Relative importance of fertility and mortality in economic impacts of ageing

Paper to be presented in Ecomod 2017 Conference 5-7.7 2017 Ljubljana

Jouko Kinnunen (PhD) Head of Research, Statistics and Research Åland

Sanna Tenhunen (PhD) Economist, Finnish Centre for Pensions

Risto Vaittinen (PhD) Economist, Finnish Centre for Pensions

Corresponding author risto.vaittinen@etk.fi

Abstract

We are using observed and expected patterns of Finnish population to illustrate different aspects of ageing as outcomes of changes in population birth and survival rates. We analyze the implications of these determinants of ageing in a stylized overlapping generations model with realistic population dynamics to emphasize the main features of these phenomena. It turns out that changes in fertility and mortality have different long term outcomes. Low fertility in the past gives room for increased consumption because of diminished need to keep productive capacity to labor force. Increased life expectancy on the other hand makes consumers save more in order to cover their spending in their later life when they are not working anymore. Changes in fertility have only temporary but long lasting effects if birth rates stabilize to some long term levels. Changes in mortality have permanent effects. In the Finnish case these seems to dominate the savings pattern in next few decades.

Key words: population ageing, economic growth, economic policy, labour supply, life expectancy, retirement age

JEL classification: J11, J18

1. Introduction

In this study we utilize the population prospects of Finland to evaluate the relative importance of fertility and mortality on the economic consequences of demographic change. We analyze the implications of these determinants of ageing in a stylized overlapping generations model with realistic population dynamics to emphasize the main features of these phenomena.

Finland has already entered the stage of demographic transition where the share of the working-age population is declining because of the population ageing. This is expected to continue at an accelerating rate during the next two decades. Impacts of this pattern are intensified by the fact that the baby-boom generations are exceptionally large.

Our particular attention is focused at the rapid deterioration of the old-age dependency ratio and the relative importance of earnings-related pensions in this process. The public sector in Finland has positive net financial wealth, unlike most of the OECD countries. This is because of partially-funded statutory employment pension insurance, compulsory for all employers and employees as well as for the self-employed. However, population aging and rising dependency ratio are putting pressure on public finances also in Finland. In this paper we abstract from other age related public programs and analyze only implications of ageing for the pension system.

Changes in fertility and mortality both affect old- age dependency ratio, which is important determinant of expenditures in age related public programs. In an economy without migration aging results from two sources: an increase in the age at which people die, and a decrease in the birth rate. An increase in longevity rises the average age of the population by increasing the number of years in which each individual is old relative to the number in which he is in working age. A decrease in fertility rises the average age of the population by changing the relative numbers of working and old age people. Reduced fertility also lowers the rate at which the population grows. In characterizing the relative importance of these factors in the future we use model of stable population (Preston, Heuveline and Guillot et al., 2001 pp. 138-167).

Even rapid aging is a slow process compared to most macroeconomic phenomena. For the effects of ageing it takes decades to materialize completely. It is difficult to disentangle empirically the effects of aging from the effects of other, contemporaneous changes. In this study we rely on computable macroeconomic model to isolate the effects of aging by simulating the impacts of changes in birth and death rates to consumption, wages, public pensions, and saving.

The method

The macroeconomic framework we use in our study is Auerbach-Kotlikoff (1987) type numerical overlapping generations (OLG) model that describes the population by its generational structure. In the model each generation is represented by an economic agent who has specific age-related consumption and saving patterns and who maximizes utility over her entire lifetime. The model enables us to analyze dynamics of demographic developments with intergenerational feedback effects.

We are using observed and expected patterns of Finnish population to illustrate different aspects of ageing as outcomes of changes in population birth and survival rates. It turns out that changes in fertility and mortality have different long term outcomes. Changes in fertility have only temporary effects if birth rates stabilize to some long term levels but changes in mortality have permanent effects.

Earnings-related pensions

Public pension expenditure represented more than half of the total volume of public transfers. Finnish statutory pensions are made up of partly-funded earnings-related pensions and tax-financed national pensions. Private voluntary pensions play a relatively minor role in the total pension provision in Finland. Earnings-related pensions are defined-benefit in the sense that the size of the pension expenditure determines the contribution level and the need for other financing.

2. The Model

We study the economic consequences of population ageing using a numerical overlapping generation model of Auerbach Kotlikoff (1987) type. In the model each generation is represented by an economic agent who maximises utility over her entire lifetime having specific age-related consumption and saving patterns. In the model, demographic shocks lead to behavioural changes of individual generations taking into account interdependencies and interactions in the variables of interest. Our OLG model is based on a closed economy and comprises only of private sector and mandatory earnings related pension plan.

The distribution of lifetime consumption over the different periods is determined by households' time preferences, their willingness and ability to forgo consumption in the present, and the prevailing rate of return on savings. Children are supported financially by their parents and are not taken explicitly into consideration. The retired households draw a public pension and use up their savings for consumption purposes. The households in their working phase supply their labour to firms, which according to a Cobb-

Douglas production function produces a good which can be both consumed as well as invested. Interest rates and wages are determined by the marginal productivity of labour and capital. The public sector functions as an administrator of the pension plan.

2.1 The Production Sector

In the economy, a representative firm produces at time *t* a single good using a Cobb-Douglas technology. The firm hires labour and rents physical capital. With Y representing output, K physical capital, L effective units of labour defined in equation (7) *z* is labour productivity, *A* is a scaling factor and α the share of physical capital in value added:

$$Y_t = AK_t^{\alpha}\left(z_t L_t\right)^{1-\alpha} \tag{1}$$

Firms are assumed to be perfectly competitive and factor demands follow from profit maximization:

$$Re_t = \alpha A\left(\frac{K_t}{z_t L_t}\right)^{\alpha-1} \tag{2}$$

$$W_t = (1-\alpha)Az_t\left(\frac{K_t}{z_t L_t}\right)^{\alpha} \tag{3}$$

where Re_t and W_t are the rental rates of capital and wages.

2.2 Household Behaviour

Households are represented by 83 overlapping generations. Individuals enter the labour market at the age of 18, retire on average at the age of 64, and die at the latest at age 100. Younger generations (<18) are fully dependent on their parents and play no active role in the model.

In characterization of household's intertemporal $C_{t,g}$ stands for total consumption of generation *g* at time *t*. Agents of a generation lives at most *T=83* periods. Total consumption consist of consuming a single (aggregate) commodity *($Con_{t,g}$)*. Commodity consumption may differ from disposable income, which can be covered by accumulating or de-cumulating assets *($Lend_{t,g}$)* from financial markets.

Household's optimization problem is to choose a profile of consumption over the life cycle to maximize a CES type inter-temporal utility function of consumption, subject to discounted lifetime income. Inter-temporal preferences of an individual born at time *t* are as follows:

$$U = \frac{1}{1-\theta}\sum_{s=1}^{T-g+1} sr_{t,g}^{t+g-1}\beta^{g-1}(\lambda_{t,g}C_{t+g-1,g})^{1-\theta} + \Theta sr_{t,g^*}^{t+g^*-1}\beta^{g^*-1}\frac{B^{1-\theta}}{1-\theta} \qquad g = 1,2,...,83 \tag{4}$$

with 0 < ϑ < 1. *C* denotes consumption; ρ is the pure rate of time preference and ϑ is the inverse of the constant inter-temporal elasticity of substitution. The future consumption is discounted by the probability of survival up to the age *g+k* represented by the term $\Pi_k sr_{t+k,g+k}$, where $sr_{t+k,g+k}$ is an age and time variable survival rate between periods *t+k* and *t+k+1* and ages *g+k* and *g+k+1*. Utility function contains parameter $\lambda_{t,g}$ that is equivalent adult consumers in the household whose head is g years old. We discuss how it is calculated in the calibration section. The household is altruistic, that is, it leaves bequests to its children.. Each period in the model corresponds to one years and a unit increment in the index *k* represents both the next period *(t+k)* and, for this individual, a shift to the next age group (*g+k*).

Dynamic budget constraint of a household is:

$$sr_{t+k,g+k} Lend_{t+k+1,g+k+1} = \left(1-Ctr_{t+k}\right)Y^{L}_{t+k,g+k} + \left[1+ri_{t+k}\right]Lend_{t+k,g+k} + Pens_{t+k,g+k} - Con_{t+k,g+k} + \mathrm{BR}_{t+1,g1+t} - BG_{t,g}, \quad k=0,\ldots,82. \tag{5}$$

where *Ri* is the rate of return on household assets (defined later on in equation (15) with respect to the rental price of capital), *Lend* is assets held by household (g+k), *sr* is survival probability from age g to age g+1, and *Ctr* the contribution to the public pension system at age g+k. Labour income is defined as:

$$Y^{L}_{t+k,g+k} = w_t EP_{g+k} \times LS_{g+k} \quad , \text{gj}=1,2,\ldots,45 \tag{6}$$

where LS_g is the exogenous supply at specific age. We assume that labour income is a function of the individual's age-dependent productivity (earnings) profile ($EP_{,g}$) defined as a quadratic function of age:

$$EP_{gi} = \gamma + \sum_{i=1}^{5} \varepsilon_i g^i \tag{7}$$

with parameters values estimated from NTA wage profile (Riihelä, Vaittinen and Vanne, 2011)

.

Assets in the next period are accumulated subject to the survival probability. Budget constraint as specified in (5) incorporates life expectancy variation with a perfect annuity market, through which unintentional bequests are implicitly distributed. The theoretical description of this approach was first presented in Yaari (1965).

Assuming no borrowing constraints and perfect capital markets, the present value of household wealth (W) can be derived from (5) as a discounted sum of labour income received at each period of time, $Y^{L}_{t+k,g+k}$, over lifetime, taking into consideration the survival rate $\Pi_k sr_{t+k,g+k}$:

$$W = \sum_{k=0}^{82} \left\{ \frac{\Pi_k sr_{t+k,g+k}}{\prod_{\tau=t}^{t+k}[1+Ri_\tau]} \left(Y^{L}_{t+k,g+k}\left(1-Ctr_{t+k}\right) + Pens_{t+k,g+k} \right) \right\} \tag{9}$$

Differentiating the household utility function with respect to its lifetime budget constraint yields the following first-order condition for consumption:

$$\begin{aligned} C_{t+1,g+1} &= \left[\frac{\lambda_{t+1,g+1}}{\lambda_{t,g}} \frac{[1+Ri_{t+1}]}{(1+\rho)} \right]^{\frac{1}{\theta}} C_{t,g} \\ BG_{t,g^*} &= \frac{\Theta}{1+\rho} C_{t,g^*} \end{aligned} \tag{10}$$

2.3 Pensions

Pension benefits in the retiree's budget constraint are a fraction of their average labour earnings. The fraction is determined by the age specific accrual rates *(acc_{gj})* and wage indexation *($wind_{t-1}$)*:

$$\begin{aligned} Pens_{gT+1,t} &= E\left(t,gT\right)\sum_{gj=1}^{gT} acc_{gj}(0.2+0.8wind_{t-gT-1+gj})^{gT-gj} w_{t-gT+gj} EP_{gj} LS_{gj} \quad gj = 1,\ldots,gT \\ Pens_{gm,t+1} &= \sum_{gm=gT+1}^{gM} (0.8+0.2wind_{t-1})^{gM-gT-1} Pens_{gT+1,t} \quad gm = gT+1,\ldots,gM \end{aligned} \tag{8}$$

The insured is entitled to a normal old-age pension at the age of 63, but he or she can continue to work up to the age of 68 at an increased accrual rate. The national pension guarantees a minimum income for pension recipients with no other pension income or with only a small earnings-related pension.

Every year's earnings and accrual rates directly affect the future pension. The accrual rate is 1.5 % per year between the ages of 18 and 53 and 1.9 % between the ages 53 and 62. Between the ages 63 and 68 the accrual is 4.5 % per year, aiming to reward later retirement in a cost- neutral way. Both pension rights and benefits are index linked, with 80-20 weights on wages and consumer prices respectively during working years and 20-80 weights after retirement, irrespective of retirement age.

Longevity adjustment

The pensions are adjusted for increasing life expectancy simply by taking the increasing longevity into account in the value of the annuity. The adjustment coefficient is a ratio of two present values of a unit pension, calculated at two different periods. The present value of a unit pension, which begins in period *t* and is calculated forward from age 62, is as follows.

$$A(t,62)=\sum_{k=63}^{100}\frac{\prod_{k}^{100} sr_{t-1,k}}{1.02^{(k-62)}} \tag{11}$$

The present value of a unit pension is a discounted sum of terms generated during various retirement years. The terms have two parts. The first term, *sr,* expresses the survival probability from age k to age *k+1*, and the first subscript of the term demonstrates that the probability is evaluated using information available in period *t*, when the latest the observed mortalities are from period *t-1*. The survival probabilities are actually five-year moving averages. The second term is the discount factor where the discount rate is 2 % per year. In the model individuals die at the age of 100 at the latest.

The pension of a person born in period *t* – 62 is multiplied by the longevity adjustment coefficient *E(t,*62*)* after age 62. The coefficient is a ratio of two *A*-terms as follows.

$$E(t,62)=\frac{A(2009,62)}{A(t,62)} \quad (12)$$

Funding of future obligations

The Finnish earnings-related pension scheme is a partially-funded scheme with worth of assets about double of the insured wage sum. Two thirds of these assets are owned by private-sector pension providers. Funds are invested both domestically and internationally in commercial assets. The state and local government pension schemes were originally based on a pure pay-as-you-go system but started funding pensions in late 1980's in order to curb the increase in pension contributions. The aim of this fund is to gather assets so that the cost burden caused by the pensions of the post-war baby-boomers can be lessened in the years when the pension expenditure is at its highest. In this study we treat pension institutions as a single buffer stock fund, which has prefunded 25 % of its liabilities. Pension fund's budget constraint is defined as:

$$PA_{t+1}=\sum_{gj}^{gT} Ctr_t Y_{t,gj}^{L} P_{t,gj}+\left[1+ri_t\right]PA_t-\sum_{gm=gT+1}^{gM} Pens_{t,gm} \qquad gT=45,\ gM=82 ,$$

(13)

where PA_t is assets of the pension fund.

2.5 Market clearing Conditions

The accumulation of capital stock (*Kstock*) is subject to depreciation:

$$Kstock_{t+1}=Inv_t+(1-\delta)Kstock_t \quad (14)$$

where *Inv* represents investment and δ the depreciation rate of capital. Let us denote by *Ri* the rate of return on physical assets; it is defined as the rental rate minus the depreciation rate, plus capital gains:

$$1+Ri_t = re_t + (1-\delta) \qquad (15)$$

The model assumes that all markets are perfectly competitive. In a closed economy the equilibrium condition for the goods market is that output must be equal to total demand originating from consumption and investments:

$$Y_t = \sum_g Pop_{t,g} C_{g,t} + Inv_t \qquad (16)$$

The demand for labour equals the supply:

$$\frac{(1-\alpha)Y}{W_t} = L_t = \sum_g Pop_{t,g} LS_g EP_g \qquad (17)$$

and the stock of capital accumulated at a point in time in period *t* is equal to the demand expressed by firms:

$$Kstock_t = K_t = \frac{\alpha Y}{\mathrm{Re}_t} \qquad (18)$$

The capital market must be in equilibrium, that is, the total stock of private wealth (*Lend*) and accumulated at the start of period *t* must be equal to the value of the total stock of capital at the start of *t*:

$$\sum_g Pop_{t+1,g+1} Lend_{t+1,g+1} + PA_{t+1} = Kstock_{t+1} \qquad (19)$$

National savings equals investment:

$$\underbrace{\left(\sum_g Pop_{t+1,g+1} Lend_{t+1,g+1} - \sum_g Pop_{t,g+1} Lend_{t,g+1}\right) + PA_{t+1} - PA_t}_{\text{Savings}} = \underbrace{\left(Kstock_{t+1} - Kstock_t\right)}_{\text{Investment}}$$

(20)

3 Demographic Process

In an economy with closed population (no in- or out migration) aging results from two sources: an increase in the age at which people die and a decline in the birth rate. An increase in longevity rises the average age of the population by increasing the number of years in which each individual is old relative to the number in which she is young. A decrease in fertility rises the average age of the population by changing the relative numbers of young and old people. Reduced fertility also lowers the rate at which the population grows.

Population dynamics is modelled in a similar fashion as in Brown, Ikeda and Joines (2009) or Chen, Imrohoroglu and Imrohoroglu (2007). First working age generation are those reaching age 18 at year t. The size of the young generation increases over time at an exogenous growth rate:

$$Pop_{t,g1} = N_{t-1,g1} G_{t-1} \qquad (21)$$

where $N_{t-1,g1}$ measures the initial size of the first generation and G_t is one plus the demographic growth rate. Each individual lives a maximum of 83 periods ($g = 0, ..., 82$) but faces a survival probability *(sr_g)* decreasing with age. The size of each generation declines through time:

$$Pop_{t,t+g} = Pop_{t-1,t+g-1}\, sr_{t-1,t+g-1} \qquad (22)$$

where $0 \leq sr_{t,,t+g} \leq 1$ is the fraction of generation g alive at age t (hence, at period t + g) We also assume $sr_{t,g1} = 1$. Total population at time t amounts to $Tpop_t = \sum_g Pop_{g,t}$.

A stable population is one in which the age-specific rates of birth and death have been constant for sufficiently long that the age structure of the population – that is, the fraction of the population made up of people of each age - has stabilized. Constant demographic growth rate and the survival probabilities generate a stable population. If $N_{t-1,g1}$ is size of a cohort in a stable population one can show that with fixed fertility and mortality rates the growth rate of population is *G-1* (Preston, Heuveline and Guillot et al., 2001 pp. 138-167). Giving shocks to *G* or $sr_{t,g}$ one can isolate the impacts of specific changes in fertility or mortality.

4. Calibration

We have specified our model in per capita values and in efficiency units by dividing all macro variables by total population in period t (P_t) and productivity factor $z_t \left(\widetilde{X_t} = X_t / z_t P_t\right)$. Our starting year is 2005, when Finnish economy was growing in a balanced fashion. In this year new set of rules for benefit accrual were in use for the firs time. We use the procedures described by Marchel and Georges (2015) to calibrate the parameters that replicate the data main macroeconomic variables as a steady state. Since we want to compare alternative population scenarios we use the steady state values only as starting point to make a calibration of these scenarios as transition paths of a temporary equilibrium towards a steady state. We have used a method suggested by Wendner (1999) to calibrate the initial values as a point in transition path. Using Wendner’s procedure we avoid modelling the future population scenarios as model surprises.

In calibration we find out the rate of return and time preference that are compatible with age structure supporting the equilibrium demand for capital in producing the output. With standard specification of preferences we get more patient consumption patterns by age than we observe in reality (Figure 1). The actual profile for total consumption was constructed by Riihelä et al. (2011). Although we are able to match the macro balances the standard specification of preferences gives as in calibration a consumption profile that has average age of consumption higher than the actual one. Georges et al. (2016) discuss alternative ways to better match the observed consumption patterns. Since we assume fixed labour supply we are able to match wage profile rally accurately using 5th order polynomial.

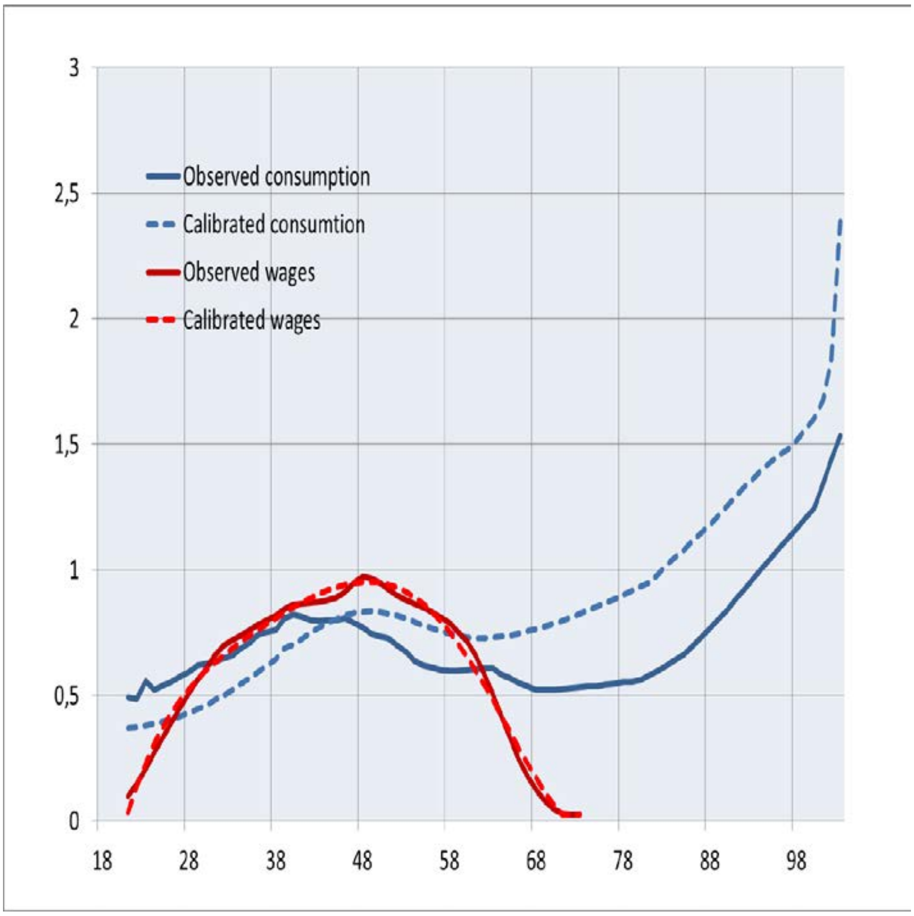


Figure 1: Calibrated and actual labour income and consumption by age in Finland

With stable population we get aggregate old age pension expenditures that are around 8% relative to the GDP. They are financed by 12.8 contribution rate on wages together with prefunded assets that are 62% relative to GDP.

Survival probabilities in 2005 generate 78.9 years life expectancy at birth of Finnish population. Annual population growth of 0.9 % generates the observed old age dependency ratio for population over 62 (29.9%) in a stable population model.

Table 1: Parameters in the model

Parameters	***Values***
θ	0.25
EP_{gi}	Separate graph
Initial pension expenditure (% of GDP)	8.3
Ctr_0	12.8% (benchmark)
Time preference	5.4
Initial rate of return	5.7
Average pensions/Average wage	49.2%
δ_j	4.1%
sr_g	Appendix table
G	1.009
Old age dependency ratio	29.9%
Initial pension assets (% of GDP)	62%
Initial capital-output ratio	4.6

5. Simulation experiments

In analysing shocks to birth and survival rates we compare their economic consequences to the stable population scenario. In this scenario the population growth is on average the same as expected by Statistics Finland population forecast. This growth expectation is feeded in as an input to a stable population, which has the same old age dependency ratio that we observed in Finland at 2005. The growth path with stable population is our benchmark and population shocks are reported as deviations from it.

Variations in the past birth and survival rates affect timing and force of population ageing: baby booms resulting from increased fertility in rich countries after the Second World War are now changing population structures older as the cohort of boomers passes the retirement age. For this reason population ageing in Finland is especially pronounced in the immediate future (Riihelä, Vaittinen and Vanne, 2011).

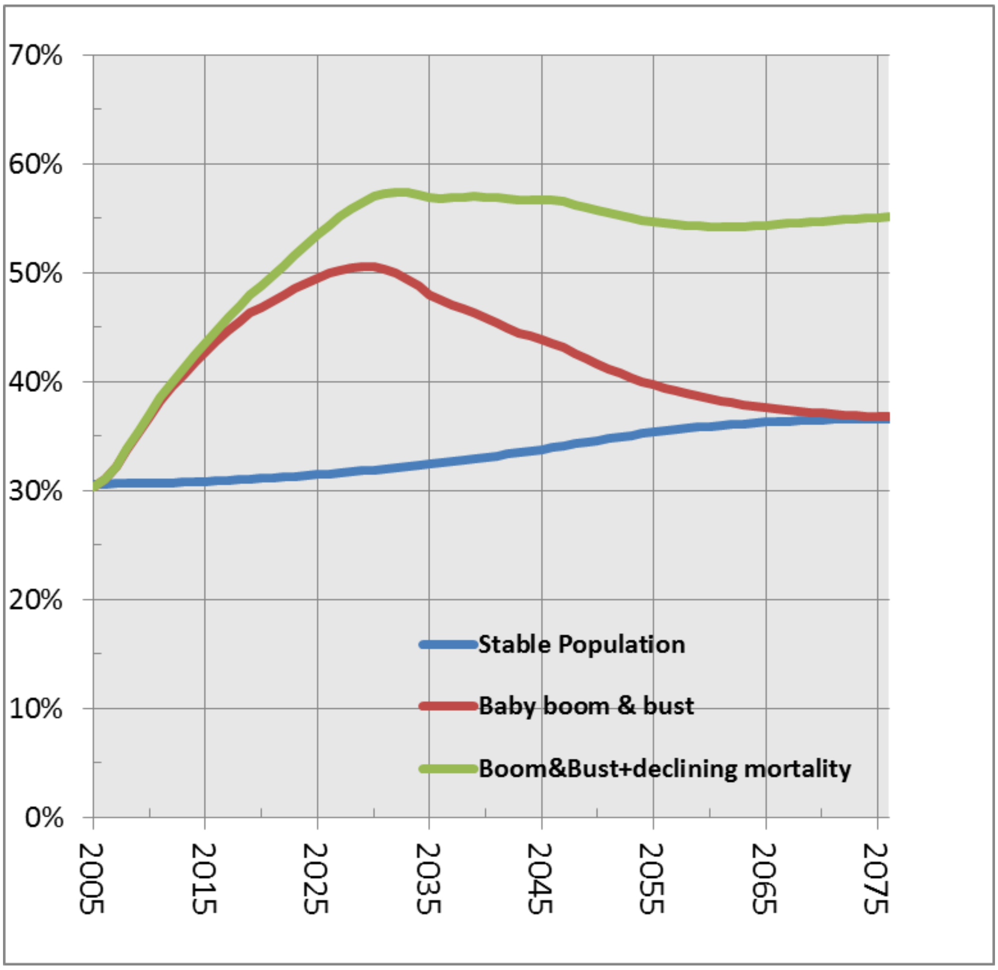


Figure 2: Old-age dependency in alternative population scenarios

Feeding expected growth rate to the stable population would increase dependency ration only moderately (Figure 2).This will replicate the change we are expecting to take place (Figure A1 in appendix). To introduce a baby boom baby bust type of fertility shock, observed in population history, we change the relative shares of working age population in the first simulation period to the stable population model. This will introduce much faster ageing pattern to the demography that with dependency ratio peaking in 2030's and gradually approaching the dependency ratio produced by stable population model.

As a mortality shock we assume that life expectancy increases after first simulation period at same rate it is assumed to change in the latest Statistics Finland population forecast. This implies that life expectancy at birth increases in this century on average almost two months in a year or one year in less seven years period (Tikanmäki et al., 2016, Table L.6.1). This would introduce permanently a significantly higher dependency ratio.

6. Simulation results

In this section we first describe effects of demographic change on the macro economy. After that we discuss shortly the implications for pension plan and finally look at the consequences on generational welfare.

Macroeconomic effects

Both population shocks reach their maximum impact on relative labour supply around 2030. That is in a 25 years' time after the starting date in our exercise. Down the road to the lowest point of per capita labour supply in the fertility scenario, the decline in labour force relative to the baseline is 0.5% annually adding up to 12 %-points overall drop. The increasing life expectancy adds 0.2% to the annual figure making it 0.7% in 2005-2030. Labour supply will shrink altogether around 15 %-points. While fertility shocks have only temporary but long lasting effects on the labour supply, the increase of life expectancy lowers it permanently relative to the baseline.

Shrinking labour supply implies declining output per capita that is in relative terms about than half of the size of the population shock on labour markets. Elasticity of output relative to labour force change is 0.55, which explains largest part of the difference caused by baby boom – baby bust fertility shock.

In the scenario combing fertility shock with increasing life expectancy output decline is of the same size as in the pure fertility scenario, although change in labour supply in the later scenario is far smaller (around 8%- points). The reason for the similarity in output pattern,s despite the differences in the labour supply, is explained by the diverse effect of alternative scenarios on savings behaviour.

In both of the population scenarios labour supply will start to decline before long since the starting date of simulations. A decline in the number of working age population, due to ageing, reduces the investment rate, since smaller labour force will hamper maintenance of a sufficient production capacity per employed person (Cutler et al., 1990). In the pure fertility shock scenario there's a short period when declining investments give room for increased per capita consumption even in the period of declining output. However, after a while the decline in the income per capita is also reflected as diminished consumption.

In the fertility scenario changes in the consumption are smoother than those in the income since consumers are evening out their spending over a longer period of time than is the reaction of incomes to the population shock. The baby boom – baby bust shock generates a significant overall decline in savings rate.

Things are different in the scenario combining fertility and increased life expectancy. Since people are expecting to live longer, they increase savings in order to cover their spending in their later life when they are not working anymore. In this scenario aggregate savings rate is at first about 1.5 %-points higher than in the baseline, but after 2030 is increasing considerably being 4%-point above the baseline level at the last period under review.

Increasing needs to save because of longer life expectation and decreasing need to invest because of diminished labour force implies a permanent and rather significant drop in the rate of return on savings and higher reward on labour. In pure fertility scenario these are mainly a temporary although a long lasting phenomena.

In our model labour supply reacts only to demographic factors and individuals do not respond to changes in wages by increasing their labour supply. In the scenario with both factors affecting the population ageing, the change in the wage rate induced by combination of labour supply and savings is so large that one expects some of the declined consumption of commodities be smoothed out by decreased consumption of leisure. This would be a future research topic.

Brown, Ikeda and Joines (2007) find out that large part of decline in Japanese savings rate in 1990 – 2000 can be explained by demographic factors. In their model aging accounts for 2 to 3 percentage points of the 9 percent decline in the Japanese national saving rate at that period. They also expect that demography persistently depresses Japan's national saving rate in future years.

What explains the difference in these model outcomes as we expect the savings rate to increase in the most likely scenario? Japanese fertility rate immediately after the Second World War was significantly higher than in Finland. There was no boom – bust –type cycle in the fertility in Japan but it started to decline immediately after the war at faster rate than in Finland. This decline has continued to the beginning of this century. In Finland, on the other hand, since the baby bust in 1970's the fertility rate has recovered to much higher level it's currently in Japan (see Ogawa, 2009 and Rønsen, 2004). The fertility shock seems to dominate savings patterns in Japan whereas the declining mortality is more important in Finland.

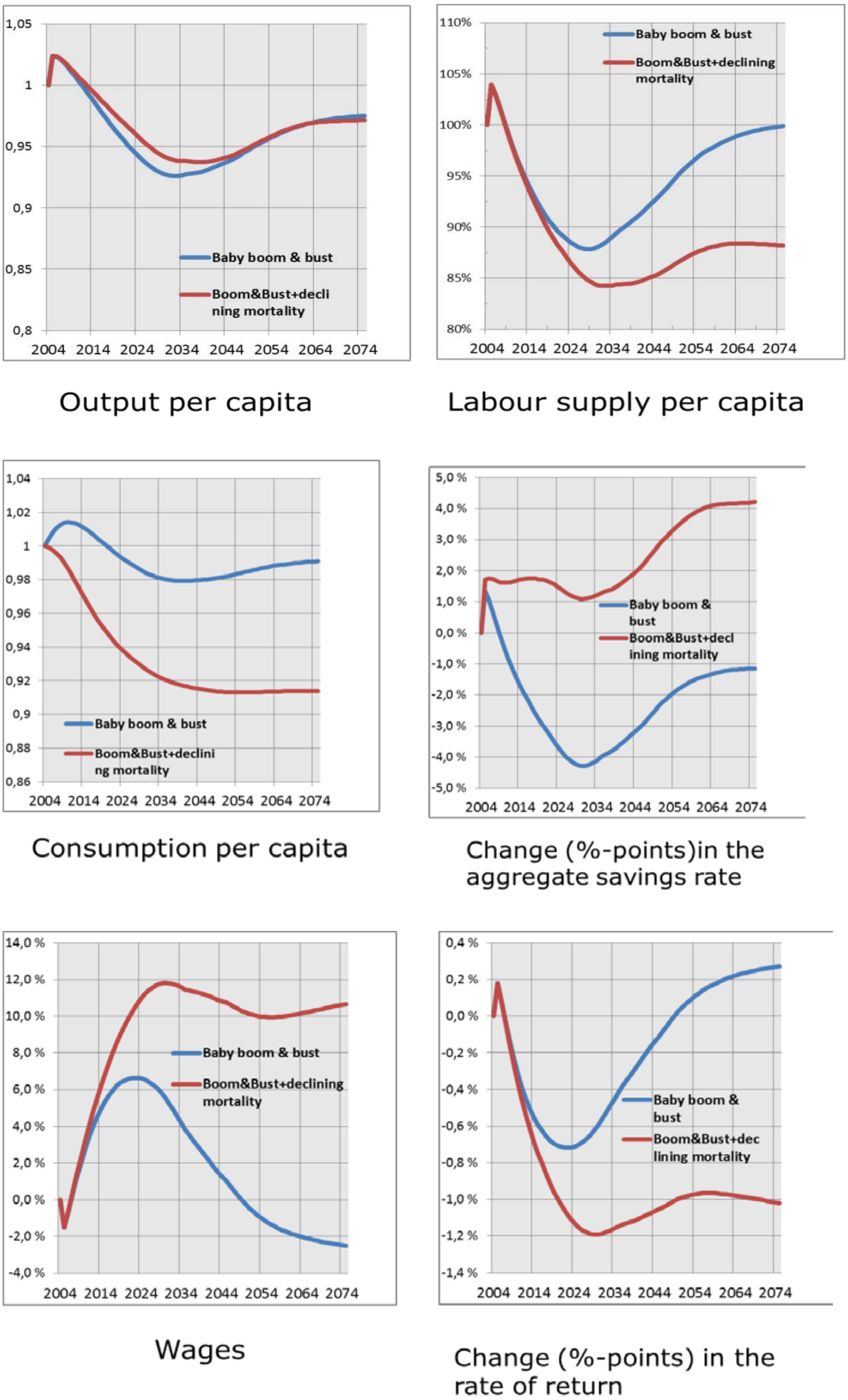


Figure 3: Macroeconomic impacts of demographic change

(deviations from the stable population baseline)

Effects on the pension plan

Since we are conducting counterfactual experiments the easiest way to analyse financial consequences of alternative fertility and mortality patterns to the pension system is to look constant contribution rates that would be sufficient to cover the future pension liabilities.

Relative to the stable population baseline both alternative scenarios have much higher sustainable pension contribution rate. In the fertility scenario the rate is 3.6 %-points higher than in the baseline and adding increased longevity to population prospects makes contribution rate that is sustainable 6 %-point higher. The relatively high level of contributions in fertility scenario is interesting since in this case the dependency ratio ultimately converges towards the baseline. Although a one shot boom-bust fertility cycle has temporary effects to the economy it has rather large permanent effects for the pension system that has to some degree been prepared to such a shock.

Table 2: Impacts of the population shocks on the mandatory pension plan

	Contribution rate	*Pension expenditure in 2005-2030-2050 (% of GDP)*	*Pension assets in 2005-2030-2050 (% of GDP)*
Stable population	*12.2*	*8,2 - 8,6 - 8,9*	*62- 75-89*
Baby boom & bust	*15.8*	*8,2 - 12,6 - 12,2*	*62-79-45*
Baby boom & bust + declining mortality	*18.2*	*8,2 - 12,5 -12,9*	*62-110-102*

The stable contribution rate which is sufficient to cover future liabilities in Finnish pension system differs considerably in alternative population scenarios. The contribution rate is 2.4 %-points higher in the scenario taking into account the declining mortality. Relative to the scenario where only fertility matters this implies total amount of contributions that is about 1.3%-points higher relative to the GDP in the mortality scenario although the growth of expenditures are of similar size. The similarities of expenditures are explained by the operation of life-expectancy coefficient, which adjust the expected life time stream of starting benefits to the declining mortality.

In the fertility scenario pension assets are used in larger scale to smooth the financing needs to the variations of expenditure caused by demography. In the pure fertility scenario old-age dependency ratio is already declining in the 2050's putting less pressure to the asset stock to cover the target share in financing pension expenditures.

Generational effects

We evaluate generational effects calculating compensating variations of alternative scenarios relative to baseline. We ask what is the expected gain or loss in remaining lifetime utility relative to the baseline.

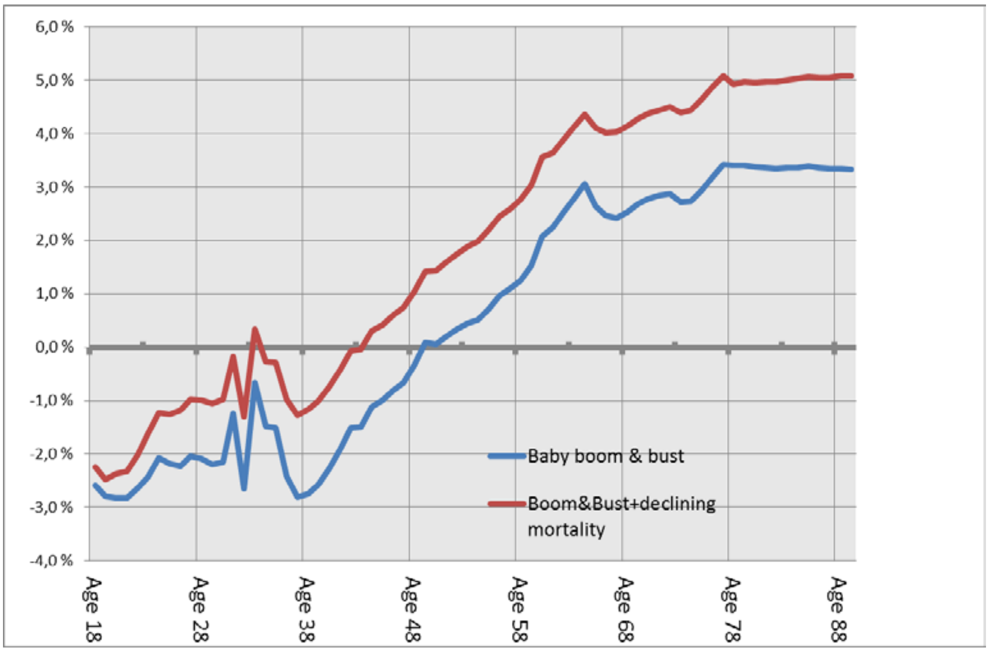


Figure 4: Compensating variation of life-time for different generations

Generational effects of ageing in terms of consumption are largest for the generation at latter phase in their working life. In the pure fertility case those who are expected to retire in less than 15 years benefits from the fertility shock. In this case it means generations born in mid-1950's or earlier. The projected growth in life-expectancy increases utility of all generations in the welfare comparisons. Effect is more pronounced in older generations but it is about 2%-points in age bracket from 35to 65 years. It also moves the cut-off point of winners and losers to a five years younger cohort (from 49 to 45 years of age). The life-time losses are also much smaller for most of the younger working age generations.

7. Concluding remarks

Fertility has only temporary effects if birth rates stabilize to some long term levels. Andersen (2012) has pointed out that the tax-smoothing argument of Barro (1979) is a valid argument for prefunding to absorb the expected changes in age structure caused by fertility shocks. Barro pointed out that tax distortions are minimized by keeping tax rates constant, and therefore taxes should be set at a level consistent with long run revenue requirements. Temporal variations in expenditures should be allowed to affect financial balance of public programs. However, changes in mortality have permanent effects on fiscal burden and it has also direct welfare consequence for individuals. Increasing longevity is a fundamental indication of improved living standards. It is thus in itself a welfare improvement that simultaneously raises the challenge for public finances. Andersen (2014) shows that, if the dependency ratio is increasing due to increases in longevity, part of the optimal policy is to adjust eligibility rules proportionally to changes in longevity.

References

Andersen, Torben M. (2012) "Fiscal sustainability and demographics–Should we save or work more?" Journal of Macroeconomics 34: 264-280.

Auerbach A., and L. Kotlikoff (1987) Dynamic Fiscal Policy, Cambridge University Press.

Barro, R. (1979) 'On the Determination of Public Debt', Journal of Political Economy, vol. 87, pp 940-971

Bloom D., E, D. Canning, and G. Fink (2010) 'Implications of population ageing for economic growth', Oxford Review of Economic Policy, Vol. 26, pp. 583–612.

Braun, R., Ikeda, D., and Joines, D. (2009) ' The Saving Rate in Japan: Why It Has Fallen and Why It Will Remain Low', International Economic Review, 50(1), 291-321.

Chen, K., İmrohoroğlu, A., & İmrohoroğlu, S. (2007) 'The Japanese saving rate between 1960 and 2000: productivity, policy changes, and demographics', Economic Theory, 32(1), 87-104.

Preston S., P. Heuveline and M. Guillot (2001): Demography – Measuring and Modeling Population Process, Blackwell.

Lutz W., W. Sanderson, and S. Scherbov, (2008) 'The Coming Acceleration of Global Population Ageing', Nature, 451 pp. 716–19.

Mason, A. and Lee, R., 2011. Introducing Age into National Accounts, in: Lee, R., Mason, A., (eds.), Population Ageing and the Generational Economy – A Global Perspective. Edgar Elgar, Cheltenham.

Merette M. and P. Georges (2015) Overlapping Generations General Equilibrium Modeling with GAMS, Lecture notes (mimeo).

Ogawa, Naohiro (2009) "Demographic dynamics in Japan." Area Studies (Regional Sustainable Development Review) Japan 16: 55.

Rønsen, Marit (2004) "Fertility and public policies-Evidence from Norway and Finland." Demographic Research 10: 143-170.

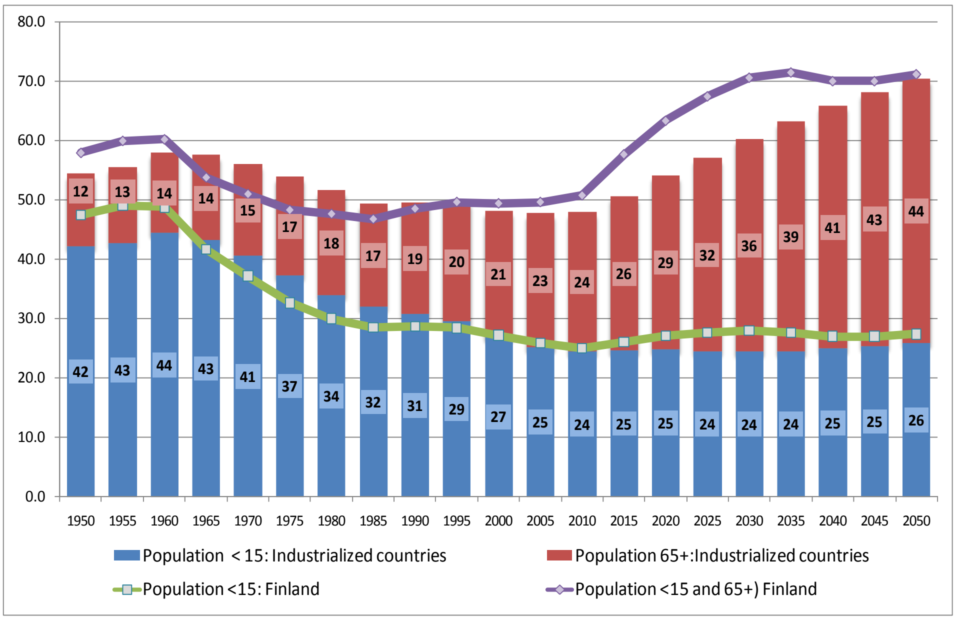
Riihelä M., R. Vaittinen and R. Vanne (2011) Changing patterns of intergenerational resource allocation in Finland, Finnish Centre for Pensions, Reports 2011:1.

Risku I., J. Appelqvist, M. Sankala, H. Sihvonen, H. Tikanmäki and R. Vaittinen (2014) Statutory pensions in Finland: long-term projections 2013, Finnish Centre for Pensions, Reports 03/2014.

Wendner R. (1999) A Calibration Procedure of Dynamic CGE Models for Non-Steady State Situations Using GEMPACK, Computational Economics 13: 265–287.

United Nations, 2013. National Transfers Accounts: Manual. Measuring and Analyzing the Generational Economy. Population Division, New York.

Figure A1: Age dependency ratios for population under 15 and over 65 years in Finland and industrialized countries



Source: UN Population Prospects.