



Helvi Kinnunen

**Government funds and demographic transition – alleviating ageing costs in a small open economy**



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The views expressed in this paper are those of the author and do not necessarily reflect the views of the Bank of Finland.

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# Government funds and demographic transition – alleviating ageing costs in a small open economy

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## Abstract

This paper investigates public pension funding using a dynamic general equilibrium macroeconomic model (DSGE) that facilitates investigation of distortionary effects of fiscal and pension policy responses to ageing. The model is calibrated to the Finnish economy, which will encounter substantial ageing pressures in the near future. During the transition to an older population structure ageing costs can be substantially lowered by allowing public funds to smooth out the tax responses. Cutting down on pension prefunding at a time when the pace of ageing is at its peak reduces the necessary tax hikes and stimulates labour supply growth at the moment when the labour market is tightest. With smaller funding needs, ageing leads to a slower growth in labour costs, a better employment conditions and faster production growth.

Keywords: ageing, general equilibrium, public finance, government funds

JEL classification numbers: E13, H55, J11, J26

# Julkisen talouden rahastot ja väestön ikääntyminen pienessä avotaloudessa

Suomen Pankin keskustelualoitteita 21/2008

Helvi Kinnunen  
Rahapolitiikka- ja tutkimusosasto

## Tiivistelmä

Tutkimuksessa tarkastellaan julkisen talouden rahastoja (erityisesti eläkerahastoja) tilanteessa, jossa väestön ikääntyminen aiheuttaa tuntuvia kokonaistaloudellisia kustannuksia. Tarkasteluissa käytetään dynaamista yleisen tasapainon mallia ja otetaan huomioon tehokkuustappiot, joita aiheutuu taloudenpitäjien reaktioista verojen ja maksujen muutoksiin. Malli on sovitettu Suomen talouteen, missä väestön ikääntyminen etenee nopeasti lähivuosina ja aiheuttaa veronkorotuspaineita. Työn verotuksen kiristyminen vähentää työvoiman tarjontaa, hidastaa kasvua ja aiheuttaa hyvinvointitappioita. Puskuroimalla rahastojen avulla verojen korotustarvetta voidaan lisätä työn tarjontaa ja lievittää hyvinvointitappioita. Vaikutukset ovat merkittäviä lähivuosisikymmenien aikana, jolloin verojen korotustarve on suurimmillaan samalla, kun työmarkkinat ovat kireimmillään. Rahastoja on mahdollista käyttää puskuroimaan verotuksen kiristymistä. Näin voidaan tehdä jonkin verran ilman että pitkän aikavälin kestävyys vaarantuu, sillä työvoiman tarjonnan lisäys muuttaa tuotannon rakennetta työvoimavaltaisemmaksi, mikä puolestaan tukee julkisen talouden tasapainoa.

Avainsanat: väestön ikääntyminen, yleisen tasapainon malli, julkinen talous, julkisen talouden rahastot

JEL-luokittelu: E13, H55, J11, J26

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# 1 Introduction

Population ageing is a major issue in most of the European countries. The average old age dependency ratio for the EU is projected to roughly double in the coming four decades. Demographic trends are unfavourable in virtually all EU countries, whereas the extent and timing of ageing stress differ substantially across countries.

One example of a country where the ageing problem is severe and acute is Finland. Whereas in most countries demographic shifts start from the late 2020s, in Finland demographic change is already in progress. Finnish demographic structure is dominated by baby boom cohorts that were born earlier and were clearly larger than in other countries. The fertility rate increased to an exceptionally high level (3.5 children per woman) after the second world war and went into a steep decline already in the 1960s, earlier than in other countries. As a consequence, record-large age cohorts have been reaching retirement age already in recent years, at the same time when cohorts entering work force are at their smallest. These trends will raise the old age dependency ratio from the current ca 25 per cent to more than 40 per cent by 2015. After that, the ratio will gradually level off at around 45 per cent.

To address ageing pressures, two kind of policy actions have been taken in Finland. First, the pension system have been revamped. A group of smaller revisions were effected in the 1990s and then, effective from 2005, there were some very fundamental changes in the public pension system. In particular, labour supply incentives were increased. Benefit ratios were lowered by linking the replacement rate explicitly to expected life span and to retirement age. The second fundamental change was an increase in pension funding as well as a cut in state indebtedness. This has increased the financial wealth of general government. The general government net debt (debt of centrl and local governments minus public pension funds), which was amounted to 20 per cent of GDP at the end of 1990s, posted an asset surplus of about 30 per cent at the end of 2006. Under the current pension scheme government funds will increase further. For example, under the current funding rule, public pension funds are projected to increase to two and half times the wage bill by 2030 and remain at that level even after the population structure is stabilized.<sup>1</sup> Altogether, the public pension funding and the entire general government wealth position in Finland is stronger than in other EU countries. In spite of this, sustainability of general government finances requires further increases in pension contribution rates and tax rates.

In this paper we discuss the role of public pension funding in the situation Finland is facing. With the dependency ratio increasing rapidly, causing rises in pension contribution rates and wage taxes, we would ask: to what extent can pension funds or state debt be used as an instrument to lower the adjustment costs of ageing? This issue is, no doubt, quite the opposite of the problems most EU countries are currently facing. Rather modest public pension funding is feared to increase future tax pressures and violate intergenerational fairness.

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<sup>1</sup>Biström, Elo, Klaavo, Risku and Sihvonen (2008)

The need for greater prefunding of public pension schemes is widely recognized, and some countries are already on the way to increasing their funding rates.<sup>2</sup>

Despite quite large prefunding relative to other countries, Finland's pension scheme is a defined benefit PAYG type, as are most public pension systems. But, unlike in most European countries, the coverage of the mandatory public pension scheme is extensive. Private voluntary pension insurance is in practice quite negligible. The earnings-related pension scheme is accrued at the individual level. Pension contributions accrue to future pension benefits according to certain accrual rates, without upper limits in pension benefits. On the aggregate level, however, the accrual rates are independent of changes in general contribution rates, which are often subject to policy actions aimed to correct possible sustainability gaps. That feature, in the end, distinguishes it from the pure accrual pension schemes. Accordingly, since there are no links between pension benefit and contribution rate, any changes in contributions will have the same kinds of efficiency costs as those generally attributed to wage taxation. Moreover, since pension funding is collective, neither does the pension funding rate affect the expected future wealth of households.

On the other hand, in an ageing economy, pension funding and a strong financial position of the public sector are, no doubt, key factors in sustaining the pension system and public finances. The strengthening of government funding is an efficient way to smooth the fiscal burden over generations. In addition, under the assumption that the real interest rate exceeds the real growth rate, the contribution rate under prefunding will be lower than the PAYG contribution rate in the long term, when the pension system is mature and demographic is completed.<sup>3</sup> The drawback of the funding strategy in a defined benefit system is, however, its distortionary effects on the labour market. In Finland, where funding rate remains high in a period of steeply rising dependency ratio, it will put an extra burden on the economy. If labour supply reacts strongly to tax changes, the longer term funding gains will be offset at least in the medium term.

Our question about the role of public funding in smoothing ageing costs relates only partially to the main branches of pension literature. The literature has on the other hand focused on analysing consequences of movement from a publicly provided PAYG based pension scheme towards private investment based funding.<sup>4</sup> There are also numerous papers on the effects of pension funding on financial markets, capital movements and the macroeconomy in multiregion models.<sup>5</sup> Closer to our question of funding adjustment in a small open economy is the paper of Bovenberg and Knaap (2008) on pension funding in the Netherlands. Also the paper of Jafarov and Leigh (2007) on fiscal policy rules and pension funding in Norway relates to our topic. Both of these countries face ageing pressures in situation analogous to that of Finland:

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<sup>2</sup>See discussions on European pension reforms for example in Holzmann, MacKellar and Rutkowski (2003).

<sup>3</sup>See discussion on PAYG and funding contribution rate in Hemming (1998).

<sup>4</sup>See for example Feldstein (2005), Bergstrom and Hartman (2007), Demange (2007) and MCMorrow and Roeger (2004) as well as OECD (2007) for discussions of costs of pension prefunding.

<sup>5</sup>Attanasio et al (2006) and Börsch-Supan et al (2003) as well as Saarenheimo (2004).

public pension funds are substantial but public finances are unsustainable under unchanged tax rates or spending policy. For the most part, however, ageing-related stress on the economy is analysed by evaluating pension reforms. In these considerations the issue of deadweight losses associated with ageing induced tax changes depends on how reforms change the tax-benefit link.<sup>6</sup> Under clear tax-benefit links, efficiency losses in terms of employment are typically absent. In addition, since the analysis usually concentrates on the closed economy case, a funding-induced increase in national saving tends also increase real capital formation and productivity, thereby improving long term growth prospects. In our case, under a public prefunding framework with weak or absent tax-benefit linkages, the advantages of funding are not very clear-cut, particularly since in a small open economy framework real interest rate reactions do not support economic growth. Besides the costs of tax distortions, in defined benefit framework, increased prefunding does not increase the wealth of households, unlike under an investment-based pension scheme where prefunding partially substitutes for private saving thereby reducing the funding-induced additional costs.

We use a dynamic general equilibrium macroeconomic model (DSGE) with features that facilitate investigation of distortionary effects of fiscal and pension policy responses to ageing on the aggregate economy and separately on two age groups representing life cycle phases of ‘a worker’ and ‘a retiree’. A pension system with wage-dependent pension benefits and collective prefunding is incorporated into the model. Households’ wealth includes social security wealth in the form of discounted pension entitlements, independent of funding and contribution rates. Realistic population change is incorporated into the model by the means of ageing shocks representing current population prognoses. The model contains separate fiscal policy rules and accounts for the state and public pension institution. Moreover the supply side, labour market and production, is explicitly modelled.

Simulation experiments made clear that, during the transition to an older population structure, ageing costs can be lowered, allowing public funds to smooth out tax reactions. Lower tax rates stimulate labour supply at the moment when the labour market is most tight. Under lower funding, ageing leads to less growth of labour costs, better employment and faster production growth. Given the collective nature of pension funding, cutting back on funding did not redistribute welfare between retirees and workers. Altogether the experiment indicated quite substantial gains achievable of funding adjustment. Since interest rate reactions for a small open economy are absent, even temporarily lower taxation exerts long term effects on factor prices, thereby changing the production structure to a more labour-intensive one. In our experiment the funding rate could be lowered by 20 percentage points of the wage bill from the currently prevailing level without any losses in welfare.

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<sup>6</sup>See for example Jaag, Keuschnigg, and Keuschnigg (2007) and Nickel, Rother and Theophilopoulou (2008).

The rest of the paper is organized as follows. Section 2 introduces the model, including a description of the pension system. Sections 3 discuss the results from policy experiment. Section 4 concludes.

## 2 The model

The model used in this paper features dynamic optimization of a small open economy. It is based on Gertler's (1999) overlapping generations model, which merges the perpetual youth model of Yaari (1965) and Blanchard (1985) with an important aspect of life-cycle behaviour. Our model is an extension of Gertler's model in the sense that it allows for distortionary taxation and time varying demographics. Households are forward looking, with stochastic transition from work to retirement and from retirement to death, which captures the life cycle behaviour of households. The defined benefit pension system is part of households' social security wealth and, accordingly, future pension entitlements are considered equal to other public transfers.

OLG features of the model facilitate investigating intergenerational aspects. Supply side (production structure) is based on CES production technology with factor augmentation in the underlying technological progress and nominal and real rigidities. The model is closed by fiscal rules. Budgetary solvency of public finances is achieved by setting an explicit target for public pension funds and a debt target for other government finances. In a small open economy, any imbalance between domestic savings and investment is reflected in the net foreign asset position.

Given our focus on the policy of public funding, the key relationships are the setting of fiscal policy rules and the way taxation affects the labour market, households' wealth and intergenerational wealth distribution. The model and the impact of population ageing in a DSGE model is reported in detail in Kilponen, Kimmunen and Ripatti (2007). The benchmark for the simulations is an economy where ageing-related demographic change is already incorporated in the model outcome.

### 2.1 Households

Households smooth consumption over the lifecycle. An individual lives for two distinct periods: in the first period as a worker and in the second as a retiree. Transitions from work to retirement and from retirement to death are captured by parameters measuring the length of the working period and life-expectancy.

#### 2.1.1 Demographics and preferences

Demographic parameters vary in time and are set to produce a realistic demographic structure. Dependency ratio,  $\varphi_t = \frac{N_t^r}{N_t^w}$ , is expressed as

$$\varphi_t \equiv \frac{N_t^r}{N_t^w} = \frac{1 - \omega_t}{\hat{N}_t^w} + \gamma_t \frac{\varphi_{t-1}}{\hat{N}_t^w} \quad (2.1)$$

where the number of working population  $\hat{N}_{t+1}^w$  grows at an exogenous growth rate  $1 + n_{t+1}^w$  and  $\omega_t$  is the probability that an individual remains a worker in the next period, while the probability of retiring is  $1 - \omega_t$ . Once an individual has retired, she faces a periodic probability of death of  $(1 - \gamma_t)$ .

In the steady state, the demographic change has ended, so that

$$\varphi = \frac{1 - \omega}{\hat{N} - \gamma} \quad (2.2)$$

$$\hat{N} = \hat{N}^w = \hat{N}^r \quad (2.3)$$

Households smooth consumption over the lifecycle and maximize a welfare function formulated separately for worker and retiree. Workers' preferences reflect the period at work and the expected period at retirement while retirees take into account, beyond retirement period, also the 'interim' period when they participate in the labour market upon retirement. This categorising is needed to enable us to capture the tax effects on labour supply of retirees. Preferences are summarized as

$$V_t^z = \left\{ [(C_t^z)^v (1 - l_t^z)^{1-v}]^{\rho_c} + \beta^z [E_t(V_{t+1}|z)]^{\rho_c} \right\}^{\frac{1}{\rho_c}}$$

where

$$E_t(V_{t+1}|w) = \omega_t V_{t+1}^w + (1 - \omega_t) V_{t+1}^r, \quad \beta^w = \beta \quad (2.4)$$

$$E_t(V_{t+1}|r) = V_{t+1}^r, \quad \beta_t^r = \beta \gamma_t. \quad (2.5)$$

$z = w, r$  indicates whether the individual is a worker or retiree. The finite (constant) intertemporal elasticity of substitution  $\sigma = 1/(1 - \rho_c)$  indicates the willingness to smooth consumption over time. Parameter  $v$  is the elasticity of periodic utility with respect to consumption. The retirees' effective discount factor  $\beta^r$  takes into account the periodic probability of death.

### A Retiree

The maximization problem for a retiree born at time  $j$ , retiring at time  $k$  and surviving at least until  $t + 1$  is

$$\max_{C_t^{rjk}, l_t^{rjk}} V_t^{rjk} = \left\{ [(C_t^{rjk})^v (1 - l_t^{rjk})^{1-v}]^{\rho_c} + \beta \gamma_t [E_t(V_{t+1}^{rjk})]^{\rho_c} \right\}^{\frac{1}{\rho_c}} \quad (2.6)$$

s.t.

$$A_{t+1}^{rjk} = \frac{1}{\gamma_t} R_t A_t^{rjk} + W_t (1 - \tau_t) \xi l_t^{rjk} + T_t^{rjk} - P_t^c C_t^{rjk} \quad (2.7)$$

where  $R_t$  denotes after-tax gross rate of return on financial assets  $A_t^{rjk}$  and  $T_t^{rjk}$  denotes pension benefits. Retirees who participate in the workforce are

assumed to have lost part of their efficiency compared to workers. Relative efficiency is denoted by  $\xi < 1$ . Efficiency slow-down captures, besides real labour productivity, another factor that lowers retirees' labour input as measured by work days, such as part time work. Parameter  $\beta$  is the subjective discount factor,  $P_t^c$  is a price index for consumption and  $\mathbf{t}_t$  is the total labour income tax rate including pension contribution rate,  $\mathbf{t}_t^{WP}$ .

Retirees' human capital is  $\mathcal{H}_t^r$  and social security wealth  $\mathcal{S}_t^r$ . Wealth is valued on a net basis, after wage taxes and taxes levied on pension income as well as pension contributions. Maximizing with respect to consumption and aggregating over retirees results in the following aggregate consumption equation for retirees

$$P_t^c C_t^r = \epsilon_t \pi_t [R_t A_t^r + \mathcal{H}_t^r + \mathcal{S}_t^r] \quad (2.8)$$

where  $\epsilon_t \pi_t$  is retirees' marginal propensity to consume out of wealth.  $\mathcal{H}_t^r$  and  $\mathcal{S}_t^r$  represent discounted after-tax labour income and pensions. They evolve as

$$\mathcal{H}_t^r = (1 - \mathbf{t}_t) W_t \xi L_t^r + \frac{\mathcal{H}_{t+1}^r}{\hat{N}_{t+1}^r R_{t+1} / \gamma_{t+1}} \quad (2.9)$$

$$\mathcal{S}_t^r = \mathcal{T}_t^r + \frac{\mathcal{S}_{t+1}^r}{\hat{N}_{t+1}^r R_{t+1} / \gamma_{t+1}} \quad (2.10)$$

The growth rate of retirees  $\hat{N}_{t+1}^r$  is entered into the discount factor because total social security payments (pensions) are distributed equally among retirees. Also the discount factor for human wealth is augmented by the growth rate of retirees. Retiree's marginal propensity to consume out of wealth  $\epsilon_t \pi_t$  evolves according to the following non-linear difference equation

$$\epsilon_t \pi_t = 1 - \left( \frac{W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \frac{(1 - \mathbf{t}_t)}{(1 - \mathbf{t}_{t+1})} \right)^{\frac{(1-v)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left( \frac{R_{t+1}}{\hat{P}_{t+1}^c} \frac{\gamma_t}{\gamma_{t+1}} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\epsilon_t \pi_t \gamma_{t+1}}{\epsilon_{t+1} \pi_{t+1}} \quad (2.11)$$

where  $\hat{P}_{t+1}^c \equiv P_{t+1}^c / P_t^c$ . A retiree's marginal propensity to consume varies with the real interest rate,  $R_{t+1} / \hat{P}_{t+1}^c$ , as well as with expected changes in real net wage income. In addition, the survival probability,  $\gamma$ , influences a retiree's effective discount rate, thereby introducing further dynamics into the marginal propensity to consume equation.

### A Worker

The maximization problem for a worker born at time  $s$  is

$$\max_{C_t^{ws}, l_t^{ws}} V_t^{ws} = \left\{ [(C_t^{ws})^v (1 - l_t^{ws})^{1-v}]^{\rho_c} + \beta [E_t(V_{t+1}^{ws})]^{\rho_c} \right\}^{\frac{1}{\rho_c}} \quad (2.12)$$

s.t.

$$A_{t+1}^{ws} = R_t A_t^{ws} + (1 - \mathbf{t}_t) W_t l_t^{ws} + \mathcal{T}_t^{ws} - P_t^c C_t^{ws} \quad (2.13)$$

where  $\mathcal{T}_t^{ws}$  denotes financial transfers to workers and  $\mathfrak{t}_t$  is the total labour income tax rate. After intertemporal maximization, the worker's consumption plan aggregates to

$$P_t^c C_t^w = \pi_t [R_t A_t^w + \mathcal{H}_t^w + \mathcal{S}_t^w] \quad (2.14)$$

where  $\pi_t$  is the worker's marginal propensity to consume and  $\mathcal{H}_t^w$  and  $\mathcal{S}_t^w$  denote human and social security wealth.

Marginal propensity to consume out of wealth follows a non-linear first order difference equation

$$\pi_t = 1 - \left( \frac{(1 - \mathfrak{t}_t) W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \right)^{\frac{(1-\nu)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left( \frac{\Omega_{t+1} R_{t+1}}{\hat{P}_{t+1}^c} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\pi_t}{\pi_{t+1}} \quad (2.15)$$

where  $\Omega_{t+1}$  is the factor that weights the gross real return  $R_{t+1} / \hat{P}_{t+1}^c$ . This factor evolves according to

$$\Omega_{t+1} = \left( \frac{1}{1 - \mathfrak{t}_t} \right)^{1-\nu} \left[ \omega_t + (1 - \omega_t) \epsilon_{t+1}^{-\frac{1-\rho_c}{\rho_c}} \left( \frac{1}{\xi} \right)^{1-\nu} \right] \quad (2.16)$$

where  $\epsilon_{t+1} > 1$  is the ratio of a retiree's marginal propensity to consume to that of a worker.

$\mathcal{H}_t^w$  is the discounted sum of a worker's wage bill (in net terms) and  $\mathcal{S}_t^w$  is the sum across workers alive at  $t$  of the capitalized value of social security (in net terms). Both of these measures take account of the corresponding discounted values at the time of retirement. Formally,

$$\mathcal{H}_t^w = \frac{\omega_t \left( \frac{1}{1 - \mathfrak{t}_{t+1}} \right)^{1-\nu} \mathcal{H}_{t+1}^w}{R_{t+1} \Omega_{t+1} \hat{N}_{t+1}^w} + (1 - \mathfrak{t}_t) W_t L_t^w \quad (2.17)$$

$$+ \frac{(1 - \omega_t) (\epsilon_{t+1})^{-\frac{1-\rho_c}{\rho_c}} \left( \frac{1}{\xi(1 - \mathfrak{t}_{t+1})} \right)^{1-\nu} \varphi_{t+1}^{-1} \mathcal{H}_{t+1}^{r(t+1)}}{R_{t+1} \Omega_{t+1} \hat{N}_{t+1}^r}$$

$$\mathcal{S}_t^w = \mathcal{T}_t^w + \frac{\omega_t \left( \frac{1}{(1 - \mathfrak{t}_{t+1})} \right)^{1-\nu} \mathcal{S}_{t+1}^w}{R_{t+1} \Omega_{t+1} \hat{N}_{t+1}^w} \quad (2.18)$$

$$+ \frac{(1 - \omega_t) (\epsilon_{t+1})^{-\frac{1-\rho}{\rho}} \left( \frac{1}{\xi(1 - \mathfrak{t}_{t+1})} \right)^{1-\nu} \varphi_{t+1}^{-1} \mathcal{S}_{t+1}^{r(t+1)}}{R_{t+1} \Omega_{t+1} \hat{N}_{t+1}^r}$$

$\mathcal{H}_{t+1}^{r(t+1)}$  and  $\mathcal{S}_{t+1}^{r(t+1)}$  are the values of human wealth and social security for a working retiree who retires at time  $t + 1$  but is still working at time  $t$ . The enlarged discount rate due to the presence of  $\Omega_{t+1} > 1$  in the denominator means that workers value human wealth and social security less than does a retiree. This tends to reduce the worker's consumption and increase saving compared to a retiree.

The factor  $\hat{N}_{t+1}^w$  augments the discount rate of the capitalized value of a worker's social security because the share of total social security entitlements going to those currently alive declines over time as the working-age population grows. By a similar argument,  $\hat{N}_{t+1}^w$  enters into the discount factor of aggregate human wealth.

### 2.1.2 Labour and wages

Standard labour supply for a retiree born at time  $j$ , retiring at time  $k$  and surviving at least until  $t + 1$  and a worker born at time  $s$  evolve as

$$1 - l_t^{rjk} = \frac{1 - v}{v} \frac{P_t^c C_t^{rjk}}{(1 - \mathfrak{t}_t) \xi W_t} \quad (2.19)$$

$$1 - l_t^{ws} = \frac{1 - v}{v} \frac{P_t^c C_t^{ws}}{(1 - \mathfrak{t}_t) W_t} \quad (2.20)$$

where  $\mathfrak{t}_t$  denotes taxes levied on labour income.

In the model, the worker faces a quadratic adjustment in re-setting the wage rate. A fraction of workers is assumed to adjust wages in each period. For those not able to optimize in the period, the wage is adjusted using the steady state growth rate of wages, denoted  $d\bar{w}$ , which equals the steady state productivity growth rate plus the inflation rate.

The behaviour of aggregate nominal wages is then characterized two wage rate equations

$$W_t^* = \frac{\frac{(1-v)}{v} P_t^c C_t^w / (1 - \mathfrak{t}_t)}{[N_t^w - L_t^w]} \quad (2.21)$$

$$W_t = \frac{(1 - q) \beta d\bar{w}}{(1 + \beta(1 - q)^2 d\bar{w}^2)} E_t W_{t+1} + \frac{(1 - q) d\bar{w}}{(1 + \beta(1 - q)^2 d\bar{w}^2)} W_{t-1} \quad (2.22)$$

$$+ \frac{q(1 - (1 - q)\beta d\bar{w}^2)}{(1 + \beta(1 - q)^2 d\bar{w}^2)} W_t^*$$

where  $P_t^c C_t^w$  is consumption of workers,  $N_t^w$  is worker population,  $L_t^w$  denotes the number of workers demanded,  $q \in (0, 1)$  is the exogenous probability that determines how often a randomly chosen worker is allowed to re-set her wage. The equation for the optimal wage rate,  $W_t^*$ , is derived directly from the aggregate version of worker's labour supply decision.

Workers' and retirees' aggregate labour supply is derived by multiplying individual labour supplies by population shares

$$L_t^r = \frac{\varphi_t}{(1 + \varphi_t)} - \frac{1 - v}{v} \frac{P_t^c C_t^r}{(1 - \mathfrak{t}_t) W_t \xi} \quad (2.23)$$

$$L_t^w = \frac{1}{(1 + \varphi_t)} - \frac{1 - v}{v} \frac{P_t^c C_t^w}{(1 - \mathfrak{t}_t) W_t} \quad (2.24)$$

Aggregate labour supply is measured by the effective labour supply index,  $L_t$ , which takes into account differences in workers' and retirees' labour efficiency

$$L_t = L_t^w + \xi L_t^r \quad (2.25)$$

Labour demand for workers,  $L_t^w$ , is derived by assuming that retirees are always on their labour supply curve at the prevailing wage ( $W$ ), and domestic intermediate goods producers are on their labour demand curve.

### 2.1.3 Wealth distribution, financial assets and aggregate consumption

Since workers discount wealth at a higher rate than retirees, they tend to consume a smaller part of any wealth increase. This means that the distribution of wealth is an essential element in aggregate consumption.

Using previous equations for human and social security wealth, the share of financial wealth held by retirees  $\lambda_{t+1}^r \equiv \frac{A_{t+1}^r}{A_{t+1}}$  evolves according to

$$\begin{aligned} \lambda_{t+1}^r = & (1 - \frac{\epsilon_t \pi_t}{\nu}) \frac{R_t \lambda_t^r A_t}{A_{t+1}} \\ & + \frac{(1 - \tau_t) \xi W_t N_t^r + \mathcal{T}_t^r - \frac{\epsilon_t \pi_t}{\nu} (\mathcal{S}_t^r + \mathcal{H}_t^r)}{A_{t+1}/\omega_t} + \frac{(1 - \omega_t)}{\omega_t} \end{aligned} \quad (2.26)$$

where  $\mathcal{H}_t^r$  and  $\mathcal{S}_t^r$  denote discounted after-tax values of labour income and pensions as denoed above, and  $\epsilon_t \pi_t$  is retirees marginal propensity to consume out of wealth.

Assuming that all assets are eventually held by domestic consumers, aggregate private consumption is

$$P_t^c C_t^H = \pi_t ([(1 - \lambda_t^r) R_t A_t + \mathcal{H}_t^w + \mathcal{S}_t^w] + \epsilon_t [\lambda_t^r R_t A_t + \mathcal{H}_t^r + \mathcal{S}_t^r]) \quad (2.27)$$

Individuals receive transfers from both the central government and pension funds. However, in order to maintain analytical tractability, pensions are related to the prevailing aggregate wage level but not to individual characteristics.

Financial assets available to consumers consist of three items: domestic government bonds,  $A_t^S$ , foreign bonds,  $A_t^W$ , and stocks issued by domestic firms,  $A_t^F$ . Pension funds invest in the same assets. Their investment is denoted by  $-A_t^P$ .

In simulations, asset returns on domestic and foreign bonds are assumed to equalize ( $r_t^S = r_t^F$ ). The share price  $r_t^D$  is the nominal price (ex-dividend) of a unit of equity in period  $t$ . The factor defining the gross return on stocks is firms' profits,  $\Pi_t^D$ .

This gross return is defined as

$$1 + r_t^D = [A_{t+1}^F + (1 - \mathfrak{t}_t^K) \Pi_t^D] / A_t^F \quad (2.28)$$

where  $\mathfrak{t}_t^K$  denotes the corporate tax rate.

### 2.1.4 Welfare

Workers welfare can be written using (2.6) and (2.12) and the corresponding optimality condition for consumption and labour as

$$V_t^w = \pi_t^{-\frac{1}{\rho}} (C_t^w / P_t^c) \left( \frac{1 - v}{v} \frac{P_t^c}{(1 - t) W_t} \right)^{1-v} \quad (2.29)$$

Retirees welfare evolves analogously to that of the workers with differences only in propensity to consume and in labour efficiency rate

$$V_t^r = (\epsilon_t \pi_t)^{-\frac{1}{\rho}} (C_t^R / P_t^c) \left( \frac{1-v}{v} \frac{P_t^c}{(1-t)W_t \xi} \right)^{1-v} \quad (2.30)$$

Given that agents maximise welfare over their life-cycles, welfare measures represent discounted future value for an average worker or a retiree at each moment. Consequently, the welfare effects of a policy or economic shock depends on its direct impact on wealth and on its impact on discount rates. Moreover, welfare is affected by tax-distortions from the labour market.

## 2.2 Social security

### 2.2.1 Pension expenditures

The model's pension expenditures are linked to the demographic structure and aggregate wages such that  $\mathcal{T}_t^R = \mu_t N_t^r W_t$ , where  $\mu_t (= \bar{e}_t / \bar{W})$  is the average pension rate evaluated at the initial steady state level of aggregate wages  $\bar{W}$ . Total pension expenditures,  $\mathcal{T}_t^R$ , are thus linked to average wages and the number of pensioners. Making use of our demographic assumptions, we can express pension expenditures per capita in terms of the dependency ratio, wages and pension rate

$$\frac{\mathcal{T}_t^R}{N_t} = \mu_t \frac{N_t^r}{N_t} W_t = \mu_t \frac{\varphi_t}{1 + \varphi_t} W_t \quad (2.31)$$

Pension expenditure is the component that brings ageing structure to social security wealth. Other transfers for households are assumed to evolve in line with production growth. In simulating demographic shocks, we have pension benefits depend on wage developments over the longer time, thereby imitating the actuarial structure of the pension system.

### 2.2.2 Fiscal balances

General government is divided into two sectors: state government (central and local governments) and pension funds. Separation of sectors allows us to investigate pension funding apart from other fiscal policy questions. This is well-grounded from the intergenerational viewpoint since tax treatment differs for retirees and workers. On the public spending side, in turn, pension outlays are in principle equal to other public transfers not linked to tax payments. In that sense pension funding is equivalent to government debt.<sup>7</sup>

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<sup>7</sup>In practice, separation is well-grounded also because administration of pension funds is usually independent from the central government. For example in Finland pension policy is quite independent from other public administration and fiscal policy setting. Even though the government in the end makes formal decisions on contribution rates, pension funds are de facto governed by an entity outside the government consisting of three parties: labour union, insurance companies and the government. For more details see Finnish Centre for Pensions (2007).

The fiscal balance of the state consists of three taxes: labour income is taxed at the rate  $\tau_t^{WS}$ , capital gains tax levied at the rate  $\tau_t^K$  and consumption taxed at the indirect tax rate  $\tau_t^C$ . State expenditure items are consumption,  $C_t^S$ , transfers to firms and households,  $\mathcal{T}_t^S$ , and interest payments on government debt with nominal rate of  $r_t$ . The state issues government bonds amounting to  $A_t^S$  in a net basis. In each period, the following budget constraint holds

$$\begin{aligned}
& - (A_t^S - A_{t-1}^S) \text{ (net lending)} \\
& = \tau_t^{WS} (W_t L_t^w + \xi W_t L_t^r) \text{ (income tax revenue)} \\
& + \tau_t^K \Pi_t \text{ (corporate income tax revenue)} \\
& + \tau_t^C P_t^C C_t^F \text{ (indirect taxes)} \\
& + \tau_t^{FS} W_t L_t \text{ (firms' social security contributions)} \\
& - P_t^C C_t^S \text{ (state consumption)} \\
& - \mathcal{T}_t^S \text{ (total net transfers)} \\
& - r_t A_{t-1}^S \text{ (interest payments)}
\end{aligned} \tag{2.32}$$

Accordingly, the fiscal balance of public pension funds consists of pension contributions levied on wage income. Pensions are financed by collecting pension contributions from firms and workers as well as from revenue from pension funds. The overall pension contribution rate is  $\tau_t^P = \tau_t^{FP} + \tau_t^{WP}$ , with separate rates for employers' and employees' contributions. Pensions to retirees total  $\mathcal{T}_t^{PR}$  and include, besides old age pensions, disability pensions and other pensions. Pension funds accumulate financial assets  $A_t^P$ .

In each period the following flow budget constraint holds for the pension fund

$$\begin{aligned}
& - (A_t^P - A_{t-1}^P) \text{ (net lending)} \\
& = \tau_t^P W_t L_t \text{ (social security contributions of employer and employee)} \\
& - \mathcal{T}_t^{PR} \text{ (total transfers paid to retirees)} \\
& - r_t A_{t-1}^P \text{ (interest payments)}
\end{aligned} \tag{2.33}$$

### 2.2.3 Fiscal rules

The model is closed by the tax rule and contribution rate rule set separately for the state and the public pension funds. Fiscal targets are set to maintain sustainability in terms of the SGP requirement for general government finance.

The state targets the debt/GDP ratio and adjusts the labour income tax rate to stabilize debt at the targeted level within a ‘proper’ time horizon. The fiscal rule is of tax difference type<sup>8</sup>

$$\Delta\tau_t^{ws} = \theta_1(A_t^S - \bar{A}^S)/Y_t + \theta_2 [\Delta(A_t^S - \bar{A}^S)] / Y_t \quad (2.34)$$

where  $\bar{A}^S/Y_t$  is an exogenous target for the actual indebtedness ratio. If the government spending ratio is exogenous, the debt will also render the steady state tax rate exogenous, in effect determined unambiguously by the debt ratio. The parameters  $\theta_1$  and  $\theta_2$  determine the speed of adjustment. In the benchmark simulations, the debt ratio is a constant set at the steady state value of 0.5. Values of the adjustment parameters were set at  $\theta_1=0.08$  and  $\theta_2=0.9$ , which cause the debt ratio to proceed smoothly to the target within the period of demographic changes.

Using the same analogy, the pension contribution rate is targeted at the pension funds to wages ratio. Formally

$$\Delta\tau_t^P = \theta_1(A_t^P - \bar{A}^P)/W_tL_t + \theta_2 [\Delta(A_t^P - \bar{A}^P)] / W_tL_t \quad (2.35)$$

where  $\bar{A}^P/W_tL_t$  is the target level for the pension fund. In benchmark simulations, we set

$$\bar{A}^P/W_tL_t = \varphi_t/\varphi_{t-1} * A_{t-1}^P/(W_{t-1}L_{t-1}) + (1 - \varphi_t/\varphi_{t-1}) * \bar{A}^P/(W_tL_t) \quad (2.36)$$

where  $\varphi_t$  is old age dependency ratio and  $\bar{A}^P/W_tL_t = 1.6$  is the targeted value of the pension fund relative to the wage sum in the steady state. The faster the change in the dependency ratio, the slower the funding rate will approach the target.

Altogether, in our benchmark, given targets will bring the net debt of general government to about 20 per cent of GDP, which represents the sustainability ratio of unchanged net debt position that is applied as a sustainability criteria of in the framework of public surveillance in the EU.

#### 2.2.4 Production

The supply side is based on a production structure where domestic intermediate goods are combined with imported intermediate goods to produce final goods, broken down into consumption goods, capital goods and export goods. Producers of intermediate goods combine labour and capital using CES production technologies with factor-augmenting technical trends exogenously given. The production differs across final goods in terms of elasticity of substitution.

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<sup>8</sup>See the discussion of Mitchell, Sault and Wallis (2000) on the properties of fiscal rules in macro models. See also Railavo (2004) for a discussion of alternative fiscal policy rules and their stability properties.

### *Production of intermediate goods*

The production function for intermediate goods,  $Y_t(j)$ , is

$$Y_t(j) = \left[ \delta (\Lambda_t^K K_t)^{-\rho} + (1 - \delta) (\Lambda_t^L L_t^F)^{-\rho} \right]^{-1/\rho}$$

where  $K_t$  is capital,  $L_t^F$  labour, parameters  $\Lambda_t^K$  and  $\Lambda_t^L$  denote time-varying capital and labour-augmenting technical progress respectively,  $1/(1 + \rho)$  is elasticity of technical substitution with  $\rho$  the substitution parameter and  $\delta$  the share parameter in the production function. The technical change is labour-augmenting on the balanced growth path.

Cost minimization implies the following real marginal costs

$$\frac{MC_t(j)}{P_t(j)} = \left[ \delta^{\frac{1}{1+\rho}} \left( \frac{R_t}{\Lambda_t^K P_t(j)} \right)^{\frac{\rho}{1+\rho}} + (1 - \delta)^{\frac{1}{1+\rho}} \left( \frac{W_t^F}{\Lambda_t^L P_t(j)} \right)^{\frac{\rho}{1+\rho}} \right]^{\frac{1+\rho}{\rho}}$$

where  $R_t$  denotes the nominal rental price of capital services and  $W_t^F = (1 + \tau_t^F)W_t$  represents nominal labour costs including employers' pension and social security contributions.

In the steadystate, prices  $P(j)$  are determined by the markup,  $\Upsilon (= -\frac{1}{\rho^z})$  over marginal costs

$$P(j) = \Upsilon MC(j) \tag{2.37}$$

The first order conditions (in logs) with respect to capital services and labour are given by

$$r_t - p_t = \log \delta - \log(\Upsilon) - \rho \log \Lambda_t^K + (1 + \rho)(y_t - k_t) \tag{2.38}$$

$$w_t^F - p_t = \log(1 - \delta) - \log(\Upsilon) - \rho \log \Lambda_t^L + (1 + \rho)(y_t - l_t) \tag{2.39}$$

The aggregate pricing equation for intermediate goods producers, assuming Calvo pricing, is of the form

$$\Delta p_t = \beta E_t \Delta p_{t+1} + \Xi [v + mc_t - p_t] \tag{2.40}$$

where  $\Xi$  captures the frequency of price changes.<sup>9</sup> Inflation is determined by expected inflation and log markup  $v$  over the real marginal costs  $mc_t - p_t$ .

### *Production of final goods*

Final goods producers combine domestic intermediate inputs and imported goods. Producers take the market price for their products as given, since product markets are set to be competitive. The demand for retailers' output is given by consumption and investment of the private and general government

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<sup>9</sup>Formally,  
 $\Xi = \frac{(1-\zeta)(1-\zeta\beta)}{\zeta}$ ,

where  $1 - \zeta$  ( $\zeta \in [0, 1]$ ) is the constant probability of implementing a price change. Since there is a continuum of intermediate producers,  $1 - \zeta$  also represents the share of producers that are able to change their prices. The average time between price changes is given by  $1/(1 - \zeta)$ .

sectors. The output of the consumption-goods retailer divides into the private consumption and public purchases of market goods,  $C_t^T \equiv C_t^H + C_t^{SF}$ . The capital-goods retailer faces similar demand comprising private sector and public sector investment,  $I_t^T \equiv I_t + I_t^S$ .

The production technology for consumption and investment goods is

$$Q_t^j = \left[ \delta^j (Y_t^j)^{-\rho^j} + (1 - \delta^j) (M_t^j)^{-\rho^j} \right]^{-1/\rho^j}, \quad j = I, C^T$$

$\delta^j$  is the respective share parameter and  $\rho^j$  the respective substitution parameter ( $\sigma^j = 1/(1 + \rho^j)$ ).  $M^j$  denotes imports and  $Y^j$  the domestic intermediate good. Cost minimization generates following price indices

$$P_t^j = (1 - \tau_t^c)^{-1} \left[ (\delta^j)^{\frac{1}{1+\rho^j}} (P_t)^{\frac{\rho^j}{1+\rho^j}} + (1 - \delta^j)^{\frac{1}{1+\rho^j}} (P_t^{Mj})^{\frac{\rho^j}{1+\rho^j}} \right]^{\frac{\rho^j+1}{\rho^j}}$$

and conditional factor demands

$$Y_t^j = (\delta^j)^{1+\rho^j} \left( \frac{P_t}{(1 - \tau_t^c) P_t^j} \right)^{\frac{-1}{1+\rho^j}} Q_t^j$$

$$M_t^j = (1 - \delta^j)^{1+\rho^j} \left( \frac{P_t^{Mj}}{(1 - \tau_t^c) P_t^j} \right)^{\frac{-1}{1+\rho^j}} Q_t^j$$

The consumption-goods producer (retailer) pays the indirect taxes,  $\tau_t^C$ . Hence the tax base for indirect taxes consists of private consumption and government purchases. No indirect taxes are levied on investment goods.

The exporter is a firm that combines domestic intermediate input,  $Y_t^X$ , and imported raw materials,  $M_t^R$ , to produce export good,  $X_t$ , in competitive markets. Technology and preferences are identical to those of the retailers.

### *Capital rental firms*

Production capital is modelled as a homogeneous factor of production that is owned by a firm that rents capital to producers of domestic intermediate goods. The capital rental firm operates under perfect competition. Physical capital accumulation generates real adjustment costs in the form of lost capital stock. Capital accumulation is given by

$$K_t^p = I_t - \mathcal{S}(K_t^p, K_{t-1}^p, K_{t-2}^p) + K_{t-1}^p (1 - \delta_K) \quad (2.41)$$

where  $\mathcal{S}(\cdot)$  denotes adjustment costs of physical capital stock and  $\delta_K$  is the capital depreciation factor. The capital rental firm maximizes its expected discounted profits

$$\max_{\{I_t\}} E_t \sum_{s=0}^{\infty} M_{t,t+s} \Pi_{t+s}^K \quad (2.42)$$

subject to the capital accumulation equation (2.41) and the definition of capital services,<sup>10</sup>  $K_t = K_{t-1}^p$ . Its momentary profits are given by

$$\begin{aligned}\Pi_t^K &= R_t K_t - P_t^I I_t \\ &= R_t K_{t-1}^p - P_t^I (K_t^p + \mathcal{S}_t(K_t^p, K_{t-1}^p, K_{t-2}^p) - K_{t-1}^p (1 - \delta_K))\end{aligned}\quad (2.43)$$

The price index for investment goods,  $P_t^I$ , is the price index of the domestic investment good retailer and  $R_t$  denotes rental rate for capital. Future profits are discounted using the nominal stochastic discount factor (pricing kernel)  $M_{t,t+s} = \beta^s U'(C_{t+s}) P_t^C / [U'(C_t) P_{t+s}^C]$ . The first order condition with respect to capital stock  $K_t^p$  is given by

$$\begin{aligned}& - P_t^I E_t [1 + \mathcal{S}'_t(K_t^p, K_{t-1}^p, K_{t-2}^p)] \\ & + E_t M_{t,t+1} \{R_{t+1} - P_{t+1}^I [\mathcal{S}'_{t+1}(K_{t+1}^p, K_t^p, K_{t-1}^p) - (1 - \delta^K)]\} \\ & - E_t M_{t,t+2} [P_{t+2}^I \mathcal{S}'_{t+2}(K_{t+2}^p, K_{t+1}^p, K_t^p)] = 0\end{aligned}\quad (2.44)$$

Due to the end-of-period timing of physical capital stock, the accumulated physical capital is in use in the following period. Hence, the expected following period's rental rate,  $R_{t+1}$ , governs the current period investment decision. The adjustment cost function is quadratic in changes of the physical capital stock:

$$\mathcal{S}_t(\cdot) = \frac{\gamma_1}{2} \frac{(\Delta K_t^p - \gamma_2 \Delta K_{t-1}^p)^2}{K_{t-1}^p}\quad (2.45)$$

The usual ‘investment equation’ can be obtained by substituting the parametric version of adjustment costs for the share parameter in the first order condition.

### 2.3 Market equilibrium

All markets are in equilibrium at all point of time. The capital goods market is in equilibrium when the supply of capital services by the capital-rental firm equals the demand for capital services by intermediate goods producers. Similarly, the labour markets are in equilibrium when the demand for labour equals its supply,  $L_t^s = L_t^D$ . In the intermediate goods sector, the demand for intermediate goods by retailers and exporters equals total supply

$$Y_t^C + Y_t^I + Y_t^X = Y_t\quad (2.46)$$

Markets for final goods clear when

$$\begin{aligned}C_t^S + C_t^H &= C_t^T \\ I_t^G + I_t &= I_t^T \\ \left(\frac{P_t^X}{S_t P_t^W}\right)^{-\rho^W} M_t^W &= X_t\end{aligned}\quad (2.47)$$

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<sup>10</sup>For simplicity we assume that capital services obtain a lagged value of physical capital stock. In a more general case capital services would depend also on the endogenous utilization rate. This extension alters the results only in business cycle frequencies and is thus beyond the scope of this study.

where  $P_t^W$  is the aggregated export price of competing economies and  $M_t^W$  is aggregate imports of export markets. When the market clearing conditions hold, the workers' and pensioners' budget constraints (2.7) and (2.13), the general government budget constraint (2.36) and the pension fund's budget constraint (2.37) imply the following equation for the accumulation of foreign assets

$$S_t A_t^W = (1 + r_t^F) S_t A_{t-1}^W + \underbrace{P_t^X X_t - P_t^{MR} M_t^R - P_t^{MC} M_t^C - P_t^{MI} M_t^I}_{\text{trade balance}} \quad (2.48)$$

The current account balance is given by  $S_t(A_t^W - A_{t-1}^W)$  and the factor income account by  $r_t^F S_t A_t^W$ .

## 2.4 Key model parameters

The model's key parameters are calibrated to reflect the main features of the Finnish economy. Calibration principles are described and discussed in detail in Kilponen and Ripatti (2006). Key parameters of the model are summarised in the following table.

Given our interest in distortionary effects of taxes, the crucial parameter affecting our results is the periodic utility of consumption, which determines the labour supply elasticities. The elasticity of utility is calibrated at 0.80 and it produces uncompensated labour supply elasticity values of 0.23–0.26. This is broadly in line with elasticities applied in the standard European models. Elasticity of labour supply is of course highly uncertain. Concerning the ageing issues, some authors have argued that European elasticities could be much higher if, for example, all the ways in which taxes affect labour-supply decisions of retirees were taken properly into account.<sup>11</sup> An actuarially unfair defined benefit system, in particular, tend to raise the implicit tax rate for a retiree. High tax rates also create incentives for early retirement. Unfortunately, our model setting does not allow us to investigate these impacts. In principle for Finland, where mandatory public pension scheme is exceptionally extensive and tax-benefit links are particularly weak, the calibrated values of labour supply elasticities can be considered conservative.

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<sup>11</sup> According to Jacobs (2008) uncompensated elasticity of tax base could double in Europe if besides labour supply, also retirement and learning are endogenised.

**Table 1. Key model parameters****Households**

$\beta$	Subjective discount factor, parameter	0.99
$v$	Elasticity of periodic utility with respect to consumption	0.80
$\sigma$	Inter-temporal elasticity of substitution, parameter	0.45
$\xi$	Labour efficiency of retirees, parameter	0.30
$\epsilon$	Relative marginal propensity to consume, variable	1.59
$\pi$	Worker's marginal propensity to consume, variable	0.019
$\Omega$	Additional discounting factor	1.10
$\bar{v}^w$	Elasticity of labour supply (workers), variable	0.26
$\bar{v}^r$	Elasticity of labour supply (pensioners), variable	0.23

**Production**

$\hat{\Lambda}_L$	Labour-saving technical change p.a., parameter	2.08
$\delta^K$	Capital depreciation rate, parameter	0.08
$\Upsilon$	Price markup, parameter	1.08
$A^F/\Pi$	Price to equity ratio, variable	15.0
$\delta$	Capital share parameter	0.1
$\rho$	El. of substitution between capital and labour	0.72

**Public finances**

$\theta_1$	Fiscal rule adjustment, parameter	0.08
$\theta_2$	Fiscal rule adjustment, parameter	0.9
$a^S$	State debt (% of output)	0.50
$a^P$	Pension funds (% of wage bill)	1.7
$c^S$	Public consumption (% of output)	20.8
$\mathcal{T}^{SW}$	Transfers to workers (% of output)	6.4
$\tau^K$	Corporate tax rate %, parameter	19.2
$\tau^C$	Sales tax rate %, parameter	21.0

**Interest rate**

$\bar{R}^F/\hat{P}^c$	Real interest rate, p.a., variable	2.4
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### 3 Simulations

#### 3.1 Benchmark economy

The benchmark for simulations is an economy where demographic changes have already passed through to the economic structure, eg labour market, production and public finances. After demographic shock, the economy grows along a new steady state growth path where the old age dependency ratio is permanently higher than in the initial steady state without ageing. The demographic shock is calibrated using parameters for the dependency ratio and probability of death to closely represent the situation Finland is facing in the light of current population projections.

Public finances are sustainable in terms of the SGP definition with government net debt remaining unchanged in the long term.<sup>12</sup> The wage tax rate and pension contribution rates adjust to keep the state debt and pension funds at the currently prevailing level in relation to GDP or wage bill. Other tax parameters, as well as government consumption as a share of GDP, are assumed to remain unchanged. Table 2 presents the main fiscal and macroeconomic variables at the initial steady state, where the demographic structure is assumed to be unchanged and at final steady state after a permanent demographic shock.

**Table 2. Public finances, labour market and households' welfare: Initial steady states and the final steady state in aged economy (benchmark)**

	Initial	Benchmark
Income tax rate % of workers, implicit	29.2	39.9
Pension contribution rate (firms and workers), implicit	19.9	27.0
Pension expenditure (% of output), variable	11.3	15.0
Employment rate, workers	0.745	0.61
Employment rate, retirees	0.17	0.32
Output growth, %	2.2	1.7
Private consumption per capita	4.7	4.0
Distribution of financial asset wealth, variable	0.17	0.25
Capital-output ratio	1.93	1.92
Net foreign assets % of output	-21.1	35.6

Under unchanged government net funds, reflecting the steep increase in the old age dependency ratio, labour tax rates had to increase altogether by about 17 percentage points in the long term (Table 2).<sup>13</sup> Both the pension contribution rate and wage tax rate should increase. As a consequence, because of distortionary taxation, the employment rate of workers would be in the steady state much lower than under stationary demography. That dominates the overall employment developments. Retirees' employment rate increases slightly. This is due to the fact that retirees' desire to compensate a decline in after tax wealth dominates the negative effect caused by a decline in wage compensation. Also real growth will be slower, consumption per capita lower and retirees' share of financial wealth much larger than in the initial steady state. A more detailed description of ageing effects is reported in Kilponen, Kinnunen and Ripatti (2007).

Altogether, in the benchmark, sustainability of public finances requires large tax hikes. The tax burden should increase during the period when government is a net creditor in the financial market and the labour market is extremely tight.

<sup>12</sup>More precisely, the sustainability condition represents sustainability with the S2 indicator fulfilling the intertemporal budget constraint over an infinite horizon.

<sup>13</sup>Note that possible effects of pension reform were not included. According to Ministry of Finance (2007), the direct effect of ageing on general government would amount to 8 p.p. of GDP. Finnish Centre of Pensions estimates that pension contribution rate should be increased by 4 p.p.(see Biström et al (2008) ). Both institutions took reform into account.

### 3.2 Funding adjustments during demographic transition

In this section we consider government assets as an additional policy option in alleviating ageing stress. Simulation results are compared to the benchmark situation where government funds remain unchanged in relation to GDP. In the following simulations we assume that pension fund targeting is relaxed and endogenised to respond inversely to changes in the dependency ratio (see 2.38). A new target is set to reduce the current ratio of 1.7 to 1.4 after completion of demographic change by the end of the 2050s. In terms of general government net assets to GDP, that means a decline from the prevailing level of 25 per cent of GDP to about 10 per cent (Figure 1). Net lending of General Government would raise the deficit by 1 percentage point of GDP at its highest at the beginning of the period. The magnitude of targeted pension funds represents the level that would maintain sustainability of the public finances and would keep tax rates close the benchmark in the steady state.<sup>14</sup>

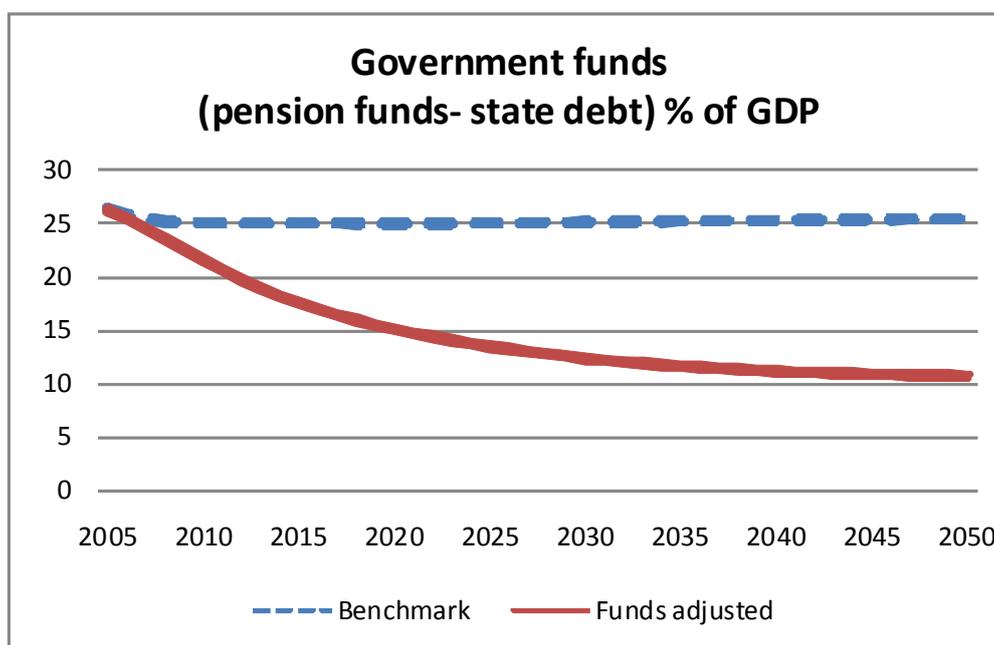


Figure 1: Adjustment in government funds

Given the small open economy environment with fixed interest rates, the counterpart of the weakening of the general government financial position is in net foreign financial assets. A reduction in government assets means that the current account surplus declines due to lower national saving. Net foreign assets decline by about 10 percentage points as a consequence of fund run-down in the long run (Figure 2).

The following figures display simulation results. The top panel of Figure 3 shows that the dampening of pension fund accumulation would clearly ease

<sup>14</sup>Since under normal assumption the real interest rate exceeds the real growth rate, reducing funding will weaken pension fund balances and cause contribution rates to increase later.

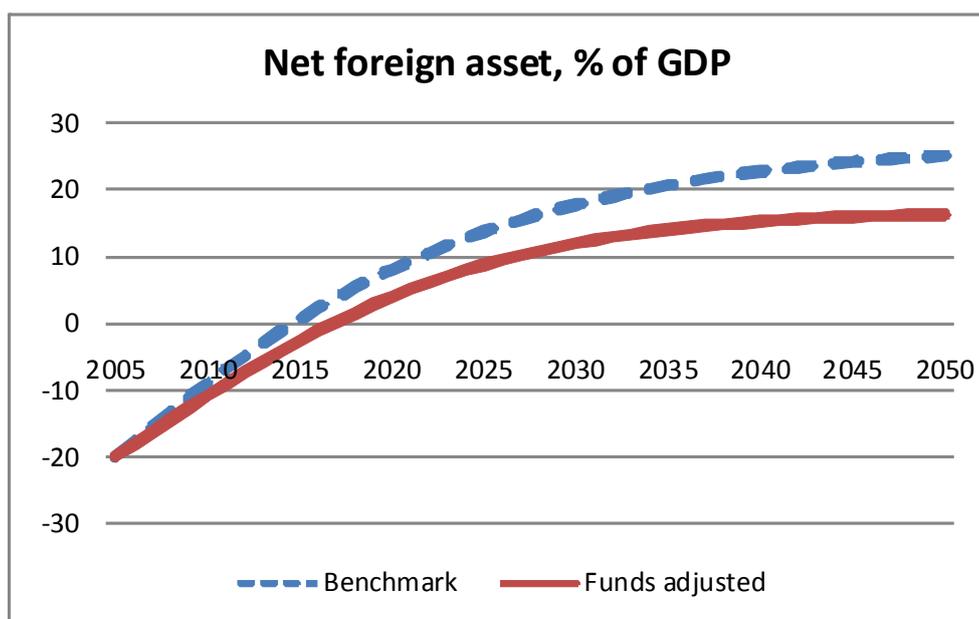


Figure 2: Foreign net assets in the benchmark and simulation

the tax burden on labour. The need to raise the pension contribution rate remains about 3 percentage points lower up to 2020 and the increase in wage taxes would remain about 2 percentage points smaller during the same time. The difference versus the benchmark in overall tax burden on labour peaks at the midpoint of the 2020s and amounts to 5.5 percentage points of wage bill. Pension contribution rates could stay lower than in the benchmark also for quite a long time, covering the entire period of demographic transition. In our experiment, tax rates actually do not reach the benchmark level until after four decades.

Labour market reactions to lower tax rates indicate substantial employment gains (second and third panel of Figure 3). The employment rate of workers would be nearly one percentage point higher on average during the next 15 years and retirees' employment would improve even in absolute terms as a reaction to a tax cut. Retirees' labour supply reacts stronger than workers', reflecting a wage set-up for the model with retirees reacting along their labour supply curve. Workers' employment reactions are more subdued because an increase in average wage will reduce labour demand. Due to the increase in average wages and labour supply, the capital-labour ratio, which declines after a tax cut, increases later on, at around 2015.

A lower tax burden increases the present value of net human capital as well as social security wealth, since pension benefits are subject to income taxation (Figure 4). Improved wealth boosts consumption and labour demand. The consumption level would stay during the demographic transition about 2 percentage points above the benchmark. GDP real growth will exceed benchmark by more than 1 percentage point on average during the same period. This represents substantial economic gains for the economy.

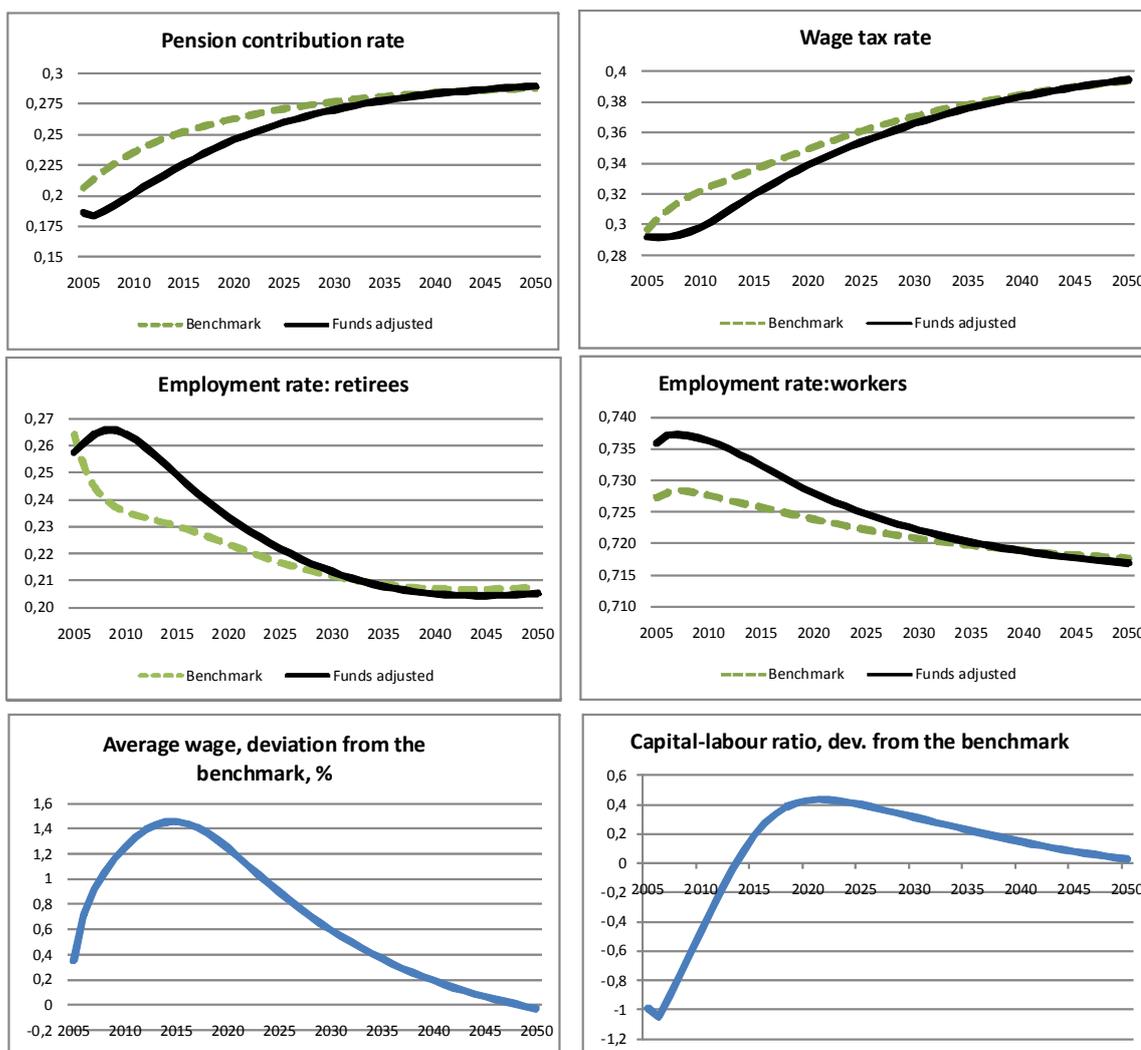


Figure 3: Results of an experiment where funding rate declines

The model with heterogeneous agents allows us to consider intergenerational effects of fund adjustment. Figure 4 shows that consumption of retirees constantly rises a bit more than that of workers. Retirees and workers differ with respect to planning horizon and combination of wealth. Retirees' shorter planning horizon means that any policy changes that affect their net present value of wealth is smoothed over a shorter period than that of workers. This and retirees' larger marginal propensity to consume out of wealth lead them to respond more strongly than workers to tax changes. But lower funding has practically no effect on income distribution. Welfare measures confirm the overall result. During the transition period, both retirees and workers are better off with rather similar welfare gains amounting to 1–2 per cent (Figure 4, bottom panel).

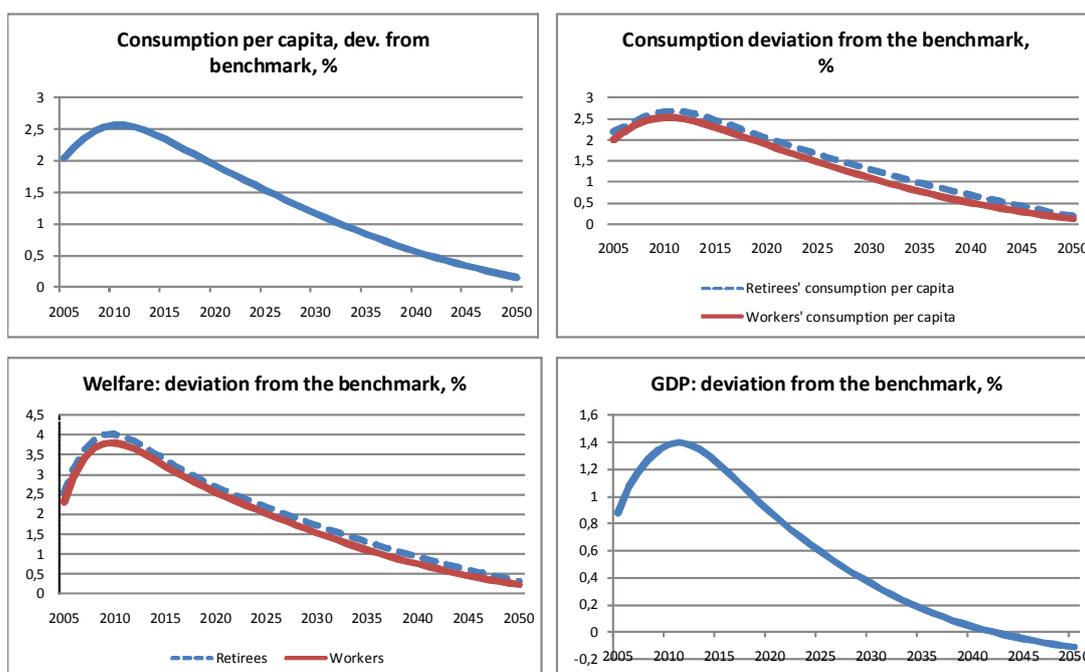


Figure 4: Results of an experiment where funding rate declines

### 3.3 Sensitivity analysis

Sensitivity of the experiment was investigated under alternative assumptions as to some key parameters of the model. We conducted the same simulation experiment allowing parameter estimates to vary around the values used in the base simulations.<sup>15</sup>

First we set the periodic elasticity of consumption,  $v$ , at slightly higher or lower than in the benchmark. Fund adjustments are particularly sensitive to cuts in the elasticity parameter (Figure 5). In particular, a lower elasticity value strengthens the labour supply reaction (see 2.29 and 2.20). Then lower funding with a lower tax rate gives a stronger boost to labour supply, allowing for larger tax reductions. This also improves after tax wealth compared to the benchmark simulations and can be seen to have larger effect on consumption per capita. The following figures show, instead, how an increase of the same magnitude in the elasticity of consumption would make hardly any difference compared to the benchmark.

<sup>15</sup>The chosen procedure was not quite accurate since the balanced growth paths were not controlled for. If steady state values change substantially, due to parameter changes, then the analysed deviation from benchmark might not be quite comparable. This bias seems to relate to low values of the parameter  $v$  and particularly the reactions of retirees' participation. The employment rate of retirees gets quite different initial and final steady state values with a lower parameter value than in the benchmark.

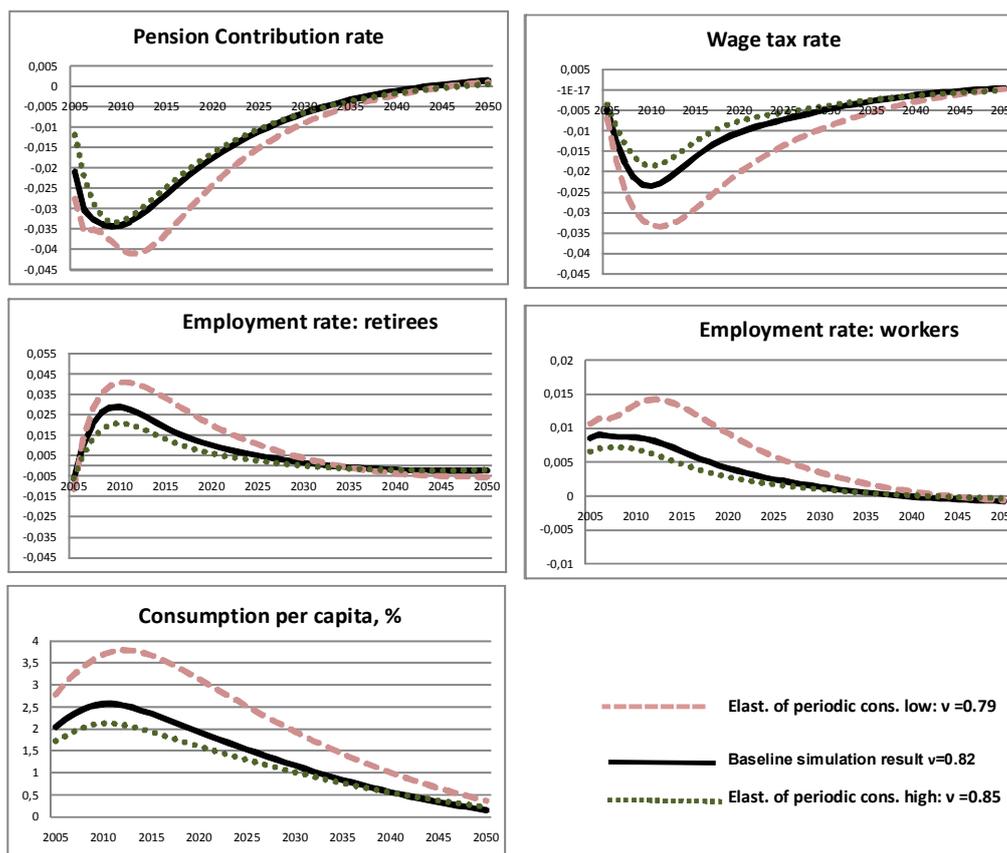


Figure 5: Alternative reactions on funds adjustment: elasticity of periodic utility of consumption varies

Secondly, we varied the intertemporal elasticity of substitution parameter,  $\sigma$ . Figure 6 indicates only a slight variation in tax rates, employment and consumption. Lower values for the IES parameter, when households are slightly more willing to allow consumption to vary over time, brings forward slightly the gains of funds adjustment in terms of consumption per capita.

The last parameter we varied was the elasticity of substitution between capital and labour,  $\rho$ . A noticeable effect is that, with a higher elasticity of substitution, employment of workers improves a bit more but somewhat later than in the benchmark (Figure 7). If capital and labour are more readily substitutable, lower pension contribution rates for employers induce them to demand more labour (see eq. 2.41).

Besides uncertainties associated with parameter values, important risks are naturally related to demographic trends. Using stochastic population forecasts for Finland, Lassila and Valkonen (2008) reported substantial variations in forecasts. For example, they found a 50 per cent probability that the number of prime age workers in Finland is between 2.4 million and 2.8 million. Uncertainty as to aggregate labour supply however increase with a long lag when the fertility risk is realised, which will take place after 2–3 decades.

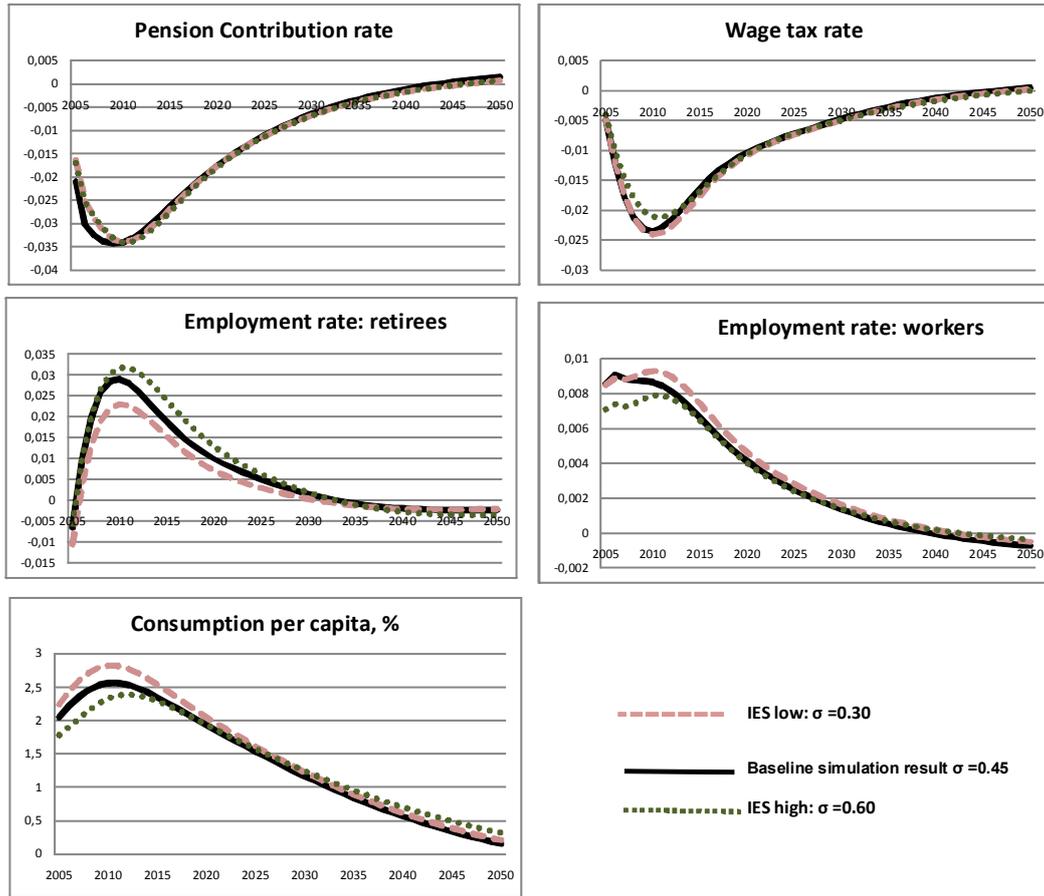


Figure 6: Alternative reactions on funds adjustment: Intertemporal elasticity of substitution (IES) varies

### 3.4 Steady state results

The simulation experiment shows that ageing costs can be lowered if funding is used to smooth tax reactions during the transition period of demographic change. An interesting point here is that the reduction in prefunding exerts only minor effects on welfare or economic activity in the long term. Table 3 shows that in our experiment the levels of labour taxation, employment, consumption and welfare remain practically the same as in the benchmark, even though less (some 20 percentage points of GDP) financial resources are devoted to preparing future pension outlays. This is in contrast to the fact that in the long term pension prefunding should be preferable to a PAYG pension scheme when the real interest rate exceeds the real growth rate, as it does in our set-up. Thus, in the steady state, the PAYG contribution rate should be higher than that under prefunding. With this in mind, our results should be interpreted cautiously: under certain limits and certain circumstances, pension prefunding may also raise long term costs.

A reduction in the funding rate produced only minor steady state effects for the macroeconomy. Smaller tax increases than in the benchmark, however, led to a slightly lower wage level, thereby making the production structure

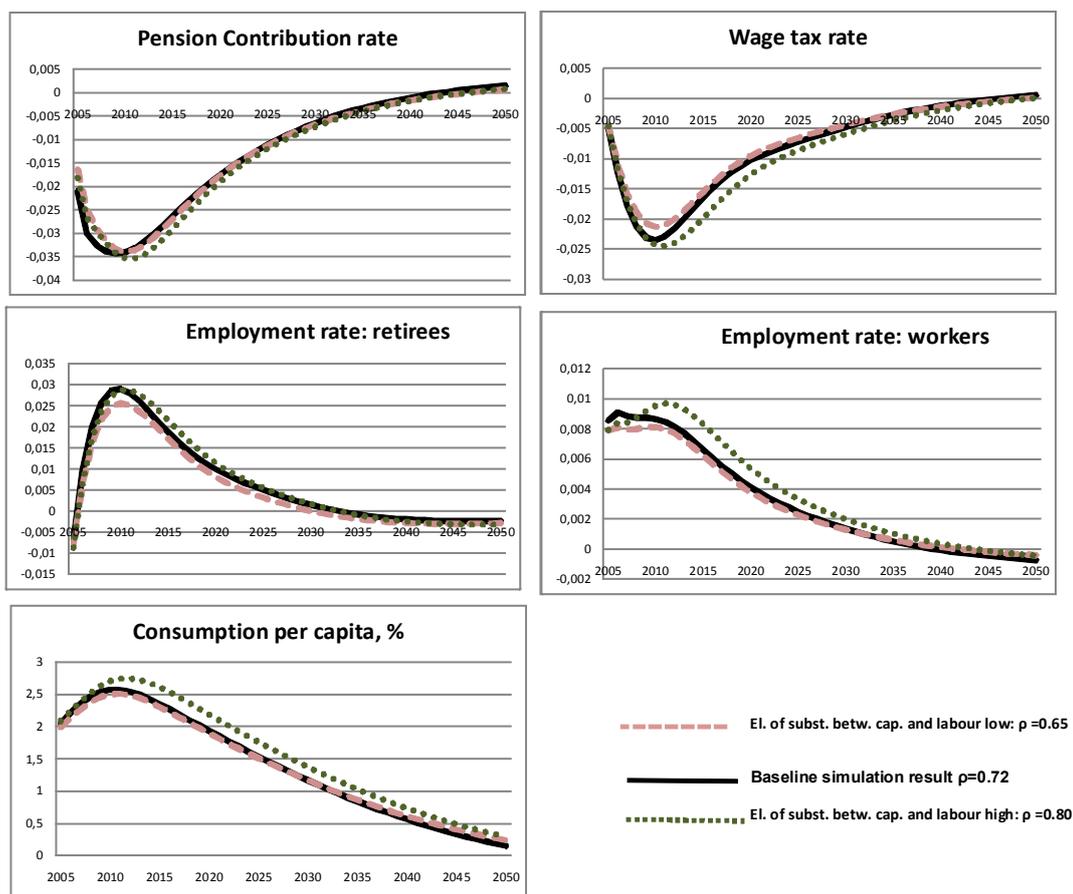


Figure 7: Alternative reactions on funds adjustment: Elasticity of substitution between labour and capital varies

slightly more labour intensive. Transitional changes seem to have exerted long term effects on the production structure. A lower wage level also means lower pension benefits compared to the benchmark. This means that the property income of pension funds will cover a larger share of pension benefits, which helps to reach the benchmark welfare and consumption levels with smaller prefunding. Note also that, even under larger fund adjustments, tax rates and welfare effects remain quite modest (Figure 8). For example, moving from a pure PAYG system to current funding level would lower the tax ratio by only some 2 percentage points. This would reduce the welfare of consumers by about 1 percentage point.

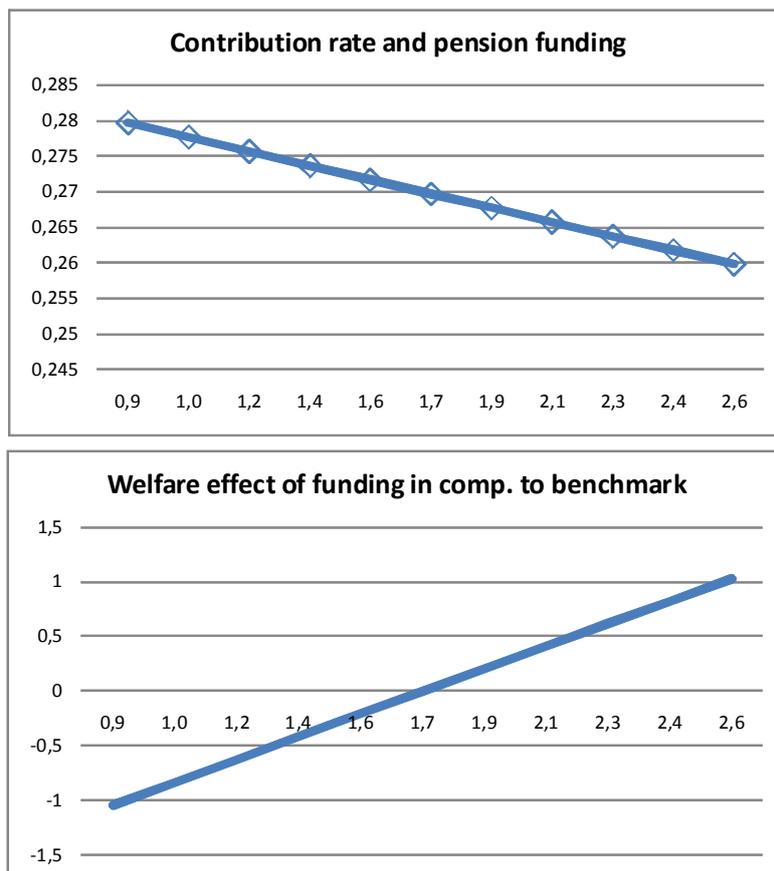


Figure 8: Reactions of welfare and pension contribution rate on funding adjustment in the steady state

**Table 3. Long term effect of funding adjustment**

	Steady states	
	Benchmark	Lower funding
Pension funds, % of wage bill	1.7	1.4
State debt, % of GDP	0.5	0.5
Pension contribution rate	27.0	27.4
State taxes	39.9	40.1
Employment rate, workers	0.61	0.61
Employment rate, retirees	0.32	0.33
Wealth distribution	0.245	0.245
Consumption per capita	3.976	3.954
Welfare, workers	0.00346	0.00345
Welfare, retirees	0.00266	0.00264
Capital-output ratio	7.87364	7.86974

### 3.5 Discussion of results

Rather modest relaxation of the general government financial target made room for substantial tax reductions, with considerable economic consequences during the demographic transition. The macroeconomic reactions are related to tax distortions, the specific nature of public pension schemes and the framework of a small open economy.

Concerning the pension scheme, the key issue is the lack of a tax-benefit link characteristic of a defined benefit public pension scheme. Since pension benefits at the individual level depend only on accrual parameters and past wages, general changes in contribution rates do not affect expected pension benefits. Contribution changes are driven by the need to maintain sustainability of public finances, as assumed in our experiment instead of being a result of pension parameter adjustments. Due to the lack of a tax-benefit-link, distortions from the labour market are of key importance. If, instead, the actuarial parameters were adjusted, the economic consequences could be quite different. Adjustments in pension parameters would directly affect individual pension benefits, thereby rendering contribution payments similar to investments in annuities. In the literature on pension reforms, the degree of actuariality has been pinpointed as a crucial condition for macroeconomic reactions and intergenerational income distribution. Any policies that improve the actuarial rate will lessen the distortionary effects of the pension system. For example Fischer and Keuschnigg (2007) found that reforms that strengthen the tax-benefit link clearly stimulated labour supply, even though the responses of older workers and prime age workers went in opposite directions. Keuschnigg (2008) pointed out that even in a DB pension scheme, changes in contribution rates do not entail efficiency losses if the benefits change accordingly. Jaag, et al (2007) also reported pronounced economic gains from Austrian pension reform, which greatly improved the actuariality of the pension system.

The second issue related to design of the pension scheme is that, despite prefunding, there is no link between fund return and pension benefit. Neither does the size of pension fund affect households' social security wealth. An individual's benefit at retirement depends, not on the performance of asset prices during that time, but on his earnings during his working years. Unlike in an investment-based system, the actuarial present value of benefits is not equal to that of Social Security savings. Consequently, funding affects distortions only to the extent that it reduces pressures for contribution rate hikes. In the literature, pension funding has generally been analysed from this point of view. Typically, economic gains from funding have been found to come from a reduction in distortions. For example, according to Feldstein (2005), deadweight losses from social security insurance could clearly be diminished by moving towards an investment-based funding system. Also Conesa and Garriga (2008) found that smoothing tax reactions to ageing will generate positive economic effects in the framework of small open economy with tax distortions. In the framework of public pension funding, Nickel, Rother and Theophilapoulou (2008) designed policy options which incorporated tax adjustments to a cut in the benefit ratio. They found that steady state consumption improved under a policy package comprising a cut in pension

level and a cut in proportional corporate taxes. Supply side gains from lower tax distortions boosted long term gains by changing factor prices.

Favourable economic reactions are also crucially related to the environment of a small open economy. Neither interest rates nor capital supply respond to changes in national saving. This strengthens the positive effect of a tax decline compared a closed economy framework. Bovenberg and Knaap (2007) confirmed this with the framework of the Dutch pension scheme. They reported substantial gains in terms of macroeconomic variables and welfare attainable from smoothing ageing-induced tax hikes by temporarily increasing government debt. Attanasio, Kitao and Violante (2006) also noted that pension reforms were particularly welfare-improving in an open economy. They compared different pension policy options in the framework of a two-region model.

## 4 Conclusions

Given the growth in the old-age dependency ratio, ensuring sustainability of public finances requires a substantial increase in tax burden or a down-grading of Social Security in most European countries. This burden differs by country, depending on timing of ageing, coverage and generosity of the public pension scheme, as well as the degree of prefunding. Our experiment highlighted the use of the option of adjusting public funds in Finland, where ageing problems are more severe than in any other European country, but where, on the other hand, quite focal policy measures have already been taken to prepare for ageing stress. In this paper public funds adjustment was considered as an additional policy option to alleviate the costs tax hikes pose for the economy during the transition to an older population structure. The analytical tool was the DSGE model, which features the Finnish pension scheme with defined benefit, high but collective funding and tax distortions.

A simulation experiment illustrated that, during the transition to an older population structure, ageing costs can be lowered, allowing public funds to decline and smoothing the tax reactions. Lower tax rates stimulate labour supply when the labour market is tight. Easing the funding target leads to a slower growth in the costs of labour, better employment and faster production growth. Given the collective nature of pension funding, a reduction in funding redistributed welfare between retirees and workers. Altogether, the experiment indicated quite substantial gains achievable with a funding adjustment during demographic transition. Macroeconomic gains were supported by the framework of a small open economy. Since interest rate reactions were absent, even temporarily lower taxation could change factor prices thereby rendering the production structure more labour intensive. In the experiment, the funding rate could be lowered by 20 percentage points of the wage bill without any losses in welfare.

As discussed in this paper, Finland's public pension scheme is unique in many respects. Still, our experiment highlights issues common to all public pension schemes. Concerning efforts to increase public pension funding in

other European countries, the long term costs of funding depend on how funds could be used to smooth ageing pressures. In most European countries, the old age dependency ratios start to accelerate in about 20 years time, which means that pension funds could be accumulated before the labour market becomes extremely tight. This creates room for fiscal policy to alleviate labour shortages when ageing stresses are at their highest level.

Finally, there is a number of questions that require further investigations. For example, the effects of a pension funding change towards personal accounts would help to determine the extent to which funding design would matter. Also, a wider range of policy options would be interesting to investigate. The most important further issue is the uncertainty associated with both the demographics and the return on of government funds.

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