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Pensions and fertility: a simple proposal for reform

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Abstract

This paper evaluates the effects of a parametric adjustment to an earnings-related PAYG pension system. We show that a simple but 'intelligent' reform, in which the calculation of the pension base is changed, may result not only in more employment and growth, but also in an increase in fertility. Such an 'intelligent' pension design would maintain a strong link between own labor income and the future pension, while putting more (less) weight on the labor income earned as an older (young) worker in the calculation of the pension base. The higher (lower) marginal utility from work when older (young) following this reform makes it interesting to shift work from the first to later periods of active life. Part of the available time that arises during youth is spent on education. Another part can be spent on raising offspring. By contrast, a shift to a fully-funded system might even reduce fertility.

Keywords: demographic change, fertility, retirement, pension reform, overlapping generations

JEL Classification: E62, H55, J13, J22

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1. Introduction: research question and related literature

Public pension systems face increasing pressure in many OECD countries given the overall rise in life expectancy and decline in fertility rates. In order to face the pension challenge in an ageing society, many economists agree on the need for higher employment, especially among older individuals, and higher productivity growth. While a lot of research has been performed on this issue[1], a consensus on best pension reform has not yet been reached. Some studies are in favor of parametric adjustments to the pay-as-you-go (PAYG) system that many countries rely on (see for instance Diamond, 2004 and Cigno, 2010), while others prefer a move to an actuarially neutral fully-funded private system (Feldstein, 2005; Börsch-Supan and Ludwig, 2010).

Given the importance of the demographic evolution for the sustainability of a pension system, a large literature has studied the interaction between public pensions and the fertility rate. Some authors see the public pay-as-you-go pension system as one of the reasons for the decline in fertility rates (e.g. Zhang, 1995; Cigno and Rosato, 1996; Sinn, 2004 and Boldrin *et al.*, 2005). The general idea is that the introduction of a public pension system diminishes the necessity to raise children as a source of old-age income support. As such, public pensions reduce transfers within the family and hence distort demand for children.

With respect to the issue of declining fertility, several pension reform proposals have already been put forward. In order to revert the decline in population growth, some economists are in favor of a switch to a fully-funded system since such a system is stable in case of demographic change. Others advocate the idea of relating the pension benefit received at the time of retirement (partly) to the number of children raised by the pensioner (e.g. Voigtländer, 2004 and Sinn, 2005). Such a children-pay-as-you-go (CPAYG) system directly raises the return to having children. Moreover, it does not suffer from problems related to ageing as individuals who do not have children are forced to save for their own old-age income. One possible caveat, however, would arise if quality (i.e. investments in a child's education) is substituted by quantity (Becker, 1960).[2]

In this paper, and in contrast to studies that analyze how pension benefits can be related directly to the number of offspring (see e.g. Fenge and Meier, 2005), we take the existing PAYG pension system that most OECD countries rely on as given. We propose a fertility-increasing reform that does not require the introduction of a CPAYG. We propose one specific parametric adjustment policy, which is also shown to be beneficial for economic growth and employment of older workers. More specifically, we are in favor of a pension system that maintains the strong link between own labor income and the earned pension, while putting a high weight on the labor income earned as an older worker in the calculation of the pension assessment base. Pension reform in this direction not only

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[1] Many studies document how the pension system may affect the incentives of individuals of different ages to work (e.g. Auerbach *et al.*, 1989; Fisher and Keuschnigg, 2010; de la Croix *et al.*, 2010). Others investigate the relationship between the pension system and human capital investment (e.g. Zhang and Zhang, 2003).

[2] It should be mentioned that, as a remedy to low fertility, many countries have resorted to other policy instruments such as child subsidies, parental leave schemes and public provision of day-care centres.

encourages young individuals to study and build human capital and encourages older individuals to work and postpone retirement, it may also bring about behavioral effects that induce individuals to bear more children and may hence increase total fertility. To show these effects, we extend the general equilibrium four-period OLG model of Buyse *et al.* (2013) to allow for an endogenous fertility choice. The model explains hours of work of young, middle-aged and older individuals, education and human capital formation of the young, fertility, retirement of the older generation and aggregate growth (per capita). It includes a public PAYG old-age pension system. The statutory retirement age is 65 and exogenous. To keep the model as streamlined as possible, we abstract from concerns as longevity and the inability of certain individuals to bear children. The remainder of this paper is organized as follows. Section 2 describes the model and calibration. In Section 3 we show the results of some straightforward pension reform proposals. Section 4 concludes.

2. The model

We use the computable 4-period overlapping-generations model for a small open economy of Buyse *et al.* (2013) as our starting point. We maintain most of the assumptions in their model such as perfect international mobility of physical capital and immobile labor. We will not develop the complete model here – we refer to the original paper of Buyse *et al.* and to Appendix A in this paper – but instead focus on the novelties such as the decision about the number of offspring and the old-age social security system.

Demographics and notation

A certain generation *t,* which enters the model at the age of 20 at time *t*, consists of N_t individuals. Within each generation agents are assumed homogeneous. Individuals live for four periods which all last for 15 years in real life. Individuals are young (age 20-34), middle-aged (35-49), older (50-64) and retired (65-79). There is no uncertainty concerning mortality: all individuals die when they reach the age of 80. We indicate by d_1^t and d_2^t the number of children raised by generation *t,* born either during the young or middle-aged period of adulthood. Both the total number of offspring and the time to have children are hence decision variables for the household. Population grows according to the following equation $N_{t+1} = d_1^t N_t + d_2^t N_{t-1}$.
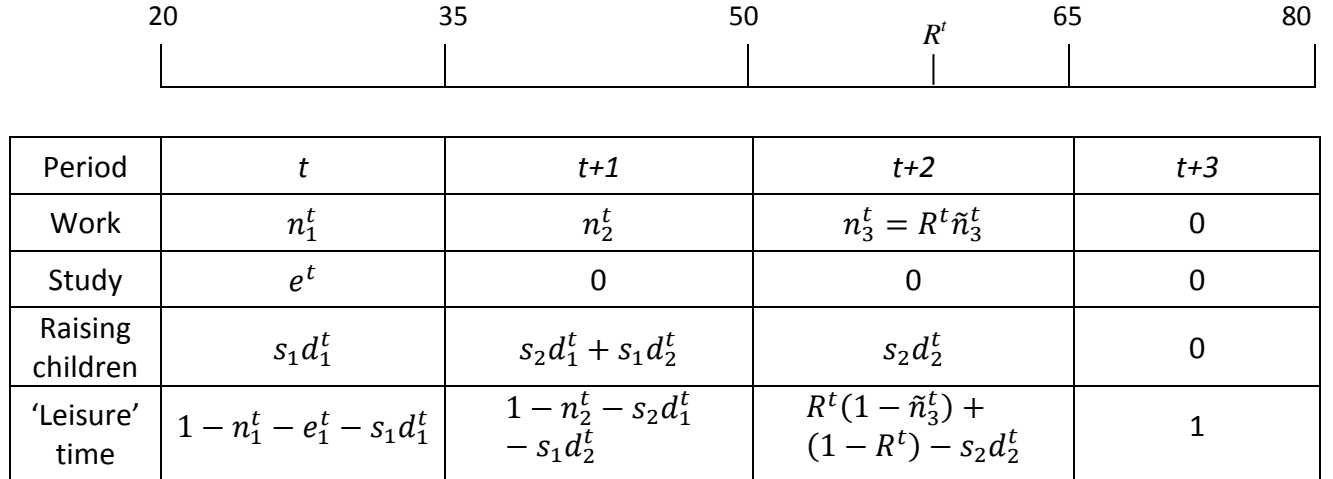
As to notation, a superscript *t* indicates the period an individual enters the model (the period of youth). Subscript *t* refers to the historical time period, while subscripts 1, 2, 3 and 4 indicate whether variables relate to the first, second, third or fourth period of the individual's live.

Individuals

Figure 1 shows the life-cycle time profile of an individual reaching age 20 in *t*. Young people can choose either to work and generate labor income (n_1), to study and build human capital (*e*) or to devote time to raising children ($s_1 d_1$), where s_1 is a time cost per child (see further on). The remaining time is spent on 'leisure' (including other non-market activities). Time endowment is

normalized to 1 in each period. Middle-aged workers may also raise children but they do not study. Older workers do not bear children and do not study; they only work, have 'leisure' and continue raising their children born the period before. Note that the period of childhood (i.e. the period before the age of 20 when children live with their parents) is not modeled explicitly.

Figure 1. Life-cycle of an individual of generation t

20	35	50	R^t	65	80

Period	t	$t+1$	$t+2$	$t+3$
Work	n_1^t	n_2^t	$n_3^t = R^t \tilde{n}_3^t$	0
Study	e^t	0	0	0
Raising children	$s_1 d_1^t$	$s_2 d_1^t + s_1 d_2^t$	$s_2 d_2^t$	0
'Leisure' time	$1 - n_1^t - e_1^t - s_1 d_1^t$	$1 - n_2^t - s_2 d_1^t - s_1 d_2^t$	$R^t(1 - \tilde{n}_3^t) + (1 - R^t) - s_2 d_2^t$	1

Note: A superscript t indicates the historical period of youth of an individual. Subscripts 1, 2, 3 and 4 refer respectively to the period in which the individual is young, middle-aged, older or retired.

The statutory old-age retirement age is 65. Individuals may however optimally choose to leave the labor force sooner in a regime of early retirement. The determination of early retirement is part of the individuals' optimal choice of 'leisure' time in the third period of life (50-64). Individuals choose R, 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 in the labor market; $(1-R)$ is then time in early retirement. We use n_3 to denote the fraction of time devoted to work between 50 and 65, and $\tilde{n}_3$ as the fraction of time devoted to work before early retirement, but after 50. As labor market exit is irreversible and post-retirement employment is not allowed in our model, the relationship between n_3 and $\tilde{n}_3$ is as follows: $n_3 = R \cdot \tilde{n}_3$. Finally, note that retired agents leave no debts, nor bequests.

$$U_t = \sum_{j=1}^{4} \beta^{j-1} \left[\ln c_j^t + \gamma_j \frac{l_j^{t\,1-\theta}}{1-\theta} \right] + \gamma_{d1} \ln d_1^t + \gamma_{d2} \ln d_2^t \qquad (1)$$

Equation (1) shows the intertemporal utility function of an individual of generation t. Lifetime utility depends on consumption (c_j) and enjoyed 'leisure' (l_j) in each period of life. The intertemporal elasticity of substitution in consumption is 1, the intertemporal elasticity to substitute leisure $1/\theta$. Furthermore, β is the discount factor ($0 < \beta < 1$). Finally, γ_j specifies the relative value of leisure versus consumption. Note that γ may be different in each period of life.

A final part of Equation (1) is related to the utility of having children. As mentioned above, individuals decide upon the number of offspring they bear in their first (d_1^t) or second (d_2^t) period of life. When

choosing this number of children, individuals take into account both the benefits and costs from raising them. As to the benefits, we assume that individual utility depends directly on the number of children. This assumption of weak altruism is mainstream in the literature (e.g. Eckstein and Wolpin, 1985; Galor and Weil, 1996; Eckstein *et al.*, 1988; Fanti and Gori, 2012 and Cipriani, 2013). It implies that children are considered as a pure consumption good and not as an investment good, i.e. children yield utility to their parents only in the period in which they are born. [3] For simplicity, we assume a logarithmic specification: $u(d_j^t) = \gamma_{dj} \ln(d_j^t)$ for $j = 1, 2$. [4]

Raising children is also costly. There are two types of costs which prevail both in the first (subscript 1) and second (subscript 2) period after a child is born. First, parents spend some exogenous amount s_1 (resp. s_2) of their available time on child rearing (see also Figure 1). If raising an additional child thus implies taking less leisure, this has a direct negative effect on utility. If on the other hand, it means less labor supply, it has an indirect financial effect due to lower labor income. [5] Second, there is also a direct financial cost to bring up offspring. We think of food costs, living expenditures, college tuition... We define the latter as a fraction of the after-tax wage income (see also Cipriani, 2013). We assume these fractions to be ω_1 resp. ω_2.

As mentioned before, we will not describe in detail all equations of the model in the main text. However, we do mention the first order condition for the decision on the number of children in Equations (2a) and (2b) below.

$$\frac{\gamma_{d1}}{d_1^t} = \gamma_1 \frac{s_1}{\left(1-n_1^t-e^t-s_1 d_1^t\right)^\theta} + \beta\gamma_2 \frac{s_2}{\left(1-n_2^t-s_2 d_1^t-s_1 d_2^t\right)^\theta} + \frac{\omega_1 n_1^t w_t h_1^t(1-\tau_w)}{c_1^t(1+\tau_c)} + \beta \frac{\omega_2 n_2^t w_{t+1} h_2^t(1-\tau_w)}{c_2^t(1+\tau_c)} \qquad (2a)$$

$$\frac{\gamma_{d2}}{d_2^t} = \beta\gamma_2 \frac{s_1}{\left(1-n_2^t-s_2 d_1^t-s_1 d_2^t\right)^\theta} + \beta^2\gamma_3 \frac{s_2}{\left(l_3^t\right)^\theta} + \beta \frac{\omega_1 n_2^t w_{t+1} h_2^t(1-\tau_w)}{c_2^t(1+\tau_c)} + \beta^2 \frac{\omega_2 n_3^t w_{t+2} h_3^t(1-\tau_w)}{c_3^t(1+\tau_c)} \qquad (2b)$$

These first order conditions state that individuals choose the number of children d_j^t to equalize the costs and benefits of raising an additional child. The left-hand side of Equations (2a) and (2b) describe the direct utility gain from bearing an additional child given our assumption of children as consumption goods. The right-hand side shows the marginal utility loss. This loss consists of two

[3] Many studies exist in which children are considered as investment goods. Bental (1989) and Sinn (2004) consider a transfer from children to elderly parents. However, given the fact that developed countries have social security systems and old-age pension systems, the motive for having children as an investment good is not that prevalent anymore.

[4] Note that the utility-value of offspring can be different depending on their timing of birth. In our model, for instance, the fact that γ_{d2} might be smaller than γ_{d1} could capture the fact that the higher the mother's age when pregnant, the higher the possibility of difficulties during the period of pregnancy, premature birth or congenital handicap of the child.

[5] We do not model a time cost of bearing children in the third period after the child is born. We believe this is a realistic assumption. It would of course be possible to introduce such a cost s_3. In that case, as long as children require more care and attention (in terms of time costs) when parents are younger than age 50, the results in this paper will hold.

components. All things equal, more children reduce the available leisure time in the first two periods of parenthood, as shown by the first two terms on the right-hand side. These terms thus capture the time cost of having children. The last two components in Equations (2a) and (2b) capture the financial cost of having children. That is, bearing an additional child implies that a higher fraction of income has to be spent on children (according to fraction $\omega_{1,2}$). Again, given the set-up of the model, these effects occur both in the first and second period of parenthood. The resulting fall in after tax-consumption leads to a drop in utility.

Another important feature of the model is the social security system. Our set-up is as follows. First, between the moment of withdrawal from the labor market (time R^t) and the age of 65, individuals receive an early retirement benefit. This benefit is defined as a proportion of the after-tax wage of a full-time worker. Second, after the statutory retirement age at 65, individuals receive an old-age pension benefit. 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. Individual net pension benefits consist of two components. These are shown in Equation (3) below. A first component is related to the individual's earlier net labor income. It is a fraction of his so-called pension base, i.e. a weighted average of *revalued* net labor income in each of the three active periods of life. The net replacement rate is ρ_w. The parameters p_1, p_2 and p_3 represent the weights attached to each period. In our calibration (see further on), it is assumed that these three parameters are equal to 1/3. This part of the pension rises in the individual's hours of work n_j^t and his human capital h_j^t. It will be lower when the individual retires early (lower R^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 and hence follow practice in many OECD countries (OECD, 2005; Whiteford and Whitehouse, 2006). 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_f.

$$pp_4^t = \rho_w \sum_{j=1}^{3}\left(p_j w_{t+j-1} h_j^t n_j^t (1-\tau_j) \prod_{i=j}^{3} x_{t+i-1}\right) + \rho_f \frac{1}{3}\sum_{j=1}^{3}\left(w_{t+3} h_j^{t+4-j} n_j^{t+4-j}(1-\tau_j)\right) \quad (3)$$

with: $0 \leq p_j \leq 1$

$\sum_{j=1}^{3} p_j = 1$

$n_3^t = R^t \tilde{n}_3^t$

Firms
Domestic firms act competitively on both input and output markets. They use physical capital together with existing technology and effective labor provided by the three active generations as inputs in the production process. All firms are identical and total domestic output is given by a standard Cobb-Douglas production function with constant returns to scale. Firm maximization leads

to two well-known equations. First, the wage per unit of effective labor equals its marginal productivity. Second, the real interest rate equals the net after-tax marginal productivity of capital. These first order conditions are also reported in Appendix A.

Human capital

Human capital has a crucial role in the model. We assume that the average level of human capital of a middle-aged generation is inherited by the next young generation. This mechanism, which is the source of per capita growth in the model, generates a positive externality from education in the sense of Azariadis and Drazen (1990). A young individual may subsequently augment its stock of human capital through time investment in education. The private return to schooling depends not only on the initial stock of human capital but also on the quality of the education system (q) and the amount of government expenditures on education (g_y). We impose a CES-specification for the human capital accumulation function, with the degree of complementarity between private education time and government expenditures being higher than in the Cobb-Douglas case. Heylen and Van de Kerckhove (2013) show the empirical relevance of this specification. It matches the data in 13 OECD countries better than several alternatives.

Government

The model includes an extensive fiscal block. The government raises taxes on individuals' consumption (τ_c) and labor income (τ_w) and on firms' capital income (τ_k). The expenditures consist of productive expenditures (G_y), which raise the return to education, consumption goods (G_c), which are wasteful, benefits related to non-employment (B_t), including early retirement benefits, old-age pension benefits (PP_t), lump sum transfers (Z_t) and interest payments on outstanding debt ($r_t D_t$). Note that we disregard alternative government expenditures in the model such as expenditures for child benefits or public subsidies for child care. A comparative analysis of different policies to raise fertility (either through pension reform or child care) is not the purpose of this paper. Fenge and Meier (2009) for instance, compare the effects of family allowances and fertility-related pensions.

Calibration

We calibrate our model to Belgian data on employment, education rates and growth rates. We choose this country since in Belgium the calculation of pension benefits fits exactly within the way we model it. Belgian public pensions are proportional to average annual labour income earned over a period of 45 years, with equal weights to all years. There is no basic pension (OECD, 2005). As to the pension equation in our model, i.e. equation (3) above, this comes down to ρ_w>0, ρ_f=0 and p_1=p_2=p_3=1/3. We believe that the decision to calibrate our model to Belgium does not restrict us in any way to generalize the results to other OECD countries. In Buyse et al. (2013), where the authors also calibrate on Belgium, the model is first validated empirically for a group of 13 OECD countries. Before using the parameterized theoretical model for policy simulations, the authors thus test whether the model's predictions are within reliable bands. More specifically, the authors impose common technology and preference parameters on all countries, but country-specific fiscal policy

and pension system parameters. Simulating the model for each country they find that its predictions match the main facts in most countries. These facts concern observed hours of work in three age groups (20-34, 35-49, 50-64), education of the young (20-34), the effective retirement age of older workers, and per capita growth since 1995.

We basically follow the same calibration strategy as in the above mentioned paper. We report the resulting parameter values in Appendix B. As to the novel parameters in this model, i.e. on the costs and utility of children, our assumptions are as follows. The average total fertility rate (TFR) for Belgium in the period 2003-2012 was about 1.8 children per couple. Given that we do not consider men and women in our model, but a representative individual, we target a TFR of 0.9 (=1.8/2) in the calibration. Data for Belgium further reveal that about 85% of the offspring are born before the age of 35. This implies that we set d_1 and d_2 to a value of respectively 0.765 and 0.135. We calibrate the relative utility value of children (γ_{d1} and γ_{d2}) versus consumption to match these figures. We further assume a time cost of 10% of available time per child in the first period after the child is born and 5% in the second period (i.e. s_1=0.1 and s_2=0.05). This assumption is in line with for instance Casarico and Sommacal (2012), who assume a time cost of raising children of about 6% in the adult period (which in their model lasts for 25 years). In our simulations, we will neglect the financial cost of raising offspring and set $\omega_1 = \omega_2 = 0$. Note that for the main results in this paper, the presence of financial costs in in fact superfluous in our model. We come back to this at the end of the next section.

3. Simulation results

The objective of this paper is to exploit the above model in order to analyze the impact of pension policy on fertility, employment, education and growth. Before we proceed, it is important to note that any impact of these policies on the government budget is neutralized by a change in lump-sum transfers. In other words, we assume that lump sum transfers are endogenously changed to maintain a constant debt to GDP ratio.[6] Table 1 shows the results of our simulations. We show the steady-state effects on labor supply of young, middle-aged and older workers, the retirement decision of older workers, the education decision of the young, per capita growth, TFR and population growth. The required change in lump-sum transfers to maintain a constant debt ratio is indicated at the bottom of the table.

In the first and second column of Table 1, we adopt the preferred policies put forward in Buyse *et al.* (2013). More specifically, in Policy 1, we alter the calculation of the pension base, such that more weight is given to the net labor income of workers when they are 'older'. In Equation (3) above, this policy involves an increase in p_3, and a fall in p_1. We assume that this reform does not hold for the current generation of retirees, as they are no longer able to adapt their behavior to these new pension weights.

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[6] Alternative simulations in which the consumption tax is used as the endogenous instrument are available on request. The general results obtained in this paper do not change.

Table 1. Steady-state effects of pension reform – Effects for Belgium

Initial values:	Policy 1	Policy 2	Policy 3	Policy 4
p_1=1/3	p_1=0	p_1=0	ρ_w=0	ρ_w=0
p_2=1/3	p_2=1/3	p_2=1/3	ρ_f=0	ρ_f=0
p_3=1/3	p_3=2/3	p_3=2/3	$\Delta\tau_j < 0$	$\Delta\tau_j < 0$
ρ_w =0.631		ρ_w=0.70		$\Delta\left[b_j(1-\tau_j)\right]=0$
ρ_f =0				
Effect [(a)]:				
Δn_1	-6.46	-6.88	0.54	4.17
Δn_2	-1.22	-0.81	-1.05	1.72
Δn_3	7.69	8.94	-13.67	-0.50
ΔR [(b)]	1.36	1.59	-2.28	0.28
Δe	2.02	2.33	-0.24	-1.34
TFR	2.1	2.1	1.8	1.6
Δd annual [(c)]	0.88	0.88	0.03	-0.67
Δ annual per capita growth [(a)]	0.16	0.18	-0.02	-0.11
ΔLump sum ex post [(d)]	2.83	2.64	-5.24	3.40

Notes: The benchmark values are as follows: n_1=51.1, n_2=56.8, n_3=29.3, R=57.9, e=14.1, d=0.91, TFR=1.8, with n the fraction of time devoted to market work, R the effective retirement age, e the time devoted to tertiary education, d the population growth rate and TFR the total fertility rate.

(a) difference in percentage points between new steady state and benchmark, except R.

(b) change in optimal effective retirement age in years.

(c) change in annual population growth rate, in % points.[7]

(d) change in lump sum transfer (as a fraction of output) to keep the debt-to-GDP ratio constant at the level of the benchmark, in percentage points.

An important effect from Policy 1 is the rise in the fertility rate. We observe an increase of 0.88 percentage points in the annual population growth rate after this reform. For Belgium, this would imply a rise in the population growth rate from about -0.60% to 0.28% per year. The mechanism driving this increase is a substitution effect. The higher (lower) marginal utility from work when older (young) makes it interesting to shift work from the first period of active life to the third. Part of the available time that arises during youth is spent on education. Young individuals are encouraged to study because the lifetime net rate of return to building human capital rises. This follows first from the reduction of the opportunity cost of studying when young, second from the perspective of working longer, and third from the greater importance of effective human capital when old in the pension calculation. Another part of the available time is spent on raising children. As such, the positive effect on fertility is indirect as the drop in hours worked during the period of youth allows for more time to be spent on raising children. We also observe a small drop in the mean age at birth (not presented). As bearing offspring after the age of 35 also leads to more time costs during the third active period (that is, after the age of 50), the proposed pension reform in fact discourages

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[7] While the total fertility rate (TFR) of a certain generation is given by $d_1^t + d_2^t$, the population growth rate at time t is defined as $d_t = N_{t+1}/N_t$

having children at later ages. Overall, however, the net effect on the total fertility rate is strongly positive.

The increase in fertility reduces the financial pressure on the pension system and the overall government budget. The drop, although small, in the mean age at birth is also positive from the point of view of pension funding. Note that the impact on the government budget is not negative at all: lump-sum transfers are allowed to rise due to this reform, as shown in the final row in Table 1.

Given the rise in lump-sum transfers to maintain a constant debt-to-GDP ratio, it becomes possible to even slightly increase the generosity of the pension system by augmenting ρ_w, the income-related pension replacement rate. We do this in Policy 2 where we let the earnings-related replacement increase from the initial 0.631 to 0.70. The rise in the pension replacement rate strengthens the link between earned labor income and work (especially at older ages) on the one hand, and the pension benefit on the other. Further increases in employment, education rates and growth can be observed. Fertility and population growth are constant.

The second part of Table 1 (Policies 3 and 4) shows the effects of a gradual shift from the PAYG system in the benchmark to a system with full private capital funding. These policies completely abolish old-age pension benefits (ρ_w, ρ_f). For the government, this reform would imply a drastic cut in pension expenditures. We therefore assume that this drop in expenditures feeds through into lower social security contributions for all workers such that, ex ante, the decline in total labor tax receipts in % of GDP is exactly the same as the drop in pension expenditures.[8] Policy 4 adds an additional feature to this reform. It acknowledges that, when the move to a fully-funded system implies a cut in taxes on labor, this will in our model also raise net non-employment benefits, as these are proportional to net wages. The gain from work versus non-employment then remains unaffected. In Policy 4 we keep the net non-employment benefit replacement rate unchanged, such that the labor tax cut raises the relative gain from work.[9] In a way, this feature biases upwards the impact on employment. However, this setup is much more in line with the existing literature, where non-employment benefits are often disregarded (see our discussion in Buyse et al., 2013).

An important effect of shifting to a fully-funded system is that the direct positive link between individual labor income and the pension system, which exists in the PAYG system as we have modeled it, is broken. Interestingly, as one can see in Table 1, the effect on employment depends on the assumption we make with respect to the net replacement rate of non-employment benefits. In Policy 3, where we only lower labor taxes to compensate for the decline in pension benefits, the effect on employment is clearly negative. (See the significant drop in employment of older workers).

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[8] In particular, the gradual decline in ρ_w and ρ_f is announced at time t=1 and implemented as follows. Pensions benefits are not reduced for retirees at the moment of policy implementation (t=1), since retirees are not able to react to a pension reduction. In t=2 and t=3 the replacement rates are respectively reduced to 2/3 and 1/3 of their initial rates. From t=4 onwards, ρ_w and ρ_f are zero. At each moment, overall labor tax rates are reduced to ex ante compensate for the decline in pension expenditures.

[9] Mathematically, this implies constant $b_j(1 - \tau_j)$.

In Policy 4, when we keep the net benefit rates constant, the effect becomes positive due to the mechanism explained above. Whatever set-up is chosen, however, both policies imply the same negative impact on schooling. Growth decreases (up to -0.10%-points in Policy 4) as tertiary education is discouraged by the fall in the pension replacement rate ρ_w. Finally, both policies indicate either a zero or negative impact on the total fertility rate and population growth rate. Although the reduction in hours worked due to the drop in pension generosity in Policy 3 leads to more available time to raise children, the drop in labor taxes (partly) offsets this effect. Moreover, the drop in public pensions increases private savings (see next paragraph) and decreases households' consumption. This drop in consumption raises the marginal utility of additional consumption and again indirectly increases the cost from bearing children.

As a final remark, note that our simulations confirm an additional feature of moving to a fully-funded system as observed in Buyse *et al.* (2013). Although this reform encourages national savings (see e.g. Feldstein, 1974 and 2005), it need not imply an increase in domestic physical capital formation, and capital taxes, in an open economy. If effective labor supply and employment fall, the marginal product of physical capital will also decline, causing savings to be invested abroad. This result is not shown but available on request.

All the above results hold as long as children require more care and attention, in terms of time costs, when parents are younger than age 50 (which is a realistic assumption). Moreover, our results prevail even when we would have included a direct financial cost of raising children in the simulation exercises (that is $\omega_1, \omega_2 > 0$). Interestingly, including such a financial cost implies that the pension policies that increase the accrual rate by age (i.e. Policy 1 and 2), which lead to a rise in household consumption, further reduce the relative cost of having children. As a result, fertility would increase even more.

     Moreover, as to the policies that shifts the pension to a fully-funded system (i.e. Policy 3 and 4), the depressing effect of this reform on the total fertility rate and population growth rate is even larger than presented above. In this case, labor tax cuts, which increase the net income of individuals, also raise the financial cost of having children.

4. Conclusion

In this paper, we evaluate the effects of a parametric adjustment to an earnings-related PAYG pension system. We show that a simple but intelligent reform in which the calculation of the pension base is changed, may result not only in more employment and growth, but also in an increase in fertility. Such an intelligent pension design would maintain a strong link between own labor income and the future pension, while putting more (less) weight on the labor income earned as an older (young) worker in the calculation of the pension base. By contrast, a shift to a fully-funded system can even reduce fertility.

Note that our proposal above is not in any way questioning the possible desirability of introducing a child-related pension pillar or other policy instruments as remedies to low fertility. We acknowledge the possible positive impact of such instruments. However, we do show that when one takes the existing earnings-related pension scheme as given, and wants to maintain it, there exist other possibilities of reform such that fertility is stimulated. The main mechanism that drives our result goes as follows. Given that bearing children is costly and that this cost occurs mainly in the beginning of adulthood, a reform in which the future pension benefit depends more on hours worked and earned labor income in the later periods of active life, reduces the relative cost of bearing children. As a positive side effect, it may also stimulate individuals to study longer, as already shown by previous research (Buyse *et al.,* 2013). Finally, note that we have not allowed for an exogenous increase in longevity in the model, as to reflect the issue of ageing. Therefore, it is important to stress that we do not argue that the 'proposed' pension reform is a panacea for all negative effects due to ageing. The only statement we want to make based on the results put forward in this paper is that our proposed pension reform is capable of relieving some of the pressure on the pension budget that arises due to an ageing population. The crucial element in this reasoning is that investment in education, employment at older age, per capita growth and the fertility rate all rise after the introduction of the pension reform.

More generally, our results can be aligned with a recent proposal by Cigno (2010). He proposes a two-scheme pension system: "*a part being Bismarckian in which individuals qualify for a pension by working and paying contributions, and an unconventional one allowing them to qualify for a pension by having children, and investing time and money in their upbringing.*" We believe that future research should focus on how these two pillars can be optimally combined and constructed. That is, how can parametric adjustments of the current pension system, combined with the introduction of a child-related pension, be constructed in such a way that benefits employment, growth and welfare best? The results in this paper give insight on how to construct the former part.

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Appendix A: Model description

Our analytical framework consists of the computable four-period OLG model for a small open economy developed in Buyse *et al.* (2013). For a detailed development of the model, we refer to their paper. We assume perfect international mobility of physical capital but immobile labor and human capital. New in our model is that employment by age, education and human capital, and growth, are jointly endogenous.

Demographics

$$N_{t+1} = d_1^t N_t + d_2^t N_{t-1} \qquad\qquad \text{(Population growth)}$$

Individuals

$$U_t = \sum_{j=1}^{4} \beta^{j-1} \left[\ln c_j^t + \gamma_j \frac{l_j^{t^{1-\theta}}}{1-\theta} \right] + \gamma_{d1} \ln d_1^t + \gamma_{d2} \ln d_2^t \qquad\qquad \text{(Utility function)}$$

with γ_j >0, θ >0 $(\theta \neq 1)$

$$l_1^t = 1 - n_1^t - e^t - s_1 d_1^t \qquad\qquad \text{(Time constraints)}$$

$$l_2^t = 1 - n_2^t - e^t - s_2 d_1^t - s_1 d_2^t$$

$$l_3^t = \Gamma \left[\frac{1}{\Gamma} \left(R^t (1 - \tilde{n}_3^t) \right)^{1 - \frac{1}{\rho}} + \frac{1}{\Gamma} (1 - R^t)^{1 - \frac{1}{\rho}} \right]^{\frac{\rho}{\rho-1}} - s_2 d_2^t$$

$$l_4^t = 1$$

$$d_1^t < \frac{1}{s_1} \text{ and } d_2^t s_1 + d_1^t s_2 < 1 \text{ and } d_2^t s_2 < 1$$

$$(1 + \tau_c) c_1^t + a_1^t + \omega_1 d_1^t w_t h_1^t n_1^t (1 - \tau_w) = w_t h_1^t n_1^t (1 - \tau_w) \qquad\qquad \text{(Budget constraints)}$$
$$+ b w_t h_1^t (1 - \tau_w)(1 - n_1^t - e^t) + z_t$$

$$(1 + \tau_c) c_2^t + a_2^t + (\omega_2 d_1^t + \omega_1 d_2^t) w_{t+1} h_2^t n_2^t (1 - \tau_w) = w_{t+1} h_2^t n_2^t (1 - \tau_w)$$
$$+ b w_{t+1} h_2^t (1 - \tau_w)(1 - n_2^t) + (1 + r_{t+1}) a_1^t + z_{t+1}$$

$$(1 + \tau_c) c_3^t + a_3^t + \omega_2 d_2^t w_{t+2} h_3^t R^t \tilde{n}_3^t (1 - \tau_w) = w_{t+2} h_3^t R^t \tilde{n}_3^t (1 - \tau_w)$$
$$+ b w_{t+2} h_3^t (1 - \tau_w) R^t (1 - \tilde{n}_3^t) + b_{er} w_{t+2} h_3^t (1 - \tau_w)(1 - R^t) + (1 + r_{t+2}) a_2^t + z_{t+2}$$

$$(1 + \tau_c) c_4^t = (1 + r_{t+3}) a_3^t + p p_4^t + z_{t+3}$$

$$pp_4^t = \rho_w \sum_{j=1}^3 \left(p_j w_{t+j-1} h_j^t n_j^t (1-\tau_w) \prod_{i=j}^3 x_{t+i-1}\right)$$
$$+\rho_f \frac{1}{3}\sum_{j=1}^3 \left(w_{t+3} h_j^{t+4-j} n_j^{t+4-j}(1-\tau_{jw})\right) \qquad \text{(Old-age pension benefit)}$$

Domestic firms, output and factor prices

$$Y_t = K_t^\alpha H_t^{1-\alpha} \qquad \text{(Private production function)}$$
$$H_t = n_1^t h_1^t + n_2^{t-1} h_2^{t-2} + n_3^{t-2} h_3^{t-2} \qquad \text{(Effective labor)}$$

Production of effective human capital

$$h_1^t = h_2^{t-1} \qquad \text{(Human capital externality)}$$
$$h_3^t = h_2^t = \left(1 + \Psi(e^t, g_y, q)\right) h_1^t = x_t h_1^t \qquad \text{(Evolution of human capital)}$$
$$\Psi(e, g_y, q) = \phi q \left(v g_y^{1-\left(\frac{1}{k}\right)} + (1-v)e^{1-\left(\frac{1}{\kappa}\right)}\right)^{\sigma\kappa/(\kappa-1)} \qquad \text{(Human capital accumulation function)}$$

Government

$$\Delta D_{t+1} = D_{t+1} - D_t = G_{yt} + G_{ct} + B_t + PP_t + Z_t - T_{nt} - T_{ct} - T_{kt} + r_t D_t$$
$$\text{(Government budget constraint)}$$

with:

$$G_{yt} = g_y Y_t \qquad \text{(Productive expenditures)}$$
$$G_{ct} = g_c Y_t \qquad \text{(Government consumption expenditures)}$$

$$B_t = (1 - n_1^t - e^t) b w_t h_1^t (1-\tau_w) N_t \qquad \text{(Non-employment benefits)}$$
$$+(1 - n_2^{t-1}) b w_t h_2^{t-1}(1-\tau_w) N_{t-1}$$
$$+R^{t-2}(1-\tilde{n}_3^t) b w_t h_3^{t-2}(1-\tau_w) N_{t-2} + (1 - R^{t-2}) b_{er} w_t h_3^{t-2}(1-\tau_w) N_{t-2}$$

$$Z_t = z_t(N_t + N_{t-1} + N_{t-2} + N_{t-3}) \qquad \text{(Lump-sum transfers)}$$

$$T_{nt} = \sum_{j=1}^3 n_j^{t+1-j} w_t h_j^{t+1-j} \tau_j N_{t+1-j} \qquad \text{(Labor taxes)}$$

$$T_{kt} = \tau_k[\alpha Y_t - \delta_k K_t] \qquad \text{(Capital taxes)}$$

$$T_{ct} = \tau_c \sum_{j=1}^4 c_j^{t+1-j} N_{t+1-j} \qquad \text{(Consumption taxes)}$$
$$PP_4^t = \rho_w \sum_{j=1}^3 \left(p_j w_{t+j-4} h_4^{t-3} n_j^{t-3}(1-\tau_{jw}) \prod_{i=j}^3 x_{t+i-4}\right) \qquad \text{(Pension expenditures)}$$
$$+\rho_f \frac{1}{3}\sum_{j=1}^3 \left(w_t h_j^{t+1-j} n_j^{t+1-j}(1-\tau_w)\right)$$

$$Y_t + r_t F_t = C_t + I_t + G_{ct} + G_{yt} + CA_t \qquad \text{(Aggregate equilibrium)}$$

with:
$$F_t = A_t - K_t - D_t$$

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

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

Appendix B: Calibration of main parameters

Production parameters (output)	$\alpha = 0.285$
Effective human capital production	$\phi = 4.2, \sigma = 0.96, v = 0.125, \kappa = 0.375$
Preference parameters	$\beta = 0.8, \theta = 2, \gamma_1 = 0.052, \gamma_2 = 0.093, \gamma_3 = 0.162$
	$\gamma_{d1} = 0.06, \gamma_{d2} = 0.01 \; \rho = 1.63, \Gamma = 2$
World real interest rate	$r = 0.935$
Physical capital depreciation rate	$\delta_k = 0.714$
Child costs	$\omega_1 = 0, \omega_2 = 0, s_1 = 0.10, s_2 = 0.05$

Fiscal policy data used for calibration

Capital tax rate (%)	$\tau_k = 27.1$
Labor tax rate (%)	$\tau_w = 67.2$
Consumption tax rate (%)	$\tau_c = 13.4$
Government debt (% of GDP)	$D_t/Y_t = 111.7$
Non-employment benefit replacement rates (%)	$b = 59.6$
Early-retirement benefit replacement rate (%)	$b_{er} = 79.0$
Pension benefit (net replacement rate, %)	$\rho_w = 63.1$
Basic pension (% of net average earnings)	$\rho_f = 0$
Government consumption (% of GDP)	$g_c = 16.9$
Government productive expenditures (% of GDP)	$g_y = 8.9$
PISA-science (divided by 1000)	$q = 5.05$

Note: for more information on the construction and sources of these data, we refer to Buyse et al. (2013).