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GETTING LOW EDUCATED AND OLDER PEOPLE INTO WORK: FISCAL POLICY IN AN OLG MODEL WITH HETEROGENEOUS ABILITIES

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Getting low educated and older people into work: fiscal policy in an OLG model with heterogeneous abilities

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Abstract

Rising pressure on the welfare state due to aging, forces governments in all OECD countries to develop effective policies to raise employment, in particular employment among older individuals and low educated individuals. Increased sensitivity to rising inequality in society has made the challenge for policy makers only greater. In this paper we evaluate alternative fiscal policy scenarios to face this challenge. We construct and use an overlapping generations model for an open economy where individuals differ not only by age, but also by innate ability and human capital. The model allows us to study effects on aggregate employment, per capita income and welfare, as well as effects for specific age and ability groups. We show that well-considered fiscal policy changes can significantly improve macroeconomic productive efficiency, without increasing intergenerational or intragenerational welfare inequality. Our results strongly prefer a reduction in the labor tax rate on older workers and on all low-wage earners, financed by an overall reduction in non-employment benefits. These results are to be seen as long-run effects for economies at potential output.

Key words: employment by age, employment of low educated individuals, fiscal policy, heterogeneous ability, human capital, welfare inequality, overlapping generations (OLG)

JEL Classification: E62, H5, I28, J22, J24

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1. Introduction

Rising pressure on the welfare state due to aging, forces governments in all OECD countries to develop effective employment and growth policies. In all countries, and especially in those with poor labor market performance, the challenge is mainly to raise employment among low educated individuals and among older individuals. As we show in Figure 1 for a cross-section of OECD countries in 2016, it is among these two groups of individuals that by far the most progress can (and must) be made. While employment rates for prime age and high educated individuals are between 80% and 90% in most of these countries, they are generally (far) below 75% for older and low educated individuals. Moreover, Figure 2 highlights the importance for aggregate performance of getting at work individuals without a higher secondary degree and individuals older than 50. It is exactly in countries like Sweden and Norway that are relatively successful in activating the 'weaker' groups, that aggregate employment rates are the highest. By contrast, in countries like Belgium and France, where employment among the 'weaker' groups is relatively low, also aggregate employment is low. Correlation equals 0.56 in the left panel of Figure 2. It is even 0.66 in the right panel. Only Italy somewhat disturbs the picture.

Concern for employment is not new, however. It has been high on the agenda of both policy makers and researchers since at least two decades. Many researchers have demonstrated the major influence of the composition of fiscal policy on aggregate employment, both in general equilibrium models (e.g. Prescott, 2004; Rogerson, 2007; Dhont and Heylen, 2008; Ohanian *et al*., 2008) and in econometric panel data studies (e.g. Bassanini and Duval, 2006; Berger and Heylen, 2011). In more recent general equilibrium models with overlapping generations, Rogerson and Wallenius (2009), Ludwig *et al.* (2012), Heylen and Van de Kerckhove (2013) and Wallenius (2013) for example, also pay attention to life cycle patterns in labor supply and to employment differences across age groups. Erosa *et al.* (2012) and Alonso-Ortiz (2014) focus particularly on the influence of taxes and social security programs on labor supply late in the life cycle and on the retirement decision of older workers. Much less attention has been paid, however, to the employment performance of low educated workers, and the related cross-country differences. The main reason is that most of the existing (dynamic) general equilibrium models explaining aggregate employment and employment over the life cycle assume equal ability and capacity to build human capital for all people[1]. This makes it hard for these existing models to answer questions not only about productive efficiency (output, employment), but also about equity. Increasing sensitivity in recent years to the problem of inequality has however brought exactly the questions about equity to the forefront, making the challenge for policy makers only larger. Not only productive efficiency, but also equity demands attention.

[1] Clearly, there are many studies in the overlapping generations tradition that do realistically assume individuals with heterogeneous ability and human capital (e.g. Cahuc and Michel, 1996; Fehr, 2000; Sommacal, 2006; Kotlikoff *et al.,* 2007; Guvenen *et al*., 2014; Buyse *et al*. 2017). Most of these papers also model labor supply, and/or human capital accumulation as endogenous variables. However, their focus is not on the relationship between the composition of fiscal policy and employment among the lower skilled. They mainly pay attention to the impact of the pension system and/or the introduction of a minimum wage. Only in Guvenen *et al.* (2014) the impact of (potentially progressive) labor income tax rates is at the centre of the analysis, but their focus is on human capital and wage inequality.

Figure 1. Employment rates by age or education in OECD countries (2016)

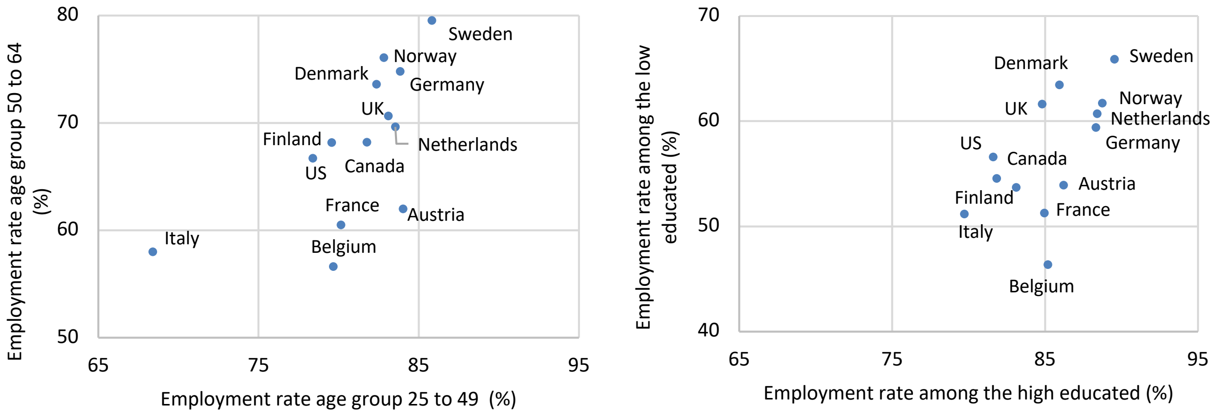
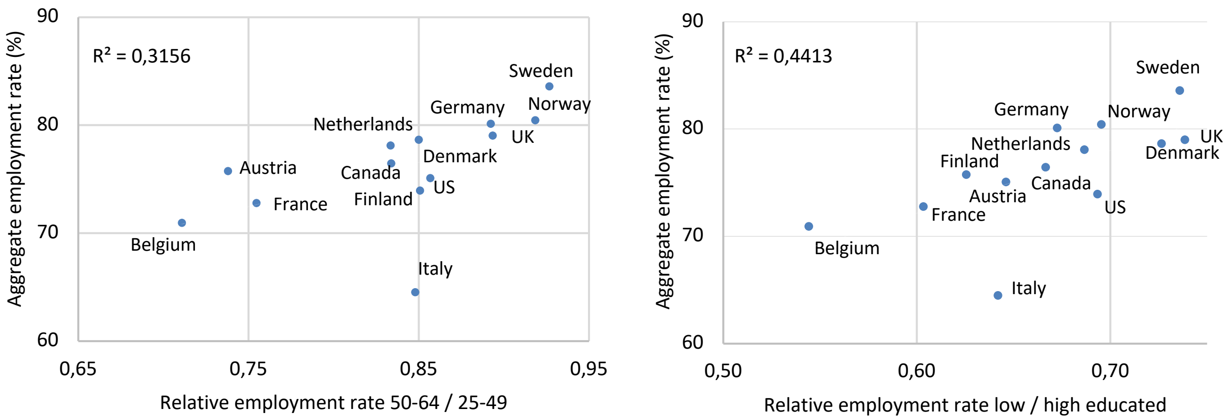


Figure 2. Relative employment of low educated or older individuals and the aggregate employment rate



Sources: OECD Stat, Labour Force Statistics & Education at a Glance, Educational attainment and labour force status.

Notes: The reported employment rates indicate the fraction of people in an age or skill group with a job. The aggregate employment rates in Figure 2 concern the age group 25 to 64. We define as low educated individuals without higher secondary degree and as high educated individuals with a tertiary degree.

Our aim and contribution in this paper is an analysis of the impact of the composition of fiscal policy on employment (hours worked) of individuals with different ability and different age in an overlapping generations model for an open economy. The same model has recently been used for an analysis of alternative reforms of the public pension system by Buyse *et al.* (2017). Next to employment, the model allows to study human capital accumulation, the retirement decision of older workers, per capita income, and welfare. The fiscal government in our model sets tax rates on labor, capital and consumption, and allocates its revenue to consumption, pensions and non-employment benefits, including early retirement benefits. To concretize heterogeneity in abilities, we define in each generation individuals who are born with high, medium or low innate ability. Individuals with higher ability enter the model with more human capital. They are also more productive in building additional human capital when they allocate time to (tertiary) education. Individuals with low ability enter the model with low human capital and have zero productivity to study and build additional human capital[2]. This extension allows a richer and more realistic analysis of fiscal policy effects. Labor taxes and benefits may differ not only by the age of workers, but also by their ability (earned labor income). Moreover, in addition to aggregate income and welfare effects of policy changes, it will be possible to investigate income and welfare effects for specific age or ability groups. A discussion then becomes possible of the effects of policies on both intragenerational and intergenerational inequality.

Our main findings are the following. First, we confirm some of our key results in Heylen and Van de Kerckhove (2013). We identify labor taxes and (especially) non-employment benefits as the most effective policy variables with respect to employment. Again, we observe that labor tax cuts targeted at older workers are far more effective than overall labor tax cuts. They have stronger employment effects. Moreover, they also promote human capital accumulation by individuals of high and medium ability and – as a consequence – productivity and output. Labor tax cuts targeted at young workers rather have the opposite effects. Second, however, a new result in this paper is that if labor tax cuts are targeted at older workers, this also implies clearly differential welfare effects between the ability groups. Current and near future low ability individuals may experience significant relative welfare losses. Third, as another new result, better overall employment effects and better welfare effects for low ability groups (implying reduced welfare inequality) are possible, if one complements policies that cut labor taxes on older workers with labor tax cuts on all low-wage earners. The best effects on employment follow if this combined tax cut is financed by an overall reduction of non-employment benefits. Fourth, we find that a general equilibrium OLG model assuming perfect competition on the labor market, as is adopted by the lion's share of the literature to which this paper belongs, can go a very long way in explaining cross-country differences in aggregate employment and in employment by age. Such a model will have difficulty, however, to explain the huge differences in the level of employment between high and low educated individuals. Explaining these, may require elements of imperfect competition.

The structure of the paper is as follows. Section 2 sets out our model. In Section 3 we calibrate the model on actual data. In Section 4 we confront the model's predictions with some key facts in 12 OECD countries. Our procedure is as follows. We impose common technology and preference parameters on all countries, but country-specific fiscal policy parameters. Simulating the model for each individual country we find that its predictions match important cross-country performance differences quite well. At the same time these simulations reveal how the model can be further improved. Section 5 includes the results of a wide range of policy simulations. In this section we discuss the employment, education, output and welfare effects of fiscal policy changes. We study effects per generation and per ability (income) group. Section 6 concludes the paper and discusses policy implications and directions for further research.

[2] This set of assumptions may offer the best match to the findings of Huggett, Ventura and Yaron (2011) and Keane and Wolpin (2007) that heterogeneity in human capital endowment at young age and learning abilities, rather than shocks to human capital, account for most of the variation in lifetime utility. Our approach also matches findings that innate learning ability and human capital at the age of 23 are strongly correlated (Huggett *et al*., 2011).

2. The model

Our analytical framework borrows heavily from Heylen and Van de Kerckhove (2013). It consists of a computable four-period OLG model for a small open economy with endogenous employment and human capital. An important extension in this paper is that we realistically take into account differences in individuals' innate abilities, building on Buyse *et al.* (2017).

2.1. Basic set-up and demographics

We consider three active adult generations (the young, the middle aged and the older) and one generation of retired agents. Each period of life is modeled to last 15 years. Individuals enter the model at age 20 and die at age 80. Within each generation we assume three types of individuals with different ability: a group H with high ability, a group M with medium ability and a group L with low ability. We normalize each ability group to 1, so that the size of a generation is 3, and total population is 12, and constant. Consistent with findings by Huggett *et al.* (2011), differences in ability are reflected both in the amount of human capital with which individuals enter the model and in their productivity of schooling (at the tertiary level) when young. Low ability individuals enter with the lowest human capital and will never go into tertiary education. They only work or have 'leisure' (including other non-market activities). High and medium ability young people enter the model with more human and will also invest a fraction of their time in tertiary education. Middle aged and older individuals do not study anymore: whatever their innate ability, they only work or have 'leisure'. The statutory old-age retirement age in our model is 65. Individuals may however optimally choose to leave the labor force sooner in a regime of early retirement.

Output is produced by domestic firms acting on competitive markets. These firms employ physical capital together with existing technology and effective labor provided by the three active generations. Physical capital is internationally mobile, whereas labor and human capital are assumed immobile.

In what follows, we concentrate on the core elements of the model: the behavior of individuals, the formation of human capital, the behavior of domestic firms and the determination of aggregate output, capital and wages. We pay particular attention to the impact of fiscal policy.

2.2. Individuals: preferences and time allocation

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

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

with $0 < \beta < 1, \gamma_j > 0, \theta > 0 \ (\theta \neq 1)$. Superscript *t* indicates the period of youth, when the individual comes into the model. Subscript *j* refers to the *j*th period of life and *a* refers to ability. Lifetime utility depends on consumption (c_{ja}^t) and enjoyed leisure (ℓ_{ja}^t) in each period of life. The parameters β, γ and θ define the discount factor, the relative value of leisure versus consumption, and the inverse of the intertemporal elasticity to substitute leisure. These parameters are common across ability types. The preference parameter γ may, however, 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. Rogerson, 2007; Erosa *et al.*, 2012).

Figure 3 shows the individuals' time allocation over the life cycle. Equations (2)-(5) describe how this is reflected in enjoyed leisure ℓ_{ja}^{t}. Time endowment in each period is normalized to 1.

$$\ell_{1a}^{t} = 1 - n_{1a}^{t} - e_{1a}^{t}, \quad \text{with } e_{1L}^{t} = 0. \tag{2}$$

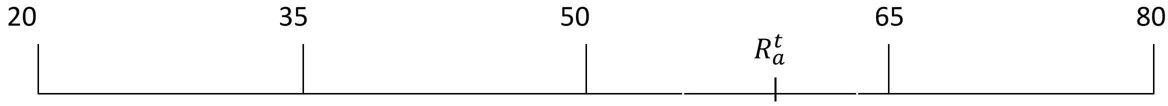
$$\ell_{2a}^{t} = 1 - n_{2a}^{t} \tag{3}$$

$$\ell_{3a}^{t} = \Gamma\left(\mu\left(R_a^t(1-\tilde{n}_{3a}^t)\right)^{1-\frac{1}{\zeta}} + (1-\mu)(1-R_a^t)^{1-\frac{1}{\zeta}}\right)^{\frac{\zeta}{\zeta-1}} \tag{4}$$

$$\ell_{4a}^{t} = 1 \tag{5}$$

In the first period of active life (Equation 2), enjoyed leisure falls in labor supply (n_{1a}^t) and in education time (e_{1a}^t). Only the low ability individuals do not study $(e_{1L}^t = 0)$. In the second and third period, no one studies. Individuals only work or have leisure (Equations 3 and 4). Following the approach in Buyse *et al.* (2017), part of the individuals' optimal choice of leisure in their third period of life concerns the determination of early retirement. Individuals choose R_a^t which relates to the optimal effective retirement age and which is defined as the fraction of time between age 50 and 65 that the individual participates on the labor market; $(1 - R_a^t)$ is the fraction of time in early retirement. Assuming that labor market exit is irreversible and post-retirement employment is not allowed, the relationship between the fraction of time devoted to work between 50 and 65 (n_{3a}^t) and the fraction of time devoted to work before early retirement but after 50 $(\tilde{n}_{3a}^t)$, is as follows: $n_{3a}^t = R_a^t.\tilde{n}_{3a}^t$. Leisure time in the third period therefore consists of two parts: non-employment time before the effective retirement age $R_a^t(1-\tilde{n}_{3a}^t)$, and time in early retirement after it $(1 - R_a^t)$. Equation (4) then describes composite enjoyed leisure of an older worker as a CES-function of both parts. Like Buyse *et al.* (2017), we assume imperfect substitutability between the two leisure types. While leisure time between periods of work may be particularly valuable from the perspective of relaxation and time to spend on personal activities of short duration, leisure time in early retirement may be most valuable to enjoy activities that last longer and ask for longer term commitment (e.g. long journeys, non-market activity as a volunteer). Equation (4) expresses that individuals prefer to have a balanced combination of both, rather than an extreme amount of one of them (and very little of the other). In this equation ζ is the constant elasticity of substitution, μ is a usual share parameter and Γ is added as a normalization constant such that the magnitude of ℓ_{3a}^t corresponds to the magnitude of total leisure time $(1 - n_{3a}^t)$. The latter assumption allows us to interpret γ_3 as the relative value of leisure versus consumption in the third period, comparable to γ_1 and γ_2.

Figure 3. Life cycle of an individual of generation *t* and ability *a*



Period	*t*	*t+1*	*t+2*	*t+3*
Work	n_{1a}^t	n_{2a}^t	$n_{3a}^t = R_a^t \tilde{n}_{3a}^t$	*0*
Study	e_{1a}^t	*0*	*0*	*0*
Leisure time	$1 - n_{1a}^t - e_{1a}^t$	$1 - n_{2a}^t$	$R_a^t(1 - \tilde{n}_{3a}^t) + (1 - R_a^t)$	*1*

Note: $e_{1L}^t = 0, 0 < R_a^t < 1$.

2.3. Individuals: budget constraints

Equations (6)-(9) describe the main budget constraints that individuals are subject to. The LHS shows that individuals allocate their disposable income to consumption (including consumption taxes, τ_c) and to the accumulation of non-human wealth. We denote by Ω_{ja}^t the stock of wealth held by a type a individual of generation *t* at the end of the *j*th period of his life. Individuals start adult life with zero assets. As is clear from Equation (9), they also finish life with zero assets. During the three periods of active life, disposable income at the RHS includes after-tax labor income and non-employment benefits. From the second to the fourth period, it may also include interest income. We denote by $w_{a,k}$ the real wage per unit of effective labor supplied at time *k* by an individual with ability *a* and by r_k the exogenous (world) real interest rate at time *k*.

Effective labor of an individual with ability *a* depends on hours worked (n_{ja}^t) and human capital (h_{ja}^t). Given the tax rate on labor income τ_w, young individuals in Equation (6) earn an after-tax real wage equal to $w_{a,t} h_{1a}^t n_{1a}^t (1 - \tau_w)$. After-tax labor income of middle aged and older workers in Equations (7) and (8) is determined similarly. For the fraction of time that young, middle aged and older individuals are inactive, they receive a non-employment benefit from the government. Older individuals may be eligible to two types of benefits: standard non-employment benefits as long as they are on the labor market, and early retirement benefits after having withdrawn from the labor market. All benefits are defined as a proportion of the after-tax wage of a full-time worker. The net replacement rate for standard non-employment benefits is *b*, for early retirement benefits it is b_{er}.

$$(1 + \tau_c) c_{1a}^t + \Omega_{1a}^t = w_{a,t} h_{1a}^t n_{1a}^t (1 - \tau_w) + b w_{a,t} h_{1a}^t (1 - \tau_w)(1 - n_{1a}^t - e_{1a}^t) \quad (6)$$

$$(1 + \tau_c) c_{2a}^t + \Omega_{2a}^t = w_{a,t+1} h_{2a}^t n_{2a}^t (1 - \tau_w) + b w_{a,t+1} h_{2a}^t (1 - \tau_w)(1 - n_{2a}^t)$$
$$+ (1 + r_{t+1}) \Omega_{1a}^t \quad (7)$$

$$(1+\tau_c)c_{3a}^t + \Omega_{3a}^t = w_{a,t+2}h_{3a}^t R_a^t \tilde{n}_{3a}^t(1-\tau_w) + b w_{a,t+2}h_{3a}^t(1-\tau_w)R_a^t(1-\tilde{n}_{3a}^t)$$
$$+b_{er}w_{a,t+2}h_{3a}^t(1-\tau_w)(1-R_a^t) + (1+r_{t+2})\Omega_{2a}^t \quad (8)$$

$$(1+\tau_c)c_{4a}^t = (1+r_{t+3})\Omega_{3a}^t + pp_a^t \quad (9)$$

$$pp_a^t = \rho_{wa}\left(\frac{1}{3}\right)\sum_{j=1}^{3}\left(w_{a,t+j-1}h_{ja}^t n_{ja}^t(1-\tau_w)(1+x)^{4-j}\right)$$
$$+\rho_{fa}\left(\frac{1}{9}\right)\sum_{j=1}^{3}\sum_{a=H,M,L}\left(w_{a,t+3}h_{ja}^{t+4-j}n_{ja}^{t+4-j}(1-\tau_w)\right) \quad (10)$$

with: $n_{3a}^t = R_a^t \tilde{n}_{3a}^t$

After the statutory retirement age (65) in Equation (9) individuals receive an old-age pension benefit (pp_a^t) and enjoy interest income from accumulated non-human wealth. We assume a public PAYG pension system in which pensions in period *k* are basically financed by contributions from the active generations in that period *k* (see below). As described by Equation (10), individual net pension benefits consist of two components. A first one is related to the individual's earlier net labor income. It is a fraction of his so-called pension base, i.e. the average of revalued net labor income in each of the three active periods of life. The net replacement rate is ρ_{wa}. This part of the pension rises in the individual's hours of work n_{ja}^t and his human capital h_{ja}^t. It will be lower when the individual retires early (lower R_a^t). Thanks to revaluation, this part of the net pension is adjusted to increases in the overall standard of living between the time that workers build their pension entitlements and the time that they receive the pension. We assume that past earnings are revalued in line with economy-wide wage growth x (see also Section 2.6). The second component of the pension is a flat-rate or basic pension. Every retiree receives the same amount related to average net labor income in the economy at the time of retirement. This assumption assures that also basic pensions rise in line with productivity. Here, the net replacement rate is ρ_{fa}.

2.4. Individuals: human capital formation

Individuals enter our model at the age of 20 with a predetermined level of human capital. This level is generation-invariant, but it rises in innate ability. In Equation (11) we normalize the human capital of a young individual with high ability to h_0. A young individual with medium (low) ability enters the model with only a fraction ε_M (ε_L) of this. The fractions ε_M and ε_L will be calibrated.

$$h_{1a}^t = \varepsilon_a h_0 \qquad \forall\, a = H,M,L \quad (11)$$

with $0 < \varepsilon_L < \varepsilon_M < \varepsilon_H = 1$.

During youth, individuals with high and medium ability will invest a fraction of their time to expand their human capital, making them more productive in the second and third period. We adopt in Equation (12.a) a human capital production function similar to Lucas (1990) and Bouzahzah *et al.* (2002). The production of new human capital by these individuals rises in the amount of time they allocate to education (e_{1a}^{t}) and in their initial human capital (h_{1a}^{t}). We assume a common elasticity of time input (σ) and a common efficiency parameter (ϕ) for both ability types. Individuals with low innate ability do not study. In Equation (12.b) their human capital remains constant. Finally, we assume in Equation (13) that the human capital of all individuals remains unchanged between the second and the third period. Learning by doing in work may counteract depreciation. The same assumption explains the lack of depreciation in Equation (12).

$$h_{2a}^{t} = h_{1a}^{t}(1 + \phi(e_{1a}^{t})^{\sigma}) \qquad \forall a = H, M \tag{12.a}$$

$$h_{2L}^{t} = h_{1L}^{t} \tag{12.b}$$

$$h_{3a}^{t} = h_{2a}^{t}, \qquad \forall\, a = H, M, L \tag{13}$$

with $0 < \sigma \leq 1, \phi > 0$.

2.5. Individuals: optimization and the influence of fiscal policy

Individuals will choose consumption, labor supply in each period of active life, education when young (for the medium and high ability individuals), and their effective retirement age to maximize Equation (1), subject to Equations (2)-(13). For details on the optimality conditions, we refer to Appendix A. Here we restrict the discussion to the role of fiscal policy, which mainly affects individuals in their optimal labor-leisure choice in each period of active live. In the third period this also includes the decision when to retire. Furthermore, fiscal policy has an impact on the choice of young individuals of high and medium ability either to work or to continue education.

Individuals supply labor up to the point where the marginal utility of leisure equals the marginal utility gain from work. The latter depends on the extra consumption that can be financed out of additional labor income, and consists of two parts. Working more hours in a particular period brings additional resources for consumption (and utility) both in that period and when retired. Next to higher human capital (and its underlying determinants), lower tax rates on labor (τ_w), lower tax rates on consumption (τ_c), and lower non-employment benefits (b) increase the gain from work, and consequently promote labor supply. In the same logic, lower early retirement benefits will encourage individuals to remain active longer. Extra consumption during retirement will also rise, depending on the level of the own-income-related pension replacement rate (ρ_{wa}). All these described effects are substitution effects. To the extent that tax reductions raise individuals' lifetime resources, however, they will also cause adverse income effects on labor supply. In this respect it is important to see how the government finances these tax reductions. If they are financed by cutting government demand for goods, individuals' disposable income will increase more (and the adverse income effect will be stronger) than in the case of financing by a reduction of transfers to households. When a fiscal policy change mainly concerns a reduction of non-employment benefits, both substitution and income effects will operate in the same direction, stimulating labor supply.

Fiscal policy also matters for young high and medium ability individuals' decision to allocate time to tertiary education rather than work. In the optimum the marginal utility loss from investing in human capital when young will be equal to the total discounted marginal utility gain in later periods from having more human capital. As a result, individuals will study more the higher the marginal effect of education on human capital ($\sigma\phi(e_{1a}^t)^{\sigma-1}$), and the higher future relative to current after-tax real wages. Labor taxes during youth therefore encourage individuals to study, whereas labor taxes in later periods of active life discourage them. A final interesting result is that young people study more – all other things equal – if they expect to work harder and longer in later periods (n_{2a}^t, $n_{3a}^t = R_a^t.\tilde{n}_{3a}^t$). Next to the future after-tax wage, also future labor supply is a key determinant of the return to investment in education when young.

2.6. Domestic firms, output and factor prices, and the impact of fiscal policy

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 (14). Production exhibits constant returns to scale in aggregate physical capital *(K_t)* and labor in efficiency units ($A_t H_t$), so that profits are zero in equilibrium. Technology A_t is growing at an exogenous and constant rate x: $A_{t+1} = A_t(1 + x)$. Equation (15) defines total effective labor as a CES aggregate of effective labor supplied by the three ability groups. In this equation *s* is the elasticity of substitution between the different ability types of labor and η_H, η_M and η_L are the input shares. We will impose that $\eta_H = 1 - \eta_M - \eta_L$.

$$Y_t = K_t^\alpha (A_t H_t)^{1-\alpha} \tag{14}$$

$$H_t = \left(\eta_H H_{H,t}^{1-\frac{1}{s}} + \eta_M H_{M,t}^{1-\frac{1}{s}} + \eta_L H_{L,t}^{1-\frac{1}{s}}\right)^{\frac{s}{s-1}} \tag{15}$$

Equation (16) specifies effective labor per ability group at time t. Within each ability group we assume perfect substitutability of labor supplied by the different age groups.

$$H_{a,t} = n_{1a}^t h_{1a}^t + n_{2a}^{t-1} h_{2a}^{t-1} + n_{3a}^{t-2} h_{3a}^{t-2} \tag{16}$$

Competitive behavior implies in Equation (17) that firms carry physical capital to the point where its after-tax marginal product net of depreciation equals the world real interest rate. Physical capital depreciates at rate δ_k. The real interest rate being given, firms will install more capital when the amount of labor in efficiency units ($A_t H_t$) increases or the capital tax rate (τ_k) 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 for each ability type (Equation 18). Workers of a particular ability type will earn a higher pre-tax real wage when their supply is relatively scarce, when the level of technology is higher, and when physical capital per unit of aggregate effective labor is higher.

$$\left[\alpha\left(\frac{A_tH_t}{K_t}\right)^{1-\alpha}-\delta_k\right](1-\tau_k)=r_t \tag{17}$$

$$(1-\alpha)A_t^{1-\alpha}\left(\frac{K_t}{H_t}\right)^{\alpha}\eta_a\left(\frac{H_t}{H_{a,t}}\right)^{\frac{1}{s}}=w_{a,t}\quad \forall a=H,M,L \tag{18}$$

Our assumptions of constant population and of individuals entering the model with a predetermined and generation-invariant level of human capital imply that in steady state effective labor H_t will be constant. Physical capital, output and wages by contrast will all grow at the exogenous technology growth rate x.

The effect of fiscal policy on firm behavior and production is direct via the capital tax rate (τ_k) and international capital flows, as described above.

After our discussion of optimal behavior by households and firms, it is important now also to see the general equilibrium effects induced by both agents' responses to fiscal policy changes. If individuals work more or longer, or build more human capital, this will raise the marginal product of physical capital and investment in K. The positive effects of a higher physical capital stock will subsequently raise wages and the return for individuals to work. A virtuous circle is then created. Our model captures all these possible effects. It will require careful calibration to get a realistic estimate of the size of these effects.

2.7. Government

Equation (19) describes the government's budget constraint. Demand for goods G_t, benefits related to non-employment B_t (including early retirement benefits), old-age pension benefits PP_t, and interest payments r_tD_t are financed by taxes on labor T_{nt}, taxes on capital T_{kt}, and taxes on consumption T_{ct} and/or by new debt ΔD_{t+1}. We define D_t as outstanding public debt at the beginning of period t.

$$\Delta D_{t+1}=D_{t+1}-D_t=G_t+B_t+PP_t+r_tD_t-T_{nt}-T_{kt}-T_{ct} \tag{19}$$

with: $G_t=gY_t$

$$B_t=\sum_{a=H,M,L}\Big((1-n_{1a}^t-e_{1a}^t)bw_{a,t}h_{1a}^t(1-\tau_w)+(1-n_{2a}^{t-1})bw_{a,t}h_{2a}^{t-1}(1-\tau_w)$$
$$+R_a^{t-2}(1-\tilde{n}_{3a}^{t-2})bw_{a,t}h_{3a}^{t-2}(1-\tau_w)+(1-R_a^{t-2})b_{er}w_{a,t}h_{3a}^{t-2}(1-\tau_w)\Big)$$

$$PP_t=\sum_{a=H,M,L}\left(\frac{\rho_{wa}}{3}\sum_{j=1}^{3}\left(w_{a,t+j-4}h_{ja}^{t-3}n_{ja}^{t-3}(1-\tau_w)(1+x)^{4-j}\right)\right.$$
$$\left.+\rho_{fa}\left(\frac{1}{9}\right)\sum_{j=1}^{3}\sum_{a=H,M,L}\left(w_{a,t}h_{ja}^{t+1-j}n_{ja}^{t+1-j}(1-\tau_w)\right)\right)$$

$$T_{n,t}=\tau_w\sum_{a=H,M,L}\Big(\sum_{j=1}^{3}n_{ja}^{t+1-j}w_{a,t}h_{ja}^{t+1-j}\Big)$$

$$T_{kt}=\tau_k(\alpha Y_t-\delta_kK_t)$$

$$T_{ct}=\tau_c\sum_{j=1}^{4}\Big(c_{jH}^{t+1-j}+c_{jM}^{t+1-j}+c_{jL}^{t+1-j}\Big)$$

The government claims a given fraction g of output. Goods bought by the government have no effect on private sector productivity, nor do they directly affect individuals' utility. Non-employment benefits (B_t) are an unconditional source of income support related to inactivity (leisure) and non-market household activities as in Rogerson (2007) and Dhont and Heylen (2008). Although it may seem strange to have such transfers in a model without involuntary unemployment, there is clear practical relevance. Unconditional or quasi unconditional benefits to structurally non-employed people are a fact of life in many European countries. Note also our assumption that the pension system is fully integrated into government accounts. We do not impose a specific financing of the PAYG pension plan. The government can use resources from the general budget to finance pensions.

2.8. Aggregate equilibrium and the current account

Equation (20) describes aggregate equilibrium as it can be derived from the model's equations. The LHS of (20) represents national income. It is the sum of domestic output Y_t and net factor income from abroad $r_t F_t$, with F_t being net foreign assets at the beginning of *t.* The latter are a part of the aggregate stock of wealth Z_t held by individuals who entered the model in *t-1*, *t-2* and *t-3*. The RHS of (20) is total demand for goods. Optimal behavior by firms and households and government spending underlie aggregate domestic demand ($C_t + I_t + G_t$) in period *t*, while CA_t stands for the current account in *t.*

$$Y_t + r_t F_t = C_t + I_t + G_t + CA_t \tag{20}$$

with: $F_t = Z_t - K_t - D_t$

$$CA_t = F_{t+1} - F_t = \Delta Z_{t+1} - \Delta K_{t+1} - \Delta D_{t+1}$$

$$I_t = \Delta K_{t+1} + \delta_k K_t$$

3. Parameterization

The economic environment described above allows us to simulate the effects on employment, education, output and welfare of various changes in fiscal policy. Our main contribution in this paper is that we model and assess differential effects for individuals with different ability. This simulation exercise requires us first to parameterize and solve the model. Table 1 contains an overview of all parameters. Many have been set in line with the existing literature. Others have been calibrated to match key data.

We set the rate of time preference at 1.5% per year, the (exogenous and constant) world real interest rate at 4.5% per year and the physical capital depreciation rate at 8% per year. Considering that periods in our model last 15 years, this choice implies a discount factor β = 0.8, an interest rate r = 0.935 and physical capital depreciation δ_k = 0.714. In the production function for goods we assume a capital share coefficient α equal to 0.3. The elasticity of substitution s between the different ability types of effective labor is set equal to 1.5. Our values for the rate of time preference, the capital share and capital depreciation are well within the range of values imposed in the literature (e.g. Altig *et al*., 2001; Ludwig *et al*., 2012; Buyse *et al*., 2017). So is the value for *s* (see Caselli and Coleman, 2006). For the value of the intertemporal elasticity of substitution in leisure ($1/\theta$) we follow Rogerson (2007). For studies with a macro focus he puts forward a reasonable range for θ from 1 to 3 (see also Rogerson and Wallenius, 2009).

Four parameters relate to human capital production. For the elasticity with respect to education time (σ) we choose a conservative value of 0.3. This value is within the range considered by Bouzahzah *et al.* (2002), but much lower than the elasticity of 0.80 that we see in Lucas (1990). The choice of a conservative value for σ excludes that our main findings in the next sections might be due to an overestimation of the returns to education. For the calibration of the relative initial human capital of medium and low ability individuals (relative to the initial human capital of high ability individuals, ε_M and ε_L), we follow the procedure of Buyse *et al.* (2017). They rely on PISA science scores obtained by students at the 17th percentile, the 50th percentile, and the 83th percentile. The ratios between these scores are remarkably similar across OECD countries. We take them as objective indicators of the relative cognitive capacity of low and medium ability individuals. Exploiting these ratios, we set ε_L equal to 0.67 and ε_M equal to 0.84 (while $\varepsilon_H = 1$). Last but not least, the efficiency parameter ϕ in the human capital production function has been determined by a calibration procedure that we discuss now.

We determined eight parameters by calibration, mainly following Buyse *et al.* (2017). Next to the efficiency parameter in human capital production (ϕ), these are the exogenous technology growth rate (*x*), two share parameters in aggregate effective labor (η_M and η_L, where η_H follows as $1 - \eta_L - \eta_M$), three taste for leisure parameters ($\gamma_1, \gamma_2, \gamma_3$) and the elasticity of substitution (ζ) in the composite leisure function in Equation (4). The calibration target values are reported at the bottom of Table 1. Six of them concern Belgium in 1995-2007: the employment rates in hours among young, middle aged and older individuals, the effective retirement age, aggregate participation in tertiary education, and potential per capita growth[3]. Our main reason for choosing Belgium is that it is a small open economy and therefore matches key assumptions of our model. We choose average data for 1995-2007 as this was the last period of relative stability on the labor market before the financial crisis and the euro crisis. To study equilibrium employment, it is clearly more appropriate to use average data for a long relatively stable period. For details on the construction of these data, we refer to Appendix B. The other two target values are the relative wages of young workers with below upper secondary education or with upper secondary education in the US compared to workers with tertiary education.

The calibrated growth rate of technology (*x*) reflects total per capita output growth over a period of 15 years. The underlying average annual growth rate is 1.77%. The leisure parameters, including the elasticity of substitution in the composite leisure function (4), are determined so that with observed levels of the policy variables (tax rates, non-employment benefit replacement rates, pension replacement rates, etc.) in Belgium, the model correctly predicts Belgium's employment rates by age (n_1, n_2, n_3) and effective early retirement age (R). By the same approach the efficiency parameter in human capital production (ϕ) is determined to correctly predict participation in education (*e*). We find that the taste for leisure rises with age ($\gamma_1 = 0.074, \gamma_2 = 0.147, \gamma_3 = 0.258$) and observe a stronger degree of substitutability than in the Cobb-Douglas case between the two types of leisure for older workers ($\zeta = 1.54$). The efficiency

[3] For a description of these variables and details on their construction and sources, see the notes below Table 1 and Appendix B.

Table 1. Parameterization

Technology and preference parameters	
Goods production (output)	$\alpha = 0.30, s = 1.5, \eta_H = 0.48, \eta_M = 0.33, \eta_L = 0.19$
Exogenous technology growth	$x = 0.301$
Human capital	$\phi = 1.21, \sigma = 0.3$
Initial human capital	$\varepsilon_M = 0.84, \varepsilon_L = 0.67$
Preference parameters	$\beta = 0.80, \theta = 2, \gamma_1 = 0.074, \gamma_2 = 0.147, \gamma_3 = 0.258$
	$\mu = 0.5,\ \zeta = 1.54, \Gamma = 2$
World real interest rate	$r = 0.935$
Capital depreciation rate	$\delta_k = 0.714$
Fiscal policy and pension policy parameters [(a)]	
$\tau_w = 67.2\%,\ \tau_c = 13.4\%,\ \tau_k = 27.1\%,\ b = 59.6\%,\ b_{er} = 79.0\%,$	
$\rho_{wL} = 55.4\%,\ \rho_{wM} = 63.1\%,\ \rho_{wH} = 42.7\%,\ \rho_{fL} = 17.2\%,\ \rho_{fM} = \rho_{fH} = 0\%$	

Target values for calibration					
Employment, education and growth [(b)]					
n_1	n_2	n_3	R (age)	e	*Annual per capita growth*
51.1%	56.8%	29.3%	57.9	14.1%	1.77%
Relative wages of young workers, US [(c)]					
$w_L h_{1L}/w_H h_{1H}$	$w_M h_{1M}/w_H h_{1H}$				
0.43	0.63				

Notes:

(a) Values for Belgium. For a detailed description of these policy parameters, see Appendix B;

(b) Values for Belgium. Employment rates (n_j) are computed as actual annual per capita hours worked divided by 2080 in the respective age groups (20–34, 35–49, 50–64). The employment rate would be 100% if all people in the age group worked 2080 hours per year (52 weeks, 40 hours per week). Education (e) is our proxy for the fraction of time spent studying by the average person of age 20–34. It is computed as the total number of students in full-time equivalents, divided by total population in this age group. R (in years) is the average age of all persons older than 40 withdrawing from the labor force. The data for n_j and e are averages over 1995–2007. The value for R is an average over 1995–2006. For a detailed description of the construction of these data and their sources, see Appendix B. Per capita growth is the average annual growth rate of real potential GDP per person of working age (source: OECD, Economic Outlook).

(c) As a proxy for the relative wage of low ability (medium ability) young workers, we use data on earnings of workers of age 25-34 with below upper secondary education (with secondary education) in the US relative to earnings of workers with a tertiary degree. The data concern 2007. Source: OECD Education at a Glance, 2009, Table A7.1a.

parameter ϕ turns out to be 1.21. Finally, calibration of the share parameters η_M and η_L is mainly driven by the values for relative wages of young workers in the US. They are determined so that with observed policy variables in the US, and given the whole set of other parameters, the model correctly predicts these relative wages. As shown by Equation (18), the share parameters are important determinants of the relative productivity of labor. Actual wages are informative if a close link can be assumed between wages and productivity. This condition is much more likely fulfilled in the US than in Europe, which explains the introduction here of US relative wages rather than Belgian ones. We provide more detail on our calibration procedure to obtain η_L and η_M in Appendix C. The results imply $\eta_L = 0.19, \eta_M = 0.33$ and $\eta_H = 0.48$.

Finally, we impose equal weights for both leisure types (μ=0.5) in the composite leisure function (4) . The normalization parameter Γ equals 2. The size of this parameter has no impact at all on our results.

4. Empirical relevance of our model and labor market performance

Figures 1 and 2 revealed huge differences in labor market performance across OECD countries in 2016. These differences have existed for many years. Thinking about the empirical relevance of our model, the obvious question is whether it can rationalize such differences. Can it explain why some countries perform much better or worse than others? In this section we confront our model's predictions with the data for 1995-2007. We show the data for each country, and the underlying policy parameters, in Appendix B.

Our calibration implies that our model's predictions match the data in Belgium exactly. The test of the model's validity is whether it can also match the data for the other countries and (especially) the size of the cross-country differences. Our test is tough since we impose the same preference and technology parameters, reported in the upper part of Table 1, on all countries. Only the fiscal policy variables and the pension replacement rates differ.

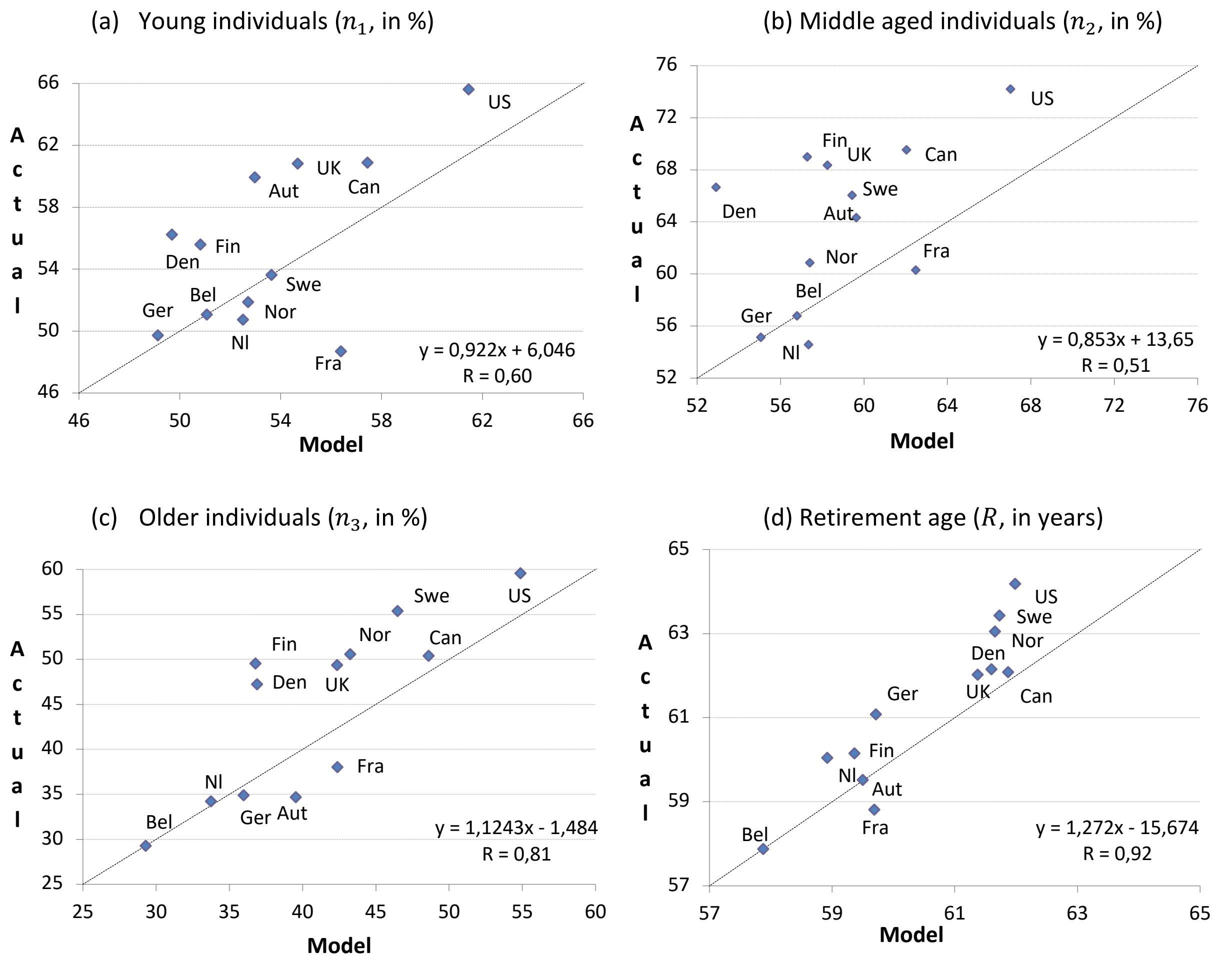
Clearly, one should be aware of the limitations of such an exercise. First of all, our model is highly stylized and may (obviously) miss potential determinants of employment or education. Second, even if we compute the data as averages over a long and fairly stable period before the financial crisis, these averages need not be equal to the steady state. Countries may still be moving towards their steady state. In spite of this, if one considers the extreme variation in the predictions of existing calibrated models investigating for example 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.

To solve our model and to perform our simulations, we choose an algorithm that preserves the non-linear nature of the model. We use the program Dynare. Underlying our model's predictions for each country, is the assumption that government spending *G* adjusts endogenously in Equation (19) to keep the government debt to GDP ratio constant at the level observed for each country in 1997-2005.

Figure 4 relates our model's predictions to actual observations for three employment rates by age (aggregated over the three ability groups) and the effective retirement age. The interrupted line in each figure is the 45°-line. In the bottom right corner of each figure we also report the specification of the regression line that would provide the best fit between the model's predictions and the data, as well as the coefficient of correlation. The regression line itself is not drawn. All in all, our model performs quite well in this group of countries[4]. In each age group, it correctly predicts relatively high employment rates in the US and Canada and relatively low employment in Germany and the Netherlands. For young workers

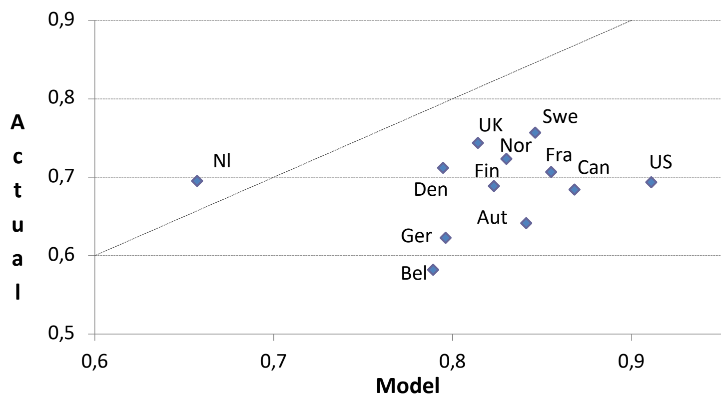
[4] Italy is not included. The simulation results for this country are much less close to the data than for the other countries. Considering the deviating position of Italy in Figure 2, this does not come as a big surprise. Heylen and Van de Kerckhove (2013) do include Italy, but observe the same "problem". For a discussion, we refer to their paper.

Figure 4. Employment rate in hours and retirement age in 12 countries, 1995-2007



Note: The dotted line is the 45°-line.

Figure 5. Relative employment rate among low versus high educated individuals (n_L/n_H).



Note: The dotted line is the 45°-line. On the horizontal axis we report the average of our model's predictions for relative employment n_L/n_H among the middle aged and among the older individuals. These two age groups have finished their education. The vertical axis is the ratio of the employment rate (in persons) among individuals without a higher secondary degree to the employment rate (in persons) among individuals with a tertiary degree. The data are for 2005. Correlation between the data and the model's predictions is 0.14. Without the Netherlands, it becomes 0.33.

it also correctly predicts relatively low employment rates in the Nordic countries. For older workers the model has relatively high employment and a high retirement age right in Sweden and Norway and – to a lesser extent – the UK. Overall correlation between the model's predictions and the actual data varies between 0.51 in panel (b) and 0.92 in panel (d). Moreover, and most importantly, the slopes of the regression lines are fairly close to 1. The model 'translates' observed policy differences between countries into realistic performance differences: the variation in the model's predictions when actual policy parameters are introduced, is fairly close to the variation in the performance data. In other words, our model does not systematically overestimate the effects of policy differences (slope below 1), nor does it systematically underestimate these effects (slope above 1). This information is important to assess the reliability for policy analysis of the simulations that we present in the next section.

Figure 5 compares our model's predictions with the facts for the relative employment rate of low educated versus high educated individuals[5]. A first observation is that our model overpredicts relative employment among low educated individuals. Except for the Netherlands, all observations in Figure 5 are situated to the right of the 45°-line. The main explanation for this result is our assumption of perfect competition. In a recent paper, Boone and Heylen (2018) get a much better fit when they introduce union wage setting for low educated workers and involuntary unemployment among these workers. Second, however, our model does seem to capture at least some of the main drivers of cross-country differences in relative employment among the low educated. Without the Netherlands, correlation in Figure 5 is 0.33. Third, next to the Netherlands, our model also has particular difficulty to match relative employment in the US. Our model is not the only one that overestimates the employment rate among low ability Americans, though. A large literature has tried to explain this (see for example The Economist, 2011)[6].

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 specific policy variables for the employment rate in three age groups, the employment rate in three ability groups, aggregate employment, older workers' retirement age, education of the young, and aggregate output (income). We report steady state effects. Furthermore, we pay particular attention to the welfare effects for current and future generations of individuals of high and low ability, and the evolution of welfare inequality.

Starting from budget balance, we impose permanent (and unanticipated) fiscal shocks equal to 2% of initial output. More precisely, if everything else remained unchanged, each single policy measure would have an effect on the government budget balance equal to 2% of GDP. We consider reductions in the tax rates on labor and in the benefit replacement rates. The benchmark from which we start, and against which all policy shocks are evaluated, is the same as in Buyse *et al.* (2017). It is an average of six

[5] Since hours worked per employed person by ability/education in 1995-2007 are not available (as far as we know), it is not possible to compute data that are fully comparable with the model employment rates. We therefore use data for employment rates in persons. Our approach can therefore only act as a rough proxy for n_L/n_H.

[6] A comparison of our model's predictions with the cross-country data for participation in education is included in Appendix D.

euro countries as reported at the bottom of Table 2[7]. This table considers the steady state effects of policy changes assuming that these changes are compensated by another fiscal variable to maintain budget balance. In 6 out of 7 simulated policies, compensation is realized by adjusting the consumption tax rate.

Figure 6 shows the welfare effects of the policy scenarios described in Table 2 for the current and future generations of high and low ability individuals. Welfare effects for the individuals of medium ability are in general close to those for the high ability group. We report on the vertical axis the welfare effect on individuals of the generation born *k* periods after the introduction of the policy reform, where *k* is indicated on the horizontal axis. So, the data at *k=0* for example concern the young in the period of the policy change. The data at *k=-3* concern the retirees in that period. 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). To compute this percentage change we keep employment rates at the benchmark. For example, policy 1 implies a welfare gain for the current high ability young (*k*=0) equal to 4% of their benchmark consumption. For the current older low ability individuals (*k*=-2) the gain is only equal to 1,5% of their benchmark consumption. In Table 3 we integrate the welfare effects induced by each policy reform into a single aggregate summary measure. For each individual we first compute the present discounted value of the total consumption change over life that is required in the benchmark to make him equally well off as under the policy reform. The basis of our computation is the data that we report in Figure 6. But now we also take into account differences in the length of remaining life. For young individuals the data in Figure 6 apply to four periods, whereas for retired individuals they only apply to one remaining period. Next, we impose that all those who lose under the new policy are compensated by the winners. Our summary measure is the present discounted value of the net aggregate consumption gain of all winners after having compensated the losers, in percent of initial GDP. The first row in Table 3 includes all current and four future generations of all three ability types into the computation. The second row includes only those generations that live at the moment the reform is introduced.

Our main findings are as follows:

(i) We confirm our earlier result in Heylen and Van de Kerckhove (2013) that the most effective policy to promote aggregate equilibrium employment should include an overall cut in non-employment benefits ($\Delta b < 0$). In Table 2, policy 3 imposes an overall reduction of the benefit replacement rate by almost 8 percentage points. This reduction (and the general equilibrium effects it induces) allow the government to cut the consumption tax rate by 10.4 percentage points. In response to a strong increase in the relative marginal utility from work versus inactivity, all age and ability groups supply more labor. Aggregate hours worked would rise by about 6%. So would output. Older and low ability individuals show the strongest reaction ($\Delta n_3 = 4.7,\ \Delta n_L = 3.34$).

(ii) Overall labor tax cuts in policy 1 also bring about positive labor supply and employment effects among all age and ability groups, but these effects are in general only about half as large as those

[7] 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. Nor would choosing a different benchmark.

Table 2. Steady state effects of fiscal policy shocks (equal to 2% of output, ex ante)

Change in policy variable	(1) $\Delta\tau_{w}$= -2.86 (for all j and a)	(2) $\Delta\tau_{w3}$= -9,33 (for all a, but only j=3)	(3) Δb= -7.95 (for all j and a)	(4) $\Delta\tau_{w,low}$= -13.0	(5) $\Delta\tau_{w3}$ = -7.52 $\Delta\tau_{w,low}$ = -2.5	(6) $\Delta\tau_{w1,low}$ = -21.2	(3b) Δb= -7.95 (for all j and a)
Compensating change[e]	$\Delta\tau_c$ = 1,44	$\Delta\tau_c$ = -1,01	$\Delta\tau_c$ = -10,42	$\Delta\tau_c$ = 4,23	$\Delta\tau_c$ = -0,72	$\Delta\tau_c$ = 6,68	$\Delta\tau_{w3}$ = -12.0 $\Delta\tau_{w,low}$ =-4.0
Effect [a]:							
Δn_1	1,08	-2,39	2,55	5,09	-0,54	7,65	0,44
Δn_2	1,08	-0,78	2,59	0,62	-0,39	-2,75	1,30
Δn_3	2,50	10,0	4,70	1,87	8,73	-4,27	9,22
ΔR [c]	0,36	1,23	0,57	0,32	1,10	-0,40	0,99
Δe	-0,15	1,60	-0,34	-2,29	0,66	-3,17	1,04
Δn [a, b]	1,49	1,80	3,19	2,50	2,21	0,34	3,30
Δ% total hours [d]	2,81	3,39	6,01	4,73	4,16	0,65	6,23
Δn_H	1,46	1,33	3,13	-0,01	1,20	-0,01	2,45
Δn_M	1,43	1,27	3,08	2,30	1,96	2,70	3,24
Δn_L	1,57	2,79	3,34	5,22	3,45	-1,66	4,22
Δ% per capita output [d]	2,90	6,24	6,05	0,55	5,55	-2,29	8,15

Notes: Initial steady state (benchmark): $n_1 = 55.1\%$, $n_2 = 61.3\%$, $n_3 = 39.9\%$, $R = 59.4$, e = 13.7%, $n = 53.0\%$, $n_H = 52.1\%$, $n_M = 52.2\%$, $n_L = 54.7\%$. Initial fiscal policy parameters $\tau_c = 13.6\%$, $\tau_w = 57.1\%$, $b = 49.8\%$. These performance and policy data are an average for Austria, Belgium, France, Germany, Italy and the Netherlands.

(a) difference in percentage points between the new steady state and the benchmark, except for total hours worked, per capita output and R.

(b) change in (weighted) aggregate employment rate in hours, change in percentage points.

(c) change in optimal effective retirement age, in years.

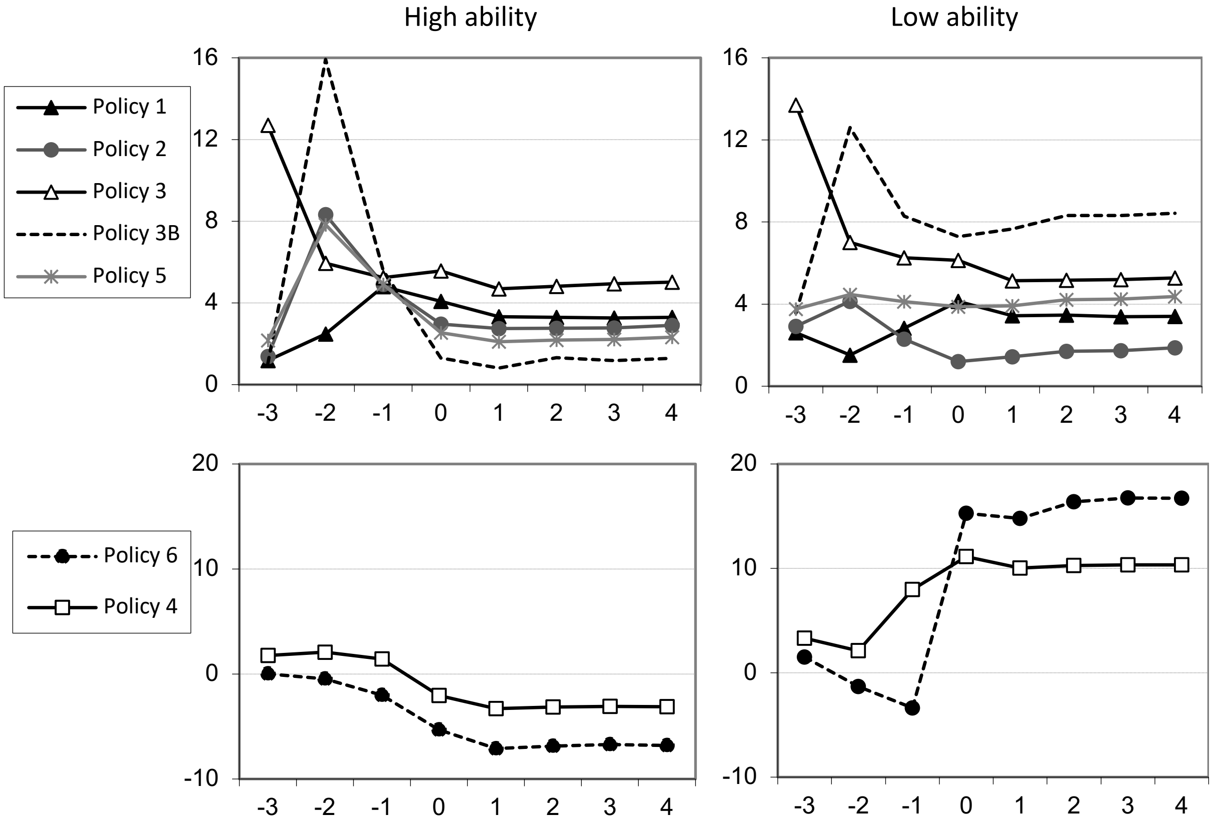
(d) difference in percent between new steady state and the benchmark.

(e) change in percentage points to keep the ratio of debt to GDP constant.

induced by policy 3. In Heylen and Van de Kerckhove (2013) we called it a much more effective strategy to target labor tax reductions at older workers ($\Delta\tau_{w3} < 0$). Our results in Table 2 for policy 2 fully confirm this. Policy 2 brings not only a stronger increase in aggregate hours worked than policy 1 (thanks to a strong rise in n_3 and R), it also promotes education by individuals of high and medium ability ($\Delta e = 1.60$). The reason is that, by encouraging individuals to work longer (at lower tax rates) during their third period of life, policy 2 also raises the marginal return to education. The growth in human capital induces higher productivity, which helps explaining why policy 2 brings the best output response of all policies in Table 2 that are compensated by an adjustment of the consumption tax. Comparing policies 1 and 2, the latter also has better aggregate welfare implications (Table 3). A major disadvantage of policy 2, however, is that it enlarges intragenerational welfare inequality. High and medium ability individuals will benefit from the incentives to build human capital and to raise future productivity and wages. Low ability individuals cannot. For them policy 2 is the least beneficial of all policies that we consider in Table 2. They work harder and longer at unchanged productivity.

(iii) From a welfare perspective policy 3 comes out better than policies 1 and 2, both for current and future generations, and for low and high ability individuals[8]. A critical comment that one can raise, though (at times of intergenerational tensions due to ageing and high public debt), is that policy 3 is far from neutral across generations. Those who are retired when policy 3 is introduced, experience by far the largest gain. They can consume much more thanks to the drop in consumption taxes, without having to work more. Current young and future generations experience the smallest gains.

Figure 6. Welfare effects of fiscal policy shocks on current and future high and 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.*

Table 3. Net welfare effect after compensating welfare transfers (expressed as % of initial GDP)

Included generations	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 3B
All current + 4 future	3,12	3,53	5,89	1,85	3,73	0,21	5,28
All current	2,11	2,74	4,41	1,21	2,82	-0,43	4,26

Note: for a description of the computation of these data, see main text.

[8] The only exception is the group of older high ability workers who are slightly better off with policy 2.

Policies 4, 5, 6 and 3B explore four alternative strategies to combine increased productive efficiency with progress in equity. Ideally, the latter includes an increase in aggregate welfare and a reduction in welfare inequality both within generations and between generations. Policy 4 targets the whole labor tax cut at low-income earners. These are all the low ability individuals and the young individuals of medium ability[9]. According to policy 4, they enjoy a reduction of the tax rate by 13 percentage points. Policy 5 extends policy 2's labor tax cut for all older workers to all low-income earners. Policy 6 targets the whole labor tax reduction at young low-income earners. A reduction of the labor tax rate by about 21 percentage points would be possible. Finally, policy 3B repeats the overall non-employment benefit reduction of policy 3. It differs from 3, however, by redirecting the gains from this benefit reduction to labor tax cuts for all older and all low-income earners (in line with policy 5). Observing our results, we draw the following conclusions:

(iv) Policies 4 and 6 are the best when the objective is to promote the welfare of young and future generations of low ability individuals (Figure 6). They fail, however, in their political economy consequences. Both policies imply negative welfare effects for most high ability individuals. They may have no chance politically. Policy 6 may even get no support from older generations of low ability individuals. Policy 6 also fails in its effects on efficiency. In the new steady state in Table 2 aggregate output and income will be more than 2% lower than initial output. Moreover, aggregate employment hardly rises following policy 6. The drastic rise in the consumption tax rate to finance this policy affects everyone's marginal gain from work negatively. Even the low ability individuals will not work more over their life cycle. They will just shift labor from their middle aged and older period to youth. The employment effects of policy 4, by contrast, are much better. Employment rises strongly among all individuals of low ability and among the young of medium ability. Considering all policies financed by a change of the consumption tax rate, only policy 3 has better employment effects than policy 4. In this respect, our results are fully in line with empirical studies showing that labor tax cuts targeted at low-wage earners are more effective than overall labor tax cuts (e.g. OECD, 2011). At the same time, encouraging young individuals of medium ability to work more also comes at a cost as they will then substitute work for education ($\Delta e < 0$), which undermines future human capital and wages.

(v) Spreading the labor tax cut on both older and low-income earners, makes policy 5 better than policy 2 in most respects. It is comparable from the perspective of intergenerational equity, but it brings larger aggregate welfare gains than policy 2. Moreover, being more beneficial to low ability individuals, policy 5 also reduces intragenerational welfare inequality. And it has better aggregate employment effects. Only participation in education and aggregate output and income would rise more under policy 2 than under policy 5. (Note though that, relative to all other policies in Table 6, policy 5 is still among the better ones for education and aggregate output).

(vi) Among all policies that we discussed above, policy 3 came out as best for aggregate welfare and employment. All generations of all ability types would gain. A critical point, however, was that policy

[9] Ideally, only individuals of low innate ability should enjoy this labor tax cut. However, since the government cannot observe ability, its best alternative is to target the tax cut at all low-income earners.

3 would imply higher intergenerational welfare inequality. Furthermore, it would not bring the positive effects of policies 2 and 5 on the participation in education by individuals of high and medium ability. Policy 3B deals with all these points of criticism. Rather than redirecting the financial gains from cutting non-employment benefits to a reduction of consumption taxes, this policy uses these gains to reduce taxes on labor for older and low-income individuals. It combines the strongest aggregate output (income) and employment gains with a reduction in intragenerational inequality. For individuals of low ability policy 3B is by far the best among all feasible policies (i.e. policies that do not reduce other people's welfare). Moreover, policy 3B also brings a more equal intergenerational distribution of welfare gains than policy 3. Gains are more or less the same for all generations of workers of the same innate ability. Only third generation (older) workers stand out to gain much more. They capture the full gain of the reduction in τ_{w3} and do no longer carry the cost of lower non-employment benefits at younger age. Policy 3B may thus deal with most of the comments raised against policy 3. In the end it should be recognized though, that for aggregate welfare in Table 3, policy 3 still performs best, at least in this model[10].

6. Policy conclusions and direction for further research

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 ability workers. In recent years, increasing sensitivity to the problem of inequality has made the challenge for policy makers only larger. Not only productive efficiency, but also equity demands attention.

In this paper we have looked for the most effective composition of fiscal policy to face this whole challenge. We build a general equilibrium model that explains hours of work of young, middle aged and older individuals, education of the young and human capital, and aggregate output (income) and welfare within one coherent framework. Moreover, to allow a realistic analysis of welfare and welfare inequality, not only across generations but also within generations, we introduce heterogeneity in individuals' ability to build human capital. Some individuals enter our model with high human capital and have a high capacity to learn (and earn). Others enter with low human capital and have very low learning ability.

Simulating the model, we show that fiscal policy can substantially increase employment, labor productivity (human capital), aggregate per capita income, and aggregate welfare without increasing intergenerational or intragenerational welfare inequality. Our results strongly prefer a reduction in the labor tax rate on older workers and on all low-wage earners, financed by an overall reduction in non-employment benefits. A second option to finance these tax cuts, which also improves aggregate productive efficiency (output, employment) without cost in terms of growing inequality, is to the raise the consumption tax rate. Alternative compositions of the fiscal policy change (e.g. targeting the labor tax cut at all workers or targeting it only at older workers or only low wage earners) is inferior from the

[10] Policy 3B would perform better for example if we gave up the assumption of generation-invariant initial human capital (Eq. 11). The increased investment in education induced by policy 3B would then also come to the benefit of future generations, and its welfare effects would be better than those of policy 3. Details are available upon request.

perspective of either productive efficiency or equity, or both. We emphasize that these results are to be seen as long-run effects for economies at potential output. Our model abstracts from the business cycle and from short-run frictions that may hinder or slow down the matching of labor supply and demand.

Our results provide one clear direction for further research. In line with the lion's share of the dynamic general equilibrium literature modeling employment, we assume perfect competition in this paper. We have seen, however, that this assumption implies a clear overestimation in all countries of the relative employment rate among low educated individuals. Boone and Heylen (2018) show that progress can be made by introducing elements of imperfect competition, e.g. union wage setting on the labor market for low educated individuals. It will be interesting to investigate the fiscal policy shocks of this paper in a model with imperfect labor markets. We plan to do this in the near future.

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Appendix A: Optimality conditions for individual behavior

An individual with ability *a* entering the model at time *t* will choose consumption, labor supply in each period of active life, education when young (for the medium and high ability individuals), and the effective retirement age to maximize

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

subject to Equations (2)-(13) in the main text. Equation (A.1) expresses the law of motion of optimal consumption over the lifetime. Equations (A.2a), (A.2b) and (A.2c) 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. Equation (A.3) gives the first order condition for the optimal effective retirement age. It equalizes the marginal utility loss from postponing retirement to the related marginal utility gain. Equation (A.4) 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.

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

$$\frac{\gamma_1}{\left(\ell_{1a}^t\right)^{\theta}} \frac{-\partial \ell_{1a}^t}{\partial n_{1a}^t} = \frac{w_{a,t} h_{1a}^t (1-\tau_w)(1-b)}{c_{1a}^t (1+\tau_c)} + \frac{\beta^3}{3} \frac{\rho_{wa} w_{a,t} h_{1a}^t (1-\tau_w)(1+x)^3}{c_{4a}^t (1+\tau_c)} \tag{A.2a}$$

$$\frac{\gamma_2}{\left(\ell_{2a}^t\right)^{\theta}} \frac{-\partial \ell_{2a}^t}{\partial n_{2a}^t} = \frac{w_{a,t+1}\left(1+\phi\left(e_{1a}^t\right)^{\sigma}\right) h_{1a}^t (1-\tau_w)(1-b)}{c_{2a}^t (1+\tau_c)} + \frac{\beta^2}{3} \frac{\rho_{wa} w_{a,t+1}\left(1+\phi\left(e_{1a}^t\right)^{\sigma}\right) h_{1a}^t (1-\tau_w)(1+x)^2}{c_{4a}^t (1+\tau_c)} \tag{A.2b}$$

$$\frac{\gamma_3}{\left(\ell_{3a}^t\right)^{\theta}} \frac{-\partial \ell_{3a}^t}{\partial \tilde{n}_{3a}^t} = \frac{w_{a,t+2}\left(1+\phi\left(e_{1a}^t\right)^{\sigma}\right) h_{1a}^t R_a^t (1-\tau_w)(1-b)}{c_{3a}^t (1+\tau_c)} + \frac{\beta}{3} \frac{\rho_{wa} w_{a,t+2}\left(1+\phi\left(e_{1a}^t\right)^{\sigma}\right) h_{1a}^t R_a^t (1-\tau_w)(1+x)}{c_{4a}^t (1+\tau_c)} \tag{A.2c}$$

$$\frac{\gamma_3}{\left(\ell_{3a}^t\right)^{\theta}} \frac{-\partial \ell_{3a}^t}{\partial R_a^t} = \frac{w_{a,t+2}\left(1+\phi\left(e_{1a}^t\right)^{\sigma}\right) h_{1a}^t (1-\tau_w)\left(\tilde{n}_{3a}^t + b\left(1-\tilde{n}_{3a}^t\right) - b_{er}\right)}{c_{3a}^t (1+\tau_c)} + \frac{\beta}{3} \frac{\rho_{wa} w_{a,t+2}\left(1+\phi\left(e_{1a}^t\right)^{\sigma}\right) h_{1a}^t \tilde{n}_{3a}^t (1-\tau_w)(1+x)}{c_{4a}^t (1+\tau_c)} \tag{A.3}$$

$$\frac{\gamma_1}{\left(\ell_{1a}^t\right)^{\theta}} \frac{-\partial \ell_{1a}^t}{\partial e_{1a}^t} - \frac{1}{c_{1a}^t} \frac{\partial c_{1a}^t}{\partial e_{1a}^t} = \beta \frac{1}{c_{2a}^t} \frac{\partial c_{2a}^t}{\partial e_{1a}^t} + \beta^2 \frac{1}{c_{3a}^t} \frac{\partial c_{3a}^t}{\partial e_{1a}^t} + \beta^3 \frac{1}{c_{4a}^t} \frac{\partial c_{4a}^t}{\partial e_{1a}^t} \quad \forall a = H, M \tag{A.4}$$

with: $$\frac{\partial c_{1a}^t}{\partial e_{1a}^t} = -\frac{b w_{a,t} h_{1a}^t (1-\tau_w)}{1+\tau_c}$$

$$\frac{\partial c_{2a}^t}{\partial e_{1a}^t} = \sigma\phi(e_{1a}^t)^{\sigma-1} \frac{w_{a,t+1} h_{1a}^t (1-\tau_w)\left[n_{2a}^t + b\left(1-n_{2a}^t\right)\right]}{1+\tau_c}$$

$$\frac{\partial c_{3a}^t}{\partial e_{1a}^t} = \sigma\phi(e_{1a}^t)^{\sigma-1} \frac{w_{a,t+2} h_{1a}^t (1-\tau_w)\left[R_a^t\left(\tilde{n}_{3a}^t(1-b)+b-b_{er}\right)+b_{er}\right]}{1+\tau_c}$$

$$\frac{\partial c_{4a}^t}{\partial e_{1a}^t} = \rho_{wa}\sigma\phi(e_{1a}^t)^{\sigma-1} \frac{1}{3} \frac{\sum_{j=2}^{3}\left(n_{ja}^t w_{a,t+j-1} h_{1a}^t (1-\tau_w)(1+x)^{4-j}\right)}{1+\tau_c}$$

Appendix B: Construction of data and data sources

In this appendix we provide more detail on the data, the construction and the data sources of our performance variables (Table A.1) and policy variables (Tables A.2 – A.4).

Table A.1
Employment rate in hours (n) by age and educational attainment, effective retirement age and education rate ($\boldsymbol{e}$) in 12 OECD countries (1995-2007)

	n_1 (20-34)	n_2 (35-49)	n_3 (50-64)	*Effective retirement age*	n_L/n_H	e
Austria	59.9	64.3	34.7	59.5	0.64	12.5
Belgium	51.1	56.8	29.3	57.9	0.58	14.1
France	48.7	60.3	38.0	58.8	0.71	14.9
Germany	49.7	55.2	34.9	61.1	0.62	17.2
Netherlands	50.8	54.6	34.2	60.0	0.70	14.7
Denmark	56.2	66.7	49.6	62.2	0.71	21.7
Finland	55.6	69.0	47.3	60.2	0.69	23.1
Norway	51.9	60.9	50.6	63.1	0.72	18.1
Sweden	53.6	66.1	55.4	63.4	0.76	17.7
US	65.6	74.2	59.6	64.2	0.69	12.8
UK	60.8	68.4	49.4	62.0	0.74	12.3
Canada	60.9	69.5	50.4	62.1	0.68	13.6
Overall average	**55.4**	**63.8**	**44.5**	**61.2**	**0.69**	**16.1**

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 and total population by 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.

Average effective retirement age *(1995-2006)*

Definition: Average age of all persons (being 40 or older) withdrawing from the labor force in a given period.

Data source: OECD, Ageing and Employment Policies – Statistics on effective age of retirement.

Relative employment among low ability versus high ability individuals *(n_L/n_h, 2005)*

Definition: Ratio of the employment rate in persons among people with less than upper secondary education to the employment rate in persons among those with a tertiary degree.

Data source: OECD, OECD Stat, Education at a Glance, Educational attainment and labour force status

Note: Ideally, we have data for relative employment in hours. As far as we know, however, data on hours worked per employed person by education in 1995-2007 are not available.

Education rate of the young *(age group 20-34, 1995-2007)*

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

As a proxy we have computed the ratio: $\left(fts_{20-34} + 0.5pts_{20-24} + 0.25pts_{25-34}\right) / \ pop_{20-34}$

with: *fts* the number of full-time students in the age group 20-34

pts the number of part-time students in the age groups 20-24 and 25-34.

pop total population of age 20-34

Full-time students are assumed to spend all their time studying. For part-time students of age 20-24 we make the assumption (for all countries) that they spend 50% of their time studying, part-time students of age 25-34 are assumed to spend 25% of their time studying. Due to the limited number of part-time students, these specific weights matter very little.

Data sources:

* Full-time students in age groups 20-24, 25-29, 30-34: OECD Stat, Education and Training, Students enrolled by age (all levels of education, all educational programmes, full-time)

* Part-time students in age groups 20-24, 25-29, 30-34: OECD Stat, Education and Training, Students enrolled by age (all levels of education, all educational programmes). We subtracted the data for full-time students from those for 'full-time and part-time students'.
For those countries where data for specific years are missing, we computed period averages on the basis of all available annual data.

Tax rate on labor income *(*τ_w)
Definition: Total tax wedge, marginal tax rate in % of gross wage earnings. The data cover personal income taxes and social security contributions paid by employees on their wage earnings as well as social security contributions and payroll taxes paid by employers.
Data source: OECD, Taxing Wages, Comparative tax rates and benefits (new definition).
The OECD publishes marginal labor tax rates for several family and income situations: single persons at 67%, 100% and 167% of average earnings (no children), single persons at 67% of average earnings (two children), one-earner married couples at 100% of average earnings (two children), two-earner married couples, one at 100% of average earnings and the other at 33 % (no children, 2 children), two-earner married couples, one at 100% of average earnings and the other at 67 % (2 children). Our data in Table A.2 are the averages of these eight cases. Data for 2000-04.

Tax rate on capital *(*τ_k)
Definition: effective marginal corporate tax rates (EMTR, base case)
Data source: Institute for Fiscal Studies (see also Devereux *et al*., 2002).

Tax rate on consumption *(*τ_c)
Data source: Dhont and Heylen (2009).

Government debt *(*D_t*)*
Definition: General government gross financial liabilities.
Data source: OECD.Stat, Economic Outlook, Government Accounts.

Net benefit replacement rate when young, middle aged and older before early retirement *(b*)
Definition: The data concern net transfers received by structurally or 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[11]. We use these data since in our model non-employment is a structural or

[11] In the period that we study, 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).

equilibrium phenomenon. The data are expressed in % of after-tax wages. The OECD provides net replacement rates for six family situations and three earnings levels. Our data in Table A.3 are the averages of these 18 cases. Data 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.

Net early retirement replacement rates *(b_{er})*

To calculate our proxy for b_{er} we have focused on 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 benefit replacement rate r_{er}. However, these implicit tax rates are only very rough estimates of the real incentive to retire embedded in early retirement schemes and are subject to important caveats (Duval, 2003, p. 15). The available implicit tax rates take into account neither the strictness of eligibility criteria nor the presence of alternative social transfer programs that may de facto be used as early retirement devices. Our assumption will be that a realistic replacement rate for the early retirement route (b_{er}) will be a weighted average of r_{er} and b, where we take the latter as a proxy for the replacement rate in alternative social transfer programs. If $r_{er} > b$, older workers will aim for the official early retirement route, but they may not all meet eligibility criteria and have to fall back on alternative programs. If $r_{er} < b$, workers will aim for the alternative, but again they may not be eligible. We propose that $b_{er} = \xi b + (1\text{-}\xi) r_{er}$. Underlying the data in Table A.3 is the assumption that ξ=0.5. Correlation between b_{er} and r_{er} lies around 0.92. Cross-country differences roughly remain intact. Our results in the main text do not depend in any serious way on this assumption for ξ.

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

Table A.2 Fiscal policy: Tax rates and government debt

	tax rate on labor income (in %)	consumption tax rate (%)	tax rate on capital income (%)	Public debt (% of GDP)
Proxy for :	τ_w	τ_c	τ_k	D/Y
Austria	54.9	13.2	17.3	69.6
Belgium	67.2	13.4	27.1	111.7
France	52.9	17.1	21.7	68.9
Germany	60.4	11.1	34.4	63.1
Netherlands	52.0	12.2	24.3	68.2
Denmark	48.6	18.9	22.5	60.3
Finland	56.2	15.2	17.2	54.1
Norway	50.8	16.4	22.1	40.4
Sweden	56.0	17.9	16.1	67.2
UK	44.9	14.5	21.2	46.6
US	37.4	7.2	23.6	61.9
Canada	46.4	14.5	24.8	83.8
Overall average	52.3	14.3	22.7	66.3

Notes: Labor tax rates are for 2000-2004. Earlier data are not available. Capital tax rates and consumption tax rates are for 1995-2001.

Table A.3 Fiscal policy: net benefit replacement rates

	Non-employment benefit (net replacement rate, %)	Early retirement benefit (net replacement rate, %)
Proxy for :	b	b_{er}
Austria	56.3	71.6
Belgium	59.6	79.0
France	46.0	63.8
Germany	64.7	70.8
Netherlands	55.0	68.1
Denmark	61.9	43.2
Finland	61.3	73.8
Norway	56.9	39.9
Sweden	55.4	39.0
UK	51.1	39.4
US	30.5	18.3
Canada	44.4	27.0
Overall average	53.6	52.8

Notes: A description of both variables is given in the text of this Appendix. The data are an average for 2001-2004 (earlier data are not available).

Net pension replacement rates *(ρ_{wa} and ρ_{fa} for a=L,M,H)*

OECD (2005, p. 52) presents net pension replacement rates for individuals at various multiples of average individual earnings in the economy. We consider the data for individuals at 50% of average earnings as representative for the low ability group, individuals with average earnings as representative for the medium ability group, and individuals with twice average earnings as representative for the high ability group. Country studies in OECD (2005, part II) show the composition (sources) of this net replacement rate. This composition may be different for individuals with different income levels. Our proxy for ρ_{wa} includes all earnings-related pensions and mandatory occupational pensions when they depend on wages or hours worked. Note that the precise organization of the earnings-related system may differ across countries. Some countries have pure defined-benefit systems (e.g. Belgium, Finland, US), others have so-called point systems (Germany) or notional-account systems (Sweden). Although these three systems can appear very different, OECD (2005) shows that they are all similar variants of earnings-related pension schemes. Our proxy for ρ_{fa} includes basic pensions, minimum pensions, targeted pensions, and old-age social assistance benefits, i.e. all categories that are not (or even inversely) related to individual earnings. Since in our model ρ_{fa} is a percentage of the average net wage in the economy (Equation 10), whereas the above described OECD data are in percent of an individual's net wage, we multiply the OECD data with the ratio of the replacement in percent of average earnings to the replacement rate in percent of individual earnings to obtain our ρ_{fa}. This ratio can be derived from the 'pension modelling' tables in the individual country studies, at various multiples of average earnings.

Table A.4 Net pension replacement rates

	Net earnings-related pension replacement rate (% of average earned net labor income)			Net basic pension replacement rate (% of economy-wide average net labor income)		
Proxy for:	Low ρ_{wL}	Medium ρ_{wM}	High ρ_{wH}	Low ρ_{fL}	Medium ρ_{fM}	High ρ_{fH}
Austria	88.7	88.9	75.9	0.0	0.0	0.0
Belgium	55.4	63.1	42.7	17.2	0.0	0.0
France	62.9	68.8	59.2	23.2	0.0	0.0
Germany	60.4	71.8	67.0	0.8	0.0	0.0
Netherlands	0.0	42.1	62.9	46.4	42.1	36.2
Denmark	15.3	11.0	10.0	43.6	43.1	42.2
Finland	82.3	78.8	78.3	4.9	0.0	0.0
Norway	36.4	43.0	38.4	26.4	22.1	20.3
Sweden	64.6	65.9	74.3	13.6	2.3	0.0
UK	0.0	5.0	8.0	43.6	42.6	41.2
US	61.4	51.0	39.0	0.0	0.0	0.0
Canada	31.6	33.9	18.1	31.5	23.2	23.3
Overall average	46.6	51.9	47.8	20.9	14.6	13.6

Notes: The data concern 2002.

Appendix C: Details on the calibration procedure to determine η_a (with $a = L, M, H$)

Given the data for US relative wages in Table 1, we have for the low ability group that:

$$\frac{w_{L,t}h_{1L}^t}{w_{H,t}h_{1H}^t} = \frac{w_{L,t}\varepsilon_L h_{1H}^t}{w_{H,t}h_{1H}^t} = \frac{w_{L,t}}{w_{H,t}}\varepsilon_L = 0.43.$$

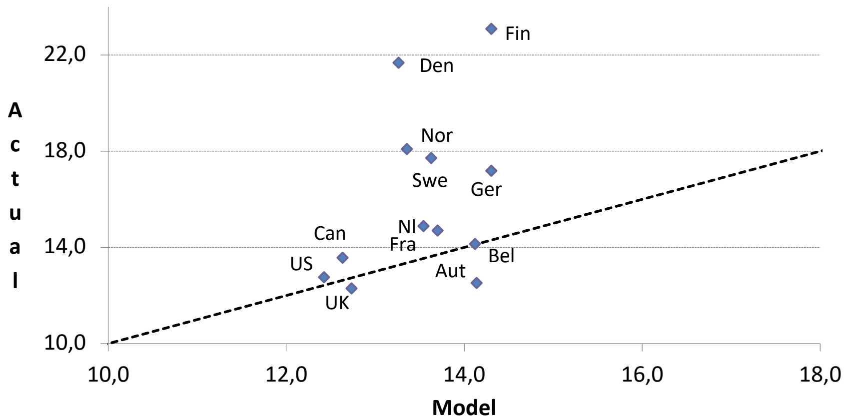
We also know from Equation (18) that $\frac{w_{L,t}}{w_{H,t}} = \frac{\eta_L}{\eta_H}\left(\frac{H_{H,t}}{H_{L,t}}\right)^{\frac{1}{S}}$, which implies for the US:

$$\frac{\eta_L}{\eta_H}\left(\frac{H_{H,t}}{H_{L,t}}\right)^{\frac{1}{S}} = \frac{0.43}{\varepsilon_L} = \frac{0.43}{0.67} = 0.64.$$

Similarly, it is easy to obtain for the medium ability group: $\frac{\eta_M}{\eta_H}\left(\frac{H_{H,t}}{H_{M,t}}\right)^{\frac{1}{S}} = \frac{0.63}{\varepsilon_M} = \frac{0.63}{0.84} = 0.75.$

If we finally take into account that $\eta_H = 1 - \eta_M - \eta_L$, and we introduce values for $H_{H,t}/H_{M,t}$ and $H_{H,t}/H_{L,t}$ which we simultaneously obtain elsewhere in the calibration (as functions of the employment rates, education rates, σ and ϕ, it is easy to see that we have three remaining equations in three unknowns (η_H, η_M, η_L) that can be solved.

Appendix D: Model predictions and facts for education



Note: The dotted line is the 45°-line.

The model performs very well for the euro area countries and the Anglo-Saxon countries. It underestimates participation in tertiary education in the Nordic countries, though. This does not come as a surprise, considering our earlier results in Heylen and Van de Kerckhove (2013). In that paper we used a much richer CES specification for the human capital production function, including also government spending on education and an indicator for the quality of education, both exogenous to the behavior of individuals and firms. Since the current paper is about fiscal policy (mainly taxes and non-employment benefits), it is important to capture the effects of (changes in) these policy variables well, including the induced effects on education. Our model does this. Adding other (exogenous) variables in the human capital production function could improve the figure above, but it would not affect our results in this paper in any relevant way, and certainly not our policy implications.

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