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Employment by age, long-run growth and the pension challenge in OECD countries: what policies?

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Abstract

We build and parameterize a four-period OLG model for an open economy to study hours of work in three age groups, education of the young, and aggregate per capita growth within one coherent framework. We explain these endogenous variables as functions of various tax rates, various kinds of government expenditures, and key characteristics of the public PAYG pension system. We find that our model explains the facts remarkably well for many OECD countries. We then use the model to investigate the effects of various fiscal policy shocks and the effects of changes in the pension system. To face today's challenges of low employment, in particular among older workers, low growth and rising pressure on the welfare state, our results underscore the need to raise the share of productive government expenditures (mainly for education), to cut 'non-employment' benefits, and to cut labor taxes on older workers. A reform of the pension system may also raise growth and employment among older workers. Our results speak in favor of the combination of a rise in the pension replacement rate and an increase in the weight of labor income earned as an older worker in computing the pension base. Further analysis reveals that policy reforms in this direction may also raise welfare levels of current and future generations.

Key words: employment by age, endogenous growth, pensions, pension reform, fiscal policy, overlapping generations, ageing

JEL Classification: E62, H55, J22, O41

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Executive Summary

Ageing of the population puts rising pressure on the welfare state in most OECD countries. Health and pension related expenditures are expected to increase strongly. To make it worse, rising expenditures come at a time when all countries face high public debts and deficits after the recent recession, and are forced to adopt fiscal consolidation strategies. Everyone agrees that effective policies promoting employment and long-run growth, as well as reform of pension and social security systems, should be key components of the solution to these challenges. The need to raise employment is the most urgent in many European countries, mainly for older workers.

How to bring about this solution, however, and how these key components interact, is much less clear.

Starting point of this paper is the observation that aggregate employment, employment by age, and growth vary significantly across OECD countries. Employment and growth are much higher in some countries than in others. We can learn from these differences. It is our hypothesis that variation in fiscal policy and in the public pension system explain a major part of these performance differences. Our aim is first to clarify the link between policies and employment and growth, and second to exploit this information for policy simulations.

We develop and parameterize an overlapping generations model for an open economy which explains employment in three age groups (young, middle-aged and older), tertiary education of the young, and aggregate growth within one coherent framework. The young are of age 20 to 34, the middle-aged 35 to 49 and the older 50 to 64. A fourth generation of retirees is of age 65 to 79. We explain employment by age, tertiary education, and growth as functions of various tax rates, various kinds of government expenditures, and key characteristics of the public pension system. The government sets taxes on labor, capital and consumption. It allocates its resources to consumption, productive expenditures e.g. for education, R&D or infrastructure, and non-employment benefits. Pensions in our model are paid by the social security system (PAYG). Retirees receive a pension which is a fraction (the replacement rate) of their so-called 'pension base'. The pension base is a weighted average of the after-tax labor income that individuals earn during their active years (20-64y). In various countries, e.g. Belgium or Germany, all years have equal weight, but clearly this does not have to be the case. Pensions rise if – other things equal – the replacement rate rises, or the pension base rises.

We show that our model is empirically relevant. Taking into account observable fiscal policy differences and differences in the pension replacement rates in 13 OECD countries, our model predicts for each country employment by age, education of the young, and aggregate growth. In a large majority of countries the model's predictions match the facts quite well.

Having established its empirical relevance, we then use the model to investigate the effects of various fiscal policy shocks and the effects of changes in the pension system. As to fiscal policy, our main finding are as follows. Cuts in labor taxes and cuts in non-employment benefits are the most effective to raise employment. The reason is that these policies have the strongest positive effect on the net gain from work versus inactivity. The effects of changes in consumption taxes or capital taxes are much smaller. When it comes to promoting long-run output and growth, productive government expenditures are the most effective. Higher productive expenditures raise the productivity of investing in human capital (education) and investing in physical capital. Investment in human capital is particularly important. Each generation's investment creates new human capital and knowledge which are also to the benefit of the next generation, thanks to an intergenerational transfer. This transfer makes current and future workers more productive, and raises their real wage. More productive workers also raise the productivity of physical capital. In an open economy, internationally mobile physical capital will then be attracted. Output and growth will rise. Furthermore, we observe that education, output and growth may benefit also from labor tax cuts targeted at older workers. Lower labor taxes when old raise the net return to building human capital when young. The reason is obvious. Lower labor taxes when old make individuals work longer (= enjoy their human capital during a longer period), and at higher after-tax wages. 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. Tax cuts on capital income (i.e. corporate tax reductions) also have significant positive output effects, since they attract physical capital, but they have only negligible long-run growth effects. A key policy implication of our results for many European countries would be to cut benefits to the structurally non-employed, and to reallocate these resources to tax cuts on older workers and higher productive expenditures.

Our model allows to assess the economic implications of four types of pension reform.

In a first reform (1), we change the computation of the pension base. Initially, the pension base is a simple average of the net labor income earned during the three active periods (20-34y, 35-49y and 50-65y). Each period receives an equal weight in this average. Our first reform imposes a higher weight on earned labor income during the final years before the official retirement age. Practically, we can translate this reform in two ways. We could interpret this reform as a higher pension accrual rate at higher ages. Alternatively, when computing the pension base one can include *not* all 45 years of active live, but for instance only the last 15 or 25 years. Changing the weights in the pension base strengthens the relationship between working at higher ages on the one hand and pension benefits on the other. Early retirement is therefore discouraged. Moreover, young individuals are encouraged to study in this model, for two reasons. First, as the weight on earned labor income in the period 20-34y drops (to zero), there is a smaller (or no more) loss of pension rights from studying. Second, in line with the above, the perspective of working longer implies a higher implicit return from building human capital. Higher (aggregate) employment and higher growth (induced by more schooling) also explain the beneficial effect on the government budget.

A second reform (2) consists of an increase in the net pension replacement rate (= 'higher pensions'). This increase is a way to further strengthen the link between studying and working on the one hand and pension benefits on the other. The return to working and studying rises in the net replacement rate, as for given working hours, the individual receives a higher pension. Therefore, this reform further increases aggregate employment and growth. Moreover, our simulations suggest that when this higher replacement rate is combined with the reform proposed under (1), employment and growth effects are significant while effects on the government budget need not be negative. It thus seems that changing the computation of the pension base creates the budgetary room to raise pensions.

In a third reform (3), we substitute a basic pension for the initial labor income-related public pension. This fixed basic pension is not related to previous work hours or earned income. Our simulations reveal strong negative effects on employment in all age groups, tertiary education and growth. The decrease in income-related pensions reduce the return to working and studying. A basic pension does not have the same positive effect on education and employment as an income-related pension.

In our final simulation (4), we gradually implement the transition to a fully funded pension system. In such a system, individuals do not receive a public pension but have to save to finance their retirement. We assume that the drop in public pension expenditures is compensated by lower labor taxes (read: lower social security contributions) on all workers. According to our study, this transition leads to non-negligible negative effects on employment, education and growth. Moreover, there is a strong deterioration of the government budget. There are two reasons why a fully funded system does not lead to stronger growth or employment. First, although there is a positive effect of the fully funded system on private savings, this effect is not transmitted into a higher capital stock (and output) as savings may flow abroad (remember our assumption of an open economy). Second, our model contains an externality in education: each generation's investment in education also raises human capital and productivity of the next. Individuals as such will not take this into account. Positive effects on the next generation do not affect their productivity and wage, which implies that in a laissez-faire economy (=fully funded) individuals study too little. A public PAYG pension system, however, directly influences the return to studying/working since in such a system higher future productivity and labor income also generate more pension benefits. This effect stimulates young individuals to take (part of) the externality into account. As such, they increase their time investment in tertiary education. Moreover, higher human capital then further increases employment (when middle-aged and old).

Although the previous results are obtained under the assumption of a constant population size and structure, our conclusions regarding preferable policies to pension reform survive once we allow for ageing.

1. Introduction

Ageing of the population puts rising pressure on public pension systems and the welfare state in most OECD countries. Old-age dependency ratios are expected to increase strongly. So are health and pension related expenditures. To make it worse, rising expenditures come at a time when all countries face high public debts and deficits after the recent recession. The challenges are quite well-known (Pestieau, 2003; Barr, 2006; Whiteford and Whitehouse, 2006; United Nations, 2009; IMF, 2010). There seems to be general agreement also on key components of the solution. All OECD countries are forced to develop effective employment and growth policies and to reconsider pension and social security systems. The need to raise employment is the most urgent in many European countries, mainly for older workers. How to bring about this solution, however, and how these key components interact, is much less clear. A large literature has discussed determinants of aggregate employment and employment differences across OECD countries, and many papers have tried to explain growth and growth differences. Only very few studies, however, have investigated employment and growth within one coherent framework. Moreover, among the studies that focus on employment, only very few explain employment differences by age. In line with the previous, the relationship between employment by age and growth has remained largely unexplored. Finally, despite the often emphasized need for pension reform, the influence of the specific characteristics of the pension system on employment (by age) and growth has hardly been studied within one framework.

In this paper we construct and parameterize a simple general equilibrium four-period OLG model for an open economy. The model explains within one coherent framework the employment rate of young, middle-aged and older workers, as well as the fraction of time that the young allocate to (tertiary) education, and aggregate growth. It includes a public PAYG pension system which pays out pensions to a fourth generation of retired. The model is situated within the 'capital–accumulation' endogenous growth tradition initiated by Lucas (1988) and Barro (1990), with education and the composition of fiscal policy playing a major role in the growth process. The government sets tax rates on labor, capital and consumption. It allocates its revenue to productive expenditures (mainly for education), consumption, 'non-employment' benefits and pensions. Labor taxes and benefits may differ across age groups. The government decides on the pension replacement rate and on the weights of the three active periods in the computation of the pension base, i.e. earned lifetime labor income to which the replacement rate applies. The retirement age in our model is 65, it is no government decision.

Before we use our model for policy analysis, we test its empirical validity for a group of 13 OECD countries. We impose common technology and preference parameters on all countries, but country-specific fiscal policy and pension system parameters. We find that the model's predictions match the main facts in most OECD countries. These facts concern observed 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 consider is larger than in many papers on the debate of employment and growth in 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. Having established its empirical relevance, we simulate our model to investigate the effects of various shocks to fiscal policy and to the key characteristics of the pension system on employment by age, growth and the government's financial balance, as well as on the welfare of current and future generations. Since this paper is an extension of our earlier work (Heylen and Van de Kerckhove, 2010) we here focus mainly on effects of pension reform.

We identify the following policy changes as most promising to face the current challenges. Cuts in labor taxes and 'non-employment' benefits are most needed to raise employment. Productive government expenditures are the most effective with respect to long-run output and growth. Furthermore, we observe that education, 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. Overall labor tax cuts have only very small positive output and growth effects. A key policy implication of our results for many European countries would be to cut benefits to the structurally non-employed, and to reallocate these resources to tax cuts on older workers and higher productive expenditures.

We assess to what extent pension reform may contribute to employment and growth. Our simulation results speak in favor of the combination of a rise in the replacement rate and a shift of the pension base to labor income earned in the third period. This reform encourages young individuals to study, which promotes long-run growth. Furthermore, it encourages older workers to work longer. Strengthening the link between one's future pension, on the one hand, and one's human capital and labor supply when older, on the other, introduces strong financial incentives which may bring about important changes in behavior. Positive effects on employment and growth raise the government's resources which makes it possible to finance a larger pension burden. When we introduce (for Belgium) a realistic pattern of population ageing, our main findings are largely unaffected. We even find evidence that such a pension system reform could mitigate some of the negative effects of population ageing on the government's budget. From a welfare perspective, most of these policy measures are also preferred by current generations.

The structure of this paper is as follows. In Section 2 we discuss the progress and remaining weaknesses in recent literature studying the relationships between fiscal policy, social security and pension systems, and employment and growth. We situate our paper and contribution within this literature. In Section 3 we document differences in employment by age, education of the young and per capita growth across 13 OECD countries since 1995. Section 4 sets out our model. In Section 5 we calibrate the model on actual data and confront its predictions with the facts described in Section 3. Sections 6 and 7 include the results of a range of model simulations. In Section 6 we focus on effects of fiscal policy changes and pension reforms under the assumption of constant population structure. In Section 7, we allow for population ageing. In this section, we focus on Belgium. We further include transitional dynamics, and the welfare effects per generation. Section 8 concludes the paper.

2. Employment, growth and social security: background

Employment and growth vary widely across OECD countries. The reasons for these cross-country differences have been the subject of intense discussion in the economic literature. 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; Bassanini and Duval, 2006; Berger and Everaert, 2009). Other authors 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 approaches. They study the influence of various taxes and expenditures in an imperfectly competitive model where technological progress is due to investment in private firms.

In both perspectives on growth, education and social security 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. 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; Docquier and Michel, 1999; Kaganovich and Zilcha, 1999; Bouzahzah *et al*., 2002; Blankenau and Simpson, 2004; Glomm and Kaganovich, 2008; Dhont and Heylen, 2009). Higher education expenditures have empirically been found to promote growth by e.g. Kneller et al. (1999), Nijkamp and Poot (2004), and Blankenau et al. (2007). Several studies in this tradition also highlight the influence of social security systems on endogenous growth, via the channel of human capital investment (e.g. Zhang, 1995; Fougère and Mérette, 1999; Kemnitz and Wigger, 2000; Zhang and Zhang, 2003). Others assess the optimality of education versus social security policies to deal with demographic shocks (e.g. Docquier and Michel, 1999; Kaganovich and Zilcha, 1999). Following Auerbach and Kotlikoff (1987) and Auerbach *et. al.* (1989), many studies also explore the economic effects of ageing and longevity (e.g. Boucekinne *et al.*, 2002; de la Croix *et al.*, 2007; Heijdra and Romp, 2009a,b; Ferreira and Pessôa, 2007; Fougère *et al.*, 2009; Gonzales-Eiras and Niepelt, 2010; Ludwig et al., 2010; Martín, 2010).

The above mentioned literature has strongly improved our understanding of employment and growth at both sides of the Atlantic. It has improved knowledge about the relationships between social security, education and growth. 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, and neglect the other aspect[1]. All of the above mentioned studies on the relationship between social security and growth and between education and growth disregard labor supply and employment or assume them to be inelastic. Second, with the exception of Rogerson (2006), Faggio and Nickell (2007) and Rogerson and Wallenius (2009), most employment studies neglect differences across age

[1] Only Roeger and De Fiore (1999), Daveri and Tabellini (2000), Turnovsky (2000), Dhont and Heylen (2009), Fougère et al. (2009) and Gonzales-Eiras and Niepelt (2010) model both aggregate employment and growth endogenously.

groups. These differences are however obvious in the data. Third, most of the above mentioned studies on pensions, ageing and longevity lack a rich specification of the composition of fiscal policy. The expenditure side in particular is generally underdeveloped (e.g. no non-employment benefits, no productive expenditures).

Our main contribution in this paper is to analyze the mutual relationships between employment by age, education, growth, fiscal policy and the characteristics of the pension system within one coherent framework. These relationships are legion. The level of employment determines the marginal productivity of physical capital and therefore the incentive to invest. 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. Growth may therefore be negatively related to the employment rate of young workers. However, since hours worked in later periods of life raise the return to investment in education, growth may be positively related to the employment of middle aged and older workers. Furthermore, in a model where pensions are related to earned labor income, the pension replacement rate determines the return to investing in human capital and to working, which may make it an important determinant of education, growth and employment. Along the same argument, the weights attached to labor income in various periods of active life to compute the pension base also affect the return to education. A high weight on labor income when young will discourage education and growth (and vice versa for a high weight on labor income when middle aged or old). Changes in budgetary policy (taxes and expenditures) may also influence the decision to work or build human capital.

In Sections 4 and 5 we construct our OLG model and test its empirical relevance. Then we use it for policy simulations. The empirical test involves a comparison of our model's predictions to actual values for key variables in 13 OECD countries. We describe these variables now.

3. 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 are 2080 per person per year (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 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 55.0%, 63.7% 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[2]. 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 points lower in the period under consideration. The US and the other 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.

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.

4. 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

[2] Note that the US' lead in the employment rate in hours is mainly due to higher hours worked per employed person. Heylen and Van de Kerckhove (2010) 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 for the middle aged.

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 homogenous. At time t, the (exogenous) size of generation j is represented by μ_{jt} and total population equals $\sum_{j=1}^{4} \mu_{jt}$. Each period is modeled to last for 15 years. This also means that retirement age and the retirement decision are exogenous in the 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[3].

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 their available resources, coming from earlier savings and a public pension. They do not work, and leave neither bequests nor debts. Economy-wide savings in a particular period generate the stock of non-human wealth in the next period. 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.

4.1. Individuals

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

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

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[3] 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).

with $\gamma_j>0$, $\theta>0$ ($\theta\neq1$) 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 jth period of life. In line with our data presented in Section 2, periods are considered to last for 15 years. Furthermore, β 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, γ specifies the relative value of 'leisure' versus consumption. Note that γ 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).

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

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

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

$$(1+\tau_c)c_4^t = (1+r_{t+3})s_3^t + pp_4^t + z_{t+3} \tag{5}$$

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

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

and: $$pp_4^t = b_4\sum_{j=1}^{3}\left(p_j w_{t+j-1} h_j^t n_j^t(1-\tau_j)\right) \tag{8}$$

$$0\leq p_j \leq 1 \text{ and } \sum_{j=1}^{3} p_j = 1$$

The LHS of Equations (2)-(5) shows that individuals allocate their disposable income to consumption (including consumption taxes, τ_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 allocate a fraction n_1^t of their time to work, and pay a tax rate on labor income τ_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 of middle aged and older workers 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 rises 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 4.2. 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 young, middle aged and older individuals are inactive, they receive a non-employment benefit from the government. The benefit replacement rate b_j (with j=1,2,3) 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, do not save and leave debts nor bequests. They consume their savings from the third period plus interest, the lump sum transfer z and a public pension pp. Equation (8) describes this pension. We assume a public PAYG pension system in which pensions in period k are financed by contributions (labor taxes) from the active generations in that period k (see below). Individual pension benefits are related to earlier labor income as follows: individuals earn a net pension which is a fraction of their so-called pension base. The latter is a weighted average of net labor income in each of the three active periods of their life. The net replacement rate is b_4. The parameters p_1, p_2 and p_3 represent the weights attached to each period. A full pension is granted if one has a full career, which is achieved when $n_j^t = 1$ for j = 1,2,3. Intuitively this implies 45 years of full time work. Note that the possibility of early retirement is implicitly allowed via $n_3^t < 1$ and b_3 >0.

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 agent entering the model at time t. Equation (9) expresses the law of motion of optimal consumption over time. Equations (10.a) and (10.b) describe the optimal labor-leisure choice in each period of active live. In each period, individuals supply labor up to the point where the marginal utility of leisure equals the marginal utility gain from work. The latter consists of two parts. Working more hours in a particular period of life raises additional resources for consumption both in that period and when retired. The marginal utility gain from work rises when the marginal utility of consumption 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. Extra consumption during retirement rises in the pension replacement rate and in the weight attached to the relevant period when computing the pension base.

Equation (11) 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) and a high pension replacement rate (b_4) will encourage young individuals to study. The reason is that any future benefits and the future pension rise in future human capital (see also Zhang, 1995). 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).

It will be obvious from the above discussion that the specific characteristics of the pension system may have strong effects on behavior in earlier periods of life. A higher replacement rate b_4 raises the return to working (n) and building human capital (e, h) in earlier periods. Changes in the particular weight attached to these earlier periods may modify these incentive effects. The return to education will rise in p_2 and p_3, but fall in p_1. The return to working in the third period will rise in p_3, etc.

$$\frac{c_{j+1}^t}{c_j^t} = \beta\left(1+r_{t+j}\right) \qquad \forall\, j=1,\,2,\,3 \tag{9}$$

$$\frac{\gamma_1}{\left(1-n_1^t-e^t\right)^{\theta}} = \frac{w_t h_1^t\left(1-\tau_1\right)\left(1-b_1\right)}{c_1^t\left(1+\tau_c\right)} + \beta^3\,\frac{b_4 p_1 w_t h_1^t\left(1-\tau_1\right)}{c_4^t\left(1+\tau_c\right)} \tag{10.a}$$

$$\begin{aligned}\frac{\gamma_j}{\left(1-n_j^t\right)^{\theta}} &= \frac{w_{t+j-1}\left(1+\psi\left(e^t,g_y,q\right)\right)h_1^t\left(1-\tau_j\right)\left(1-b_j\right)}{c_j^t\left(1+\tau_c\right)} \\ &+ \beta^{4-j}\,\frac{b_4 p_j w_{t+j-1}\left(1+\psi\left(e^t,g_y,q\right)\right)h_1^t\left(1-\tau_j\right)}{c_4^t\left(1+\tau_c\right)} \qquad \forall\, j=2,3\end{aligned} \tag{10.b}$$

$$\frac{\gamma_1}{(1-n_1^t-e^t)^{\theta}} - \frac{1}{c_1^t}\frac{\partial c_1^t}{\partial e^t} = \beta\,\frac{1}{c_2^t}\frac{\partial c_2^t}{\partial e^t} + \beta^2\,\frac{1}{c_3^t}\frac{\partial c_3^t}{\partial e^t} + \beta^3\,\frac{1}{c_4^t}\frac{\partial c_4^t}{\partial e^t} \tag{11}$$

with: $$\frac{\partial c_1^t}{\partial e^t} = \frac{-b_1 w_t h_1^t\left(1-\tau_1\right)}{1+\tau_c}$$

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

$$\frac{\partial c_4^t}{\partial e^t} = b_4\,\frac{\partial\psi\left(e^t,g_y,q\right)}{\partial e^t}.\frac{\sum_{j=2}^{3}\left(p_j n_j^t w_{t+j-1}h_1^t\left(1-\tau_j\right)\right)}{1+\tau_c}$$

4.2. Production of effective human capital

The specification and parameterization 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, nor about the underlying functional form and parameter values (Bouzahzah *et al*, 2002, Arcalean and Schiopu, 2010). The literature shows a variety of functions, typically including one or two of the following inputs: individual time allocated to education, private expenditures on education by individuals themselves of 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 function 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, our specification is broader than this. 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 5.3)[4]. 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. PISA scores 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 (12) 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: ϕ is a positive efficiency parameter, σ a scale parameter, v is a share parameter and κ the elasticity of substitution. These parameters will be calibrated.

$$\Psi(e, g_y, q) = \phi q \left(\nu g_y^{\,1-(1/\kappa)} + (1-\nu) e^{1-(1/\kappa)} \right)^{\sigma\kappa/(\kappa-1)} \tag{12}$$

Lack of existing empirical evidence makes an ex-ante assessment of our specification very difficult. In previous work, however, we have been able to verify that this specification performs better than alternative specifications without quality, with a narrower definition of government expenditures or with a different functional form (Heylen and Van de Kerckhove, 2010).

4.3. Domestic firms, output and factor prices

Firms act competitively on output and input markets and maximize profits. All firms are identical. Total domestic output is given by the production function (13). Technology exhibits constant returns to scale in aggregate physical capital (K_t) and effective labor (H_t), so that profits are zero in

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[4] 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 5.3 (Table 4) confirms this lack of relationship between expenditures and quality.

equilibrium. Equation (14) describes total effective labor supplied by young, middle aged and old workers. Remember that μ_{jt} represents the size of generation j at time t and that young workers inherit the human capital of the middle aged ($h_1^t = h_2^{t-1}$).

$$Y_t = K_t^{\alpha} H_t^{1-\alpha} \tag{13}$$

$$H_t = \mu_{1t} n_1^t h_1^t + \mu_{2t} n_2^{t-1} h_2^{t-1} + \mu_{3t} n_3^{t-2} h_3^{t-2} = \left(\mu_{1t} n_1^t + \mu_{2t} n_2^{t-1} + \frac{\mu_{3t} n_3^{t-2}}{x_{t-1}} \right) h_1^t \tag{14}$$

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 (15) 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 τ_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 16). Higher real wages follow from an increase in physical capital per unit of effective labor. Taking into account (15), real wages per unit of effective labor will therefore fall in the world real interest rate and in domestic capital tax rates.

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

$$(1-\alpha) \left(\frac{K_t}{H_t} \right)^{\alpha} = w_t \tag{16}$$

Rewriting (13) as

$$Y_t = \left(\frac{K_t}{H_t} \right)^{\alpha} H_t = \left(\frac{\alpha(1-\tau_k)}{r_t} \right)^{\alpha/(1-\alpha)} \left(\mu_{1t} n_1^t + \mu_{2t} n_2^{t-1} + \frac{\mu_{3t} n_3^{t-2}}{x_{t-1}} \right) h_1^t,$$

where we have substituted (14) for H_t and (15) for K_t/H_t, and recognizing that in steady state r, τ_k, x, e, μ_{jt}[5] and n_j are constant, we obtain the long-run (per capita) growth rate of the economy as

$$ln\left(\frac{Y_t}{Y_{t-1}} \right) = ln\left(\frac{h_1^t}{h_1^{t-1}} \right) = ln\left(\frac{h_2^{t-1}}{h_1^{t-1}} \right) = ln\left(1 + \psi(e, g_y, q)\right) \tag{17}$$

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

[5] For a steady state, it is necessary to impose an unchanged population structure.

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).

4.4. Government

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

$$G_{yt} + G_{ct} + B_t + PP_t + Z_t = T_{nt} + T_{kt} + T_{ct} \tag{18}$$

with: $G_{yt} = g_y Y_t$

$$G_{ct} = g_c Y_t$$

$$B_t = \mu_{1t}(1 - n_1^t - e^t) b_1 w_t h_1^t (1-\tau_1) + \sum_{j=2}^{3} \mu_{jt}(1 - n_j^{t+1-j}) b_j w_t h_j^{t+1-j}(1-\tau_j)$$

$$PP_t = \mu_{4t}\left[b_4 \sum_{j=1}^{3} \left(p_j w_{t+j-4} h_j^{t-3} n_j^{t-3}(1-\tau_j) \right) \right]$$

$$Z_t = z_t \sum_{j=1}^{4} \mu_{jt}$$

$$T_{nt} = \sum_{j=1}^{3} \mu_{jt} n_j^{t+1-j} w_t h_j^{t+1-j} \tau_j$$

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

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

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. We further assume the pension system is fully integrated into the government accounts. We do not impose a specific financing of the PAYG pension plan such that the government can use resources from the general budget to finance retirement pensions.

5. 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 and of changes to the pension system. This simulation exercise requires us first to parameterize and solve the model. In Section 5.1 we discuss our choice of preference and technology parameters. Starting from actual cross-country fiscal policy data in Section 5.2, we compare in Section 5.3 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 6 we consider both long-run equilibrium effects and transitional dynamics of policy changes. In that section we assume all generations to be of equal size and constant. In Section 7 we run similar policy simulations while imposing a realistic ageing pattern. To solve the model and to perform our 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.

5.1. 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 β equal to 0.74. With respect to effective labor, we assume a share coefficient 1-α 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-α equal to 2/3. There is more controversy in the literature about the value of the intertemporal elasticity of substitution in leisure (1/θ). 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 elasticity may be unrelated. Rogerson (2007) also adopts a macro framework. He puts forward a reasonable range for θ from 1 to 3 (Rogerson, 2007, p. 12). In line with this, we impose θ to be equal to 2. The world real interest rate is assumed constant in steady state 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.

Table 2 Basic parameterization

Technology and preference parameters	
Production parameters (output)	$1-\alpha=0.7$
Effective human capital production	$\phi=3.54,\ \sigma=0.86,\ v=0.2,\ \kappa=0.45$
Preference parameters	$\beta=0.74,\ \theta=2,\ \gamma_1=0.049,\ \gamma_2=0.116,\ \gamma_3=0.241$
World real interest rate	$r=0.558$

A second series of parameters have been determined by calibration: three taste for leisure parameters (γ_1, γ_2, γ_3) and two parameters in the human capital production function (the efficiency parameter ϕ and the scale parameter σ). We have calibrated these parameters to Belgium. We choose this country since in Belgium the calculation of pension benefits exactly matches the way we model it. Public pensions are proportional to average annual labor income earned over a period of 45 years, with equal weights to all years (OECD, 2005)[6]. In our model this comes down to p_1=p_2=p_3=1/3. The parameters γ_1, γ_2, γ_3, ϕ and σ have been determined such that with observed levels of the policy variables (tax rates, benefit replacement rates, pension replacement rate, etc.) and the observed level of schooling quality (q)[7] in Belgium, the model correctly predicts Belgium's employment rates (n_1, n_2, n_3), per capita growth rate and education rate (e) in 1995-2007. Underlying performance and policy data are reported in Tables 1, 3 and 4. We find that the taste for leisure rises with age (γ_1=0.049, γ_2=0.116, γ_3=0.241). Furthermore, we observe decreasing returns in human capital production (σ=0.86).

Finally, we had no ex ante indication on two parameters in the human capital production function: the share parameter v and the elasticity of substitution parameter κ. 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 model to explain five important macro variables in 13 OECD countries. Although the influence of v and κ on the explanatory power of our model is very limited, our guideline to pin down specific values for these parameters (within a sensible range) was to minimize the deviation of our model's predictions from the true data[8]. This procedure implied v=0.2 and κ= 0.45. The result for κ 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.

5.2. Fiscal policy, pensions and education quality

Tables 3 and 4 describe key characteristics of fiscal policy and the pension replacement rate in 1995-2001/2004. All reported data are averages of the available annual data in that period, unless indicated otherwise. 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

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[6] For robustness, we have also calibrated our model to the average of a group of six countries: Belgium, Canada, Finland, Germany, Sweden and the US. These countries have pure defined-benefit systems (Belgium, Canada, Finland and the United States), point systems (Germany) or notional-account systems (Sweden). Although these three systems can appear very different, the OECD (2005) shows they are all similar variants of earnings-related pension schemes. Calibration to this group of countries yields highly similar parameters: γ_1=0.042, γ_2=0.098, γ_3=0.206, ϕ=3.51, σ=0.89. Using these alternative parameter values for our simulations in later sections does not change our results in any significant way.

[7] And with the values of two parameters in the human capital production function (v, κ) that we discuss below (see also footnote 8).

[8] From our model's predictions and the true data for 13 countries we computed for each variable (n_1, n_2, n_3, e, *growth*) the root mean squared error normalized to the mean. We minimized the average normalized RMSE over all five variables. We then adopted the following iterative procedure. Given chosen values for v and κ we calibrated the efficiency parameter ϕ and the scale parameter σ. The values for v and κ had no influence on the calibration results for γ_j. Given the values for ϕ and σ, we checked whether changes in v and κ could further improve the model's explanatory power. New values for v and κ led to a recalibration of σ and ϕ, etc.

calculated our τ_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[9]. As one can see in Table 3, however, differences within countries between τ_1 on the one hand and τ_2 and τ_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 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 :	τ_1	τ_2, τ_3	τ_c	τ_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

Note: Labor tax rates are data for the total tax wedge, marginal rate (OECD, Taxing Wages). Data for 2000-04. For details on the calculation of tax rates by age group, see Appendix 1. Capital tax rates are effective marginal corporate tax rates (Institute for Fiscal Studies, their EMTR; data for 1995-2001, see also Devereux et al., 2002). Consumption tax rate: see Dhont and Heylen (2009). Data 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 (j = 1,2,3). 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 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

[9] For further details, see Appendix 1.

unemployed for more than five years without losing benefit eligibility[10]. The data are expressed in 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 in some countries reflects the availability of generous early retirement regimes. 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. Overall, the euro area and the Nordic countries pay the highest net benefits on average. Transfers to structurally non-employed people are by far the lowest in the US.

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, %)	Pension benefit (net replace-ment rate, %)	government consumption (% of GDP)	Government productive expenditure (% of GDP)	PISA – science (divided by 1000)
Proxy for :	b_1	$b_{2,}$	b_3	b_4 [(a)]	g_c	g_y	q
Austria	60.8	50.9	58.9	88.9	14.6	9.1	5.07
Belgium	65.1	51.7	62.3	63.1	16.9	8.9	5.05
France	52.3	38.3	55.6	68.8	18.3	11.0	5.02
Germany	65.4	59.7	63.8	71.8	15.3	8.6	5.02
Italy	18.5	15.3	34.0	88.8	14.3	8.0	4.80
Netherlands	62.5	46.6	55.8	84.1	18.4	10.3	5.25
Denmark	67.8	55.4	55.4	54.1	18.4	12.5	4.84
Finland	68.4	54.4	61.7	78.8	16.0	11.4	5.50
Norway	64.8	49.4	49.4	65.1	14.7	12.1	4.90
Sweden	62.8	47.8	47.8	68.2	20.0	14.0	5.07
UK	57.8	44.4	44.4	47.6	14.4	7.3	5.23
US	34.3	26.6	26.6	51.0	10.3	9.3	4.93
Canada	49.7	39.5	39.5	57.1	14.7	9.3	5.27
Overall country average	56.2	44.6	49.9	68.3	15.9	10.1	5.07

Notes: A description of all variables is given in the main text. For more details, see Appendix 1. The data for net non-employment 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. The pension replacement rate concerns 2002 (source OECD, Pensions at a Glance, 2005, p. 52). The PISA science scores are an average for 2000, 2003 and 2006.

(a) The weights p_j to compute the pension base (with j=1, 2, 3) are in all countries assumed equal to 1/3 (see motivation in the main text).

Our data for productive government expenditures in Table 4 include education, active labor market expenditures, government financed R&D and public investment. Governments in the Nordic

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

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 countries of the core euro area[11]. In the US, government consumption is (much) lower. Our data for the net pension replacement rate concern an individual with mean earnings before retirement. They include only (quasi-)mandatory public pensions, and are expressed as a percentage of this individual's average lifetime labor income (OECD, 2005). Voluntary, occupational pensions are not included. The overall average replacement rate is 68.3%, but there are strong cross-country differences. We observe the lowest rates in the Anglo-Saxon countries, and the highest in Austria and the Netherlands. An important remark should here be made. The straightforward way in which the OECD computes the pension replacement rates comes down to assuming in our model that the weights p_1, p_2 and p_3 are all equal to 1/3. For reasons of consistency we will therefore make this assumption for all individual countries when we derive our model's predictions. We are aware however that equal weights do not fully match the practice in all countries. Belgium, Canada, Finland, Germany, Italy, Sweden and the US come close to such a system: they use lifetime average (or close to lifetime average) pay as the earnings measure to calculate pension benefits (OECD, 2005). The other countries however deviate from this prototype, to varying degrees.[12] When we compare our model's predictions for these countries to the facts in the next section, we should take this into account. Assuming equal weights may slightly bias our predictions.

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 (12). 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.[13] Both variables seem to tell different stories (see also Woessmann, 2003).

5.3. Predicted versus actual employment by age, education of young and growth in the OECD

Can our model explain 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.

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[11] 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.

[12] In Austria, Norway and France earnings-related pensions are not calculated on average lifetime income but on average income during the final working years or a number of years with the highest earnings. Ideally, one would impose different weights p_1, p_2 and p_3, although exact data are often not available. Moreover, the OECD pension replacement rate would then no longer be reliable since it is based on the assumption of equal weights. Other countries (e.g. Denmark, UK and the Netherlands) have pension systems that do not fit into our modelling. For instance, in the Netherlands and Denmark, there is no public earnings-related scheme. The UK relies mostly on minimum or basic pensions and has a more limited earnings-related scheme. (OECD, 2005)

[13] Heylen and Van de Kerckhove (2010) report correlation between education expenditures in percent of GDP and the PISA score. This one is -0.12.

Countries may still be moving towards their steady state.[14] Third, this exercise only concerns the last 15 years. Lack of data – especially with respect to marginal labor tax rates and non-employment transfers in the early 1990s – makes it impossible for us to execute the maybe most convincing test, which is to relate changes in growth and employment to changes in policy within countries over longer time periods. In spite of that, 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 employment rates by age, education and per capita growth in Belgium. The test of the model's validity is whether it can also match the data for the other countries, and the 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. Only fiscal policy variables, the pension replacement rate and education quality differ. 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 for three employment rates to actual observations for all countries. We add the 45°-line to assess the absolute differences between predictions and facts, as well as 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 Canada and – within Europe – relatively strong employment in the Nordic countries and the UK. The rather poor employment performance in countries like Germany and Belgium is also correctly predicted. Overall correlation in Figure 2 is 0.50, in Figure 3 it is 0.69. Moreover, the slope of the regression line (not shown) in both figures is close to the 45°-line. This suggests that our model correctly assesses the size of the employment effects of policy differences across countries. The model explains less well, however, for the Netherlands in both figures, for Finland in Figure 2 and for Italy and Austria 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 difference for Italy. A major element behind the deviation for this country 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 other European countries is much smaller than it seems.[15] Including Italy,

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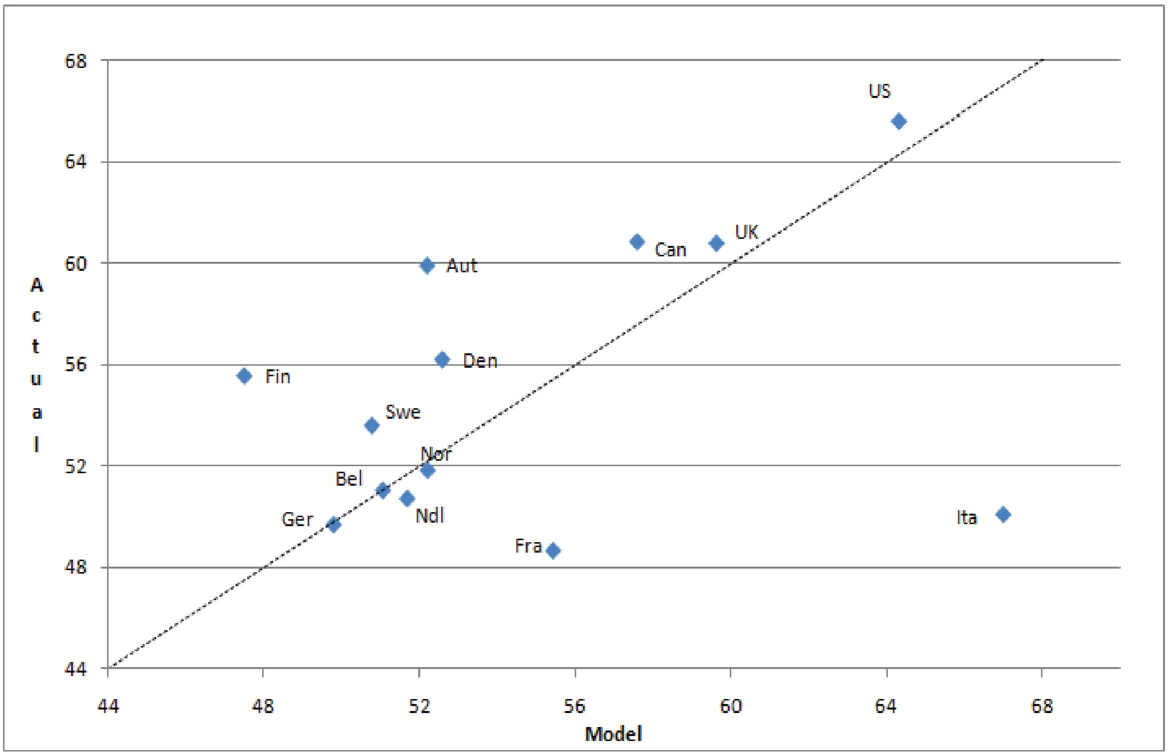
[14] This argument explains why we have not included convergence countries like Ireland and Portugal in our dataset.

[15] 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%.

correlation between our model's predictions and the facts in Figure 1 is only 0.35. Excluding Italy, it is 0.70. Although the model underestimates the employment rate of young workers in countries like Austria and Finland, it has major differences between European countries and the US right.

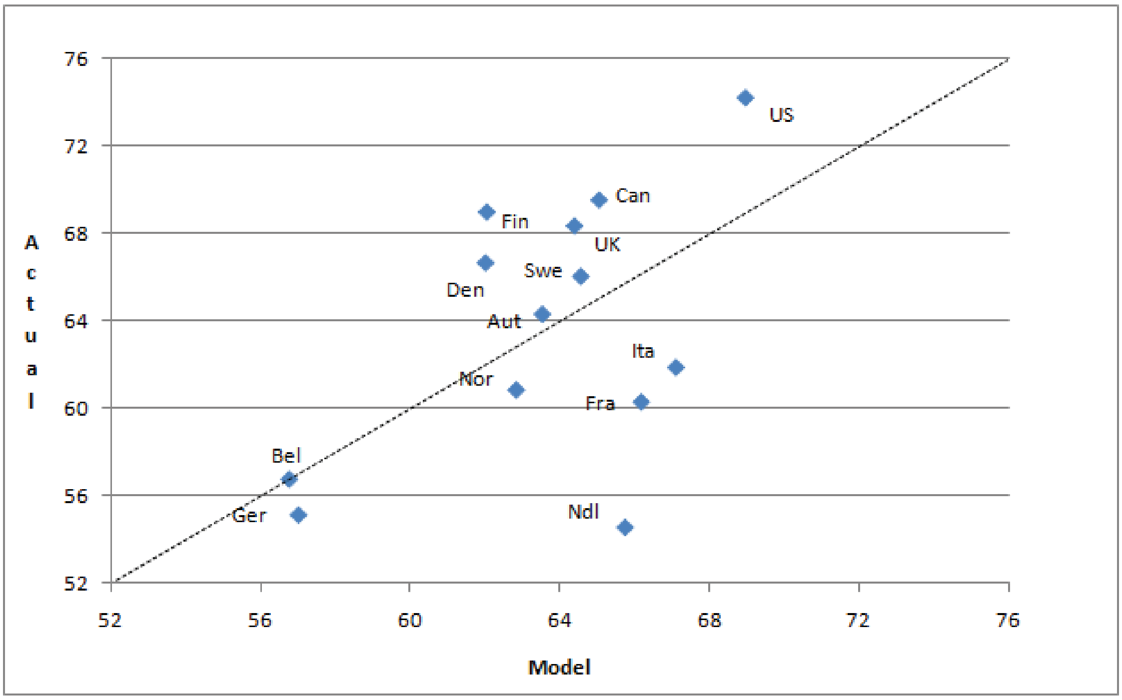
In Figures 4 and 5 we relate our model's predictions to the facts for education and growth. For education, the model correctly captures key differences between the Nordic countries on the one hand and countries like the US, the UK, Italy and Belgium on the other. Predictions for education are quite close to the 45°-line for all individual countries except Austria, Denmark and the Netherlands. The model also has important cross-country differences right for growth. The model only has some difficulty to explain observed growth for France and the UK.

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



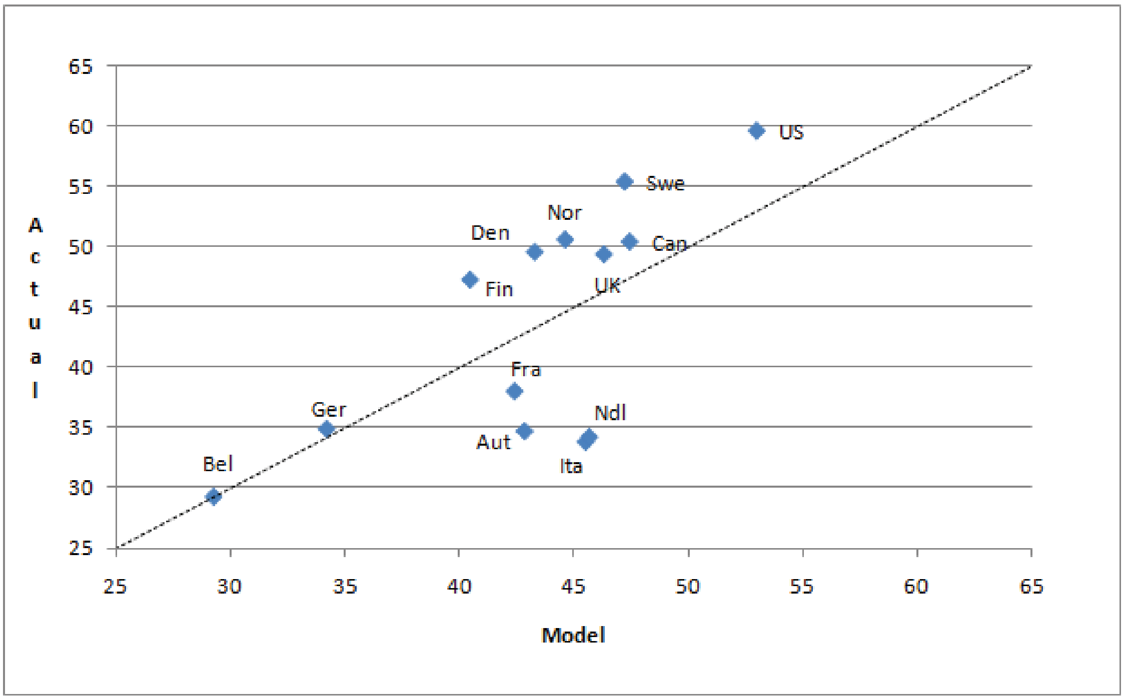
Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.35. Excluding Italy, correlation rises to 0.70.

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



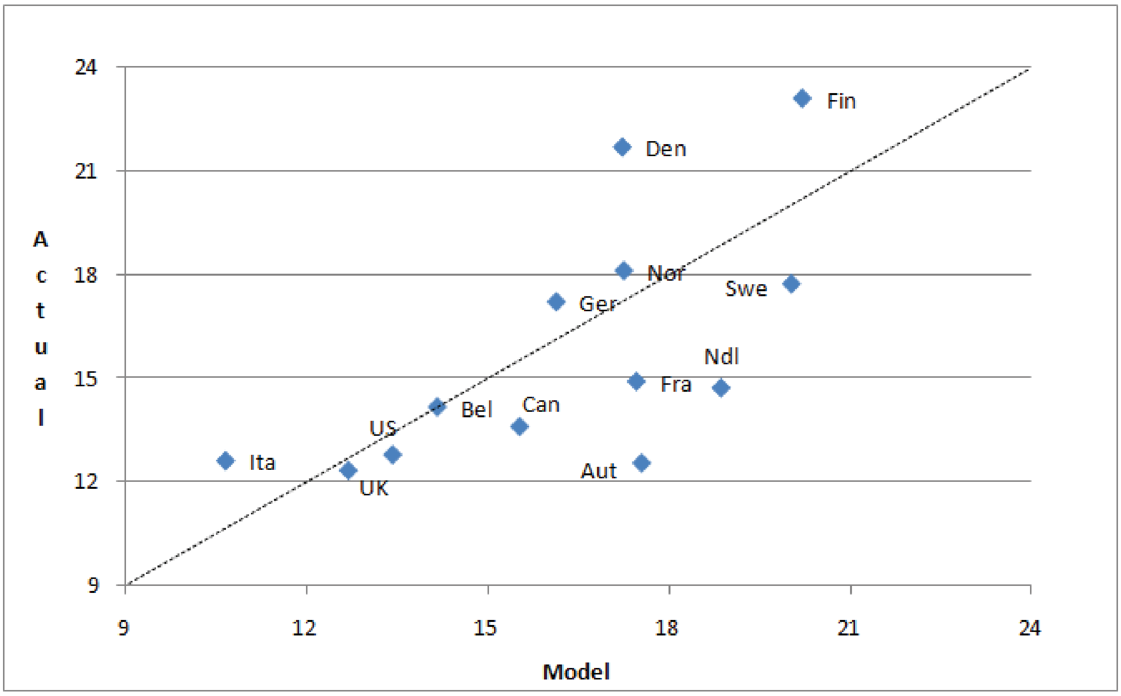
Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.50.

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



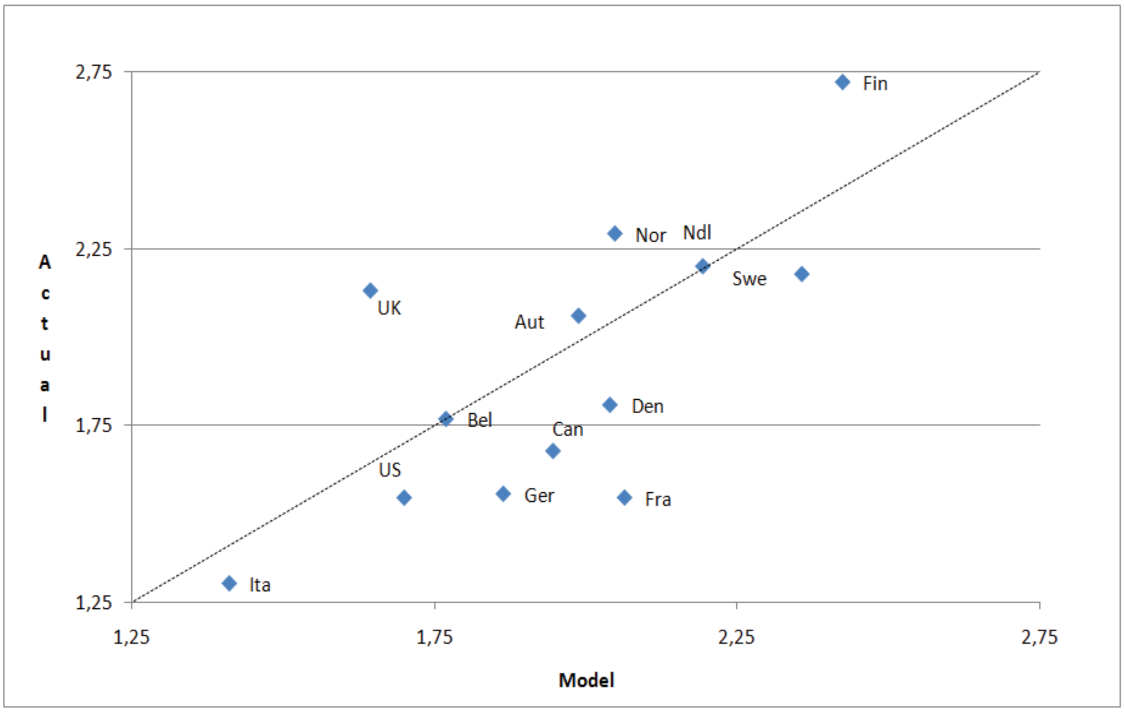
Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.69.

Figure 4. Tertiary education rate OECD 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 OECD countries, in %, 1995-2007



Note: The dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.72.

6. Fiscal policy shocks and public pension reform when ageing is ignored.

Having established the empirical relevance of our model, we now simulate a series of 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, education of the young, and growth. Our earlier work (Heylen and Van de Kerckhove, 2010) focussed on a wide range of fiscal policy shocks. In this section we revisit the most important of these. Our main objective now, however, is to investigate the effects of reform of the pension system. In Section 6.1 we consider steady state effects, in Section 6.2 transitional dynamics and welfare effects per generation. The particular pattern of transitory effects implies that subsequent generations' welfare may be affected differently. The benchmark from which we start, and against which all policy shocks are evaluated, is the average of all ten European countries in our sample.

Throughout Section 6 we assume a constant population structure. In particular, we start from zero population growth and generations of equal size, normalized to 1. Total population hence amounts to 4. In Section 7 we run similar policy simulations while imposing a realistic ageing pattern.

6.1. Numerical steady state effects.

Table 6 shows the effects of (i) an overall reduction in the labor tax rate on all age groups, (ii) a reduction in the labor tax rate on young workers, (iii) a reduction of labor taxes on middle-aged workers, (iv) a reduction of labor taxes on older workers (v) , an overall cut in the 'non-employment' benefit replacement rate (b_1, b_2, b_3) and (vi) an increase in productive government expenditures. All shocks are expected to increase employment. 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[16]. A last assumption is that these policy changes are financed by changes in lump sum transfers (z) to maintain budget balance.

The results in Table 6 demonstrate some of our main findings in Heylen and Van de Kerckhove (2010). Putting (aggregate) employment n first, cuts in non-employment benefit replacement rates seem to be the most effective, followed by labor tax cuts. Each of these measures raises the marginal utility of work versus inactivity. We find that an overall reduction of the net benefit replacement rate by 13.1%-points raises the aggregate employment rate in hours by 3.28%-points. A comparable overall labor tax rate cut by 4.3%-points raises the aggregate employment rate by 1.24 %-points. Considering that the aggregate employment rate in hours in the benchmark is about 54%, corresponding increases in the employment volume in hours (N) are respectively 6.10% and 2.31%. 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).

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[16] 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).

Higher productive expenditures raise labor supply and employment of middle aged and older workers thanks to their positive effects on labor productivity and wages before taxes. The overall employment effects are however slightly negative. A first reason is that an increase in productive expenditures raises individuals' permanent income, which raises the demand for leisure (of course less so for older workers, who are not able to reap the benefits from future productivity gains). A second reason is that higher productive expenditures encourage young individuals to study rather than work. In net terms we observe that a 3% of output increase in productive government expenditures would reduce the aggregate employment rate by 0.16%-points. Aggregate employment in volume would decline by 0.29%. Observing a fall in employment after an increase in productive expenditures may be somewhat surprising, considering that for example Turnosvky (2000) and Dhont and Heylen (2009) obtain positive effects. In their models, however, individuals do not allocate time to education.

Table 6. Fiscal shocks in the model (equal to 3% of output, ex ante) - compensated by changes in lump sum transfers (z) – Effects starting from a benchmark of 10 European countries.

Change in policy variable[(a)]	$\Delta\tau_1=\Delta\tau_2=\Delta\tau_3=-4.3$	$\Delta\tau_1=-11.8$	$\Delta\tau_2=-10.0$	$\Delta\tau_3=-20.4$	$\Delta b_1=\Delta b_2=\Delta b_3=-13.1$	$\Delta g_y=+3.0$
Effect [(b)]:						
Δn_1	0.63	8.09	-3.77	-4.91	3.73	-3.86
Δn_2	1.24	-1.32	3.68	0.04	2.38	1.40
Δn_3	1.96	-2.08	0.12	10.19	3.90	2.21
Δe	0.29	-5.07	3.41	4.42	-0.97	4.19
Δn [(b, c)]	1.24	1.66	0.12	1.30	3.28	-0.16
$\Delta N/N$ [(d)]	2.31	3.09	0.22	2.42	6.10	-0.29
Δannual growth rate[(b)]	0.02	-0.36	0.19	0.24	-0.06	0.38
Δz ex-post [(e)]	-3.81	-4.28	-3.78	-4.89	4.05	-2.73

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 aggregate employment rate in hours; n is a weighted average of n_1, n_2 and n_3.
(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.

Putting long-run growth first, three policy measures stand out as most effective: a cut in labor taxes on older or middle aged workers and (especially) an increase in productive government expenditures. Our results predict positive effects on the steady state annual growth rate of about 0.2 to 0.4%-points. 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 4 to 5%-points. Reductions of labor tax rates on middle aged and older workers are among the very few policy measures that succeed in raising aggregate employment, and education, and growth. 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 overall changes in labor tax rates have only very limited growth effects, are 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). Heylen and Van de Kerckhove (2010) show the results of (maybe more realistic) combined fiscal policy changes, i.e. shocks financed by a change in another fiscal policy variable. Their main conclusions are fully in line with those reported in Table 6.

In Table 7 we report the results of changes in key characteristics of the pension system. Starting from our benchmark, policies 1a and 2a alter the calculation of the pension base, such that more weight is given to the net income of workers when they are 'old'. These policies involve an increase in p_3, and a fall in p_1 and p_2.[17] The higher (lower) marginal utility from work when old (young/middle aged) makes it interesting to postpone work. Young individuals are also encouraged to study because the lifetime return to building human capital rises. This follows from the perspective of working longer and from the greater importance of effective human capital when old in the pension calculation. Extra schooling contributes to steady-state growth. Interestingly, the government budget does not worsen. For instance, policy 2a implies an increase in total pension expenditures by 0.20 %-point whereas the budget balance improves by 0.09%-points[18]. All in all, this simple reform succeeds in strongly increasing employment among older workers (+11.06%-points). Effects on the aggregate employment rate (+0.37%-points) and the per capita growth rate (+0.14%-points) are also positive.

A comparison of policies 1a and 1b allows to assess the effects of changes in the pension replacement rate. We find that a simulated increase of the replacement rate from 73% in the benchmark to 80% implies an increase in employment, especially among older workers. It also provokes a modest increase in education and growth. The reason is that a higher replacement rate raises the return to working and building human capital in earlier periods of life. This rise in the replacement rate (and the gains in employment and growth) may however go along with an increase in the pension burden and a deterioration in the government's financial balance. An interesting observation, however, follows from comparing the results of policy 1b to the benchmark. This comparison shows that an increase in the pension replacement rate combined with a rise in the weight p_3 of earned labor income when old in the computation of pensions, has beneficial effects on

[17] In practice, this implies a higher accrual rate for earnings later in life. This rate gives the pension benefit earned each year as a fraction of earnings in that year (OECD, 2005). For instance, in policy 1a, the pension accrual rate for earnings after the age of 50 is twice the accrual rate for earnings before this age. In policy 2a, the accrual rate for earnings before the age of 50 is zero. We assume that this reform does not hold for the current generation of retirees as they are no longer able to adapt their behavior to these new pension weights.

[18] That is, to maintain budget balance (as in the benchmark) the government can raise lump sum transfers by 0.09% of output.

employment and growth without additional financial burden on the government's budget (as lump sum transfers do not decline).

Table 7. Effects of pension reform – Effects starting from a benchmark of 10 European countries.

Initial values: P_1=1/3 P_2=1/3 P_3=1/3	**Policy1a** P_1=1/4 P_2=1/4 P_3=1/2	**Policy2a** P_1=0 P_2=0 P_3=1	**Policy1b** P_1=1/4 P_2=1/4 P_3=1/2 Δb_4=0.07	**Policy2b** b_4=0.50 bp=1.3	**Policy 3** Fully Funded
Effect [(a)]:					
Δn_1	-1.18	-4.89	-1.24	-0.10	0.38
Δn_2	-0.78	-3.16	-0.61	-0.70	-0.91
Δn_3	3.36	11.06	4.14	-2.08	-5.19
Δe	0.57	2.48	0.72	-0.30	-0.64
Δn [(a, b)]	0.28	0.37	0.55	-0.49	-1.71
$\Delta N/N$ [(c)]	0.52	0.70	1.03	-1.67	-3.19
Δannual growth rate [(a)]	0.04	0.14	0.05	-0.02	-0.04
ΔZ ex post[(d)]	0.26	0.09	0.02	-0.49	-2.46
Δpension benefit expenditure[(e)]	-0.09	0.20	0.29	-1.27	-4.04

Notes: (a) difference in percentage points between new steady state and benchmark, except $\Delta N/N$.
(b) change in (weighted) aggregate employment rate in hours, change in percentage points.
(c) change in volume of employment in hours, in %.
(d) change in lump sum transfer (as a fraction of output) to maintain budget balance, in %-points.
(e) change in percentage points. Pension benefits are defined as a fraction of output. In the benchmark, our model predicts a government expenditure on net pension benefits equal to 4.04% of output.

Policy 2b shows the effects of introducing a basic pension (bp), unrelated to earlier labor income and human capital[19]. The total cost of this basic pension is equal to 1.3% of output. To neutralize ex-ante the effects on the government's financial balance, the replacement rate b_4 is reduced. As can be seen, overall employment, education and growth effects are negative. A key element is the fall in the return to working and studying when the pension replacement rate is reduced. A final experiment in Table 7 is a gradual shift in policy 3 from a PAYG system in the benchmark to a fully funded system. For the government this implies a drastic cut in pension expenditures. We assume that this feeds through into lower social security contributions for all workers such that, ex ante, the decline in total labor tax revenues in % of GDP is exactly the same as the drop in pension expenditures.[20] We observe that this transition to a fully funded pension scheme is neither beneficial for growth nor employment. The aggregate employment rate drops by 1.71%-points whereas growth is slightly

[19] In essence, a basic pension comes down to increasing lump sum transfers to the generation of retired.

[20] In particular, this gradual decline in b_4 is announced at time t=1 and implemented as follows. PAYG pensions are not reduced for retirees at the moment of policy implementation (t=1), as they are not able to react to a pension reduction. In t=2 and t=3 the replacement rate is respectively reduced to 2/3 and 1/3 of the initial rate. From t=4 onwards, b_4 is zero. At each moment, overall tax rates are reduced to ex ante compensate for the decline in pension expenditures.

reduced (-0.04%-points). In this respect our results are in line with those obtained by e.g. Kemnitz and Wigger (2000) and Zhang and Zhang (2003). Moreover, we find that the government balance deteriorates (as lump sum transfers decline by 2.46% of GDP). The latter is explained by the decline in the tax base as work hours decrease.

6.2. Transitional dynamics and welfare effects per generation.

We now describe the transitory adjustment path of key variables, including welfare, after the pension reforms discussed in the previous section. Figures 6 and 7 show the aggregate output level and aggregate employment effects of the policies of pension reform discussed in Table 7. Policy changes are introduced in period 1. We assume that these policy changes are unanticipated and permanent. We observe the strongest 'short-run' output gain following policy 1b although the differences between policies are very small (ranging from -1.6% after policy 3 to +0.4% after policy 1b). In the long-run, differences are more pronounced. The strongest 'long-run' output effects follow from policy 2a (+10.6% after 6 periods) although the short-run output effect of this reform is slightly negative (-0.1%). Note also the negative output evolution (in comparison to the benchmark) of policy 3, the transition to a fully funded system, both in the 'short-run' and the 'long-run'. The reason for the latter is the strong decline in both tertiary education and aggregate employment, as can be seen in Figure 7. We further notice in Figure 7 that policies that change the calculation of pension benefits (1a, 2a and 1b) have small but beneficial effects on average employment (although labor supply of the young and middle aged falls). We remember that these are also the policies with the most beneficial effects for output and growth.

Figure 6. Output level evolution after permanent policy shocks introduced in period 1 in the pension model (index, benchmark period=0, benchmark output level =1)

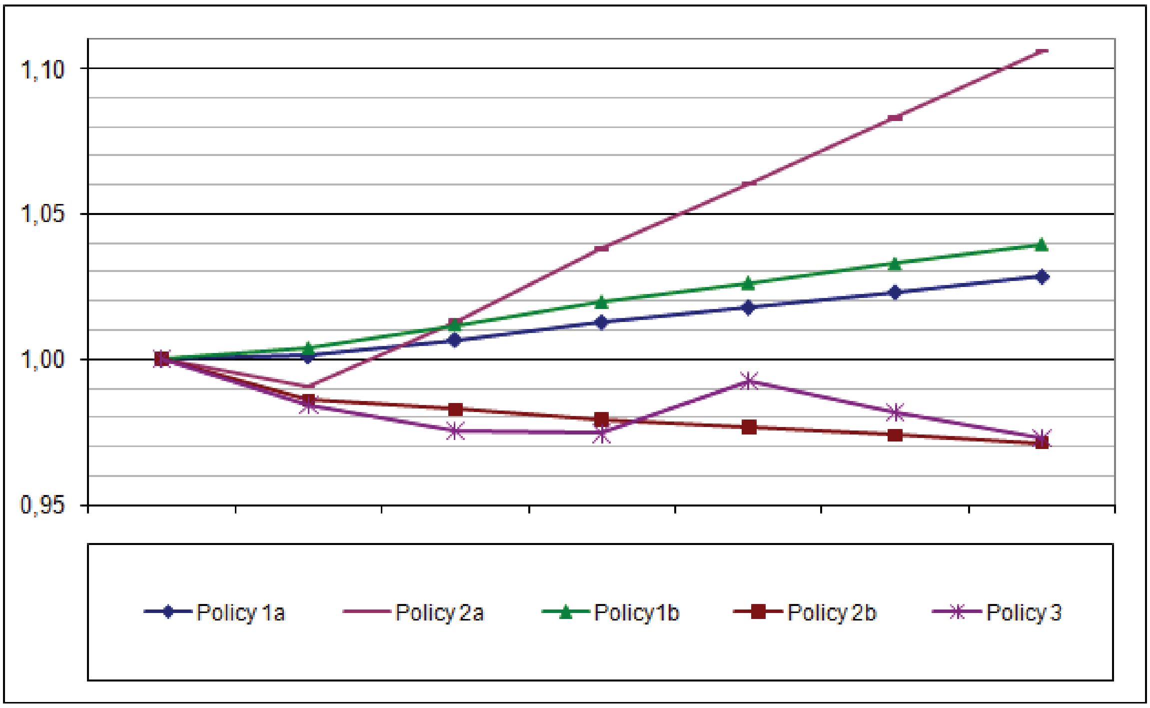


Figure 7. Aggregate employment rate after permanent policy shocks introduced in period 1 in the pension model (benchmark period=0)

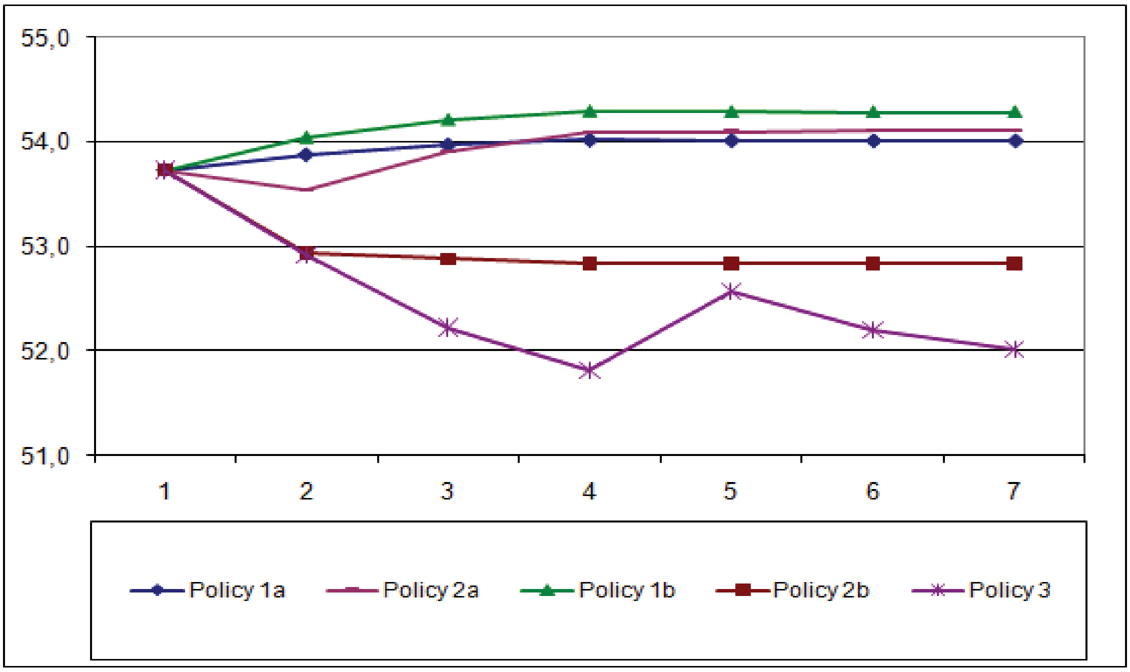
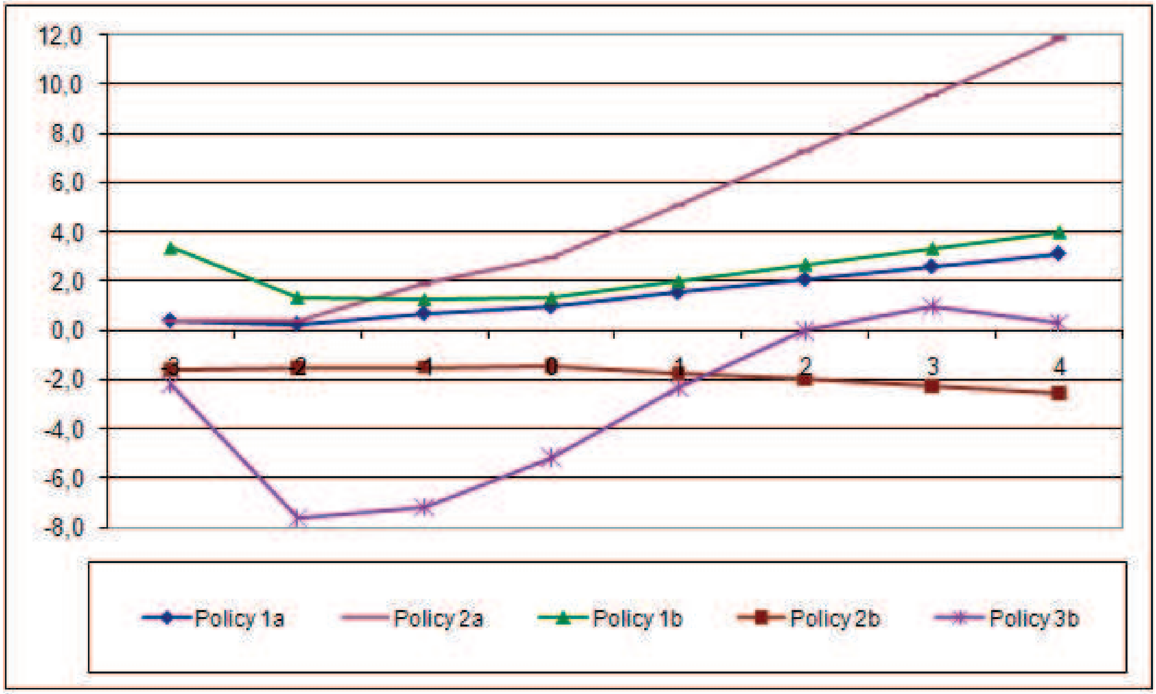


Figure 8 shows the welfare effects of these policy changes for current and future generations. We report on the vertical axis the welfare effect on the generation born in $t+k$, where k is indicated on the horizontal axis, and where t is the period when the (permanent, unanticipated) policy change is 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 policy 2a, a shift in the weights underlying the pension base in favor of the third period (p_3) implies a welfare gain for the current young (k=0), equal to 2.9% of benchmark consumption. The gain for the current retired (k=-3) is much smaller (0.36% of benchmark consumption). All future generations ($k>0$) gain.

Our most interesting findings concern the overall welfare gain for current and future generations following the adoption of policy 1b. An increase in the pension replacement rate combined with a rise in the weight p_3 of earned labor income when old in the computation of pensions, does not only have significant beneficial effects on employment and growth, but also on welfare for all generations. Moreover, this reform results in the largest welfare gains for current retired (+3.4%) and older workers (+1.4%) when compared to our other policy measures. Furthermore, we observe the overall welfare loss for current generations following the adoption of policy3 (the shift to a fully funded system combined with labor tax cuts). Some future generations may however gain under this reform. In the long-run, welfare rises most under the adoption of policy 2a, thanks to its strong positive effects on growth.[21]

[21] Considering policy 2b, the welfare effects are sensitive to the size of the basic pension.

Figure 8. Welfare effects for current and future generations after pension reform



Note: The vertical axis indicates the welfare effect for the generation born in $t+k$, where t is when the policy change is introduced. The horizontal axis indicates k.
For a description of our welfare measure, see the main text.

When interpreting the previous results, caution is required. All of the above described effects have been obtained under the assumption of generations of equal and constant size. For instance, we observe beneficial effects on the government balance from policy 2a. Clearly, we should analyze if these effects persist when we allow for demographic change and population ageing. It is generally understood that ageing will put significant pressure on pension expenditures and the government's financial balance. Therefore, we cautiously address this topic in the next section.

7. Pension reforms with ageing.

In order to assess the influence of ageing, we focus on one country: Belgium[22]. In this section, we first repeat for Belgium the above simulations of pension reform, assuming generations of equal size. Then we impose a more realistic pattern of ageing, allowing a change in the population structure. Our main question is whether our conclusions regarding preferable policies to pension reform, as discussed in the previous section, survive once we allow for ageing. Are the effects of these policies different under ageing? Will they be financially sustainable, or do they imply a (further) worsening of the government's budget?

Table 8. Steady state effects of pension reform for Belgium

Initial values: $P_1=1/3$ $P_2=1/3$ $P_3=1/3$	**Policy1a** $P_1=1/4$ $P_2=1/4$ $P_3=1/2$	**Policy2a** $P_1=0$ $P_2=0$ $P_3=1$	**Policy1b** $P_1=1/4$ $P_2=1/4$ $P_3=1/2$ $\Delta b_4=0.07$	**Policy2b** $b_4=0.40$ bp=1.0	**Policy 3** Fully Funded
Effect [(a)]:					
Δn_1	-1.16	-4.74	-1.17	-0.28	0.01
Δn_2	-0.98	-3.83	-0.81	-0.75	-0.70
Δn_3	4.05	13.34	5.11	-2.84	-6.38
Δe	0.38	1.68	0.49	-0.20	-0.27
Δn [(a, b)]	0.42	0.84	0.78	-1.20	-2.11
$\Delta N/N$ [(c)]	0.89	1.80	1.68	-2.55	-4.50
Δannual growth rate [(a)]	0.03	0.11	0.03	-0.02	-0.02
ΔZ ex post[(d)]	0.41	0.64	0.32	-0.71	-2.92
Δpension benefit expenditure[(e)]	-0.15	-0.08	0.15	-1.00	-2.74

Notes: (a) difference in percentage points between new steady state and benchmark, except ΔN/N.
(b) change in (weighted) aggregate employment rate in hours, change in percentage points.
(c) change in volume of employment in hours, in %.
(d) change in lump sum transfer (as a fraction of output) to maintain budget balance, in %-points.
(e) change in percentage points. Pension benefit expenditures are defined as a fraction of output. For Belgium, our model predicts government expenditure on pension benefits equal to 2.74% of output

Table 8 reports the results of simulating the five policies of pension reform for Belgium disregarding ageing. Most results are similar to our benchmark results for the ten European countries in Section 6, Table 7. For instance, a change in the pension calculation (policies 1a and 2a) is always beneficial for the government budget (+0.41%-points resp. 0.64%-points) while overall employment effects are slightly better (+0.42%-points resp. +0.84%-points). Furthermore, note that policy 1b still improves the government's balance (+0.32%-points) when compared to the initial equilibrium. It thus seems that for Belgium, an increase in the pension replacement rate combined with a rise in the weight p_3 of earned labor income when old in the computation of pensions, is beneficial for employment and growth without additional financial burden on the government's budget, at least in steady state.

[22] Results for Germany are highly similar and available upon request.

Simulations for Germany (not presented) indicate the same. Moreover, focusing on policy 2b shows that a basic pension reduces overall employment, education and growth, as was the case in our benchmark simulations in Section 6. Finally we notice that the transition to a fully funded pension system (policy 3) seems to be neither beneficial for growth nor employment. This conclusion again confirms the results from benchmark simulations. We show the output evolution and welfare implications for Belgium in Appendix 2. Again, these results are similar to those in Section 6.2.

An important assumption underlying our results in Table 8 was that all generations are of equal and constant size. We now proceed our analysis by allowing the size of the four generations to differ and change over time. We depart from official demographic prospects by the United Nations (2008) presented in Table 9 and translate these projections into an evolution of our demographic parameters μ_{jt}. We normalize the total Belgian population in 2000 to 4. The demographics capture both the change in total population and its composition. Note that our measure for μ_4 does not contain the population older than 80. Table 9 shows that the Belgian population aged 20-80 is predicted to increase. Furthermore, we observe an increase in the old-age dependency ratio from 22.4% in 2000 to 31.6% in 2030.

Table 9. Prospected Belgian population in thousands[(a)]

	2000 (t=0)	2015 (t=1)	2030 (t=2)	2045 (t=3)	2060[(c)] (t=4)
μ_1 [(b)]	2046	1986	1913	1975	1971
μ_2 [(b)]	2308	2189	2051	1983	2004
μ_3 [(b)]	1724	2231	2135	2018	1996
μ_4 [(b)]	1359	1432	1927	1875	1818
Old-age dependency ratio	22.4	22.4	31.6	31.4	30.4
$\sum_{j=1}^{4} u_{jt}$	7437[(d)]	7838	8026	7851	7789

Notes: (a) source: United Nations – Populations Division. World population prospects: the 2008 Revision. http://esa.un.org/UNPP/

(b) projected population in age group 20-34 (μ_1), 35-49(μ_2), 50-64(μ_3) and 65-79(μ_4).

(d) We use figures for 2050 as an approximation.

(e) calculated as $\mu_4 \Big/ \sum_{j=1}^{3} \mu_{jt}$

We will use these population prospects to construct a new baseline scenario, against which all policies are compared. However, we first make some theoretical considerations. Until now, government lump sum transfers to individuals were determined to balance the budget. For the remainder of this section, we make the following assumption. In 2000, every individual receives an amount share of lump sum transfer, such that total lump sum transfers are equal to our predicted initial steady state for Belgium. In our model this absolute amount is indexed every period in line with predicted long-run growth (equation (17)). These individual lump sum transfers can be seen as transfers from government which are not explicitly part of our model (health care, child care, other subsidies…). It is our assumption that changes in the population structure do not lead to changes in individual transfers. Instead, the government budget absorbs changes in these transfers due to changes in the population size.[23] Moreover, note that if ageing leads to a temporarily smaller GDP-growth, individual lump sum transfers (growing at the long-run growth rate) will constitute a larger percentage of current GDP. These assumptions do not influence our simulation results in any significant way. We now calculate the government deficit as the difference between total current government revenues and expenditures (including lump sum transfers and debt servicing costs). A deficit is financed on the 'world capital market'. In case of a surplus, the government pays off previous debt or invests abroad.

$$BB_t = T_{nt} + T_{kt} + T_{ct} - G_{yt} - G_{ct} - B_t - PP_t - Z_t - r_t D_{t-1} \tag{18.b}$$

with: $Z_t = z_t * \sum_{j=1}^{4} \mu_{jt}$

where D_t is government debt and BB_t the government balance at time t (BB_t>0 represents a surplus).

In our model, and for several reasons, neither pure ageing nor population growth will have an effect on individual behavior. First, remember that our model assumes exogenous retirement at 65 and a fixed life length. Our ageing scenario does not include increases in longevity. Hence there is no Ben-Porath (1976) mechanism at work in our model (see e.g. de la Croix and Licandro, 1999; Boucekinne et al., 2002). Second, as we hold lump sum transfers for individuals fixed, the government, and not the individuals, bears the fiscal cost of a growing population. Third, population ageing does not put upward pressure on future wages as is the case in many closed economy models (e.g. Auerbach et al., 1989; Hviding and Mérette, 1998; Fougère and Mérette, 1999). As we assume an open economy, the decrease in effective labor supply due to a smaller working age population is in our model offset by capital outflow, so that ex post the capital/labor ratio (and the factor price ratio) is unchanged. Finally, wage income taxes (as well as other taxes) do not automatically rise due to ageing as the increase in public pension expenditures is allowed to translate into accumulating government debt.[24] We do not implement any fiscal rules to keep government debt evolution from exploding. For the purpose of this study, we are not interested in government debt. Therefore, we will, in the remainder of this text, focus our attention only on the evolution of the primary balance: government revenues – government expenditures (excluding debt servicing costs). We believe the previous assumptions will not influence our main results. We only want to know whether our results concerning pension reforms persist when the model includes realistic demographic prospects.

We now construct our baseline ageing scenario. Therefore we let the population structure evolve as in Table 9. Table 10 shows our model's forecast of the evolution of the Belgian primary government surplus and pension expenditures, both in % of GDP. Focusing on the government balance in 2000, we start from a projected primary surplus of 3.39% of GDP. Due to ageing, this surplus is reduced to -0.01% in the following 30 years, whereafter a slight improvement is observable until 2060 (0.54% of

[23] Remember that retirees are assumed to die at the age of 80. Hence we do not take into account the fact that ageing will entail an increase in government expenditures due to an increasing life length.

[24] By contrast, a.o. Fougère and Mérette (1999) assume that the government must maintain solvency of the pension fund by adjusting social security contributions. If we include this assumption in our model, population ageing would in the long run lead to a drop of 0.11%-points in n_1 and 0.14%-points in n_2 and 0.13%-points in n_3. Furthermore, young individuals then spend slightly less time in education (-0.03%-point). The growth effect is zero. The deterioration in the government balance is smaller than presented in Table 10.

GDP). There are two main reasons for this deterioration. First, we notice an increase in total lump sum transfers as the total population grows (not presented). Second, there is an increase in pension benefit expenditures. Table 10 shows a rise from 1.76% of GDP in 2000 to 2.50% of GDP in 2060. The evolution of pension expenditures is important, much more than its absolute size. Note that our model has not been calibrated to match observed wages. Remember that we use OECD pension replacement rates multiplied by average lifetime income to calculate pension benefits. Consequently, the model is not assumed to correctly predict the exact Belgian pension expenditures in % of GDP (approx. 5.4% for employees in 2009). However, our model predicts an increase in pension expenditures of about 42% in 2060 compared to 2000. This is close to the predicted increase of 50% (= 8.3% in 2050 compared to 5.4% in 2009) by the ScvV (Study Committee on Ageing, Annual Report 2010, p. 30).

Table 10. Predicted Belgian government balance and pension expenditures (in % of GDP)[25]

	2000 (t=0)	2015 (t=1)	2030 (t=2)	2045 (t=3)	2060 (t=4)
PB_t	3.39	1.75	-0.01	0.23	0.54
PP_t	1.76	1.85	2.63	2.58	2.50

Source: own calculations. PB_t is the period-specific primary balance as a fraction of output (PB_t>0 is a primary surplus).

We now analyze how the pension reforms from the beginning of this section may affect the government's primary balance. We show its evolution after different pension reforms in Figure 9. We are particularly interested in the effects from our preferred policies 2a and 1b. For completeness, we also show the effects of the transition to a fully funded system[26]. As a benchmark, we use the predicted primary balance evolution of Table 10 (ageing scenario). We observe some interesting results. First, instead of leading to an improvement in the government accounts, the transition to a fully funded pension system (policy 3) has dramatic effects on the government balance. Indeed, in 2015 the primary government balance will have deteriorated by 3.1%-points compared to 2000. Although pension expenditures are reduced to zero, this effect on the government balance is compensated by lower labor tax rates. Despite these lower taxes, the net effect on the return to working and education is negative due to the disappearance of public pensions. The decline in hours worked translates into a decreasing tax income and increasing non-employment benefits. Add to this the decline in working age population due to ageing (= additional reduction of the tax base) and the before mentioned increase in lump sum transfers to the growing group of retired, and the strong negative effects on the government balance are obvious. Second, policy 2a and 1b which involve a change in the calculation of the pension benefits seem to lead to a less negative evolution of the government budget. Positive effects on employment and growth (as shown in Table 7 and 8) raise the government's resources which makes it possible to finance a larger future pension burden.

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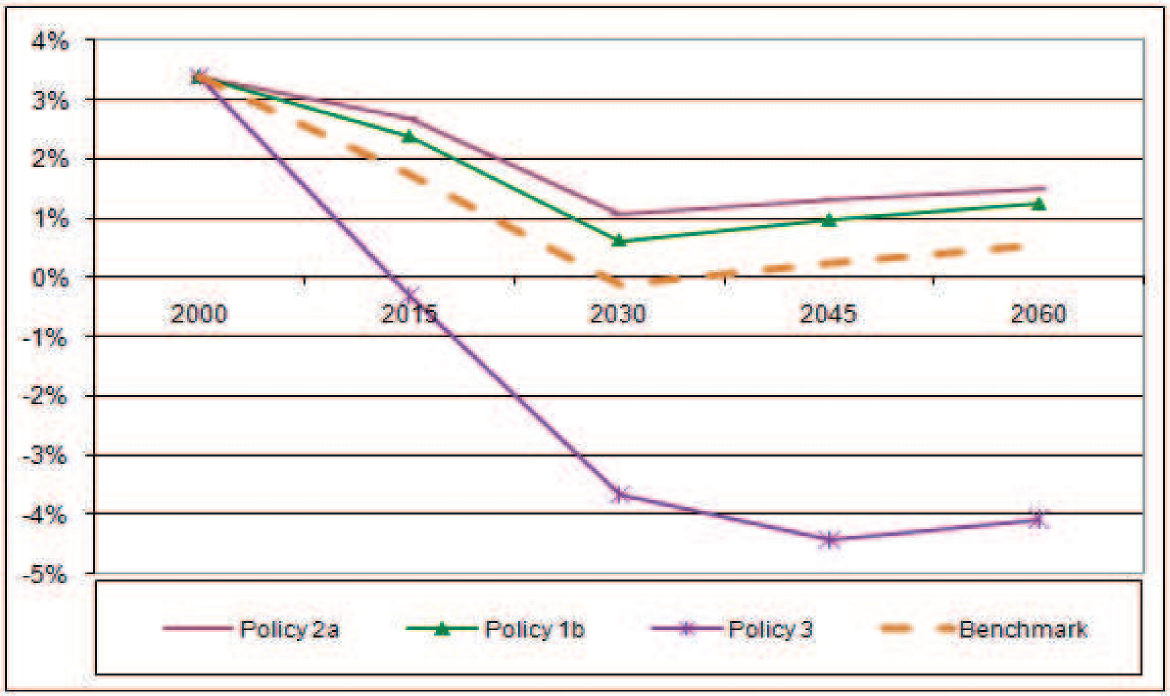
[25] These figures are conditional on a key implication of our model that ageing in itself has no effect on individual behavior.

[26] For convenience of comparison, we omit policies 1a and 2b. The effects of the former are comparable to those of policy 2a. The latter is ignored as previous simulations indicated negative effects on employment and growth.

Overall, pension reforms which include a rise in the weight of labor income earned as an older worker (2a and 1b) may partly mitigate the negative effects of ageing on the government's financial balance. Nevertheless, we still observe a net deterioration of the government balance due to ageing. Furthermore, lowering pensions does not seem to improve the government budget. For completeness, Appendix 3 shows the welfare implications of these policies when ageing is included. Interestingly, despite negative effects on employment, growth and the government's financial balance, the transition to a fully funded pension system seems to induce large welfare gains for future generations once ageing is implemented.

Figure 9. Evolution of Belgian primary government surplus (2000-2060) under alternative pension reforms (benchmark = Table 10)



8. Conclusions

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.

We build and parameterize a four-period OLG model for an open economy to study hours of work among young, middle aged and older workers, education of the young, and aggregate per capita growth within one coherent framework. We explain these endogenous variables as functions of various tax rates, various kinds of government expenditures, and key characteristics of the public PAYG pension system. We find that our model explains the facts remarkably well for many OECD countries. We then use the model to investigate the effects of various fiscal policy shocks. To face today's challenges of low employment, in particular among older workers, low growth and rising pressure on the welfare state, our results underscore the need to raise the share of productive government expenditures (mainly for education), to cut 'non-employment' benefits, and to cut labor taxes targeted at older workers.

Our main focus in this paper was on the effects of changes in the pension system. In our model pensions are related to earned labor income over three periods of active life. Our simulations indicate that pension reform can raise growth and employment if it includes a rise in the weight of labor income earned as an older worker in the computation of the pension base. Furthermore, lowering pensions does not seem beneficial for growth, employment or the government budget. By contrast, our simulations indicate a much better response of these variables when the change in the calculation of the pension base is combined with an increase in the pension replacement rate. A rise in the pension replacement rate raises the return to investing in human capital and working. Moreover, when we allow for population ageing, this reform leads to a less negative evolution of the government's financial balance than the constant-policy scenario. Further analysis reveals that policy reforms in this direction may also raise welfare levels of current and future generations.

We see various possibilities for future research. First, the demographic block in the current model is modest. It seems interesting to implement a birth and death rate with uncertain life length. This set-up allows for a more realistic determination of the effects of population ageing. Second, the retirement age in our model here is exogenous. Recent models (e.g. Martin, 2010) analyze the effect of pension reforms when the retirement age is endogenous. We hope to develop the model further to allow for an endogenous retirement decision. Finally, the pension modeling needs further attention. We think about the introduction of an age penalty for early retirement and minimum pensions. These extensions will be developed in the near future.

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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 *(τ_1, τ_2, τ_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 τ_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 τ_2 and τ_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.

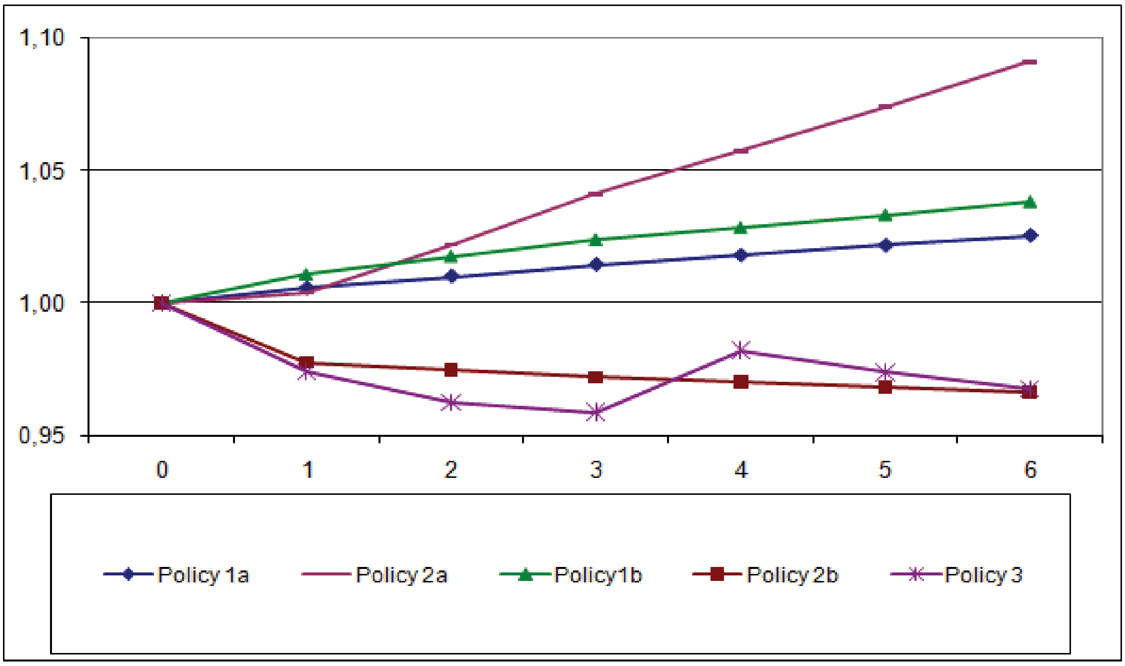
Net benefit replacement rates *(b_1, b_2)*
Definition: The data concern net transfers received by long-term unemployed people and include social assistance, family benefits and housing benefits in the 60th month of benefit receipt. They also include unemployment insurance or unemployment assistance benefits 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 in earlier years, 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

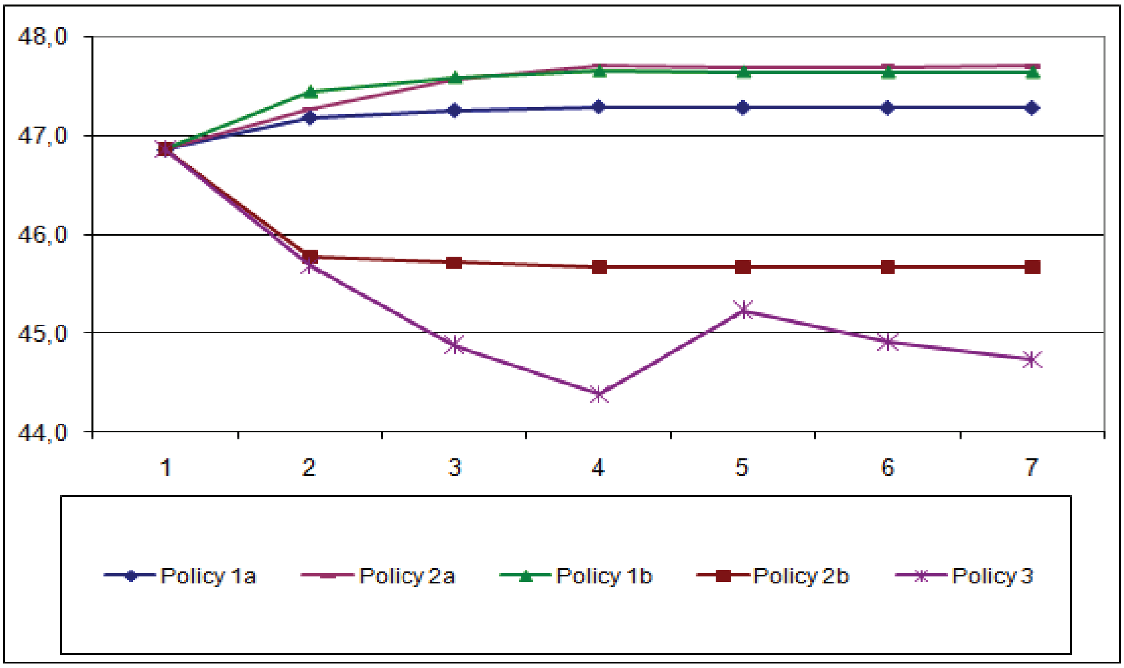
group of countries. They may however strongly prefer this option in the former group. The implication of these arguments is that we will assume $b_3 = b_2$ in countries where $r_3 < b_2$. By contrast, in countries where $r_3 > b_2$, it seems more adequate to model b_3 as a weighted average of r_3 and 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. For France, the official retirement age is 60 instead of 65. Therefore, in our model, part of the non-employment benefits for older workers concern pension payments. The calculation for b_3 takes account of this fact.
Data Source: OECD, Tax-Benefit Models, www.oecd.org/els/social/workincentives, Duval (2003), Brandt et al. (2005).

Appendix 2: Transitional effects of pension reforms for Belgium (without ageing, Table 8).

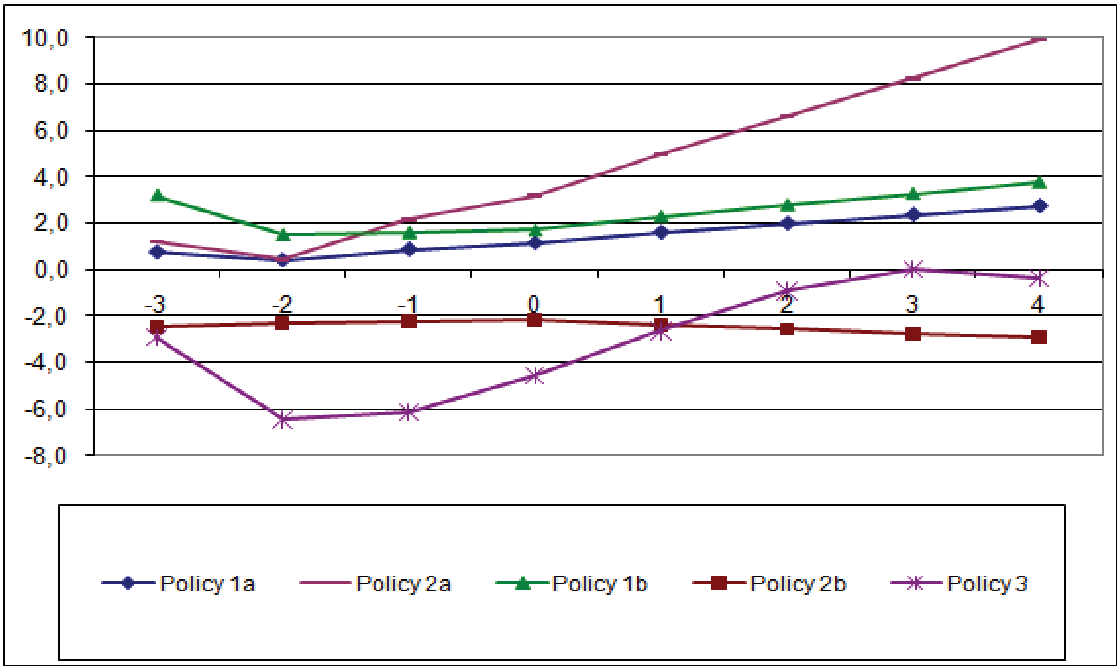
Aggregate output level (vertical axis, index, benchmark = 1) after unanticipated and permanent pension reforms introduced in period 1 (periods on horizontal axis)



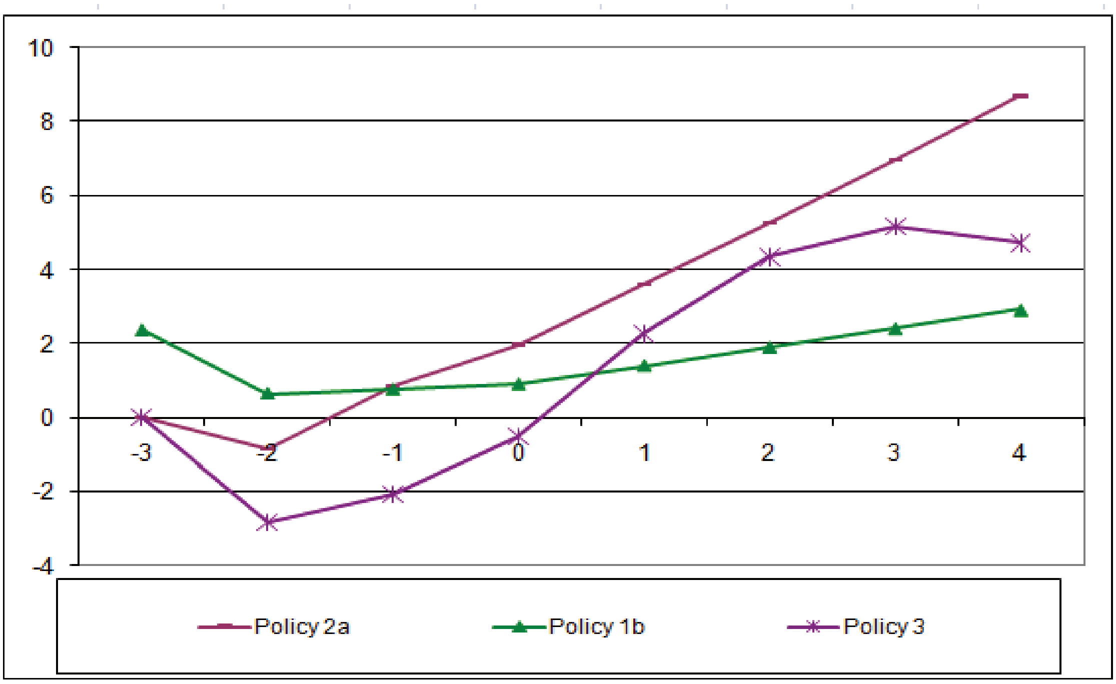
Aggregate employment level (vertical axis, in %) after unanticipated and permanent pension reforms introduced in period 1 (periods on horizontal axis)



Welfare effects for current and future generations after unanticipated and permanent pension reforms for Belgium (without ageing)



Appendix 3: Welfare effects for current and future generations after pension reforms for Belgium (in comparison to the baseline ageing scenario).



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