

Heterogeneous ability and the effects of fiscal policy composition on employment and growth

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Abstract

We build and parameterize a general equilibrium OLG model for an open economy to jointly study hours of work of young, middle aged and older individuals, education of the young, and aggregate growth. We distinguish within each age group three types of individuals, with high, medium or low ability to build human capital. The composition of taxes and government expenditures plays a crucial role in our model. The government sets tax rates on labor, capital and consumption. It allocates its revenue to productive expenditures (mainly to promote human capital accumulation), study grants, consumption and 'non-employment' benefits. Labor taxes and benefits may differ across age groups and across ability types. We find that our model's predictions match the facts well for key variables in many OECD countries. We then use the model to investigate the effectiveness of various fiscal and educational policy measures in promoting employment and growth. We also evaluate welfare effects for current and future generations. Our main results support a reduction of labor taxes on older workers and on all low ability individuals, as well as an increase of productive expenditures, financed by a reduction of 'non-employment' benefits.

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

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1. Introduction

Rising pressure on the welfare state due to ageing forces all OECD countries to develop effective employment and growth policies. The need to raise employment is particularly pressing among older and lower skilled workers. Concern for employment and growth is not new. They have been high on the agenda of both policy makers and researchers since at least two decades.

The literature that has studied the determinants of employment and employment differences across OECD countries is huge. Almost all studies emphasize the role of unemployment benefit systems and labor taxes, although the importance attached to them may differ. Next to benefits and taxes, many authors emphasize the role of labor and product market institutions, like union power, employment protection legislation and wage bargaining systems (e.g. Blanchard and Wolfers, 2000; Nickell *et al.*, 2005). Other authors pay no attention to differences in market characteristics, but explore in greater detail the influence of fiscal policy, i.e. differences in the level and composition of taxes and government expenditures (e.g. Prescott, 2004; Rogerson, 2007; Dhont and Heylen, 2008). Recent empirical work by Ohanian *et al.* (2008) and Berger and Heylen (2010) testing the institutional versus the fiscal view tends to support the latter.

When it comes to growth, market characteristics and fiscal policy composition are again at the centre of the discussion. Market characteristics are important in the innovation based view on growth, as for example in Aghion and Howitt (2006). Fiscal policy composition is a central element in the analysis of growth by e.g. Barro (1990), King and Rebelo (1990), Turnovsky (2000) and Dhont and Heylen (2009). In both perspectives on growth, education and education policy play an important role. Krueger and Kumar (2004) and Aghion and Howitt (2006) emphasize the importance of tertiary education in times of rapid innovation and the need for new technology adoption. Fiscal policy models often have education expenditures/subsidies as a major component of (productive) government expenditures, enhancing effective human capital accumulation and possibly growth (e.g. Glomm and Ravikumar, 1992, 1997; Buiter and Kletzer, 1993; Docquier and Michel, 1999; Kaganovich and Zilcha, 1999). Empirical work by Kneller *et al.* (1999) confirms the importance of productive government expenditures for growth in OECD countries. Blankenau *et al.* (2007) show that differences in education expenditures contribute significantly to explain growth differences. Nijkamp and Poot (2004) have recently shown the empirical importance of public education expenditures for growth in a meta-analysis. De la Fuente and Doménech (2000) find a significant and plausible positive effect of human capital accumulation on growth¹. Hanushek and Woessmann (2009) emphasize the crucial role of education quality and the institutional features of the schooling system for growth.

The above mentioned literature has strongly improved our understanding of employment and growth. Still, there is room for progress. Most of the above mentioned studies focus on only one aspect of macro performance, either employment or growth. Most studies explaining employment disregard growth. Models explaining education and growth generally disregard labor supply and the labor-leisure choice. We refer to Heylen and Van de Kerckhove (2010) for a more extensive discussion of the literature. Second, a few recent exceptions notwithstanding (e.g. Rogerson and Wallenius, 2009; Fougère *et al.*, 2009), most employment studies neglect life cycle patterns in labor supply and employment differences across age groups. The data, however, show that in all countries the middle aged work more hours than the young and the older.

¹ Not all studies investigating the relationship between human capital accumulation and growth, come up with significant positive and plausible results, however (e.g. Barro, 2001). De la Fuente and Doménech (2000) point at the low quality of schooling and human capital data as an important factor that may explain the mitigated results in many studies.

In Heylen and Van de Kerckhove (2010) we therefore constructed and parameterized a general equilibrium OLG model for an open economy which jointly explains the employment rate of young, middle aged and older individuals, the fraction of time that young individuals allocate to (tertiary) education, and economic growth. This setup reveals various mutual relationships between these variables², from which follows the need for an integrated analysis. The model is situated in the fiscal policy endogenous growth tradition, with growth being related to education. The composition of taxes and government expenditures plays a crucial role. The government sets tax rates on labor, capital and consumption. It allocates its revenue to productive expenditures (mainly for education), consumption and ‘non-employment’ benefits. Labor taxes and benefits may differ across age groups. Simulating the model to investigate the effectiveness of various fiscal policy measures in promoting employment and growth, our main results were as follows. We identified labor taxes and ‘non-employment’ benefits as the main policy variables affecting employment. Effects are the strongest when policy focuses on younger or older workers. Productive government expenditures are the most effective with respect to long-run output and growth. Furthermore, we observe that output and growth may benefit also from labor tax cuts targeted at older workers. By contrast, tax cuts targeted at younger workers and non-employment benefit reductions tend to imply lower future output and growth since they may discourage the young to study. A key policy implication of our results for many European countries would be to cut non-employment benefits, and to reallocate these resources to tax cuts on older workers and higher productive expenditures.

Our analysis in Heylen and Van de Kerckhove (2010) remains weak in at least one respect. We assume homogeneous individuals in each generation, and disregard obvious *differences in abilities* and motivation of people to learn. Everyone in the model is able to study and succeed at the tertiary level. Reality is different, however. Data reveal that in 2008 about 30% of the 25-64 year old population on average in the OECD has no upper secondary degree. About 44% has an upper secondary degree but no tertiary degree. The fraction of people with a tertiary degree therefore remains below 30%. Among young cohorts, educational attainment is higher. Yet, the fraction that does not complete upper secondary education is still about 20% on average. About 40% obtains an upper secondary degree, but no tertiary degree. More or less another 40% completes both secondary and tertiary education (OECD, Education at a Glance, Tables A1, A2.2, A3.2). Cross-country variation in these data suggests that *differences in the schooling system and government policies*, for example policies affecting the cost of education, may have an important influence on these numbers. But the simple fact that innate ability as for example reflected by IQ, varies across people, implies that one can never expect everyone to succeed at the tertiary level. A second important observation is that these differences in school results feed through directly into *labor market outcomes*. On average in the OECD, the employment rate among people of age 25 to 64 with less than an upper secondary degree is less than 60%, the employment rate among people with a tertiary degree is higher than 80% (OECD, Employment Outlook).

² For example, the level of employment determines the marginal productivity of capital and therefore the incentive to invest, and possibly growth (e.g. Turnovsky, 2000). Also, due to a possible tradeoff between employment of the young and education, and given the importance of education for growth, employment by age matters in the analysis of growth. In line with this, if people expect to work longer, the return to education when young may rise. So may human capital accumulation and growth. Conversely, if people study more, they may want to work longer to get a higher return from their investment in human capital.

These observations may raise doubt about some of our policy conclusions in Heylen and Van de Kerckhove (2010). Is it efficient to target tax cuts on older workers only? If not everyone can succeed in tertiary (or even secondary) education, what about taxes on low skilled young workers? Also, if government expenditures are mainly targeted at education, not everyone may benefit. Such policies may promote aggregate employment and growth, but maybe they also generate highly unequal welfare effects, which may undermine them. In that case, what are efficient policies to counteract these inequalities?

In this paper we extend our earlier OLG model by allowing heterogeneous abilities. We make the assumption that within each generation three ability groups exist. One group has low ability and will never engage in tertiary education, they will only work or have 'leisure'. A second group has medium ability, a third group high ability. Both these groups will allocate time to tertiary education, but given the variation between them in the productivity of knowledge assimilation and schooling, the amount of time will differ. A second extension in this paper is that we pay much more attention to the cost of tertiary education and related government grants, and to the quality of the schooling system. A high quality schooling system may to some extent counteract the effects of differences in innate ability. Our extensions allow for a richer analysis of policy. Labor taxes and benefits may not only differ across age groups, but also across ability and skill groups. Next to an analysis of the effects of taxes and direct government expenditures, a richer analysis become possible also from the side of education policy.

Our main findings are the following. First, we confirm our earlier results in Heylen and Van de Kerckhove (2010). We again identify labor taxes and (especially) 'non-employment' benefits as the main policy variables affecting employment. Productive government expenditures are the most effective with respect to long-run output and growth. Again we observe that output and growth may benefit also from labor tax cuts targeted at older workers. Second, however, a first new result in this paper, is that if these policies are imposed, they also imply clearly differential welfare effects between the ability groups. Current and near future low ability individuals may experience welfare losses. Third, better overall employment effects and better welfare effects for low ability groups, at a slight cost in terms of growth, are possible if one complements policies that cut labor taxes on older workers with labor tax cuts on the low skilled. The best effects on employment follow if this combined tax cut is financed by overall benefit cuts.

The structure of the paper is as follows. In Section 2 we document differences in employment by age and educational attainment, education of the young, and per capita growth across 13 OECD countries since 1995. Section 3 sets out our model. In Section 4 we calibrate the model on actual data and confront its predictions with the facts described in Section 2. Our procedure is as follows. We impose common technology and preference parameters on all countries, but country-specific fiscal policy and education quality parameters. Simulating the model for each country we find that its predictions match the main facts in most countries. Section 5 includes the main results of a wide range of policy simulations. In Section 5 we discuss the long-run equilibrium effects of policy changes, and the welfare effects per generation and ability group. Section 6 concludes the paper.

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

Table 1 contains key data on employment, education and growth in 13 OECD countries in 1995-2007. One would like a reliable model to match the main cross-country differences reported here. The employment rate in hours (n) indicates the fraction of potential hours that are actually being worked by the average person in one of three age groups: n_1 for young persons (age 20-34), n_2 for middle aged persons (35-49), and n_3 for older persons (50-64). Potential hours are 2080 per person per year (52 weeks times 40 hours per week). The observed employment rate rises if more people in an age group have a job, and if the employed work more hours. The fourth column in Table 1 reports employment differences by skill. Since data on hours worked per person by skill level are not available (as far as we know), it is not possible to compute data that are comparable to the employment rates by age. We therefore focus on employment rates in persons, i.e. the fraction of people with a certain educational attainment who have a job. Concentrating on the upper and lower group, we present the ratio of the employment rate in persons among people with less than upper secondary education to the employment rate among those with a tertiary degree. If it can be assumed that hours worked per person are comparable, these data would act as a (rough) proxy for n_L/n_H . The education rate (e) is our proxy for the fraction of *effective time* spent studying by the average young person. The data combine fractions of *time as such* spent in tertiary education, and completion rates³. Taking into account completion rates is one (possible) way to control for the fact that students may spend more time on the same program than 'normal', or spend time but in the end fail. Our data for (average annual) real per capita growth concern real potential GDP per person of working age. We refer to Appendix 1 for further details on the calculation of all our data, and on the assumptions that we have to make.

As is well-known, middle aged individuals work most hours, followed by the young. The older generation works the lowest number of hours. Average employment rates over all countries in these three age groups are 55.0%, 63.7% and 43.6% respectively. Furthermore, the data reveal strong cross-country differences. We observe the highest employment rates in each age group in the US. Employment rates are much lower in the core countries of the euro area. The Nordic countries take intermediate positions, although they are close to the core euro area for the younger generation. As to skill groups, we see in all countries lower employment rates among lower educated people than among people with a tertiary degree ($n_L/n_H < 1$). On average over all countries in Table 1, the former is only about 67% of the latter. Again we observe significant cross-country differences, with the lowest numbers in countries like Belgium and Germany, and the highest in the Nordic countries.

Young people's effective participation in education is also by far the highest in the Nordic countries. These countries also show the highest potential per capita growth rates. On average, growth in the core euro area and the US was more than 0.5 percentage points lower in the period under consideration. The US and the other Anglo-Saxon countries tend to have the lowest effective participation in education among people of age 20 to 34.

³ We calculate the fraction of *time as such* as the total number of tertiary students in full-time equivalents, divided by total population in the age group 20-34. To obtain the fraction of *effective time* we multiply by the completion rate (normalized to its cross-country average). The completion rate indicates the percentage of students who follow tertiary education, and also graduate from a tertiary program. The OECD average in 2008 was about 69%. It was much less for example in the US and Italy, much higher in Denmark and France (OECD Education at a Glance). For details, see also Appendix 1.

Table 1

Employment rate in hours (n), education rate (e) and per capita growth in OECD countries (1995-2007)

	n_1 (20-34)	n_2 (35-49)	n_3 (50-64)	n_L/n_H	e	<i>Annual real per capita growth</i>
Austria	59.9	64.3	34.7	63.4	15.5	2.06
Belgium	51.1	56.8	29.3	58.1	19.5	1.77
France	48.7	60.3	38.0	67.3	19.1	1.54
Germany	49.7	55.2	34.9	61.0	16.0	1.56
Italy	50.1	61.9	33.8	62.0	9.5	1.30
Netherlands	50.8	54.6	34.2	67.4	15.2	2.20
Core euro area Average	51.7	58.8	34.2	63.2	15.8	1.74
Denmark	56.2	66.7	49.6	70.7	22.3	1.81
Finland	55.6	69.0	47.3	67.5	22.5	2.72
Norway	51.9	60.9	50.6	71.3	17.8	2.29
Sweden	53.6	66.1	55.4	80.8	16.4	2.18
Nordic Average	54.3	65.6	50.7	72.6	19.7	2.25
US	65.6	74.2	59.6	66.9	13.8	1.54
UK	60.8	68.4	49.4	66.7	12.9	2.13
Canada	60.9	69.5	50.4	66.9	16.1	1.68
All country average	55.0	63.7	43.6	66.9	16.7	1.91

Data sources: OECD and Eurostat (see Appendix 1); data description: see main text and Appendix 1. The data for employment by age and growth concern 1995-2007, those for education 1998-2007. The data for n_L/n_H are an average for 1995, 2000 and 2006. All data are in percent.

When it comes to data in this paper, one further point of clarification may be useful. As we have done in Table 1 for n_L and n_H , we will use data for people with below upper secondary education as a proxy for the low ability group, data for people with an upper secondary but no tertiary degree as a proxy for the medium ability group, and data for people with a tertiary degree as a proxy for the high ability group. Considering the distribution of these degrees within the population, and even within young cohorts (as we have mentioned in the introduction), the match between these data and our model with three equal sized ability groups is close. The median low ability individual in our model would be at the 17th percentile, the median medium ability individual at the 50th percentile and the median high ability person at the 83th percentile. In the data individuals at the 17th percentile have no upper secondary degree in most countries. Individuals at the 83th percentile have a tertiary degree.

3. The model

Our analytical framework consists of a computable four-period OLG-model for a small open economy. We assume perfect international mobility of physical capital but immobile labor and human capital. Seminal work in the OLG tradition has been done by Samuelson (1958) and Diamond (1965). Auerbach and Kotlikoff (1987) initiated the study of public finance shocks in a computable OLG model. Buiter and Kletzer (1993) developed an open economy version of the model with endogenous growth, putting human capital at the centre. As we have documented in Section 1, a

large recent literature has used OLG models to study the effects of fiscal policy on employment, assuming exogenous growth, or on human capital and growth, ignoring the labor-leisure choice and assuming exogenous employment. We here explain both employment by age, and human capital and growth as endogenous variables. Furthermore, we realistically take into account differences in individuals' abilities.

We consider three active adult generations, the young, the middle aged and the older, and one generation of retired agents. Within each generation we assume three types of individuals with different ability 'a' to build human capital: one group 'H' with high ability, a group 'M' with medium ability and a group 'L' with low ability. The last group will never enter into tertiary education. We assume that the three ability types are of equal size, and so are the different generations. We normalize each ability group to 1, so that the size of a generation is 3, and total population is 12, and constant. Individuals enter the model at age 20. Each period is modeled to last for 15 years. High and medium ability young people can choose either to work and generate labor income, to study and build human capital, or to devote time to 'leisure' (including other non-market activities). Low ability young individuals and all middle aged and older workers do not study anymore, they only work or have 'leisure'. Individuals retire at 65. The retirement age and decision are exogenous in our model. New is that education of the young and human capital accumulation, per capita growth, and employment in each of three age groups are jointly endogenous.

Output is produced by domestic firms which act competitively and employ physical capital together with existing technology and effective labor provided by the three active generations. A final important assumption is that education generates a positive externality in the sense of Azariadis and Drazen (1990). The average level of human capital of a middle aged generation is inherited by the next young generation. High ability individuals inherit the average human capital of the previous generation completely. Medium and low ability individuals inherit only a fraction ($0 < \epsilon_L < \epsilon_M < \epsilon_H = 1$). In what follows, we concentrate on the core elements of the model: the optimizing behavior of individuals, the production and inheritance of effective human capital, the behavior of domestic firms and the determination of aggregate output and growth, capital and wages.

3.1. Individuals

An individual with ability a ($a=H,M,L$) reaching age 20 in period t maximizes an intertemporal utility function of the form:

$$u_a^t = \sum_{j=1}^4 \beta^{j-1} \left(\ln c_{ja}^t + \gamma_j \frac{(1 - e_{ja}^t - n_{ja}^t)^{1-\theta}}{1-\theta} \right), \quad \forall a=H,M,L \quad (1)$$

with $0 < \beta < 1$, $\gamma_j > 0$, $\theta > 0$ ($\theta \neq 1$) and where we shall impose that $e_{2a} = e_{3a} = e_{4a} = n_{4a} = 0$ and $e_{1L} = 0$. Superscript t indicates the period of youth, when the individual comes into the model. Subscript a refers to the 'ability type' and j refers to the j th period of life. Lifetime utility depends on consumption (c_{ja}) and 'leisure' in each period of life, with 'leisure' falling in hours worked (n_{ja}) during the three active periods and in education time (e_{1a}) when young. (Since individuals only allocate time to education in their first period, we drop the subscript 1 in what follows). The intertemporal elasticity of substitution in consumption is 1, the intertemporal elasticity to substitute leisure $1/\theta$. Finally, β is the discount factor and γ specifies the relative value of 'leisure' versus consumption. The preference parameters θ , β and γ do not depend on ability type. Note, however, that γ may be different in each period of life. Except for the latter assumption, our specification of the

instantaneous utility function is quite common in the macro literature (e.g. Benhabib and Farmer, 1994; Rogerson, 2007).

Individuals will choose consumption, labor supply and education to maximize Equation (1), subject to the constraints described in (2)-(5). The LHS of these equations shows that individuals allocate their disposable income to consumption (including consumption taxes, τ_c), education expenditures net of government subsidies while young, and the accumulation of non-human wealth. In Equation (2), ec and es indicate full-time equivalent private education costs and education subsidies paid by the government, respectively. In each equation we denote by Ω_j^t the stock of wealth held by an individual who enters the model at time t at the end of his j th period of life. During the three periods of active life disposable income at the RHS includes after-tax labor income, non-employment benefits, interest income and lump sum transfers. In each equation, w_k stands for the real wage per unit of effective labor at time k , r_k is the exogenous (world) real interest rate at time k , and z_k is the lump sum transfer that the government pays out to all individuals at time k . Effective labor of an individual with ability a depends on hours worked (n_{ja}^t) and effective human capital (h_{ja}^t). Since young individuals with ability a pay a tax rate on labor income τ_{1a} ⁴, they earn an after-tax real wage equal to $w_t h_{1a}^t n_{1a}^t (1 - \tau_{1a})$. After-tax labor income when middle aged and older in Equations (3) and (4) is determined similarly. As we show in Equations (6) and (7), at the age of 20 a young worker with ability H inherits the average effective human capital from the middle aged generation completely. A young worker with ability M enters our model with only a fraction ε_M , a young worker with ability L enters with an even lower fraction ε_L . Lower ability may imply more difficulty to learn and accumulate knowledge at secondary school. Lower ability individuals may also be less motivated or suffer from school fatigue, etc. During the second and third period, workers supply more units of effective human capital. It is our assumption in Equation (8) that h_{2a} and therefore worker productivity, rise in education time when young (e_a), productive government spending in percent of GDP (g_y , mainly education) and education quality (q_a). Individuals take g_y and q_a to be exogenous. We assume in Equation (9) that human capital remains unchanged between the second and third period. We have in mind that learning by doing in work may counteract depreciation. We specify and discuss the effective human capital production function and human capital inheritance in Section 3.2.

$$(1 + \tau_c) c_{1a}^t + (ec - es) e_a^t + \Omega_{1a}^t = w_t h_{1a}^t n_{1a}^t (1 - \tau_{1a}) + b_{1a} w_t h_{1a}^t (1 - \tau_{1a}) (1 - n_{1a}^t - e_a^t) + z_t \quad (2)$$

$$(1 + \tau_c) c_{2a}^t + \Omega_{2a}^t = w_{t+1} h_{2a}^t n_{2a}^t (1 - \tau_{2a}) + b_{2a} w_{t+1} h_{2a}^t (1 - \tau_{2a}) (1 - n_{2a}^t) + (1 + r_{t+1}) \Omega_{1a}^t + z_{t+1} \quad (3)$$

$$(1 + \tau_c) c_{3a}^t + \Omega_{3a}^t = w_{t+2} h_{3a}^t n_{3a}^t (1 - \tau_{3a}) + b_{3a} w_{t+2} h_{3a}^t (1 - \tau_{3a}) (1 - n_{3a}^t) + (1 + r_{t+2}) \Omega_{2a}^t + z_{t+2} \quad (4)$$

$$(1 + \tau_c) c_{4a}^t = (1 + r_{t+3}) \Omega_{3a}^t + pp_{4a}^t + z_{t+3} \quad (5)$$

⁴ We allow for different labor tax rates and different non-employment benefits by ability for two reasons. First, this assumption reflects reality in many countries where low and high income earners may pay different tax rates. Second, and most importantly, this way of modeling opens the possibility in later sections for the government to change tax rates on some ability groups, but not on others. The same it can do for age groups.

$$\text{with: } h_{1a}^t = \varepsilon_a h_2^{t-1} = \varepsilon_a \frac{(h_{2H}^{t-1} + h_{2M}^{t-1} + h_{2L}^{t-1})}{3}, \forall a = H, M, L \quad (6)$$

$$0 < \varepsilon_L < \varepsilon_M < \varepsilon_H = 1 \quad (7)$$

$$h_{2a}^t = \left(1 + \psi_a(e_a^t, g_y, q_a)\right) h_{1a}^t, \quad \psi_a > 0, \psi'_a(\cdot) > 0 \quad (8)$$

$$h_{3a}^t = h_{2a}^t, \quad \forall a = H, M, L \quad (9)$$

$$\text{and: } pp_{4a}^t = b_4 \sum_{j=1}^3 \frac{1}{3} \left(w_{t+j-1} h_{ja}^t n_{ja}^t (1 - \tau_{ja}) \right). \quad (10)$$

For the fraction of time that young, middle aged and older individuals are inactive, they receive a non-employment benefit from the government. The net benefit replacement rate b_{ja} (with $j=1,2,3$ and $a=H,M,L$) is defined as a proportion of the after-tax wage of a full-time worker. Retired individuals in Equation (5) have no labor income and no non-employment benefits anymore. They consume their savings from the third period, plus interest, a public pension pp and the lump sum transfer z . Equation (10) describes this pension. We assume a public PAYG pension system in which pensions in period k are financed by contributions (labor taxes) from the active generations in that period k (see below). Individual pension benefits are related to earlier labor income. Individuals earn a net pension which is a fraction of their so-called pension base. The latter is a weighted average of net labor income in each of the three active periods of their life. The net replacement rate is b_4 . The weights attached to each period are $1/3$. A full pension is granted if one has a full career, which is achieved when $n_{ja}^t = 1$ for $j = 1,2,3$. Intuitively this implies 45 years of full time work.

Substituting Equations (2)-(5) for c_{ja}^t into (1), and maximizing with respect to $\Omega_{1a}^t, \Omega_{2a}^t, \Omega_{3a}^t, n_{1a}^t, n_{2a}^t, n_{3a}^t$ and e_a^t , yields seven first order conditions for the optimal behavior of an individual with ability a entering the model at time t . Equation (11) expresses the law of motion of optimal consumption over the lifetime. Equations (12.a) and (12.b) describe the optimal labor-leisure choice in each period of active live. Individuals supply labor up to the point where the marginal utility of leisure equals the marginal utility gain from work. The latter consists of two parts. Working more hours in a particular period raises additional resources for consumption both in that period and when retired. The marginal utility gain from work rises when the marginal utility of consumption ($1/c_{ja}^t$) is higher, and when an extra hour of work yields more extra consumption. Higher human capital (and its underlying determinants), lower taxes on labor, lower taxes on consumption and lower non-employment benefits contribute to the gain from work. Extra consumption during retirement rises in the pension replacement rate (b_4).

$$\frac{c_{j+1,a}^t}{c_{ja}^t} = \beta(1 + r_{t+j}), \quad \forall j = 1,2,3 \ \& \ \forall a = H,M,L \quad (11)$$

$$\frac{\gamma_1}{(1-n_{1a}^t - e_a^t)^\theta} = \frac{w_t h_{1a}^t (1-\tau_{1a})(1-b_{1a})}{(1+\tau_c)c_{1a}^t} + \frac{\beta^3 b_4 w_t h_{1a}^t (1-\tau_{1a})}{3 c_{4a}^t (1+\tau_c)}, \quad \forall a = H, M, L \quad (12.a)$$

$$\frac{\gamma_j}{(1-n_{ja}^t)^\theta} = \frac{w_{t+j-1} (1+\psi_a(e_a^t, g_y, q_a)) h_{1a}^t (1-\tau_{ja})(1-b_{ja})}{(1+\tau_c)c_{ja}^t} \quad (12.b)$$

$$+ \beta^{4-j} \frac{b_4 w_{t+j-1} (1+\psi_a(e_a^t, g_y, q_a)) h_{1a}^t (1-\tau_{ja})}{3 c_{4a}^t (1+\tau_c)}, \quad \forall j = 2, 3 \text{ \& } \forall a = H, M, L$$

Equation (13) imposes for high and medium ability individuals that the marginal utility loss from investing in human capital when young equals the total discounted marginal utility gain in later periods from having more human capital. Individuals will study more the higher future versus current after-tax real wages and the higher the marginal return of education to human capital ($\partial \psi_a / \partial e_a$). Labor taxes during youth therefore encourage individuals to study, whereas labor taxes in later periods of active life and net education costs discourage them. Notice also that high benefit replacement rates in later periods (b_2, b_3) and a high pension replacement rate (b_4) will encourage young individuals to study. The reason is that any future benefits rise in future human capital. A final interesting result is that young people study more – all other things equal – if they expect to work harder in later periods (n_{2a}, n_{3a}).

$$\frac{\gamma_1}{(1-n_{1a}^t - e_a^t)^\theta} - \frac{1}{c_{1a}^t} \frac{\partial c_{1a}^t}{\partial e_a^t} = \beta \frac{1}{c_{2a}^t} \frac{\partial c_{2a}^t}{\partial e_a^t} + \beta^2 \frac{1}{c_{3a}^t} \frac{\partial c_{3a}^t}{\partial e_a^t} + \beta^3 \frac{1}{c_{4a}^t} \frac{\partial c_{4a}^t}{\partial e_a^t}, \quad \forall a = H, M \quad (13)$$

$$\text{with: } \frac{\partial c_{1a}^t}{\partial e_a^t} = \frac{-(ec - es) - b_{1a}(1-\tau_{1a})w_t h_{1a}^t}{1+\tau_c}, \quad \forall a = H, M$$

$$\frac{\partial c_{ja}^t}{\partial e_a^t} = \frac{\partial \psi_a(e_a^t, g_y, q_a)}{\partial e_a^t} \cdot \frac{w_{t+j-1} h_{1a}^t (1-\tau_{ja}) [n_{ja}^t + b_{ja}(1-n_{ja}^t)]}{1+\tau_c}, \quad \forall j=2,3 \text{ \& } \forall a=H,M$$

$$\frac{\partial c_{4a}^t}{\partial e_a^t} = \frac{b_4}{3} \frac{\partial \psi_a(e_a^t, g_y, q_a)}{\partial e_a^t} \cdot \frac{\sum_{j=2}^3 (n_{ja}^t w_{t+j-1} h_{1a}^t (1-\tau_{ja}))}{1+\tau_c}, \quad \forall a = H, M$$

3.2. Production and inheritance of effective human capital

The specification and parameterization of the human capital production function is often a problem in numerical endogenous growth models. In contrast to goods production functions, there is not much empirical evidence and no consensus about the determinants of human capital growth, nor about the underlying functional form and parameter values (Bouzahzah *et al*, 2002, Arcalean and Schiopu, 2010). The literature shows a variety of functions, typically including one or two of the following inputs: individual time allocated to education, private expenditures on education by

individuals themselves or by their parents, and government expenditures on education (e.g. Lucas, 1988, Glomm and Ravikumar, 1992; Docquier and Michel, 1999, Kaganovich and Zilcha, 1999; Bouzahzah et al., 2002; Dhont and Heylen, 2009; Fougère et al., 2009; Arcalean and Schiopu, 2010). In case of two inputs, the adopted functional form is very often Cobb-Douglas (e.g. Glomm and Ravikumar, 1992; Kaganovich and Zilcha, 1999; Docquier and Michel, 1999).

Our specification also includes education time of young individuals and education expenditures by the government. We see these variables as indicators for the quantity of invested private and public resources. However, we extend this in two directions. First, we take recent empirical evidence seriously that the quality of education and the schooling system is very important (Hanushek and Woessmann, 2009). Better quality implies higher cognitive skills for the same allocation of resources. As a proxy for quality we will use OECD PISA science scores (see Section 4.2 for further discussion). As a second extension, our definition of relevant (productive) government expenditures includes more than education. It also includes active labor market expenditures, public R&D expenditures and public fixed investment. This approach goes back to our use of the broader concept of *effective* human capital. As in Dhont and Heylen (2009), effective human capital (and worker productivity) rise not only in accumulated schooling or training, but also in the productive efficiency of accumulated schooling. Education and active labor market expenditures directly contribute to more human capital being accumulated, public R&D and fixed investment expenditures will mainly raise the productive efficiency of accumulated human capital. The hypothesis that public investment and infrastructure services may also matter for aggregate human capital, next to education expenditures, has been developed recently by Agénor (2008).

Equation (14) shows our specification for the growth rate of effective human capital for each ability group a . We adopt a flexible CES-specification in education time when young (e_a) and productive government expenditures in % of output (g_y). We add the quality of education (q_a) in a multiplicative way. We allow q_a to vary across countries in later Sections. Next to q_a we introduce (constant, common) technical parameters: ϕ_a is a positive efficiency parameter, σ a scale parameter, ν is a share parameter and κ the elasticity of substitution. These parameters will be calibrated. Note in Equation (14.b) that low ability individuals supply no education time, but they also enjoy positive effects on their effective human capital and productivity from productive government expenditures.

$$\Psi_a(e_a, g_y, q_a) = \phi_a q_a \left(\nu g_y^{1-(1/\kappa)} + (1-\nu) e_a^{1-(1/\kappa)} \right)^{\sigma \kappa / (\kappa - 1)}, \forall a = H, M \quad (14.a)$$

$$\Psi_L(g_y, q_L) = \phi_L q_L g_y^\sigma \quad (14.b)$$

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

Equation (7) above describes the different capacity of individuals with different ability to inherit human capital and assimilate existing knowledge. Equation (15) captures the elements behind this. A major exogenous element is obviously 'nature'. Next to nature, however, the quality of the schooling system may play a role. It is well-known for example that PISA scores at the bottom of the distribution, as well as the variance of PISA scores, differ substantially across countries. Some countries seem better able than others to develop and improve skills among youngsters with lower

innate ability. Nature is reflected in Equation (15) by the two exogenous and constant parameters ε_{L0} and ε_{M0} . We will calibrate these. As a proxy for the quality of the schooling system in a country, and its capacity to bring knowledge and skills also to people without the highest ability, we will use relative PISA science scores. Basically we use the normalized ratio of the mean PISA score to the PISA score at the 83 percentile $(q_M/q_H)_N$ as a proxy for the schooling system component behind ε_M . We use the normalized ratio of the PISA scores at the 17th and the 83th percentile $(q_L/q_H)_N$ as a proxy for the schooling system component behind ε_L . We normalize each ratio by its average across all countries in our sample. Due to nature these ratios will be smaller than 1 in each country. Low ability individuals will obviously have lower PISA test scores everywhere. Normalized ratios are informative about the extent to which the schooling system in each particular country can change this. Algebraically,

$$\varepsilon_L = \left(\frac{q_L}{q_H}\right)_N \varepsilon_{L0}, \quad \varepsilon_M = \left(\frac{q_M}{q_H}\right)_N \varepsilon_{M0}, \quad \varepsilon_H = \varepsilon_{H0} = 1 \quad \varepsilon_{H0} > \varepsilon_{M0} > \varepsilon_{L0} \quad (15)$$

3.3. Domestic firms, output and factor prices

Firms act competitively on output and input markets and maximize profits. All firms are identical. Total domestic output (Y_t) is given by the production function (16). Technology exhibits constant returns to scale in aggregate physical capital (K_t) and effective labor (H_t), so that profits are zero in equilibrium. Equation (17) describes aggregate effective labor as the sum of effective labor supplied by the three ability groups.

$$Y_t = K_t^\alpha H_t^{1-\alpha} \quad (16)$$

$$H_t = H_{t,H} + H_{t,M} + H_{t,L} \quad (17)$$

Equation (18) specifies effective labor per ability group.

$$\begin{aligned} H_{t,a} &= n_{1a}^t h_{1a}^t + n_{2a}^{t-1} h_{2a}^{t-1} + n_{3a}^{t-2} h_{3a}^{t-2} \\ &= \left(n_{1a}^t + n_{2a}^{t-1} \frac{x_{a,t-1}}{x_{t-1}} + n_{3a}^{t-2} \frac{x_{a,t-2}}{x_{t-1}x_{t-2}} \right) h_{1a}^t, \quad \forall a = H, M, L \end{aligned} \quad (18)$$

Substituting this equation for H , M and L into (17), and recognizing differences in the capacity ε to inherit human capital as indicated by Equations (6) and (7), yields Equation (19).

$$H_t = \left[\sum_{a=H,M,L} \varepsilon_a \left(n_{1a}^t + n_{2a}^{t-1} \frac{x_{a,t-1}}{x_{t-1}} + n_{3a}^{t-2} \frac{x_{a,t-2}}{x_{t-1}x_{t-2}} \right) \right] h_{1H}^t \quad (19)$$

To derive Equation (18) we make use of Equations (8) and (9) and we define:

$$x_{a,t} \equiv 1 + \psi_a (e_a^t, g_y, q_a) \quad (20)$$

It then follows that: $h_{3a}^{t-j} = h_{2a}^{t-j} = x_{a,t-j} h_{1a}^{t-j}$, $\forall a = H, M, L$.

Furthermore, we exploit the result that⁵: $h_{1a}^t = x_{t-1}h_{1a}^{t-1} = x_{t-1}x_{t-2}h_{1a}^{t-2}$ (21)

$$\text{where by definition: } x_t \equiv \frac{x_{H,t} + \varepsilon_M x_{M,t} + \varepsilon_L x_{L,t}}{3}.$$

Competitive behavior implies in Equation (22) that firms carry physical capital to the point where its after-tax marginal product equals the world real interest rate (see also Backus *et al.*, 2008). We assume no depreciation of physical capital. Capital taxes are source-based: the tax rate τ_k applies to the country in which the capital is used, regardless of who owns it. The real interest rate being given, firms will install more capital when the amount of effective labor increases or the capital tax rate falls. In that case the net return to investment in the home country rises above the world interest rate, and capital flows in. Furthermore, perfect competition implies equality between the real wage and the marginal product of effective labor (Equation 23). Higher real wages follow from an increase in physical capital per unit of effective labor. Taking into account (22), real wages per unit of effective labor will therefore fall in the world real interest rate and in domestic capital tax rates.

$$\alpha \left(\frac{H_t}{K_t} \right)^{1-\alpha} (1-\tau_k) = r_t \quad (22)$$

$$(1-\alpha) \left(\frac{K_t}{H_t} \right)^\alpha = w_t \quad (23)$$

Substituting (19) for H_t and (22) for K_t/H_t , we can rewrite (16) as

$$Y_t = \left(\frac{K_t}{H_t} \right)^\alpha H_t \\ = \left[\frac{\alpha(1-\tau_k)}{r_t} \right]^{\alpha/(1-\alpha)} \left[\sum_{a=H,M,L} \varepsilon_a \left(n_{1a}^t + n_{2a}^{t-1} \frac{x_{a,t-1}}{x_{t-1}} + n_{3a}^{t-2} \frac{x_{a,t-2}}{x_{t-1}x_{t-2}} \right) \right] h_{1H}^t$$

If we finally recognize that in steady state r , τ_k , x_a , e_a and n_{ja} are constant, we obtain the long-run (per capita) growth rate of the economy as :

⁵ Starting from Equation (6), and using (8), it is easy to see that:

$$h_{1H}^t = \frac{h_{2H}^{t-1} + h_{2M}^{t-1} + h_{2L}^{t-1}}{3} = \frac{x_{H,t-1}h_{1H}^{t-1} + x_{M,t-1}h_{1M}^{t-1} + x_{L,t-1}h_{1L}^{t-1}}{3} \\ = \frac{(x_{H,t-1} + \varepsilon_M x_{M,t-1} + \varepsilon_L x_{L,t-1})}{3} h_{1H}^{t-1} = x_{t-1} h_{1H}^{t-1}$$

Human capital of the lower ability individuals (a= M, L) will grow at the same rate ($\frac{h_{1a}^t}{h_{1a}^{t-1}} = \frac{\varepsilon_a h_{1H}^t}{\varepsilon_a h_{1H}^{t-1}} = \frac{h_{1H}^t}{h_{1H}^{t-1}}$)

which explains the first part of Equation (24). Lagging this result by one period, generates the second part.

$$\begin{aligned}
\ln\left(\frac{Y_t}{Y_{t-1}}\right) &= \ln\left(\frac{h_{1H}^t}{h_{1H}^{t-1}}\right) = \ln(x_{t-1}) \\
&= \ln\left(\frac{\left(1 + \psi_H(e_H^{t-1}, g_y, q_H)\right) + \varepsilon_M\left(1 + \varepsilon_M\psi_M(e_M^{t-1}, g_y, q_M)\right) + \varepsilon_L\left(1 + \varepsilon_L\psi_L(g_y, q_L)\right)}{3}\right)
\end{aligned} \tag{24}$$

In line with earlier models (e.g., Lucas, 1988; Azariadis and Drazen, 1990; Buiter and Kletzer, 1993), the long-run (per capita) growth rate is positively related to the quality of schooling (q) and to the fraction of time that young people allocate to education (e). It is also positively related to the share of productive government expenditures (g_y), like in Barro (1990). Growth will rise also if lower and medium ability young individuals incorporate a larger fraction of average human capital of the middle aged generation (ε). Quality of schooling may also play a role here (Equation 15).

3.4. Government

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

$$G_{yt} + G_{ct} + B_t + P_t + E_t + Z_t = T_{nt} + T_{kt} + T_{ct} \tag{25}$$

with:

$$\begin{aligned}
G_{yt} &= g_y Y_t \\
G_{ct} &= g_c Y_t \\
B_t &= B_{t,H} + B_{t,M} + B_{t,L} \\
P_t &= P_{t,H} + P_{t,M} + P_{t,L} \\
E_t &= (e_H^t + e_M^t) e s \\
Z_t &= 12 z_t
\end{aligned}$$

$$\begin{aligned}
T_{nt} &= T_{nt,H} + T_{nt,M} + T_{nt,L} \\
T_{kt} &= \tau_k \alpha Y_t \\
T_{ct} &= \tau_c \sum_{j=1}^4 \left(c_{j,H}^{t+1-j} + c_{j,M}^{t+1-j} + c_{j,L}^{t+1-j} \right).
\end{aligned}$$

And $\forall a = H, M, L$:

$$\begin{aligned}
B_{t,a} &= (1 - n_{1a}^t - e_a^t) b_{1a} w_t h_{1a}^t (1 - \tau_{1a}) + \sum_{j=2}^3 (1 - n_{ja}^{t+1-j}) b_{ja} w_t h_{ja}^{t+1-j} (1 - \tau_{ja}) \\
P_{t,a} &= b_4 \sum_{j=1}^3 \left(\frac{1}{3} w_{t+j-4} h_{ja}^{t-3} n_{ja}^{t-3} (1 - \tau_{ja}) \right) \\
T_{nt,a} &= \sum_{j=1}^3 n_{ja}^{t+1-j} w_t h_{ja}^{t+1-j} \tau_{ja}.
\end{aligned}$$

Note our assumption that each ability group has size 1 and that each generation has size 3. Following Turnovsky (2000) and Dhont and Heylen (2009), we assume that the government claims given fractions g_y and g_c of output for productive expenditures and consumption. Non-employment benefits (B_t) are an unconditional source of income support related to inactivity ('leisure') and non-market household activities. Although it may seem strange to have such transfers in a model without involuntary unemployment, one can of course analyse their employment and growth effects as a theoretical benchmark case (see also van der Ploeg, 2003; Rogerson, 2007; Dhont and Heylen, 2008, 2009). Moreover, there is also clear practical relevance. Unconditional or quasi unconditional benefits to structurally non-employed people are a fact of life in many European countries.

4. Parameterization and empirical relevance of the model

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

4.1. Preference and technology parameters

Table 2 contains an overview of all parameters. Following among others Barro (1990), we set the rate of time preference equal to 2% per year. Considering that periods in our model consist of 15 years, this choice implies a discount factor β equal to 0.74. With respect to effective labor, we assume a share coefficient $1-\alpha$ equal to 0.7. This value is well in line with the literature. For example, King and Rebelo (1990) also model goods production as a function of effective labor (human capital) and physical capital. They assume a value for $1-\alpha$ equal to $2/3$. There is more controversy in the literature about the value of the intertemporal elasticity of substitution in leisure ($1/\theta$). Micro studies often reveal very low elasticities. However, given our macro focus, these studies may not be the most relevant ones. Rogerson and Wallenius (2009) show that micro and macro elasticities may be unrelated. Rogerson (2007) also adopts a macro framework. He puts forward a reasonable range for θ from 1 to 3 (Rogerson, 2007, p. 12). In line with this, we impose θ to be equal to 2. The world real interest rate is assumed constant and equal to 3% per year, which is approximately the average real return on 10 year US government bonds in the last decade. Considering a period of 15 years, this implies that $r = 0.558$.

A second series of parameters have been determined by calibration. We calibrated the two human capital inheritance parameters (ε_{L0} and ε_{M0}) on data for relative wages of young workers with below upper secondary education, upper secondary education and tertiary education in the US. Taking relative wages as reference follows from our model, where $\varepsilon_L = wh_{1L}/wh_{1H}$ and $\varepsilon_M = wh_{1M}/wh_{1H}$. We choose the US because here relative wages are expected to reflect productivity

differences best. In many other countries unions and/or minimum wage regulation may disturb the link between productivity and wages⁶. The results of our calibration suggest that young individuals with medium ability assimilate about 65% of available human capital and knowledge, individuals with low ability about 50%. Furthermore, we calibrated three taste for leisure parameters ($\gamma_1, \gamma_2, \gamma_3$) and four parameters in the human capital production function: the efficiency parameters (ϕ_H, ϕ_M and ϕ_L) and the scale parameter (σ). Five of these ($\gamma_1, \gamma_2, \gamma_3, \phi_H$ and σ) have been calibrated to the average employment and growth performance of all 13 countries in our study. They have been determined such that with observed average levels of the fiscal policy variables (tax rates, benefit replacement rates, etc.) and the observed average levels of schooling quality (q)⁷ over all countries, the model correctly predicts the average of these countries' employment rates by age (n_1, n_2, n_3), per capita growth rates, and education rates (e) in 1995-2007. The bottom part of Table 2 reports these average employment, growth and education rates. We find that the taste for leisure rises with age ($\gamma_1=0.044, \gamma_2=0.129, \gamma_3=0.263$). Furthermore, we observe decreasing returns in human capital growth ($\sigma=0.77$)⁸. Given ϕ_H , the efficiency parameters ϕ_M and ϕ_L can again be determined from relative wages of middle aged workers in the US⁹.

Finally, we had no strong ex ante indication on two parameters in the human capital production function: the share parameter ν and the elasticity of substitution parameter κ . We could assign sensible values to these parameters thanks to a sensitivity analysis on the results that we report in the next section. There we evaluate the capacity of our model to explain five important macro variables in 13 OECD countries. Our guideline to pin down specific values for ν and κ was to minimize the deviation of our model's predictions from the true data¹⁰. This procedure implied $\nu=0.25$ and $\kappa=0.55$. The result for κ reveals a higher degree of complementarity between private education time and government expenditures than in the Cobb-Douglas case. The result for ν demonstrates relatively high importance for human capital formation of private education time versus productive public expenditures.

⁶ More precisely, earnings of workers of age 25-34 with below upper secondary education (secondary education) in the US are equal to about 45% (62%) of earnings of workers with a tertiary degree (OECD Education at a Glance, 2009, Table A7). This earnings difference may reflect 'nature' and the quality of the schooling system, as in Equation (15). Dividing the above mentioned relative wages by normalized relative PISA scores (q_L/q_H)_N and (q_M/q_H)_N for the US (which are below one, Table 5) allows to obtain a proxy for ε_{L0} and ε_{M0} .

⁷ And with the values of two parameters in the human capital production function (ν, κ) that we discuss below (see also footnote 10).

⁸ Changes in (the group of) countries for which we calibrate do not affect our basic parameters in any significant way (see Heylen and Van de Kerckhove, 2010).

⁹ For example, to determine ϕ_L we can make use of relative wage data for the US and the following equation:

$$\frac{w h_{2L}^t}{w h_{2H}^t} = \frac{x_{L,t} \varepsilon_L h_{1H}^t}{x_{H,t} h_{1H}^t} = \frac{x_{L,t}}{x_{H,t}} \cdot \varepsilon_L$$

With what we know about ϕ_H and ε_L there is only one unknown left.

¹⁰ For each variable ($n_1, n_2, n_3, e, \text{growth}$) we computed the root mean squared error normalized to the mean. We minimized the average normalized RMSE over all five variables. (Minimizing only over e and growth implied the same values for ν and κ). We then adopted the following iterative procedure. Given chosen values for ν and κ we calibrated the efficiency parameter ϕ and the scale parameter σ . The values for ν and κ had no influence on the calibration results for γ . Given the values for ϕ and σ , we checked whether changes in ν and κ could further improve the model's explanatory power. New values for ν and κ led to a recalibration of ϕ and σ , etc.

Table 2 Basic parameterization and benchmark equilibrium

Technology and preference parameters				
Production	$1 - \alpha = 0.7$			
Effective human	$\phi_H = 5.950, \phi_M = 5.796, \phi_L = 2.528, \nu = 0.25, \kappa = 0.55, \sigma = 0.774$			
Human capital	$\varepsilon_{M0} = 0.65, \varepsilon_{L0} = 0.50$			
Preference	$\beta = 0.74, \theta = 2, \gamma_1 = 0.044, \gamma_2 = 0.129, \gamma_3 = 0.263$			
World real interest	$r = 0.558$			
Fiscal policy parameters in benchmark ^(a, b)				
Government	$g_y = 9.9, g_c = 15.9, b_{1L} = b_{2L} = b_{1M} = 62.8, b_{3L} = 65.7$ $b_{2M} = b_{1H} = 49.8, b_{3M} = 54.4, b_{2H} = 39.7, b_{3H} = 45.6, b_4 = 68.3$			
Tax rates (in %)	$\tau_k = 22.1, \tau_c = 14.3, \tau_{jL} = \tau_{1M} = 50.7, \tau_{2M} = \tau_{3M} = \tau_{1H} = 52.5, \tau_{2H} = \tau_{3H} = 53.6$			
Average schooling quality (benchmark)	$q_M = 0.507, q_L = 0.406, q_H = 0.608$			
Benchmark equilibrium ^(a)				
n_1	n_2	n_3	Per capita growth (annual)	e
55.0	63.7	43.6	1.91 %	16.7 %

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

4.2. Fiscal policy and education quality

Tables 3 and 4 describe key characteristics of fiscal policy in 1995-2001/2004. Our proxy for the tax rate on labor income concerns the total tax wedge, for which we report the marginal rate in %. The data cover personal income taxes, employee and employer social security contributions payable on wage earnings and payroll taxes. The OECD publishes these marginal tax data for several family and income situations. We use OECD tax rates on low income earners as a proxy for labor tax rates on low skilled individuals and young medium skilled individuals in our model. In our benchmark economy, these categories of workers earn about 67% or less of the aggregate average wage. Along the same line, we use OECD tax rates on average wage earners as a proxy for middle aged and older medium skilled individuals, as well as young high skilled individuals, in our model. These workers earn about 100% of the average wage in the model. Finally, we use OECD tax rates on high income earners as a proxy for middle aged and older high skilled individuals in our model. For further details, see Appendix 1. As one can see in Table 3, however, differences within countries between these tax rates are very small. Cross-country differences are much bigger. Belgium, Germany, Sweden and Finland have marginal labor tax rates above 55% or even 60%. The US and the UK have marginal labor tax rates below, or close to, 40%. Capital tax rates are effective marginal corporate tax reported by the Institute for Fiscal Studies (their EMTR). Germany and Belgium have the highest rates. In contrast to labor (and consumption), capital is taxed relatively little in the Nordic countries. As to consumption taxes, we follow Dhont and Heylen (2009) in computing them as the ratio of government indirect tax receipts (net of subsidies paid) to total domestic demand net of indirect taxes and subsidies. Our simplifying assumption is that consumption tax rates correspond to aggregate indirect tax rates. The Nordic countries stand out with the highest consumption tax rates, the US with the lowest. for 1995-2001, see also Devereux *et al.*, 2002). Consumption tax rates are from Dhont and Heylen (2009). Data are for 1995-2001.

Table 3 Fiscal policy (Tax rates)

	tax rate on labor of low wage earners (%)	tax rate on labor of medium wage earners (%)	tax rate on labor of high wage earners (in %)	consumption tax rate (%)	tax rate on capital income (%)
Proxy for :	τ_{L}, τ_{LM}	$\tau_{2M}, \tau_{3M}, \tau_{1H}$	τ_{2H}, τ_{3H}	τ_c	τ_k
Austria	55.9	57.2	49.0	13.2	17.3
Belgium	66.9	66.7	69.0	13.4	27.1
France	52.5	52.1	55.1	17.1	21.7
Germany	59.1	63.1	56.8	11.1	34.4
Italy	53.4	56.1	57.9	14.7	14.9
Netherlands	52.3	52.3	51.9	12.2	24.3
Denmark	45.0	47.8	55.6	18.9	22.5
Finland	54.4	56.7	59.0	15.2	17.2
Norway	44.3	55.1	55.1	16.4	22.1
Sweden	53.7	55.1	60.9	17.9	16.1
UK	39.8	39.8	43.4	14.5	21.2
US	34.3	34.3	39.6	7.2	23.6
Canada	47.9	46.0	43.2	14.5	24.8
Overall country average	50.7	52.5	53.6	14.3	22.1

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

Table 4 summarizes our data for the expenditure side of fiscal policy. A first variable is our proxy for the net non-employment benefit replacement rate (b_{ja}). Since in our model non-employment is a structural or equilibrium phenomenon, the data that we use concern net transfers received by structurally or long-term unemployed people. They include social assistance, family benefits and housing benefits in the 60th month of benefit receipt. They also include unemployment insurance or unemployment assistance benefits if these benefits are still paid, i.e. if workers can be structurally unemployed for more than five years without losing benefit eligibility¹¹. The data are expressed in percent of after-tax wages. In line with our approach to determine labor tax rates by skill level, we are again guided by the same income cases to determine b_{jH} , and b_{jM} and b_{jL} , at least for young and middle aged workers. Benefit replacement rates for older workers are typically higher, at least in some countries due to the availability of generous early retirement regimes¹². Overall, the euro area and the Nordic countries pay the highest net benefits. The only exception is Italy. Transfers to structurally non-employed people are by far the lowest in the US.

Our data for productive government expenditures (g_y) in Table 4 include education (except study grants to households), active labor market expenditures, government financed R&D and public investment, in percent of GDP. On average, education expenditures constitute close to 60% of total

¹¹ This is the case in Austria, Belgium, France, Germany, Finland, Ireland, and the UK. Workers cannot be structurally non-employed and still receive unemployment benefits in the Netherlands, Italy, Denmark, Norway, Sweden, Spain, Portugal, Switzerland and the US (OECD, 2004, www.oecd.org/els/social/workincentives, Benefits and Wages, country specific files).

¹² To assess the generosity of early retirement we rely on data for the implicit tax rate on continued work in the early retirement route (see Duval, 2003; Brandt *et al.*, 2005). For further details on the calculation of b_3 we refer to Appendix 1.

g_y . Governments in the Nordic countries allocate by far the highest fractions of output to productive expenditures. Productive expenditures in percent of GDP are the lowest in the UK. The US and most core countries of the euro area take intermediate positions. Government consumption in percent of GDP is the highest also in the Nordic countries, followed at close distance by several countries of the core euro area¹³. In the US, government consumption is (much) lower. As a final variable in Table 4 we include the net pension replacement rate. Available data concern an individual with mean earnings before retirement. They include only (quasi-)mandatory public pensions, and are expressed as a percentage of this individual's average lifetime labor income, as is the case in our Equation (10). Voluntary, occupational pensions are not included. The overall average replacement rate is 68.3%, but there are strong cross-country differences.

Table 4 Fiscal policy (net transfer replacement rates, government consumption, productive expenditures)

Proxy for :	Non-employment transfer, young and middle aged (net replacement rate, %) with income:			Non-employment transfer, older workers (net replacement rate, %) with income:			Pension replacement rate (net, in %)	government consumption (% of GDP)	government productive expenditures (% of GDP)
	Low	medium	high	Low	medium	high			
	b_{1L}, b_{2L} b_{1M}	$b_{2M},$ b_{1H}	b_{2H}	b_{3L}	b_{3M}	b_{3H}			
Austria	66.3	56.5	45.9	70.5	63.2	55.2	88.9	14.6	9.0
Belgium	73.5	58.9	46.3	78.6	67.7	58.3	63.1	16.9	8.8
France	60.8	44.7	32.3	66.0	53.9	44.6	68.8	18.3	10.8
Germany	71.8	61.7	60.5	72.9	65.3	64.4	71.8	15.3	8.5
Italy	20.0	17.1	13.8	37.5	35.3	32.2	88.8	14.3	8.0
Netherlands	72.0	53.0	40.1	74.9	60.7	51.0	84.1	18.4	9.8
Denmark	74.8	60.6	50.3	74.8	60.6	50.3	54.1	18.4	12.0
Finland	75.1	61.3	47.4	77.2	66.9	56.4	78.8	16.0	10.9
Norway	72.8	53.4	43.3	72.8	53.4	43.3	65.1	14.7	11.9
Sweden	71.5	53.5	41.3	71.5	53.5	41.3	68.2	20.0	13.6
UK	64.5	51.2	37.6	64.5	51.2	37.6	47.6	14.4	7.2
US	38.3	30.4	22.9	38.3	30.4	22.9	51.0	10.3	8.8
Canada	54.4	44.6	34.0	54.4	44.6	34.0	57.1	14.7	9.1
Overall country average	62.8	49.8	39.7	65.7	54.4	45.6	68.3	15.9	9.9

Notes: A description of all variables is given in the main text. For more details, see Appendix 1. The data for net benefit replacement rates are an average for 2001-2004 (earlier data are not available). The data for government consumption and productive expenditures concern 1995-2001. Pension replacement rates have been taken from OECD (Pensions at a Glance, 2005, p. 52). The data concern 2002.

A final set of data concern net education costs, and our indicator for education quality. Education costs include tuition fees, additional mandatory ancillary fees, costs of books and study material, and

¹³ Like Dhont and Heylen (2009) we calculate our data for government consumption as total government consumption in % of GDP, diminished with the fraction of public education outlays going to wages and working-expenses. The latter are included in productive expenditures.

living costs. Net costs can be obtained after deducting government grants. Net costs are among the highest in the US and the UK. They are among the lowest in the Netherlands, and the Nordic countries. We use PISA science score as a proxy for the quality of schooling (q) in the human capital production function (14). We concentrate on science scores given their expected closer link to growth. Although available PISA scores relate to secondary education, we do not see this as a weakness. PISA scores may be very informative about the quality that young people attain in secondary education, and with which some enter tertiary education. Quality at entrance should have a positive influence on people's capacity to learn and to raise human capital during tertiary education. Furthermore, PISA scores have been found empirically significant for growth (Hanushek and Woessmann, 2009). Finally, these scores are easily available for all countries, which is not obvious for 'better' quality indicators. The OECD presents the mean score obtained by pupils as well its standard deviation (q_{STDEV}). We use this mean as our indicator for q_M . The mean plus one standard deviation is relevant for high ability individuals (q_H), as only 16% will do better. The mean minus one standard deviation is relevant for low ability individuals (q_L). The mean score is best in Finland, followed by the Netherlands, Canada and the UK. Finland also shows the lowest standard deviation, the UK the highest. Average quality in the UK may be relatively good, but results at the lower end are relatively weak. Note that there is no correlation between productive government expenditures in Table 4 and the PISA score in Table 5. Correlation is -0.04. There is no correlation either if we restrict productive expenditures to education only. Both variables seem to tell different stories (see also Woessmann, 2003).

Table 5 Education (cost, subsidies, PISA science)

	Education cost (% GDP per capita)	Education grants (% of GDP per capita)	PISA- science (divided by 1000)	
Proxy for :	<i>ec</i>	<i>es</i>	q_M	q_{STDEV}
Austria	24.35	2.85	0.507	0.098
Belgium	18.31	0.91	0.505	0.104
France	26.12	4.92	0.502	0.107
Germany	23.54	1.14	0.502	0.106
Italy	24.24	0.94	0.480	0.102
Netherlands	23.51	13.51	0.525	0.098
Denmark	24.63	11.68	0.484	0.098
Finland	20.18	9.38	0.550	0.089
Norway	17.18	3.86	0.490	0.100
Sweden	23.57	10.37	0.507	0.101
UK	43.75	3.55	0.523	0.107
US	42.70	10.80	0.493	0.104
Canada	29.74	3.64	0.527	0.097
Overall country average	26.29	5.97	0.507	0.101

Note: Data source for education costs: Usher and Cervenán (2005), complemented for Denmark and Norway by Usher and Medow (2010). The data relate to 2003, except for Denmark and Norway (2008). The PISA science scores are an average for 2000, 2003 and 2006.

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

Can our model match the facts that we have reported in Table 1? In this section we confront our model's predictions with the true data for 1995-2007. Clearly, one should be aware of the serious limitations of such an exercise. First of all, our model is highly stylized and may (obviously) miss potential determinants of growth or employment. Second, even if we compute the true data in Table 1 as averages over a longer period, these averages need not be equal to the steady state. Countries may still be moving towards their steady state¹⁴. Third, this exercise only concerns the last 15 years. Due to lack of data – especially with respect to marginal labor tax rates and non-employment benefits before the mid 1990s – it is impossible for us to relate changes in growth and employment to changes in policy within countries over longer time periods. In spite of all this, if one considers the extreme variation in the predictions of existing calibrated models investigating the effects of fiscal policy in the literature (see Stokey and Rebelo, 1995), even a minimal test of the 'goodness of fit' of our model is informative. This information is important to assess the value of the simulation results that we present in the next section, and their reliability for policy analysis. In most papers in the literature a test of the external validity of the model is missing.

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

Figures 1 to 3 relate our model's predictions to actual observations for the three employment rates by age (aggregated over the three ability groups). We add the 45°-line, and also report the coefficient of correlation between predictions and facts. Our model performs quite well for the employment rates of middle aged and older workers (Figures 2 and 3). It correctly predicts the highest employment rates in the US and Canada and – within Europe – relatively strong employment in the Nordic countries and the UK. The model also correctly predicts the rather poor employment performance in countries like Germany and Belgium. Overall correlation in Figure 2 is 0.52, in Figure 3 it is 0.61. Moreover, the slope of the regression line (not shown) in both figures is very close to the 45°-line. This suggests that our model correctly assesses the size of the employment effects of fiscal policy differences across countries. The model explains less well, however, for The Netherlands in both figures, and for Italy in Figure 3. Deviations between the model and the facts are somewhat more important for the employment rate of young workers in Figure 1. We observe the largest differences for Finland and especially Italy. A major element behind the deviation for Italy may be underestimation of the fallback income position for structurally non-employed young workers. OECD data show very low replacement rates in Italy. However, as shown by Reyneri (1994),

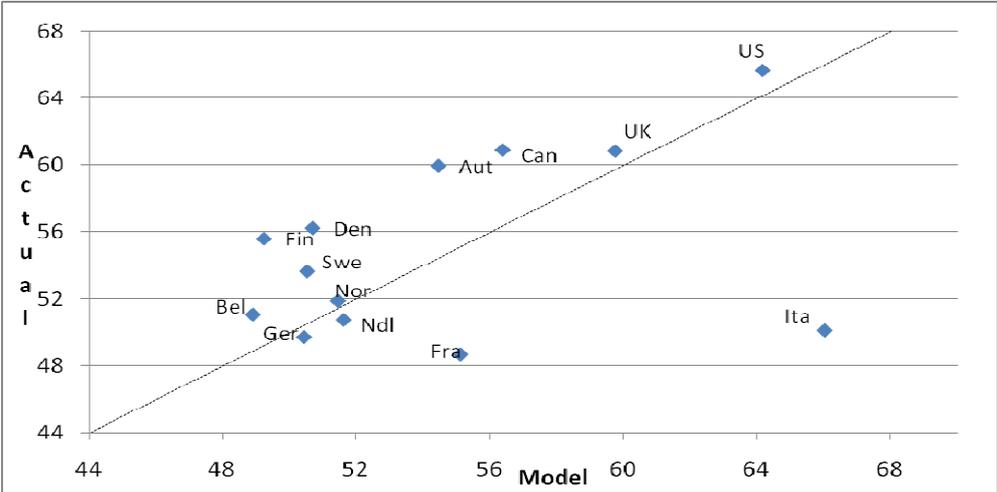
¹⁴ This argument explains why we have not included convergence countries like Ireland and Portugal in our dataset. It also explains why we calibrate technical and preference parameters to the average of all 13 countries, rather than to one individual country. Differences between actual and steady state values of individual countries may cancel out in this overall average.

the gap between Italy and the other European countries is much smaller than it seems¹⁵. Including Italy, correlation between our model’s predictions and the facts in Figure 1 is only 0.41. Excluding Italy, it is 0.75. Although the model tends to underestimate the employment rate of young workers in countries like Austria, Denmark and Finland, it has major differences between European countries and the US right.

In Figures 4 and 5 we relate our model’s predictions to the facts for education and growth. The model performs well for both variables. For education it correctly captures key differences between the Nordic countries on the one hand and countries like the UK and Italy on the other. Predictions for education are quite close to the 45°-line for all individual countries except Belgium, the Netherlands and Sweden. Correlation between predictions and facts in Figure 4 is 0.70. The model also has important cross-country differences right for growth. Correlation between predictions and facts in Figure 5 is 0.72. The model seems to have some difficulty to explain observed growth, however, in France and the UK.

Figure 6 compares our model’s predictions with the facts for the employment rate of the low ability group relative to the employment rate of high ability group (twice aggregated over the three generations). Our model has important cross-country differences right, for example between countries like Belgium and Germany on the one hand, and Sweden and Denmark on the other, but it tends to fail for Italy and the US. Underestimation of the fallback income position in case of non-employment for mainly the low-skilled, may be a major element explaining ‘failure’ in Italy (see footnote 15). As to the US, our model is not the only one that misses the rather low employment rate among low-skilled Americans. A large literature has tried to explain this (see The Economist, 2011 for a recent article).

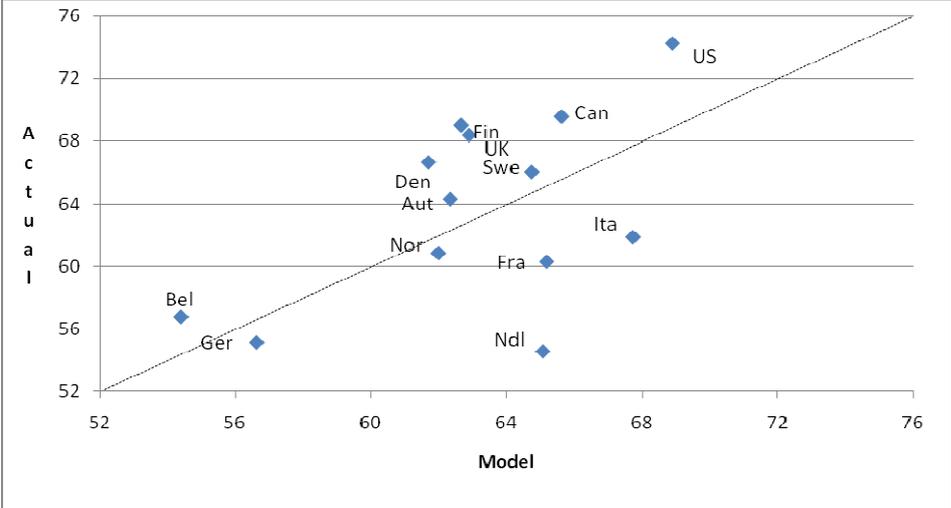
Figure 1. Employment rate in hours of young individuals in 13 countries, in %, 1995-2007



Note: The dotted line is the 45°-line. Correlation between actual data and the model’s predictions is 0.41. Excluding Italy correlation rises to 0.75.

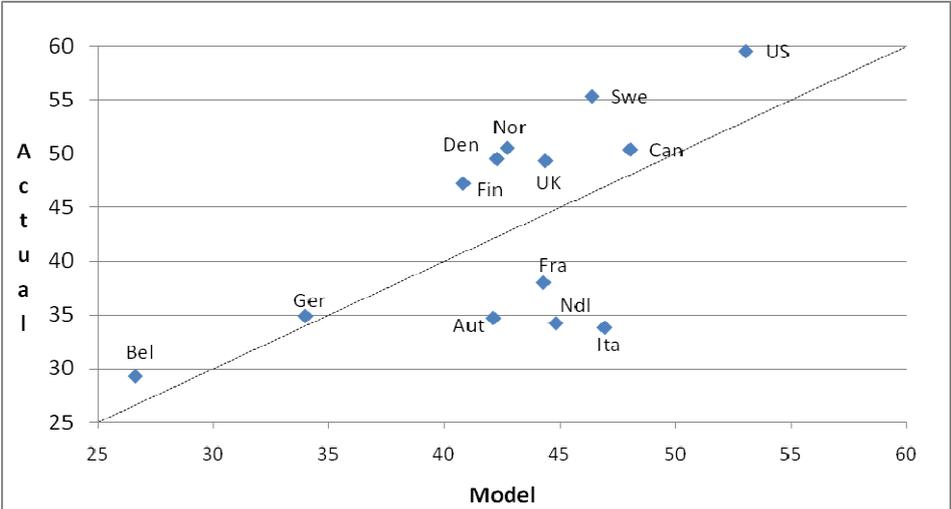
¹⁵ Reyneri (1994) points to the importance of family support as an alternative to unemployment benefits. Fernández Cordón (2001) shows that in Italy young people live much longer with their parents than in the other countries in our sample. In 1995 for example 56% of people aged 25-29 were still living with their parents in Italy. In about all other countries this fraction was below 23%. Of all non-working males aged 25-29 in Italy more than 80% were living with their parents. In France or Germany corresponding numbers were close to 40%.

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



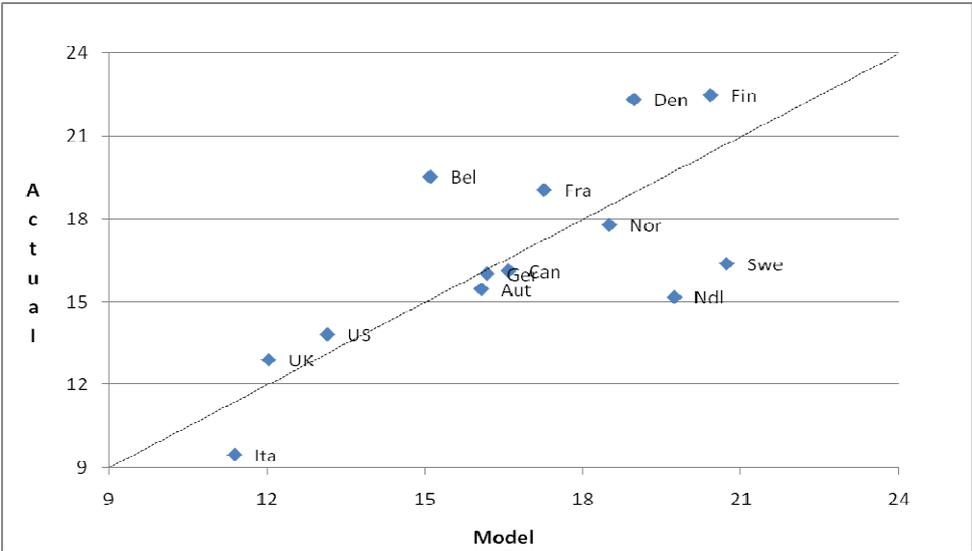
Note: The dotted line is the 45°-line. Correlation between actual data and the model’s predictions is 0.52.

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



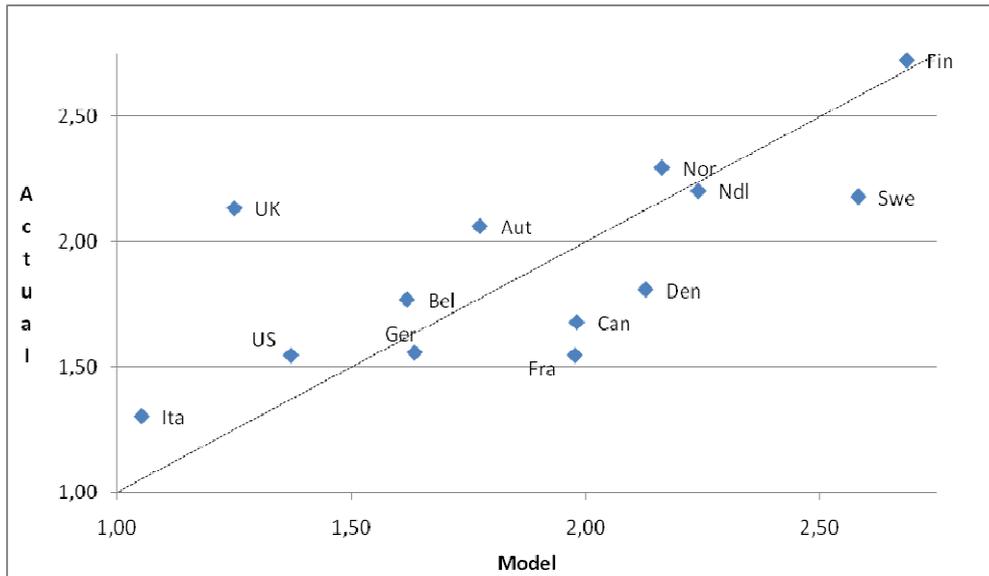
Note: The dotted line is the 45°-line. Correlation between actual data and the model’s predictions is 0.61.

Figure 4. Effective tertiary education rate in individual countries, in %, 1998-2007



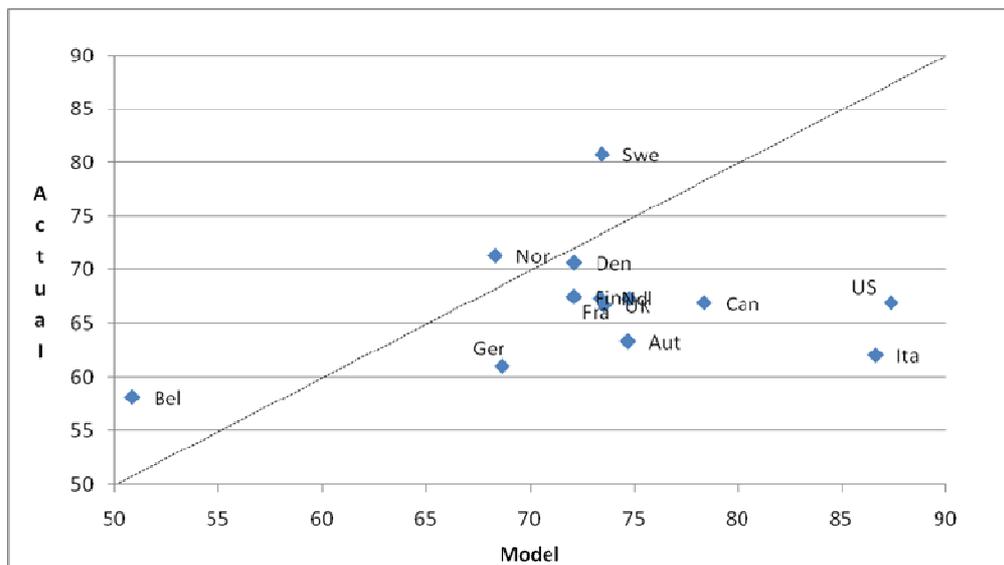
Note: The dotted line is the 45°-line. Correlation between actual data and the model’s predictions is 0.70.

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



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

Figure 6 Relative employment of low skilled (n_L/n_H) in % in 13 OECD countries (average for 1995, 2000, 2006)



5. Numerical steady state and welfare effects of fiscal policy shocks

Having established the empirical relevance of our model, we now simulate a series of fiscal policy shocks. Our aim is to discover the (relative) effectiveness of changes in individual policy variables for the employment rate of three age groups, the employment rate of three ability groups, aggregate employment, and growth. We focus on steady state effects and welfare effects for current and future generations.

Starting from budget balance, we impose permanent (and unanticipated) shocks equal to 2% of initial output, i.e. output before any changes in employment or growth have taken place. We consider reductions in the tax rates and in the benefit replacement rates, and increases in

government expenditures. All shocks are therefore expected to increase employment. Our benchmark from which we start, and against which all policy shocks are evaluated, is the average of 13 countries as reported in Table 2¹⁶. Table 6 considers the effects of policy changes on steady state growth and employment, assuming that policy changes are financed by changes in lump sum transfers (z) to maintain budget balance. In Table 7 we assume shocks to be compensated by a change in another fiscal policy variable.

Figures 7 and 8 show welfare effects on the current and future generations of the high and low ability groups of the policy measures described in Table 7. Effects for the medium group are in between. We report on the vertical axis the welfare effect on the generation born in $t+k$, where k is indicated on the horizontal axis, and where t is the period when the (permanent, unanticipated) policy change is introduced. Our welfare measure is the (constant) percentage change in benchmark consumption in each period of remaining life that individuals should get to attain the same lifetime utility as after the policy shock (see also King and Rebelo, 1990).

Our main findings are as follows:

- (i) We confirm our earlier results in Heylen and Van de Kerckhove (2010) that the most effective policy to promote aggregate employment should include an overall cut in non-employment benefits, i.e. a cut for all age and ability groups (policy 3 in both Table 6 and Table 7). A key element is that this policy strongly raises the marginal utility from work versus inactivity. We observe positive responses among all age and ability groups. The young and the older tend to respond somewhat more. Overall labor tax cuts in policy 1 have much smaller effects, especially when financed by consumption taxes (Table 7).
- (ii) The most effective fiscal policies to promote growth include an increase in productive government expenditures and a labor tax cut on older workers (policies 2 and 4 in both tables). Both these policies raise the marginal return to education, either by making education time more productive, or by encouraging individuals to work longer during their third period. Aggregate employment effects from policy 2 are still positive, but smaller than from policy 3, mainly because the young (of medium and high ability) cut hours worked and study more.
- (iii) Figures 7 and 8 reveal that the future generations of all ability groups benefit most from policies including higher productive expenditures (financed by a reduction of government consumption¹⁷). This holds also for the low ability individuals, who inherit (a fraction of) the effective human capital accumulated by high and medium ability groups. For current generations, however, especially older and retired individuals, and individuals with low ability, this policy induces a welfare loss.
- (iv) Welfare differences by ability are even more explicit under policy 2. With the exception of the retired, who pay higher consumption taxes but receive no compensating gain, all high ability individuals see their welfare increase after a labor tax cut on older workers. For future high skilled generations, policy 2 is the second best among the fiscal policy measures that we have simulated. Low ability individuals see much smaller welfare gains. The current generation of young (and retired) even lose significantly.

¹⁶ The choice of 2% is arbitrary. Imposing smaller or larger shocks would not generate different results as far as the sign and the relative size of effects is concerned. Our main conclusions do not change either if we impose the same policy shocks on a different benchmark, i.e. a different initial set of policy parameters and initial employment and growth (but the same preference and technology parameters). The size of effects is somewhat larger for example starting from the core euro area as benchmark.

¹⁷ The same results follow from financing by means of higher consumption taxes for example.

Table 6. Fiscal shocks in the model (equal to 2% of output, ex ante) - compensated by changes in lump sum transfers (z)

Change in policy variable ^(a)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\Delta\tau$ =-2.9	$\Delta\tau_3$ = -11.3	Δb = -8.7	Δg_y = +2.0	$\Delta\tau_L$ = -13.8	$\Delta\tau_3$ =-9.3, $\Delta\tau_L$ = -2.5	GRANTS (es) x 2	$\Delta\tau_1$ = -10.5	$\Delta\tau_{1L}$ = -34.1
Effect ^(b) :									
Δn_1	0.36	-1.88	2.15	-1.81	0.71	-1.42	-0.99	5.18	2.00
Δn_2	0.88	0.15	1.60	1.33	1.01	0.33	0.18	-0.87	-0.70
Δn_3	1.35	5.78	2.58	1.71	1.56	5.06	0.22	-1.16	-1.06
Δe	0.28	1.85	-0.59	2.28	0.05	1.54	1.05	-2.93	0.09
Δn ^(b, c)	0.84	1.09	2.07	0.37	1.07	1.11	-0.21	1.10	0.11
$\Delta N/N$ ^(d)	1.53	1.99	3.77	0.68	1.94	2.02	-0.38	2.01	0.21
Δn_H	0.42	0.12	1.81	-0.51	0.51	0.21	-0.40	1.60	0.47
Δn_M	0.83	0.98	2.03	0.25	0.91	1.00	-0.39	1.25	0.85
Δn_L	1.27	2.18	2.38	1.39	1.79	2.13	0.17	0.47	-0.98
Δ annual growth rate ^(b)	0.02	0.12	-0.04	0.40	0.00	0.10	0.07	-0.22	0.01
Δz ex-post ^(e)	-2.50	-2.85	2.72	-1.41	-2.79	-2.83	-0.19	-2.92	-2.59

Notes : (a) change in policy variable, in percentage points

(b) difference in percentage points between new steady state and benchmark, except $\Delta N/N$

(c) change in (weighted) aggregate employment rate in hours

(d) change in volume of employment in hours, in %. Approximately, $\Delta N/N = \Delta n/n$ with N total hours worked (and assuming potential hours constant)

(e) change in lump sum transfer (as a fraction of output) to maintain budget balance, in %-points.

- (v) Overall benefit cuts in policy 3 may be most effective to promote employment, but its long-run welfare effects are among the poorest of all fiscal policy measures. A key element is that since benefits are related to a person's human capital, they constitute part of the return to studying. Lower benefit replacement rates are therefore negative for education (see also Tables 6 and 7), and long-run output and growth.
- (vi) Better overall employment effects, an improvement of the labor market position of the low ability group, and better welfare effects for this group, at a slight cost in terms of growth, are possible if one complements policies that cut labor taxes on older workers with labor tax cuts on the low skilled (policy 6). The best effects on employment follow if this combined tax cut is financed by overall benefit cuts (policy 6b in Table 7).
- (vii) Additional simulations (policy 9) reveal that focusing tax cuts on young low ability workers alone does not bring much gain, not even for the employment rate among the low ability group. Young workers would simply substitute hours worked when young for hours worked when middle aged and older.
- (viii) Policy 7 shows effects of a doubling of education grants. The financial cost of this policy is not comparable to the other policies, it is much smaller. This policy has significant positive effects on education time and growth, but relatively strong negative effects on the employment rate of the

young and the high and medium ability groups. When financed by an increase in consumption taxes, an increase in education subsidies is beneficial for all future generations' welfare, except the next generation of low skilled. But it implies welfare losses on all current generations, except the young high skilled.

Table 7. Fiscal shocks in the model (equal to 2% of output) - compensated by a change in another fiscal policy variable

Change in policy variable ^(a)	(1) $\Delta\tau$ =-2.9	(2) $\Delta\tau_3$ = -11.3	(3) Δb = -8.7	(4) Δg_y = 2.0	(5) $\Delta\tau_L$ = -13.8	(6a) $\Delta\tau_3$ = -9.3 $\Delta\tau_L$ = -2.5	(6b) $\Delta\tau_3$ = -9.3, $\Delta\tau_L$ = -2.5	(7) GRANTS x 2
Compensating change ^(e)	$\Delta\tau_c$ = 5.8	$\Delta\tau_c$ = 6.7	$\Delta\tau_c$ = -6.1	Δg_c = -1.4	$\Delta\tau_c$ = 6.4	$\Delta\tau_c$ = 6.6	Δb = -9.0	$\Delta\tau_c$ = 0.43
Effect ^(b) :								
Δn_1	-0.14	-2.46	2.66	-2.10	0.19	-1.99	0.78	-1.03
Δn_2	0.17	-0.70	2.37	0.91	0.24	-0.50	1.97	0.12
Δn_3	0.25	4.60	3.76	1.06	0.38	3.89	7.50	0.13
Δe	0.23	1.79	-0.52	2.25	-0.01	1.47	0.92	1.04
Δn ^(b, c)	0.09	0.24	2.87	-0.07	0.26	0.27	3.17	-0.27
$\Delta N/N$ ^(d)	0.16	0.43	5.23	-0.13	0.48	0.49	5.77	-0.49
Δn_H	0.00	-0.36	2.28	-0.76	0.00	-0.28	2.03	-0.43
Δn_M	0.06	0.11	2.85	-0.21	0.00	0.12	3.01	-0.44
Δn_L	0.22	0.97	3.49	0.77	0.79	0.97	4.47	0.09
Δ annual growth rate ^(b)	0.02	0.12	-0.04	0.39	0.00	0.10	0.06	0.07

Notes : (a) change in policy variable, in percentage points, except for q (absolute change).

(b) difference in percentage points between new steady state and benchmark, except $\Delta N/N$.

(c) change in (weighted) aggregate employment rate in hours

(d) change in volume of employment in hours, in %

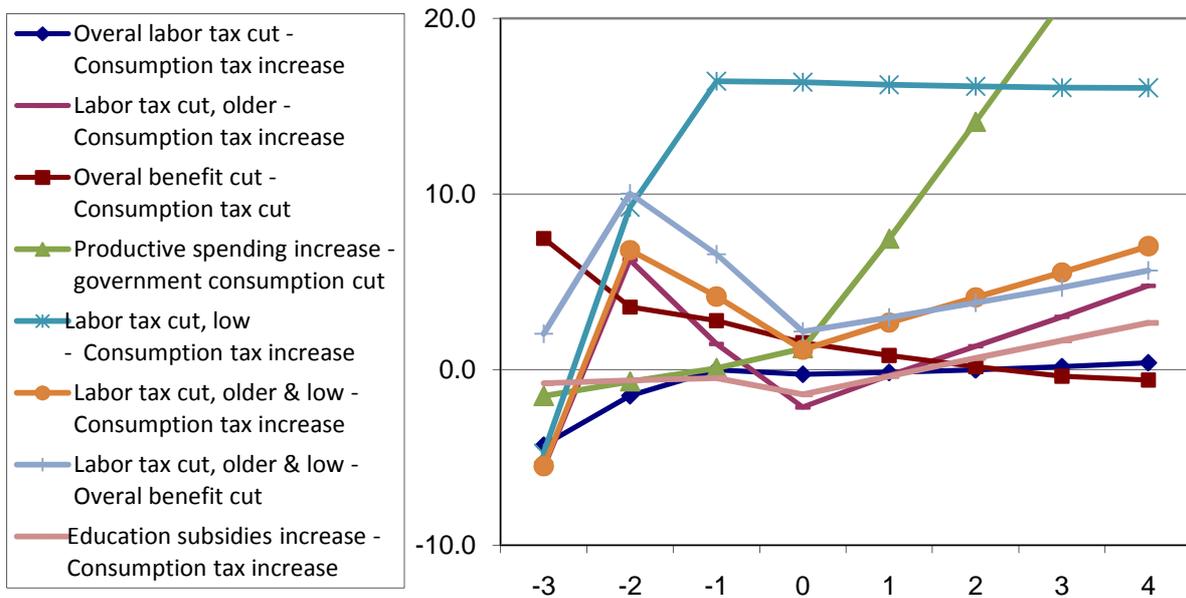
(e) compensating change, in percentage points

6. Conclusions

Rising pressure on the welfare state due to ageing forces all OECD countries to develop effective employment and growth policies. The need to raise employment is particularly pressing among older and lower skilled workers. Concern for employment and growth is not new. They have been high on the agenda of both policy makers and researchers since at least two decades.

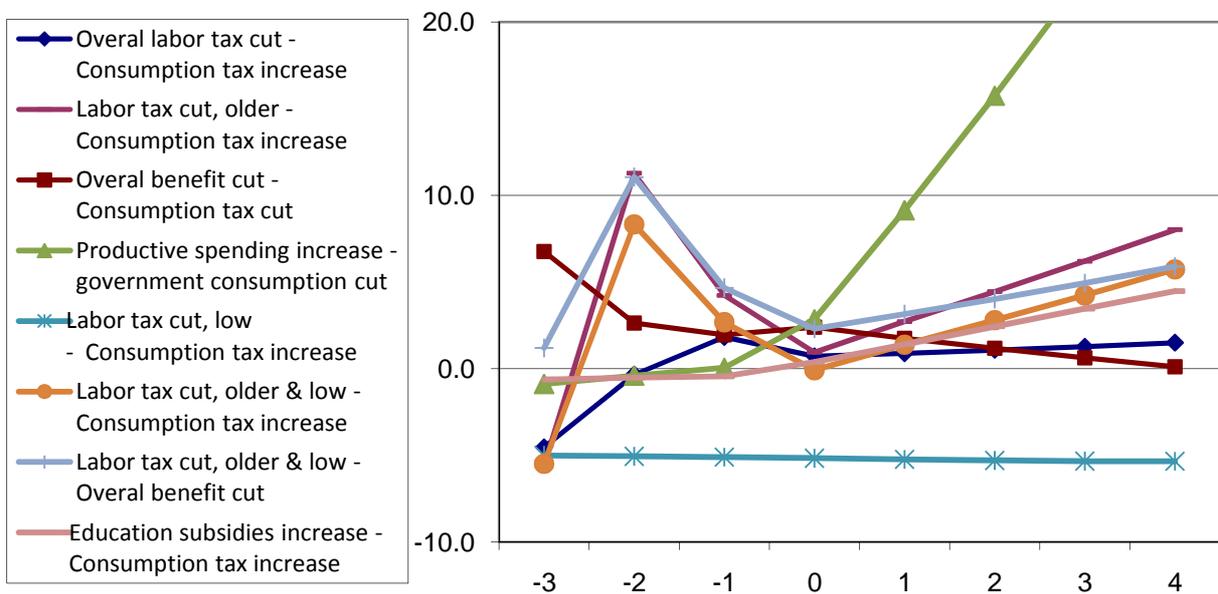
Our main contribution in this paper is to build and parameterize a general equilibrium OLG model for an open economy that explains hours of work of young, middle aged and older individuals of three ability types, education of the young, and aggregate growth, within one coherent framework. The composition of fiscal policy and several education policy instruments play a crucial role. The government sets tax rates on labor, capital and consumption. It allocates its revenue to productive

Figure 7. Welfare effects on current and future low ability individuals



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 .

Figure 8. Welfare effects on current and future high ability individuals



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 .

expenditures (mainly for education), study grants, consumption and non-employment benefits. Labor taxes and benefits may differ across age groups.

We evaluate the empirical relevance of our model on a group of 13 OECD countries. While we exploit cross-country differences in the composition of fiscal, and educational policy and quality, we impose the same labor and product market institutions (perfect competition), the same taste for leisure, and the same technology in all countries. We find that the predictions of our model match the main facts well for all key variables in a large majority of countries.

We then simulate our model to investigate the strength of the effects of various fiscal policy shocks on steady state employment by age and ability, and growth. Our main findings are as follows. First, we confirm our earlier results in Heylen and Van de Kerckhove (2010). We again identify labor taxes and (especially) 'non-employment' benefits as the main policy variables affecting employment. Productive government expenditures are the most effective with respect to long-run output and growth. Again we observe that output and growth may benefit also from labor tax cuts targeted at older workers. Second, however, a first new result in this paper, is that if these policies are imposed, they also imply clearly differential welfare effects between the ability groups. Current and near future low ability individuals may experience welfare losses. Third, better overall employment effects and better welfare effects for low ability groups, at a slight cost in terms of growth, are possible if one complements policies that cut labor taxes on older workers with labor tax cuts on all the low skilled. The best effects on employment follow if this combined tax cut is financed by overall benefit cuts.

A key policy implication of our results for many European countries would be to cut non-employment benefits, and to reallocate these resources to tax cuts on older workers, tax cuts on all the low-skilled, and higher productive expenditures.

Appendix 1: Construction of data and data sources

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

Employment rate in hours (in one of three age groups, 1995-2007)

Definition: total actual hours worked by individuals in the age group / potential hours worked.

Actual hours worked = total employment in persons x average hours worked per week x average number of weeks worked per year

Potential hours = total population in the age group x 2080 (where 2080 = 52 weeks per year x 40 hours per week)

Data sources:

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

* Average hours worked per week: OECD Stat, Labour Force Statistics, Average usual weekly hours worked on the main job. These data are available only for age groups 15-24, 25-54, 55-64. We use the OECD data for the age group 15-24 as a proxy for our age subgroup 20-24, the OECD data for the age group 25-54 as a proxy for our age (sub)groups 25-34, 35-49 and 50-54.

* Average number of weeks worked per year: Due to lack of further detail, we use the same data for each age group. The average number of weeks worked per year has been approximated by dividing average annual hours actually worked per worker (total employment) by average usual weekly hours worked on the main job by all workers (total employment). Data source: OECD Stat, Labour Force Statistics, Hours worked.

Employment rate by educational attainment

We use data for the employment/population ratio by educational attainment for persons of age 25-64. Our ratio n_L/n_H has been computed from data for people (both sexes) with less than upper secondary education and people with tertiary education. The data in Table 1 are an average for 1995, 2000 and 2006.

Data sources: OECD Employment Outlook, Statistical Annex, Table D.

Effective education rate of young, e (age group 20-34, 1998-2007)

Definition: total effective hours studied by individuals of age 20-34 / potential hours studied

This variable is constructed as the fraction of hours spent by young people in tertiary education, multiplied by the normalized completion rate of tertiary education, as shown in the Table below.

As a proxy for the fraction of hours spent by young people in tertiary education we use the ratio of students in tertiary education in full-time units, to population of age 20-34.

Not all hours need to be effective hours, however. Students may take more years than required to complete a degree. Some students may never complete it. Countries may differ in the incidence of ineffective hours. Our approach is that the completion rate gives an indication of the overall effectiveness of hours in tertiary education. This variable is computed as the ratio of the number of graduates from a degree in a particular year to the number of new entrants in this degree z years ago, where z is the number of years of full-time study required to complete the degree. We compute the effective time in tertiary education as the fraction of hours spent, multiplied by the completion rate normalized to the overall country average (see Table). We do not adjust by the absolute completion rate since that would imply that each successful year that a student spends in tertiary education would be classified as 'leisure' if he/she does not obtain the degree in the end.

Data sources:

* Students in tertiary education in full-time units: Eurostat, Students by ISCED level, study intensity (full-time, part-time) and sex [educ_enr1ad], levels 5-6. Missing data for some years in some countries were obtained by interpolation from existing data.

* Completion rate in tertiary education: OECD, Education at a Glance, 2009, Table A3.4.

	Unadjusted fraction of time in tertiary education, 1998-2007	Completion rate, 2005	Normalized completion rate	effective e
Austria	15,1	0,71	1,03	15,5
Belgium (FI)	16,5	0,82	1,19	19,5
France	16,7	0,79	1,14	19,1
Germany	14,4	0,77	1,11	16,0
Italy	14,5	0,45	0,65	9,5
Netherlands	14,8	0,71	1,03	15,2
Denmark	18,2	0,85	1,23	22,3
Finland	21,6	0,72	1,04	22,5
Norway	18,9	0,65	0,94	17,8
Sweden	16,4	0,69	1,00	16,4
US	20,3	0,47	0,68	13,8
UK	13,9	0,64	0,93	12,9
Canada	15,5	0,72	1,04	16,1
Overall average	16,7	0,69	1,00	16,7

Annual real potential per capita GDP growth rate (aggregate, 1995-2007)

Definition: Annual growth rate of real potential GDP per person of working age

Data sources:

* real potential GDP: OECD Statistical Compendium, Economic Outlook, supply block, series GDPVTR.

* population at working age: OECD Statistical Compendium, Economic Outlook, labour markets, series POPT.

Tax rate on labor income (τ_L , τ_M , τ_H)

Definition: Total tax wedge, marginal tax rate in %. The data cover personal income taxes, employee and employer social security contributions payable on wage earnings and payroll taxes.

Data source: OECD, Statistical Compendium, Financial and Fiscal Affairs, Taxing Wages, Comparative tax rates and benefits (new definition).

The OECD publishes these tax data for several family and income situations. We computed tax rates on low income individuals in our model (τ_{jL} and τ_{iM}) as the average of marginal tax rates for (i) a single person at 67% of average earnings (no children) and (ii) a one-earner married couple at 100% of average earnings (two children). We computed tax rates on medium income individuals in our model (τ_{2M} , τ_{3M} , τ_{iH}) as the average of tax rates for (i) a single person at 100% of average earnings (no children) and (ii) a two-earner married couple, one at 100% of average earnings and the other at 33 % (2 children). We computed tax rates on high income individuals in our model (τ_{2H} , τ_{3H}) as the average of tax rates for (i) a single person at 167% of average earnings (no children) and (ii) a two-earner married couple, one at 100% of average earnings and the other at 67 % (2 children). two-earner married couple at 100% of average earnings (2 children), (ii) a two-earner married couple,

Net benefit replacement rates when young and middle aged (b_{ja} for $j=1,2$ and $a=L,M,H$)

Definition: The data concern net transfers received by long-term unemployed people and include social assistance, family benefits and housing benefits in the 60th month of benefit receipt. They also include unemployment insurance or unemployment assistance benefits if these benefits are still paid, i.e. if workers can be structurally unemployed for more than five years without losing benefit eligibility. The data are expressed in % of after-tax wages. The OECD provides net replacement rates for six family situations and three earnings levels. In line with our assumptions for labor tax rates (see above), we computed b_{jL} with $j=1,2$ and b_{1M} as the average of the net benefit replacement rates for ‘families’ with earnings levels corresponding to 67% the average worker’s wage (AW). We computed b_{2M} and b_{1H} as the average of the net benefit replacement rates for ‘families’ with earnings levels corresponding to 100% of the average worker’s wage, and b_{2H} as the average of the net benefit replacement rates for ‘families’ with earnings levels corresponding to 167% of the average worker’s wage. The reported data are averages for 2001-2004.

Data source: OECD, Tax-Benefit Models, www.oecd.org/els/social/workincentives

Data adjustment: Original OECD data for Norway include the so-called “waiting benefit” (ventestønad), which a person could get after running out of unemployment benefits. Given the conditional nature of these “waiting benefits”, they do not match our definition of benefits paid to structurally non-employed individuals. We have therefore deducted them from the OECD data, which led to a reduction of net replacement rates by about 19 percentage points. For example, recipients should demonstrate high regional mobility and willingness to take a job anywhere in Norway. The “waiting benefit” was terminated in 2008. We thank Tatiana Gordine at the OECD for clarifying this issue with us.

Net benefit replacement rates when older (b_{3a} for $a=L,M,H$)

To calculate our proxy for b_{3a} we have taken into account the possibility for older workers in some countries to leave the labor market along fairly generous early retirement routes. Duval (2003) and Brandt *et al.* (2005) provide data for the so-called implicit tax rate on continued work for five more years in the early retirement route at age 55 and age 60. The idea is as follows. If an individual stops working (instead of continuing for five more years), he receives a benefit (early retirement, disability,...) and no longer pays contributions for his future pension. A potential disadvantage is that he may receive a lower pension later, since he contributed less during active life. Duval (2003) calculated the difference between the present value of the gains and the costs of early retirement, in percent of gross earnings before retirement. We use his data as a proxy for the gross benefit replacement rate for older workers in the early retirement route. To compute the net benefit replacement rate, we assume the same tax rate on early retirement benefits as on unemployment benefits. We call this net early retirement benefit replacement rate r_3 . (A problem is however that these data are not differentiated by income (skill) level. We have to assume that they are valid proxies for all skill levels).

If we look at the data, we observe that r_3 is higher than the net unemployment benefit replacement rate b_{2a} in some countries (e.g. Belgium, France, Netherlands,...) but not in others (Denmark, Norway, Sweden, US). It is unlikely that older workers will choose the early retirement option in the latter group of countries. They may however strongly prefer this option in the former group. The implication of these arguments is that we will assume $b_{3a} = b_{2a}$ in countries where $r_3 < b_{2a}$. By contrast, in countries where $r_3 > b_{2a}$, it seems more adequate to model b_{3a} as a weighted average of r_3 and b_{2a} . The weight of each component would obviously depend on eligibility criteria in the early retirement system. Due to lack of specific data on this, however, we had to make a very rough assumption. Underlying the data in Table 4 is the assumption that $b_{3a} = 0.75b_{2a} + 0.25r_3$. Clearly, our results in the main text do not depend in any serious way on this assumption.

Data Source: OECD, Tax-Benefit Models, www.oecd.org/els/social/workincentives, Duval (2003), Brandt *et al.* (2005).

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