we model a perfectly competitive economy without frictions, neither on the labor market nor on the product market. We model this economy in an overlapping generations context. The use of overlapping generations models to study debt is interesting, as it breaks down the Ricardian equivalence of public debt. Diamond (1965) was one of the first to analyze the effects of an increase in public debt on the long-run economy. Many have followed his lead. Here, we mention only a few papers, without the goal of providing an exhaustive list.

Many recent studies have argued that fiscal consolidation can imply significant positive long-run effects on the macro economy (e.g. Coenen et. al., 2008a-b; Checherita and Rother, 2010 and Kumar and Woo, 2010). Coenen et. al. (2008b) show that fiscal consolidation may have positive long-run impacts on key
macroeconomic aggregates, in particular when the improved budgetary position is used to cut distortionary taxes. Unfortunately, most studies of fiscal tightening in general equilibrium have the tendency to neglect either the effects on labor supply or on tertiary education. Cournède and Gonand (2006), for instance, develop a model with many similarities as ours (e.g. an extended public finance block, endogeneity of labor supply) but they neglect the education decision and hence long-run growth. Forni et. al. (2010) analyze the macroeconomic implications of permanently reducing the public debt-to-GDP ratio in a perfect-foresight economy using a two-region dynamic general equilibrium model. They also conduct this analysis in an exogenous growth context. By contrast, Moraga and Vidal (2004), who investigate fiscal sustainability in an overlapping generations model, do model endogenous growth coming from human capital formation through parental education and educational spending. There model, however, does not have endogenous labor supply, no heterogeneous agents and has only one type of tax and public consumption. Annicchiarico and Giammarioli (2004), who explicitly model growth as a result of physical capital externalities, also neglect the individual choice of working hours. Two further characteristics have, to date, received slightly less attention in a context of fiscal tightening. The first concerns the effects of changes in welfare spending and public employment. As exceptions, we mention Ardagna (2001, 2007), Cavallo (2005), Finn (1998) and Pappa (2004). Second, theoretical work has largely ignored distributional issues. We mention Jensen and Rutherford (2002) as an important exception. The latter find that inter- rather than intra-generational equity is most likely to pose the greatest obstacle to fiscal consolidation.

In this paper, we try to fill some of the above gaps in the literature. We adopt the dynamic general equilibrium model of the economy to study the transitory and long-run effects of different consolidation scenarios. In contrast to most previous studies, we endogenize not only the labor supply decision, but also the schooling decision of young individuals. This framework has multiple advantages. Most importantly, it allows taking into account feedback effects of changes in taxes or government expenditures on individual behavior, output growth and on the economy in general. Given the importance of education for growth (and of growth for a reduction of the debt ratio) allowing for tertiary education is crucial. The goal of this paper is threefold. (1) To analyze how different fiscal consolidation scenarios influence potential employment and output, depending on the type of fiscal instrument used to reduce public debt. We model eight different scenarios of fiscal consolidation; three of them resort to tax hikes while the other implement cuts in public expenditure. We also assess the differential (welfare) impact of these scenarios on low- and high-skilled individuals. (2) To demonstrate the importance of taking into account individual schooling decisions in analyzing employment and output effects of fiscal consolidation in specific and public policy in general. (3) To shed light on how assumptions on the (un)productive nature of public services/investment may influence estimates of the difficulty of fiscal consolidation through public employment reduction.

We are not aware of any study explicitly focusing on fiscal consolidation in a similar context as ours, i.e. focusing on the effects on potential employment and growth in a framework with both endogenous work hours and human capital formation and an extensive public policy block.
We analyze various scenarios intended to completely pay off public debt. The horizon over which this goal is achieved is endogenous. We run simulations under perfect foresight in a non-stochastic setting. Unlike many authors, our interest does not lie in the business-cycle effects of fiscal shocks, but in the effects on potential growth and employment. In our model, we distinguish two ability groups: high-ability individuals who participate in tertiary education, and low-ability individuals who do not. Throughout this paper, we abstract from considerations related to a lack of credibility of fiscal policy, individual uncertainty, optimal Ramsey policy or the use of fiscal instruments to stabilize the business cycle (see also Forni et al., 2010).

Our simulations show that consolidation is most harmful for medium-run output when it resorts to hikes in the labor or capital tax or when efficiently used public employment is reduced. Lowering non-employment benefits, on the other hand, has the opposite effects. In the long run, per capita growth benefits more from fiscal consolidation when budgetary savings are used to increase productive expenditures; labor supply increases most when labor taxes are reduced. Higher public employment also stimulates growth and labor supply. Our results underscore the importance of modeling the individual’s education decision; something which is often neglected in this literature. Finally, our model confirms earlier findings that inter- rather than intra-generational equity is most likely to pose the greatest obstacle to fiscal tightening.

3. The model

The model used in this paper most closely aligns with those in Cournède and Gonand (2006), Fougère et al. (2009) and Buyse, Heylen and Van de Kerckhove (2011). However, it also builds upon many other studies mentioned in the previous section. Three characteristics are key in our model. First, we assume a closed economy. As regards Europe, ongoing and upcoming debt reduction strategies are at the forefront in almost every member country. Therefore, the possibilities to free-ride on other countries’ good economic climate are limited. It is then most suited to look at closed-economy effects of fiscal consolidation. Second, we explicitly allow individuals to devote time to education, something which is often neglected in the fiscal consolidation literature (e.g. Ardagna, 2001 and 2007; Cournède and Gonand, 2006). Third, we explicitly introduce a role for public capital/investment in private production. A mechanism which will be key to show that reducing public employment might not always be the most effective method to reduce public debt. In the remainder of this section, we present our model in more detail. Our model is non-Ricardian due to the feature of both finite-lifetime households and distortionary taxation.

3.1 Demographics

Population dynamics are kept as simple as possible. An individual lives for 30 periods, each representing two years in reality. At any period of time a new generation of size $N$ enters the model at the age of 19, retires at the age of 65 and lives until the age of 78. We assume zero population growth as our goal here is not to analyze the impact of demographic change but pure effects of fiscal consolidation. For an
analysis of population ageing in a similar though less detailed model as ours, we refer to Fougère et al. (2009). In our set-up, every generation consists of two types of heterogeneous individuals, i.e. low- and high-ability.\(^1\) We denote these groups as \(s=H,L\). We normalize the size of every generation (\(N\)) to 2. The ability groups are of equal size \(\mu_s=1\).\(^2\)

3.2 Households

For simplicity, we disregard skill level in this section, i.e. we neglect the superscript \(s\). Household preferences are represented by the following time-separable utility function:

\[
U^t = \sum_{j=1}^{20} \rho^{j-1} u(c_{j,t}, j_{t+j-1}, \ell_{j,t+j-1})
\]

where \(c_{j,t}\) and \(l_{j,t}\) are respectively consumption and leisure of an individual of age group \(j\) at time \(t\). \(\rho\) is the discount factor. The instantaneous preferences are represented by the following functions:

\[
u(c_{j,t}, l_{j,t}) = \ln c_{j,t} + \gamma_j \frac{\ell_{j,t}^{1-\theta}}{1-\theta}
\]

Preferences are hence logarithmic in consumption (both private and government) and iso-elastic in leisure. The intertemporal elasticity of substitution in consumption is 1, the intertemporal elasticity to substitute leisure \(1/\theta\). Finally, \(\gamma\) specifies the relative value of ‘leisure’ versus consumption. Note that \(\gamma\) may be different in each period of life. Except for the latter assumption, our specification of the instantaneous utility function is quite common in the macro literature (e.g. Benhabib and Farmer, 1994; Rogerson, 2007).

Contrary to the intensive labor margin, we do not endogenize the extensive labor margin (i.e. the decision to participate in the labor market). In each period of active life, an individual has an endowment of one unit of time which can be allocated to working (\(n\)), learning (\(e\)) or leisure (\(l\)).\(^3\) Time devoted to education represents human capital investment. For reasons explained later (Section 4), we only allow schooling in the first 8 periods of life i.e. between the age of 19 and 34. Time constraints are represented in equations (3)-(5). Although the official retirement age is at 65 (\(j = 24\)), individuals may optimally choose to work until the age of 69 (\(j = 1\) to 25).

\(^1\) Low- and high-ability workers will differ both in their initial endowment of human capital and in the possibility to study.
\(^2\) The normal convention used throughout this paper is that we denote variables related to an individual of ability level \(s\) with a superscript. Aggregate variables are then defined as the weighted average of both ability groups. For instance, \(c^H\) (resp. \(c^L\)) denotes the consumption level of a high- (resp. low-)ability worker, while \(c = \mu_H c^H + \mu_L c^L\) represents average consumption.
\(^3\) Our model will include both private and public employment. However, the individual is indifferent between both sectors.
An individual born at time $t$ chooses consumption, labor supply and education to maximize Equation (1), subject to Equations (2)-(5) and the constraints described in (6)-(8).

For $j = 1$ to 23:
\[
\begin{align*}
1 &= \ell_{j,t} + n_{j,t} - e_{j,t} \quad \text{for } j = 1:8 \\
1 &= \ell_{j,t} + n_{j,t} \quad \text{for } j = 9:25 \\
1 &= \ell_{j,t} \quad \text{for } j = 26:30
\end{align*}
\]

For $j = 1$ to 23:
\[
a_{j,t} - a_{j-1,t} = r_{j,t} - (1 + \tau_c) h_{j,t} n_{j,t} - w_{j,t} - e_{j,t} \quad \text{for } j = 1:23
\]

For $j = 24$ to 25:
\[
a_{j,t} - a_{j-1,t} = r_{j,t} - (1 + \tau_c) h_{j,t} n_{j,t} - w_{j,t} \quad \text{for } j = 24:25
\]

For $j = 26$ to 30:
\[
a_{j,t} - a_{j-1,t} = r_{j,t} - (1 + \tau_c) h_{j,t} n_{j,t} - w_{j,t} \quad \text{for } j = 26:30
\]

where we denote by $a_{j,t}$ the end-of-period asset holdings of an individual of age group $j$ at time $t$. The model assumes that individuals start from zero wealth (i.e. $a_{j,0} = 0$) and that there is no bequest motive (i.e. $a_{j,30} = 0$). Furthermore, $h_{j,t}$ is the human capital of the individual of age group $j$, $r_t$ is the real interest rate on private savings and $w_t$ the real wage per efficiency unit of labor. $\tau_c, \tau_w$ and $b$ are respectively the effective tax rates on labor income and consumption expenditures and the non-employment replacement rate. The tax on labor income, $\tau_w$, is the sum of two components: a labor tax $\tau_l$ and a social contribution tax $\tau_c$. Additionally, households receive lump-sum transfers $z$ from the government and profits $\pi$ from firms. Moreover, $\epsilon_j$ is an exogenous parameter linking productivity with age. It is constant over generations. While we use human capital to describe $h_{j,t}$, we will refer to $\epsilon_j h_{j,t}$ as productive efficiency. In every period of activity ($j = 1$ to 25) an individual works $n_j$ and earns a net wage $w_j \epsilon_j h_{j,t} n_j (1 - \tau_w)$. Non-employment benefits in periods before the statutory retirement age ($j=25$) are defined as a proportion of the after-tax wage of a full-time worker and are given by $b \epsilon_j h_{j,t} (1 - \tau_w) (1 - n_j - e_{j,t})$ (see Buyse et. al., 2011).

In Equations (7) and (8), $pp$ represent the per-period pension benefit received by an individual after the age of 65. Net pension benefits are a function of lifetime after-tax labor earnings as shown in Equation (9). $accr_{j,t}$ is the pension accrual rate on net income of a worker of age group $j$ in period $t$. 

\[1 = \ell_{j,t} + n_{j,t} - e_{j,t} \quad \text{for } j = 1:8 \]

\[1 = \ell_{j,t} + n_{j,t} \quad \text{for } j = 9:25 \]

\[1 = \ell_{j,t} \quad \text{for } j = 26:30 \]
\[ pp_{j,t} = \sum_{i} w_{y+j}^{y+y+j} h_{y+y+j}^{y+y+j} (1-\tau_w) \prod_{i} x_i \quad \text{for } j = 1 \text{ to } 25, \text{jj} = 26 \text{ to } 30 \text{ and } i = j \text{ to } jj \tag{9} \]

where net wages are revalued in line with average economy-wide wage growth \( x \). Thanks to this revaluation, the net pension is adjusted to increases in the overall standard of living between the time that workers build their pension entitlements and the time that they receive the pension. This follows practice in many OECD countries (OECD, 2005; Whiteford and Whitehouse, 2006).

3.3 Production

Private firms act competitively on output and input markets and maximize profits. All firms are identical. Total domestic output is given by the production function in Equation (10). It exhibits constant returns in three productive factors: physical capital, private human capital and public capital. As in Barro (1990), the stock of public capital acts as a public good and augments the productivity of private inputs. This framework is extended in Futagami et al. (1993). It differs from the original setting in Barro (1990) in that not the flow of public expenditures, but the stock of public infrastructure influences private production. \( \beta \) is a coefficient measuring the productivity of public services/capital in the production of private goods. In other words, if \( \beta = 0 \), public capital is unproductive i.e. does not increase the productivity of private inputs. Private human capital in equation (10) is represented by a constant elasticity of substitution (CES) function in private employed skilled and unskilled human capital (resp. \( H^S \) and \( H^L \)) where \( v \) is the substitution elasticity and \( \chi_H \) the share of high-ability workers in total privately employed effective labor.

\[ Y_t = \left( K^P_t \right)^{\alpha} \left( K^S_t \right)^{\beta} \left( H^P_t \right)^{1-\alpha-\beta} \tag{10} \]

with: \[ H^P_t = \left[ \chi_H \left( H^P_{H,t} \right)^{1-1/v} + (1-\chi_H) \left( H^P_{L,t} \right)^{1-1/v} \right]^{1/(1-1/v)} \]

The government uses labor input (\( H^S_t \)) and consumption goods (\( G^C_t \)) to produce a specific output, i.e. government investment goods, \( J_t \) according to the production function in Equation (11). \(^4\) We adopt a similar specification as in Cavallo (2005).

\[ J_t = \left( \omega H^S_t \right)^{\eta} \left( G^C_t \right)^{1-\eta} = \left( \omega(H^S_{H,t} + H^S_{L,t}) \right)^{\eta} \left( G^C_t \right)^{1-\eta} \tag{11} \]

\(^4\) Many studies incorporating public expenditures (flow) or capital (stock) into the production function assume constant returns in the private inputs (e.g. Ardagna, 2001 and 2007). We require assuming constant returns in all inputs in order to generate a Balanced Growth Path. As such, \( K^S_0 \) can be seen as a public input of the unpaid-factor variant (Ghosh and Roy, 2002; Colombier and Pickhardt, 2005, Feehan and Batina, 2007, Agénor, 2008).
where \( \eta \) is the elasticity of public services with respect to public employment and \( H_H^g \) and \( H_L^g \) represent the amount of low- and high-ability labor employed in the public sector. These workers are paid the competitive wage determined in the private sector (cfr. infra). In contrast to the private sector, we assume, for simplicity, perfect substitutability between low- and high-skilled labor in the public sector.\(^5\) The normalization parameter \( \omega \) is important for two reasons. First, it captures that not all public employees are employed for public investment purposes which are important for private production. Second, it also captures the efficiency with which public sector employees produce a specific output \( J \).

We will later follow Ardagna (2001, 2007) and make the simplifying assumption that \( \eta = 1 \), such that public investment/production is linear – although not on a one-to-one base – in the number of public employees. Nevertheless, our model differs from Ardagna (2001, 2007) in an important respect. We assume that the stock of public infrastructure, and not the flow of public services, enters the private production function in Equation (10). The public capital stock then evolves according to:

\[
K_{t+1}^g - K_t^g = J_t - \delta_g K_t^g
\] (12)

Where \( \delta_g \) is the public capital depreciation rate.

Competitive behavior implies in Equation (10) that firms carry physical capital to the point where its after-tax marginal product net of depreciation equals the real interest rate.\(^6\) Physical capital depreciates at rate \( \delta_k \). Similarly, Equation (14) states that for both ability levels, the wage per unit of effective labor is determined by its marginal product.

\[
\left[ \alpha \left( \frac{H_t^p}{K_t^p} \right)^{1-\alpha} \left( \frac{K_t^g}{H_t^p} \right)^{\beta} - \delta_k \right] (1 - \tau_k) = r_t
\] (13)

\[
(1 - \alpha - \beta) \left( K_t^g \right)^{\beta} \left( K_t^p \right)^{\alpha} \frac{\partial H_t^p}{\partial H_{s,t}} = w_t^s
\] (14)

It should be stressed that the non-standard production factor, public capital, has no market price. Indeed, the cost of public infrastructure is paid by the government. As such, the rent generated by this factor is not assigned to either of the two other, private, factors, leading to positive profits \( \Pi_s \) in Equation (15). We assume these profits are distributed equally to all households: \( \pi_{s,t} = \Pi_s / 30 \).

\[
\Pi_t = \beta Y_t
\] (15)

\(^5\) Turnovsky and Pintea (2006) assume public production requires the use of both labor and capital. They model a public firm that produces a given amount of public investment goods at minimum cost. As such, they impose a certain \( J \) (in % of GDP) in line with real data on public investment-to-GDP. As public investment is endogenous in our model, and as we use a simpler production function, we add a parameter \( \omega \) which will be calibrated such that the predicted fraction of public investment in GDP is in line with real data. The specific value of \( \omega \) however, has no impact on the simulation results reported later.

\(^6\) Note that our model does not include a tax on private capital earnings. Instead, we assume firms pay a tax on capital returns.
3.4 Human Capital Technology

Human capital of an individual of ability level $s (= H, L)$ evolves according to Equations (16)-(18). Equation (16) states that a first-period worker inherits his innate human capital $h_{1,t}^s$ as a fraction of the total human capital of the active population at birth (i.e. the period before entering into the model) without taking into account the age-productivity link $\varepsilon$. This externality, à la Azariadis and Drazen (1990), will generate, in Equation (17), a first difference between low-ability and high-ability workers, i.e. low-ability individuals inherit a smaller innate ability level than high-ability individuals. An individual is able to increase his human capital in the following periods through education. It is our assumption in Equation (18) that $h$ rises in education time ($e$) and publicly provided “quality” of education ($E_t$). We follow among others Glomm and Ravikumar (1998) and assume a direct link between quality of education and aggregate productive government spending on education. In previous studies, we have shown that introducing productive government expenditures as an argument in the human capital production function helps in explaining the cross-country variation in tertiary education and growth rates in 13 OECD countries (Buyse et al., 2011; Heylen and Van de Kerckhove, 2011). It is also consistent with recent empirical evidence showing a positive correlation in developed countries between public education expenditures on the one hand and growth and human capital on the other (Blankenau et al., 2007).

$$h_{1,t+1}^s = \vartheta_s^s \left[ \sum_s \sum_{j=1}^{25} \mu_{s, h_{j,t}}^s \right]$$

(16)

$$\theta_L = \zeta \theta_H \text{ with } \zeta < 1$$

(17)

$$h_{j+1,t+1}^s = \Omega_j \left( e_{j,t}^s, E_t, h_{j,t}^s \right)$$

(18)

The specification and parameterization of the human capital production function (18) is often a problem in numerical endogenous growth models. In contrast to goods production functions, there is not much empirical evidence and no consensus about the determinants of human capital growth, nor about the underlying functional form and parameter values (Bouzahzah et al., 2002, Arcalean and Schiopu, 2010). The literature shows a variety of functions, typically including one or two of the following inputs: individual time allocated to education, private expenditures on education by individuals themselves or by their parents, and government expenditures on education (e.g. Lucas, 1988, Glomm and Ravikumar, 1998 and 1992; Docquier and Michel, 1999, Kaganovich and Zilcha, 1999; Bouzahzah et al., 2002; Fougère et al., 2009; Arcalean and Schiopu, 2010; Buyse et al., 2011). In case of two inputs, the adopted functional form is very often Cobb-Douglas (e.g. Glomm and Ravikumar, 1998 and 1992; Kaganovich and Zilcha, 1999; Docquier and Michel, 1999; Blankenau and Simpson, 2004; Annabi et al., 2011). We follow the latter and assume a Cobb-Douglas function as in Equation (19).

$$\Omega_j \left( e_{j,t}^s, E_t, h_{j,t}^s \right) = h_{j,t}^s + \phi \left( e_{j,t}^s \right) \sigma \left( E_t \right) ^{\kappa} \left( h_{j,t}^s \right) ^{1-\kappa}$$

(19)
where $\phi$ is a scale parameter reflecting the efficiency of the education system, $\sigma$ represents the elasticity of human capital with respect to the education effort and $\kappa$ is the elasticity with respect to productive expenditures (mainly on education).

Two further assumptions are worth noting. First, only high-ability individuals are able to study; hence $e^j$ is zero for all $j, t$ and human capital remains constant over these workers’ life. This generates a second difference between both ability types. Second, for reasons explained later (see section 4), we do not allow schooling after the age of 34, hence high-ability workers’ human capital remains also constant from this age onwards ($j = 9$). Note however that productive efficiency does vary due to the (exogenous) age-productivity link $\varepsilon_j$.

3.5 Government

As in our previous work (Buyse et al., 2011; Heylen and Van de Kerckhove, 2011), our model is rich in terms of fiscal features. The government raises taxes on labor income, consumption and capital (see Section 3.4). It has to finance various expenditures, among which education expenditures $E$, consumption $G^c$, public wages $G^e$, benefits related to non-employment $NEB$, and lump sum transfers $Z$. It may also issue debt. We denote $B_t$ as public debt at the beginning of period $t$ while $B_{t+1}$ is public debt at the end of this period (the beginning of period $t+1$). Equation (10) describes the government budget constraint. It states that the change in government debt is equal to the primary surplus plus interest expenditures on the initial debt.

\[ \Delta B_t = B_{t+1} - B_t = r_t B_t + G_t^c + G_t^e + E_t + NEB_t + Z_t - T_{lt} - T_{kl} - T_{ct} \]

with:

\[ E_t = g_c Y_t \]

\[ G_t^c = g_c Y_t \]

\[ G_t^e = w_{H,t} H_{H,t}^s + w_{L,t} H_{L,t}^s \]

\[ H_{H,t}^s = \lambda H_{H,t} \]

\[ H_{L,t}^s = \lambda H_{L,t} \]

\[ NEB_t = \sum_{j=1}^{23} \sum_s \mu_s n_{j,s}^s (1 - \tau_w) n_{j,s}^s w_i^s \varepsilon_j h_{j,t}^s \]

\[ T_{lt} = \sum_{j=1}^{25} \sum_s \mu_s n_{j,s}^s w_i^s \varepsilon_j h_{j,t}^s \tau_t^s \]

\[ T_{kl} = \tau_k \left[ \alpha Y_t - \delta_k K^p_t \right] \]

\[ T_{ct} = \tau_c \sum_{j=1}^{30} \sum_s \mu_s c_{j,s}^t \]

\[ z_t = Z_t / 30 \]
Following Turnovsky (2000), Dhont and Heylen (2009) and our previous work in Buyse et. al. (2011), we assume that the government claims given fractions $g_e$ and $g_c$ of output for productive expenditures on education and non-wage consumption. We follow, among others, Ardagna (2001, 2007) and Cavallo (2005) in assuming the government hires a given fraction of total effective labor supplied by households. We make the simplifying assumption that this fraction is equal for both ability levels. We denote it by $\lambda$.

Effective labor (per ability level) in the public sector is denoted as $H_{s,t}^g$ and is paid the same real wage $w^i$ as in the private sector. Individuals are hence indifferent between working in the private or the government sector. Non-employment benefits (NEB) are an unconditional source of income support related to inactivity (‘leisure’) and non-market household activities. Although it may seem strange to have such transfers in a model without involuntary unemployment, one can of course analyse their employment and growth effects as a theoretical benchmark case (see also Rogerson, 2007; Dhont and Heylen, 2008, 2009; Buyse et. al., 2011). Moreover, there is also clear practical relevance. Unconditional or quasi unconditional benefits to structurally non-employed people are a fact of life in many European countries. Further, as we have mentioned before, the government pays the same lump sum transfer $z_t$ to all individuals living at time $t$.

The social security system is not embedded in the government budget. Pension benefits are paid on a pay-as-you-go basis and are financed by contributions of working individuals. We assume a system in which the uniform contribution rate $cr$ endogenously adapts to satisfy the budget constraint in Equation (21).

$$\sum_{jj=26}^{30} pp_{jj,t} = cr \sum_{s}^{25} \sum_{j=1}^{25} \mu_s n_{j,s}^w w_j^s e_j^s h_{j,t}^s$$ (21)

### 3.6 Model Closure

Equation (22) describes total human capital as the sum of total effective labor supply of households of all age groups (i.e. hours worked multiplied by productive efficiency). We further define effective labor per skill group $H_{s,t}$ and effective labor employed privately (superscript $p$) and publicly (superscript $g$).

$$H_t = \sum_{s}^{25} \sum_{j=1}^{25} \mu_s n_{j,s}^w h_{j,t}^s e_{j,t} = H_{H,t} + H_{L,t}$$ (22)

---

7 We acknowledge that public sector wages may differ from private sector wages. However, for a benchmark of 10 European countries, Ardagna (2007) shows, using OECD data, that public sector wages were only 4.59% higher than private sector wages in the period 1991-1995.
Where:

\[ H_{s,t} = \mu_s \sum_{j=1}^{25} \xi_j h_{j,t}^s n_{j,t}^s \]

\[ H_{H,t}^g = \lambda H_{H,t} \]

\[ H_{L,t}^g = \lambda H_{L,t} \]

\[ H_{H,t}^p = (1 - \lambda) H_{H,t} \]

\[ H_{L,t}^p = (1 - \lambda) H_{L,t} \]

The law of motion describing the evolution of the private capital stock is described in Equation (23) where \( I_t \) are private investments in period \( t \).

\[ K_{t+1}^p = \left(1 - \delta_k \right) K_t^p + I_t \]  

(23)

Bonds and firms’ physical capital are perfect substitutes in the portfolios of households. Therefore, the total asset accumulation rule satisfies:

\[ \sum_s \sum_j \mu_s a_{j,t-1}^s = K_t^p + B_t \]  

(24)

Finally, the model is closed with the introduction of a fiscal policy rule to assure the no-Ponzi game condition holds. We assume the government uses a single instrument to keep debt in line with the target. At this point, we do not make any specification about this rule. We just emphasize that one requires such a rule for closure of our model. In the simulations presented in section 6, we will extend on this point.
4. Model Calibration

4.1 Parameterization

The values of the preference parameters used in our model are standard in the literature. The value of the discount rate is approximately 0.96; equivalent to a rate of time preference equal to 2% per year (see e.g. Barro, 1990). The value of \( \theta \), i.e. the reciprocal of the inter-temporal elasticity of substitution, is 2. Estimates for this parameter used in the literature, lie between 1 and 10. Micro studies often reveal very low elasticities (i.e. high \( \theta \)). However, given our macro focus, these studies may not be the most relevant ones. Rogerson and Wallenius (2009) show that micro and macro elasticities may be unrelated. Rogerson (2007) also adopts a macro framework. He puts forward a reasonable range for \( \theta \) from 1 to 3 (Rogerson, 2007, p. 12).

The technological parameters are standard in the literature. We assume a share coefficient of physical capital of 0.3 and a capital depreciation rate of 7.5% per year for private capital and 4% for public capital. As for the share of the public inputs in private production, we follow a.o. Agénor (2011) and assume a value of 0.15. This is the estimate found in Easterly and Rebelo (1993) and Bose et al. (2007, Table 3). The latter found this coefficient for public capital expenditure in a growth regression. Canning (1999) estimates an elasticity of output per worker with respect to infrastructure (as measured by the number of telephone lines) equal on average to 0.14 for his full sample, and close to 0.26 for higher-income countries. Cerra et al. (2008) also use 0.15 for the elasticity of non-traded output with respect to government spending in their simulations. Turnovsky and Pintea (2006) adopt a slightly higher value of 0.20 whereas Baier and Glomm (2001), Rioja and Glomm (2003) and Chen (2003, 2007) use a slightly lower value of 0.1. Finally, Hulten (1996) estimated a value of 0.11. We set the elasticity of substitution between low- and high ability workers at 1.441. This is the value of Heckman et al. (1998a). Finally, we calibrate the share parameters \( \chi \) such that initial wage differentials \( \frac{w^{l}h^{l}}{w^{h}h^{h}} \) are equal to 66% (i.e. the average wage gap in our set of countries in 2005/2007, see OECD, Education at a Glance 2009, p. 144-145 Table 7.1A).

Following Lucas (1990) we choose the elasticity of time input, \( \sigma \), equal to 0.8. This value is again in the middle of existing studies. It coincides with the one of Glomm and Ravikumar (1998), is slightly higher than the value used by Lau (2000) and Fougère et al. (2009) but slightly lower than the estimate of Heckman et al. (1998b) and Buyse et al. (2011). The value for the elasticity of public spending input in human capital \( \kappa \) is much more debatable. Estimates of this value range from 0 (Coleman, 1996) to 0.12 (Card and Krueger, 1992) and higher (Blankenau et al., 2007). Blankenau and Simpson (2004) use a value of 0.10 while Fougère et al. (2009) and Annabi et al. (2011) adopt a higher value (0.18). As the certainty about this parameter is limited, we opt for a moderate value of 0.12. Moreover, we acknowledge that our assumption on a linear relationship between productive government expenditures on education and school quality (see Section 3.4) might be too strong i.e. the link between quality of schooling and public education expenditures might not be as close as we model it. Therefore, we believe it wise to refrain from choosing a too high value for \( \kappa \) in order to avoid overestimating the effects of public education expenditures on human capital and growth.
Table 1: Model calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preference parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount rate</td>
<td>$\rho$</td>
<td>0.96</td>
</tr>
<tr>
<td>Inter-temporal elasticity of substitution in leisure</td>
<td>$1/\theta$</td>
<td>0.5</td>
</tr>
<tr>
<td>Leisure preference</td>
<td>$\gamma_i$</td>
<td>See text and Appendix A</td>
</tr>
<tr>
<td><strong>Technological parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical capital share in output</td>
<td>$\alpha$</td>
<td>0.30</td>
</tr>
<tr>
<td>Public capital share in output</td>
<td>$\beta$</td>
<td>0.15</td>
</tr>
<tr>
<td>Share of high-ability workers in private human capital</td>
<td>$\chi_H$</td>
<td>0.63</td>
</tr>
<tr>
<td>Elasticity of substitution between high- and low ability workers</td>
<td>$\nu$</td>
<td>1.441</td>
</tr>
<tr>
<td>Efficiency parameter in the public production function</td>
<td>$\omega$</td>
<td>0.07</td>
</tr>
<tr>
<td>Share of government employment in public production</td>
<td>$\eta$</td>
<td>1</td>
</tr>
<tr>
<td>Private capital depreciation rate per year (in %)</td>
<td>$\delta_k$</td>
<td>7.5</td>
</tr>
<tr>
<td>Public capital depreciation rate per year (in %)</td>
<td>$\delta_g$</td>
<td>4</td>
</tr>
<tr>
<td><strong>Human capital technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency parameter</td>
<td>$\phi$</td>
<td>14.82</td>
</tr>
<tr>
<td>Elasticity of time input</td>
<td>$\sigma$</td>
<td>0.8</td>
</tr>
<tr>
<td>Elasticity of public spending on education</td>
<td>$\kappa$</td>
<td>0.12</td>
</tr>
<tr>
<td>Share of human capital inheritance of high ability individuals (in %)</td>
<td>$\vartheta_H$</td>
<td>6.30</td>
</tr>
<tr>
<td>Innate ability of low-ability individuals vis-à-vis high-ability workers (in %)</td>
<td>$\varsigma$</td>
<td>67.0</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of productive expenditures on education in total output (in %)</td>
<td>$g_y$</td>
<td>6.07</td>
</tr>
<tr>
<td>Share of non-wage government consumption in total output (in %)</td>
<td>$g_c$</td>
<td>7.31</td>
</tr>
<tr>
<td>Capital tax rate (in %)</td>
<td>$\tau^k$</td>
<td>21.71</td>
</tr>
<tr>
<td>Consumption tax rate (in %)</td>
<td>$\tau^c$</td>
<td>14.96</td>
</tr>
<tr>
<td>Labor tax rates (in %)</td>
<td>$\tau^w_H$</td>
<td>53.20</td>
</tr>
<tr>
<td></td>
<td>$\tau^w_L$</td>
<td>50.71</td>
</tr>
<tr>
<td>Non-employment benefit replacement rates (in %)</td>
<td>$b^H$</td>
<td>45.14</td>
</tr>
<tr>
<td></td>
<td>$b^L$</td>
<td>65.73</td>
</tr>
<tr>
<td>Pension accrual rate (in %)</td>
<td>$accr$</td>
<td>2.39</td>
</tr>
<tr>
<td>Fraction of government employment (in %)</td>
<td>$\lambda$</td>
<td>14.30</td>
</tr>
<tr>
<td>Public debt-to-GDP ratio (in %)</td>
<td>$B_t$</td>
<td>70.36</td>
</tr>
</tbody>
</table>

Note: see text for information

The parameters for the government accounts are based on the average data of 11 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, United Kingdom) in the period 1995-2007. Most of the data come from our previous study (Buyse et al., 2011) and from Van de Kerckhove and Heylen (2011). The fraction of government employment is calibrated to match the average public wage expenditure in these countries. Total public wage expenditures were on average 9.18% of GDP for the above countries, i.e. approximately 56% of total wage and nonwage...
government consumption expenditures. In our model, predicted employment (in hours) in the public sector equals 14.3% of total employment in hours. We can only compare this figure with data on public sector employment as a share of the labor force. For instance, Ardagna (2007) shows a value of 18.71% for a benchmark of 10 European countries over the period 1991-1995. Our value is slightly lower. Note however that, in reality, although public wages may be somewhat higher, hours worked in the public sector are on average lower than those in the private sector; a feature not captured by our model. This may explain why our model predicts a lower public sector employment rate (in hours) than in reality.

We assume a pension accrual rate of 2.39% per period, which translates into a net income-related pension replacement rate of 59.8% observed in Europe. Finally, we set lump sum transfers in the initial steady state such that the initial debt-to-GDP ratio is equal to 70.36%, the average value of the 11 European countries in the period 1995-2007.

Concerning public production/investment, we follow among others Ardagna (2001, 2007) and assume that government production is linear in public employment, i.e. we set \( \eta \) equal to 1. Hence government consumption is assumed to be completely wasteful while public employee expenses are not. Finally, the efficiency/normalization parameter \( \omega \) is calibrated such that our model predicts a public investment-to-GDP ratio of 3.1%. This aligns with average public expenditures on fixed capital formation and R&D investment. For a set of European countries, Kamps (2005) shows similar values for gross public investment in % of GDP. Turnovsky and Pintea (2006) report a slightly higher value for the US (i.e. 4% of GDP).

For the age-productivity profile, we follow among others Miles (1999) and Cournède and Gonand (2006) in assuming the following function \( \epsilon(a) = \exp(0.05a - 0.0006a^2) \), resulting in an inverted U-shaped pattern peaking at the age of 42. The share of human capital inheritance of high-ability individuals \( \theta_H \) is calibrated to match an average European growth of 1.96% per year over the same period. Van de Kerckhove and Heylen (2011) state that OECD PISA-scores for low ability individuals (17%-quartile) are approximately 67% of PISA-scores for high-ability individuals (83%-quartile). We take this value as a measure of the relative innate ability of low-skilled versus high-skilled workers in our model (i.e. \( \varsigma \)). The efficiency parameter \( \phi \) in the human capital accumulation function is calibrated to match average European education rates over the period 1995-2006. Data are only available for the age group 20-34. This value is 16.97% and is taken from Heylen and Van de Kerckhove (2010). The age group 20-34 exactly matches the first 8 periods in our model (\( j = 1 \) to 8). Therefore, we have imposed zero education after the age of 34 (\( j = 9 \)). Extensive analysis on this point, i.e. allowing for education after this age, reveals that the results reported in the next sections are robust for this assumption. Finally, the preference for leisure parameters \( \gamma_j \) are determined such that our model correctly predicts the average European employment rates in hours presented in Figure 1 (blue curve). Table A.1 in Appendix A contains the figures underlying this curve. We find a rising leisure preference by age (see Figure A.1 in Appendix A). Data on time allocated to employment is derived from Eurostat.

---

8 In an earlier study, see Buyse et. al. (2011), we focused on the analysis of pension reform in a benchmark of European countries.
Table 2: Steady-state value of main variables in the baseline model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\frac{K}{Y}$</th>
<th>$\frac{K}{Y^*}$</th>
<th>$\frac{C}{Y^*}$</th>
<th>$\frac{I}{Y^*}$</th>
<th>$\frac{G}{Y^*}$</th>
<th>Real interest rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>2.25</td>
<td>52.54</td>
<td>65.94</td>
<td>20.68</td>
<td>13.38</td>
<td>4.69</td>
</tr>
</tbody>
</table>

Note: * in %

Table 2 shows the predictions of our model concerning some important endogenous variables. All figures are in line with real data for developed countries. The capital-output ratio is 2.25. The public capital-to-output ratio is 0.53, which matches actual data given by Kamps (2005). In addition, investment-to-GDP ratio is 20.68%, which is in line with most findings on developed countries investment rates. Finally, our model predicts a real interest rate of about 4.69% per year. Note that, as the debt-to-GDP ratio in the benchmark economy is approximately 70%, interest payments come down to 3.52% of GDP per year.

Figure 1 shows the life-cycle time profile of a representative individual in our model (i.e. the average over both skill levels). The blue curve represents the employment rates in hours observed in the data. Our model is calibrated to match an average education rate over the first 8 periods of life of 16.97% of available time. Predictions are as one would expect. At the age of 20, young individuals spend a significantly higher amount of time to education (38% of time in the first period). As the individual ages, this share decreases gradually until the age of 34 (4.5% of time in the age group 33 and 34).

Figure 1: Life-cycle time profile of a representative individual.

Note: The data underlying the labor supply curve can be found in Appendix A (Table A.1).

Figure 2 reports the effective labor supply of an individual in both ability groups as observed in the model. It is hours worked in period $j$ multiplied by productive efficiency $\epsilon_j h_{j,t}$. We find the usual hump-shaped pattern. We also note that low-ability individuals work a lot in the beginning of their active life, but they retire earlier. By contrast, high-ability workers spend most of their available time studying while young, and work more and longer later in life.
5. Long-run macroeconomic effects of fiscal consolidation

In this section, we use our model to analyze the impact of a reduction in public debt on some important macroeconomic variables such as potential employment and growth. Reducing government debt in a setting as described above has multiple effects. First, as public debt crowds out private capital, fiscal consolidation would lead to more productive capital in firms and hence more output. Second, in an overlapping generations context, we account for a dependency of the real equilibrium interest rate on the level of government debt. Therefore, fiscal consolidation policies may have profound effects on interest rates. Such a dependency has been widely documented in the empirical literature (see e.g. Laubach, 2003, Ardagna et al., 2005 and Kinoshita, 2006). Finally, the potential positive macroeconomic effects of fiscal consolidation follow from the reduction in interest payments on public debt and hence the improvement in the budgetary position following consolidation (Coenen et al., 2008b). All our simulations will define fiscal consolidation as a complete repayment of government debt (see also Cournède en Gonand, 2006). An important question relates to the size of the budgetary savings created when debt is reduced to zero: By how much is the yearly primary surplus allowed to decrease to maintain a constant (and zero) debt-to-GDP ratio? Note that when there is no public debt, interest expenditures are also nil. As such, the primary surplus in the constant no-debt case must also be zero. In the calibration presented above, assuming a steady debt-to-GDP ratio of 70.36%, the required permanent surplus turns out to be 1.91% of GDP. As such, a consolidation strategy paying off total public debt would result in an improvement in a long-run yearly budgetary room of ex ante 1.91% of GDP. Once fiscal consolidation has brought back the debt ratio to zero, these savings can be used to permanently decrease taxes, increase expenditures or both. In the long-run simulations presented in this section, we assume a successful fiscal consolidation has already been implemented (i.e. we assume public debt is successfully reduced to zero) and analyze these various applications of the budgetary savings. In the following section, we will focus on various ways to reach this new debt level (i.e. we there focus on the shorter run).
Table 3 shows the potential long-run effects of paying off government debt. As mentioned above, fiscal consolidation allows, in the long run, to either decrease taxes (the first four columns of Table 3) or to increase government expenditure (the final four columns). A first observation in Table 3 is that a decrease in public debt reduces the interest rate with on average 4.5% depending on what instrument adjusts to maintain the zero debt level. As mentioned above, this interest rate drop has been demonstrated also in the empirical literature. The drop in the rental cost of capital is accompanied by a significant rise in the time spend on tertiary education, i.e. between 10.8% and 18.7% depending on how the improvement in the public budget is used. This is not surprising as tertiary education is financed by net lending between ages 20-34. Moreover, higher real wages per efficiency unit in the future also stimulate education. In turn, as education is the driving force behind growth, the increase in tertiary schooling translates into a rise in the long-run annual growth rate between 0.08 and 0.17%-points. This observation is consistent with studies showing that an increase in government debt lowers the rate of economic growth (i.e. van der Ploeg and Alogoskoufis, 1994). Also consistent with earlier studies (Dhont and Heylen, 2009 and Heylen and Van de Kerckhove, 2010) is that we observe the most positive impact on tertiary education and growth following an increase in productive government expenditures on education (i.e. these expenditures can increase by 1.66% once full consolidation is achieved).

Although many columns in Table 3 show similar results, there are some important differences both quantitatively and qualitatively. For instance, long-run effects on potential employment are not unambiguous. When the improvement in the budget position is used to lower labor taxes, for example, we notice a rise in aggregate labor supply by 0.51%. By contrast, when non-employment benefits are increased, labor supply drops by 3.63%. Interestingly, an increase in the share of public employment also favors aggregate labor supply. This result is driven by the rise in the real wage per effective unit of human capital resulting from a lower private labor pool. A second important observation is that the composition of output may change significantly after fiscal consolidation. Notwithstanding a definite drop in the ratio of effective labor to private capital \( \frac{H}{K} \) once fiscal consolidation is achieved, the size of this drop depends significantly on the specific policy. When productive expenditures rise, the drop is only 0.95% while it is 9.84% when the capital tax is reduced. We also notice a large drop in this ratio when government employment increases as a larger fraction of employment is distracted away from the private sector. As a final observation, again driven by the drop in interest rates, we note that once fiscal consolidation is achieved, there is a shift from consumption to investment which in turn raises the capital intensity and the capital output-ratio. The rise in the latter is higher when, in the long-run, capital taxes are reduced.
### Table 3: Long-run effects of paying off government debt

<table>
<thead>
<tr>
<th>Savings used for:</th>
<th>Lump-Sum Tax decrease $z$</th>
<th>Labor Tax decrease $\tau_l$</th>
<th>Consumption Tax decrease $\tau_c$</th>
<th>Capital Tax decrease $\tau_k$</th>
<th>Government Consumption increase $g_c$</th>
<th>Productive Expenditures increase $g_y$</th>
<th>Government Employment increase $\lambda$</th>
<th>Non-employment benefit increase $b$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effect on:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C/Y$</td>
<td>-1.00</td>
<td>-1.05</td>
<td>-0.94</td>
<td>-2.74</td>
<td>-3.43</td>
<td>-3.46</td>
<td>-1.06</td>
<td>-1.14</td>
</tr>
<tr>
<td>$K_p/Y$</td>
<td>2.15</td>
<td>2.16</td>
<td>1.96</td>
<td>7.75</td>
<td>1.96</td>
<td>1.11</td>
<td>2.12</td>
<td>2.37</td>
</tr>
<tr>
<td>$I/Y$</td>
<td>3.18</td>
<td>3.36</td>
<td>3.01</td>
<td>8.75</td>
<td>3.01</td>
<td>3.02</td>
<td>3.37</td>
<td>3.62</td>
</tr>
<tr>
<td>$H_p/K_p$</td>
<td>-2.67</td>
<td>-2.63</td>
<td>-2.40</td>
<td>-9.84</td>
<td>-2.40</td>
<td>-0.95</td>
<td>-7.89</td>
<td>-2.90</td>
</tr>
<tr>
<td>Annual growth rate (in %-point)</td>
<td>0.09</td>
<td>0.11</td>
<td>0.09</td>
<td>0.08</td>
<td>0.09</td>
<td>0.17</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Interest rate</td>
<td>-4.49</td>
<td>-4.52</td>
<td>-4.09</td>
<td>-2.97</td>
<td>-4.09</td>
<td>-2.34</td>
<td>-4.42</td>
<td>-4.93</td>
</tr>
<tr>
<td>Labor supply</td>
<td>-0.74</td>
<td>0.51</td>
<td>0.06</td>
<td>-0.08</td>
<td>0.06</td>
<td>-0.71</td>
<td>0.48</td>
<td>-3.63</td>
</tr>
<tr>
<td>Time spent on education (20-34)</td>
<td>12.30</td>
<td>14.15</td>
<td>12.52</td>
<td>10.81</td>
<td>12.52</td>
<td>18.73</td>
<td>14.52</td>
<td>15.35</td>
</tr>
<tr>
<td>Average real wage</td>
<td>0.73</td>
<td>0.60</td>
<td>0.58</td>
<td>3.04</td>
<td>0.58</td>
<td>0.14</td>
<td>6.40</td>
<td>1.05</td>
</tr>
<tr>
<td>$\Delta$instrument (%-point)</td>
<td>1.70</td>
<td>-2.05</td>
<td>-2.88</td>
<td>-11.74</td>
<td>1.64</td>
<td>1.66</td>
<td>2.76</td>
<td>4.77</td>
</tr>
</tbody>
</table>

**Notes:** All changes are in %, except when indicated otherwise.

(d) Change in total pension replacement rate
The above discussion clearly shows that a permanent reduction in public debt may profoundly change the functioning of the economy. As our most important result, we find positive overall growth effects driven by both the drop in interest rates and the increase in tertiary education. However, it is clear that a successful consolidation can only be achieved by multiple years of primary surpluses, which may put strong pressure on the economy in the medium-run. In the next section, we will use our model to analyze these medium-run effects of different fiscal consolidation strategies.

6. Medium-run macroeconomic effects of fiscal consolidation

In this section we analyze the transitional effects of various fiscal consolidation scenarios. In our model, we distinguish these scenarios on the type of fiscal measure used to settle public debt. Our simulations are executed using the following assumptions. (1) The government is assumed to introduce, at time $t=1$, a temporary consolidation measure, using only 1 budget item, in order to bring back its debt level to zero. (2) To allow for a comparison between these different scenarios, we assume all plans imply an ex-ante effort of 3% of GDP. Instead of imposing an exogenous debt path, we hence keep the horizon of debt repayment endogenous. We believe this is a realistic set-up. (3) In the short run, i.e. at the time of introducing the consolidation programme, we do not impose any fiscal rule. It is only at the time the economy reaches a debt level close enough to zero that we implement a fiscal rule to ensure stable debt dynamics in the long run. This timing is defined as the point in time when the debt-to-GDP ratio reaches a level below 5% of GDP. As such, we allow the reversed snowball to take full effect. At the moment the fiscal rule comes into effect, the instrument used for consolidation also returns to its pre-consolidation value.

Remember that we set lump sum transfers in the initial steady state such that the initial debt-to-GDP ratio is equal to 70.36%, the average value of the 11 European countries in the period 1995-2007. We will keep these transfers constant at their value for all periods until the moment the debt-to-GDP ratio falls below 5%. Then, we adjust them to ensure that the no-Ponzi game condition holds. The previous condition is required to assure convergence to a stable steady state. Once debt is close enough to zero, our baseline assumption is that the budget instrument used for consolidation returns to its pre-consolidation value while at the same time lump-sum transfers are gradually changed to bring debt further in line with the target of zero percent of GDP. More specifically, we assume in (25) that lump-sum transfers change in order to close half of the gap between actual and targeted debt. The latter ($b^*$) is assumed zero. We could have complicated our rule, to include other budget items (expenditures or taxes), a combination of them or to generate non-linear debt adjustments. However, although these changes may have a limited influence on the quantitative nature of our transitional results (due to the perfect foresight character of our simulations) they are very limited and do not change the qualitative nature of our results (i.e. the relative effect of one scenario with regards to the other remains identical). Moreover, we only report transitional effects before the rule comes into effect.

Fiscal Rule: $z_{t+1}$ is such that $(b^* - b_{t+1}) = \frac{(b^* - b_t)}{2}$  \text{iff}  $b^* < 0.05$  

(25)
Figure 3 shows the evolution of the debt-to-GDP ratio after the various consolidation scenarios. We observe a gradual decline in public debt in all scenarios. In four cases, the debt ratio falls below 5% of GDP after 18 years (i.e. 9 periods). This occurs in case consolidation is achieved by means of lump sum taxes, labor taxes or by a decrease in government consumption or productive expenditures. An increase in consumption or capital taxes of similar magnitude (3% of GDP) implies an additional duration of 2 more years, while a fiscal consolidation implemented by reducing public employment takes another 8 years. By contrast, in case of a reduction in non-employment benefits of similar magnitude, the zero debt level is attained much faster, within 14 years.

Figure 3: Evolution of the debt-to-GDP ratio after different fiscal consolidation scenarios.

Although all consolidation programmes succeed in achieving the debt target within approximately 2.5 decades, it is however clear that not all scenarios will imply the same short run dynamics. We report our results below. We show the evolution of potential output, aggregate employment, tertiary education and the real interest rate in Figures 4-8. For the data underlying these figures, we refer to Table B.1 in the Appendix B which shows some important indicators of macroeconomic performance during the consolidation episode. We there present the change in some main macroeconomic indicators at the moment of implementing the consolidation programme, 2 years after implementation and the average effect during the whole consolidation period (defined as the time between the moment of implementation and the moment of achieving a debt ratio of below 5% of GDP).

Before discussing the results, we make an important notification. It is important to remember that our model adopts the framework introduced by Futagami et. al. (1993) when simulating a temporary reduction in public employment. As we further assume perfectly competitive labor markets, those employees who are laid off by the government are immediately hired by private sector firms (i.e. within

\[ \text{Equation} \]

\[ \text{Formula} \]

\[ \text{Graph} \]

\[ \text{Table} \]

\[ \text{Figure} \]

\[ \text{Diagram} \]
1 period of 2 years). Although this might seem a strong assumption, it is however probable that governments will not be able reduce their employment base without guaranties that their employees will soon find another job (e.g. unions will oppose otherwise). With this assumption in mind, we should cautiously interpret the reported effects and we will do so in our discussion.

**Figure 4:** Output level evolution after different fiscal consolidation scenarios (index: benchmark=1).

Figure 4 reports the output level evolution after different consolidation scenarios relative to the benchmark evolution. Most consolidation programmes imply a loss in potential output in the short run, especially so when labor or capital taxes are increased to reduce public debt. For instance, an ex-ante increase of 3% of GDP in the labor tax rate reduces the output level by more than 2.2% on impact. 18 years after the start of the consolidation programme, output is still 3.5% lower than in the benchmark. It is apparent that an important factor driving this result is the drop in hours worked when labor taxes are increased (see also Figure 6). This implies a substantial slowdown of the economy. However, this does not hold for all consolidation policies. For instance, a drop in productive expenditures does not imply an immediate fallback in the economy’s output. Instead, lower education expenditures discourage education (see Figure 7) which implies a smaller initial drop in labor supply (note that labor supply is practically unaffected in this case). Both Figure 6 and Table B.1 in Appendix B show this result. Unfortunately, the reduction in tertiary education implies a slower growth in knowledge which negatively affects the output evolution in the future. Notice that after the consolidation, i.e. when productive expenditures return to its pre-consolidation level and the fiscal rule comes into effect, output declines significantly in Figure 4.
A drop in public employment also has interesting output effects which deserve some explanation. There are two opposite forces at work in this simulation. First, due to a drop in public employment, and hence public investment, the rise in the public capital stock will dampen, which will negatively affect private output. By contrast, as the number of employees in the private sector increases (assuming as mentioned above that all employees can be immediately be absorbed in the private sector), private production does too. We find a net positive output effect in the first five periods after reducing the number of public employees. Hence at first sight, a reduction in the number of public employees would seem very interesting. However, after some time, the negative effect from the reducing public capital stock becomes dominant and output performs worse than in the benchmark. With the above in mind, the initial positive effect should be regarded as an upper bound of the output-effect of reducing public employment. If we had assumed that the redundant employees move more gradually to the private sector, output may have declined instantaneously. In sum, we find that lowering public employment for consolidation purposes may lead to substantial reductions in private output during a significant period.

We treat the above results with caution. Ardagna (2001 and 2007), has studied the effect of a change in public employment in a constant-debt context within a representative agent model. She assumes that public employees produce government services which may affect the productivity of labor and capital used by firms in the private sector. An important distinction with the framework in this paper is, however, that she assumes the flow of public services (à la Barro) and not the stock of public infrastructure enters the private production function. In contrast to our results, Ardagna finds that a reduction in public employment would benefit the evolution of economic output when the productivity of public workers in the production of privately produced goods, related to our $\beta$, is zero or small. Notice, however, that she neglects the education decision and assumes constant returns in the private inputs (see also Footnote 4).

**Figure 5:** Reducing public employment: output level evolution under alternative values for $\beta$ (index: benchmark=1).
To further indicate the crucial importance of a correct value for the elasticity of private production w.r.t. public inputs, we show in Figure 5 a sensitivity analysis on the parameter $\beta$. We look only at the effect on output (effects on all other crucial variables are much more robust). Although we always observe a positive output effect on impact, we note that only for high enough values of $\beta$ the results mentioned above hold, that is, we observe significant output losses compared to the benchmark evolution in at least some consolidation years. However, if $\beta$ is low enough, private output will consistently benefit from a reduction in public employment (consistent with the results of Ardagna (2001 and 2007) mentioned above). For realistic output (and hence welfare) simulations in general equilibrium models, it is therefore required to have a good parameter estimate of the (un)productive nature of public services/investment.

**Figure 6: Employment evolution after different fiscal consolidation scenarios.**

Finally, notice that a reduction in non-employment benefits does not entail a fall in output. By contrast, as lower benefits increase the return to working, output effects are significantly positive even in the medium-run. Moreover, they remain positive throughout the consolidation episode. The positive employment effect is documented in Figure 6 where hours worked rise with over 3%-points during the period of consolidation. Note that this rise is only temporary as the benefit replacement rate returns to its pre-consolidation value after the consolidation is achieved.

Interestingly, Figure 7 shows that all but one consolidation programme induces a temporary rise in tertiary education rates. As education is both an important substitute for employment and an important driver of economic growth, it is clear that taking into account tertiary education in the analysis of fiscal consolidation (or fiscal policy in general) is important to obtain realistic simulation effects. We have
made a similar argument in an earlier paper showing the crucial importance of considering tertiary education when analyzing the macroeconomic effects of pension system reform (Buyse et. al., 2011).

**Figure 7:** Evolution of the average tertiary education rate after different fiscal consolidation scenarios.

![Graph showing evolution of average tertiary education rate](image)

**Figure 8:** Evolution of the real interest rate after different fiscal consolidation scenarios.

![Graph showing evolution of real interest rate](image)
Figure 8 reports the evolution of the real interest rate during the simulated consolidation episodes. In Section 5 we demonstrated a drop in the long run interest rate. In the medium-run however, changes are much more diverse. When the instrument to achieve fiscal sustainability is productive expenditures, non-employment benefits or government employment, we observe a rise in the real interest rate on impact, followed by a gradual decline over the years. All other simulations, show an initial drop in the interest rate which facilitates the consolidation process.

**Figure 9.A: Welfare effects after different fiscal consolidation scenarios: low-ability individuals.**

**Figure 9.B: Average welfare effects after different fiscal consolidation scenarios: high-ability individuals.**
Finally, in Figures 9.A and 9.B, we report the welfare effects after different fiscal consolidation scenarios for respectively low- and high-ability individuals. We report on the vertical axis the welfare effect on the generation born in t+k, where k is indicated on the horizontal axis, and where t is the period when the (permanent, unanticipated) policy change is introduced. Our welfare measure is the (constant) percentage change in benchmark consumption in each period of remaining life that individuals should get to attain the same lifetime utility as after the policy shock (see also King and Rebelo, 1990). When focusing on inter-cohort differences, we notice that for every consolidation programme, in the very long run, future cohorts are better off than current generations. This, however, does not imply that all current generations suffer from fiscal tightening. The same three measures which were on impact able to increase output (i.e. reducing non-employment benefits, productive expenditures and public employment), also result in positive welfare effects for some of the older current generations. Nevertheless, in these cases, the current younger generations do lose in terms of welfare. Furthermore, all other measures result in strong negative welfare effects for most current generations. For instance, a temporary increase in consumption taxes implies a loss of welfare for the current oldest generations of 4.2% of benchmark consumption (considering a high-ability individual). Current young individuals of the same ability group lose 0.28% of benchmark consumption. Interestingly, reducing government consumption results in a small welfare loss for only half of the current generations. Note however that this is a result of our assumption that government consumption does not directly influence the utility of individuals. Dhont and Heylen (2009) do include public consumption in the individuals’ utility function. Finally, we find it interesting to note that a temporary rise in consumption taxes has a significant negative effect on welfare of all current generations, although the medium-run output decline was relatively modest (see Figure 4).

When looking at the intra-cohort effects, we notice some differences in welfare changes for high- and low-ability individuals. When we look at the average effect for all current generations, we notice that low ability individuals are worse off than high-ability individuals in case of an increase in lump sum taxes (-1.12%), a drop in productive expenditures (-0.22%), a drop in non-employment benefits (-0.51%), an increase in consumption (-0.48%) or capital (-0.91%) taxes or a reduction in government consumption (-0.52%). By contrast, high-ability individuals suffer relatively more in case of a reduction in government employment (-0.25%) or a rise in labor taxes (-0.76%). Although these differences are small, we do find some heterogeneity in the impact of fiscal consolidation on different types of individuals. Nevertheless, we can say that our model confirms earlier findings that inter- rather than intra-generational equity is most likely to pose the greatest obstacle to fiscal tightening (e.g. Jensen and Rutherford, 2002).

Based on the above results, we are able to distinguish preferred measures for fiscal consolidation. It seems that consolidation programmes resorting to a reduction in non-employment benefits are preferred when it comes to the evolution of employment and output. Moreover, negative welfare effects remain rather small when compared to other measures of fiscal tightening. We conclude this section with an important note. Some might say that the negative effects of fiscal consolidation are relatively modest in the model. It may however be stronger in practice due to the omission of some powerful channels such as the progressivity of taxes, zero unemployment, and exogenous participation. While consumption tax increases lead to a smaller decline in aggregate output, they also imply a more severe reduction in welfare for all current generations.
7. Conclusion

In the aftermath of the financial crisis of 2008, automatic fiscal stabilization and massive fiscal stimulus plans in many European economies have led to drastic increases in public debt-to-GDP ratio’s. As concerns over fiscal sustainability are at the forefront of current debates, fiscal consolidation has become of paramount importance for many European countries. We contribute to this debate by simulating the medium- and long-run macroeconomic and welfare effects of different fiscal consolidation scenarios for Europe.

We adopt the dynamic general equilibrium model of the economy to study the transitory and long-run effects of different consolidation scenarios. We try to fill some of the existing gaps in the literature. For instance, we endogenize not only the labor supply decision, but also the schooling decision of young individuals, which allows to take into account feedback effects of changes in taxes or government expenditures on individual behavior, output growth and on the economy in general. Given the importance of education for growth (and of growth for a reduction of the debt ratio) allowing for tertiary education is crucial. We analyze various scenarios intended to completely pay off public debt. The horizon over which this goal is achieved is endogenous. We run simulations under perfect foresight in a non-stochastic setting. Unlike many authors, our interest does not lie in the business-cycle effects of fiscal shocks, but in the effects on potential growth and employment. In our model, we distinguish two ability groups: high-ability individuals who participate in tertiary education, and low-ability individuals who do not. Throughout this paper, we have abstracted from considerations related to a lack of credibility of fiscal policy, individual uncertainty, optimal Ramsey policy or the use of fiscal instruments to stabilize the business cycle (see also Forni et al., 2010).

The goal of this paper was threefold. (1) To analyze how different fiscal consolidation scenarios influence potential employment and output, depending on the type of fiscal instrument used to reduce public debt. We model eight different scenarios of fiscal consolidation; three of them resort to tax hikes while the other implement cuts in various public expenditures. We also assess the differential (welfare) impact of these scenarios on low- and high-skilled individuals. In this respect, our simulations show that consolidation is most harmful for medium-run output when it resorts to hikes in the labor or capital tax or when efficiently used public employment is reduced. Lowering non-employment benefits, on the other hand, has the opposite effects. In the long run, per capita growth benefits more from fiscal consolidation when budgetary savings are used to increase productive expenditures; labor supply increases most when labor taxes are reduced. Higher public employment also stimulates growth and labor supply. Finally, our model confirms earlier findings that inter- rather than intra-generational equity is most likely to pose the greatest obstacle to fiscal tightening. (2) We argue that taking into account tertiary education in the analysis of fiscal consolidation (or fiscal policy in general) is important to obtain realistic simulation effects. This is true as education is both an important substitute for employment and an important driver of economic growth. This is often neglected in this literature. (3) We shed light on how assumptions on the (un)productive nature of public services/investment may influence estimates of the difficulty of fiscal consolidation through public employment reduction.
We are not aware of any study explicitly focusing on fiscal consolidation in a similar context as ours, i.e. focusing on the effects on potential employment and growth in a framework with both endogenous work hours and human capital formation and an extensive public policy block. One extension to our model would be the introduction of imperfect labor markets. This would allow to assess how various scenarios of fiscal tightening affect unemployment dynamics. We leave this for future research.
Appendix A.

Table A.1.: Employment rates in hours by age, 1995-2009, in %

<table>
<thead>
<tr>
<th>Age</th>
<th>$n_j$</th>
<th>Age</th>
<th>$n_j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-20</td>
<td>29,44%</td>
<td>45-46</td>
<td>64,07%</td>
</tr>
<tr>
<td>21-22</td>
<td>37,44%</td>
<td>47-48</td>
<td>63,26%</td>
</tr>
<tr>
<td>23-24</td>
<td>45,61%</td>
<td>49-50</td>
<td>61,40%</td>
</tr>
<tr>
<td>25-26</td>
<td>53,85%</td>
<td>51-52</td>
<td>59,54%</td>
</tr>
<tr>
<td>27-28</td>
<td>60,36%</td>
<td>53-54</td>
<td>54,75%</td>
</tr>
<tr>
<td>29-30</td>
<td>61,73%</td>
<td>55-56</td>
<td>48,98%</td>
</tr>
<tr>
<td>31-32</td>
<td>63,09%</td>
<td>57-58</td>
<td>42,33%</td>
</tr>
<tr>
<td>33-34</td>
<td>63,77%</td>
<td>59-60</td>
<td>33,02%</td>
</tr>
<tr>
<td>35-36</td>
<td>64,24%</td>
<td>61-62</td>
<td>23,72%</td>
</tr>
<tr>
<td>37-38</td>
<td>64,61%</td>
<td>63-64</td>
<td>16,44%</td>
</tr>
<tr>
<td>39-40</td>
<td>64,73%</td>
<td>65-66</td>
<td>9,83%</td>
</tr>
<tr>
<td>41-42</td>
<td>64,84%</td>
<td>67-68</td>
<td>4,87%</td>
</tr>
<tr>
<td>43-44</td>
<td>64,53%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: OECD.Stat – authors’ calculations. Average for 11 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, UK).

Figure A.1: Preference for leisure by age $\gamma_j$ (calibrated to match the above data on employment rates).
Appendix B.

Figure B.1: Response of the investment-to-GDP ratio after different fiscal consolidation scenarios.

Figure B.2: Response of the consumption-to-GDP ratio after different fiscal consolidation scenarios.
Table B.1: Short-Run Impact of different fiscal consolidation scenarios

<table>
<thead>
<tr>
<th>Fiscal instrument</th>
<th>(1) Lump Sum</th>
<th>(2) Consumption Tax</th>
<th>(3) Capital Tax</th>
<th>(4) Labor Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 years</td>
<td>2 years</td>
<td>Short Run(^{(a)})</td>
<td>0 years</td>
</tr>
<tr>
<td>C/Y</td>
<td>-0.67</td>
<td>-0.67</td>
<td>-0.69</td>
<td>-0.71</td>
</tr>
<tr>
<td>I/Y</td>
<td>2.13</td>
<td>2.13</td>
<td>2.20</td>
<td>2.26</td>
</tr>
<tr>
<td>H/K</td>
<td>-0.71</td>
<td>-1.39</td>
<td>-1.43</td>
<td>-1.90</td>
</tr>
<tr>
<td>K/Y</td>
<td>0.39</td>
<td>0.92</td>
<td>0.97</td>
<td>1.06</td>
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<tr>
<td>Annual growth rate (%-point)</td>
<td>-0.20</td>
<td>0.05</td>
<td>0.02</td>
<td>-0.54</td>
</tr>
<tr>
<td>Interest rate</td>
<td>-0.83</td>
<td>-1.95</td>
<td>-2.05</td>
<td>-2.24</td>
</tr>
<tr>
<td>Labor supply</td>
<td>-0.09</td>
<td>-0.21</td>
<td>-0.24</td>
<td>-1.42</td>
</tr>
<tr>
<td>Time spent on education (20-34)</td>
<td>7.41</td>
<td>8.25</td>
<td>8.42</td>
<td>10.28</td>
</tr>
<tr>
<td>Real wage</td>
<td>0.09</td>
<td>0.28</td>
<td>0.29</td>
<td>0.62</td>
</tr>
</tbody>
</table>

<table>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 years</td>
<td>2 years</td>
<td>Short Run(^{(a)})</td>
<td>0 years</td>
</tr>
<tr>
<td>C/Y</td>
<td>3.71</td>
<td>3.34</td>
<td>2.80</td>
<td>3.00</td>
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<tr>
<td>I/Y</td>
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<td>3.84</td>
<td>5.58</td>
<td>4.93</td>
</tr>
<tr>
<td>H/K</td>
<td>-2.14</td>
<td>-2.69</td>
<td>-3.04</td>
<td>0.27</td>
</tr>
<tr>
<td>K/Y</td>
<td>1.20</td>
<td>1.73</td>
<td>2.05</td>
<td>-0.15</td>
</tr>
<tr>
<td>Annual growth rate (%-point)</td>
<td>-0.60</td>
<td>0.07</td>
<td>0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>Interest rate</td>
<td>-2.52</td>
<td>-3.63</td>
<td>-4.27</td>
<td>0.32</td>
</tr>
<tr>
<td>Labor supply</td>
<td>-1.61</td>
<td>-1.62</td>
<td>-1.50</td>
<td>-0.02</td>
</tr>
<tr>
<td>Time spent on education (20-34)</td>
<td>11.32</td>
<td>12.55</td>
<td>12.33</td>
<td>-8.18</td>
</tr>
<tr>
<td>Real wage</td>
<td>0.70</td>
<td>0.77</td>
<td>0.86</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Notes: All effects expressed in %, except when indicated otherwise.

\(^{(a)}\) Average effect from time of implementing the consolidation programme until the time when debt-to-GDP ratio is below 5%.
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