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FACULTEIT ECONOMIE EN BEDRIJFSKUNDE

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Public policy, employment and growth in an OLG economy with education, learning by doing and pensions.

Masterproef voorgedragen tot het bekomen van de graad van

Master in de Economische Wetenschappen

Tim Buyse

onder leiding van

Prof. dr. F. Heylen

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PERMISSION

Acknowledgments

This dissertation would not have been realized without the contributions of many people.
First, I would like to express my gratitude towards my promoter, Prof. dr. Freddy Heylen, for giving me the opportunity to undertake this challenging dissertation and for his remarks and advice on my models.
I am very grateful to Renaat Van de Kerckhove, not only for introducing me to Dynare but also for his enthusiasm, feedback and help on the technical part of this dissertation.
Finally, special thanks go to my family and girlfriend for their support during the realization of this thesis and throughout my four years of study.

Tim Buyse,
May 2010

Abstract in Dutch

In deze thesis bestudeer ik de effecten van fiscale beleidsmaatregelen en pensioenhervormingen op de werkgelegenheid, outputgroei en welvaart. Vertrekpunt van deze studie is het OLG model van Heylen en Vandekerckhove (2009). De auteurs modelleren de gedragingen en interacties van gezinnen, bedrijven en de overheid en veronderstellen daarbij dat er op eenzelfde moment vier verschillende generaties van individuen leven: jongeren (20-34), individuen van middelbare leeftijd (35-49), ouderen (50-64) en gepensioneerden (65-80). Het model legt de nadruk op fiscaal beleid (belastingen, productieve overheidsuitgaven, werkloosheidsuitkeringen…) ter verklaring van verschillen in werkgelegenheid in de eerste drie leeftijdsgroepen, tertiaire scholing en groei, in 17 OESO landen in 1995-2007. Ondanks de goede verklaringskracht van hun model, blijkt dat het groeimechanisme op basis van productieve overheidsuitgaven, scholingstijd en kwaliteit van onderwijs te beperkt is. In deze thesis concentreer ik mij op twee uitbreidingen van dit model met als doel het voorgaande probleem op te lossen en/of het model realistischer te maken.

In een eerste model implementeer ik *learning by doing* als tweede mechanisme, naast scholing, voor de opbouw van vaardigheden. Daarenboven wordt ook aandacht besteed aan verschillen in schoolsystemen tussen landen (inschrijvingsgelden, studiesubsidies…). Dit *learning by doing* model wordt gekalibreerd d.m.v. Dynare 4.0. Ondanks enkele tekortkomingen blijken de voorspellingen van het model relatief goed aan te sluiten bij de werkelijkheid en wordt de te nauwe band tussen groei en scholing gedeeltelijk doorbroken. In dit model analyseer ik de effecten van wijzigingen in belastingen en overheidsuitgaven. Wijzigingen in consumptie- of kapitaalbelastingen hebben relatief beperkte effecten op de werkgelegenheid en de groei. Een verlaging van de werkloosheidsuitkeringen en inkomensbelastingen (op jongeren of ouderen) blijken een positieve invloed te hebben op de werkgelegenheid. Studiesubsidies en productieve overheidsuitgaven (R&D, scholing, infrastructuur) zijn belangrijker voor per capita groei. Ook belastingsverlagingen op het arbeidsinkomen kunnen de groei aanmoedigen, tenzij ze gericht zijn op jongeren. Ondanks de aanwezigheid van *learning by doing* effecten, blijkt dat het aanmoedigen van tertiaire scholing nog steeds van primair belang is voor de outputgroei. Een analyse van de welvaartseffecten leert dat huidige generaties meest baat hebben bij een algemene verlaging van de werkloosheidsuitkeringen ter financiering van reducties in inkomensbelastingen op oudere werknemers. Toekomstige generaties kennen de grootste welvaartstoename indien de besparingen van deze lagere uitkeringen gebruikt worden voor extra productieve overheidsuitgaven of wanneer extra scholingssubsidies worden gefinancierd met hogere inkomensbelastingen op jongeren.

Een tweede model vertrekt opnieuw van het model van Heylen en Vandekerckhove (2009) maar implementeert een eenvoudig pay-as-you-go pensioensysteem. Dit pensioenmodel laat toe verschillende pensioenhervormingen te analyseren, wat interessant is in het kader van de vergrijzingproblematiek. Een eerste hervorming is een eenvoudige aanpassing van de berekening van de publieke pensioenen (m.n. meer gewicht geven aan het verdiende inkomen tijdens de latere werkjaren). Dit blijkt zowel de groei als de werkgelegenheid te kunnen stimuleren zonder het overheidsbudget erg aan te tasten. Een tweede hervorming betreft het verlagen van de pensioenuitkeringen. Hoewel een dergelijke maatregel resulteert in grote besparingen voor de overheid, is ze op zich niet optimaal met het oog op het stimuleren van de groei, werkgelegenheid en welvaart. Verschillende andere maatregelen, die combinaties zijn van of gebaseerd zijn op de voorgaande hervormingen, worden geëvalueerd. Kenmerkend is dat zo goed als alle gesimuleerde pensioenhervormingen een welvaartsverlies impliceren voor de huidige gepensioneerden. Wanneer echter geopteerd wordt om enkel de pensioenberekening aan te passen en deze te baseren op het verdiende inkomen tijdens de laatste werkjaren, wordt dit verlies geminimaliseerd. Het toevoegen van hogere pensioenuitkeringen aan de vorige maatregel is positief voor de welvaart, zelfs wanneer de werkloosheidsuitkeringen voor oudere werknemers worden verlaagd om dit te financieren. Ook de werkgelegenheid en groei nemen verder toe. Vandaar dat deze maatregel voor huidige generaties ook de meest aantrekkelijke is.

Dit onderzoek is zeker geen eindpunt. Een eerste beperking van de huidige modellen is de veronderstelling dat alle generaties van gelijke omvang zijn en dat de verwachte demografische evolutie verwaarloosd wordt. Toekomstig onderzoek kan deze veronderstelling loslaten om een beter idee te krijgen over de (budgettaire) effecten van pensioenhervormingen. Een tweede beperking is de assumptie van homogene economische agenten in elke generatie. Realistischer zou zijn om heterogeniteit toe te laten tussen individuen van eenzelfde generatie (bijvoorbeeld jongeren met veel of weinig talent). Ten derde worden verschillen tussen landen in de publieke pensioensystemen vooralsnog genegeerd. Tenslotte is het ook een uitdaging om het beste uit voorgaande modellen te integreren in één alomvattend model.

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Used acronyms

European Union	EU
Learning by doing	LBD
Organization for Economic Cooperation and Development	OECD
Overlapping generations	OLG
Pay-as-you-go	PAYG
Program for international student assessment	PISA
United Kingdom	UK
United States	US

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1 INTRODUCTION

Macroeconomists have found it challenging to explain the differences in growth and employment in OECD countries. Common observations are that Americans work more than Europeans and that some Europeans work more than others (Berger and Heylen, 2009). Various hypotheses have been put forward to explain the differences in employment. A first strand of literature emphasizes differences in fiscal policy (e.g. Prescott, 2004; Rogerson, 2007; Ohanian, Raffo and Rogerson, 2008; Dhont and Heylen, 2009). Other authors point out differences in the desire for leisure, possibly induced by cultural differences or differences in unionization and labor market regulations (e.g. Blanchard, 2004; Alesina, Glaeser and Sacerdote, 2005). Freeman and Schettkat (2005) on the other hand, argue that the greater marketization of traditional household production in the US can account for the large difference in employment between the EU and the US. Despite the value of this research, most existing studies do not take account of the fact that (i) in all countries the middle aged work more hours than the young and the older; (ii) the EU-US employment gap is much stronger for the young and the older than for the middle aged and (iii) employment and growth are related (Heylen and Van de Kerckhove, 2009).

Furthermore, employment and growth cannot be seen independently from one of the most important problems faced by industrialized countries today: the ageing of the population. According to the United Nations, the old-age dependency ratio (ratio of old-age to working-age population) will have almost doubled in most developed countries by 2050 (see Table 1). This will raise pressure on social security and, more specifically on pension systems, as public pension spending is projected to increase significantly. In the face of this problem, recent studies (e.g. Docquier and Michel, 1999; Fougère and Mérette, 1999; de la Croix, Docquier and Liégeois, 2007) analyze the effects of demographic changes on the economy.

Table 1 Old-age dependency ratio in selected countries

	2010	**2050**
Belgium	26	46
France	26	47
United Kingdom	25	38
United States	19	35

Source: United Nations (2009) <http://esa.un.org/unpp>

Policymakers are now more than ever beginning to understand the need for social security reform in order to secure its financial viability. Increasing job opportunities for older workers, stimulating older workers' labor supply and increasing per capita growth must be important policy goals in all OECD countries. Simplifying the pension system and changing the way it is financed, tighter pension eligibility conditions, postponing the retirement age (or at least trying to increase the effective retirement age) and more generous tax systems for older workers to raise financial rewards from working longer are possible measures that could be taken in order to achieve those goals (see Whiteford and Whitehouse, 2006).

The goal of this dissertation is to extend the overlapping generations (OLG) model of Heylen and Van de Kerckhove (2009) by (i) adding learning by doing as a growth mechanism, (ii) implementing education costs and subsidies and (iii) introducing a stylized form of the (Belgian) pension benefit scheme. The emphasis stays on fiscal policy composition. Although the two models that will be developed in this text are far from perfect, they are able to explain the facts well. The new set-up then allows to assess the impact of fiscal policy shocks on growth and employment in three age groups in a still more realistic model and to analyze the effects of pension reforms. This research is in line with previous studies illustrating the role of taxes and government spending in OLG models (Zhang, 1996; Glomm and Ravikumar, 1997; Kaganovich and Zilcha, 1999; Bouzahzah, de la Croix and Docquier, 2002).

Regarding the effects of fiscal policy changes, general results are consistent with Heylen and Van de Kerckhove (2009). First, focusing on growth, effective policy measures are labor tax cuts on middle aged or older workers and an increase in productive government spending. A rise in education subsidies also raises tertiary education and considerably improves per capita growth. When these subsidies are financed by higher labor taxes on the young, growth effects are strongest. Despite the presence of learning by doing, labor tax cuts on young workers discourage schooling and harm growth. Although the model in which these policy measures are implemented adds experience (learning by doing) as an endogenous growth mechanism, it seems that increases in tertiary education are still the most important way to achieve higher growth. Second, aggregate employment benefits most when non-employment benefits or labor taxes are cut, mostly so when both measures are implemented at the same time. Households are then maximally encouraged to substitute work for leisure. It turns out that labor tax cuts do not stimulate aggregate hours worked when aimed at middle aged workers. Third, welfare gains are maximized in the long run by higher education subsidies (financed by higher labor taxes on the young) or by cuts in non-employment benefits to finance productive spending. For current generations, benefit cuts to finance labor tax cuts on older workers are most positive for welfare.

With respect to pension reforms, I first investigate changes in the way pension benefits are computed. When more weight is put on earned after-tax wages when old, employment and growth rise without deteriorating the budget balance. A second set of policies reduces the pension benefit replacement rate. When this rate reduces to zero, the pay-as-you-go (PAYG) system transforms into a fully funded one. A large literature describes the efficiency of these systems. A common view is that the transition from PAYG to fully funded increases aggregate savings and per capita growth (Corsetti and Schmidt-Hebbel, 1995). While some authors acknowledge that current generations have to pay for this transition (Peters, 1991; Brunner, 1996), others believe it can be Pareto-improving (Belan, Michel and Pestieau, 1998; Gyárfás and Marquardt, 2001). Most of this literature uses physical capital accumulation as the engine of growth. By contrast, Kemnitz and Wigger (2000) focus on human capital accumulation. They find that an economy with a well-designed PAYG social security system is Pareto-efficient whereas an economy with a fully funded scheme is not. Furthermore, output growth is higher in the former. In the model developed in this text, these conclusions are only partly confirmed. On the one hand, the transition from PAYG to fully funded turns out to be detrimental for employment, growth and welfare if the savings from the lower pension expenditures are used to finance lump sum transfers. If, on the other hand, these savings are used to finance labor tax cuts on middle aged and older workers to maintain budget balance, which is more realistic, per capita growth and welfare for future generations may slightly increase. Nevertheless, aggregate employment and welfare for all current generations drop. This explains why such a reform would be practically impossible to implement in reality. I perform several other simulations, including a combination of a modified pension calculation and lower pension benefits. Savings from this measure can then be used to finance labor tax cuts, productive expenditures or a basic pension. An important finding of this study is that a simple change in the calculation of the pension benefits – giving more weight to earned labor income when older – minimizes welfare losses for current generations while stimulating growth and employment. This in turn could help to relieve pressure on the pension system. Interestingly, a combination of the previous policy with a slight increase in pension benefits (financed by lower non-employment benefits on older workers), has an even more positive effect on growth, employment and welfare.

The remainder of this dissertation is organized as follows. In Section 2, I shortly introduce the model of Heylen and Van de Kerckhove (2009, hereafter HV) and define its main limitations. In section 3, I enrich the HV-model by introducing education costs, subsidies and learning by doing in the hope that this tackles its shortcomings. Section 4 extends the HV-model in a different way, by introducing a simple pension scheme. Section 5 is devoted to calibrating the models on a benchmark of nine European countries and also performs a model evaluation. Sections 6 analyzes the steady state and dynamic effects of fiscal policy shocks and pension reforms, using the models of sections 3 and 4. This dissertation ends with a conclusion.

2 THE HV-MODEL AND ITS LIMITATIONS

The original overlapping generations model dates back to Samuelson (1958) and Diamond (1965). Diamond's model was originally a neoclassical model, built to examine the effects of national debt on the long-run economic equilibrium and (transitional) growth. Today however, it is a key model in modern macroeconomics. Furthermore, it is also used in a broad range of other domains including environmental economics, monetary economics and economics of social security. The central idea in the OLG model is that individuals do not live forever, but have a finite lifetime consisting of 2 or more periods (e.g. young and old). At each point in time, different generations are alive, hence "overlapping generations".

Heylen and Van de Kerckhove (2009) developed a computable OLG model with endogenous growth and employment in which an individual's life-span consists of four periods of 15 years: 20-34 (young), 35-49 (middle aged), 50-64 (older) and 65-80 (retired). They study and explain the differences between 17 OECD countries in (i) hours of work in the first three age groups, (ii) education of the young (20-34), and (iii) per capita growth. Fiscal policy composition is crucial to explain these differences. In this setting, the steady state and dynamic effects of various fiscal policy shocks are investigated. The HV-model has a high explanatory power and is able to explain a large deal of the actual cross-country differences in employment, growth and education. However, it has some drawbacks. Table 2 indicates the coefficients of correlation between growth and education and growth and employment when young in the actual data versus the predicted correlations by the model. Although such correlations are neither perfect nor complete to assess the performance of a model, they give a first idea. As table 2 shows, the correlation between growth and education is far too strong in the model. Probably, the education mechanism is too narrow for predicting growth. Furthermore, the correlation between growth and employment of the young has the wrong sign; it is predicted slightly negative whereas it is about zero in reality.

I use the same endogenous variables as Heylen and Van de Kerckhove (2009), which are presented in table 3. For a complete description of the data I refer to their paper. A good model should certainly be able to explain the main differences between the countries and age groups. For instance, note that older individuals work least hours in all countries (except Sweden) while the middle aged work most hours. Employment in all age groups is the highest in the US whereas the core euro area lags behind. Further, the Nordics have the highest tertiary education rate. Concerning growth, the Nordic countries perform much better than the US. The core euro area takes an intermediate growth position.

Table 2 Correlation between growth and education/employment when young in the actual data versus predicted by the HV-model

	Actual Data	Model
CORR(growth, e)	0.50	0.98
CORR(growth, n1)	0.01	- 0.12

Note: (a) These correlations are based on one observation per country (17 countries).
(b) Correlations involving growth do not include Ireland and Switzerland.
(c) n_1 represents the employment rate in hours in the age group 20-34.
(d) e represents the tertiary education rate in the age group 20-34.

Table 3 Employment rate in hours (n), education rate (e) and average annual per capita growth in OECD countries (1995-2006/7, in %)

	n_1	n_2	n_3	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	50.5	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	50.7	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
Ireland	58.5	57.6	41.2	11.6	4.53
Portugal	62.5	69.7	47.8	15.3	1.87
Spain	49.8	55.6	36.9	15.1	2.17
Switzerland	64.0	67.8	55.6	12.5	0.94
All country average	**55.9**	**63.4**	**44.0**	**15.3**	**2.02**

Data sources and calculation: see Heylen and Van de Kerckhove (2009). n_1, n_2 and n_3 represent the employment rate in hours for the age groups 20-34, 35-49 and 50-64, calculated as the ratio of actual hours worked by an average person in each age group over potential hours (2080 hours per person per year). The tertiary education rate (e) is the ratio of the total number of students in full-time equivalents in the age group 20-34 divided by the total population in this age group. The data for (average annual) real per capita growth concern real potential GDP per person of working age. Employment and growth data concern averages for the period 1995-2007, those for education 1995-2006.

3 LEARNING BY DOING, EDUCATION COSTS AND SUBSIDIES

3.1 THE MODEL

In this chapter I extend the HV-model with learning by doing, education subsidies and costs. The standard set-up of the model remains the same. Next to three active generations (young, middle aged and older), there is one generation of retired agents. Every person is endowed with one unit of time in each period. Every period lasts for 15 years with the first period starting at the age of 20 and the last period ending at 65. I also start from the hypothesis of homogenous agents within every generation and generations of equal size, normalized to 1. Other assumptions of a competitive open economy, international mobility of physical capital and immobile labor and human capital are maintained throughout this text.

In this section, output growth will not only be related to education, the quality of schooling (see Lucas, 1988) and productive government expenditures (see Barro, 1990) as was the case in the HV-model. Learning by doing (experience) and private expenditures on education will also have a positive effect. I will now discuss the behavior of the different agents in the model.

3.1.1 Individuals

The model consists of four generations of households which maximize their intertemporal utility function when reaching the age of 20. For an agent who is young in period t, this function is given by (1). Time allocation of the working households is as follows. The young generation can divide its unit of time between education (e_i^t), work (n_i^t) or leisure. Middle aged and older workers only choose between work or leisure. Intertemporal utility is positively related to consumption and leisure in all periods.

$$u^t = \sum_{i=1}^{4} \beta^{i-1} \left(\ln c_i^t + \gamma_i \frac{(1-e_i^t - n_i^t)^{1-\theta}}{1-\theta} \right) \quad (1)$$

With: $e_2^t = e_3^t = e_4^t = 0$, $n_4^t = 0$, γ_i>0, θ >0 (θ≠1).

I use the same notations as in the HV-model. Superscript t indicates the period of youth, subscript i indicates the i-th period of life. For instance, c_1^t is the consumption of a young person who is young at time t. Consumption for this same person in the subsequent periods is indicated as c_2^t, c_3^t and c_4^t. β indicates the discount factor (0< β<1). Alternatively, $\left(\frac{1}{\beta}-1\right)$ represents the rate of time preference. As the utility function is logarithmic in consumption, the intertemporal elasticity of substitution in consumption is 1. The intertemporal elasticity of substitution in leisure is $1/\theta$. γ_i refers to the relative value of leisure versus consumption. In other words, it represents the taste for leisure. Households maximize equation (1) by choosing consumption, education and labor supply. This optimization is however subject to four budget constraints (2)-(5) and three constraints describing the evolution of human capital (6)-(8).

$$(1+\tau_c)c_1^t + s_1^t = w_t h_1^t n_1^t (1-\tau_1) + b_1 w_t h_1^t (1-\tau_1)(1-n_1^t - e^t) - ec.e^t + es.e^t + z_t \quad (2)$$

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

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

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

With: $h_1^t = h_2^{t-1}$ (6)

$$h_2^t = x_t h_1^t \quad (7)$$

$$h_3^t = j_t h_2^t = j_t x_t h_1^t \quad (8)$$

$$z_{t+i} = Z_{t+i}/4 \quad (9)$$

Equations (2)-(5) indicate that the disposable household income in every period can be allocated to consumption (including consumption taxes τ_c) and savings. In general, the composition of disposable income is identical to the HV-model. w_k is the real wage per unit of effective labor at time k, r_{k+1} is de real interest rate paid on savings in period k and held to k+1. Effective labor of an individual decomposes into two parts: hours worked (n_i^t) and effective human capital (h_i^t). In each period, total after tax labor income is given by $w_t h_\mathrm{i}^t n_\mathrm{i}^t (1-\tau_\mathrm{i})$ where τ_i is the tax rate on labor income for age i. Beside labor income, individuals also receive a non-employment benefit (b_i) when they are inactive ("leisure time"). b_i is a fraction of the after-tax real wage. As total available time in every period is normalized to 1, leisure time is given by $(1-n_1^t - e_i^t)$ taking into account that $e_2^t = e_3^t = e_4^t = n_4^t = 0$.

Following among others Docquier and Michel (1999), individuals can choose an amount of education expenditure. ec represents an indicator of the full-time private education cost. This can be interpreted as the hypothetical cost of study when allocating total available time (=1) to education. Thus, actual total private education cost is $ec.e^t$, as only a part e^t of the available time is used for educational purposes[1]. Part of this cost is subsidized by the government (see also Docquier and Michel, 1999; Bouzahzah et al., 2002). es stands for the government subsidy (scholarships, grants), again for full-time education. Actual total received education subsidies are $es.e^t$. For a short overview of how these variables are calculated, see section 3.2. For a more detailed report, I refer to Appendix A.

In order to maintain budget balance, the government distributes a lump sum transfer Z_t to the households. Equation (9) states that each generation receives an equal share of these transfers (z_t can be negative). In addition, young, middle aged and older workers save an amount s_i^t of their income. Retired individuals consume what they have saved in the previous period (including interests), taking account of the lump sum transfer from/to the government. Note that the possibility of early retirement is included in the calculation of b_3 (replacement income of older workers) and that the pension system is fully funded (see chapter 4 where this assumption is relaxed).

Equations (6)-(8) concern the accumulation of human capital over time. Bouzahzah et al. (2002) mention two external effects of human capital accumulation. According to the authors, there is an *intergenerational externality,* meaning that the current generation (partly) inherits the human capital investment of the previous generation. They also indicate the existence of an *intratemporal externality* when "the average level of human capital at time t contemporaneously increases the productivity of each factor of production" (Bouzahzah et al., 2002, p. 2096)[2]. In this model, only the first externality is implemented (see also Azariadis and Drazen, 1990). Equation (6) states that the current young generation inherits its human capital from the current middle aged generation (which was young at t-1).

Although the explicit human capital production functions (x_t and j_t) can be found in section 3.1.2, I here give a first idea of the drivers of skill accumulation. In contrast to Heylen and Van de Kerckhove (2009), human capital will not only increase in education time (e), productive government spending (g_y) and the quality of schooling (q) but also in private education expenditure (ec) and work time (n). Following Arrow (1962) and Romer (1986), I recognize the importance of learning by doing, and see it as a driver of human capital. Wasmer (2001), uses labor market participation data to build an indicator of experience. I therefore introduce learning by doing via the impact of work time (n) on skills-accumulation

[1] Next to real private education costs (tuition fees, living costs, books…) there is also an opportunity cost of education: a loss of non-employment income due to less leisure. This cost is already part of the model.
[2] See also Lucas (1988).

(see also de la Croix and Docquier, 2007). Explicitly introducing learning by doing, I will also allow for a depreciation of human capital. Furthermore, the simplifying assumption of equal effective human capital in the second and third period of life is now dropped. Instead, human capital can grow even further because of a learning by doing component. Nevertheless, depreciation may again reduce effective human capital.

Maximizing (1) with respect to s_1^t, s_2^t, s_3^t, n_1^t, n_2^t, n_3^t and e^t leads to the following first order conditions:

$$\frac{c_2^t}{c_1^t} = \beta(1 + r_{t+1}) \tag{10}$$

$$\frac{c_3^t}{c_2^t} = \beta(1 + r_{t+2}) \tag{11}$$

$$\frac{c_4^t}{c_3^t} = \beta(1 + r_{t+3}) \tag{12}$$

$$\frac{\gamma_1}{(1-n_1^t - e^t)^\theta} = \frac{1}{c_1^t}\frac{\partial c_1^t}{\partial n_1^t} + \beta\frac{1}{c_2^t}\frac{\partial c_2^t}{\partial n_1^t} + \beta^2\frac{1}{c_3^t}\frac{\partial c_3^t}{\partial n_1^t} \tag{13}$$

$$\frac{\gamma_2}{(1-n_2^t)^\theta} = \frac{1}{c_2^t}\frac{\partial c_2^t}{\partial n_2^t} + \beta\frac{1}{c_3^t}\frac{\partial c_3^t}{\partial n_2^t} \tag{14}$$

$$\frac{\gamma_3}{(1-n_3^t)^\theta} = \frac{1}{c_3^t}\frac{\partial c_3^t}{\partial n_3^t} \tag{15}$$

With:

$$\frac{\partial c_1^t}{\partial n_1^t} = \frac{w_t h_1^t(1-\tau_1)(1-b_1)}{(1+\tau_c)}$$

$$\frac{\partial c_2^t}{\partial n_1^t} = \frac{\partial x_t}{\partial n_1^t}\frac{w_{t+1} h_1^t(1-\tau_2)\left[n_2^t + b_2\left(1-n_2^t\right)\right]}{(1+\tau_c)}$$

$$\frac{\partial c_3^t}{\partial n_1^t} = \left[\frac{\partial j_t}{\partial n_1^t}x_t + \frac{\partial x_t}{\partial n_1^t}j_t\right]\frac{w_{t+2} h_1^t(1-\tau_3)[n_3^t + b_3(1-n_3^t)]}{(1+\tau_c)}$$

$$\frac{\partial c_2^t}{\partial n_2^t} = x_t\frac{w_{t+1} h_1^t(1-\tau_2)[1-b_2]}{(1+\tau_c)}$$

$$\frac{\partial c_3^t}{\partial n_2^t} = x_t\frac{\partial j_t}{\partial n_2^t}\frac{w_{t+2} h_1^t(1-\tau_3)\left[n_3^t + b_3\left(1-n_3^t\right)\right]}{(1+\tau_c)}$$

$$\frac{\partial c_3^t}{\partial n_3^t} = x_t j_t\frac{w_{t+2} h_1^t(1-\tau_3)[1-b_3]}{(1+\tau_c)}$$

$$\frac{\gamma_1}{(1-n_1^t - e^t)^\theta} - \frac{1}{c_1^t}\frac{\partial c_1^t}{\partial e^t} = \beta\frac{1}{c_2^t}\frac{\partial c_2^t}{\partial e^t} + \beta^2\frac{1}{c_3^t}\frac{\partial c_3^t}{\partial e^t} \tag{16}$$

With:

$$\frac{\partial c_1^t}{\partial e^t} = \frac{-b_1 w_t h_1^t (1-\tau_1) - ec + es}{(1+\tau_c)}$$

$$\frac{\partial c_2^t}{\partial e^t} = \frac{\partial x_t}{\partial e^t} \frac{w_{t+1} h_1^t (1-\tau_2)\left[n_2^t + b_2(1-n_2^t)\right]}{(1+\tau_c)}$$

$$\frac{\partial c_3^t}{\partial e^t} = j_t \ \frac{\partial x_t}{\partial e^t} \frac{w_{t+2} h_1^t (1-\tau_3)\left[n_3^t + b_3(1-n_3^t)\right]}{(1+\tau_c)}$$ (as $\frac{\partial j_t}{\partial e^t}$ will be zero)

Equations (10)-(12) are known in the literature as the Euler equations. They determine the household's optimal consumption path over time and can be seen as a savings measure. The Euler conditions indicate that the ratio of future to current consumption rises in the interest rate but declines in the time preference, which is the utility cost of postponing consumption. Just as in the HV-model, equations (13)-(15) determine the optimal labor-leisure choice in the three active periods. The LHS of these equations indicates the marginal utility of leisure, while the RHS is the discounted marginal utility of work. The latter rises both in the marginal consumption possibilities induced by extra employment $\left(\frac{\partial c_i^t}{\partial n_i^t}\right)$ and in the marginal utility of consumption $\left(\frac{1}{c_i^t}\right)$. For instance, the RHS of equation (13) shows that an extra hour of work when young not only yields direct extra consumption possibilities $\frac{\partial c_1^t}{\partial n_1^t}$ but also allows for more consumption when middle aged and old (respectively $\frac{\partial c_2^t}{\partial n_1^t}$ and $\frac{\partial c_3^t}{\partial n_1^t}$) due to the accumulation of human capital via learning by doing. The same logic applies to equations (14) and (15). The gain from extra work is positively affected by lower taxes (on labor and consumption) and higher effective human capital. Non-employment benefits have a more ambiguous role. They decrease contemporaneous gains from work but increase gains in the later periods due to the accumulation of effective human capital: future benefits rise in future human capital. The latter effect arises as deciding to work more now leads to more human capital and hence a higher net replacement income later.

Equation (16) describes the optimal decision for investing in education. The LHS of equation (16) is the marginal utility loss from this investment. It contains two parts: the direct utility loss due to less leisure and the loss of consumption possibilities due to the net costs associated with tertiary education. The RHS equals the discounted marginal utility gain from higher human capital in the later periods. The mechanism is identical to the one described above: more education when young allows for extra consumption possibilities in the later periods which increase utility. Higher labor taxes and lower non-employment benefits when young, a lower cost of full-time education and more education subsidies encourage schooling. Higher taxes in the later periods discourage this decision because future after-tax real wages drop. Higher benefit replacement rates in the later periods will, just as in the HV-model, encourage young individuals to study.

3.1.2 Human capital accumulation

In the previous sections, I introduced two human capital accumulation functions. The general forms of these functions are given in equations (17) and (18).

$$x_t = 1 + \psi_1(e^t, g_y, q, ec) + \psi_2(n_1^t) - \delta_x \quad (17)$$

$$j_t = 1 + \psi_3(n_1^t, n_2^t) - \delta_j \quad (18)$$

With: $\psi_1^{'}(.) > 0, \psi_2^{'}(.) > 0, \psi_3^{'}(.) > 0$ and $\delta_x, \delta_j > 0$

x_t describes the change in human capital between the first two periods of active life. It contains two parts. ψ_1 is a part related to education and productive (among others educational) expenditures. As in Docquier and Michel (1999), young individuals can make a double private investment in education: education time (e) and educational expenditures (ec). The idea that private education expenditures have a positive influence on human capital can only hold if a higher education cost signifies a better underlying value of education. A higher cost for the same 'education package' will not work. Therefore, assume that higher private spending on education also implies better books or equipment, more motivated teachers… ψ_2 refers to a learning by doing part. As noted in section 3.1.1 work time (n) acts as a proxy for this experience component (see also de la Croix and Docquier, 2007). Experience thus comes in as a separate component in the human capital production function since the experience effect is independent of education, the quality of schooling or productive or private government expenditures (i.e. $\frac{\partial x_t}{\partial n_1^t}$ does not depend on e^t, q, g_y or ec).

j_t is the further change in human capital between middle aged and older workers, only due to learning by doing component (represented by the function ψ_3). Here, I assume that the accumulated work time when young and middle aged determines the growth in human capital when middle aged. δ_x and δ_j are two human capital depreciation rates.

The specification of ψ_2 and ψ_3 is the following general form[3]:

$$\psi_2(n_1^t) = \frac{{n_1^t}^{\omega}}{\omega} \quad (19)$$

$$\psi_3(n_1^t, n_2^t) = \frac{(n_1^t + n_2^t)^{\omega}}{\omega} \quad \text{with } \omega > 0 \quad (20)$$

where ω is an indicator of decreasing (ω<1), constant (ω=1) or increasing (ω>1) returns and will be calibrated. Equation (20) states that employment when young and middle aged interact to determine learning by doing in the second period.

Next to the introduction of learning by doing, a second difference with the HV-model lies in the specification of ψ_1. I experimented with two functional forms. In the first one (equation (21)), human capital accumulation by means of education is a simple CES-function consisting of four parts. Education time, the quality of schooling (following Hanushek and Woessman (2009)) and public productive expenditures are copied from the HV-model. As stated above, following Docquier and Michel (1999), private educational expenditures are added as a fourth component that positively affects human capital accumulation.

$$\psi_1(e^t,\, g_y, q, ec) =$$

$$\varphi\left(v_1 {g_y}^{1-(1/\kappa)} + v_2(ec.e^t)^{\,1-(1/\kappa)} + v_3 q^{1-(1/\kappa)} + (1 - v_1 - v_2 - v_3)(e^t)^{1-(1/\kappa)}\right)^{\sigma\kappa/\kappa-1} \quad (21)$$

Where φ is a positive efficiency parameter indicating the relative importance of the educational component compared to the learning by doing component in human capital accumulation. σ is a scale parameter and κ is the elasticity of substitution. Both φ and σ will be calibrated. As is the case with the learning by doing function, σ allows for constant, increasing or decreasing returns to scale.

The second specification is more complicated and allows for a different elasticity of substitution between public and private expenditures on tertiary educational institutions.

$$\psi_1(e^t,\, g_y, q, ec) = \varphi\left[v_1 {g_{py}}^{1-(1/\kappa)} + v_2\left({g_{ey}}^{1-(1/\mu)} + (ec.e^t)^{\,1-(1/\mu)}\right)^{\mu(\kappa-1)/\kappa(\mu-1)} + \right.$$

$$\left. v_3 q^{1-(1/\kappa)} + (1 - v_1 - v_2 - v_3)(e^t)^{1-(1/\kappa)}\right]^{\sigma\kappa/\kappa-1} \quad (22)$$

[3] Division by ω is done to keep the derivatives simple.

Where: $g_{py} = g_y - g_{ey}$

With: μ the elasticity of substitution between private and public expenditures, g_{ey} total public expenditures on tertiary educational institutions (excl. subsidies)[4], g_{py} other productive government expenditures (excl. subsidies and expenditures on tertiary educational institutions) and all other parameters as in equation (21).

Equation (22) reclassifies total productive government expenditures (excl. subsidies) g_y in a part related to education (g_{ey}) and a part related to other productive expenditures (g_{py}, such as infrastructure or R&D-expenditures). It is assumed that a different (most likely larger) substitutability is possible between private $(ec.e^t)$ and public $\left(g_{ey}\right)$ expenditures on education. This effect is obtained by assigning a larger value to μ than to κ (Hanushek and Welsh, 2006). I will not extensively treat this specification, as substituting equation (22) for (21) in the model does not significantly improve the performance. The latter will be demonstrated in section 5.1.

3.1.3 Production technology and factor demand

Like in the HV-model, there is perfect competition on both the input and output markets. All firms are homogenous and maximize profits. Aggregate production at time t is given by the production function in (23). As usual, constant returns to scale in aggregate physical capital (K_t) and effective labor (H_t) are assumed. Equation (24) indicates total effective labor supplied by the young, middle aged and older workers, now taking into account the learning by doing-components.

$$Y_t = K_t^{\alpha} H_t^{1-\alpha} \tag{23}$$

$$H_t = n_1^t h_1^t + n_2^{t-1} h_2^{t-1} + n_3^{t-2} h_3^{t-2} = \left(n_1^t + n_2^{t-1} + n_3^{t-2} \frac{j_{t-2}}{x_{t-1}}\right) h_1^t \tag{24}$$

With: $x_{t-1} = 1 + \psi_1\left(e^{t-1}, g_y, q, ec\right) + \psi_2(n_1^{t-1}) - \delta_x$

$j_{t-2} = 1 + \psi_3\,(n_1^{t-2}, n_2^{t-2}) - \delta_j$

As I explicitly allow for a depreciation of human capital, it would be logical to also allow for a depreciation of physical capital. Following Backus, Henriksen and Storesletten (2008), and assuming a perfectly competitive open economy, the first order condition for capital would

[4] For a note on the calculation of g_{ey} and g_{py} see appendix A (viii).

become (25). Assuming capital mobility, the world real interest rate now equals the after-tax marginal product minus depreciation. In- or outflow of capital will ensure that the equation holds. For instance, a capital tax cut in the domestic market raises after-tax marginal product of capital above the world interest rate which results in capital-inflow. This inflow then lowers the marginal product of capital until equation (25) is again satisfied. The depreciation of physical capital does however not add to the explanatory power of the model and only increases complexity. Therefore, for the remainder of this text, $\delta_k = 0$. The equation between the real wage and the marginal product of effective labor, based on the assumption of perfect competition, stays identical to the HV-model (equation (26)). Firms hire effective labor until its marginal product is equal to the real wage per unit of effective labor.

$$\left[\alpha \left(\frac{H_t}{K_t}\right)^{1-\alpha} - \delta_k\right](1-\tau_k) = r_t \tag{25}$$

$$(1-\alpha)\left(\frac{K_t}{H_t}\right)^{\alpha} = w_t \tag{26}$$

After substituting (24) for H_t and (25) for $\frac{K_t}{H_t}$ we can write (23) in an alternative way (equation (27)).

$$Y_t = \left(\frac{K_t}{H_t}\right)^{\alpha} H_t = \left(\frac{\alpha(1-\tau_k)}{r_t + \delta_k(1-\tau_k)}\right)^{\alpha/1-\alpha}\left(n_1^t + n_2^{t-1} + n_3^{t-2}\ \frac{j_{t-2}}{x_{t-1}}\right)h_1^t \tag{27}$$

As $\alpha, \tau_k, \delta_k, r, x, j\ and\ n_i$ are constant in steady state, the long-run (per capita) growth rate of the economy is given by equation (28).

$$\begin{aligned} ln\left(\frac{Y_t}{Y_{t-1}}\right) &= ln\left(\frac{h_1^t}{h_1^{t-1}}\right) = ln\left(\frac{h_2^{t-1}}{h_1^{t-1}}\right) = ln(x_{t-1}) \\ &= ln\big(1 + \psi_1(e,\ g_y, q, ec) + \psi_2(n_1) - \delta_x\big) \end{aligned} \tag{28}$$

As $ln(1+\epsilon) \approx \epsilon$ (for small ϵ), the per capita growth rate seems to be identical to the growth rate of human capital between the first and the second period of life. The growth rate is negatively related to human capital depreciation, but positively to the quality of schooling (q), the fraction of time (e) and the amount of money (ec) that young people allocate to education and to the share of productive government expenditures in GDP (g_y). Finally, learning by doing also has a role in the sense that employment of the young (n_1) positively influences growth.

3.1.4 Government budget constraint

Government revenues consist of three parts: taxes on labor (T_{nt}), capital (T_{kt}) and consumption (T_{ct}). These revenues finance productive expenditures (G_{yt}), government consumption (G_{ct}), non-employment benefits (B_t) and educational subsidies (ES_t). In addition, there are lump sum transfers (Z_t) which are equally divided to all generations of households in order to equate the government budget constraint. This constraint is given in equation (29), where g_y and g_c represent the fractions of output the government spends on productive expenditures and consumption.

$$G_{yt} + G_{ct} + B_t + ES_t + Z_t = T_{nt} + T_{kt} + T_{ct} \tag{29}$$

With: $G_{yt} = g_y Y_t$

$G_{ct} = g_c Y_t$

$B_t = \sum_{i=1}^{3} \left(1 - n_i^{t+1-i} - e^t\right) b_i w_t h_i^{t+1-i} (1 - \tau_i)$

$ES_t = es.e^t$

$Z_t = 4z_t$

$T_{nt} = \sum_{i=1}^{3} n_i^{t+1-i} w_t h_i^{t+1-i} \tau_i$

$T_{kt} = \alpha \tau_k Y_t \quad (\delta_k = 0)$

$T_{ct} = \sum_{i=1}^{4} c_i^{t+1-i} \tau_c$

3.2 EXOGENOUS VARIABLES

Most of the exogenous variables used to compute this model are identical to those in Heylen and Van de Kerckhove (2009). For an extensive description of these data, I therefore refer to their paper. Table 4 summarizes the data on tax rates on labor income (for each of the three age groups), capital and consumption in 17 OECD countries. Table 5 contains data on government expenditures. Non-employment benefit replacement rates to young, middle aged and older workers are net replacement rates expressed as a percentage of after-tax wages (Heylen and Van de Kerckhove, 2009). Furthermore, there are data on government consumption and productive expenditures. Only the latter differs from the data used in the HV-model, where educational subsidies were included in the figures for g_y. As the current model explicitly introduces these subsidies ($es.e^t$), I remove this part from the productive expenditures. Productive government spending is very high in the Nordic countries but low in Italy and the UK. The Core-EU countries (except France and the Netherlands) are below average. As in the HV-model, PISA-science scores are used as an indicator for the quality of the schooling system (q).

Table 4 Fiscal policy (Tax rates) (1995-2002)

	Tax rate on labor income when young (%)	**Tax rate on labor income when middle aged and older (%)**	**Consumption tax rate (%)**	**Tax rate on capital income.**
Proxy for:	τ_1	τ_2, τ_3	τ_c	τ_k
Austria	54.3	54.3	13.2	17.3
Belgium	66.6	66.8	13.4	21.1
France	48.7	51.0	17.1	21.7
Germany	60.9	63.2	11.1	34.4
Italy	52.9	54.7	14.7	14.9
Netherlands	52.4	52.2	12.2	24.3
Denmark	46.7	48.0	18.9	22.5
Finland	56.1	57.7	15.2	17.2
Norway	48.3	52.3	16.4	22.1
Sweden	57.2	59.3	17.9	16.1
UK	39.0	39.0	14.5	21.2
US	34.3	34.3	7.2	23.6
Canada	48.3	51.2	14.5	24.8
Portugal	39.3	44.7	13.4	22.2
Spain	47.1	45.8	10.9	18.1
Switzerland	33.6	35.9	2.9	20.3
Ireland	32.7	36.6	16.4	6.4
Overall country average	**48.1**	**49.8**	**13.5**	**20.8**

Note: For details on sources and the calculation of tax rates, see Heylen and Van de Kerckhove (2009).

Table 5 Fiscal policy (net transfer replacement rates, government consumption, productive expenditures, PISA education scores)

	Non-employment transfer, young (net replacement rate, %)	**Non-employment transfer, middle aged (net replacement rate, %)**	**Non-employment transfer, older (net replacement rate, %)**	**Government consumption (% of GDP)**	**Government productive expenditure (% of GDP)**	**PISA-science**
Proxy for:	b_1	b_2	b_3	g_c	g_y	$q * 10000$
Austria	72.3	66.3	70.5	14.6	8.8	507
Belgium	68.3	59.7	68.3	16.9	8.7	505
France	60.3	52.3	59.6	18.3	10.9	502
Germany	71.3	61.7	65.3	15.3	8.4	502
Italy	35.5	31.9	45.4	14.3	7.9	480
Netherlands	54.3	47.0	56.2	18.4	10.1	525
Denmark	57.3	49.0	49.0	18.4	11.8	484
Finland	74.0	64.3	69.1	16.0	11.1	550
Norway	41.0	35.3	35.3	14.7	11.8	490
Sweden	55.0	46.7	46.7	20.0	13.8	507
UK	70.0	60.3	60.3	14.4	7.2	523
US	19.7	18.7	18.7	10.3	9.1	493
Canada	50.3	44.0	44.0	14.7	9.0	527
Portugal	45.0	41.0	49.6	13.7	10.7	467
Spain	26.0	22.7	34.2	13.5	8.7	489
Switzerland	54.3	46.0	46.0	6.9	9.4	507
Ireland	47.0	63.7	63.7	10.7	9.0	509
Overall country average	**54.6**	**47.7**	**51.9**	**14.8**	**9.8**	**504**

Note: For more details on the calculations and sources, see Heylen and Van de Kerckhove (2009). The data for net benefit replacement rates concern 2004, the data for government consumption and productive expenditures concern 1995-2001. The PISA-science scores are an average for 2000, 2003 and 2006. Government productive expenditure excludes total subsidies for education to private entities excluding student loans (average for 1999 and 2003, see Appendix A, table 24).

In addition to the exogenous variables used in the HV-model, there is a need for data on private educational expenditures and government subsidies on education. I calculated indicators for the full-time education cost (ec) and subsidy (es) (i.e. total cost/subsidy if a young person decides to invest all his available time in education). The specific data, calculations and sources can be found in Appendix A.

With respect to the private cost of education, one would ideally add (i) gross tuition fees, (ii) private payments on instructional services and goods (such as books or tutoring) and (iii) living costs, all in percentage of GDP and all concerning tertiary education. Indications of these costs can be found in Education at a Glance (OECD, 2002 and 2006) and in Oliveira Martins et al. (2007). As data for (ii) are missing for many countries (see Appendix A), I neglected this component in my calculations and only add (i) and (iii). I subsequently divide this indicator by the country's tertiary education rate to obtain an indication of the full-time cost of study. Data on educational subsidies are also available in Education at a Glance (OECD, 2002 and 2006). As a proxy for the full-time education subsidies, I use total subsidies for education to private entities (excluding student loans, in % of GDP) divided by the tertiary education rate. Both ec and es are averages for 1999 and 2003.

Table 6 summarizes the data on full-time education costs and subsidies. As can be expected, the Anglo-Saxon countries have the highest full-time private cost of tertiary education. Spain and France also seem relatively expensive. Belgium and the Netherlands take intermediate positions whereas tertiary education in the Nordic countries and Austria is relatively cheap. The average full-time education cost for all 17 OECD countries is 8.5% of GDP. Appendix A (tables 22 and 23) contains more detailed data on actual tuition fees and living costs. Tuition fees are especially high in the US and Canada and low in the Nordics. These differences are smoothened by the higher ratio living costs/tuition fees in the Nordic countries. We see a slightly different pattern in the data for full-time subsidies for tertiary education (table 6). Average full-time subsidies are approximately 1.3% of GDP. Differences between countries turn out to be much less pronounced. Portugal, Spain and Switzerland are at the bottom of the range. Denmark and Canada have the highest subsidies.

Table 6 Education costs and subsidies (average for 1999, 2003)

	Full-time private cost of tertiary education (% of GDP)	**Full-time subsidies for tertiary education (% of GDP)**
Proxy for:	ec	es
Austria	3.9	1.8
Belgium	7.1	1.6
France	10.7	0.6
Germany	4.2	0.8
Italy	6.6	1.1
Netherlands	7.5	1.4
Denmark	3.5	3.2
Finland	2.7	1.6
Norway	3.8	1.6
Sweden	4.6	1.2
UK	14.9	1.1
US	19.5	1.4
Canada	19.7	2.2
Portugal	1.9	0.3
Spain	13.4	0.5
Switzerland	5.6	0.3
Ireland	15.3	1.4
Overall country average	**8.5**	**1.3**

Note: A description of these variables is given in the main text. For more details on the different components, calculations and sources of these data, see Appendix A. Both variables are averages for 1999 and 2003.

4 PENSION BENEFITS

As already mentioned in the introduction, it is a certainty that the share of elderly people will increase tremendously in the next couple of decades. Therefore, next to the model described in the previous section, I also compute a second model, containing a simple pay-as-you-go (PAYG) pension benefit scheme. This second model again starts from the HV-model with neither learning by doing nor education subsidies/costs.

In general, the literature distinguishes two different pension plans (Sinn, 2000). In a fully funded pension system, workers save money (make contributions) during the employment period which is then invested and returned to them with interest when old. In a PAYG-system, contributions from current workers are used to finance state pensions to retirees. In other words, labor income during the active period of life is taxed to finance the social security benefits for retired agents. The ageing process (and the expected increase in the old-age dependency ratios) will however make this unfunded PAYG-system unbearable in many countries as a relatively smaller working population has to pay for a larger number of retirees. As almost all countries on the European mainland have such a PAYG-system, pension system reform will be indispensable in the near future.

The literature on social security is elaborate and is also frequently studied in overlapping generations models. Important studies concern the impact of social security on savings (Feldstein, 1995), the welfare impact of the financing of social security (Sheshinski and Weiss, 1981; Wiedmer, 1996), the effect of ageing on pension schemes (Meijdam and Verbon, 1997) and pension reforms (Brunner, 1996; Belan et al., 1998; Shimasawa, 2004; Bettendorf and Heijdra, 2006). The goal of this and the following sections is not to give an overview of this literature but to add a pension system to the OLG model of Heylen and Van de Kerckhove (2009) which makes it possible to analyze the effects of simple pension reforms on employment by age, growth and welfare.

In its present form, the HV-model implicitly has a fully funded system in which households have to save to finance consumption when retired. In what follows, I will enrich the model by means of a simple PAYG pension system. As most equations are identical to the learning by doing model of the previous section, only the most important differences will be reported. Later in this dissertation, I will assess the economic and welfare effects of simple pension reforms such as changes in the calculation of pension benefits and cuts in the pension replacement rate.

4.1 THE MODEL

The pension model presented in this section starts from the basic HV-model without learning by doing, education costs and subsidies. This means the following restrictions are imposed:

$$ec = es = \delta_x = \delta_j = \delta_k = 0, \tag{30}$$

$$x_t = 1 + \varphi \left(v_1 {g_y}^{1-(1/\kappa)} + v_3 q^{1-(1/\kappa)} + (1 - v_1 - v_3)(e^t)^{1-(1/\kappa)} \right)^{\sigma\kappa/\kappa-1}, \tag{31}$$

$$j_t = 1 \tag{32}$$

Intertemporal utility is still given by (1) and is maximized by households subject to the constraints (2)-(4) and (6)-(9). Equation (5) changes: consumption when retired now equals savings from the previous period (including interest), lump sum transfer from/to the government and pension benefits received from government:

$$(1 + \tau_c)c_4^t = (1 + r_{t+3})s_3^t + b_4[a.n_1^t w_t h_1^t (1 - \tau_1) + b.n_2^t w_{t+1} h_2^t (1 - \tau_2) + c.n_3^t w_{t+2} h_3^t (1 - \tau_3)] + z_{t+3} \tag{5'}$$

Where $0 < a, b, c < 1$ and $a + b + c = 1$. Although cross-country institutional realities can be quite different (see Whiteford and Whitehouse, 2006), all countries are assumed to have a PAYG pension system in which current pensions are financed by current taxes. b_4 is the net pension replacement rate, defined as “the individual net pension entitlement divided by net pre-retirement earnings, taking account of personal income taxes and social security contributions paid by workers and pensioners” (OECD, 2007, p. 34). I use a weighted average of lifetime net income as a proxy for pre-retirement earnings where a, b and c represent the weights. A full pension is granted if one has a full career, which is achieved when $n_i^t = 1$ for $i = 1, 2, 3$. Intuitively this implies 45 years of full time work. A comparable calculation for pension benefits is used in the MIDAS-model of the Belgian Federal Planning Bureau (Dekkers, Desmet and De Vil, 2010). Therefore I consider this modeling as a stylized form of the Belgian pension system. The possibility of early retirement is implicitly allowed in the model via the calculation of b_3 (see Heylen and Van de Kerckhove, 2009).

The new budget constraint (5)’ does not alter first order conditions (10)-(12). Equations (13)-(16) change due to the fact that received pension benefits are a function of employment and effective human capital accumulated during the active period. Equations (13)’-(15)’ now determine optimal employment and equation (16)’ the optimal investment in education.

$$\frac{\gamma_1}{\left(1-n_1^t-e^t\right)^{\theta}} = \frac{1}{c_1^t}\frac{\partial c_1^t}{\partial n_1^t} + \beta^3 \frac{1}{c_4^t}\frac{\partial c_4^t}{\partial n_1^t} \qquad (13)'$$

$$\frac{\gamma_2}{(1-n_2^t)^{\theta}} = \frac{1}{c_2^t}\frac{\partial c_2^t}{\partial n_2^t} + \beta^2 \frac{1}{c_4^t}\frac{\partial c_4^t}{\partial n_2^t} \qquad (14)'$$

$$\frac{\gamma_3}{(1-n_3^t)^{\theta}} = \frac{1}{c_3^t}\frac{\partial c_3^t}{\partial n_3^t} + \beta \frac{1}{c_4^t}\frac{\partial c_4^t}{\partial n_3^t} \qquad (15)'$$

With:

$$\frac{\partial c_4^t}{\partial n_1^t} = b_4 \frac{a\, w_t h_1^t (1-\tau_1)}{(1+\tau_c)}$$

$$\frac{\partial c_4^t}{\partial n_2^t} = b_4 \frac{b\, w_{t+1} h_2^t (1-\tau_2)}{(1+\tau_c)}$$

$$\frac{\partial c_4^t}{\partial n_3^t} = b_4 \frac{c\, w_{t+2} h_3^t (1-\tau_3)}{(1+\tau_c)}$$

$$\frac{\gamma_1}{(1-n_1^t-e^t)^{\theta}} - \frac{1}{c_1^t}\frac{\partial c_1^t}{\partial e^t} = \beta \frac{1}{c_2^t}\frac{\partial c_2^t}{\partial e^t} + \beta^2 \frac{1}{c_3^t}\frac{\partial c_3^t}{\partial e^t} + \beta^3 \frac{1}{c_4^t}\frac{\partial c_4^t}{\partial e^t} \qquad (16)'$$

With:

$$\frac{\partial c_4^t}{\partial e^t} = b_4 \frac{\partial x_t}{\partial e^t} \frac{b n_2^t w_{t+1} h_1^t (1-\tau_2) + c\, n_3^t w_{t+2} h_1^t (1-\tau_3)}{(1+\tau_c)}$$

And all other derivatives as in section 3.1.1, after imposing the restrictions (30)-(32). The discounted marginal utility of work (RHS of equations (13)'-(15)') increases as received pension benefits rise in the amount of time worked during the active period. The discounted marginal utility gain of extra tertiary education (RHS of equation (16)') also rises as pension benefits are a function of effective human capital. As a result, pension benefits are part of the return to working/education but not to leisure. Equations (23)-(28) still describe behavior of the firms, after imposing the restrictions (30)-(32). As government revenues now also finance public expenditures related to social security, the government budget constraint alters to:

$$G_{yt} + G_{ct} + B_t + Z_t = T_{nt} + T_{kt} + T_{ct} \qquad (29)'$$

With: $B_t = \sum_{i=1}^{3}\left(1 - n_i^{t+1-i} - e^t\right) b_i w_t h_i^{t+1-i}(1-\tau_i) +$

$$\underbrace{b_4[a.\, n_1^{t-3} w_{t-3} h_1^{t-3}(1-\tau_1) + b.\, n_2^{t-3} w_{t-2} h_2^{t-3}(1-\tau_2) + c.\, n_3^{t-3} w_{t-1} h_3^{t-3}(1-\tau_3)]}_{A}$$

Where ‘A’ represents the net (after-tax) government expenditures on old-age pensions (excluding early retirement expenditures) at time t. ‘A’ is calculated using the lifetime income of retirees at time t (born in t-3). All other variables in equation (29)’ are defined as in section 3.

4.2 EXOGENOUS VARIABLES

Table 7 contains data on net[5] replacement rates (b_4) of 17 OECD countries for 2002. All replacement rates concern individuals with mean earnings before retirement[6] and only mandatory pensions are taken into account. Voluntary, occupational pensions are not included. The average net replacement rate over all countries is 68.2%. There are however strong cross-country differences. We observe the lowest net replacement rate in the Anglo-Saxon countries: Ireland followed by the UK and the US. Austria, Italy and Spain have high replacement rates. Belgium’s rate is slightly below the average. Note that these figures say nothing about the weights in the pension calculation (a, b and c). The pension model will later predict that (for the benchmark of nine European countries) the government spends 3.98% of GDP on public pensions[7]. Again, all other data are taken from Heylen and Van de Kerckhove (2009). In contrast to the learning by doing model, g_y does include education subsidies.

[5] As pension entitlements are usually smaller than pre-retirement earnings, retirees pay less income taxes and social contributions. Therefore, net replacement rates are in most countries larger than gross replacement rates. (Pensions at a Glance, OECD, 2007). I use the net replacement rate to avoid having to deal with income taxes and social security contributions of pensioners.

[6] Using data of 2004 or data concerning the median earner does not improve the performance of the model.

[7] It is difficult to compare this number to real estimates of public expenditures on old-age pensions, which are much higher. These estimates usually cover gross pension expenditures (before taxes and social security contributions) and also include various sorts of early retirement expenditures before the age of 65. These are not included in the pension expenditures of this model.

Table 7 Net pension replacement rate (average earner, mandatory pensions)

	Pension benefit (net replacement rate, %)
Proxy for:	b_4
Austria[(a)]	88.9
Belgium	63.1
France	68.8
Germany	71.8
Italy	88.8
Netherlands	84.1
Denmark	54.1
Finland	78.8
Norway	65.1
Sweden	68.2
UK	47.6
US	51.0
Canada	57.1
Portugal	79.8
Spain	88.3
Switzerland[(a)]	67.7
Ireland	36.6
Overall country average	**68.2**

Note: A description of this variable is given in the main text. The replacement rate concerns data of 2002, which is approximately in the middle of the time range of other variables. More recent data reveal slightly different patterns. (a) calculated as the unweighted average of men's and women's net replacement rate.
Source: Pensions at a Glance (OECD, 2005, p.52).

5 CALIBRATION AND MODEL EVALUATION

Up to now, I have introduced and developed two different OLG models. The first model introduces experience and education costs in the human capital production function and permits the government to grant education subsidies. As stated above, I distinguish two different specifications of the education part of the human capital production function; equations (21) and (22). The latter allows for a different substitutability between private and public expenditures on tertiary education whereas the former does not have this possibility. The second model develops a simple pension benefit scheme. In section 5.1, I will calibrate these models by assigning specific values to the different parameters. In section 5.2, the performance of both models is checked by comparing the models' predictions with the actual data. Chapter 6 presents simulation results describing effects of different public policy shocks. Calibration and simulations are done using Dynare 4.0.

5.1 CALIBRATION

Before solving the models, testing their empirical relevance and making policy simulations, it is important to identify the parameters. This process is called calibration. As we have more than ten parameters that have to be determined, but only five endogenous variables (tertiary education rate, growth and employment in the three age groups), it is necessary to assign specific values to some of the parameters that are frequently used in the literature. Most of them are equal to those in the HV-model.

The rate of time preference is set to 2% per year, equivalent to β being 0.74. The share of effective labor $(1-\alpha)$ equals 0.7 (King and Rebelo, 1990). As the production function exhibits constant returns to scale, it follows that the share of physical capital must be 0.3. With respect to the intertemporal elasticity of substitution in leisure, I also follow Heylen and Van de Kerckhove (2009) and assume θ = 2 (see also Rogerson, 2007). Furthermore, I maintain r = 0.558, the equivalent of a real interest rate of 3% per year. In the learning by doing (LBD) model of section 3, human capital depreciation is set to an arbitrary 5% per year such that $\delta_x = \delta_j$ = 0.53671.[8] For simplicity, I do not allow for depreciation of physical capital: $\delta_k = 0$. In the pension model of section 4, a, b and c are set to 1/3 such that an unweighted average of previously earned income arises in equation (5)'. As stated in section 4.1, $\delta_x = \delta_j = \delta_k = 0$ in the pension model.

[8] The value of δ does not have a major influence on the results.

Some of the remaining parameters $(\sigma, \omega, \varphi, \gamma_1, \gamma_2, \gamma_3)$ are obtained by calibrating the models on a benchmark of nine countries (Austria, Belgium, France, Germany, Netherlands, Denmark, Finland, Norway and Sweden). These parameters are chosen such that, given observed average values for these countries' fiscal policy variables, quality of schooling etc., each model correctly predicts average education rates, employment in the three age groups and growth in these countries in 1995-2007. The assumption behind calibration is the idea that a model is correct for the average of the benchmark countries. For that reason, it is of prime importance to check if that model is also able to explain cross-country differences (see section 5.2). Table 8 summarizes the average value of the five endogenous variables for the nine countries used to calibrate the models. As there are six remaining parameters, given certain values for κ, v_1, v_2, v_3 and μ which are determined below, but only five endogenous variables, I need one extra restriction in both of the models. In the pension model, there is no learning by doing such that ω is not present. Dynare allows to determine the five remaining parameters. In the LBD-model I impose the following restriction: $\gamma_3 = \gamma_2$. In other words, I assume the same leisure preference for middle aged and older workers.[9] This restriction does not reduce performance of the model and even gives better results than more general restrictions (e.g.: $\gamma_2 = \pi\gamma_1$ with $\gamma_3 = \pi\gamma_2$).

Table 8 Benchmark equilibrium values

Benchmark equilibrium[(a)]				
$\boldsymbol{n_1}$	$\boldsymbol{n_2}$	$\boldsymbol{n_3}$	**Per capita growth (annual)**	$\boldsymbol{e}$
53.1%	61.5%	41.5%	2.02%	17.1%

Note: (a) average for 9 European countries (Austria, Belgium, France, Germany, Netherlands, Denmark, Finland, Norway and Sweden).

The above parameters $(\sigma, \omega, \varphi, \gamma_1, \gamma_2, \gamma_3)$ can only be calibrated for given values of v_1, v_2, v_3, κ and μ. In order to determine the latter, I performed a sensitivity analysis on the predictions of the models in order to minimize the deviations from the actual data. This leads to the following optimal results for the pension model in section 4: v_1 = 0.25, v_2 = 0, v_3 = 0.20 and κ = 0.7. For the LBD-model in section 3, this analysis is more complex and depends on the chosen human capital production function: (21) or (22). Using the most simple specification (21) yields v_1 = 0.175, v_2 = 0.0275, v_3 = 0.175 and κ = 0.7 as optimal results. Substituting (22) for (21) gives v_1 = 0.15, v_2 = 0.05, v_3 = 0.20 and κ = 0.7.[10] When equation (22) is used,

[9] Not imposing this restriction but calibrating $\omega, \varphi, \gamma_1, \gamma_2, \gamma_3$ after imposing specific values for σ leads to the conclusion that $\gamma_1 \approx \gamma_2$.

[10] As $\kappa < 1$ in the CES-function, all four components of ψ_1 (private educational expenditures, tertiary education time, productive government expenditures and schooling quality) are complements (Hanushek and Welsh, 2006).

one extra parameter (μ) has to be determined. I assume private ($ec.e^t$) and public (g_{et}) expenditures on education are substitutes. Following Hanushek and Welsh (2006) this means setting $\mu > 1$ in the CES-function. Although changes in this parameter do not significantly alter outcomes, optimal results are obtained with $\mu = 4$. A summary of the assigned parameter values in the different models can be found in tables 9-11. As these tables show, the taste for leisure, as in the HV-model, rises with age. φ, which indicates both the productivity of education and the relative importance of education (as opposed to learning by doing) in the human capital production function, seems to be between values 5 and 10. Whereas Heylen and Van de Kerckhove (2009) find clear evidence for increasing returns in human capital production through education (σ=1.31), the calibration of both my models is not that distinct; σ is smaller. Increasing returns in experience is more clear (ω=1.77).

Table 9 Basic parameterization in the LBD-model using equation (21)

Technology and preference parameters	
Production parameters (output)	$1 - \alpha = 0.7$
Effective human capital production	$\phi = 7.29811, v_1 = 0.175, v_2 = 0.0275$
	$v_3 = 0.175, \kappa = 0.7, \sigma = 1.04363, \omega = 1.76538$
Preference parameters	$\theta = 2, \beta = 0.74$
	$\gamma_1 = 0.14325, \gamma_2 = \gamma_3 = 0.197499$
World real interest rate	$r = 0.558$
Human capital depreciation rate	$\delta_x = \delta_j = 0.53671$
Fiscal policy parameters in benchmark (a)	
Government expenditures variables (in %)	$g_y = 10.6, g_c = 17.0, b_1 = 61.5$
	$b_2 = 53.6, b_3 = 57.8$
Tax rates (in %)	$\tau_k = 22.5, \tau_1 = 54.6, \tau_2 = \tau_3 = 56.1, \tau_c = 15.0$
Full-time education subsidies (in %)	$es = 1.525$
Full-time education cost (in %)	$ec = 5.328$
Average schooling quality in benchmark(a)	$q = 0.051$

Note: (a) average for 9 European countries (Austria, Belgium, France, Germany, Netherlands, Denmark, Finland, Norway and Sweden).

Table 10 Basic parameterization in the LBD-model using equation (22)

Technology and preference parameters	
Production parameters (output)	$1 - \alpha = 0.7$
Effective human capital production	$\phi = 9.97068, v_1 = 0.15, v_2 = 0.05, v_3 = 0.20$
	$\kappa = 0.7,\ \sigma = 1.17097, \omega = 1.76538,\ \mu = 4$
Preference parameters	$\theta = 2, \beta = 0.74$
	$\gamma_1 = 0.14325, \gamma_2 = \gamma_3 = 0.197499$
World real interest rate	$r = 0.558$
Human capital depreciation rate	$\delta_x = \delta_j = 0.53671$
Fiscal policy parameters in benchmark [(a)]	
Government expenditures variables (in %)	$g_{py} = 9.3, g_{ey} = 1.3, g_c = 17.0$
	$b_1 = 61.5, b_2 = 53.6, b_3 = 57.8$
Tax rates (in %)	$\tau_k = 22.5, \tau_1 = 54.6, \tau_2 = \tau_3 = 56.1, \tau_c = 15.0$
Full-time education subsidies (in %)	$es = 1.525$
Full-time education cost (in %)	$ec = 5.328$
Average schooling quality in benchmark[(a)]	$q = 0.051$

Note: (a) average for 9 European countries.

Table 11 Basic parameterization in the pension model

Technology and preference parameters	
Production parameters (output)	$1 - \alpha = 0.7$
Effective human capital production	$\phi = 5.79198,\quad v_1 = 0.25,\quad v_2 = 0,\quad v_3 = 0.20$
	$\kappa = 0.7,\ \sigma = 1.29363$
Preference parameters	$\theta = 2, \beta = 0.74, \gamma_1 = 0.0485$
	$\gamma_2 = 0.1147, \gamma_3 = 0.2348$
World real interest rate	$r = 0.558$
Pension calculation weights	$a = b = c = \frac{1}{3}$
Fiscal policy parameters in benchmark[(a)]	
Government expenditures variables (in %)	$g_y = 10.9, g_c = 17.0, b_1 = 61.5$
	$b_2 = 53.6, b_3 = 57.8, b_4 = 71.4$
Tax rates (in %)	$\tau_k = 22.5, \tau_1 = 54.6, \tau_2 = \tau_3 = 56.1, \tau_c = 15.0$
Average schooling quality in benchmark[(a)]	$q = 0.051$

Note: (a) average for 9 European countries.

5.2 MODEL EVALUATION / EMPIRICAL RELEVANCE

Once a model has been developed and specific values for all parameters have been chosen, it is necessary to determine if this model is able to explain the facts. Using the predicted steady state values of the endogenous variables for each individual country, I evaluate the developed models. Predicted steady state values are obtained by introducing country specific fiscal (and other) data, holding technology and preference parameters fixed.

Naturally, the limitations Heylen and Van de Kerckhove (2009) cite are also applicable here. Lack of data, data imperfections and model simplifications explain in part why country predictions of employment, education and growth deviate from their true average value. Moreover, there is no certainty that the growth and employment data presented in section 2 represent the true steady states. It is a known fact that some European countries such as Spain or Ireland, may still be converging to their steady state. Furthermore, as in the HV-model, it seems that both models have difficulties predicting the low employment rates in Italy and Spain. It is possible to solve this problem by calibrating different tastes for leisure for Italy and Spain. Values for both models are given in table 12. Indeed, it seems that preference for leisure in these two countries is much higher than in other OECD-countries. Another problem of the HV-model that is not solved, concerns predictions for the growth of Ireland and Switzerland. Irelands' rapid convergence is referred to as the Irish hare by Honohan and Walsh (2002). Switzerland, on the other hand, experienced slow productivity growth due to its weak institutional context (e.g. restrictive product market regulation) for emerging industries (Guellec, 2006). To evaluate the models, I shall drop Ireland and Switzerland for growth.

Table 12 Calibrated leisure preferences for Italy and Spain

Taste for leisure	LBD-model	Pension model
γ_1	0.3087	0.1743
γ_2	0.2969	0.2290
γ_3	0.3692	0.4527

Source: calibration using Dynare 4.0.

5.2.1 The learning by doing model

One way to evaluate a model is to compare the coefficients of correlation between important variables in the actual data and the correlations between those variables as predicted by the model. Table 13 displays these coefficients for the HV-model, the LBD-model using equation (21) as human capital production function and a second-best model (choosing alternative parameter values for v_1 , v_2 and v_3, see note). The last column concerns the LBD-model using the extensive human capital production function (22).

Table 13 Correlation between the main variables in the actual data versus predicted by the model (15 or 17 countries, 1995-2006/7)

	ACTUAL DATA	HV (2009)	LBD_1-model	Second $Best_1$	LBD_2-model
CORR(growth,e)	0.50	0.98	0.76	0.78	0.85
CORR(growth,n_1)	0.01	-0.12	0.02	0.00	-0.03
CORR(growth,n_2)	0.03	0.26	0.46	0.48	0.47
CORR(growth,n_3)	0.19	0.27	0.28	0.30	0.28
CORR(growth,n)	0.10	0.14	0.25	0.27	0.24
CORR(growth, g_y)	0.38	0.81	0.72	0.77	0.76
CORR(g_y,e)	0.69	0.67	0.61	0.65	0.62
CORR(n_1,n_2)	0.80	0.86	0.74	0.71	0.71
CORR(n_1,n_3)	0.67	0.84	0.76	0.73	0.75
CORR(n_2,n_3)	0.80	0.97	0.92	0.92	0.92
CORR(n_1,e)	-0.31	-0.21	-0.51	-0.51	-0.47
CORR(n_2,e)	0.07	0.15	0.00	0.03	0.06
CORR(n_3,e)	0.17	0.16	-0.19	-0.15	-0.15
CORR(n_1,g)	-0.14	0.12	-0.11	-0.15	-0.12
CORR(n_2,g)	0.16	0.42	0.35	0.36	0.36
CORR(n_3,g)	0.41	0.41	0.37	0.37	0.37

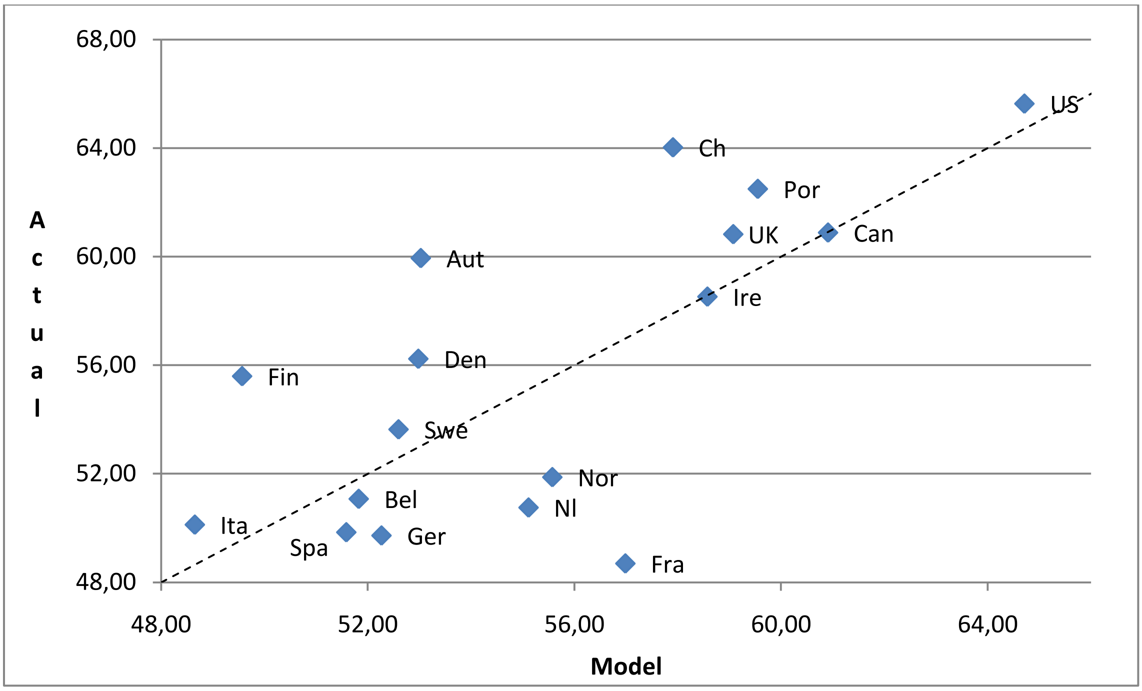
Note: (a) these correlations are based on one observation per country. Correlations involving growth do not include Ireland and Switzerland. (b) n is the aggregate employment rate over all three age groups. It is a weighted average of n_1, n_2 and n_3. (c) the LBD_1-model refers to the model using human capital production function (21). (d) the second $best_1$ model also uses human capital production function (21) but imposes other parameter values for v_1 (0.20), v_2(0.0275) and v_3 (0.15). It is obvious that this leads to slightly different values for ω and σ. (e) the LBD_2-model refers to the model using human capital production function (22).

Compared to the HV-model, much progress is made concerning the correlation between growth and education. In the best model it is now 0.76 whereas the HV-model predicted 0.98. Furthermore, the LBD-model generates a less negative (and sometimes positive) link between employment of the young and growth. This is the result of the experience effect induced by the introduction of learning by doing in the human capital production function. In addition, whereas the HV-model is not able to predict a negative correlation between productive government expenditures and employment of the young, the LBD-models indicate a correct sign and magnitude. There are some minor drawbacks. The new models strongly overestimate correlation between growth and employment when middle aged. As a result, correlation between growth and aggregate employment is also too large. A second shortcoming is the predicted negative correlation between education and employment of older workers. One possible explanation could be that the restriction $\gamma_2 = \gamma_1$ contributes to this result. In general, however, correlations are predicted correctly. As can be seen from table 13, using equation (21) or (22) or slightly changing the parameter values does not drastically change the estimated correlations. Therefore, for the remainder of this dissertation, only results for the optimal LBD-model using equation (21) will be reported (LBD_1-model in table 13).

Scatter plots relating predicted to actual values of the endogenous variables give an indication of the explanatory power of the model. Figures 1 to 5 show these scatter plots and the 45°-line on which predictions would be if the model was completely correct for all countries. Values for Italy and Spain are obtained using the leisure parameters from table 12. Overall, predictions are quite good. Compared to the HV-model, this model is able to slightly better predict employment of the young and middle aged for Finland, Norway and Austria, probably due to the introduction of education costs. The latter also adds to better predictions for the tertiary education rate in Finland, Denmark and Italy. Canada's education rate is however underestimated due to the high cost of tertiary education. Employment of the young is hugely overestimated for France whereas it is underestimated for Switzerland. Predictions for the employment rate of middle aged individuals is slightly worse for the US and Ireland. Furthermore, growth for Spain and Finland still remains underestimated.

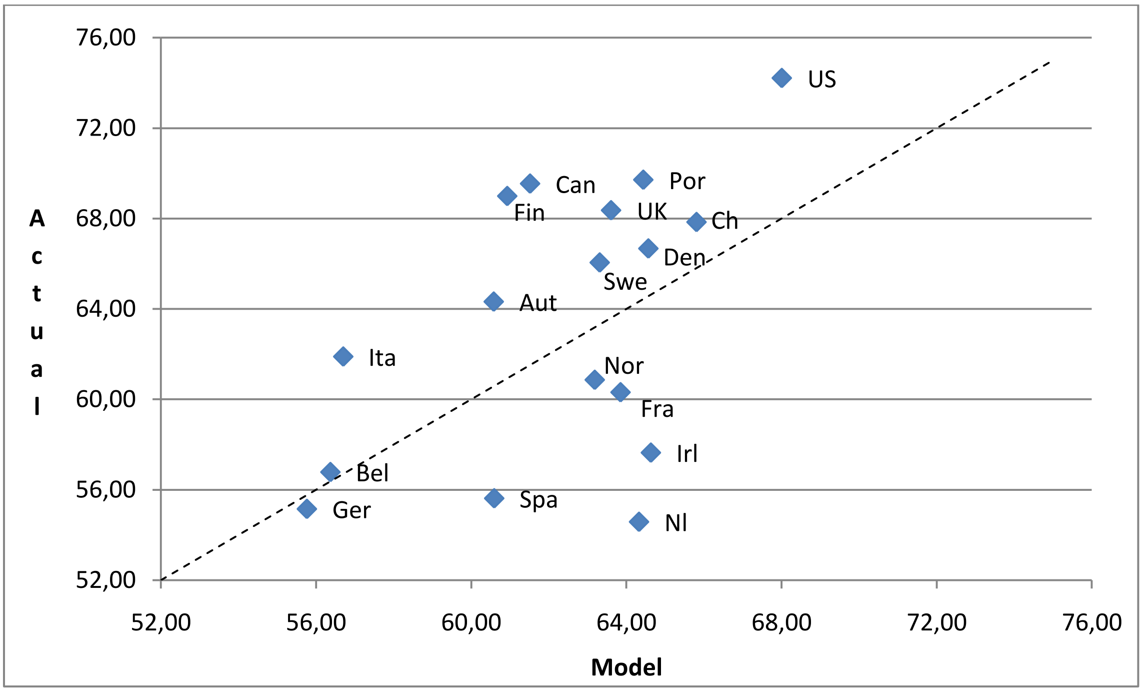
In addition to the scatter plots, the coefficients of correlation between actual and predicted values give another indication of the explanatory power of the model. All correlations are larger than 0.50. In comparison to the HV-model, the LBD-model has slightly more difficulties predicting growth (R=0.51), but has a much stronger explanatory power for the employment rate of young workers (R=0.69) and the tertiary education rate (R=0.67). Correlations for the employment rate of the middle aged (R=0.51) and older workers (R=0.82) are in line with the HV-model. On some points, the LBD-model seems to give a better explanation for the real data than the HV-model. On other points it performs slightly worse. Although the model is far from perfect, many cross-country differences are well explained. A major contribution of this model is that it allows to investigate the effect of changes in education subsidies and other budgetary components in a world were skill accumulation is also affected by experience.

Figure 1 Employment rates in hours of young individuals in individual countries, in %, 1995-2007



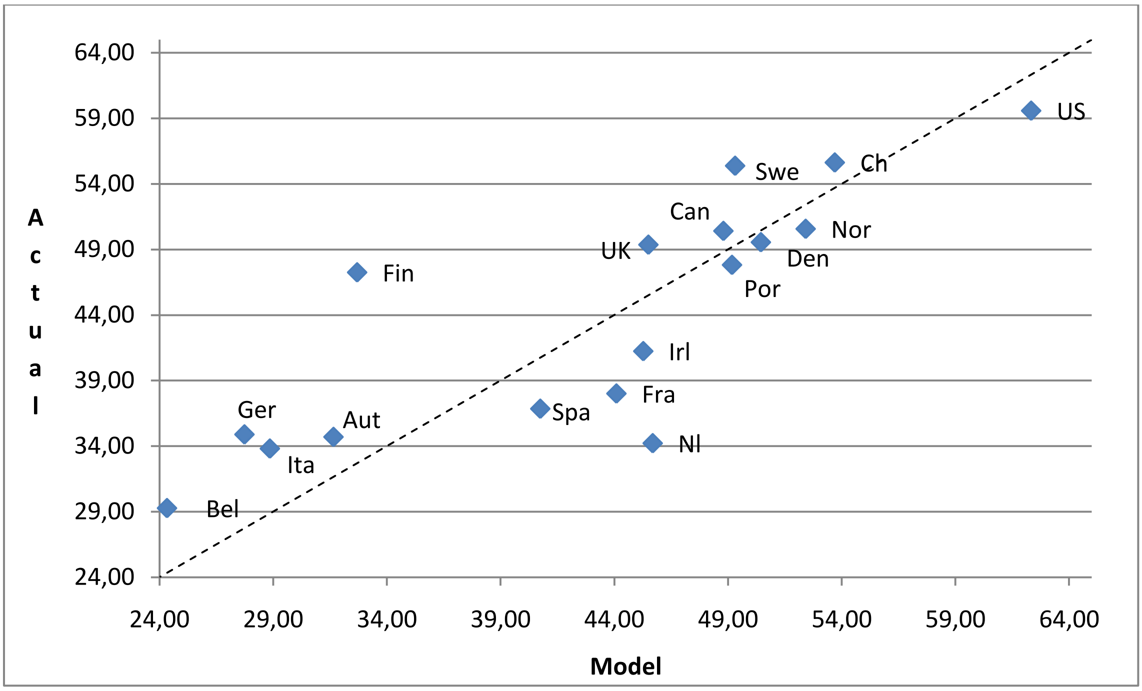
Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.69.

Figure 2 Employment rates in hours of middle aged individuals in individual countries, in %, 1995-2007



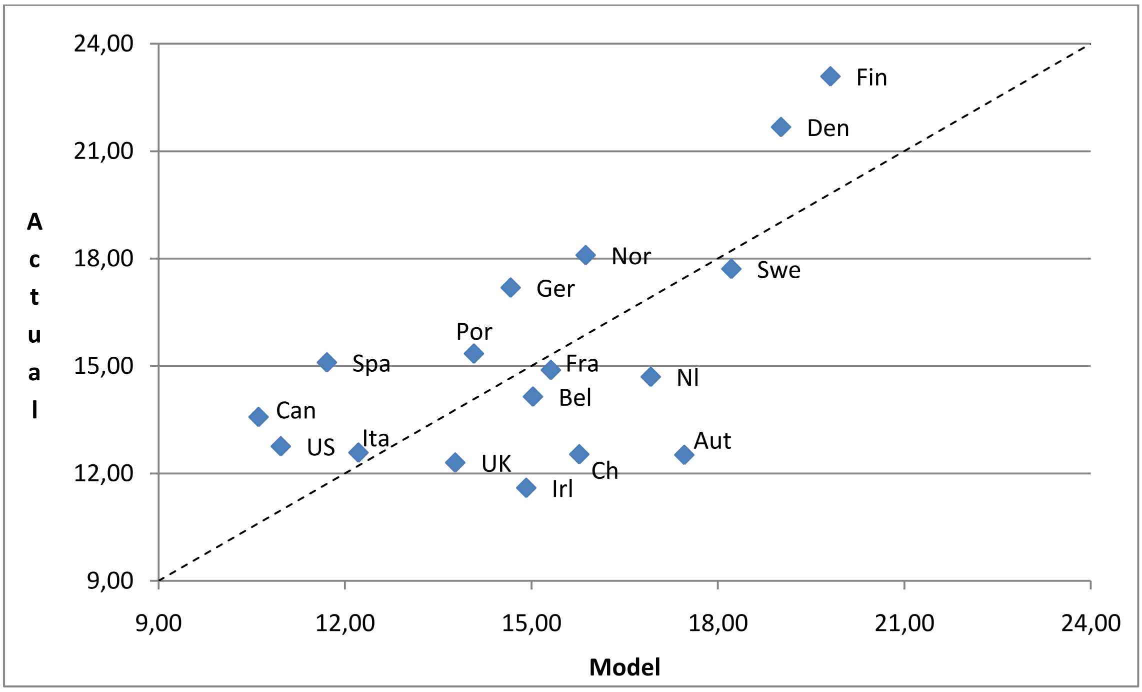
Note: the dotted line is the 45°-line. Correlation between the actual data and the model's predictions is 0.51.

Figure 3 Employment rates in hours of older individuals in individual countries, in %, 1995-2007



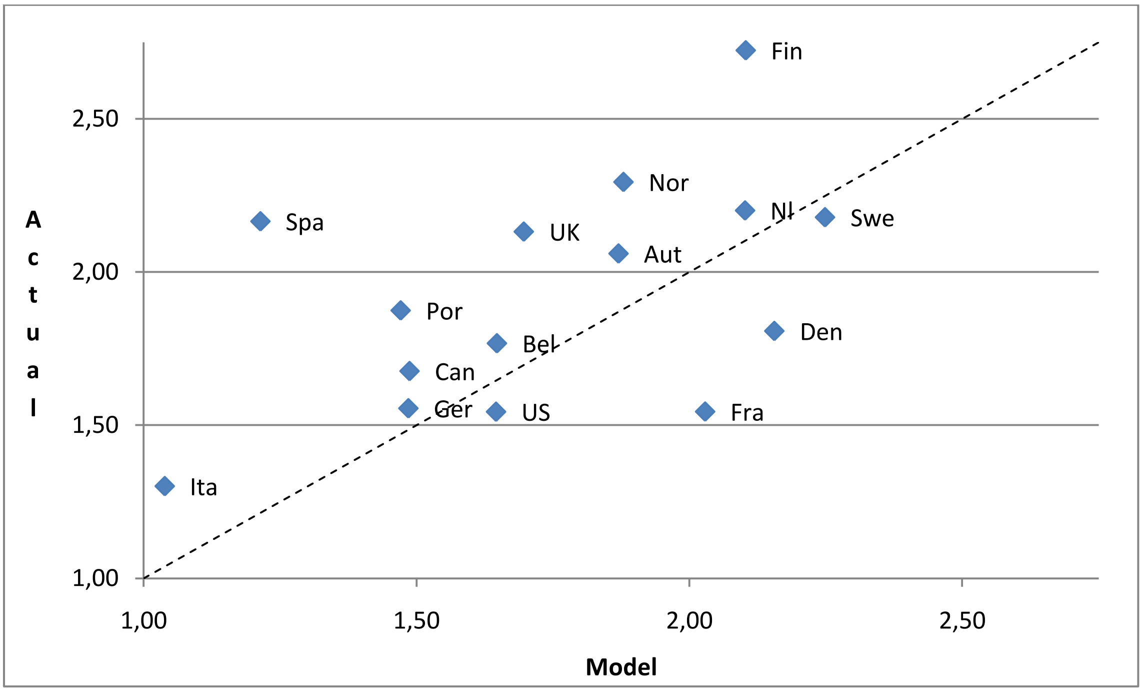
Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.82.

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



Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.67.

Figure 5 Annual per capita potential GDP growth in individual countries, in %, 1995-2007



Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.51. Correlation drops to 0.33 if Switzerland is included. The model predicts a growth rate for Switzerland equal to 1.95%, whereas actual growth is only 0.94%. Correlation drops further to 0.30 if Ireland is also included. Whereas actual growth rate for Ireland is 4.53%, the model only predicts a growth rate equal to 1.96%.

5.2.2 The pension model

The same evaluation exercises can be performed for the pension model. However, as this model does not deviate much from the original one of Heylen and Van de Kerckhove (2009), I will not treat this extensively. Appendix B shows both the correlations between the main variables (in the actual data versus predicted by the model) and scatter plots relating actual data and predicted values for employment, growth and education. Compared to the HV-model, overall performance (explanatory power) is slightly better for tertiary education, growth and employment of young and middle aged workers, but slightly worse for employment of older workers. Although the results have not significantly improved, the pension-model allows me to assess the impact of simple pension reforms in section 6.

6 PUBLIC POLICY SHOCKS: SIMULATION RESULTS

In this section, I determine the impact of various public policy shocks from the benchmark. It is my goal to discover which fiscal policy measures and pension reforms are most effective in stimulating employment and growth. This part is in line with research of among others Turnovsky (2000), Bouzahzah et al. (2002), Prescott (2004), Rogerson (2007) and Dhont and Heylen (2009). Section 6.1 describes the steady state effects and transitional dynamics of fiscal policy shocks on long-run employment, growth and welfare using the LBD-model. Section 6.2 does the same for several pension reforms in the pension model.

6.1 THE LEARNING BY DOING MODEL

6.1.1 Steady state effects

In the LBD-model, I impose the same unanticipated and permanent fiscal shocks as in Heylen and Van de Kerckhove (2009) of 3% of initial output. This allows to compare the current results to theirs. Both the problem of ageing and the risk of persistent negative effects from the recent financial crisis require effective employment and growth policies. Therefore, only the impact of policy shocks which are ex ante expected to raise equilibrium growth or employment are verified. These concern reductions in taxes and non-employment benefits and increases in government expenditures. The model further allows to verify the impact of a change in education subsidies. Many authors have already studied their effectiveness and distributional effects (Trostel, 1996; Zhang, 1996; Caucutt and Kumar, 2003; Wigger, 2004).

Table 14 summarizes the results. Let me first focus on employment. Following overall labor tax cuts, individuals choose to increase labor supply because lower labor taxes raise the marginal utility gain from working compared to leisure (Berger and Heylen, 2009). In contrast to the conclusions of Heylen and Van de Kerckhove (2009), I find the most effective policy measure to raise employment is a labor tax cut on older workers. A reduction of this tax by 16%-points raises the aggregate employment rate by 3.72 %-points compared to only 0.98%-points in the HV-model. The explanation is straightforward. In the HV-model, a labor tax cut on older workers increases the return to education as effective human capital is taxed less when old. In the LBD-model, as can be seen in equations (13) and (14), returns to employment when young and middle aged also increase as human capital builds up through experience. As a result, employment when young rises (instead of falls as in the HV-model) and employment when middle aged increases even more. The reverse side of the medal is that the increase in tertiary education is smaller and hence growth effects will be slightly more moderate although still significant. Tax cuts seem most effective for employment when applied to younger or older workers. This confirms findings of Bassanini and Duval (2006). Middle aged workers already work more so the disutility of extra labor will be larger than for young or older workers. As was the case in the HV-model, a labor tax cut on the middle aged even lowers the aggregate employment rate (-0.10%-points) as young individuals substitute study for work. This in turn explains the higher growth that follows from this measure. Yet, the fall in employment of the young and the rise in tertiary education are both smaller than in the HV-model due to the same effects mentioned earlier[11]. Note that, compared to the HV-model, the effect of a labor tax cut on young workers on the aggregate employment rate is only half as large (0.76%-points compared to 1.49%-points). Furthermore, following tax cuts, the change in the tertiary education rate is always smaller (in absolute value). The mechanisms underlying both the cost of education as such and the fact that private expenditures on education and employment also determine skills-accumulation might help to explain these differences. Despite the smaller impact compared to the HV-model, non-employment benefit cuts are still very effective measures to boost employment, with a cut in the overall replacement rate of 8.8%-points leading to a rise in the aggregate employment rate in hours by 1.88%-points. The volume of employment in hours grows by 3.56 %.

Columns 5 and 6 of table 14 report the impact of a cut in capital or consumption taxes. The effect on employment is positive but relatively small. Lower consumption taxes do not only raise marginal utility from working but also from taking leisure, which explains the more moderate effect on employment. Capital taxes on the other hand do not have a direct influence on the optimal allocation of time between labor, leisure or education. As Berger and Heylen (2009, p. 6) note, “they mainly operate through their […] effects on physical capital formation and labor productivity, which indirectly affect employment”. The last two columns analyze the impact of a rise in government consumption or productive government expenditures. In general, extra government consumption has the same effects as in Heylen and Van de Kerckhove (2009) and Dhont and Heylen (2009), with extra employment provoked by the fall in lump sum transfers (negative permanent income effect). Finally, with respect to a rise in productive government expenditures, the effect on employment of the young(-) and education(+) is only half as large as in the HV-model. The effect on aggregate employment is more positive (due to the smaller fall in n_1).

[11] The mechanism for a tax cut on middle aged workers is as follows. In the LBD-model and following this labor tax cut, the returns to both employment when young and education rise as effective human capital is taxed less in the subsequent period of life. In the HV-model on the other hand, only the return to education rises as human capital does not increase in experience. This explains the more moderate increase in tertiary education and the smaller fall in employment of the young in the LBD-model. The growth effect is not that obvious as both education and employment of the young now stimulate growth.

Table 14 Fiscal shocks in the LBD-model equal to 3% of ex ante output – compensated by changes in lump sum transfers (Z)

Change in policy variable[(a)]	$\Delta\tau_1=\Delta\tau_2=\Delta\tau_3$ = -4.3	$\Delta\tau_1=$ -11.6	$\Delta\tau_2=$ -10.1	$\Delta\tau_3=$ -16.0	$\Delta\tau_c=$ -6.0	$\Delta\tau_k=$ -10.0	$\Delta b_1=\Delta b_2=\Delta b_3$ = -8.8	$\Delta b_1=$ -41.3	$\Delta b_2=$ -34.0	$\Delta b_3=$ -22.4	$\Delta g_c=$ 3.0	$\Delta g_y=$ 3.0
Effect[(b)]:												
Δn_1	0.79	4.27	-2.98	0.93	0.66	0.76	0.91	4.06	0.80	-0.88	0.76	-1.46
Δn_2	1.42	-1.07	2.21	3.00	0.82	0.94	0.61	-0.16	4.75	-1.86	0.94	1.41
Δn_3	2.32	-0.99	0.33	7.84	1.37	1.58	4.60	0.38	0.03	9.74	1.58	1.96
Δe	0.30	-3.28	3.32	1.09	0.01	0.01	-0.69	-0.41	-1.37	-0.47	0.01	1.94
Δn [(b, c)]	1.47	0.76	-0.10	3.72	0.92	1.07	1.88	1.43	2.03	1.87	1.07	0.60
$\frac{\Delta N}{N}$ [(d)]	2.78	1.44	-0.18	7.05	1.75	2.02	3.56	2.70	3.84	3.55	2.02	1.14
Δannual growth rate[(b)]	0.06	-0.31	0.30	0.16	0.02	0.03	-0.06	0.08	-0.15	-0.09	0.03	0.36
ΔZ ex post [(e)]	-3.41	-3.62	-3.68	-2.74	-2.47	-2.85	3.02	2.89	3.06	3.07	-2.85	-2.91

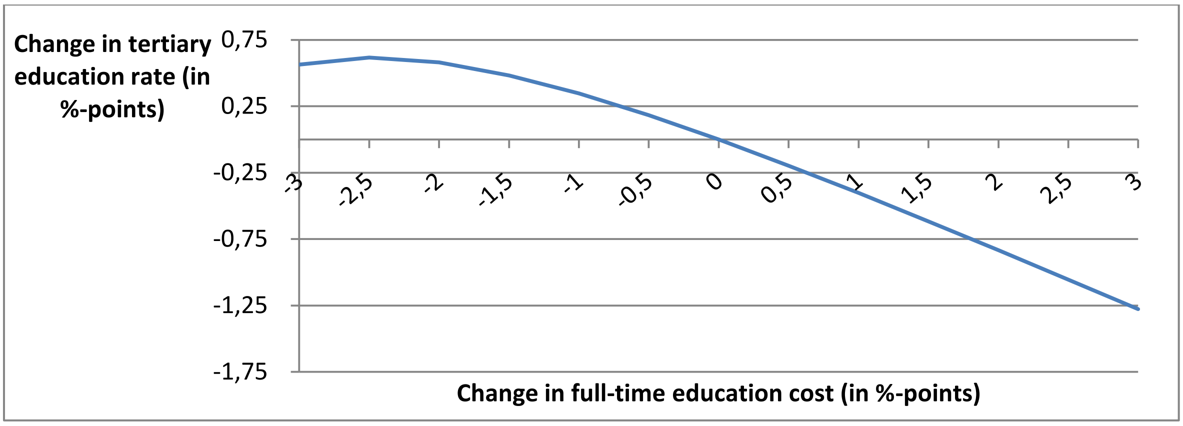
Notes: (a) change in policy variable, in percentage points.
(b) difference in percentage points between new steady state and benchmark, except ΔN/N.
(c) change in (weighted) aggregate employment rate in hours.
(d) change in volume of employment in hours, in %. Approximately, ΔN/N = Δn/n. With N total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

Focusing on growth, it would be most effective for the government to increase productive spending (see also Dhont and Heylen, 2009; Turnovsky, 2000). Following a 3% of output lump sum financed increase in these expenditures, the annual growth rate is predicted to rise by 0.36%-points. For comparison, Dhont and Heylen (2009) predict an increase of growth by 0.45%-points. Whereas tertiary education and employment when young are less affected than in Heylen and Van de Kerckhove (2009), the effect on annual growth is equal (partly due to the learning by doing effect). Also effective in raising steady state growth are labor tax cuts on middle aged and older workers as they increase education and prevent employment of the young from falling too much (see footnote 11, p. 35). As in the HV-model, cuts in benefit replacement rates in general do not succeed in raising growth as they discourage studying. However, a lower benefit replacement rate on younger workers raises the marginal utility of work versus leisure and consequently leads to higher employment of the young which, through the experience effect, positively affects growth (+0.08%-points). This effect was not present in the HV-model which predicted a small but negative impact. Due to this same mechanism, the negative growth effect of a drop in labor taxes on young workers is somewhat smaller than in Heylen and Van de Kerckhove (2009). In line with the HV-model, consumption and capital taxes only have minor long-term growth effects.

I further verify the impact of a change in full-time education costs (assume tuition fees), holding education subsidies, public expenditures and taxes constant. Intuitively, a rise in education costs is expected to discourage enrollment in tertiary education. This is confirmed by figure 6 relating the %-point change in the tertiary education rate (between new steady state and benchmark) to the %-point change in full-time education costs. For instance, figure 6 reveals that a 1%-point increase in full-time education costs reduces the tertiary education rate by 0.40%-points compared to the initial steady state. The impact on growth is however less clear. First, the lower education rate following an increase in education costs has a negative growth effect. Second, a positive effect through experience is found when employment is substituted for education (n_1 rises). Third, more private expenditures on education induce a positive effect on growth as they directly appear in the human capital production function. The combined effect of these mechanisms is shown in figure 7, which relates the %-point change in the annual growth rate (between new steady state and benchmark) to the corresponding %-point change in full-time education costs. The figure reveals a hump-shaped pattern. Moderate increases in education costs (via higher tuition fees) increase growth to some extent. How to explain this pattern intuitively? Higher tuition fees allow more funds to be allocated to universities that can be used to buy equipment or other resources for educational purposes. It could also strengthen the motivation of students because of the higher opportunity cost of failing in university. However, when tuition fees rise too much, growth is negatively affected by the lower education rate which outweighs the positive effect of higher private expenditures. The optimal full-time education cost appears to be around 6.5% of GDP which is equivalent to a private expenditure of 1.1% of GDP[12]. For comparison, in the benchmark, the full-time education cost is 5.3% of GDP, equivalent to a private expenditure of 0.91% of GDP.

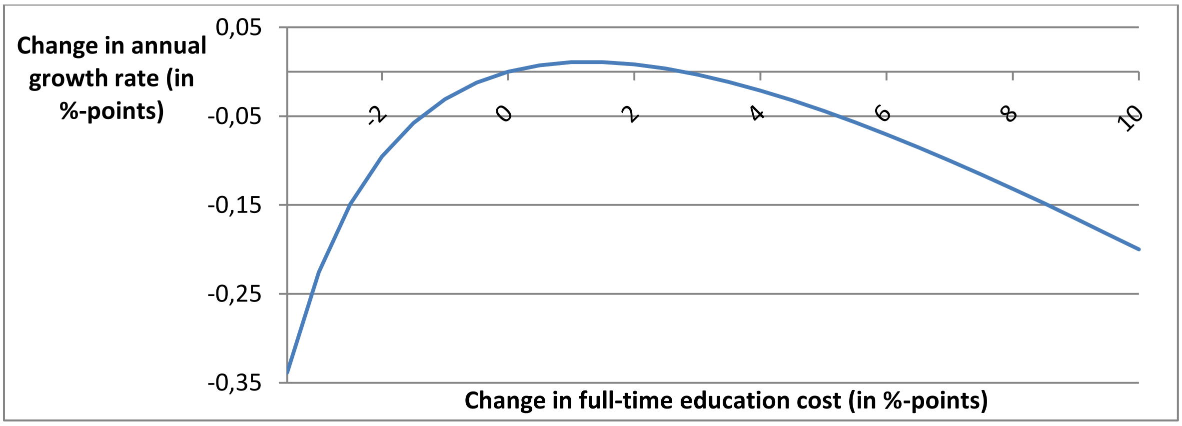
[12] Calculated using predicted values for the tertiary education rate after imposing a full-time education cost of 6.5% of GDP. Exactly the same pattern can be found in the LBD-model using equation (22). The optimal full-time cost is however slightly lower than presented above (approx. 5.45% of GDP, equivalent to a real private expenditure of 0.093% of GDP).

Figure 6 Change in the tertiary education rate between new steady state and benchmark following a change in full-time education costs



Source: own calculations using D ynare 4.0.

Figure 7 Change in the annual growth rate between new steady state and benchmark following a change in full-time education costs



Source: own calculations using Dynare 4.0.

Gross education costs are not completely under control of the government. It is more realistic for the government to influence the net education costs by altering subsidies. In the benchmark, the government spends approximately 0.26% of GDP $(= es.e^t)$ on subsidies for tertiary education. Imposing a 3%-point change on this variable would be relatively large. I therefore assume subsidies for full-time education (es) to increase by 3%-points instead, leading to a rise in government spending on subsidies by 0.61%-points to 0.87% of GDP. The effect of this shock is shown in table 15. As expected, tertiary education rises whereas employment of the young (as aggregate employment) falls. Annual growth is expected to increase by a considerable 0.19%-points. It is interesting to note that this effect is larger than the effect of a comparable increase in productive spending g_y. For the latter, an initial budget of 3% of output is required to achieve 0.36%-points of extra growth (see table 14 p. 36) while here only a budget of 0.61% of output is needed for a growth bonus of 0.19%-points.

Table 15 Shock in education subsidies - compensated by a change in lump sum transfers (Z)

Change in policy variable [(a)]	Δes = 3.00
Effect [(b)]:	
Δn_1	-2.40
Δn_2	0.36
Δn_3	0.19
Δe	2.20
Δn [(b, c)]	-0.62
$\frac{\Delta N}{N}$ (d)	-1.18
Δannual growth rate[(b)]	0.192
ΔZ ex post [(e)]	-0.70

Notes: (a) change in policy variable, in percentage points.
(b) difference in percentage points between new steady state and benchmark, except ΔN/N.
(c) change in (weighted) aggregate employment rate in hours.
(d) change in volume of employment in hours, in %.
(e) change in lump sum transfer (as a fraction of output) to maintain budget balance, in %-points.

In line with previous research (Turnovsky, 2000), table 16 considers budget-neutral fiscal changes, in which the impact of a fiscal policy shock on the government balance is neutralized by a change in another budget variable to keep lump sum transfers constant ($\Delta Z = 0$). Only measures that are expected to increase employment or growth are considered. Columns 1 and 2 indicate the effects of a cut in labor taxes compensated by increasing consumption taxes. Columns 3 to 6 analyze the impact of cuts in non-employment benefits. Decreasing benefits are, as in the HV-model, most effective in increasing employment, mostly so when compensated by labor tax cuts on older workers. Here, the simulations also suggest that a shift from labor taxes on older workers to consumption taxes is an adequate tool to increase aggregate employment. This is mainly the result of the employment of the young which is, for reasons explained earlier, slightly above its original level, whereas it drops almost 6%-points in the HV-model. The European Commission (2006) also finds that a shift from direct to indirect taxation might result in employment gains. Still, this effect is substantially smaller when overall labor tax cuts are implemented. The previous simulations indicate that for employment to rise, cuts in non-employment benefits or lower labor taxes on older workers are necessary. Other results stay in line with Heylen and Van de Kerckhove (2009). For instance, in order to have a substantial effect on growth, the government has to focus on increasing productive expenditures (see also Dhont and Heylen, 2009). The annual growth rate is expected to rise by approximately 0.289%-points when budget savings from lower benefits are used to finance productive spending. If on the other hand higher productive spending goes together with lower government consumption in order to keep lump sum transfers equal, growth rises even more (+0.332%-points). Growth also rises following a labor tax cut on older workers compensated by a rise in consumption taxes, although this effects was larger in the HV-model. Table 14 indicated that cuts in labor taxes on middle aged workers stimulate growth. I therefore perform two additional simulations (not presented in the table): (i) a cut in τ_2 compensated by a rise in the consumption tax and (ii) an overall cut in benefits to finance a cut in τ_2. The former is very good for growth (+0.277%points) but the employment rate falls (-1.43%-points). The latter combines a positive growth effect (+0.209%-points) with an increase in employment (+1.85%-points). In sum, a higher long-run growth rate can be achieved by more productive expenditures or labor tax cuts on middle aged or older workers. The last column of table 16 investigates the results of a rise in the quality of schooling with one standard deviation (a rise in the PISA score by 20). Both growth and education rise whereas employment falls moderately.

Table 16 Fiscal shocks in the LBD-model equal to 3% of ex ante output – compensated by a change in another fiscal policy variable

Change in policy variable (a)	$\Delta\tau_1=\Delta\tau_2$ $=\Delta\tau_3$ = -4.29	$\Delta\tau_3$= -15.96	$\Delta b_1=\Delta b_2$ $=\Delta b_3$ = -8.76	$\Delta b_1=\Delta b_2$ $=\Delta b_3$ = -8.76	$\Delta b_1=\Delta b_2$ $=\Delta b_3$ = -8.76	$\Delta b_1=\Delta b_2$ $=\Delta b_3$ = -8.76	Δg_y= 3.0		Δq= +0.002
Compensating change (e)	$\Delta\tau_c$= 8.30	$\Delta\tau_c$= 6.59	$\Delta\tau_1=\Delta\tau_2$ $=\Delta\tau_3$ = -3.88	$\Delta\tau_3$= -15.70	$\Delta\tau_c$= -7.01	Δg_y= 2.67	Δg_c= -3.08		/
Effect (b):									
Δn_1	-0.06	0.25	1.58	1.58	1.65	-0.48	-2.27		-0.47
Δn_2	0.37	2.17	1.90	3.37	1.56	1.98	0.44		0.10
Δn_3	0.56	6.57	6.58	11.82	6.10	6.39	0.33		0.08
Δe	0.28	1.08	-0.38	0.52	-0.65	1.18	1.93		0.41
Δn (b, c)	0.28	2.81	3.16	5.24	2.92	2.44	-0.51		-0.10
$\frac{\Delta N}{N}$ (d)	0.53	5.33	5.99	9.94	5.53	4.62	-0.96		-0.18
Δannual growth rate(b)	0.034	0.140	0.001	0.114	-0.032	0.289	0.332		0.071

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

Finally, table 17 analyzes shocks in education subsidies financed by higher taxes or lower alternative government expenditures. As young households substitute education for work, aggregate employment always drops following a compensated shock in education subsidies.

The fall in employment is smaller when overall cuts in non-employment benefits are used as a compensating mechanism, as cuts in benefits increase the bonus from work (both n_2 and n_3 rise). Growth effects are similar and substantial for all five scenarios. The highest growth bonus (+0.269%-points) is achieved when education subsidies are combined with tax cuts on young workers. This follows as both the higher education subsidies and higher income taxes on the young stimulate schooling. All effects are equal when a government consumption cut or a rise in the consumption tax is used to compensate the change in education subsidies.

Table 17 Shock in education subsidies - compensated by a change in another fiscal policy variable

Change in full-time education subsidies of 3%-points compensated by [(a)]	Δb_1= -8.33	Δb_1=Δb_2=Δb_3 = -1.89	Δg_c= -0.74	$\Delta \tau_c$= 1.72	$\Delta \tau_1$= 2.53
Effect [(b)]:					
Δn_1	-1.39	-2.22	-2.58	-2.58	-3.70
Δn_2	0.31	0.50	0.14	0.14	0.60
Δn_3	0.27	1.29	-0.19	-0.19	0.36
Δe	2.09	2.06	2.19	2.19	3.22
Δn [(b, c)]	-0.28	-0.19	-0.88	-0.88	-0.93
$\frac{\Delta N}{N}$ [(d)]	-0.52	-0.36	-1.66	-1.66	-1.75
Δannual growth rate [(b)]	0.209	0.181	0.186	0.186	0.269

Notes: (a) compensating change, in percentage points
(b) difference in percentage points between new steady state and benchmark, except ΔN/N.
(c) change in (weighted) aggregate employment rate in hours.
(d) change in volume of employment in hours, in %.

Some interesting conclusions can already be drawn from the previous simulation exercises. First, cuts in non-employment benefits or labor tax cuts on older workers are most effective to promote employment. Second, changes in consumption or capital taxes have minor effects on both growth and employment. Third, in order to stimulate economic growth, labor tax cuts on middle aged and older workers work well although a rise in productive government spending (R&D, infrastructure, education) has more effect. Fourth, labor tax cuts on young workers reduce growth as they discourage schooling. Finally, higher education subsidies reduce employment but work remarkably well for growth, mostly so when financed by an increase in labor taxes on the young. As already mentioned, some of these conclusions have many similarities to the HV-model. Nevertheless, it is worth noting that the mechanisms that drive these results are different and more complex compared to the model without learning by doing. In addition, despite the presence of learning by doing, an increase in tertiary education is still the most important driver of the growth rate.

6.1.2 Dynamic effects

In addition to the steady state effects of the previous unanticipated and permanent policy changes, it is interesting to investigate the transitional path from one steady state to the other. This section describes the dynamic evolution of some important variables (output-level, employment, welfare) after the policy changes of the previous section. Appendix C presents the transitional effects of lump sum financed fiscal policy changes of tables 14 and 15. Figures 8-10 show the response of output, aggregate employment and welfare after the combined fiscal policy shocks of tables 16 and 17. The effects on employment in all age groups are given in Appendix D. The welfare measure used, 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” (Heylen and Van de Kerckhove, 2009, p.24). Welfare effects for current generations are denoted as k=-3 (current retired), k=-2 (current older workers), k=-1 (current middle aged workers) and k=0 (current young workers). Positive values for k indicate future generations.

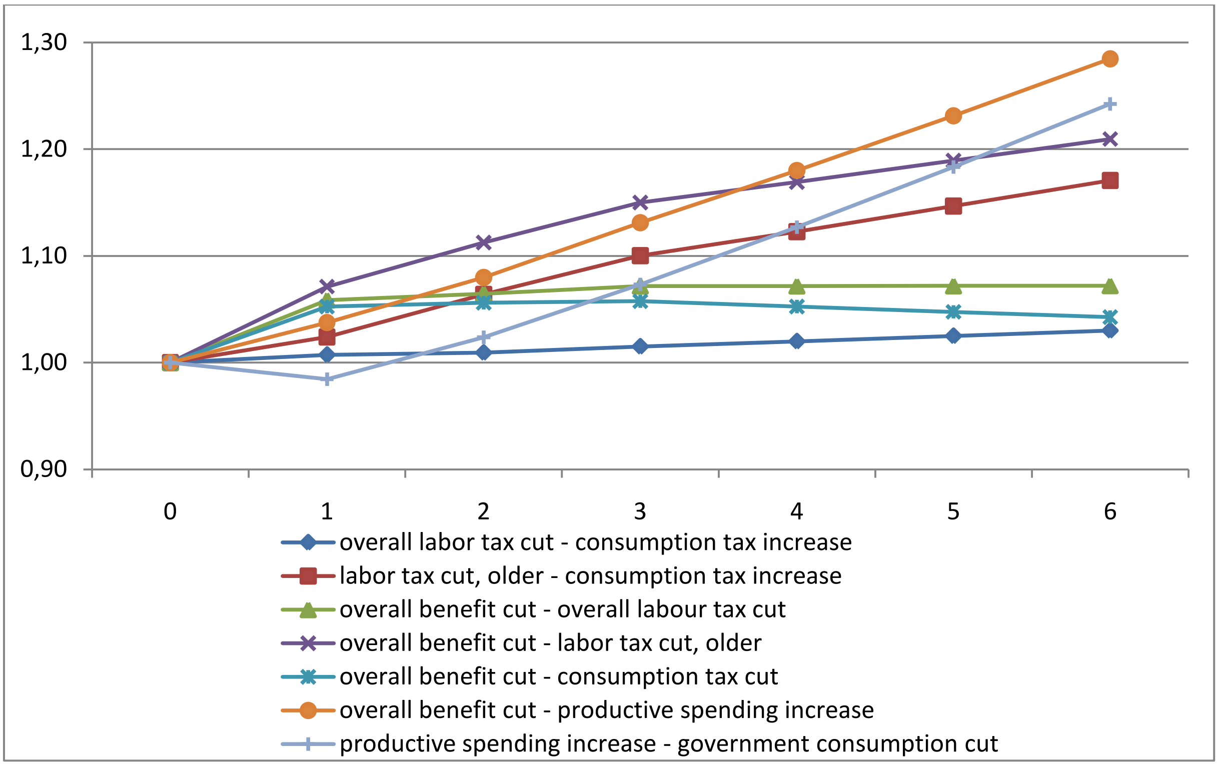
Focusing on the lump sum financed fiscal policy changes (see Appendix C) reveals broadly the same patterns as in Heylen and Van de Kerckhove (2009). In the short run, the strongest output effect still follows from a capital tax cut and the subsequent capital inflow. In addition, an 11.6%-point labor tax cut on young workers raises output after one period by about 5% compared to the benchmark. However, this measure also discourages education and therefore, human capital and output fall again over longer time periods. An increase in education subsidies seems to reveal a drop in output in the short run (15 years) as a result of the instantaneous fall in employment. Nevertheless, the rise in tertiary education following this shock leads to an output level of about 12% above the benchmark after 6 periods. In the long run, output rises most following an increase in productive expenditures or labor tax cuts on older/middle aged workers. Long-run employment effects are most positive following a labor tax cut on older workers. As could be seen from table 14, this measure does not induce a cut in employment of the young as was the case in the HV-model, since this would enormously reduce experience and hence accumulation of effective human capital (as reflected in x_t and j_t). Furthermore, middle aged employment rises more than in the HV-model without learning by doing. This in turn leads to stronger positive employment effects in the long run.

Figures 8-10 reveal the transitional paths of the more realistic fiscal policy changes of tables 16 and 17. As could be already derived from the steady state growth effects in section 6.1.1, long-run output will benefit most from a productive spending increase financed by an overall benefit cut. Welfare gains are however higher for both current and future generations when this productive spending is financed by a cut in government consumption. I refer to the remark made in Heylen and Van de Kerckhove (2009, footnote 14 p. 24) that this effect arises because public consumption does not to have a direct utility effect, in contrast to Turnovsky (2000) and Dhont and Heylen (2009). Current generations benefit most from an overall benefit cut used to finance labor tax cuts on older workers. Therefore, as Heylen and Van de Kerckhove (2009) note, this reform is more likely to be adopted than benefit cuts to finance productive spending, although the output and welfare effects of the latter are larger in the long run. A shift from direct to indirect taxation only seems to work (for output, employment and welfare) if the labor tax cut focuses on older workers only.

Focusing on education subsidies, all policies concerning an increase in these subsidies have similar output effects: a slight drop in the short run (following lower effective human capital as n_1 drops) but significant increases in the long run (following higher human capital growth because of a higher tertiary education rate). Employment knows the smallest drop when these subsidies are financed by benefit cuts, as the latter reduces relative returns to leisure compared to work and education. Yet, both output and welfare benefit most in the long run when subsidies are financed by a labor tax increase on young workers.

In sum, the simulation exercises in the LBD-model provide four interesting conclusions and implications for policy design. First, the importance of productive spending on tertiary education institutions, infrastructure and R&D is supported (see also Heylen and Vandekerckhove, 2009; Dhont and Heylen, 2009). Second, the simulations also confirm the positive effects on growth and employment of cutting labor taxes on older workers, although the size of these effects differ from the HV-model (smaller effect on growth, larger effect on employment, see Heylen and Vandekerckhove, 2009). Third, the model stresses the effectiveness of education subsidies for growth and welfare (see also Trostel, 1996). Finally, it turns out that the most effective way to finance measures as labor tax cuts or increases in productive spending would be to cut benefits to the structurally non-employed. In contrast to many European countries, which have high non-employment benefits, the US has less room for such benefit cuts and could instead focus on increasing consumption taxes.

Figure 8 Output level evolution after permanent policy shocks in period 1 in the LBD-model (index, benchmark=0)



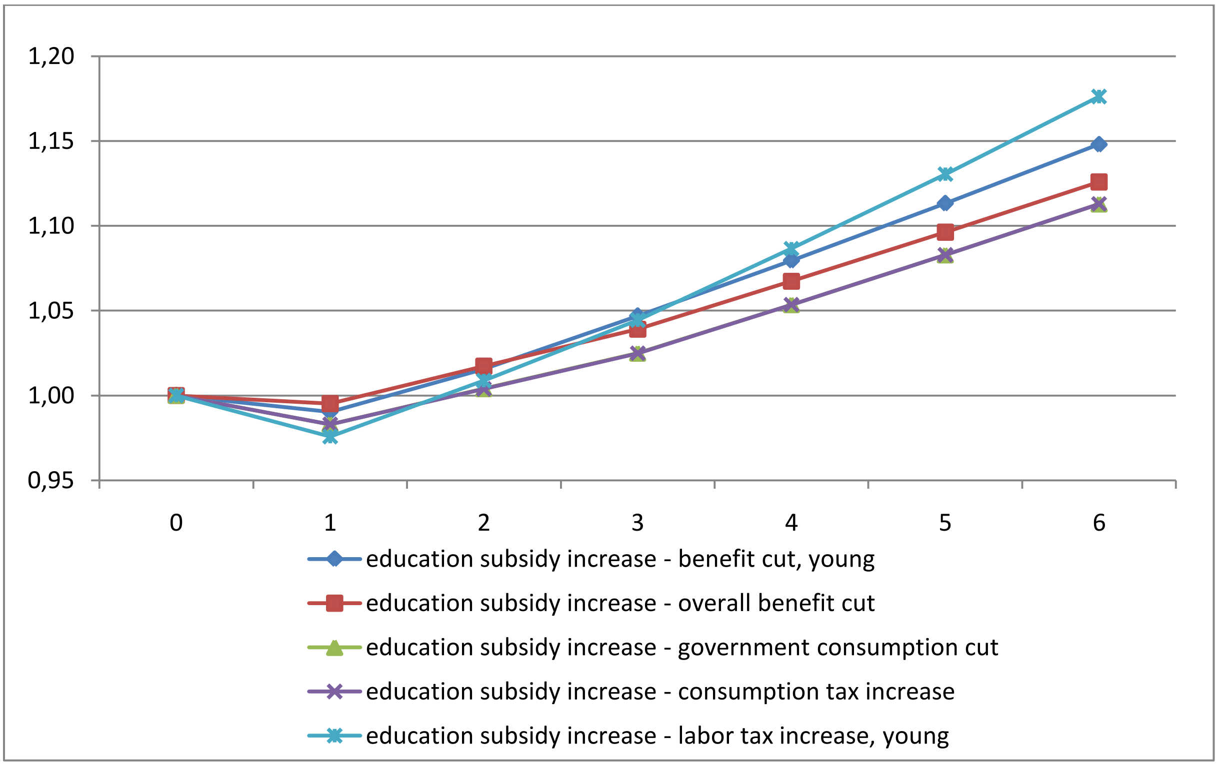
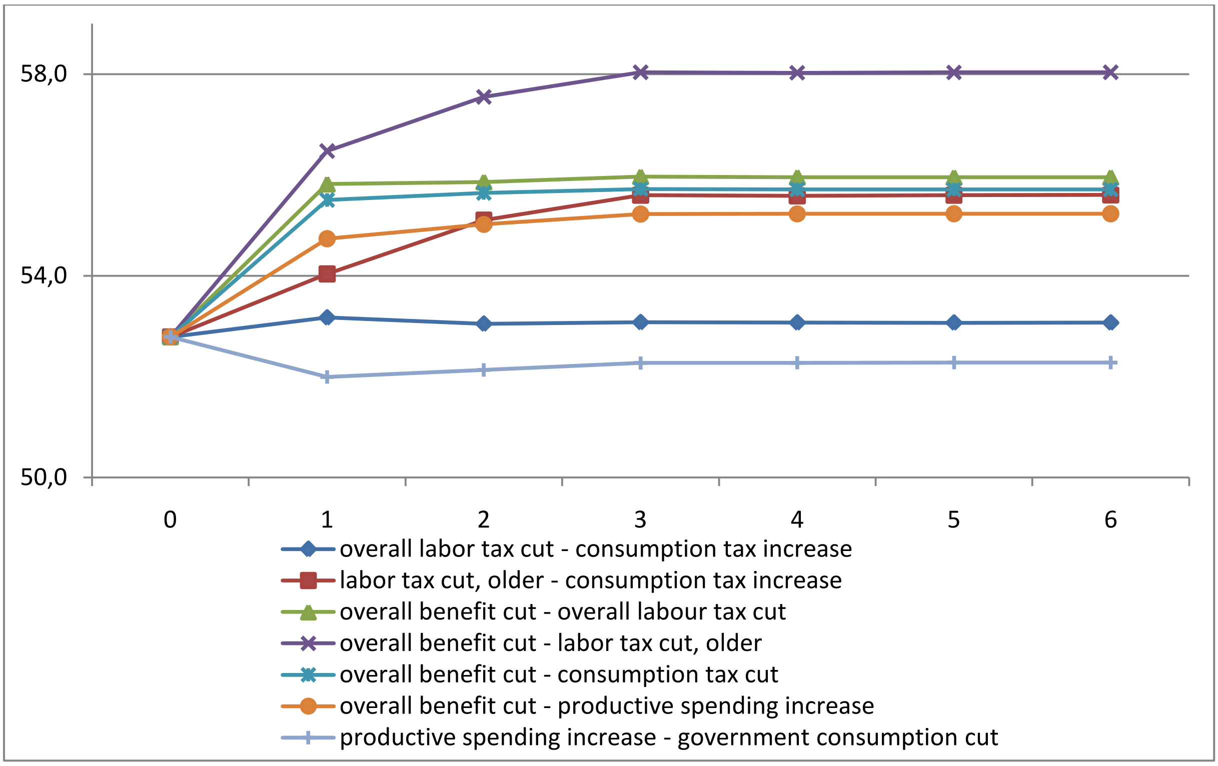


Figure 9 Aggregate employment rate (in hours) after permanent policy shocks in period 1 in the LBD-model (benchmark in period 0 is the initial steady state)



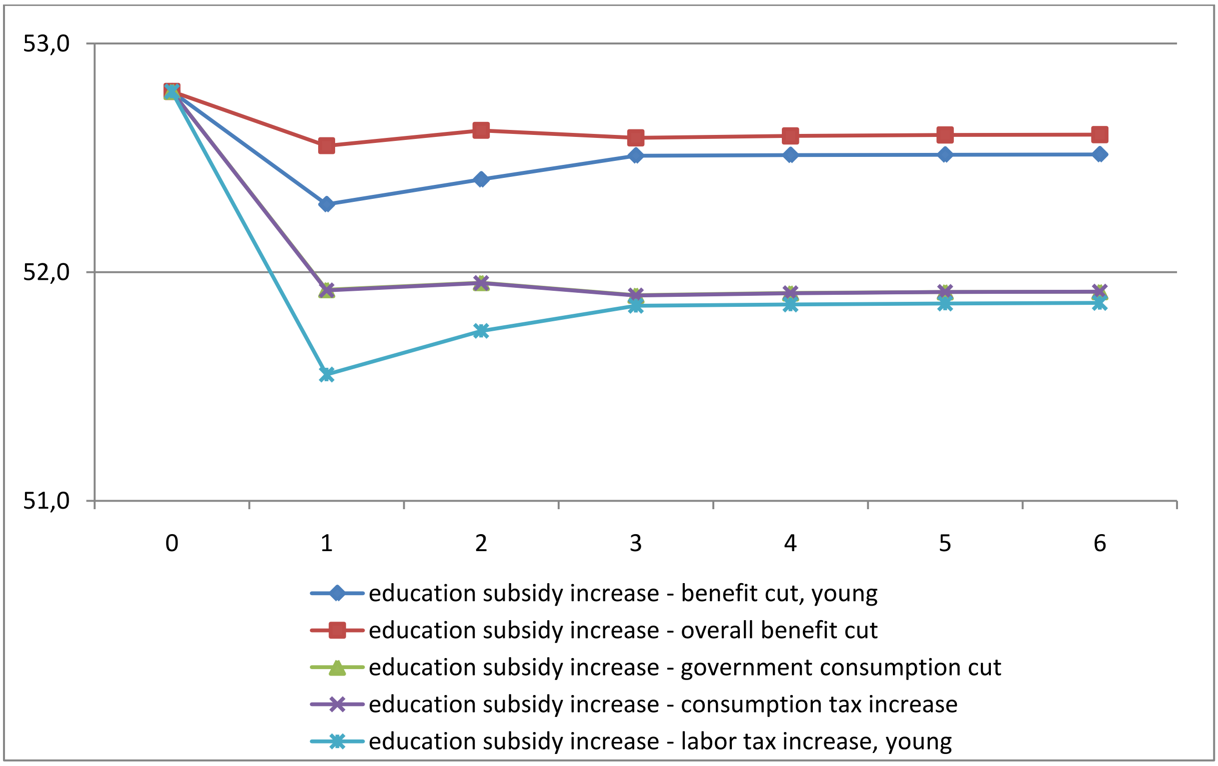
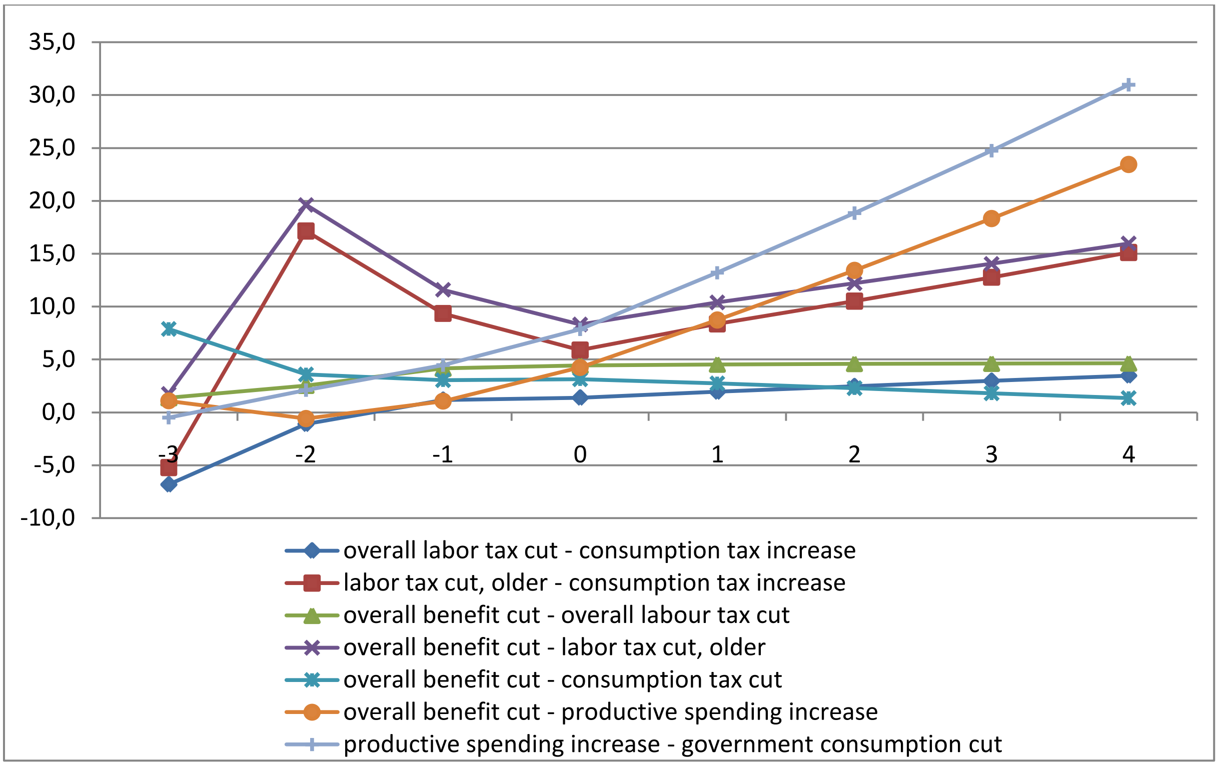
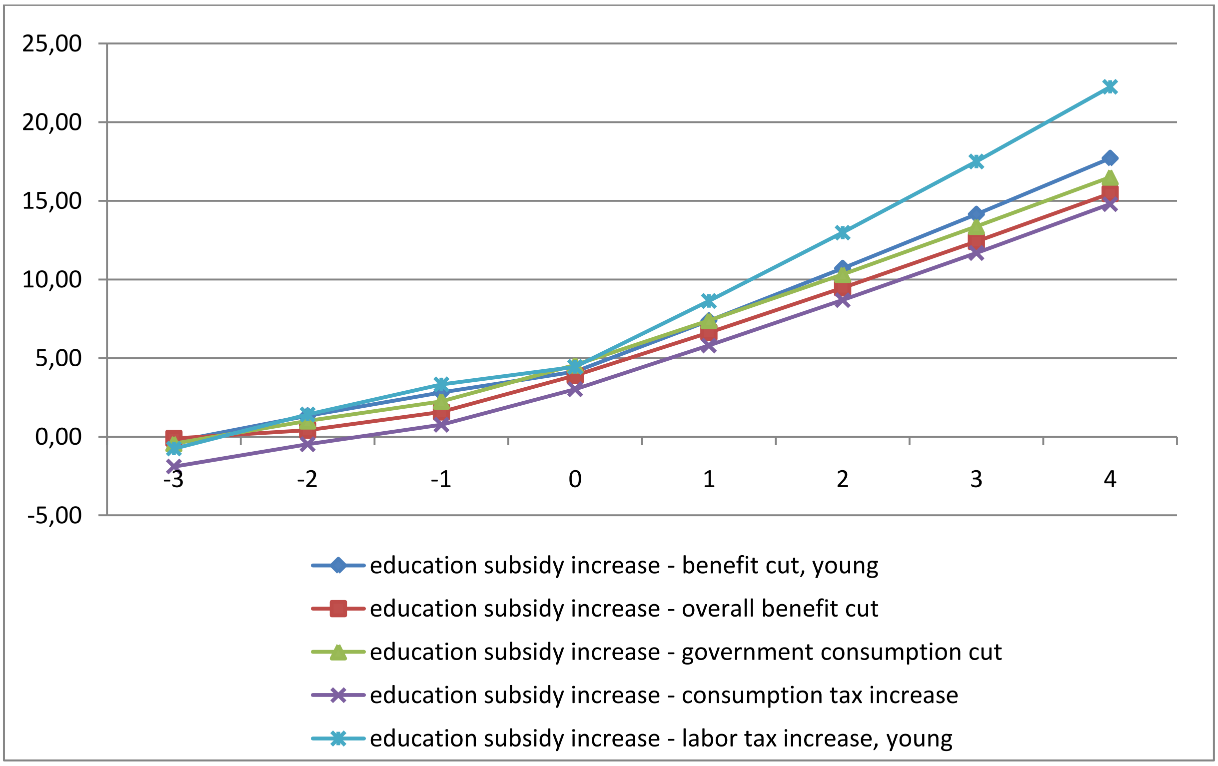


Figure 10 Welfare effects for current and future generations after fiscal policy changes in the LBD-model





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

6.2 THE PENSION MODEL

6.2.1 Steady state effects

The pension model developed in section 4 allows to evaluate the impact of simple pension system reforms. The most natural policy measure, as often modeled in the literature, is to lower the net pension benefit replacement rate b_4, or the (complete) transition to a fully funded system, in which b_4=0 (Hviding and Mérette, 1998; Shimasawa, 2004). In addition, governments could propose to give more weight to earned wages when older in the calculation of pensions. This could stimulate older workers to work longer and discourage them to chose early retirement. Ignoring political difficulties, it could even be possible to link pension benefits exclusively to earned income and amount of time worked when old. In the pension model, this policy measure can be implemented by altering the weights a, b and c. Table 18 shows the results of the two previous reforms. Note that the model predicts a government expenditure on net pension benefits of 3.98% of GDP in the benchmark.

Table 18 Effects of pension reform – compensated by changes in lump sum transfers (Z)

Initial values:	**Policy 1**	**Policy 2**	**Policy 3**	**Policy 4**	**Policy 5**	**Policy 6**	**Policy 7**
a=1/3	a=1/4	a=0	/	/	/	a=1/4	a=0
b=1/3	b=1/4	b=0	/	/	/	b=1/4	b=0
c=1/3	c=1/2	c=1	/	/	/	c=1/2	c=1
b_4=0.71	/	/	b_4=0.60	b_4=0.40	b_4=0	b_4=0.50	b_4=0.50
Effect (a):							
Δn_1	-1.34	-5.68	-0.06	-0.16	-0.40	-1.07	-4.12
Δn_2	-0.87	-3.53	-0.44	-1.24	-2.97	-1.51	-3.52
Δn_3	3.53	11.60	-1.12	-3.25	-8.31	0.66	7.46
Δe	0.71	3.16	-0.18	-0.49	-1.10	0.15	1.79
Δn (a, b)	0.26	0.18	-0.51	-1.47	-3.67	-0.73	-0.50
$\frac{\Delta N}{N}$ (c)	0.49	0.35	-0.97	-2.78	-6.95	-1.37	-0.95
Δannual growth rate (a)	0.043	0.181	-0.011	-0.031	-0.070	0.009	0.105
Δpension benefit expenditure(a)	-0.08	0.25	-0.63	-1.74	-3.98	-1.27	-1.17
ΔZ ex post(d)	0.26	-0.04	0.34	0.90	1.78	0.87	0.95

Notes: (a) difference in percentage points between new steady state and benchmark, except ΔN/N.
(b) change in (weighted) aggregate employment rate in hours.
(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.

Policies 1 and 2 alter the calculation of the pension benefits, such that more weight is given to the net income of workers when they are old. The higher (lower) marginal utility gain of 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 larger importance of effective human capital when old in the pension calculation. The extra schooling contributes to steady state growth. Effects on lump sum transfers or government pension expenditures are less clear and depend on the exact calculation of the pension benefits (magnitude of the weights). For instance, policy 2 implies an increase in total pension expenditures by 0.25%-points whereas the budget balance only deteriorates by 0.04%-points. In return, this simple reform succeeds in both increasing the aggregate employment and per capita growth rate by 0.18%-points.

Policies 3-5 gradually reduce the pension replacement rate from the initial 0.71 to 0.6, 0.4 and finally 0 (transition to a fully funded system). As expected, this considerably lowers government spending on pensions and releases funds for lump sum transfers ($\Delta Z>0$). For instance, a cut in the replacement rate from 0.71 to 0.40 reduces government spending on pension benefits by 1.74%-points[13]. However, lower pension benefits reduce the expected return to working, leading to sharp drops in employment of all age groups. In addition, the higher lump sum transfers compensate the negative income effect resulting from the fall in benefits, encouraging workers to take even more leisure[14]. The tertiary education rate drops for the same reason. Both mechanisms explain why aggregate growth does not rise. Considerable government savings are achieved by lower pension expenditures but this should not be the main focus. As mentioned in the introduction, social security reform must focus on increasing job opportunities for older workers and stimulating per capita growth. Furthermore, lowering the pension benefits is probably not the way to achieve the two main social objectives of a pension system: poverty reduction among elders and income insurance during retirement (Dekkers et al., 2010).

Although it would not be preferable, the previous results reveal that if the government wants to save on pension expenditures, it may decide to modestly lower the replacement rate. This measure might be supplemented by a pension calculation more focused on work time when old. Policy 6 and 7 analyze this combination. For instance, policy 7 combines a replacement rate of 0.50 (21%-points lower than in the benchmark case) with a calculation of pension

[13] This figure only holds under the assumption of a constant population. A more correct assessment of the effects of pension reforms on government savings should also introduce the predicted demographic evolution.

[14] More leisure raises government spending on non-employment benefits. This explains why overall budget savings (= the increase in lump sum transfers) are smaller than the drop in pension expenditures.

benefits only determined by after-tax income in the third active period. On the one hand, the higher weight on earned labor income when old makes sure older workers stay active longer so that the aggregate employment rate drops to a lesser extent (-0.50%-points). On the other hand, the lower pension replacement rate reduces government expenditures on pensions by 1.17%-points which allows total lump sum transfers to rise by 0.95%-points. Nevertheless, aggregate employment still drops and the growth bonus is smaller compared to policy 2.

Table 19 investigates some compensated policy changes. The first two reforms depart from policy 7 but use the savings from the lower pension replacement rate (instead of for lump sum transfers) to lower income taxes on middle aged workers (policy 8) or to raise productive government expenditures (policy 9)[15]. When taxes on middle aged workers are cut as a counteracting mechanism, annual growth rises by 0.173%-points whereas financing productive government expenditures leads to an increase in the growth rate by 0.229%-points. In spite of the substantial rise in employment of older workers and the annual growth rate, neither of the two reforms succeeds in raising aggregate employment.

There are other possibilities for pension reform. One idea consists of dividing the pension in two parts: a 'fixed' part equal for each individual and a part that varies with earned income and amount of time worked during the active period. The former is modeled here as a fixed percentage of per capita GDP. It could be a *basic pension* used to counter old age poverty. As a central issue in pension reforms is keeping older employees at work, the variable part of the pension could be dependent on the earned income during the last period of the career (i.e. c=1 as is also implemented above). As shown above, this encourages households to work more when old. In order to finance the fixed basic pension, the pension replacement rate (b_4) is cut from the benchmark 0.71 to 0.50. The effects of this reform are also reported in table 19, policy 10. This policy assumes the savings from the lower replacement rate are used to finance the basic pension while keeping lump sum transfers equal to the initial steady state. The basic pension represents 0.96% of per capita GDP. First, it is possible to compare the results of policy 10 to those of policy 7, which only combines a drop in b_4 with the new calculation of the pension benefits. Starting from policy 7, the fall in lump sum transfers implied by policy 10 adds an negative income effect which encourages active households to work more (as leisure is a normal good). Hence, the basic pension leads to a smaller drop in employment of the young and the middle aged whereas employment of older workers increases slightly more. Together, these results explain the smaller fall in aggregate employment compared to policy 7. The growth effect is identical. Second, it is possible to

[15] Another possibility is to use the savings to cut labor taxes on older workers or on both middle aged and older workers. These results are not presented in the text but are almost identical to policy 8.

compare policies 9 and 10. Both policies have the same basic set-up as policy 7 but use the savings from the lower pension replacement rate in a different way: policy 9 finances productive government spending, whereas policy 10 provides a basic pension. When growth is the main purpose, policy 9 is more effective since the rise in tertiary education is larger. By contrast, policy 10 has slightly better employment effects, although they remain negative[16].

Table 19 Effects of pension reform - compensated by a change in another fiscal policy variable

Initial values:	**Policy 8**	**Policy 9**	**Policy 10**	**Policy 11**	**Policy 12**	**Policy 13**
a=1/3	a=0	a=0	a=0	a=0	/	/
b=1/3	b=0	b=0	b=0	b=0	/	/
c=1/3	c=1	c=1	c=1	c=1	/	/
b_4=0.71	b_4=0.50	b_4=0.50	b_4=0.50	/	b_4=0	b_4=0
Compensating change (a)	$\Delta\tau_2$= -2.86	Δg_y= 0.96	Δbp= 0.96	Δb_3 = -0.4	$\Delta\tau_2$=$\Delta\tau_3$ = -3.25	$\Delta\tau_1$=$\Delta\tau_2$ =$\Delta\tau_3$=-2.14
Effect (b):						
Δn_1	-5.47	-5.24	-4.01	-5.67	-2.89	-0.10
Δn_2	-2.18	-3.00	-3.32	-3.54	-1.46	-2.30
Δn_3	7.51	8.10	7.71	11.70	-5.88	-7.23
Δe	3.01	3.03	1.83	3.15	1.12	-0.94
Δn (b, c)	-0.45	-0.50	-0.32	0.21	-3.24	-3.00
$\frac{\Delta N}{N}$ (d)	-0.85	-0.95	-0.60	0.40	-6.14	-5.69
Δannual growth rate(b)	0.173	0.229	0.108	0.181	0.067	-0.059
Δpension benefit expenditure(b, e)	-1.21	-1.21	0.20	0.26	-3.98	-3.98

Notes: (a) compensating change, in percentage points.
(b) difference in percentage points between new steady state and benchmark, except ΔN/N.
(c) change in (weighted) aggregate employment rate in hours.
(d) change in volume of employment in hours, in %.
(e) Basic pensions are included in the pension benefit expenditure.

Notwithstanding the positive growth effect and savings on (variable) pension expenditures, policies 8-10 do not succeed in stimulating aggregate employment. Policy 2 did. Remember that policy 2 (table 18) only altered the pension calculation. The only drawback was the minor fall in lump sum transfers induced by the higher pension expenditures. In order to restore budget balance (such that ex post ΔZ=0), policy 11 cuts the replacement rate on older

[16] When the basic pension is modeled, not a % of per capita GDP but depending on the amount of time worked during the active period (not on earned income), the employment rate rises slightly (+0.09%-points). Conversely, the growth rate increases slightly less than after policy 10 (+0.098%-points). Such a pension is already present in certain OECD countries such as Ireland, the Netherlands… (Whiteford and Whitehouse, 2006).

workers by 0.4%-points, which can be seen as a (very) slight reduction in early retirement benefits. The results remain remarkably good for both growth and employment.

As shown in policy 5 (table 18), the transition to a fully funded pension scheme is neither beneficial for growth nor employment. Policy 5 uses the money saved from the lower pension expenditures to finance lump sum transfers. The savings can also be used for other purposes (more government consumption, productive spending…). It would be more realistic if the government decides to lower labor taxes (e.g. on middle aged and older workers) to compensate for these lower pension benefits. Policy 12 analyzes this option. Next to the mechanisms of policy 5, the lower labor taxes on middle aged and older workers provoke extra employment, although the overall effect is still negative. Furthermore, discounted marginal utility of tertiary education rises and so does annual per capita growth. If labor taxes on *all* workers are cut, as in policy 13, annual growth still drops since tertiary education is discouraged by the fall in τ_1.

Before taking general conclusions, we should have a closer look at the transitional dynamics and welfare implications of these pension reforms. They will be presented in the following section. However, two important findings are already clear. First, a simple reform as policy 11 succeeds in reducing pressure on the pension system via higher growth and employment. Second, a cut in the pension replacement rate may generate substantial budget savings, but at the cost of lower employment (and growth, depending on how these savings are spent).

6.2.2 Dynamic effects

As for the fiscal policy shocks in the LBD-model, I now describe the transitory adjustment paths of output, employment and welfare after the proposed pension reforms. These are shown in figures 11-13. Details per age group are presented in Appendix E.

First, reforms that put more weight on earned after-tax wages when older in the calculation of the pension benefits (policy 1 and 2) turn out to stimulate output after two periods. In addition, these measures increase welfare for future generations. Only the current retired are worse-off as previous working-behavior is no longer optimal given the new pension calculation. It takes time for aggregate employment to show a significant increase as a result of the higher employment rate of older workers. In the short run however, the effect is smaller as both young and middle aged workers see a sharp drop in the future returns of their labor decision. Putting all weight on the third period ($c = 1$, policy 2) even implies short-run employment losses. Policy 11, which adds to policy 2 a cut in the benefit replacement rate b_3 in order to neutralize the effect on the budget balance, has approximately the same effects.

A second set of policy changes imposes a cut in the pension benefit replacement rate (policies 3-5 and 12-13). Before looking at the dynamic effects of these reforms, it is interesting to mention the ideas of Kemnitz and Wigger (2000) on the transition from a PAYG to a fully funded pension system. They claim that this transition is not necessarily welfare-improving in an endogenous growth model driven by human capital accumulation. According to the authors, a properly designed unfunded social security system can be efficient and can generate a higher economic growth rate than its funded counterpart. The explanation is linked to the *intergenerational human capital externality* mentioned in section 3.1. Efficiency will only be reached when current generations take this externality into consideration i.e. each generation has to be rewarded for the positive effect of their studying time on the human capital of the following generation. Therefore, the authors state that “any optimal scheme requires some positive reward of studying time as such. Otherwise, if this reward worked solely indirectly through the dependence of benefits on former working income, individuals would continue to maximize current labor income by choosing [studying time] as they do in the laissez-faire equilibrium.” (Kemnitz and Wigger, 2000, p. 681). In the pension model developed here, pension benefits are not directly linked to education time as such. Tertiary education only influences pension benefits indirectly through the average earned wages. The conclusions here will only be partly in line with theirs.

Policies 3-5 reveal both negative output and aggregate employment effects, both in the short and the long run. Moreover, both current and future generations feel substantial welfare losses. This effect is most distinct when the benchmark PAYG system transforms into a fully funded pension system (policy 5: $b_4 = 0$, savings used for lump sum transfers). For example, the loss for the current retired then equals 32.49% of benchmark consumption. Remember from table 18 that tertiary education and growth were also higher in the unfunded pension system than in the fully funded system of policy 5. At first sight, these findings seem to be completely in line with those of Kemnitz and Wigger (2000). However, there are more realistic transitions to a fully funded system, which keep the lump sum transfers equal: policies 12 and 13. Together with what we know from section 6.2.1, some interesting conclusion can be drawn. First, in these 2 realistic cases, aggregate employment is still lower under the fully funded scheme. Second, although the output level remains below the benchmark (due to a fall in effective human capital), the output evolution depends on the compensating change. When labor taxes on middle aged and older workers are cut (policy 12), output rises over time as growth is positively affected. When these tax cuts are aimed at all workers (policy 13), the opposite happens. Finally, welfare for current generations in these fully funded systems is in this model always lower than under the PAYG system. For future generations, the effect again depends on the compensating change. It is clear that, for the more realistic transitions to a fully funded pension system, the conclusions of Kemnitz and Wigger (2000) do not hold completely.

Policies 6 and 7 impose a combination of the two previous measures (a modified pension calculation and lower pension benefits). This reduces welfare losses for current generations whereas future generations can even realize limited welfare gains. Nevertheless, aggregate employment is lower than in the initial steady state. The final policies (8, 9 and 10) use the budget savings from policy 7 respectively to lower labor taxes on the middle aged, to increase productive government expenditures or to distribute a basic pension. The output level rises in all three cases but most when productive expenditures are used as a compensating change. Remember that the long-run growth increase from policy 9 was twice as high as that from policy 10. By contrast, aggregate employment benefits most from the basic pension (reform 10) although it is still lower than the initial steady state[17]. The measures including basic pensions also imply lower welfare losses for current retired as this generation immediately receives the additional (fixed) pension. Nevertheless, in the long run willingness to pay is significantly higher for reforms 8 and 9.

The previous simulations suggest that cuts in the pension benefits are bad for growth, employment and welfare and that a combination with a modified pension calculation is still negative for aggregate employment and welfare of current generations. Therefore, it is interesting to mention the results of one last simulation that is not presented in the tables/figures. I simulated a combination of a changed pension calculation ($c = 1$) with moderate increases in the pension benefit replacement rate (e.g. from 0.71 to 0.80). The findings are interesting. First, the effects on growth, aggregate employment and welfare for all generations are positive and substantial. Second, as can be expected, public pension expenditures rise and there is a negative though limited effect on the budget balance. Third, when this measure is financed by lower non-employment benefits on older workers to maintain budget balance, growth, aggregate employment and welfare are still much higher than in the benchmark. Although public pension expenditures rise considerably, the very strong and positive effect on employment (of older workers) and the higher growth rate help to relieve pressure on the pension system.

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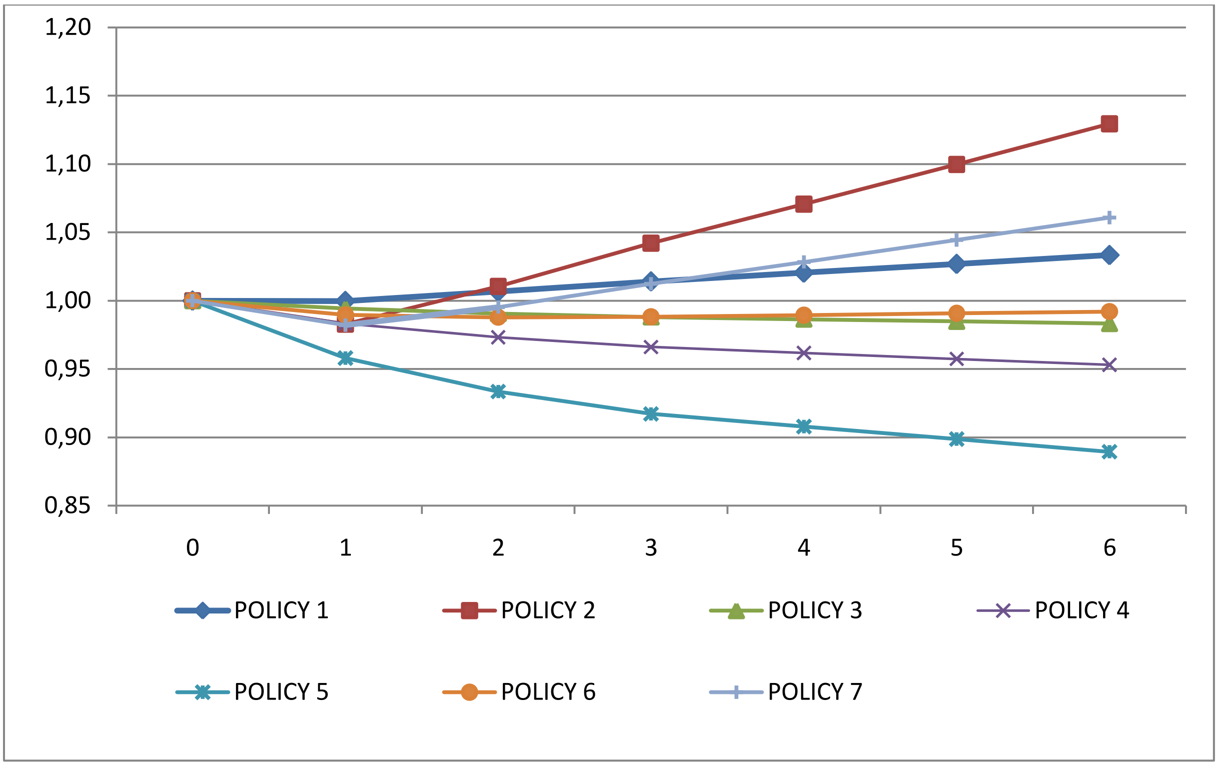
[17] Note that a basic pension dependent on the amount of time worked does slightly increase employment (see footnote 16 p. 50). The output level evolution and welfare implications are quasi identical to those of policy 10.

The dynamics presented in this section add to a better understanding of the effects of different pension reforms. Note that almost all the proposed reforms imply welfare losses for the current retired. Future generations are better off than current generations. If the government aims at reducing pressure on the social security system while stimulating growth and maintaining aggregate employment, policy 2 is a good start. This reform consists of a changed calculation of the pensions and has a negligible effect on the budget balance. What’s more, welfare for current retired falls only modestly. Willingness to pay for most other reforms is much lower. Therefore, this measure is more likely to receive support from current generations than other reforms (for instance those that imply a cut in the pension benefits). Another option would be to add a slight increase in the pension replacement rate to the previous policy. Although the budget balance further deteriorates, this measure does combine even higher employment and growth with, for all generations, higher welfare. The budget effect can be neutralized by lower non-employment benefits for older workers. As a last remark, it seems that the effects of a transition to a fully funded pension scheme depend on the compensating change, with a change in lump sum transfers being remarkably bad for employment, growth and welfare. Simply reducing the pension benefits is certainly not a panacea.

Figure 11 Output level evolution after permanent policy shocks in period 1 in the pension model (index, benchmark=0)



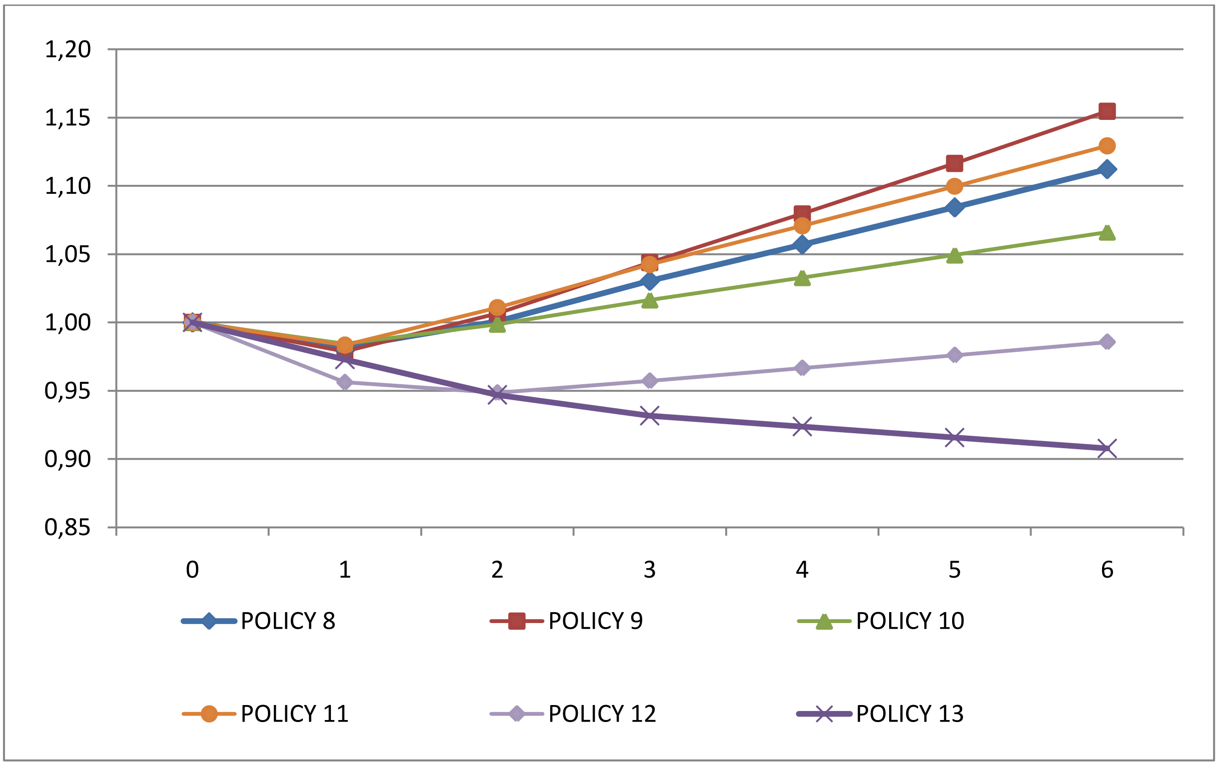
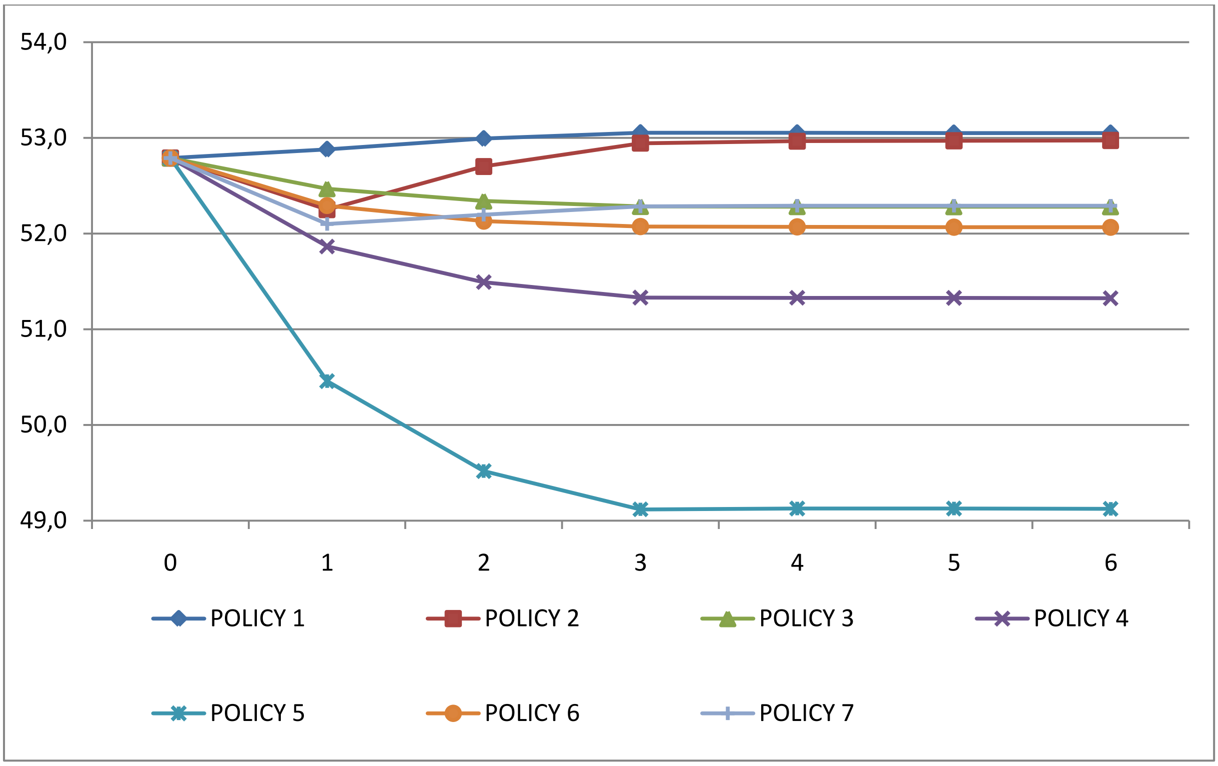


Figure 12 Aggregate employment rate (in hours) after permanent policy shocks in period 1 in the pension model (benchmark in period 0 is the initial steady state)



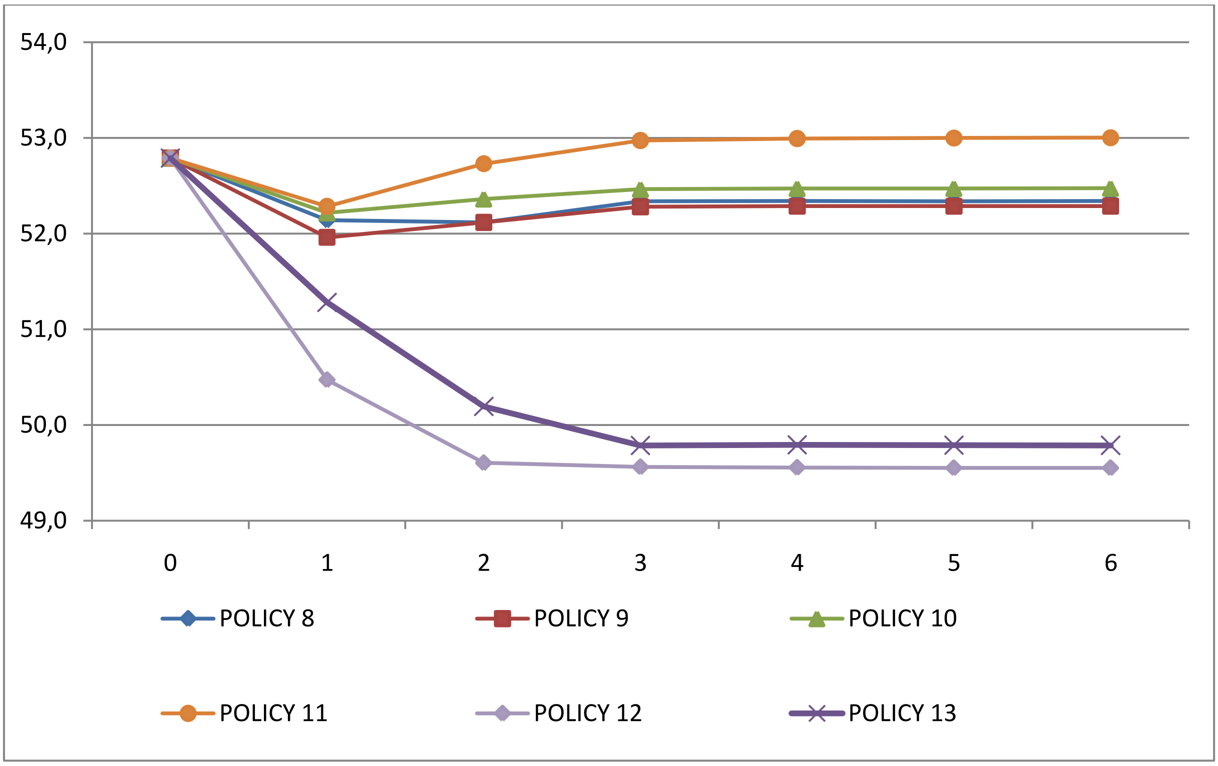
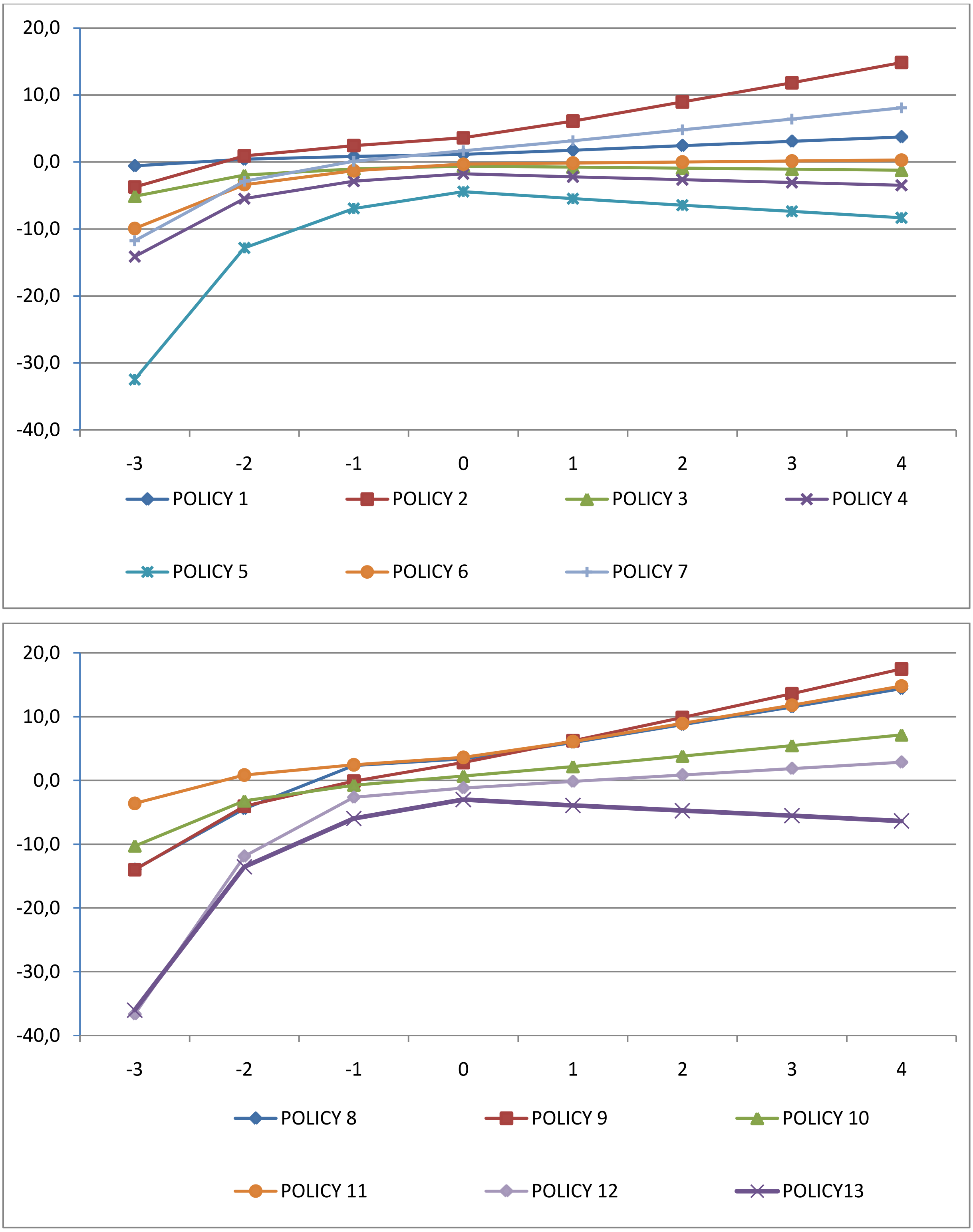


Figure 13 Welfare effects for current and future generations after fiscal policy changes in the pension model



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

7 CONCLUSIONS AND POLICY IMPLICATIONS

Annual per capita growth, tertiary education and employment per age group differ among countries. Americans work more than Europeans and some Europeans work more than others. In all countries, the middle aged work more than older or younger workers. Furthermore, annual per capita growth and tertiary education are, on average, higher in the Nordic countries than in the US or the core euro area. Many authors have tried to find an explanation for these differences. In this dissertation, I did not have the intention to give an overview of the literature. Instead, I follow the fiscal policy tradition and focus on cross-country differences in fiscal policy (i.e. taxes and government expenditures).

Heylen and Vandekerckhove (2009) developed a general equilibrium OLG model to explain (i) hours of work in three age groups, (ii) education of the young and (iii) per capita growth in a range of 17 OECD countries. Their model has a high explanatory power, although it has some drawbacks. Most importantly, the model predicts an almost perfect correlation between growth and education. I extend the model in two ways. In the learning by doing model, I introduce work experience as a means of skills-accumulation in the hope that this tackles the shortcomings of the HV-model. Work time acts as a proxy for this learning by doing effect. Furthermore, private expenditures on tertiary education are added. Using data on tuition fees and living costs, I compute an indicator of the full-time education cost. A part of the private education cost is subsidized by the government. In the pension model, I again start from the basic HV-model but now add a simple pension scheme based on the Belgian system. As almost all OECD-countries are/will be confronted with an ageing population, pension reforms are at the center of current policy debates. Despite the simple set-up, the pension model gives a first indication of which policy measures could be taken to tackle this problem.

I then calibrate both models on a benchmark of nine countries. All the technology and preference parameters are identical for all countries. Only for Italy and Spain is the preference for leisure allowed to differ. As the pension model only slightly changes the HV-model, overall performance is almost identical. With respect to the learning by doing model, more is to be said. On the one hand, the too high correlation between education and growth that was characteristic for the HV-model is significantly reduced and a positive link between growth and employment of the young is established. On the other hand, the correlation between growth and aggregate employment is now overestimated. Overall, explanatory power is high. Compared to the HV-model, predictions for employment of the young and tertiary education are better while those for growth are slightly worse. Knowing that the models are able to explain the facts, they can be used to evaluate the impact of various (fiscal) policy shocks. The results can be valuable for OECD countries that seek to develop effective long-run employment and growth policies in the aftermath of the financial crisis.

In the learning by doing model, I investigate the effects of changes in taxes, benefits, education subsidies and other government spending. It is important to note that despite the presence of learning by doing, the main way to support annual per capita growth is still to encourage tertiary education. Increases in education subsidies and productive government expenditures have the strongest effects on growth, followed by labor tax cuts on middle aged workers. The growth effect of a tax cut on older workers is also positive, although the impact is larger in the HV-model. By contrast, tax cuts on young workers discourage education and hamper growth. Regarding employment, non-employment benefit cuts are very effective while labor tax cuts only work when aimed at young or older workers. Governments that want to support both employment and growth can cut benefits to the structurally non-employed and use the savings to finance productive government spending or a labor tax cut on older workers. Shifts from labor to consumption taxes are also effective, but most when labor taxes are only cut for older workers. Finally, welfare changes differ for current and future generations. With respect to current generations, benefit cuts to finance labor tax cuts on older workers stand out. From the perspective of future generations, the welfare impact is most positive following overall benefit cuts to finance productive spending or higher labor taxes on young workers to finance education subsidies.

In the pension model, I investigate the effects of simple pension reforms. A first set of measures consists of changing the way pension benefits are computed. Policies that put more weight on the net income when older, succeed in stimulating both growth and employment without significantly affecting the budget balance. A second set of reforms imposes a cut in the pension benefit replacement rate to save on pension expenditures. Aggregate employment, growth and welfare always fall following these measures. The effects of a complete transition from the benchmark PAYG to a fully funded system depend on how the savings from the lower pension benefits are used. Financing lump sum transfers is pernicious for per capita growth, employment and welfare for all generations. When tax cuts are implemented, which is more realistic, the effects are less negative and depend on which labor taxes are cut. Although in some cases future generations may benefit from the transition to a fully funded system, current generations always pay. Several other simulations are performed, including a combination of the previous measures (changed pension calculation and lower pension benefits). The savings generated by these policies could then be used to finance labor tax cuts, productive government expenditures or even a basic pension.

Overall, one reforms stands out: a simple modification of the pension calculation (based only on earned income when old). Although almost all measures imply welfare losses for the current retired, this reform is more likely to receive support from current generations as the losses are minimal. Interestingly, another option would be to add a slightly higher pension replacement rate financed by lower non-employment benefits on older workers to the previous policy. In addition to the positive welfare effect, the further increase in growth and aggregate employment that results from this reform could further ease pressure on the pension system.

This dissertation has possibilities for extensions and further investigation. First, a limitation of the current models is the assumption that all generations are of equal size and the fact that predicted demographic changes are neglected. Future research could focus on this aspect to get a better view on the long-run economic and budgetary effects of pension reforms. A second extension would be to allow for heterogeneity within generations. As mentioned in section 3, the current models assume all agents in every generation are homogenous. This is not realistic. For instance, it is clear that not all individuals have the same talent or motivation to study or work the same hours. Third, it would be interesting to relax the simplifying assumption that all countries have an identical PAYG pension system. For example, more attention could be given to cross-country differences in public pension calculation. Finally, it would be challenging to develop one single model that combines both the pension system of the pension model and the cross-country differences in school systems of the LBD-model.

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APPENDIX A: Construction of the indicators for full-time education costs and subsidies

Table 20 Public expenditures on tertiary education (1999)

Country	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Austria	1.652	1.436	0.216	0.216	0.216	0.000	NA	0.000
Belgium	1.501	1.262	0.239	0.239	0.239	0.000	NA	0.000
France	1.050	0.992	0.058	0.084	0.084	0.025	0.025	0.000
Germany	1.095	0.970	0.124	0.134	0.114	0.010	0.000	0.010
Italy	0.800	0.718	0.082	0.137	0.137	0.054	0.050	0.004
Netherlands	1.314	1.018	0.296	0.323	0.242	0.027	0.027	0.000
Denmark	2.352	1.524	0.828	0.828	0.714	0.000	NA	0.000
Finland	2.094	1.752	0.343	0.358	0.358	0.015	0.000	0.015
Norway	1.996	1.426	0.570	0.570	0.225	0.000	0.000	0.000
Sweden	2.087	1.496	0.591	0.635	0.211	0.044	NA	0.044
United Kingdom	1.062	0.789	0.273	0.390	0.247	0.117	0.114	0.003
United States	1.352	1.093	0.259	0.259	0.149	0.000	NA	0.000
Canada	1.900	1.552	0.348	0.415	0.293	0.066	NA	0.066
Portugal	1.041	0.979	0.063	0.063	0.063	0.000	NA	0.000
Spain	0.903	0.853	0.049	0.084	0.084	0.035	0.035	0.000
Switzerland	1.223	1.213	0.010	0.050	0.050	0.040	0.000	0.040
Ireland	1.169	1.095	0.074	0.173	0.173	0.099	0.055	0.044

(1) Total public expenditure on tertiary education (% of GDP). Source: Education at a Glance (OECD, 2002), Table B3.1
(2) Total public expenditure on institutions (including subsidies to households attributable to institutions, % of GDP). Source: Education at a Glance (OECD, 2002), Table B2.1b
(3) Public expenditure outside institutions (scholarships, subsidies on living costs, books, student loans, % of GDP) = (2)-(1). Source: own calculations.
(4) Total subsidies for education to private entities (scholarships, other grants, student loans, transfers to other private entities…, % of GDP). Source: education at a Glance (OECD, 2002), Table B5.2
(5) Total subsidies for education to private entities excluding student loans (% of GDP) = (4) – student loans. Student loans are calculated as a % of (4) using Education at a Glance (OECD, 2002), Table B5.2
(6) Subsidies in favor of private entities paid to institutions (% of GDP) = (4)-(3). Source: own calculations.
(7) Subsidies to households attributable to institutions (% of GDP) Source: Education at a Glance (OECD, 2002), Table B5.2 Column F *(1).
(8) Subsidies to other private entities (% of GDP) = (6)-(7). Source: own calculations.

NA: not available.

Table 21 Public expenditures on tertiary education (2003)

Country	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Austria	1.288	1.057	0.232	0.232	0.232	0.000	NA	0.000
Belgium	1.314	1.193	0.121	0.208	0.208	0.087	0.060	0.027
France	1.198	1.146	0.052	0.098	0.098	0.047	0.031	0.016
Germany	1.191	0.995	0.196	0.205	0.161	0.009	0.000	0.009
Italy	0.799	0.711	0.088	0.136	0.136	0.047	0.041	0.006
Netherlands	1.330	1.054	0.276	0.344	0.161	0.068	0.019	0.049
Denmark	2.497	1.692	0.805	0.805	0.668	0.000	NA	0.000
Finland	2.085	1.722	0.363	0.374	0.374	0.011	0.000	0.011
Norway	2.316	1.467	0.849	0.849	0.344	0.000	NA	0.000
Sweden	2.155	1.597	0.559	0.613	0.224	0.054	NA	0.000
United Kingdom	1.064	0.807	0.256	0.263	0.017	0.007	0.007	0.000
United States	1.486	1.221	0.265	0.265	0.206	0.000	NA	0.000
Canada	1.709	1.342	0.367	0.375	0.309	0.008	NA	0.000
Portugal	1.066	1.038	0.028	0.028	0.028	0.000	NA	0.000
Spain	0.996	0.941	0.055	0.079	0.079	0.024	0.024	0.000
Switzerland	1.636	1.615	0.021	0.032	0.030	0.011	NA	0.000
Ireland	1.094	1.016	0.078	0.151	0.151	0.072	0.047	0.025

(1) Total public expenditure on tertiary education (% of GDP). Source: Education at a Glance (OECD, 2006), Table B4.1
(2) Total public expenditure on institutions (including subsidies to households attributable to institutions, % of GDP). Source: Education at a Glance (OECD, 2006), Table B2.1b
(3) Public expenditure outside institutions (scholarships, subsidies on living costs, books, student loans, % of GDP) = (2)-(1). Source: own calculations
(4) Total subsidies for education to private entities (scholarships, other grants, student loans, transfers to other private entities…, % of GDP). Source: Education at a Glance (OECD, 2006), Table B5.2
(5) Total subsidies for education to private entities excluding student loans (% of GDP) = (4) – student loans. Student loans are calculated as a % of (4) using Education at a Glance (OECD, 2006), Table B5.2
(6) Subsidies in favor of private entities paid to institutions (% of GDP) = (4)-(3). Source: own calculations.
(7) Subsidies to households attributable to institutions (% of GDP) Source: Education at a Glance (OECD, 2006) Table B5.2. Column F *(1).
(8) Subsidies to other private entities (% of GDP) = (6)-(7). Source: own calculations.

NA: not available.

Table 22 Private education expenditures (1999)

Country	(1)	(2)	(3)	(4)
Austria	0.039*	NA	6.9	0.271
Belgium	0.131*	NA	7.0	0.917
France	0.136	0.083	7.7	1.042
Germany	0.086	0.131	5.2	0.448
Italy	0.112	0.402	3.8	0.421
Netherlands	0.259	0.058	3.1	0.816
Denmark	0.038*	0.828	-	0.885
Finland	0.031*	NA	-	0.696
Norway	0.084	0.000	9.2	0.768
Sweden	0.190	0.635	-	0.723
United Kingdom	0.279	0.094	4.8	1.338
United States	1.240	0.103	0.7	0.909
Canada	0.958	0.400	1.7	1.585
Portugal	0.074	0.063	2.4	0.177
Spain	0.250	NA	6,9	1,739
Switzerland	0.100**	NA	5.7	0.575
Ireland	0.307	NA	6.6	2.035

(1) Private expenditure on institutions (net of subsidy from public, % of GDP). Source: Education at a Glance (OECD, 2002), Table B2.1b.
(2) Private payments on instructional services and goods (% of GDP). Source: Education at a Glance (OECD, 2002), Table B6.1b.
(3) Ratio living costs/tuition fees. See note.
(4) Living costs (% of GDP) = (3)*(1). Own calculations, see note.

Note: The proxy for living costs is based on Oliveira Martins et al. (2007). The authors' calculations allow a comparison of tuition fees with living costs in USD (PPP) (see Oliveira Martins et al., 2007, table 3.4 p. 32). Based on these figures, I calculated the ratio living costs/tuition fees in column (3). For Germany I assume tuition fees in USD (PPP) to be equal to those of Austria. For three Nordic countries (Denmark, Finland and Sweden), tuition fee data are missing in Oliveira Martins et al. (2007). For those countries I compared the available living cost data (in USD) in each of those countries to the available living cost data (in USD) in Norway and used this ratio to approximate the living costs.

*: data for 2000 as an approximation.
**: Arbitrary number.

Table 23 Private education expenditures (2003)

Country	(1)	(2)	(3)	(4)
Austria	0.083	NA	6.9	0.571
Belgium	0.109	0.107	7.0	0.766
France	0.223	0.077	7.7	1.713
Germany	0.146	0.041	5.2	0.760
Italy	0.216	0.144	3.8	0.813
Netherlands	0.250	0.060	3.1	0.787
Denmark	0.058	0.800	-	0.535
Finland	0.052	NA	-	0.421
Norway	0.051	NA	9.2	0.464
Sweden	0.191	NA	-	0.437
United Kingdom	0.332	0.203	4.8	1.592
United States	1.629	NA	0.7	1.195
Canada	1.030	0.125	1.7	1.704
Portugal	0.096	0.028	2.4	0.230
Spain	0.250	NA	6,9	1.740
Switzerland	0.100**	NA	5.7	0.575
Ireland	0.135	NA	6.6	0.895

(1) Private expenditure on institutions (net of subsidy from public, % of GDP). Source: Education at a Glance (OECD, 2006), Table B2.1b.
(2) Private payments on instructional services and goods (% of GDP). Source: Education at a Glance (OECD, 2006), Table B6.1b.
(3) Ratio living costs/tuition fees. See note.
(4) Living costs (% of GDP) = (3)*(1). Own calculations, see note.

Note: The proxy for living costs is based on Oliveira Martins et al. (2007). The authors' calculations allow a comparison of tuition fees with living costs in USD (PPP) (see Oliveira Martins et al., 2007, table 3.4 p. 32). Based on these figures, I calculated the ratio living costs/tuition fees in column (3). For Germany I assume tuition fees in USD (PPP) to be equal to those of Austria. For three Nordic countries (Denmark, Finland and Sweden), tuition fee data are missing in Oliveira Martins et al. (2007). For those countries I compared the available living cost data (in USD) in each of those countries to the available living cost data (in USD) in Norway and used this ratio to approximate the living costs.

**: Arbitrary number.

Table 24 Education costs and subsidies (1999, 2003, % of GDP).

Country	Education Costs (1999)	Education Subsidies (1999)	Education Costs (2003)	Education Subsidies (2003)
Austria	0.310	0.216	0.654	0.232
Belgium	1.047	0.239	0.963	0.208
France	1.203	0.084	1.983	0.098
Germany	0.544	0.114	0.915	0.161
Italy	0.587	0.137	1.076	0.136
Netherlands	1.102	0.242	1.105	0.161
Denmark	0.922	0.714	0.593	0.668
Finland	0.742	0.358	0.484	0.374
Norway	0.852	0.225	0.515	0.344
Sweden	0.957	0.211	0.682	0.224
United Kingdom	1.734	0.247	1.932	0.017
United States	2.149	0.149	2.824	0.206
Canada	2.609	0.293	2.743	0.309
Portugal	0.252	0.063	0.326	0.028
Spain	2.024	0.084	2.014	0.079
Switzerland	0.715	0.050	0.686	0.030
Ireland	2.441	0.173	1.102	0.151
Overall country average	**1.188**	**0.212**	**1.212**	**0.202**

(a) Ideally, education costs should be calculated as the sum of (a) gross tuition fees, (b) private payments on instructional services and goods and (c) living costs. As (b) is not available for many countries (see tables 22 and 23, column 2), this term is ignored. Therefore, education costs are the sum of private expenditure on institutions (net of subsidy from public) (tables 22 and 23, column 1), subsidies in favor of private entities paid to institutions (tables 20 and 21, column 6) and living costs (tables 22 and 23, column 4).

(b) Education subsidies are total subsidies for education to private entities excluding student loans (in % of GDP, see tables 20 and 21, column 5).

(c) The indicators for full-time education costs and subsidies (see table 6 p.18) are calculated by taking the average education cost/subsidy over 1999 and 2003 and subsequently dividing this number by the tertiary education rate of the country presented in table 3 (p.5).

Note: In the LBD-model using equation (22), g_{ey} is calculated as the difference between average total public expenditure on institutions (including subsidies to households attributable to institutions) and subsidies to households attributable to institutions (see tables 20 and 21, columns 2 and 7). g_{py} is then the difference between total productive government expenditure g_y (excl. subsidies, see table 5 p.17) and g_{ey}.

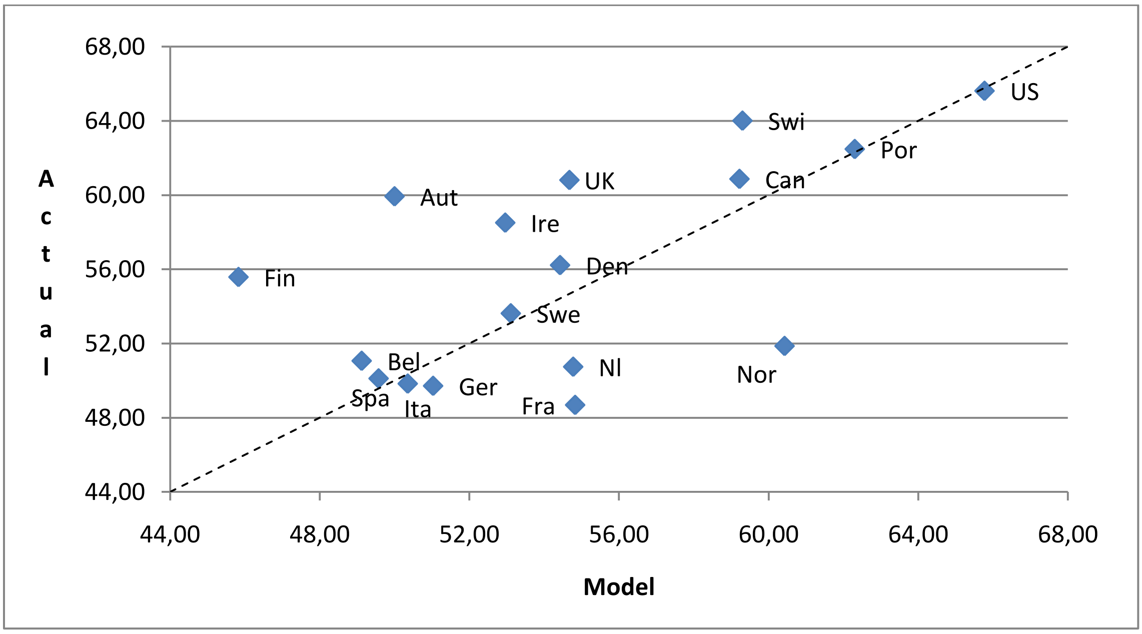
APPENDIX B: Evaluation of the pension model

Table 25 Correlation between the main variables in the actual data versus predicted by the pension model (15 or 17 countries, 1995-2006/7)

	ACTUAL DATA	HV (2009)	Pension model
CORR(growth,e)	0.50	0.98	0.98
CORR(growth,n_1)	0.01	-0.12	-0.11
CORR(growth,n_2)	0.03	0.26	0.29
CORR(growth,n_3)	0.19	0.27	0.34
CORR(growth,n)	0.10	0.14	0.17
CORR(growth, g_y)	0.38	0.81	0.82
CORR(g_y,e)	0.69	0.67	0.68
CORR(n_1,n_2)	0.80	0.86	0.83
CORR(n_1,n_3)	0.67	0.84	0.81
CORR(n_2,n_3)	0.80	0.97	0.98
CORR(n_1,e)	-0.31	-0.21	-0.20
CORR(n_2,e)	0.07	0.15	0.19
CORR(n_3,e)	0.17	0.16	0.24
CORR(n_1,g)	-0.14	0.12	0.12
CORR(n_2,g)	0.16	0.42	0.43
CORR(n_3,g)	0.41	0.41	0.44

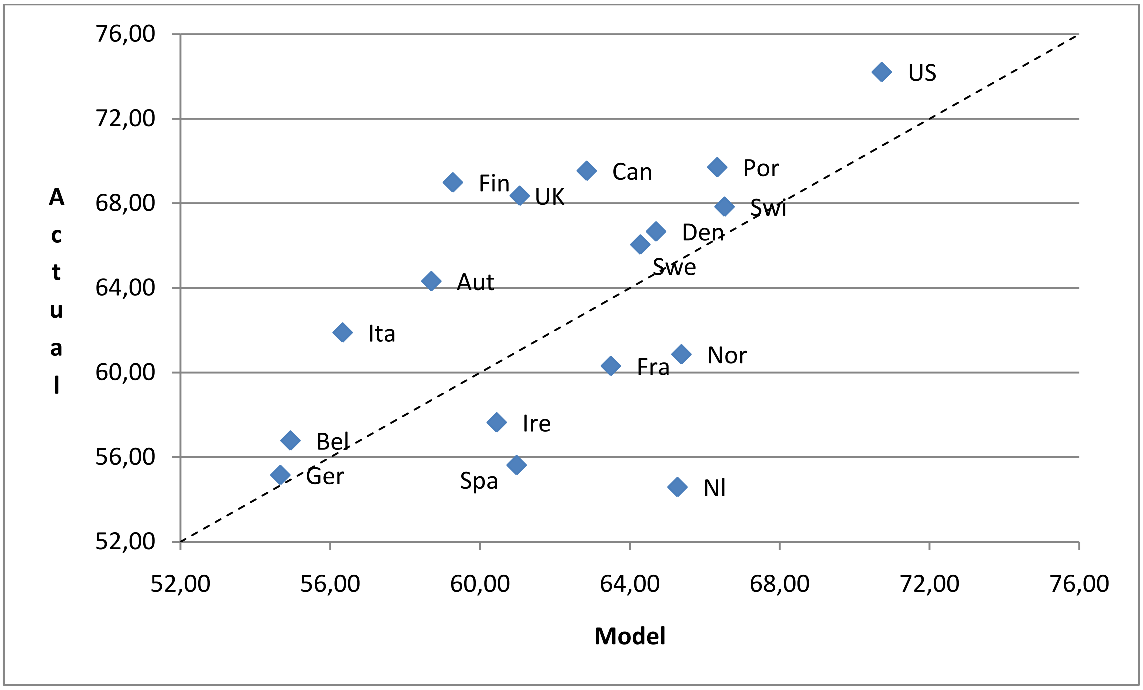
Note: (a) these correlations are based on one observation per country. Correlations involving growth do not include Ireland and Switzerland. (b) n is the aggregate employment rate over all three age groups. It is a weighted average of n_1, n_2 and n_3.

Figure 14 Employment rates in hours of young individuals in individual countries as predicted by the pension model, in %, 1995-2007



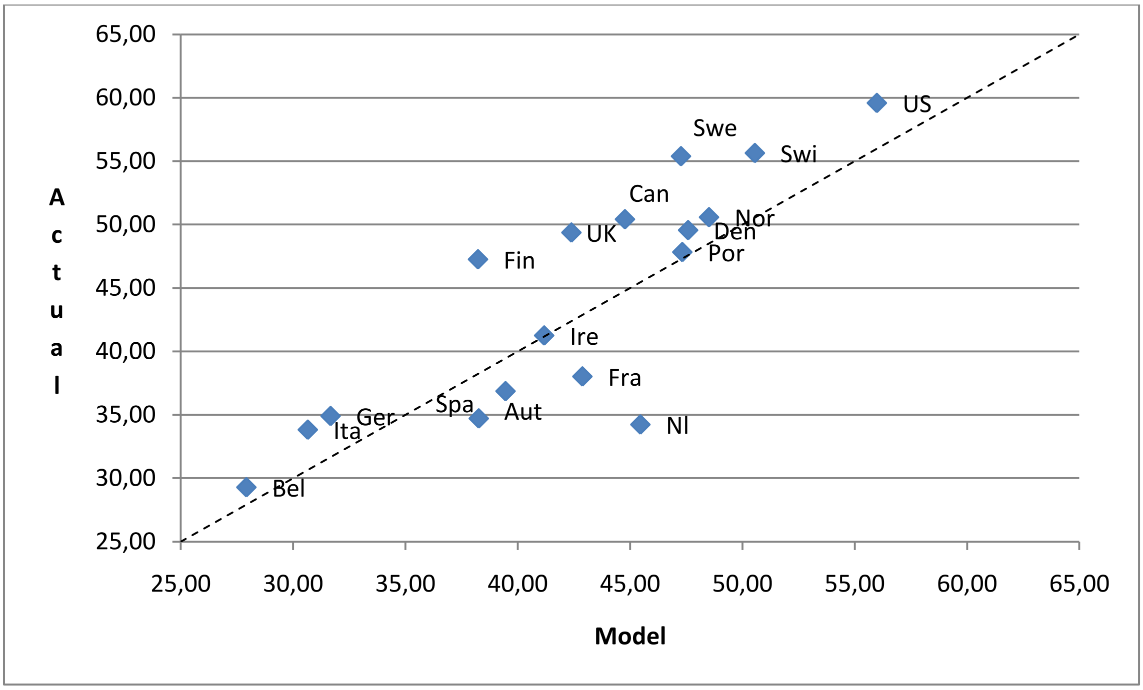
Note: the dotted line is the 45°-line. Correlation between the actual data and the model's predictions is 0.59.

Figure 15 Employment rates in hours of middle aged individuals in individual countries as predicted by the pension model, in %, 1995-2007



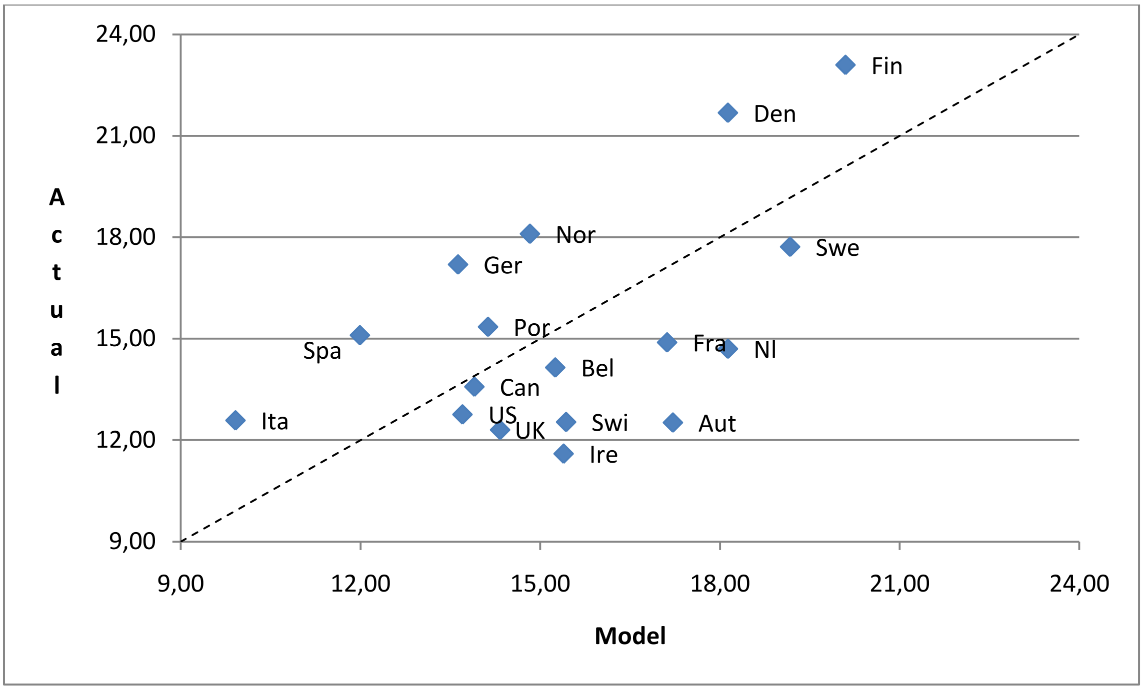
Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.54.

Figure 16 Employment rates in hours of older individuals in individual countries as predicted by the pension model, in %, 1995-2007



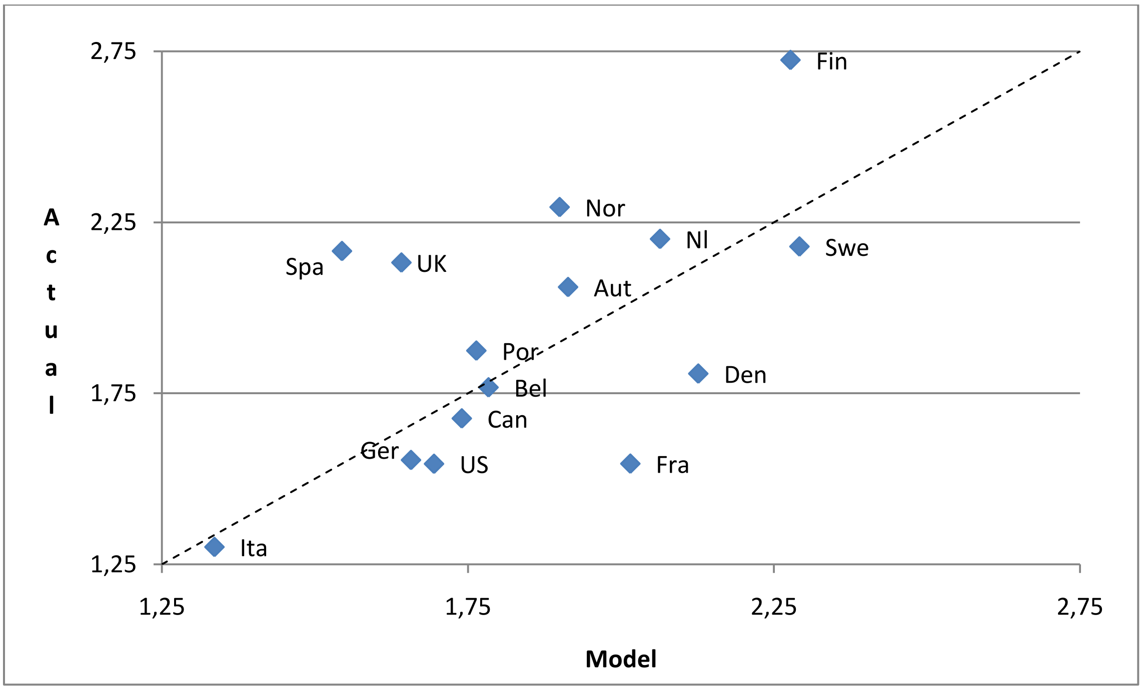
Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.83.

Figure 17 Tertiary education rate in individual countries as predicted by the pension model, in %, 1995-2006



Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.55.

Figure 18 Annual per capita potential GDP growth in individual countries as predicted by the pension model, in %, 1995-2007



Note: the dotted line is the 45°-line. Correlation between actual data and the model's predictions is 0.58. Correlation drops to 0.49 if Switzerland is included. The model predicts a growth rate for Switzerland equal to 1.83%, whereas actual growth is only 0.94%. Correlation drops further to 0.24 if Ireland is also included. Whereas actual growth rate for Ireland is 4.53%, the model only predicts a growth rate equal to 1.81%.

APPENDIX C: Transitional dynamics of lump sum financed fiscal policy changes in the learning by doing model (Tables 14-15)

Figure 19 Aggregate output level (vertical axis, index, benchmark = 0) after unanticipated and permanent lump sum financed policy changes introduced in period 1 (periods on horizontal axis)

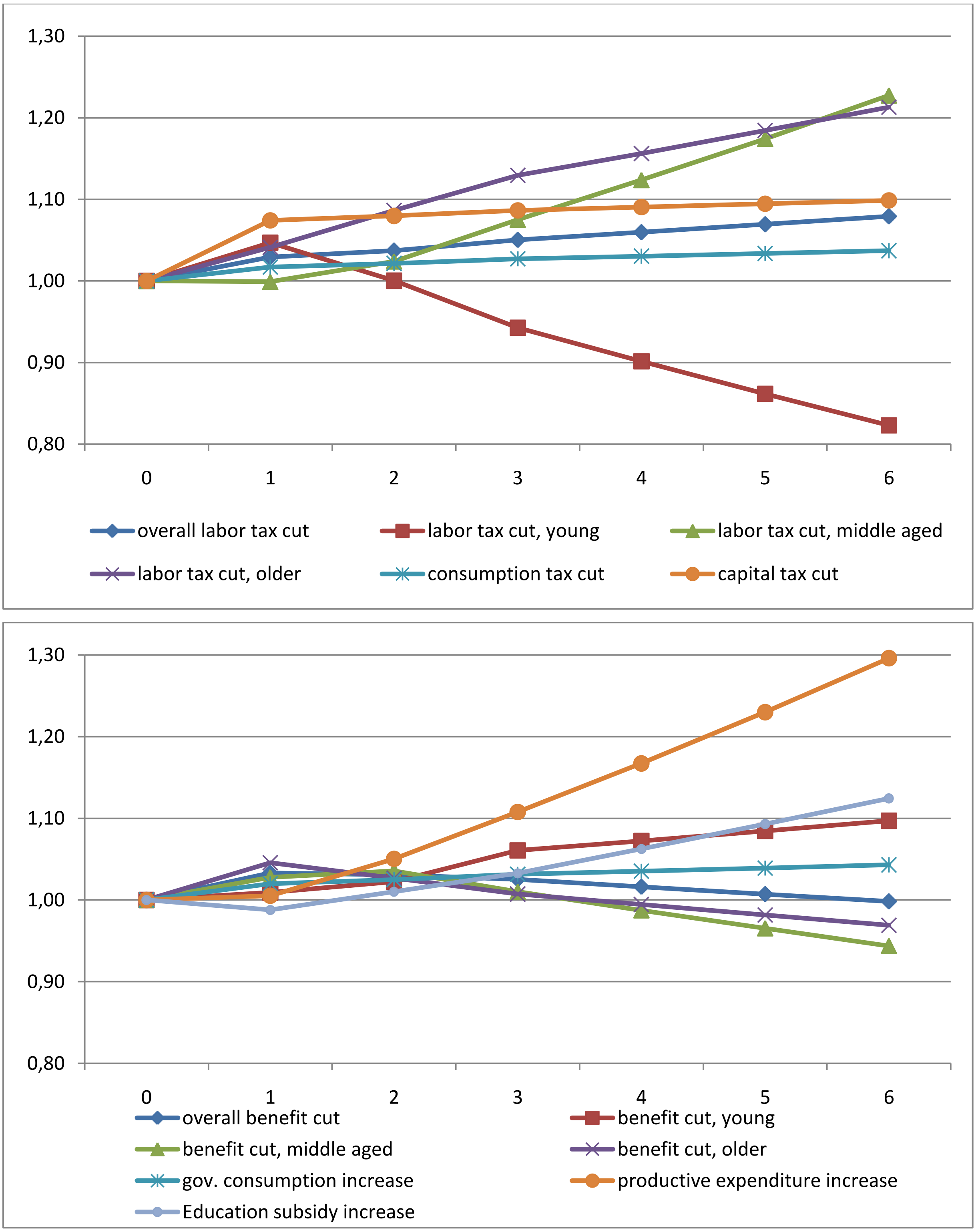
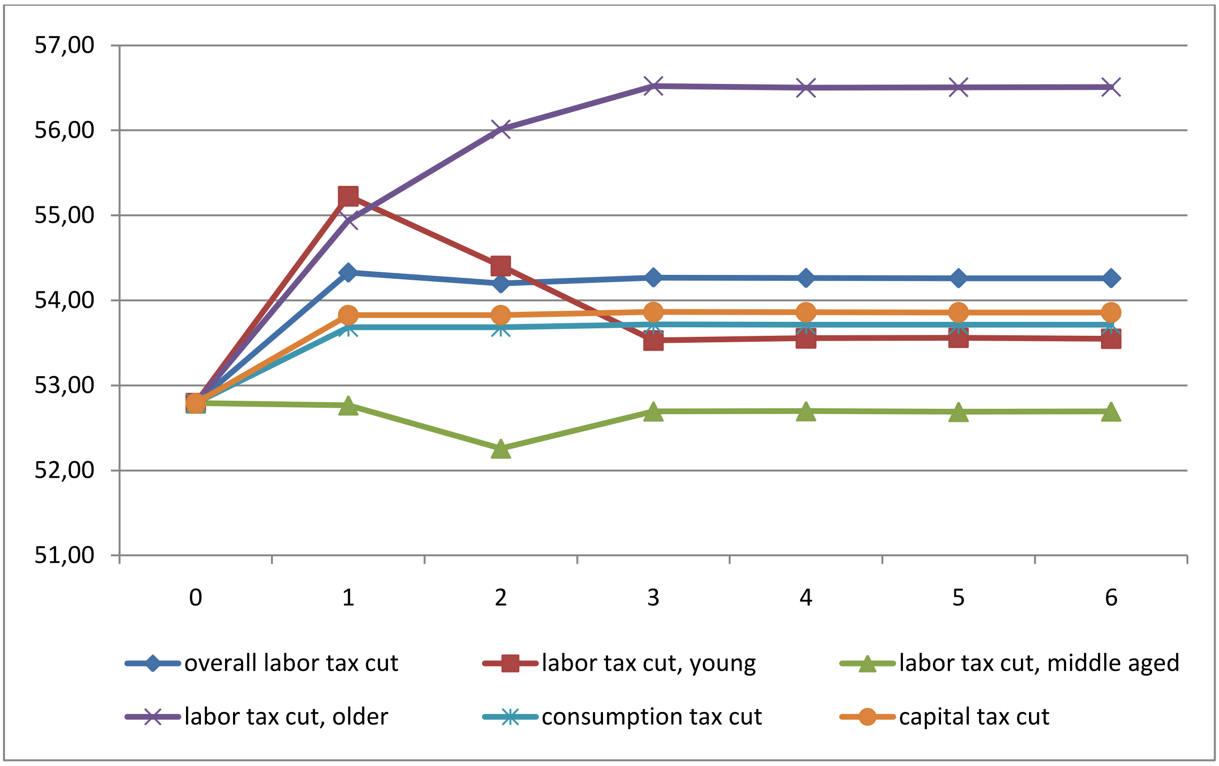
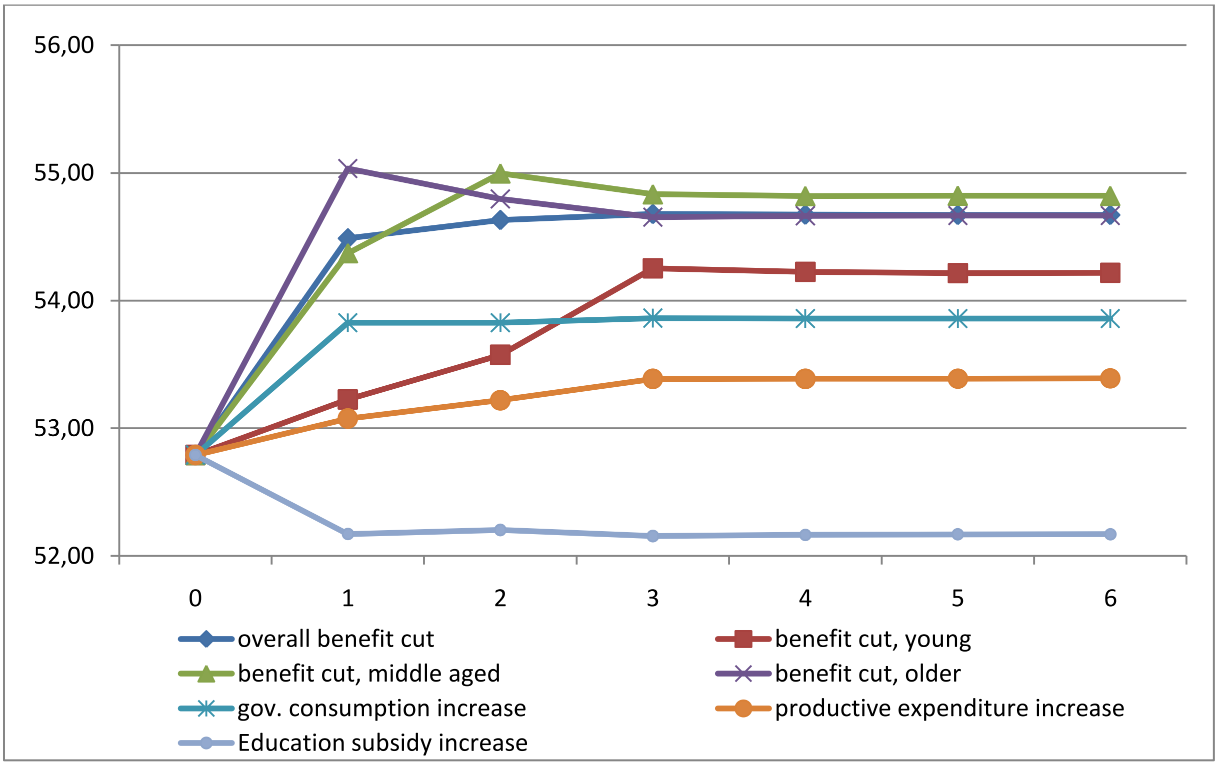


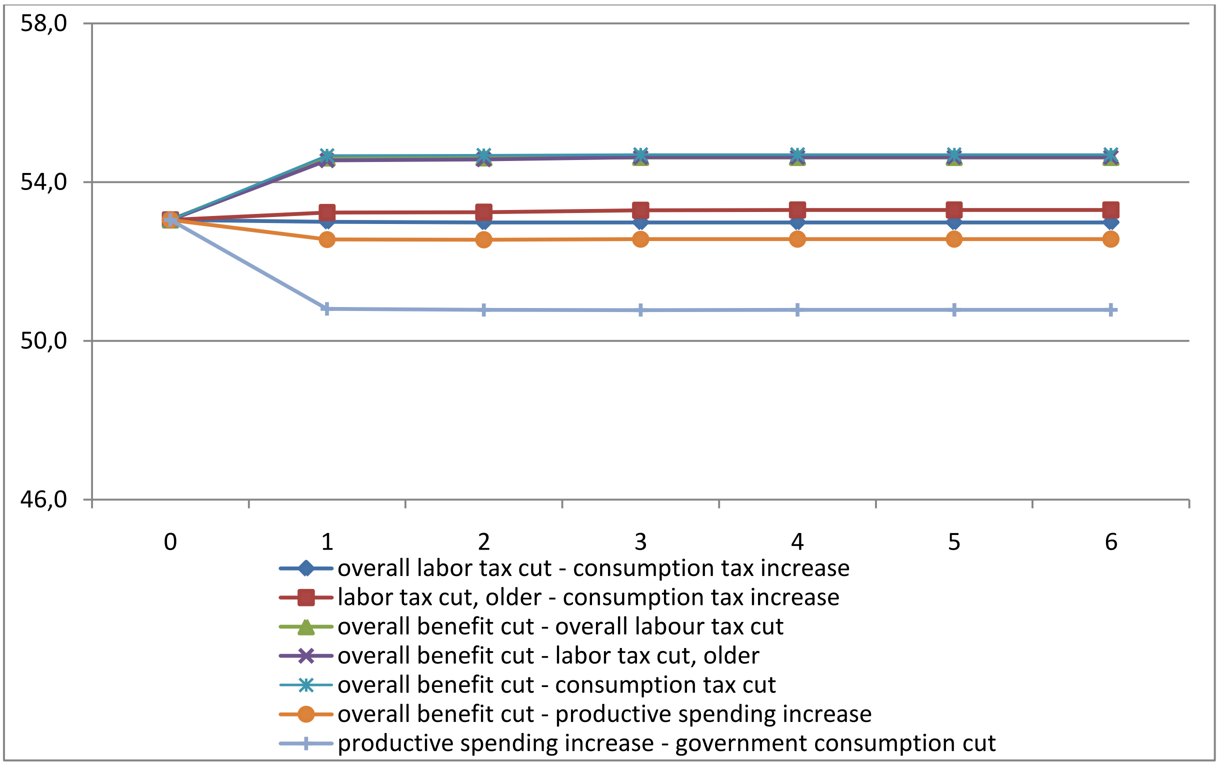
Figure 20 Aggregate employment rate (vertical axis, index, benchmark = 0) after unanticipated and permanent lump sum financed policy changes introduced in period 1 (periods on horizontal axis)





APPENDIX D: Transitional dynamics of combined fiscal policy changes in the learning by doing model (Tables 16-17)

Figure 21 Employment rate of young workers (vertical axis, in %) after unanticipated and permanent combined fiscal policy changes introduced in period 1 (periods on horizontal axis)



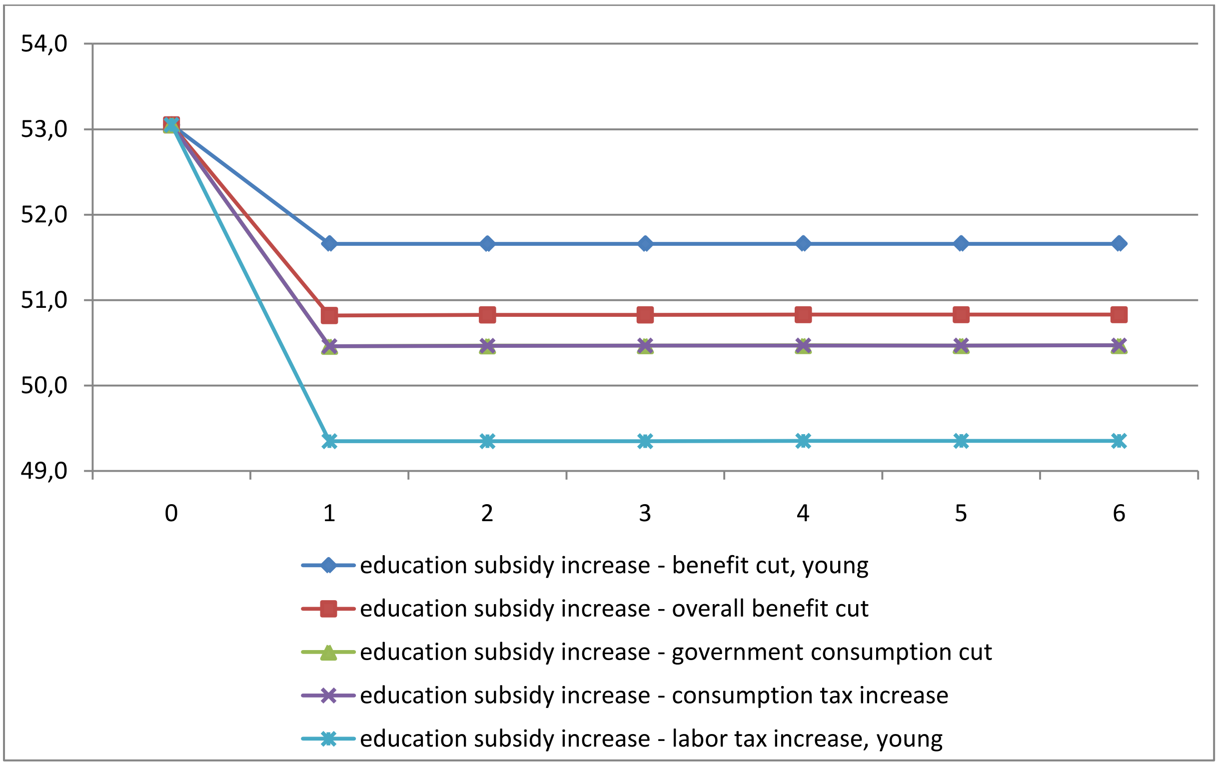
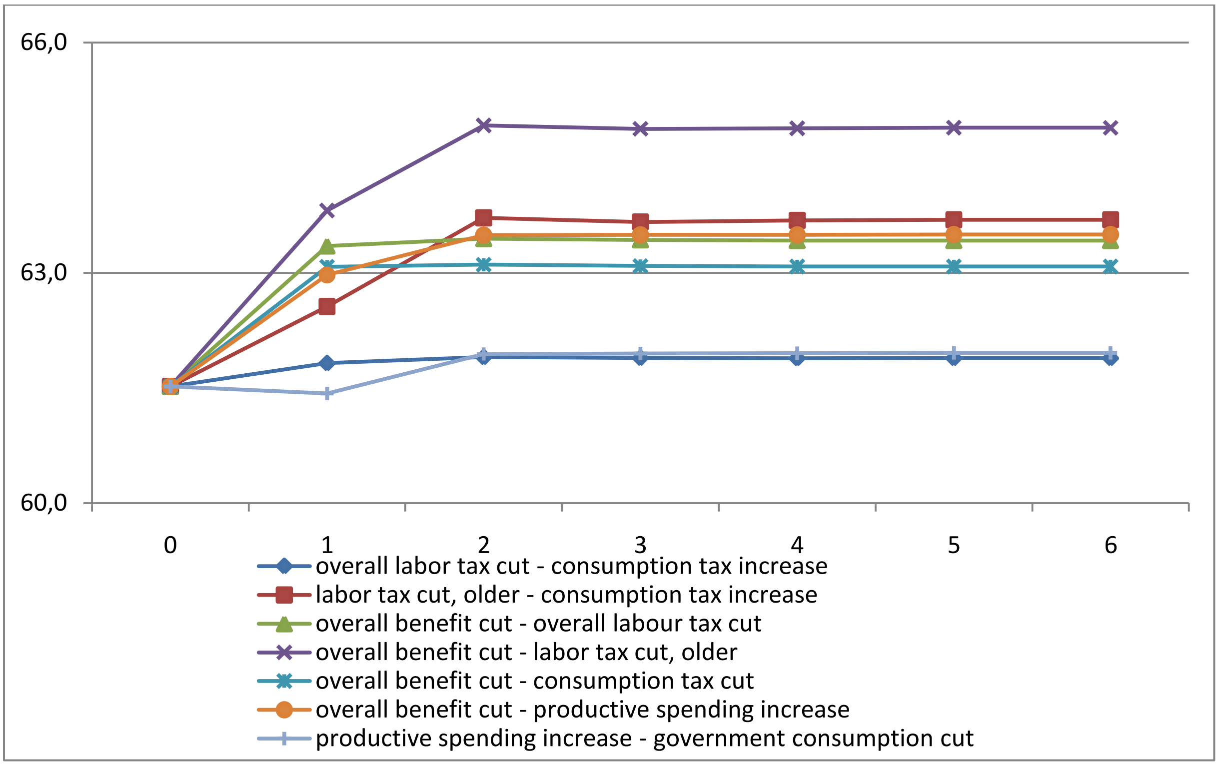


Figure 22 Employment rate of middle aged workers (vertical axis, in %) after unanticipated and permanent combined fiscal policy changes introduced in period 1 (periods on horizontal axis)



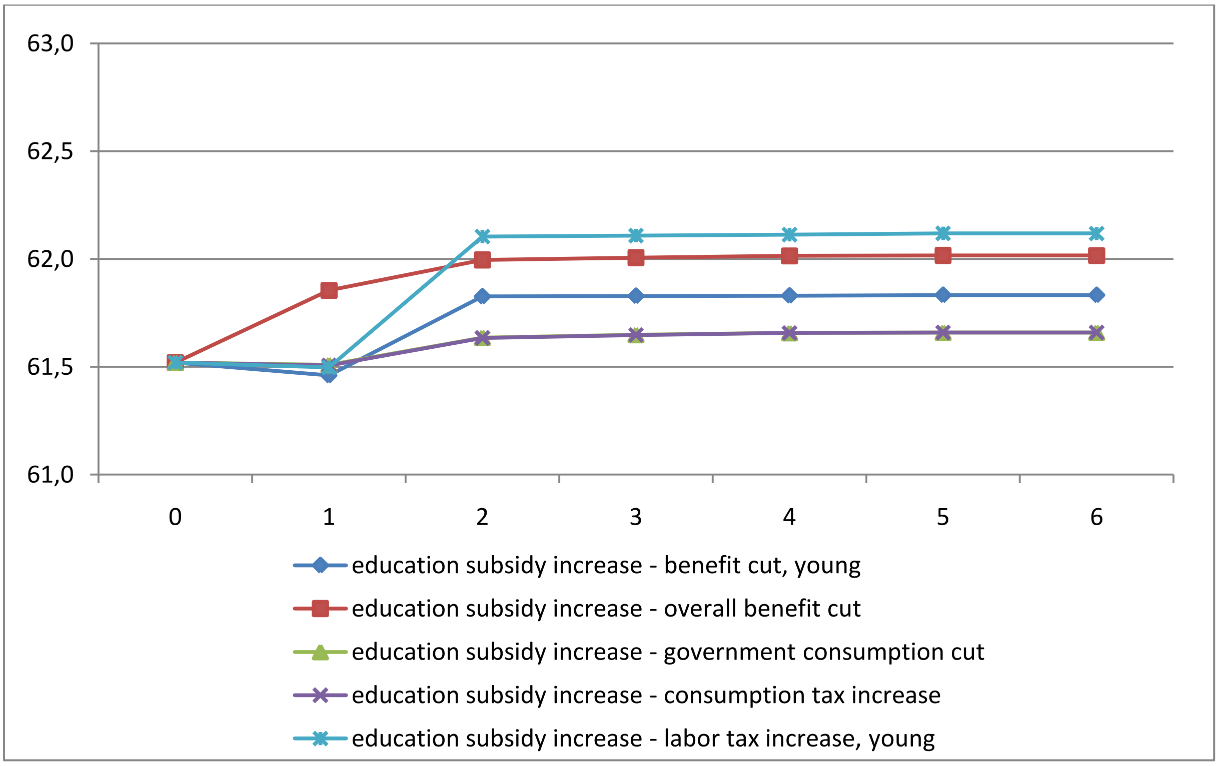
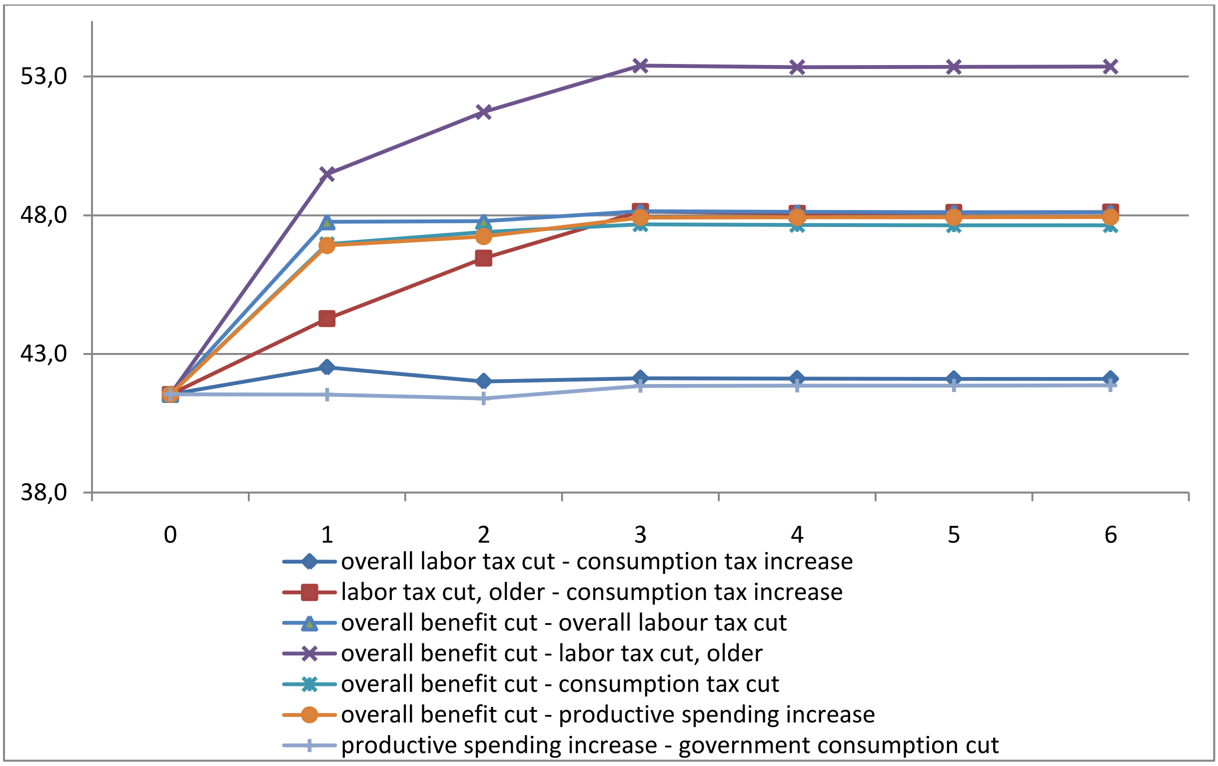
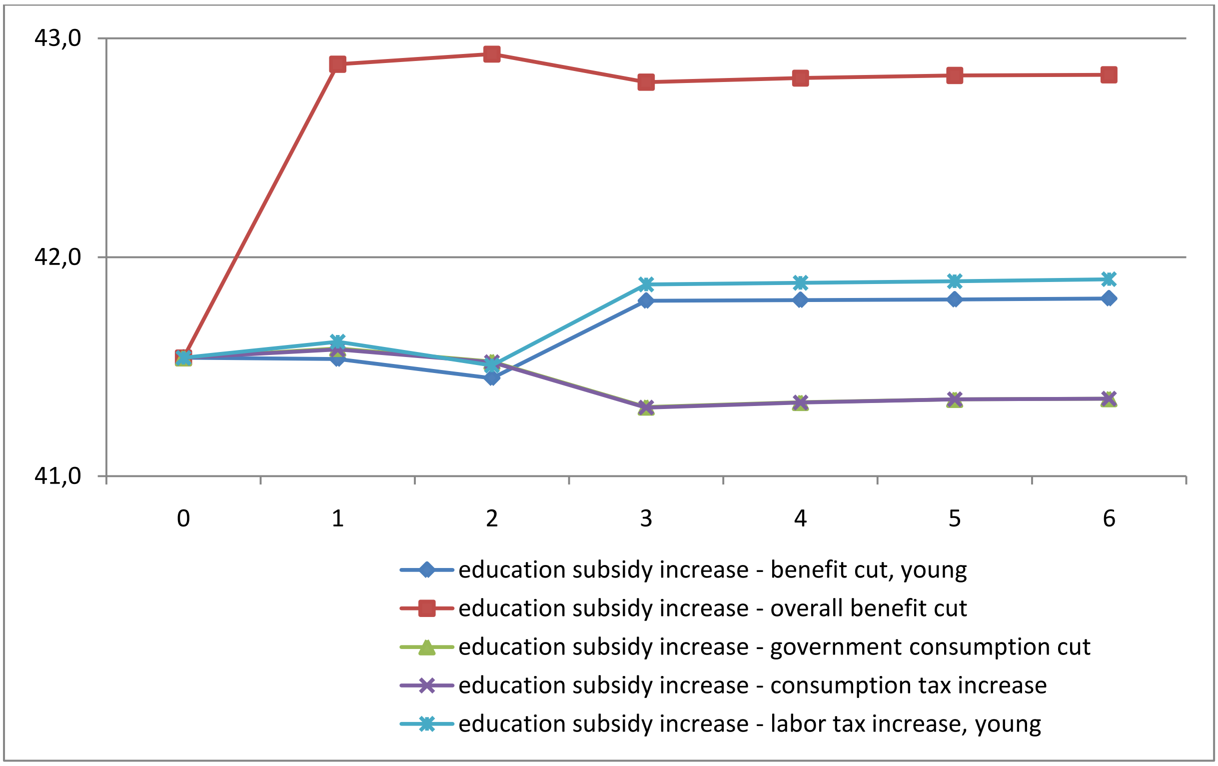


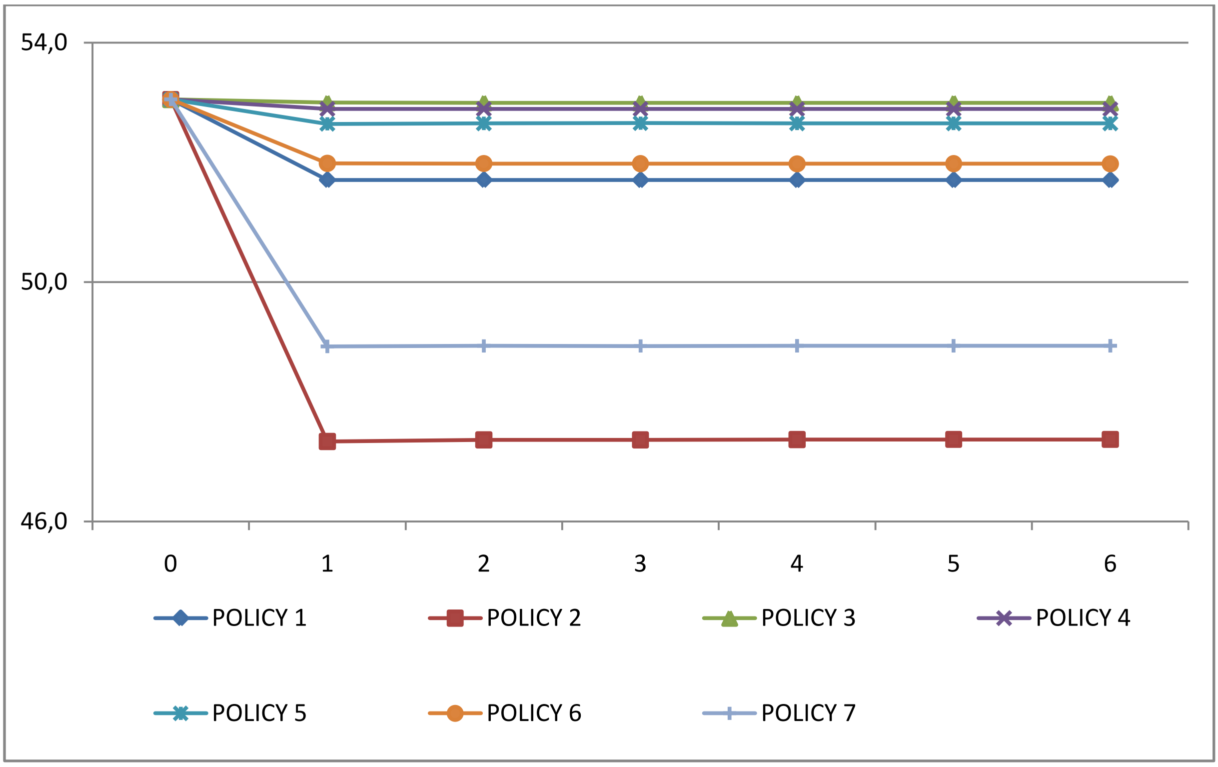
Figure 23 Employment rate of older workers (vertical axis, in %) after unanticipated and permanent combined fiscal policy changes introduced in period 1 (periods on horizontal axis)





APPENDIX E: Transitional dynamics of pension reforms (Tables 18-19)

Figure 24 Employment rate of young workers (vertical axis, in %) after unanticipated and permanent combined fiscal policy changes introduced in period 1 (periods on horizontal axis)



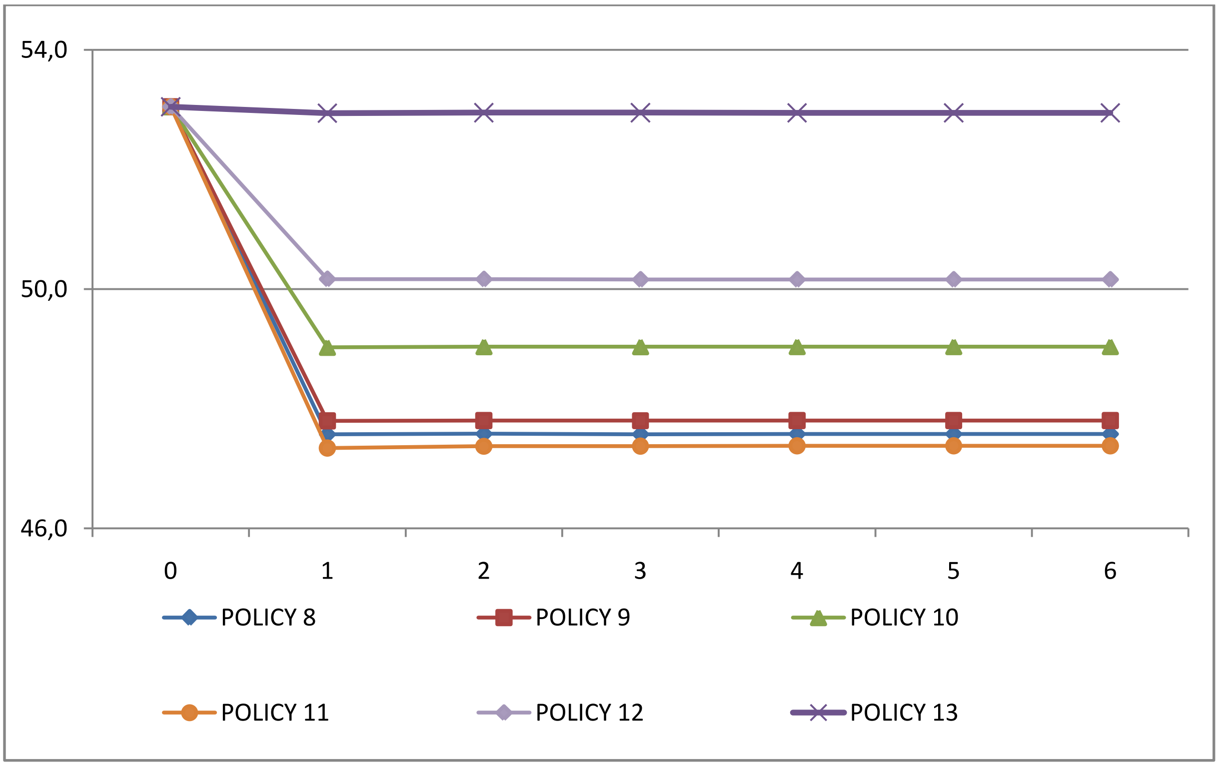
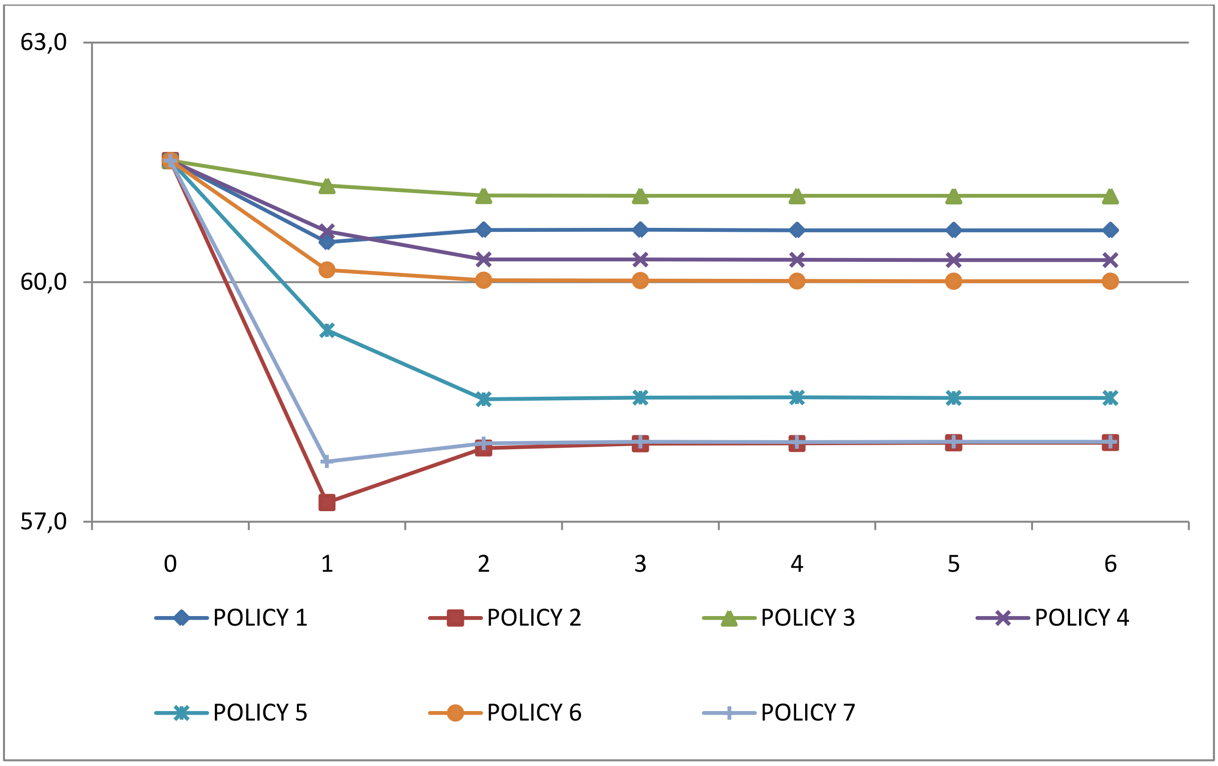


Figure 25 Employment rate of middle aged workers (vertical axis, in %) after unanticipated and permanent combined fiscal policy changes introduced in period 1 (periods on horizontal axis)



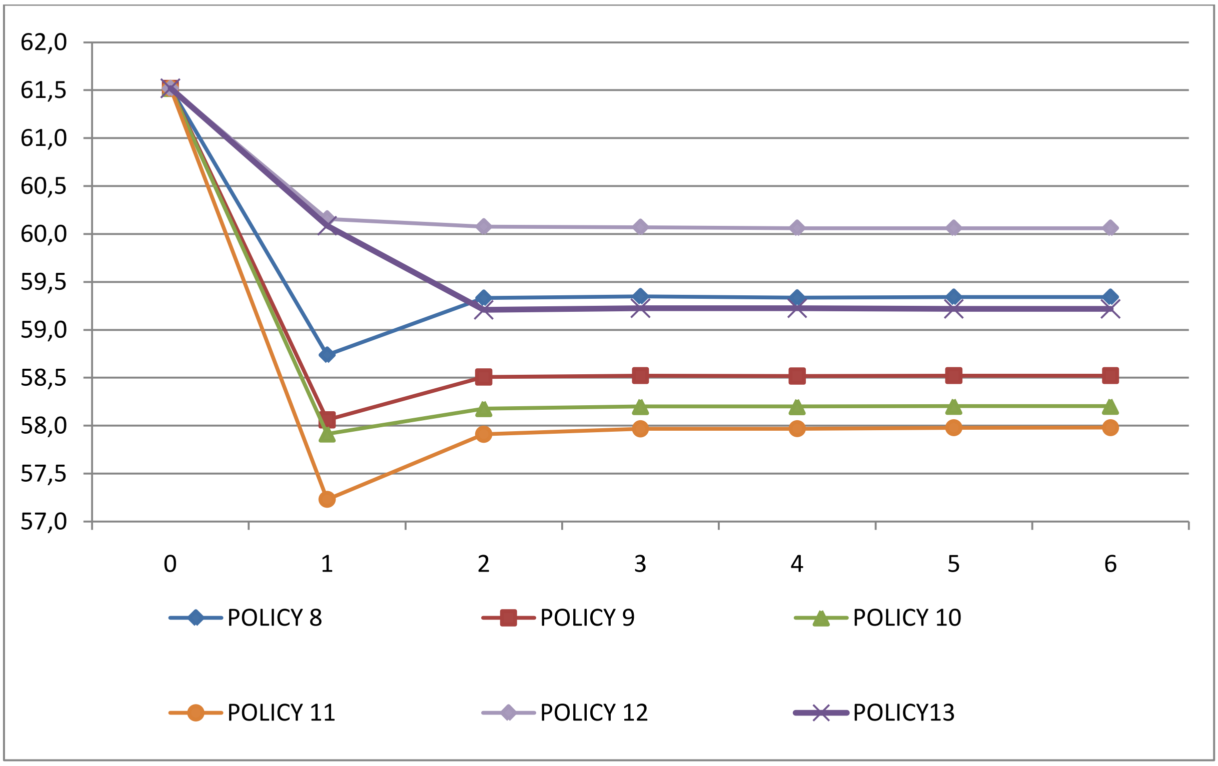


Figure 26 Employment rate of older workers (vertical axis, in %) after unanticipated and permanent combined fiscal policy changes introduced in period 1 (periods on horizontal axis)