UNIVERSITEIT
GENT

FACULTEIT ECONOMIE
EN BEDRIJFSKUNDE

TWEEKERKENSTRAAT 2
B-9000 GENT
Tel. : 32 - (0)9 – 264.34.61
Fax. : 32 - (0)9 – 264.35.92

# WORKING PAPER

# Fiscal policy, employment by age, and growth in OECD economies

**Freddy Heylen**
**Renaat Van de Kerckhove**

This version : September 2010
First version: December 2009

2009/623

D/2009/7012/75

# Fiscal policy, employment by age, and growth in OECD economies

**Freddy Heylen and Renaat Van de Kerckhove**

***SHERPPA, Ghent University***

September 2010

**Abstract**

We build and parameterize a general equilibrium OLG model for an open economy to jointly study hours of work of young, middle aged and older individuals, education of the young, and aggregate per capita growth. The composition of taxes and government expenditures plays a crucial role in our model. We find that our model's predictions match the facts remarkably well for all key variables in many OECD countries. We then use the model to investigate the effectiveness of various fiscal policy measures in promoting employment and growth. We also evaluate welfare effects for current and future generations.

**Key words:** employment by age, endogenous growth, fiscal policy, human capital, overlapping generations

**JEL Classification:** E62, J22, O41

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Correspondence to Freddy.Heylen@UGent.be, SHERPPA, Ghent University, Tweekerkenstraat 2, B-9000 Ghent, Belgium, Phone +32 9 264.34.85.

Acknowledgements: We thank Raouf Boucekkine, Tim Buyse, David de la Croix, Koen Hendrickx, Glenn Rayp, Dirk Van de gaer, the members of SHERPPA and the members of Steunpunt Fiscaliteit en Begroting for constructive comments and discussions during the development of this paper. We also benefited from comments received at the 15th International Conference on Computing in Economics and Finance (Sydney, July 2009), at the 25th Annual Congress of the European Economic Association (Glasgow, August 2010) and during seminars in Brussels, Lille and Louvain. We are grateful also to Tatiana Gordine (OECD) for her help in the construction of non-employment benefit replacement data.
We acknowledge support from the Flemish government (Steunpunt Fiscaliteit en Begroting - Vlaanderen) and the Belgian Program on Interuniversity Poles of Attraction, initiated by the Belgian State, Federal Office for scientific, technical and cultural affairs, contract UAP No. P 6/07. Any remaining errors are ours.

## 1. Introduction

Employment and growth vary widely across OECD countries. Americans are known to work more than Europeans. Some Europeans are known to work more than others. Employment is low in particular in many countries of the euro area. During the last decades, core euro area countries like Germany, France and Italy also had relatively low per capita growth. Growth was clearly stronger on average in the Nordic countries, at least since the mid 1990s. The reasons for these cross-country differences have been the subject of intense discussion in the economic literature. In recent years the importance of finding convincing explanations for what drives employment and growth has only increased. Rising pressure on social security and pension systems due to ageing as well as the risk of persistent output and job losses due to the recent financial crisis have strengthened in all countries the need to develop effective employment and growth policies.

When it comes to employment, almost all studies emphasize the role of unemployment benefit systems and labor taxes, although the importance attached to them may differ. In addition to these determinants, many authors see a major role for labor and product market characteristics, like employment protection legislation, union power, wage bargaining systems, and barriers to entry (e.g. Blanchard and Wolfers, 2000; Daveri and Tabellini, 2000; Alesina *et al.*, 2005; Nickell *et al.*, 2005; Faggio and Nickell, 2007; Berger and Everaert, 2010). Other authors pay no attention to differences in market characteristics, but explore in greater detail the influence of fiscal policy. In their view, differences in the level and composition of taxes and government expenditures are key to explain differences in employment (Prescott, 2004; Rogerson, 2006, 2007; Dhont and Heylen, 2008, 2009; Ohanian *et al.*, 2008; Olovsson, 2009).

When it comes to growth, market characteristics and fiscal policy composition are again at the centre of the discussion. Market characteristics are important in the 'innovation-based' models, first developed by Romer (1990) and Aghion and Howitt (1992). For example, Nicoletti and Scarpetta (2003) and Aghion and Howitt (2006) see higher entry costs, less intense competition and lower firm turnover as an important part of the explanation for many European countries' disappointing growth since the 1990s. Other authors analyze growth and growth differences within the alternative 'capital-accumulation' endogenous growth framework, going back to Lucas (1988), Barro (1990) and King and Rebelo (1990). The level and structure of taxes and government expenditures explain observed growth differences in e.g. Kneller *et al.* (1999), Daveri and Tabellini (2000) and Dhont and Heylen (2009). Roeger and De Fiore (1999) combine both perspectives to explain weak European growth during the last decades.

In both perspectives on growth, education and education policy play an important role. Krueger and Kumar (2004) and Aghion and Howitt (2006) emphasize the importance of tertiary education in times of rapid innovation and the need for new technology adoption. In their view, weaker growth in many European countries in recent decades is due also to a relative focus on secondary and skill-specific education, implying a tertiary education deficit compared to the US. Fiscal policy models often have education expenditures/subsidies as a major component of (productive) government expenditures, enhancing effective human capital accumulation and possibly growth (e.g. Glomm and Ravikumar, 1992, 1997; Buiter and Kletzer, 1993; Docquier and Michel, 1999; Kaganovich and Zilcha, 1999; Bouzahzah *et al.*, 2002; Blankenau and Simpson, 2004; Glomm and Kaganovich, 2008; Dhont and Heylen, 2009). In related empirical applications, Blankenau *et al*. (2007) and Dhont and Heylen (2009) show that differences in education expenditures contribute significantly to explain growth differences. Nijkamp and Poot (2004) have recently shown the empirical importance of public education expenditures for growth in a meta-analysis. Hanushek and Woessmann (2009) emphasize the crucial role of education quality and the institutional features of the schooling system.

The above mentioned literature has strongly improved our understanding of employment and growth at both sides of the Atlantic. Still, there is room for progress. First, most of the above mentioned studies focus on only one aspect of macro performance, either employment or growth. Models explaining employment differences generally disregard growth, some exceptions notwithstanding (Roeger and de Fiore, 1999; Daveri and Tabellini, 2000; Dhont and Heylen, 2008). Models explaining education and growth generally disregard labor supply and the labor-leisure choice. Second, with the exception of Rogerson (2006), Faggio and Nickell (2007) and Rogerson and Wallenius (2009), existing employment studies neglect life cycle patterns in labor supply and employment differences across age groups. The data, however, show that in all countries the middle aged work more hours than the young and the older. Furthermore, the employment gap between many European countries and the US is much stronger for the young and the older than for the middle aged.

Our first objective in this paper is to construct and parameterize a general equilibrium OLG model for an open economy which jointly explains the employment rate of young, middle aged and older individuals, the fraction of time that young individuals allocate to (tertiary) education, and economic growth. Given that employment (by age), education and growth are related, analysis within one coherent framework is important. For example, the level of employment determines the marginal productivity of capital and therefore the incentive to invest (e.g. Daveri and Tabellini, 2000; Turnovsky, 2000). Also, due to a possible tradeoff between employment of the young and education, and given the importance of education for growth, employment by age matters in the analysis of growth. In line with this, if people expect to work longer, the return to education when young may rise. So may human capital accumulation and growth. Our model is situated within the 'capital – accumulation' fiscal policy tradition, with education playing a major role in the growth process. In line with most of this literature, we assume competitive markets. However, unlike the existing OLG literature in this tradition (see the above mentioned studies), we introduce a choice between labor and leisure for each generation and no longer assume labor supply to be inelastic. The composition of taxes and government expenditures plays a crucial role in our model. The government sets tax rates on labor, capital and consumption. It allocates its revenue to productive expenditures (mainly for education), consumption and 'non-employment' benefits. Labor taxes and benefits may differ across age groups. As a second objective of this paper, we simulate our model to investigate the effectiveness of various fiscal policy measures in promoting employment and growth. We also evaluate welfare effects for current and future generations. We study both transitional dynamics and steady state effects.

Before we use our model for policy analysis we demonstrate that its predictions match the main facts. These facts concern the observed differences across 13 OECD countries in hours of work in three age groups (20-34, 35-49, 50-64), education of the young (20-34), and per capita growth since 1995. The set of countries that we focus on is larger than in many papers on the debate of the US versus Europe. Next to the US and the core countries of the euro area we also include the UK, Canada and the Nordic countries. To have a model which can match most of these cross-country differences is important. Stokey and Rebelo (1995) have shown that the variation in the predictions of existing calibrated fiscal policy models is extreme. Results seem to be very sensitive to the choice of some parameters, which makes these models vulnerable to criticism when they are used for policy analysis. A particular problem in models with education is the specification and parameterization of the human capital production function. In contrast to goods production functions, there is not much empirical evidence about what the human capital production function should be (Bouzahzah *et al.*, 2002). All this makes a prior test of the 'goodness of fit' of a model useful and informative. Our procedure goes further than what is standard in the literature. First we calibrate important parameters to make the model correctly predict the *average values* of growth, employment in three age groups, and education, in the group of 13 countries. Then, the important test is whether the model can explain the *variation* in these variables *across all individual countries*. To obtain the model's predictions, we impose the same preference parameters and technology in all countries. Performance differences are due only to variation in fiscal policy composition and in the quality of education. We find that the predictions of our model match the facts remarkably well for all key variables in most countries. Our results also allow us to reduce the uncertainty in existing literature about the specification of the human capital accumulation function.

Our main findings on policy are the following. We identify labor taxes and 'non-employment' benefits as the main policy variables affecting employment. Effects are the strongest when policy focuses on younger or older workers. Productive government expenditures are the most effective with respect to long-run output and growth. Furthermore, we observe that output and growth may benefit also from labor tax cuts targeted at older workers. By contrast, tax cuts targeted at younger workers and non-employment benefit reductions tend to imply lower future output and growth since they may discourage the young to study. The net output and growth effects of overall labor tax cuts are positive, but very small. Capital tax cuts have relatively strong positive effects on the level of output in the short run, but a negligible effect on long-run growth. In general, the size of the effects that we obtain is well within the range of existing studies, although often at the lower end. A key policy implication of our results for many European countries would be to cut non-employment benefits, and to reallocate these resources to tax cuts on older workers and higher productive expenditures. From a welfare perspective, these policies are beneficial to current young and future generations, but only some are likely to get support from current middle aged, older and retired individuals.

The structure of the paper is as follows. In Section 2 we document differences in employment by age, education of the young and per capita growth across 13 OECD countries since 1995. Section 3 sets out our model. In Section 4 we calibrate the model on actual data and confront its predictions with the facts described in Section 2. Sections 5 and 6 include the results of a wide range of model simulations. In Section 5 we discuss the long-run equilibrium effects of policy changes, in Section 6 the transitional dynamics, and the welfare effects per generation. Section 7 concludes the paper.

## 2. Cross-country differences in employment by age, tertiary education and per capita growth

Table 1 contains the data that we try to explain in this paper. The employment rate in hours ($n$) indicates the fraction of potential hours that are actually being worked by the average person in one of three age groups (20-34, 35-49, 50-64). Potential hours per person per year are assumed to be 2080 (52 weeks times 40 hours per week). The observed employment rate rises if more people in an age group have a job, and if the employed work more hours. The education rate ($e$) is our proxy for the fraction of time spent studying by the average person of age 20-34. It has been calculated as the

**Table 1**
Employment rate in hours ($n$), education rate ($e$) and per capita growth in OECD countries (1995-2006/7, in %)

| | $n_1$ (20-34) | $n_2$ (35-49) | $n_3$ (50-64) | $e$ | *annual real per capita growth* |
|---|---|---|---|---|---|
| Austria | 59.9 | 64.3 | 34.7 | 12.5 | 2.06 |
| Belgium | 51.1 | 56.8 | 29.3 | 14.1 | 1.77 |
| France | 48.7 | 60.3 | 38.0 | 14.9 | 1.54 |
| Germany | 49.7 | 55.2 | 34.9 | 17.2 | 1.56 |
| Italy | 50.1 | 61.9 | 33.8 | 12.6 | 1.30 |
| Netherlands | 50.8 | 54.6 | 34.2 | 14.7 | 2.20 |
| **Core euro area Average** | **51.7** | **58.8** | **34.2** | **14.3** | **1.74** |
| Denmark | 56.2 | 66.7 | 49.6 | 21.7 | 1.81 |
| Finland | 55.6 | 69.0 | 47.3 | 23.1 | 2.72 |
| Norway | 51.9 | 60.9 | 50.6 | 18.1 | 2.29 |
| Sweden | 53.6 | 66.1 | 55.4 | 17.7 | 2.18 |
| **Nordic Average** | **54.3** | **65.6** | **50.7** | **20.2** | **2.25** |
| **US** | **65.6** | **74.2** | **59.6** | **12.8** | **1.54** |
| UK | 60.8 | 68.4 | 49.4 | 12.3 | 2.13 |
| Canada | 60.9 | 69.5 | 50.4 | 13.6 | 1.68 |
| **All country average** | **55.0** | **63.7** | **43.6** | **15.8** | **1.91** |

Data sources: OECD (see Appendix 1); data description: see main text and Appendix 1. The data for employment and growth concern 1995-2007, those for education 1995-2006.

total number of students in full-time equivalents, divided by total population in this age group. Our data for (average annual) real per capita growth concern real potential GDP per person of working age. We refer to Appendix 1 for further details on the calculation of all our data, and on the assumptions that we have to make.

As is well-known, middle aged individuals work most hours, followed by the young. The older generation works the lowest number of hours. Average employment rates over all countries in these three age groups are 63.7%, 55.0% and 43.6% respectively. Furthermore, the data reveal strong cross-country differences. We observe the highest employment rates in each age group in the US. Employment rates are much lower in the core countries of the euro area. The Nordic countries take intermediate positions, although they are close to the core euro area for the younger generation[1]. The latter, however, seems to be related to education. Young people's participation in education is by far the highest in the Nordic countries. These countries also show the highest potential per capita growth rates. On average, growth in the core euro area and the US was more than 0.5 percentage

[1] Note that the US' lead in the employment rate in hours is mainly due to higher hours worked per employed person. In Appendix 2 we report additional data for the employment rate in persons. These are higher on average in the Nordic countries than in the US. The core euro area countries are also much closer to the US when one considers employment in persons, especially among the middle aged.

points lower in the period under consideration. The Anglo-Saxon countries tend to have the lowest participation in education among people of age 20 to 34.

If we look at the data in greater detail, some countries tend to deviate strongly from these general patterns. Within the Nordic group, employment is low in Norway, except for older workers. Austria has much higher employment among young and middle aged individuals than the other euro area countries. Participation of young people in education is fairly low in Austria, however.

### 3. The model

Our analytical framework consists of a computable four-period OLG-model for a small open economy. We assume perfect international mobility of physical capital but immobile labor and human capital. We consider three active adult generations, the young, the middle aged and the older, and one generation of retired agents. Within each generation agents are homogeneous. We assume that all generations are of equal size, normalized to 1. Each period is modeled to last for 15 years. This also means that retirement age and the retirement decision are exogenous in our model. New is that education of the young and human capital accumulation, per capita growth, and employment in each of three age groups are jointly endogenous[2].

In each period people are endowed with one unit of time. Young people can choose either to work and generate labor income, to study and build human capital, or to devote time to 'leisure' (including other non-market activities). Middle aged and older workers do not study anymore, they only work or have 'leisure'. Active generations allocate their income partly to consumption and partly to savings. The retired only consume. They do not work, and leave neither bequests nor debts. Economy-wide savings generate the stock of non-human wealth. Non-human wealth is held as physical capital employed in domestic or foreign firms. The rate of return on non-human wealth is the (exogenous) world real interest rate. Domestic firms act competitively and employ physical capital together with existing technology and effective labor provided by the three active generations. A final important assumption is that education generates a positive externality in the sense of Azariadis and Drazen (1990). The average level of human capital of a middle aged generation is inherited by the next young generation. In what follows, we concentrate on the core elements of the model: the optimizing behavior of individuals, the production of effective human capital, the behavior of domestic firms and the determination of aggregate output and growth, capital and wages.

[2] Seminal work in the OLG tradition has been done by Samuelson (1958) and Diamond (1965). Auerbach and Kotlikoff (1987) initiated the study of public finance shocks in a computable OLG model. Buiter and Kletzer (1993) developed an open economy version of the model putting human capital at the centre. Many authors have constructed OLG models explaining education of the young and growth, as functions of fiscal policy variables (e.g. Glomm and Ravikumar, 1992, 1997; Buiter and Kletzer, 1993; Kaganovich and Zilcha, 1999; Docquier and Michel, 1999; Bouzahzah *et al*., 2002; Blankenau and Simpson, 2004; Glomm and Kaganovich, 2008). However, labor supply and employment have generally been disregarded, or assumed inelastic in this literature. Fougère *et al.* (2009) is the only study we know that also introduces a labor-leisure choice and endogenous employment in an OLG model with endogenous education and growth. However, the focus of this study is on the effects of population ageing, not on fiscal policy. Moreover, it concerns only one country (Canada).

3.1. Individuals

An individual reaching age 20 in $t$ maximizes an intertemporal utility function of the form:

$$u^t = \sum_{j=1}^{4} \beta^{j-1} \left( \ln c_j^t + \gamma_j \frac{(1-e_j^t - n_j^t)^{1-\theta}}{1-\theta} \right) \tag{1}$$

with $\gamma_j$>0, $\theta$>0 ($\theta \neq 1$) and where we shall impose that $e_2=e_3=e_4=n_4=0$. Superscript $t$ indicates the period of youth, when the individual comes into the model. Subscript $j$ refers to the $j$th period of life. In line with our data presented in Section 2, periods are considered to last for 15 years. Furthermore, $\beta$ is the discount factor ($0<\beta<1$). Lifetime utility depends on consumption ($c_j$) and 'leisure' in each period of life, with 'leisure' falling in labor supply ($n_j$) during the three active periods and in education time ($e_1$) when young. (Since individuals only allocate time to education in their first period, we drop the subscript 1 in what follows). 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). Individuals will choose consumption, labor supply and education to maximize Equation (1), subject to the constraints described in (2)-(7).

$$(1+\tau_c)c_1^t + s_1^t = w_t h_1^t n_1^t (1-\tau_1) + b_1 w_t h_1^t (1-\tau_1)(1-n_1^t - e^t) + z_t \tag{2}$$

$$(1+\tau_c)c_2^t + s_2^t = w_{t+1} h_2^t n_2^t (1-\tau_2) + b_2 w_{t+1} h_2^t (1-\tau_2)(1-n_2^t) + (1+r_{t+1})s_1^t + z_{t+1} \tag{3}$$

$$(1+\tau_c)c_3^t + s_3^t = w_{t+2} h_3^t n_3^t (1-\tau_3) + b_3 w_{t+2} h_3^t (1-\tau_3)(1-n_3^t) + (1+r_{t+2})s_2^t + z_{t+2} \tag{4}$$

$$(1+\tau_c)c_4^t = (1+r_{t+3})s_3^t + z_{t+3} \tag{5}$$

with:
$$h_1^t = h_2^{t-1} \tag{6}$$

$$h_3^t = h_2^t = \left(1+\psi(e^t, g_y, q)\right) h_1^t \qquad \psi>0,\ \psi'(.)>0 \tag{7}$$

The LHS of Equations (2)-(5) shows that individuals allocate their disposable income to consumption (including consumption taxes, $\tau_c$) and savings. Disposable income at the RHS includes after-tax labor income, non-employment benefits, interest income and lump sum transfers. In each equation, $w_k$ stands for the real wage per unit of effective labor at time $k$, $r_k$ is the (world) real interest rate paid on savings collected in period $k$-$1$ and held to $k$. Effective labor of an individual depends on hours worked ($n_j^t$) and effective human capital ($h_j^t$). Since young individuals pay a tax rate on labor income $\tau_1$, they earn an after-tax real wage equal to $w_t h_1^t n_1^t (1-\tau_1)$. After-tax labor income when middle aged and older in Equations (3) and (4) is determined similarly. A young worker inherits his effective human capital from the middle aged generation, as shown in Equation (6). During the second and third period, workers supply more units of effective human capital. It is our assumption in Equation (7) that $h$, and therefore worker productivity, rise in education time when young ($e$), productive government spending in percent of GDP ($g_y$, mainly education) and the quality of education ($q$). We specify and discuss the effective human capital production function in Section 3.2. Individuals take $g_y$ and $q$ as exogenous. We assume that human capital remains unchanged between the second and third period. We have in mind that learning by doing in work may counteract depreciation. For the fraction of time that individuals are inactive, they receive a non-employment benefit from the government. The benefit replacement rate $b_j$ is defined as a proportion of the after-tax wage of a fulltime worker. Finally, in each period $k$, individuals also receive a lump sum transfer ($z_k$) from the government. Retired individuals in Equation (5) have no labor income and no benefits. They consume their savings from the third period, plus interest, and the lump sum transfer.

Maximizing with respect to $s_1^t, s_2^t, s_3^t, n_1^t, n_2^t, n_3^t$ and $e^t$ yields seven first order conditions for optimal behavior of an individual entering the model at time $t$. Equation (8) expresses the law of motion of optimal consumption over the lifetime. Equations (9.a) and (9.b) describe the optimal labor-leisure choice in each period of active live. Individuals supply labor up to the point where the marginal utility of leisure equals the marginal utility gain from work. The latter will rise when the marginal utility of consumption $(1/c_j^t)$ is higher, and when an extra hour of work yields more extra consumption. Higher human capital (and its underlying determinants), lower taxes on labor, lower taxes on consumption and lower non-employment benefits contribute to the gain from work. Equation (10) imposes that the marginal utility loss from investing in human capital when young equals the total discounted marginal utility gain in later periods from having more human capital. Individuals will study more the higher future versus current after-tax real wages and the higher the marginal return of education to human capital $(\partial\psi/\partial e)$. Labor taxes during youth therefore encourage individuals to study, whereas labor taxes in later periods of active life discourage them. Notice also that high benefit replacement rates in later periods ($b_2$, $b_3$) will encourage young individuals to study. The reason is that any future benefits rise in future human capital. A final interesting result is that young people study more – all other things equal – if they expect to work harder in later periods ($n_2$, $n_3$).

$$\frac{c_{j+1}^t}{c_j^t} = \beta\left(1+r_{t+j}\right), \qquad \forall\, j = 1,2,3. \tag{8}$$

$$\frac{\gamma_1}{\left(1-n_1^t-e^t\right)^{\theta}} = \frac{w_t h_1^t\left(1-\tau_1\right)\left(1-b_1\right)}{(1+\tau_c)c_1^t} \tag{9.a}$$

$$\frac{\gamma_j}{\left(1-n_j^t\right)^{\theta}} = \frac{w_{t+j-1}\left(1+\psi\left(e^t,g_y,q\right)\right)h_1^t\left(1-\tau_j\right)\left(1-b_j\right)}{(1+\tau_c)c_j^t}, \qquad \forall\, j = 2,3 \tag{9.b}$$

$$\frac{1}{c_1^t}\left(\frac{w_t h_1^t(1-\tau_1)}{1+\tau_c}\right) = \sum_{j=2}^{3}\beta^{j-1}\frac{\partial\psi\left(e^t,g_y,q\right)}{\partial e^t}\left(\frac{w_{t+j-1}h_1^t\left(1-\tau_j\right)\left[n_j^t+b_j\left(1-n_j^t\right)\right]}{(1+\tau_c)c_j^t}\right) \tag{10}$$

3.2. Production of effective human capital

The specification of the human capital production function 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, the underlying functional form and parameter values (Bouzahzah *et al*, 2002; Arcalean and Schiopu, 2010). The literature shows a variety of specifications, 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, 1992, 1997; Docquier and Michel, 1999; Kaganovich and Zilcha, 1999; Bouzahzah *et al.*, 2002; Glomm and Kaganovich, 2008; Dhont and Heylen, 2009; Fougère *et al.*, 2009; Arcalean and Schiopu, 2010). In case of two inputs, the adopted functional form is very often Cobb-Douglas (e.g. Glomm and Ravikumar, 1992; Kaganovich and Zilcha, 1999; Docquier and Michel, 1999).

Our specification also includes education time of young individuals and education expenditures by the government. We see these variables as indicators for the quantity of invested private and public resources. However, we extend this in two directions. First, we take recent empirical evidence seriously that the quality of education and the schooling system is very important (Hanushek and Woessmann, 2009). Better quality implies higher cognitive skills for the same allocation of resources. As a proxy for quality we will use OECD PISA science scores (see Section 4.2) [3]. We concentrate on science scores given their expected closer link to growth. Although available PISA scores relate to secondary education, we do not see this as a weakness. They may be very informative about the quality with which young people enter tertiary education. Quality at entrance should have a positive influence on people's capacity to learn and to raise human capital during tertiary education. Furthermore, PISA scores have been found empirically significant for growth (Hanushek and Woessmann, 2009). Finally, these scores are easily available for all countries, which is not obvious for 'better' quality indicators. As a second extension, our definition of relevant (productive) government expenditures includes more than education. It also includes active labor market expenditures, public R&D expenditures and public fixed investment. This approach goes back to our use of the broader concept of *effective* human capital. As in Dhont and Heylen (2009), effective human capital (and worker productivity) rise not only in accumulated schooling or training, but also in the productive efficiency of accumulated schooling. Education and active labor market expenditures directly contribute to more human capital being accumulated, public R&D and fixed investment expenditures will mainly raise the productive efficiency of accumulated human capital. The hypothesis that public investment and infrastructure services may also matter for aggregate human capital, next to education expenditures, has been developed recently by Agénor (2008).

Equation (11) shows our specification for the growth rate of effective human capital. We adopt a flexible CES-specification in education time when young ($e$) and productive government expenditures in % of output ($g_y$). We add the quality of education ($q$) in a multiplicative way. In line with earlier explanation we allow $q$ to vary across countries in later sections. Next to $q$ we introduce (constant, common) technical parameters: $\phi$ is a positive efficiency parameter, $\sigma$ a scale parameter, $v$ is a share parameter and $\kappa$ the elasticity of substitution. These parameters will be calibrated.

$$\Psi(e, g_y, q) = \phi q \left( \nu g_y^{1-(1/\kappa)} + (1-\nu) e^{1-(1/\kappa)} \right)^{\sigma\kappa/(\kappa-1)} \tag{11}$$

[3] Many papers refer to quality of schooling as important for human capital production, but in general quality is not further operationalized. It is added as some constant parameter. Glomm and Ravikumar (1992, 1997) include public expenditures as a proxy for the quality of public schools. Empirical research, however, shows no clear relationship between public expenditures on education and student performance (e.g. Woessmann, 2003). Our discussion in Section 4.2. (Table 4) confirms this lack of relationship between expenditures and quality.

Lack of existing empirical evidence makes an ex-ante assessment of our specification very difficult. As we shall briefly discuss in Section 4.3., however, a confrontation of our model's predictions with the facts about education and growth reveals that our specification performs better than alternative specifications without quality, with a narrower definition of government expenditures or with a different functional form.

### 3.3. Domestic firms, output and factor prices

Firms act competitively on output and input markets and maximize profits. All firms are identical. Total domestic output ($Y_t$) is given by the production function (12). Technology exhibits constant returns to scale in aggregate physical capital ($K_t$) and effective labor ($H_t$), so that profits are zero in equilibrium. Equation (13) describes total effective labor supplied by young, middle aged and old workers. Note our assumption that each generation has size 1 and that young workers inherit the human capital of the middle aged ($h_1^t = h_2^{t-1}$).

$$Y_t = K_t^{\alpha} H_t^{1-\alpha} \tag{12}$$

$$H_t = n_1^t h_1^t + n_2^{t-1} h_2^{t-1} + n_3^{t-2} h_3^{t-2} = \left( n_1^t + n_2^{t-1} + \frac{n_3^{t-2}}{x_{t-1}} \right) h_1^t \tag{13}$$

with: $x_{t-1} = 1 + \psi(e^{t-1}, g_y, q)$

and where we use Equations (6) and (7).

Competitive behavior implies in Equation (14) that firms carry physical capital to the point where its after-tax marginal product equals the world real interest rate (see also Backus *et al.*, 2008). We assume no depreciation of physical capital. Capital taxes are source-based: the tax rate $\tau_k$ applies to the country in which the capital is used, regardless of who owns it. The real interest rate being given, firms will install more capital when the amount of effective labor increases or the capital tax rate falls. In that case the net return to investment in the home country rises above the world interest rate, and capital flows in. Furthermore, perfect competition implies equality between the real wage and the marginal product of effective labor (Equation 15). Higher real wages follow from an increase in physical capital per unit of effective labor. Taking into account (14), real wages per unit of effective labor will therefore fall in the world real interest rate and in domestic capital tax rates.

$$\alpha \left( \frac{H_t}{K_t} \right)^{1-\alpha} (1 - \tau_k) = r_t \tag{14}$$

$$(1-\alpha) \left( \frac{K_t}{H_t} \right)^{\alpha} = w_t \tag{15}$$

Rewriting (12) as

$$Y_t = \left( \frac{K_t}{H_t} \right)^{\alpha} H_t = \left( \frac{\alpha(1-\tau_k)}{r_t} \right)^{\alpha/(1-\alpha)} \left( n_1^t + n_2^{t-1} + \frac{n_3^{t-2}}{x_{t-1}} \right) h_1^t,$$

where we have substituted (13) for $H_t$ and (14) for $K_t/H_t$, and recognizing that in steady state $r$, $\tau_k$, $x$, $e$ and $n_j$ are constant, we obtain the long-run (per capita) growth rate of the economy as

$$ln\left(\frac{Y_t}{Y_{t-1}}\right)=ln\left(\frac{h_1^t}{h_1^{t-1}}\right)=ln\left(\frac{h_2^{t-1}}{h_1^{t-1}}\right)=ln(1+\psi(e,g_y,q)) \tag{16}$$

In line with earlier models (e.g., Lucas, 1988; Azariadis and Drazen, 1990; Buiter and Kletzer, 1993), the long-run (per capita) growth rate is positively related to the quality of schooling ($q$) and to the fraction of time that young people allocate to education ($e$). It is also positively related to the share of productive government expenditures ($g_y$), like in Barro (1990).

### 3.4. Government

The government runs a balanced budget. Productive expenditures, consumption, benefits related to non-employment, and lump sum transfers at time $t$ are financed by taxes on labor, capital and consumption.

$$G_{yt}+G_{ct}+B_t+Z_t=T_{nt}+T_{kt}+T_{ct} \tag{17}$$

with: $G_{yt}=g_yY_t$

$$G_{ct}=g_cY_t$$

$$B_t=(1-n_1^t-e^t)b_1w_th_1^t(1-\tau_1)+\sum_{j=2}^{3}(1-n_j^{t+1-j})b_jw_th_j^{t+1-j}(1-\tau_j)$$

$$Z_t=4z_t$$

$$T_{nt}=\sum_{j=1}^{3}n_j^{t+1-j}w_th_j^{t+1-j}\tau_j$$

$$T_{kt}=\tau_k\alpha Y_t$$

$$T_{ct}=\tau_c\sum_{j=1}^{4}c_j^{t+1-j}$$

Following Turnovsky (2000) and Dhont and Heylen (2009), we assume that the government claims given fractions $g_y$ and $g_c$ of output for productive expenditures and consumption. Non-employment benefits ($B_t$) 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 van der Ploeg, 2003; Rogerson, 2007; Dhont and Heylen, 2008, 2009). 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.

## 4. Parameterization and empirical relevance of the model

The economic environment described above allows us to simulate the transitory and steady state growth and employment effects of various fiscal policy changes. This simulation exercise requires us first to parameterize and solve the model. In Section 4.1 we discuss our choice of preference and technology parameters. Starting from actual cross-country fiscal policy data in Section 4.2, we compare in Section 4.3 our model's predictions with the employment and growth differences that we have reported in Table 1. This comparison provides a first and simple test of our model's empirical relevance. In Section 5 we consider long-run equilibrium effects of policy changes. Section 6 discusses transitional dynamics, and welfare effects per generation. To solve the model and to perform the simulations, we choose an algorithm that preserves the non-linear nature of our model. We follow the methodology basically proposed by Boucekkine (1995) and implemented by Juillard (1996) in the program Dynare. We use Dynare 4.0.

### 4.1. Preference and technology parameters

Table 2 contains an overview of all parameters. Following among others Barro (1990), we set the rate of time preference equal to 2% per year. Considering that periods in our model consist of 15 years, this choice implies a discount factor $\beta$ equal to 0.74. With respect to effective labor, we assume a share coefficient $1-\alpha$ equal to 0.7. This value is well in line with the literature. For example, King and Rebelo (1990) also model goods production as a function of effective labor (human capital) and physical capital. They assume a value for $1-\alpha$ equal to 2/3. There is more controversy in the literature about the value of the intertemporal elasticity of substitution in leisure ($1/\theta$). Micro studies often reveal very low elasticities. 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). In line with this, we impose $\theta$ to be equal to 2. The world real interest rate is assumed constant and equal to 3% per year, which is approximately the average real return on 10 year US government bonds in the last decade. Considering a period of 15 years, this implies that $r = 0.558$.

A second series of parameters have been determined by calibration: three taste for leisure parameters ($\gamma_1$, $\gamma_2$, $\gamma_3$) and two parameters in the human capital production function (the efficiency parameter $\phi$ and the scale parameter $\sigma$). We have calibrated these parameters to the average of all 13 countries in our study. They have been determined such that with observed average levels of the fiscal policy variables (tax rates, benefit replacement rates, etc.) and the observed average level of schooling quality ($q$)[4] over all countries, the model correctly predicts the average of these countries' employment rates ($n_1$, $n_2$, $n_3$), per capita growth rates and education rates ($e$) in 1995-2007. The bottom part of Table 2 reports these average employment, growth and education rates. We find that the taste for leisure rises with age ($\gamma_1$=0.045, $\gamma_2$=0.099, $\gamma_3$=0.187). Furthermore, we observe decreasing returns in human capital growth ($\sigma$=0.905) [5].

Finally, we had no strong ex ante indication on two parameters in the human capital production function: the share parameter $v$ and the elasticity of substitution parameter $\kappa$. We could assign sensible values to these parameters thanks to a sensitivity analysis on the results that we report in the next section. There we evaluate the capacity of our fiscal policy model to explain five important macro variables in 13 OECD countries. Our guideline to pin down specific values for $v$ and

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[4] And with the values of two parameters in the human capital production function ($v$, $\kappa$) that we discuss below (see also footnote 6).

[5] Note that changes in (the group of) countries for which we calibrate do not affect our basic parameters in any significant way. For example, calibrating to the US yields $\gamma_1$=0.04, $\gamma_2$=0.07, $\gamma_3$=0.14, $\sigma$=0.91. Calibrating to Belgium yields $\gamma_1$=0.04, $\gamma_2$=0.10, $\gamma_3$=0.18, $\sigma$=0.89.

$\kappa$ was to minimize the deviation of our model's predictions from the true data[6]. This procedure implied $v$=0.25 and $\kappa$ = 0.55. The result for $\kappa$ reveals a higher degree of complementarity between private education time and government expenditures than in the Cobb-Douglas case. The result for $v$ demonstrates relatively high importance for human capital formation of private education time versus productive public expenditures.

**Table 2** Basic parameterization and benchmark equilibrium

| | | | | |
|---|---|---|---|---|
| **Technology and preference parameters** | | | | |
| Production parameters (output) | | | $1-\alpha = 0.7$ | |
| Effective human capital production | | | $\phi = 3.856,\ v = 0.25,\ \kappa = 0.55,\ \sigma = 0.905$ | |
| Preference parameters | | | $\beta = 0.74,\ \theta = 2,\ \gamma_1 = 0.045,\ \gamma_2 = 0.099,\ \gamma_3 = 0.187$ | |
| World real interest rate | | | $r = 0.558$ | |
| **Fiscal policy parameters in benchmark** [(a, b)] | | | | |
| Government expenditures variables (in %) | | | $g_y = 10.1$, $g_c = 15.9$, $b_1 = 56.2, b_2 = 44.6, b_3 = 49.9$ | |
| Tax rates (in %) | | | $\tau_k = 22.1$, $\tau_1 = 51.7,\ \tau_2 = \tau_3 = 52.9$, $\tau_c = 14.3$ | |
| Average schooling quality in benchmark [(a, b)] | | | $q = 0.507$ | |
| **Benchmark equilibrium** [(a)] | | | | |
| ***$n_1$*** | ***$n_2$*** | ***$n_3$*** | ***Per capita growth (annual)*** | ***e*** |
| 55.0% | 63.7 % | 43.6 % | 1.91 % | 15.8 % |

Note: (a) Average for all 13 countries in Table 1; (b) For details on fiscal policy parameters and schooling quality, see the next section (Tables 3 and 4).

### 4.2. Fiscal policy and education quality

Tables 3 and 4 describe key characteristics of fiscal policy in 1995-2001/2004. Our proxy for the tax rate on labor income concerns the total tax wedge, for which we report the marginal rate in %. The data cover personal income taxes, employee and employer social security contributions payable on wage earnings and payroll taxes. The OECD publishes these tax data for several family and income situations. Considering that workers typically earn less when they are young (and have lower human capital) than when they are middle aged, we calculated our $\tau_1$ for each country as an average of marginal tax rates for lower to middle income families. Tax rates for middle aged and older workers were computed from OECD data for middle to higher income families[7]. As one can see in Table 3, however, differences within countries between $\tau_1$ on the one hand and $\tau_2$ and $\tau_3$ on the other, are very small. Cross-country differences are much bigger. Belgium, Germany, Sweden and Finland have marginal labor tax rates above 55% or even 60%. The US and the UK have marginal labor tax rates

[6] For each variable ($n_1$, $n_2$, $n_3$, $e$, growth) we computed the root mean squared error normalized to the mean. We minimized the average normalized RMSE over all five variables. (Minimizing only over $e$ and growth implied the same values for $v$ and $\kappa$). We then adopted the following iterative procedure. Given chosen values for $v$ and $\kappa$ we calibrated the efficiency parameter $\phi$ and the scale parameter $\sigma$. The values for $v$ and $\kappa$ had no influence on the calibration results for $\gamma_j$. Given the values for $\phi$ and $\sigma$, we checked whether changes in $v$ and $\kappa$ could further improve the model's explanatory power. New values for $v$ and $\kappa$ led to a recalibration of $\phi$ and $\sigma$, etc.

[7] For further details, see Appendix 1.

below, or close to, 40%. Capital tax rates are effective marginal corporate tax rates reported by the Institute for Fiscal Studies (their EMTR, base case). Germany and Belgium have the highest rates. In contrast to labor (and consumption), capital is taxed relatively little in the Nordic countries. As to consumption taxes, we follow Dhont and Heylen (2009) in computing them as the ratio of government indirect tax receipts (net of subsidies paid) to total domestic demand net of indirect taxes and subsidies. Our simplifying assumption is that consumption tax rates correspond to aggregate indirect tax rates. The Nordic countries stand out with the highest consumption tax rates, the US with the lowest.

**Table 3** Fiscal policy (Tax rates)

| | tax rate on labor income when young (%) | tax rate on labor income when middle age and older (in %) | consumption tax rate (%) | tax rate on capital income (%) |
|---|---|---|---|---|
| **Proxy for :** | $\tau_1$ | $\tau_2, \tau_3$ | $\tau_c$ | $\tau_k$ |
| Austria | 56.5 | 53.0 | 13.2 | 17.3 |
| Belgium | 66.6 | 67.6 | 13.4 | 27.1 |
| France | 52.4 | 53.3 | 17.1 | 21.7 |
| Germany | 62.5 | 60.0 | 11.1 | 34.4 |
| Italy | 54.7 | 57.1 | 14.7 | 14.9 |
| Netherlands | 52.3 | 51.6 | 12.2 | 24.3 |
| Denmark | 46.4 | 51.2 | 18.9 | 22.5 |
| Finland | 55.6 | 57.9 | 15.2 | 17.2 |
| Norway | 49.6 | 52.6 | 16.4 | 22.1 |
| Sweden | 54.5 | 58.1 | 17.9 | 16.1 |
| UK | 39.8 | 41.6 | 14.5 | 21.2 |
| US | 34.2 | 36.9 | 7.2 | 23.6 |
| Canada | 46.8 | 47.6 | 14.5 | 24.8 |
| **Overall country average** | 51.7 | 52.9 | 14.3 | 22.1 |

Notes: Labor tax rates are data for the total tax wedge, marginal rate (OECD, Taxing Wages). Data are for 2000-2004. Earlier data are not available. For details on the calculation of labor tax rates by age group, see Appendix 1. Capital tax rates are effective marginal corporate tax rates (Institute for Fiscal Studies, their EMTR; data are for 1995-2001, see also Devereux *et al*., 2002). Consumption tax rates are from Dhont and Heylen (2009). Data are for 1995-2001.

Table 4 summarizes our data for the expenditure side of fiscal policy. A first variable is our proxy for the net non-employment benefit replacement rate ($b_j$). Since in our model non-employment is a structural or equilibrium phenomenon, the data that we use concern net transfers received by structurally or long-term unemployed people. They include social assistance, family benefits and housing benefits in the 60$^{th}$ month of benefit receipt. They also include unemployment insurance or unemployment assistance benefits if these benefits are still paid, i.e. if workers can be structurally unemployed for more than five years without losing benefit eligibility[8]. The data are expressed in

[8] This is the case in Austria, Belgium, France, Germany, Finland, Ireland, and the UK. Workers cannot be structurally non-employed and still receive unemployment benefits in the Netherlands, Italy, Denmark, Norway, Sweden, Spain, Portugal, Switzerland and the US (OECD, 2004, www.oecd.org/els/social/workincentives, Benefits and Wages, country specific files).

**Table 4** Fiscal policy (net transfer replacement rates, government consumption, productive expenditures) and PISA education score

| | Non-employment transfer, young (net replacement rate, %) | Non-employment transfer, middle aged (net replacement rate, %) | Non-employment transfer, older (net replacement rate, %) | government consumption (% of GDP) | Government productive expenditure (% of GDP) | | PISA – science (divided by 1000) |
|---|---|---|---|---|---|---|---|
| **Proxy for :** | $b_1$ | $b_{2,}$ | $b_3$ | $g_c$ | $g_y$ | *educ* | *q* |
| Austria | 60.8 | 50.9 | 58.9 | 14.6 | 9.1 | 5.9 | 0.507 |
| Belgium | 65.1 | 51.7 | 62.3 | 16.9 | 8.9 | 5.5 | 0.505 |
| France | 52.3 | 38.3 | 49.0 | 18.3 | 11.0 | 5.9 | 0.502 |
| Germany | 65.4 | 59.7 | 63.8 | 15.3 | 8.6 | 4.7 | 0.502 |
| Italy | 18.5 | 15.3 | 34.0 | 14.3 | 8.0 | 4.8 | 0.480 |
| Netherlands | 62.5 | 46.6 | 55.8 | 18.4 | 10.3 | 5.0 | 0.525 |
| Denmark | 67.8 | 55.4 | 55.4 | 18.4 | 12.5 | 8.2 | 0.484 |
| Finland | 68.4 | 54.4 | 61.7 | 16.0 | 11.4 | 6.6 | 0.550 |
| Norway | 64.8 | 49.4 | 49.4 | 14.7 | 12.1 | 7.4 | 0.490 |
| Sweden | 62.8 | 47.8 | 47.8 | 20.0 | 14.0 | 7.9 | 0.507 |
| UK | 57.8 | 44.4 | 44.4 | 14.4 | 7.3 | 4.9 | 0.523 |
| US | 34.3 | 26.6 | 26.6 | 10.3 | 9.3 | 5.2 | 0.493 |
| Canada | 49.7 | 39.5 | 39.5 | 14.7 | 9.3 | 5.9 | 0.527 |
| **Overall country average** | 56.2 | 44.6 | 49.9 | 15.9 | 10.1 | 6.0 | 0.507 |

Notes: A description of all variables is given in the main text. For more details, see Appendix 1. The data for net benefit replacement rates are an average for 2001 and 2004 (earlier data are not available). The data for government consumption and productive expenditures concern 1995-2001. The PISA science scores are an average for 2000, 2003 and 2006.

percent of after-tax wages. In line with our approach to determine labor tax rates by age group, we are again guided by the same family and income cases to determine $b_1$, $b_2$ and $b_3$ (see Appendix 1). The difference between $b_2$ and $b_3$ (with the latter being higher) in some countries reflects the availability of generous early retirement regimes[9]. Overall, the euro area and the Nordic countries pay the highest net benefits. The only exception is Italy. Transfers to structurally non-employed people are by far the lowest in the US.

Our data for productive government expenditures ($g_y$) in Table 4 include education, active labor market expenditures, government financed R&D and public investment. As can be seen, we also report education expenditures separately. On average, education expenditures constitute close to 60% of total $g_y$. Governments in the Nordic countries allocate by far the highest fractions of output to productive expenditures. Productive expenditures in percent of GDP are the lowest in the UK. The US and most core countries of the euro area take intermediate positions. Government consumption in percent of GDP is the highest also in the Nordic countries, followed at close distance by several

[9] To assess the generosity of early retirement we rely on data for the implicit tax rate on continued work in the early retirement route (see Duval, 2003; Brandt *et al.*, 2005). For further details on the calculation of $b_3$ we refer to Appendix 1.

countries of the core euro area[10]. In the US, government consumption is (much) lower. As a final variable in Table 4 we include PISA science scores. We use these data as a proxy for the quality of schooling (*q*) in the human capital production function (11). Finland scores best, followed by the Netherlands, Canada and the UK. Note that there is no correlation at all in Table 4 between productive government expenditures and the PISA score. Correlation is -0.04. Correlation between public education expenditures and the PISA score is -0.12. Both variables seem to tell different stories (see also Woessmann, 2003).

### 4.3 Predicted versus actual employment by age, education of young and growth in the OECD

Can our model match the facts that we have reported in Table 1? In this section we confront our model's predictions with the true data for 1995-2006/2007. Clearly, one should be aware of the serious limitations of such an exercise. First of all, our model is highly stylized and may (obviously) miss potential determinants of growth or employment. Second, even if we compute the true data in Table 1 as averages over a longer period, these averages need not be equal to the steady state. Countries may still be moving towards their steady state[11]. Third, this exercise only concerns the last 15 years. Due to lack of data – especially with respect to marginal labor tax rates and non-employment benefits before the mid 1990s – it is impossible for us to relate changes in growth and employment to changes in policy within countries over longer time periods. In spite of all this, if one considers the extreme variation in the predictions of existing calibrated models investigating the effects of fiscal policy in the literature (see Stokey and Rebelo, 1995), even a minimal test of the 'goodness of fit' of our model is informative. This information is important to assess the value of the simulation results that we present in the next section, and their reliability for policy analysis. In most papers in the literature a test of the external validity of the model is missing.

Our calibration implies that our model's prediction matches the average over all 13 countries of employment rates by age, education and per capita growth. The test of the model's validity is whether it also matches individual country data, and cross-country differences. Before one uses a model for policy analysis, one would like to see for example that the model does not overestimate, nor underestimate the performance differences related to observed cross-country policy differences. Our test is tough since we impose the same preference and technology parameters, reported in the upper part of Table 2, on all countries. Moreover, assuming perfect competition, we disregard differences in labor and product market institutions which some authors consider of crucial importance (see Section 1). Still, we find that the model matches the facts remarkably well for a large majority of countries.

Figures 1 to 3 relate our model's predictions to actual observations for the three employment rates. We add the 45°-line, and also report the coefficient of correlation between predictions and facts. Our model performs quite well for the employment rates of middle aged and older workers (Figures 2 and 3). It correctly predicts the highest employment rates in the US and

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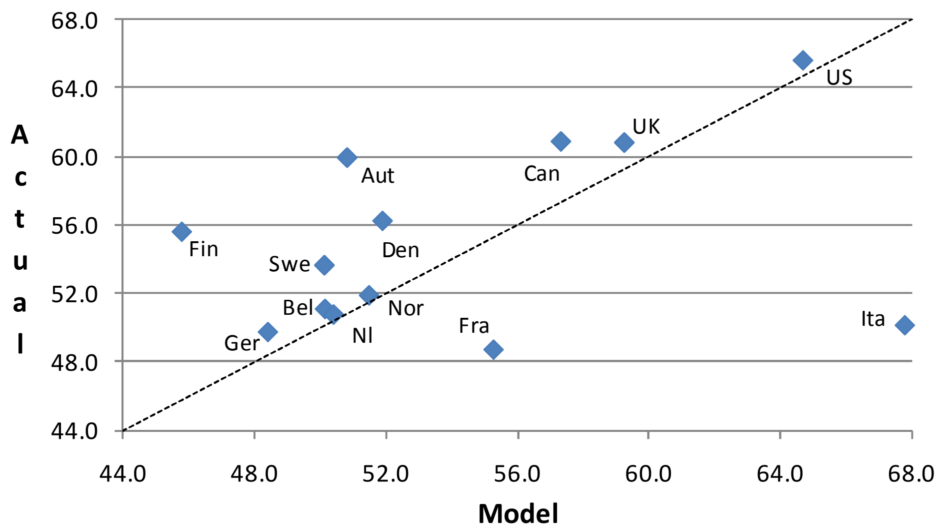
[10] Like Dhont and Heylen (2009) we calculate our data for government consumption as total government consumption in % of GDP, diminished with the fraction of public education outlays going to wages and working-expenses. The latter are included in productive expenditures.

[11] This argument explains why we have not included convergence countries like Ireland and Portugal in our dataset. It also explains why we calibrate technical and preference parameters to the average of all 13 countries, rather than to one individual country. Differences between actual and steady state values of individual countries may cancel out in this overall average.

Canada and – within Europe – relatively strong employment in the Nordic countries and the UK. The model also correctly predicts the rather poor employment performance in countries like Germany and Belgium. Overall correlation in Figure 2 is 0.54, in Figure 3 it is 0.74. Moreover, the slope of the regression line (not shown) in both figures is very close to the 45°-line. This suggests that our model correctly assesses the size of the employment effects of fiscal policy differences across countries. The model explains less well, however, for Finland and The Netherlands in both figures, and for Italy in Figure 3. Deviations between the model and the facts are somewhat more important for the employment rate of young workers in Figure 1. We observe the largest differences for Austria, Finland and especially Italy. A major element behind the deviation for Italy may be underestimation of the fallback income position for structurally non-employed young workers. OECD data show very low replacement rates in Italy. However, as shown by Reyneri (1994), the gap between Italy and the other European countries is much smaller than it seems[12]. Including Italy, correlation between our model's predictions and the facts in Figure 1 is only 0.33. Excluding Italy, it is 0.68. Although the model tends to underestimate the employment rate of young workers in countries like Austria, Denmark and Finland, it has major differences between European countries and the US right.

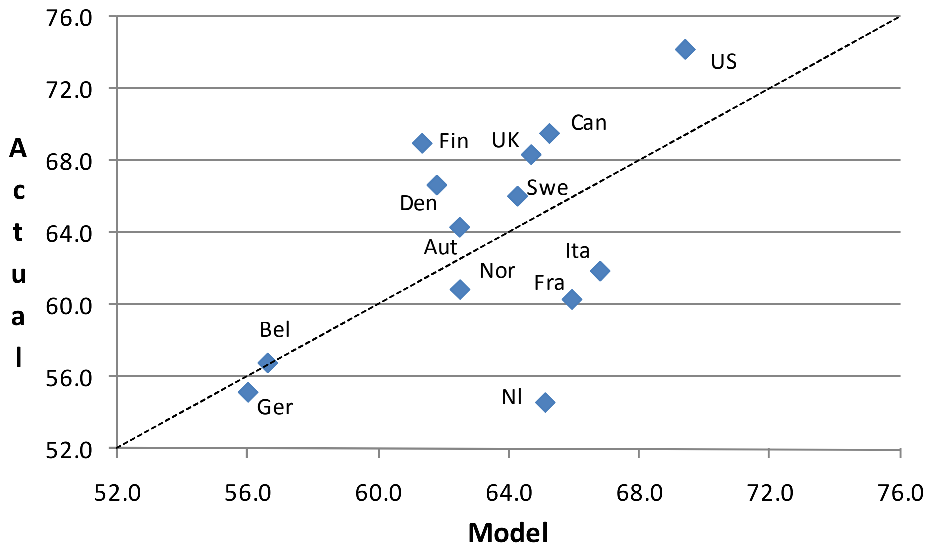
**Figure 1.** Employment rate in hours of young individuals in 13 countries, in %, 1995-2007




Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.33. Excluding Italy correlation rises to 0.68.

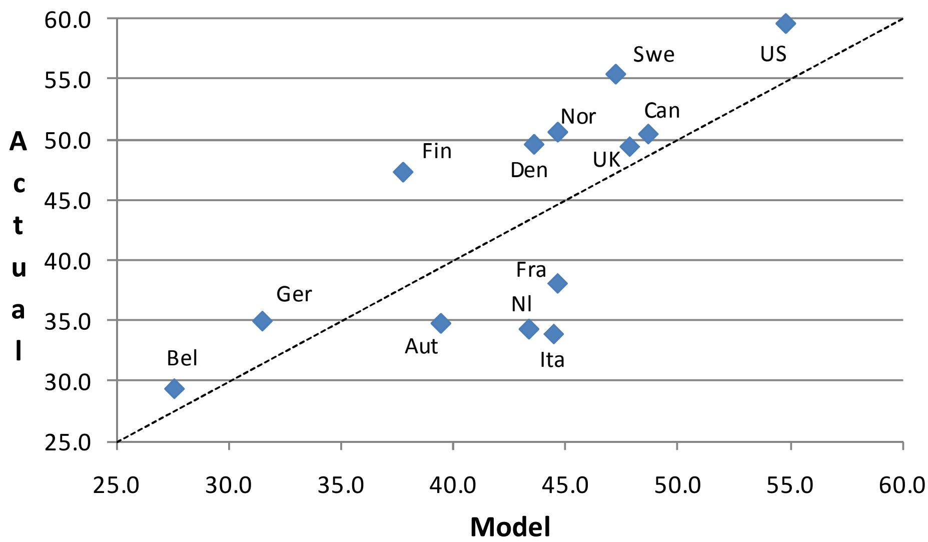
[12] Reyneri (1994) points to the importance of family support as an alternative to unemployment benefits. Fernández Cordón (2001) shows that in Italy young people live much longer with their parents than in the other countries in our sample. In 1995 for example about 56% of people aged 25-29 were still living with their parents in Italy. In about all other countries this fraction was below 23%. Of all non-working males aged 25-29 in Italy more than 80% were living with their parents. In France or Germany the corresponding numbers were close to 40%.

**Figure 2.** Employment rate in hours of middle aged individuals in 13 countries, in %, 1995-2007




Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.54.

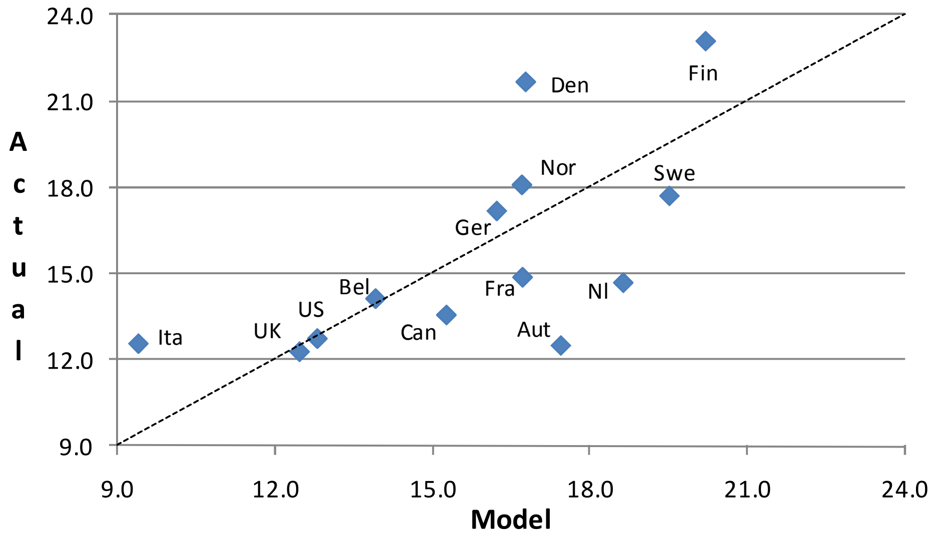
**Figure 3.** Employment rate in hours of older individuals in individual countries, in %, 1995-2007




Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.74.

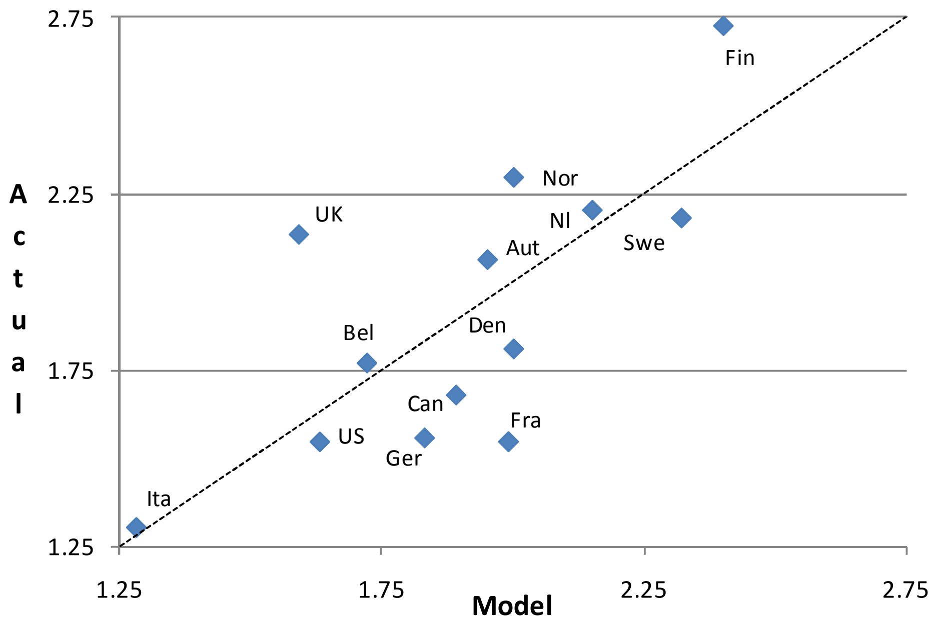
In Figures 4 and 5 we relate our model's predictions to the facts for education and growth. The model performs well for both variables. For education it correctly captures key differences between the Nordic countries on the one hand and countries like the UK, Italy and Belgium on the other. Predictions for education are quite close to the 45°-line for all individual countries except Austria, Denmark and the Netherlands. Correlation between predictions and facts in Figure 4 is 0.65. The model also has important cross-country differences right for growth. Correlation between predictions and facts in Figure 5 is 0.73. The model seems to have some difficulty to explain observed growth, however, in France and the UK.

**Figure 4.** Tertiary education rate in individual countries, in %, 1995-2006




Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.65.

**Figure 5.** Annual per capita potential GDP growth in 13 countries, in %, 1995-2007




Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.73.

Confrontation of a calibrated model's predictions with the facts is not common in the literature on public policy, education and growth. Given the lack of empirical evidence on the human capital production function and its determinants, however, confrontation with facts clearly makes sense. Our specification of effective human capital production as a CES function of education time and productive government spending in % of GDP, and with the quality of schooling (PISA) entered in a multiplicative way as an overall productivity parameter, is based on the results of such confrontation. We have adopted alternative specifications where we (i) disregard differences in the quality of schooling (PISA) across countries (i.e. drop $q$), (ii) impose a Cobb-Douglas human capital production function ($\kappa \rightarrow 1$), (iii) include only education expenditures instead of total productive expenditures, (iv) introduce the quality of schooling $q$ as a third factor within the CES-function, rather than as an overall multiplicative productivity parameter, and (v) disregard productive government expenditures (i.e. impose $v = 0$). Compared to the specification adopted in this paper, all these alternatives imply a match between predictions and facts which is (much) less good[13]. Explanatory power falls most in (v) when we drop productive government expenditures and in (ii) when we move to a Cobb-Douglas specification. The latter is remarkable given that in the literature many studies adopt such a specification. We also observe a significant fall in explanatory power for growth when we neglect quality of education differences. Here our results confirm Hanushek and Woessmann's (2009) findings. The fall in explanatory power is the smallest when we limit productive expenditures to education.

## 5. Numerical steady state effects of fiscal policy shocks

Having established the empirical relevance of our model, we now simulate a series of fiscal policy shocks. Our aim is to discover the (relative) effectiveness of changes in individual policy variables for the employment rate of three age groups, aggregate employment, and growth. In this section we focus on steady state effects. The next section discusses transitional dynamics as well as welfare effects per generation. The particular pattern of transitory effects implies that subsequent generations' welfare may be affected differently.

Starting from budget balance, we impose permanent shocks equal to 3% of initial output, i.e. output before any changes in employment or growth have taken place. We consider reductions in the tax rates and in the benefit replacement rates, and increases in government expenditures. All shocks are therefore expected to increase employment. Our benchmark from which we start, and against which all policy shocks are evaluated, is the average of 13 countries as reported in Table 2[14]. Table 5 considers the effects of policy changes on steady state growth and employment, assuming that policy changes are financed by changes in lump sum transfers ($z$) to maintain budget balance. In Table 6 we assume shocks to be compensated by a change in another fiscal policy variable.

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[13] The (minimized) average root mean squared error normalized to the mean over our five endogenous variables of interest is always higher. See also footnote 6. More details on the results are available upon request.

[14] The choice of 3% is arbitrary. Imposing smaller or larger shocks would not generate different results as far as the sign and the relative size of effects is concerned. Our main conclusions do not change either if we impose the same policy shocks on a different benchmark, i.e. a different initial set of policy parameters and initial employment and growth (but the same preference and technology parameters). The size of effects is somewhat larger for example starting from the core euro area as benchmark.

Our results in Table 5 allow us to establish a ranking of individual policy measures in their steady state effects on employment and growth. Putting (aggregate) employment *n* first, cuts in benefit replacement rates seem to be the most effective, followed by labor tax cuts. Each of these measures raise the marginal utility of work versus inactivity. We find that an overall reduction of the net benefit replacement rate by 8.6%-points raises the aggregate employment rate in hours by 2.52%-points. A comparable overall labor tax rate cut by 4.3%-points raises the aggregate employment rate by 1.12%-points. Considering that the aggregate employment rate in hours in the benchmark is about 55%, corresponding increases in the employment volume in hours (*N*) are respectively 4.60% and 2.04%. Employment effects are the strongest when policy measures focus on younger (tax cuts) or older workers (benefit cuts). Low actual employment among these age groups implies the lowest disutility from additional work. As to the size of tax effects, our results for overall labor tax cuts tend to be in the middle of existing studies. Effects are smaller than those obtained by Prescott (2004), Rogerson (2007) and Dhont and Heylen (2009), but larger than those of Turnovsky (2000). Our results are in the same range as those obtained by Coenen *et al*. (2008).

Lower consumption taxes and lower capital taxes also promote work in our model, but their effects are smaller than those of labor tax cuts (which is in line with the literature). A reduction of consumption taxes raises the return to working since the same wages buy more goods. The effect on employment will be smaller than in the case of labor tax cuts since also the non-employed enjoy the benefit of lower consumption taxes. A reduction of capital taxes stimulates the inflow of physical capital, which permanently raises labor productivity and wages. Higher wages introduce a positive substitution effect, which encourages individuals to supply labor. This positive effect will be offset however due to the income effect from permanently higher productivity, which raises demand for 'leisure'. Positive net employment effects in Table 5 are mainly due to the reduction in lump sum transfers imposed on workers by the government to finance the capital tax cuts. The same negative income effect caused by a reduction of lump sum transfers also explains the rise of labor supply and employment when the government raises public consumption.

The effects of higher productive expenditures on employment are comparable to those of a reduction in capital taxes. They induce higher productivity and have to be financed by a fall in lump sum transfers. The main difference is that higher productivity here is to an important extent dependent on, and related to, young workers' education. Higher productive expenditures encourage young individuals to study rather than work. They shift part of this work to later periods of life. In net terms we observe that a 3% of output increase in productive government expenditures leaves the aggregate employment rate more or less unchanged. Aggregate employment in volume would fall by 0.12%. These effects are clearly smaller than those obtained by Turnovsky (2000) and Dhont and Heylen (2009). In their models, however, individuals do not allocate time to education.

Putting long-run growth first, three policy measures stand out as most effective: a cut in labor taxes on middle aged workers, a cut in labor taxes on older workers and an increase in productive government expenditures. Our results predict positive effects on the steady state annual growth rate of almost 0.25%-points in the first two cases and about 0.40% in the third. Each of these measures raise the lifetime return to studying when young and building effective human capital. The education rate among young individuals rises by about 3.5 to 4.3%-points. Overall (labor) tax cuts or non-employment benefit reductions have no clear positive growth effects since they do not (or much less) contribute to effective human capital accumulation. Many of our results reveal a tradeoff between raising employment of young workers and raising growth. This tradeoff shows up sharply when labor tax cuts on the young are involved. A cut in the benefit replacement rate generally tends to reduce education. The reason is that benefits in our model are linked to wages and effective human capital. A lower replacement rate especially in the second or the third period of active life then reduces the expected return to studying when young. Our model's prediction that changes in labor tax rates have only very limited growth effects, is in line with often cited empirical findings by Mendoza *et al.* (1997). The positive link between social security and education has been demonstrated earlier by e.g. Zhang (1995) and Kemnitz and Wigger (2000).

The steady state growth effects of a reduction in capital tax rates are also positive, but almost negligible. Clearly, this does not exclude significant output *level* effects. In Appendix 3, among all simulated policy shocks, we observe the strongest 'short-run' output gain when capital tax rates are cut. Capital inflow and rising employment explain this output gain. In the long run, output remains about 8% above the benchmark after a 10%-points capital tax rate cut. This increase is significant, and larger than in a recent study by Bettendorf *et al.* (2009). Our results however challenge the idea of strong growth effects like those reported by e.g. Lee and Gordon (2005) or Johansson et al. (2008).

**Table 5.** Fiscal shocks in the model (equal to 3% of output, ex ante) - compensated by changes in lump sum transfers (z)

| Change in policy variable[(a)] | $\Delta\tau_1=\Delta\tau_2=\Delta\tau_3=-4.3$ | $\Delta\tau_1=-10.8$ | $\Delta\tau_2=-9.7$ | $\Delta\tau_3=-17.4$ | $\Delta\tau_c=-5.7$ | $\Delta\tau_k=-10.0$ | $\Delta b_1=\Delta b_2=\Delta b_3=-8.6$ | $\Delta b_1=-37.9$ | $\Delta b_2=-33.3$ | $\Delta b_3=-25.8$ | $\Delta g_c=+3.0$ | $\Delta g_y=+3.0$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effect[(b)]: | | | | | | | | | | | | |
| $\Delta n_1$ | 0.56 | 7.21 | -3.86 | -4.31 | 0.39 | 0.45 | 2.78 | 7.59 | 0.75 | 0.46 | 0.45 | -3.95 |
| $\Delta n_2$ | 1.13 | -1.33 | 3.41 | 0.15 | 0.68 | 0.79 | 1.79 | -0.61 | 6.98 | -0.85 | 0.79 | 1.49 |
| $\Delta n_3$ | 1.76 | -2.06 | 0.29 | 8.41 | 1.07 | 1.22 | 3.16 | -0.94 | -1.25 | 9.49 | 1.22 | 2.32 |
| $\Delta e$ | 0.28 | -4.70 | 3.55 | 3.93 | 0.14 | 0.16 | -0.75 | -0.12 | -1.22 | -1.00 | 0.16 | 4.29 |
| $\Delta n$[(b, c)] | 1.12 | 1.36 | 0.03 | 1.03 | 0.69 | 0.80 | 2.52 | 2.08 | 2.48 | 2.59 | 0.80 | -0.07 |
| $\Delta N/N$[(d)] | 2.04 | 2.48 | 0.06 | 1.87 | 1.26 | 1.46 | 4.60 | 3.79 | 4.51 | 4.72 | 1.46 | -0.12 |
| Δ annual growth rate[(b)] | 0.02 | -0.35 | 0.21 | 0.23 | 0.01 | 0.01 | -0.05 | -0.01 | -0.08 | -0.07 | 0.01 | 0.41 |
| $\Delta z$ ex-post (e) | -3.40 | -3.09 | -3.39 | -3.73 | -2.63 | -3.01 | 2.99 | 2.92 | 3.02 | 3.04 | -3.01 | -3.16 |

Notes : (a) change in policy variable, in percentage points
(b) difference in percentage points between new steady state and benchmark, except $\Delta N/N$
(c) change in (weighted) aggregate employment rate in hours
(d) change in volume of employment in hours, in %. Approximately, $\Delta N/N = \Delta n/n$ with N total hours worked (and assuming potential hours constant)
(e) change in lump sum transfer (as a fraction of output) to maintain budget balance, in %-points.

In Table 6 we show the results of (maybe more realistic) combined fiscal policy changes. The size of the initial shock is again equal to 3% of output, but now it is financed by change in another fiscal policy variable. The results are in line with those reported in Table 5. To obtain a significant increase in employment, cuts in benefits seem unavoidable. A shift of taxes from labor to consumption has positive effects, but they are much more limited. So are the effects of a labor tax cut financed by lower government consumption or productive expenditures (not shown in the Table). However, to raise not only employment but also growth, it is of crucial importance how the government allocates the money that it saves by cutting benefits. Growth does not rise when savings are allocated to overall labor or consumption tax cuts. Overall benefit cuts have the strongest positive effects on employment and growth when savings feed through into either tax cuts on older workers only, or higher productive expenditures. As to the latter, our simulations suggest that a budget neutral policy change involving an overall 8.6%-points cut in the net benefit replacement rate to finance higher productive expenditures would in the longer run imply an increase of average annual growth by about 0.3%-points and an increase of the aggregate employment rate by almost 2.4%-points. The latter would correspond to a growth of employment (total hours worked) by 4.36%. The long-run growth rate also rises strongly (+0.4%-points) when higher productive expenditures are financed by lower government consumption. In this case, however, aggregate employment falls moderately. Note that the same growth and employment effects follow when higher productive expenditures are financed by higher consumption taxes (not shown).

**Table 6.** Fiscal shocks in the model (equal to 3% of output) - compensated by a change in another fiscal policy variable

| Change in policy variable [(a)] | $\Delta\tau_1=\Delta\tau_2=\Delta\tau_3=-4.3$ | $\Delta\tau_3=-17.4$ | $\Delta b_1=\Delta b_2=\Delta b_3=-8.6$ | $\Delta b_1=\Delta b_2=\Delta b_3=-8.6$ | $\Delta b_1=\Delta b_2=\Delta b_3=-8.6$ | $\Delta b_1=\Delta b_2=\Delta b_3=-8.6$ | $\Delta g_y=+3.0$ |
|---|---|---|---|---|---|---|---|
| Compensating change [(e)] | $\Delta\tau_c=7.3$ | $\Delta\tau_c=8.2$ | $\Delta\tau_1=\Delta\tau_2=\Delta\tau_3=-3.9$ | $\Delta\tau_3=-14.5$ | $\Delta\tau_c=-6.2$ | $\Delta g_y=2.8$ | $\Delta g_c=-3.2$ |
| Effect [(b)]: | | | | | | | |
| $\Delta n_1$ | 0.08 | -4.87 | 3.22 | -0.76 | 3.16 | -0.71 | -4.39 |
| $\Delta n_2$ | 0.30 | -0.81 | 2.81 | 1.93 | 2.53 | 3.08 | 0.66 |
| $\Delta n_3$ | 0.47 | 7.14 | 4.71 | 10.01 | 4.29 | 5.15 | 1.02 |
| $\Delta e$ | 0.11 | 3.73 | -0.47 | 2.49 | -0.58 | 3.03 | 4.08 |
| $\Delta n$ [(b, c)] | 0.27 | 0.12 | 3.50 | 3.36 | 3.25 | 2.39 | -0.95 |
| $\Delta N/N$ [(d)] | 0.50 | 0.21 | 6.38 | 6.12 | 5.93 | 4.36 | -1.73 |
| Δ annual growth rate [(b)] | 0.007 | 0.222 | -0.031 | 0.152 | -0.038 | 0.319 | 0.395 |

Notes : (a) change in policy variable, in percentage points, except for *q* (absolute change).
(b) difference in percentage points between new steady state and benchmark, except $\Delta N/N$.
(c) change in (weighted) aggregate employment rate in hours
(d) change in volume of employment in hours, in %
(e) compensating change, in percentage points

### 6. Transitional dynamics and welfare effects per generation

We now describe the transitory adjustment path of key variables, including welfare, after the fiscal policy changes discussed in the previous section. We assume that these policy changes are unanticipated and permanent.

In Appendix 3 we show the aggregate output level and aggregate employment effects of the lump sum financed policy changes of Table 5. As we have already mentioned, despite weak long-run growth effects, we observe the strongest 'short-run' output gain when capital tax rates are cut. After one period (15 years) a 10%-point reduction of the capital tax rate raises output by about 7% compared to the benchmark. The strongest 'long-run' output effects follow from an increase in productive expenditures. Output is about 25% above the benchmark after 5 periods. A cut in labor taxes on older workers follows next, with output being 15% higher after 5 periods. The 'short-run' output effects of these two policy changes are slightly negative, however. The reason is that they encourage the young to study, implying short-run employment losses. The opposite (i.e. a short-run output gain, but long-run output loss) occurs when labor tax rates on the young are cut. Finally, despite strong employment gains, the output level effects of benefit reductions are very limited, both in the short and the long run. All generations work more than in the benchmark, but human capital may be lower.

Figures 6 and 7 describe the evolution of the aggregate output level and the aggregate employment rate after more realistic, combined fiscal policy shocks (see Table 6). Policy measures are introduced at the beginning of period 1. Employment rates by age are depicted in Appendix 4. In line with the above, to get higher output in the longer run, either an increase in productive expenditures or labor tax cuts on older workers seem to be required. The more effective way to finance these policies is to cut non-employment benefits. Figure 6 also shows that if these policies are financed by higher consumption taxes or lower government consumption, output may fall in the short run (period 1). The latter is related to the fall in employment (figure 7).

Figure 8 shows the welfare effects of these policy changes for current and future generations. 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). For example, concentrating on the first policy measure, an overall labor tax cut financed by higher consumption taxes implies welfare losses for the current retired ($k=-3$) and older workers ($k=-2$). The loss is equal to 6% of benchmark consumption for the retired and equal to 1.8% of benchmark consumption in each of the two remaining periods of life for the older workers. The current middle aged ($k=-1$) and young workers ($k=0$) gain, but their gain is very limited (less than 1% of benchmark consumption). Future generations ($k=+1,.., +4$) can also be expected to realize limited welfare gains. Considering the policy measures that contribute most to long-run output, we observe that these are also among the most favorable to the welfare of current young and future generations. Labor tax cuts on older workers, financed by overall benefit reductions, are most likely to obtain support from the representative individual in each generation. Tax cuts on older workers financed by consumption taxes also raise the lifetime utility of current middle aged and older workers, but they imply a strong welfare reduction for retired individuals. An increase of productive expenditures financed by overall benefit reductions is much less likely to get support from current generations, despite its very positive long-run output effect. Except for the young, current generations hardly gain.[15]

[15] We also observe very favorable welfare effects on current young and future generations of substituting productive government spending for public consumption ($\Delta g_y>0$, $\Delta g_c<0$). Note, however, that this result partly reflects our assumption that public consumption is not useful to the individuals. Turnovsky (2000) and Dhont and Heylen (2009) do include public consumption in the individuals' utility function. Welfare effects of substituting $g_y$ for $g_c$ are still strongly positive, but smaller than in the case where productive spending is financed by overall benefit cuts.

**Figure 6.** Output level evolution after permanent policy shocks in period 1 (index, benchmark=1)

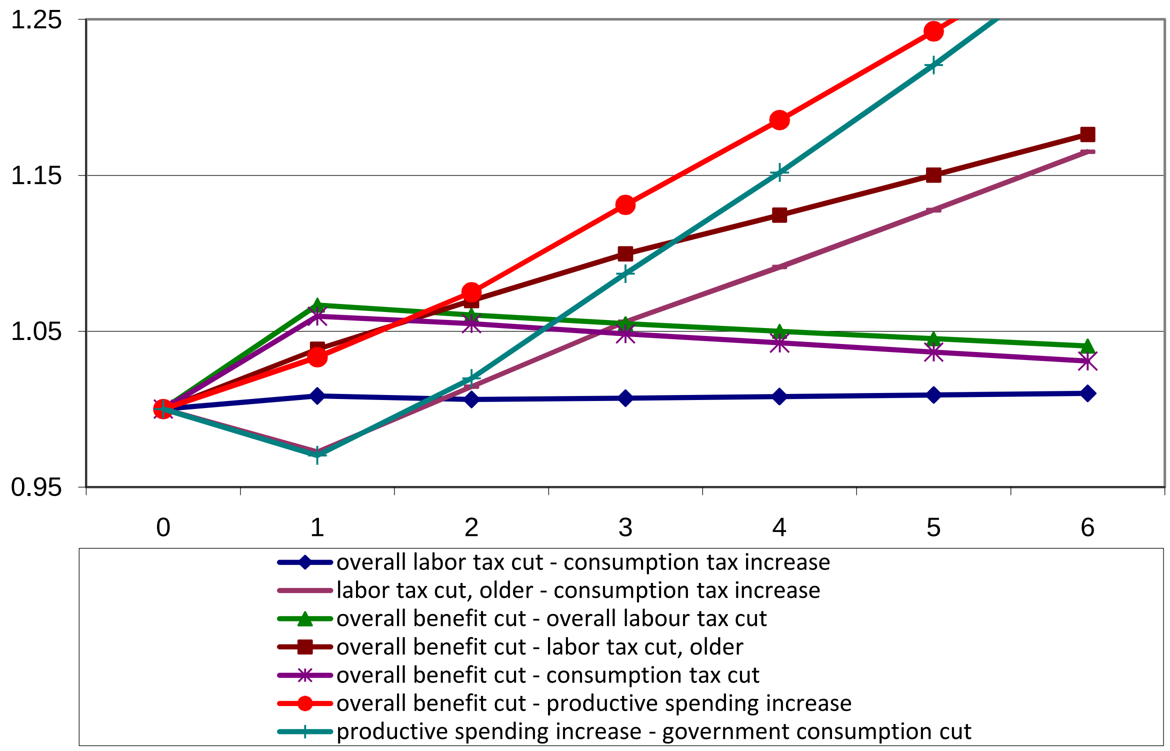



**Figure 7.** Aggregate employment rate (in hours) after permanent policy shocks in period 1 (benchmark in period 0 is the initial steady state)

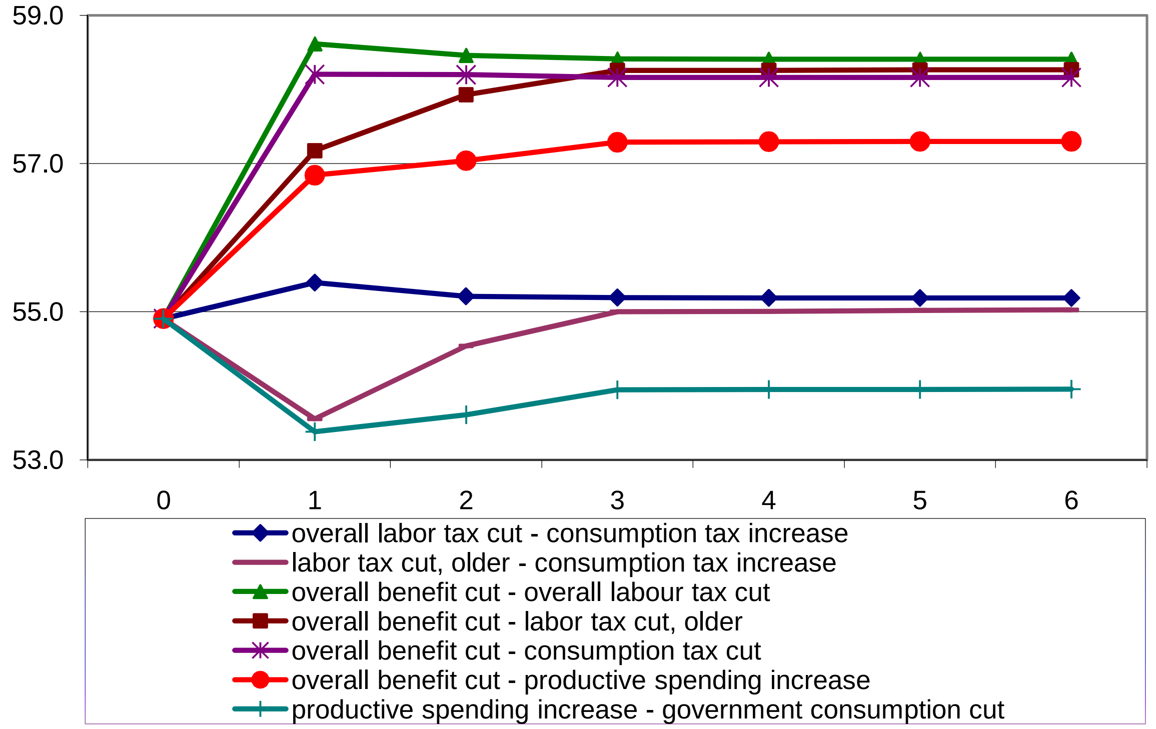
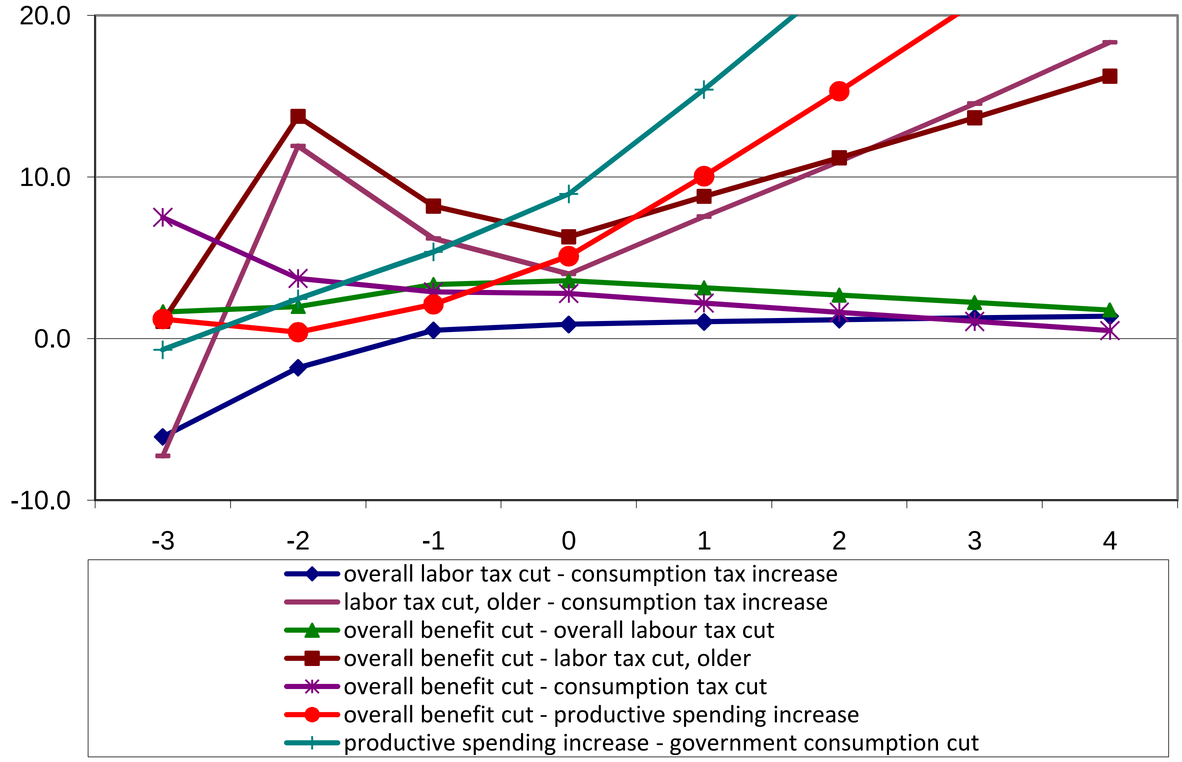


**Figure 8.** Welfare effects for current and future generations after fiscal policy changes




Note: The vertical axis indicates the welfare effect for the generation born in *t+k*, where *t* is when the fiscal policy change is introduced. The horizontal axis indicates *k.*

## 7. Conclusions

OECD countries show wide variation in aggregate employment, employment by age, (tertiary) education of the young, and per capita growth. We build and parameterize a general equilibrium OLG model for an open economy to study and explain the level of these variables and the observed cross-country differences within one coherent framework. The composition of fiscal policy plays a crucial role. We know of no such model in the literature. Models explaining employment generally disregard growth, some exceptions notwithstanding. Models explaining education and growth generally disregard the labor-leisure choice and labor supply (by age). The government sets tax rates on labor, capital and consumption. It allocates its revenue to productive expenditures (mainly for education), consumption and non-employment benefits. Labor taxes and benefits may differ across age groups. While we exploit cross-country differences in the composition of fiscal policy and the quality of education, we impose the same labor and product market institutions (perfect competition), the same taste for leisure, and the same technology in all countries.

We find that the predictions of our model match the main facts remarkably well for all key variables in a large majority of countries. A confrontation with the facts, in particular for education and growth, also allows us to reduce the uncertainty in existing literature about the specification of the human capital accumulation function. The data favor a CES function of private and public investment in education, with a higher degree of complementarity between them than in the Cobb-Douglas case. Furthermore, it seems very important to account for differences in the quality of schooling.

After having shown its empirical reliability, we simulate our model to investigate the strength of the effects of various fiscal policy shocks on steady state employment by age and growth. Our main findings are as follows. First, the effects predicted by our model seem realistic if we compare them to existing literature. In general, the size of the effects that we obtain is well within the range of existing studies. Second, our results reveal a clear ranking of policy measures in their effectiveness to promote employment and growth. (i) A reduction of non-employment benefit generosity has the strongest effects on employment, followed by labor tax cuts. The employment effects of other policy measures, e.g. capital tax cuts or productive expenditure increases, are (much) more limited. (ii) Labor tax or benefit changes have the strongest employment effects when they are targeted at young or older workers. (iii) Overall labor tax cuts and benefit cuts have only limited positive effects on the level of output, however, and almost negligible effects on long-run growth. Long-run output and growth are supported most by higher productive government expenditures. (iv) In contrast to overall tax cuts, a labor tax cut targeted at older workers may also promote long-run output and growth. The perspective of working longer at lower future tax rates raises the lifetime utility gain from building human capital when young. This encourages young individuals to study, which is a key condition for growth. Tax cuts targeted at younger workers have the opposite effects. (v) Shifting taxes from labor to consumption has positive effects on employment, but these are very limited. So are its effects on output and growth. (vi) A reduction of capital tax rates has the strongest short-run effects on output and growth, but (in relative perspective) only moderate long-run effects, and limited employment effects.

Rising pressure on the welfare state due to ageing as well as the risk of persistent output and job losses due to the recent financial crisis, are forcing all OECD countries to develop effective employment and growth policies. A key policy implication of our results for many countries would be to allocate more resources to (tertiary) education and infrastructure. In this respect, our results confirm the policy implications of earlier work by e.g. Docquier and Michel (1999), Krueger and Kumar (2004), Aghion and Howitt (2006) and Dhont and Heylen (2009). Our results also support the effectiveness for employment and growth in many European countries of cutting taxes on older workers. The most effective way to finance these policy measures would be, again in many European countries, to cut benefits to the structurally non-employed. Lower non-employment benefits encourage people to work. This is important also to counteract the 'short run' negative employment effects of policy measures promoting education. The US may raise additional resources to finance higher productive expenditures from higher consumption taxes, although this may in a transition period hurt employment. From a welfare perspective, cutting benefits to reduce taxes on older workers may (if permanent) receive full support from current generations. However, cutting benefits or raising consumption taxes to finance higher productive expenditures may require that also the welfare of future generations is taken into account.

This paper gives room to various extensions, which we are currently exploiting. First, our results and policy implications have been derived under the assumption that all individuals per generation are the same, each working the same hours, having the same talent to study, etc. Distributional issues between those within a generation who have high skills/ability and those who have not, or between those who work a lot and those who live more on benefits, are therefore inexistent. In new work we allow for different individuals within the same generation. Second, we will pay more attention to important differences in school systems between countries (e.g. differences in tuition fees, study grants, etc.). Third, we introduce pension systems, which allows to study the mutual influence of employment by age, growth, the pension system and the retirement decision. In this context we give up the assumption that all generations are of the same (constant) size, and pay more attention to demographic changes.

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## Appendix 1: Construction of data and data sources

In this appendix we provide more detail on the construction of some of our performance variables and policy variables.

***Employment rate in hours*** *(in one of three age groups, 1995-2007)*
*Definition*: total actual hours worked by individuals in the age group / potential hours worked.
Actual hours worked = total employment in persons x average hours worked per week x average number of weeks worked per year
Potential hours = total population in the age group x 2080 (where 2080 = 52 weeks per year x 40 hours per week)
*Data sources*:
* Total employment in the age group / total population in the age group: OECD Stat, Labour Force Statistics by Sex and Age. Data are available for many age groups, among which 20-24, 25-34, 35-44, 45-49, 50-54, 55-64. We constructed the data for our three age groups as weighted averages.
* Average hours worked per week: OECD Stat, Labour Force Statistics, Average usual weekly hours worked on the main job. These data are available only for age groups 15-24, 25-54, 55-64. We use the OECD data for the age group 15-24 as a proxy for our age subgroup 20-24, the OECD data for the age group 25-54 as a proxy for our age (sub)groups 25-34, 35-49 and 50-54.
* Average number of weeks worked per year: Due to lack of further detail, we use the same data for each age group. The average number of weeks worked per year has been approximated by dividing average annual hours actually worked per worker (total employment) by average usual weekly hours worked on the main job by all workers (total employment). Data source: OECD Stat, Labour Force Statistics, Hours worked.

***Education rate of young*** *(age group 20-34, 1995-2006)*
*Definition*: total hours studied by individuals of age 20-34 / potential hours studied
As a proxy we have computed the ratio: $\left( fts_{20-34} + 0.5\, pts_{20-24} + 0.25\, pts_{25-34} \right) / \, pop_{20-34}$
with: *fts* the number of full-time students in the age group 20-34
*pts* the number of part-time students in the age groups 20-24 and 25-34.
*pop* total population of age 20-34
Full-time students are assumed to spend all their time studying. For part-time students of age 20-24 we make the assumption (for all countries) that they spend 50% of their time studying, part-time students of age 25-34 are assumed to spend 25% of their time studying. Due to the limited number of part-time students, these specific weights matter very little.
*Data sources*:
* Full-time students in age groups 20-24, 25-29, 30-34: OECD Stat, Education and Training, Students enrolled by age (all levels of education, all educational programmes, full-time)
* Part-time students in age groups 20-24, 25-29, 30-34: OECD Stat, Education and Training, Students enrolled by age (all levels of education, all educational programmes). We subtracted the data for full-time students from those for 'full-time and part-time students'.
Data are available in 1995-2006. However, for many countries (quite) some years are missing. Period averages are computed on the basis of all available annual data.

***Annual real potential per capita GDP growth rate*** *(aggregate, 1995-2007)*
*Definition:* Annual growth rate of real potential GDP per person of working age
*Data sources*:
* real potential GDP: OECD Statistical Compendium, Economic Outlook, supply block, series GDPVTR.
* population at working age: OECD Statistical Compendium, Economic Outlook, labour markets, series POPT.

***Tax rate on labor income*** *($\tau_1$, $\tau_2$, $\tau_3$)*
*Definition*: Total tax wedge, marginal tax rate in %. The data cover personal income taxes, employee and employer social security contributions payable on wage earnings and payroll taxes.
*Data source*: OECD, Statistical Compendium, Financial and Fiscal Affairs, Taxing Wages, Comparative tax rates and benefits (new definition).
The OECD publishes these tax data for several family and income situations. We computed $\tau_1$ as the average of marginal tax rates for (i) a one-earner married couple at 100% of average earnings (2 children), (ii) a two-earner married couple, one at 100% of average earnings and the other at 33 % (2 children), (iii) a single person at 67% of average earnings (no child) and (iv) a single person at 100% of average earnings (no child). We computed $\tau_2$ and $\tau_3$ as the average of tax rates for (i) a one-earner married couple at 100% of average earnings (2 children), (ii) a two-earner married couple, one at 100% of average earnings and the other at 67 % (2 children), (iii) a single person at 100% of average earnings (no child) and (iv) a single person at 167% of average earnings (no child). The reported data concern 2000-2002.

***Net benefit replacement rates*** *($b_1$, $b_2$)*
*Definition*: The data concern net transfers received by long-term unemployed people and include social assistance, family benefits and housing benefits in the 60th month of benefit receipt. They also include unemployment insurance or unemployment assistance benefits if these benefits are still paid, i.e. if workers can be structurally unemployed for more than five years without losing benefit eligibility. The data are expressed in % of after-tax wages. The OECD provides net replacement rates for six family situations and three earnings levels. In line with our assumptions for labor tax rates (see above), we computed $b_1$ as the average of the net benefit replacement rates for 'families' with earnings levels corresponding to 67% and 100% of the average worker's wage (AW). We computed $b_2$ as the average of the net benefit replacement rates for 'families' with earnings levels corresponding to 100% and 167% of the average worker's wage. The reported data are averages for 2001 and 2004.
*Data source*: OECD, Tax-Benefit Models, www.oecd.org/els/social/workincentives
*Data adjustment*: Original OECD data for Norway include the so-called "waiting benefit" (ventestønad), which a person could get after running out of unemployment benefits. Given the conditional nature of these "waiting benefits", they do not match our definition of benefits paid to structurally non-employed individuals. We have therefore deducted them from the OECD data, which led to a reduction of net replacement rates by about 19 percentage points. For example, recipients should demonstrate high regional mobility and willingness to take a job anywhere in Norway. The "waiting benefit" was terminated in 2008. We thank Tatiana Gordine at the OECD for clarifying this issue with us.

***Net benefit replacement rates*** *($b_3$)*
To calculate our proxy for $b_3$ we have taken into account the possibility for older workers in some countries to leave the labor market along fairly generous early retirement routes. Duval (2003) and Brandt *et al.* (2005) provide data for the so-called implicit tax rate on continued work for five more years in the early retirement route at age 55 and age 60. The idea is as follows. If an individual stops working (instead of continuing for five more years), he receives a benefit (early retirement, disability,…) and no longer pays contributions for his future pension. A potential disadvantage is that he may receive a lower pension later, since he contributed less during active life. Duval (2003) calculated the difference between the present value of the gains and the costs of early retirement, in percent of gross earnings before retirement. We use his data as a proxy for the gross benefit replacement rate for older workers in the early retirement route. To compute the net benefit replacement rate, we assume the same tax rate on early retirement benefits as on unemployment benefits. We call this net early retirement benefit replacement rate $r_3$.

If we look at the data, we observe that $r_3$ is higher than the net unemployment benefit replacement rate $b_2$ in some countries (e.g. Belgium, France, Netherlands,…) but not in others (Denmark, Norway, Sweden, US). It is unlikely that older workers will choose the early retirement option in the latter group of countries. They may however strongly prefer this option in the former group. The implication of these arguments is that we will assume $b_3 = b_2$ in countries where $r_3 < b_2$. By contrast, in countries where $r_3 > b_2$, it seems more adequate to model $b_3$ as a weighted average of $r_3$ and $b_2$. The weight of each component would obviously depend on eligibility criteria in the early retirement system. Due to lack of specific data on this, however, we had to make a very rough assumption. Underlying the data in Table 4 is the assumption that $b_3 = 0.75b_2 + 0.25r_3$. Clearly, our results in the main text do not depend in any serious way on this assumption.
*Data Source*: OECD, Tax-Benefit Models, www.oecd.org/els/social/workincentives, Duval (2003), Brandt et al. (2005).

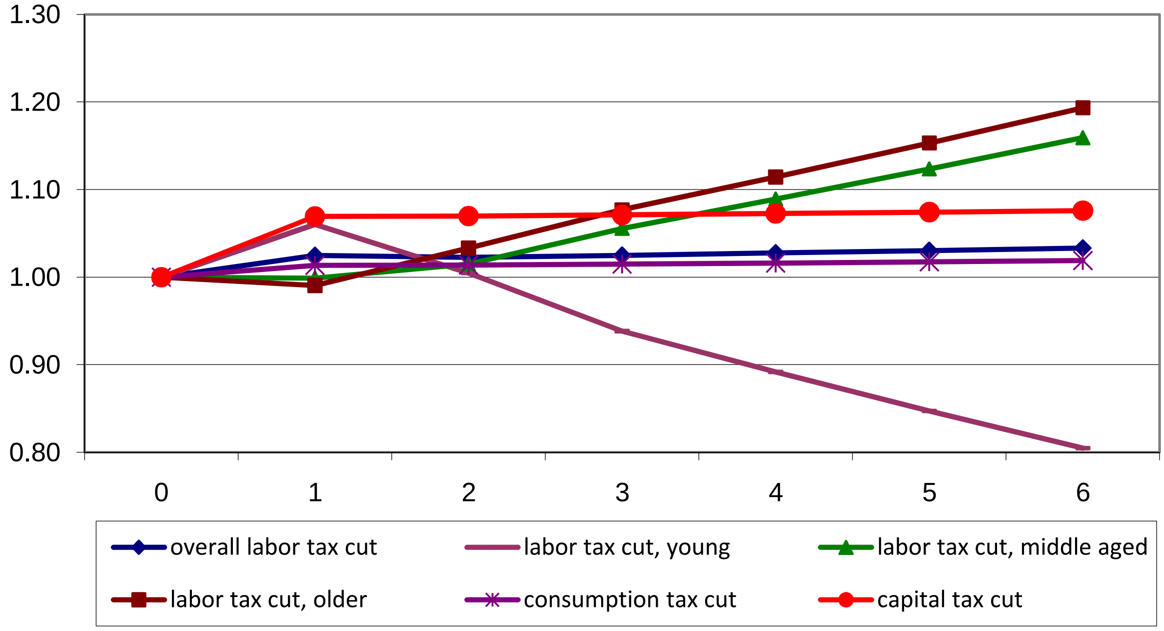
**Appendix 2: Employment rates in persons (1995-2007, in %)**

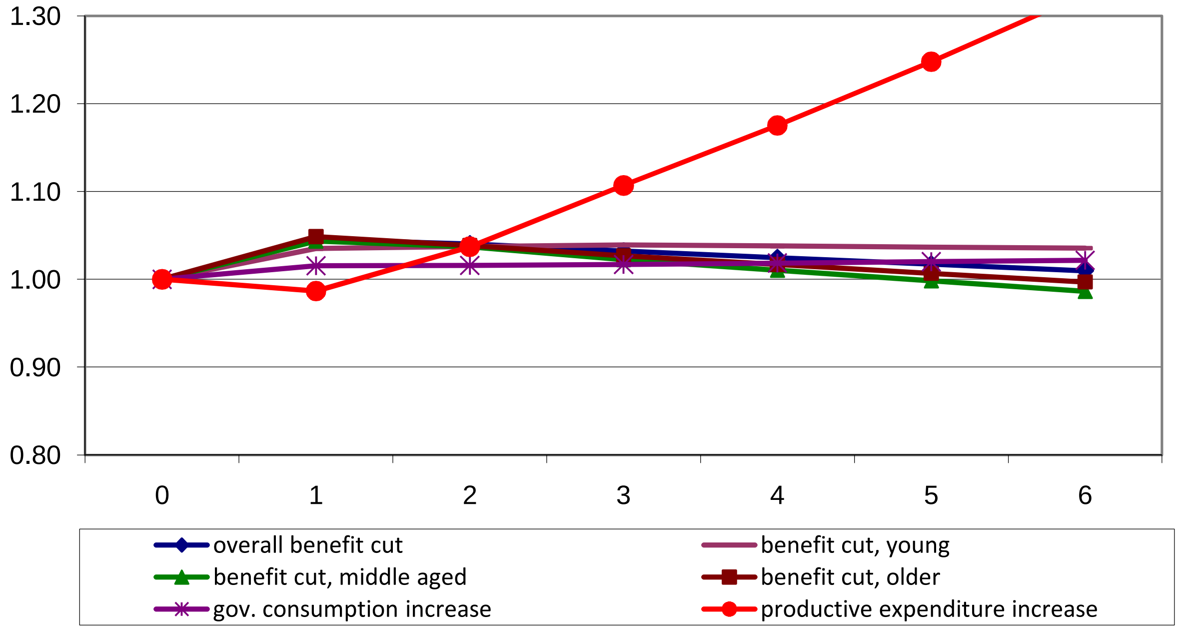
| | $n_1$ (20-34) | $n_2$ (35-49) | $n_3$ (50-64) |
|---|---|---|---|
| Austria | 78.4 | 84.4 | 45.6 |
| Belgium | 70.0 | 77.8 | 40.5 |
| France | 66.3 | 81.1 | 52.2 |
| Germany | 72.3 | 80.5 | 51.6 |
| Italy | 59.0 | 73.3 | 40.5 |
| Netherlands | 81.0 | 80.1 | 51.9 |
| **Core euro Average** | **71.2** | **79.5** | **47.1** |
| Denmark | 79.5 | 86.1 | 65.7 |
| Finland | 70.2 | 83.0 | 58.1 |
| Norway | 77.8 | 86.1 | 73.6 |
| Sweden | 72.9 | 85.4 | 73.2 |
| **Nordic Average** | **75.1** | **85.1** | **67.6** |
| **US** | **76.4** | **81.1** | **66.3** |
| UK | 75.6 | 81.3 | 61.5 |
| Canada | 75.8 | 80.7 | 59.5 |
| **All country average** | **73.5** | **81.6** | **56.9** |

*Note* :
Employment rate in persons = Total employment in the age group / total population in the age group.
*Data sources* :
OECD Stat, Labour Force Statistics by Sex and Age. Data available for many age groups, among which 20-24, 25-34, 35-44, 45-49, 50-54, 55-64. We constructed the data for our three age groups as weighted averages.

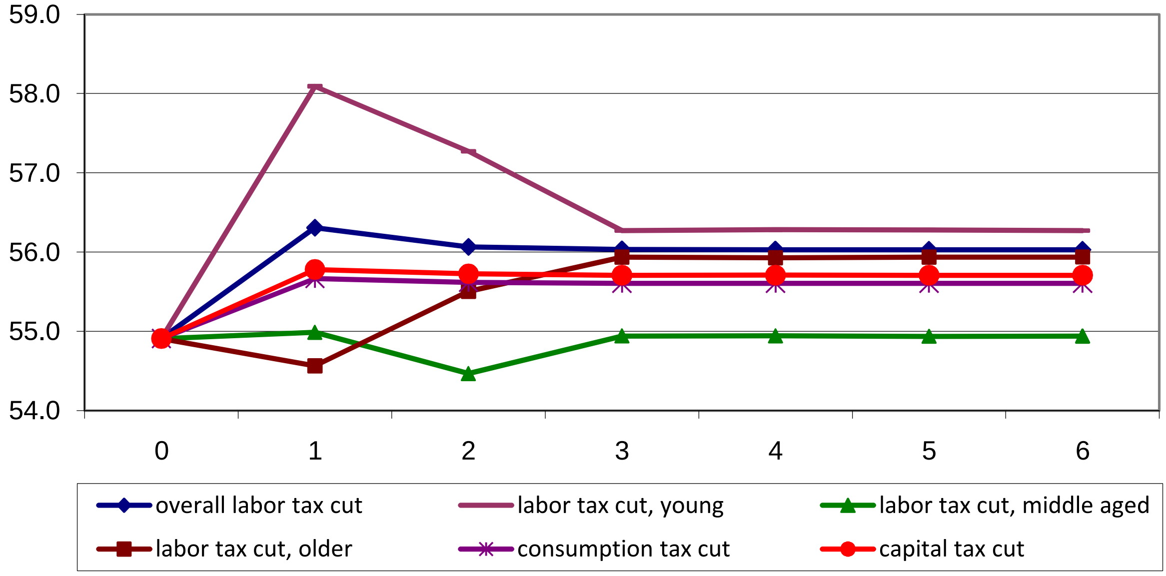
**Appendix 3. Transitional effects of lump sum financed fiscal policy changes (Table 5)**

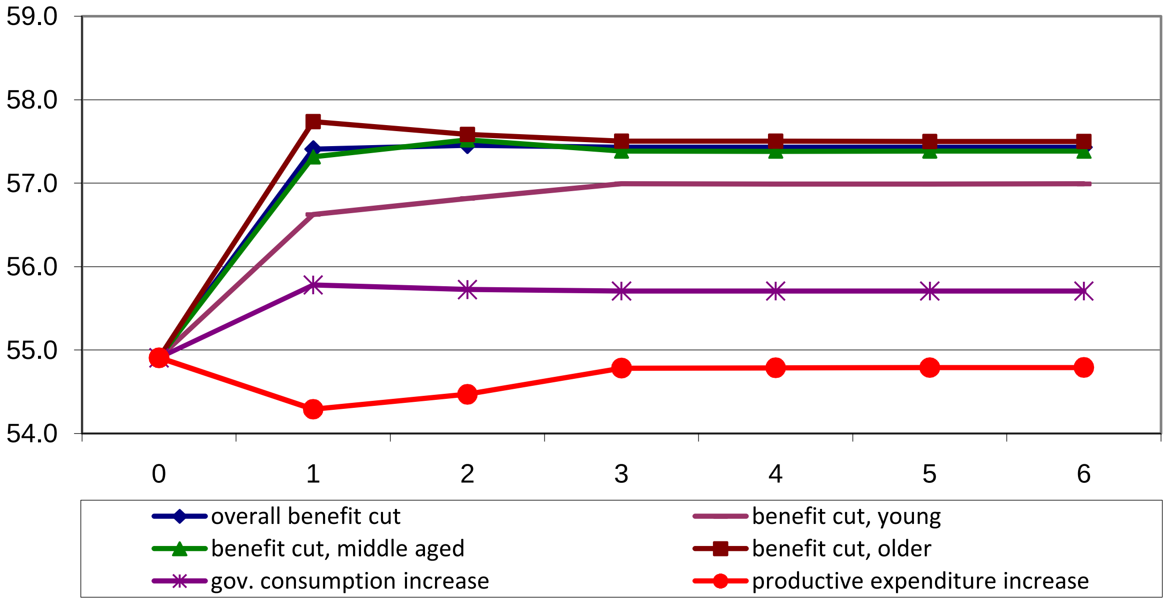
**Aggregate output level** (vertical axis, index, benchmark=1) after unanticipated and permanent lump sum financed policy changes introduced in period 1 (periods on horizontal axis)



**Aggregate employment rate** (vertical axis, in %) after unanticipated and permanent lump sum financed policy changes introduced in period 1 (periods on horizontal axis) [16].

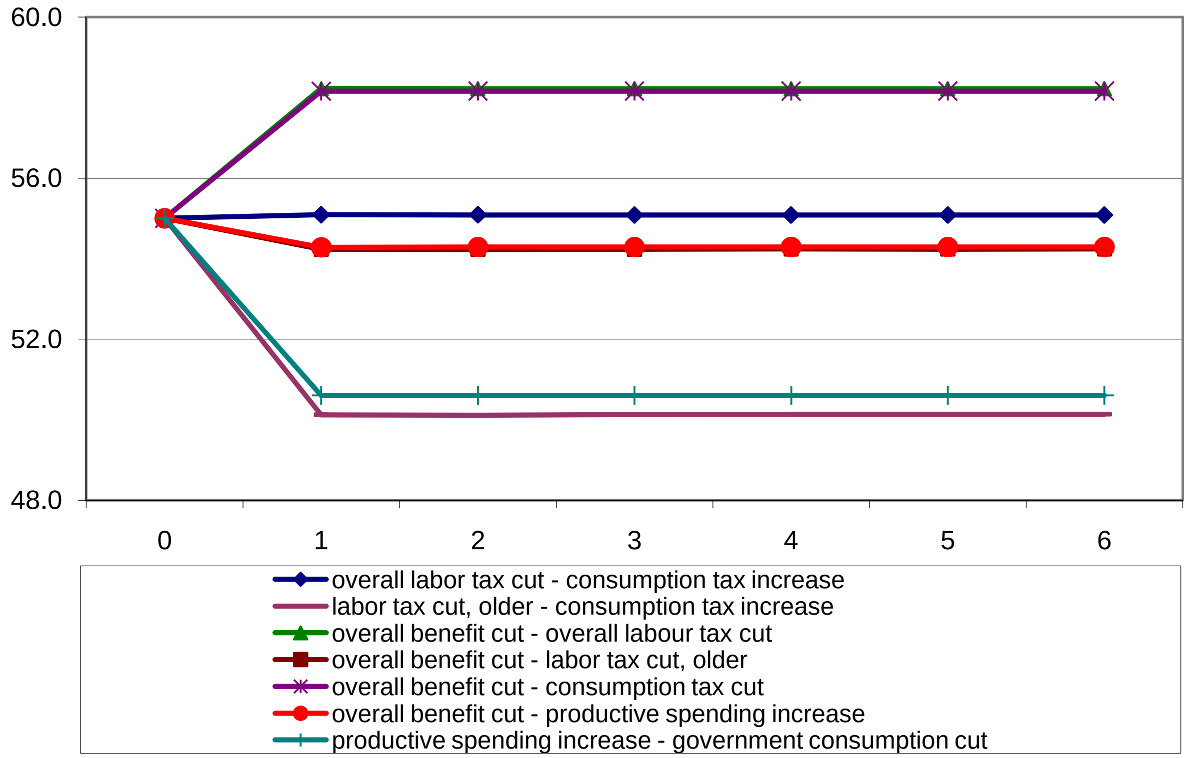


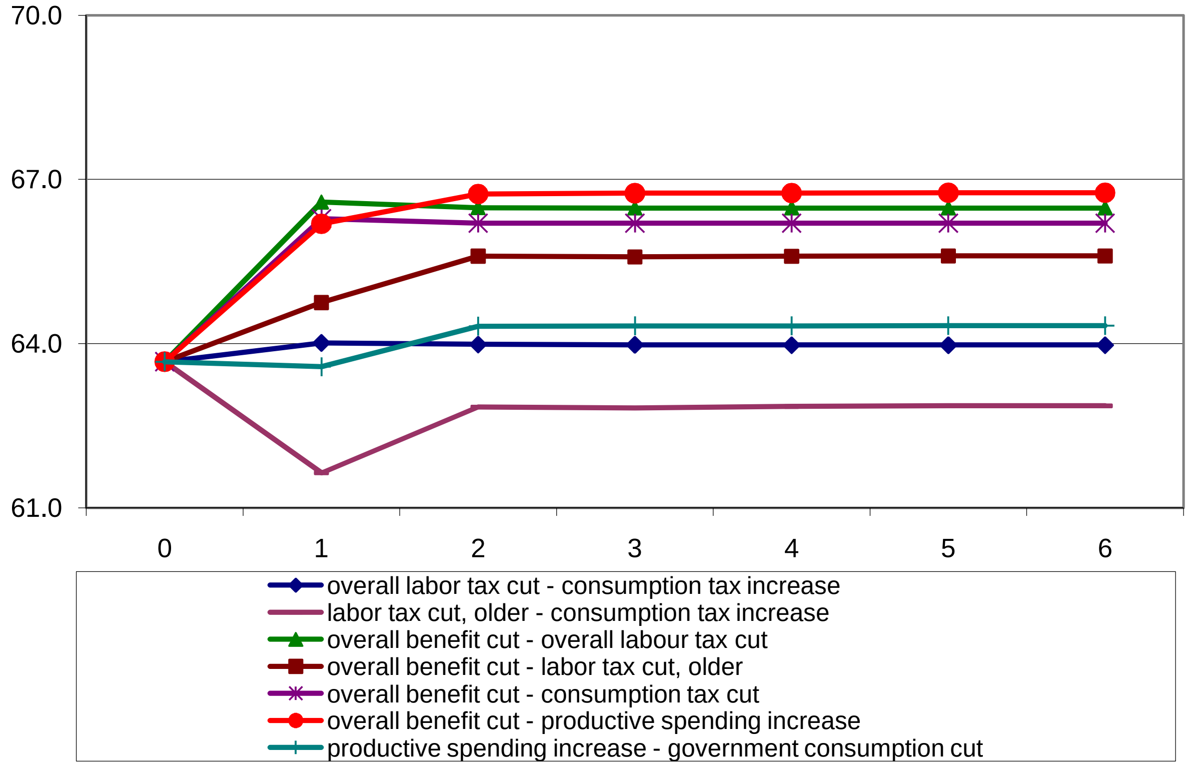

[16] A discussion of employment and welfare effects by age group is less interesting since a lot depends on which age group loses the lump sum transfer / pays the lump sum tax.

**Appendix 4. Transitional employment effects of combined fiscal policy changes (Table 6)**

Employment rate of **young workers** (vertical axis, in %) after unanticipated and permanent combined fiscal policy changes introduced in period 1 (periods on horizontal axis)




Employment rate of **middle aged workers** (in %)



Employment rate of **older workers** (in %)