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Aggregate risks, intergenerational risk-sharing and fiscal sustainability in the Finnish earnings-related pension system

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Abstract:

We study how aggregate demographic and economic risks affect the finances of the Finnish earnings-related pension system and the different generations of the insured. As a partially funded defined-benefit system, demographic risks and asset yield risks directly affect the contributions. Our analysis, based on a general equilibrium overlapping-generations model, show that these risks also affect wages and thus pension benefits and replacement rates. Productivity growth also affects wages and thus both contributions and benefits. We also analyze quantitatively the use of pension funds with the aim of smoothing contributions over time and compare the outcomes of the current system to an alternative system with the same benefit rules but no funding. Smoothing is affected by the revisions in long-term forecasts and is thus imperfect. In addition, variation in asset yields often cause clashes with solvency limits. We find that funding results in more varying contributions over time than would be the case without funding. Concerning generational equity, young generations benefit from funding in the form of lower contributions and higher wages, and their consumption possibilities are further increased by the improved fiscal stance of the state and municipalities.

Key words: Pensions, funding, contribution smoothing, risks, generational fairness

JEL: E17, H55, J11

I thank Juha Alho for simulations of future demographics with periodically revised forecasts that are crucial for the study, Eija Kauppi for careful model programming and data management, and Mauri Kotamäki, Tero Kuusi, Niku Määttänen, Ismo Risku and Tarmo Valkonen for fruitful comments and discussions. Financial support from the Finnish Pension Alliance TELA is gratefully acknowledged.

Työeläkejärjestelmän rahoitusriskit ja sukupolvittainen riskienjako

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Tiivistelmä

Työeläkejärjestelmän talouteen vaikuttavat suurimmat riskit liittyvät talouskasvuun, eläkerahastojen sijoitustuottoihin ja väestökehitykseen. Osittain rahastoidussa etuusperusteisessa järjestelmässä sijoitustuotot ja työssäkäyvien ja eläkkeensaajien lukumäärät vaikuttavat suoraan vain eläkemaksuihin, mutta mallipohjainen analyysi osoittaa, että nämä riskit vaikuttavat myös palkkakehitykseen ja sitä kautta eläke-etuihin. Myös talouden kasvuvauhti vaikuttaa palkkoihin ja siten sekä maksuihin että etuuksiin. Tutkimuksessa arvioidaan myös, kuinka hyvin työeläkemaksuja voidaan pitää sekä ajallisesti vakaina että pitkän ajan rahoituksen kannalta riittävinä. Maksujen täysi vakaus on mahdotonta, koska maksupolitiikka perustuu pitkälle tulevaisuuteen ulottuviin arvioihin ja ennusteisiin, joita ajan kuluessa joudutaan usein muuttamaan. Tutkimuksen laskelmien mukaan työeläkemaksut vaihtelisivat vähemmän, jos järjestelmä olisi täysin rahastoimaton. Rahastoinnin vuoksi työeläkemaksut ovat kuitenkin alempia kuin ne olisivat ilman rahastointia, jos eläkesäännöt muuten olisivat samanlaiset. Matalampien maksujen vuoksi nuorille ikäluokille jää enemmän rahaa kulutettavaksi, ja lisäksi valtion ja kuntien verotulot ovat suuremmat.

Asiasanat: Työeläkkeet, maksujen tasaus, talous- ja väestöriskit, sukupolvittainen tuotto
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1 Introduction

The Finnish private sector earnings-related pension system is statutory, began its economic life in 1962, and has developed to be the main income source for those retired from private sector work. Besides providing income in old age and covering longevity risk, it also includes disability insurance and benefits for survivors. The purpose of this paper is to study, from an intergenerational viewpoint, how aggregate demographic and economic risks are shared in the system. We also aim to illustrate and quantify how these risks affect the key financial outcomes of the system in the future. The role of funding is specifically studied.

The risks in this study include the key factors in the pension system's financial future, namely demographics, asset yields and growth trend of labour productivity. These uncertainties are kept explicit in all phases of the study, to avoid an unrealistically narrow perception of the size of potential outcomes and problems.

We use an open economy general equilibrium model FOG (short of Finnish Overlapping-Generations model). The model accounts for many important features of the Finnish economy, including a detailed description of the Finnish pension system after the 2017 reform, and it has been used in many published studies of population ageing and fiscal sustainability. The model looks at the long term; all cyclical aspects are absent. The overlapping-generations structure of the model facilitates the description of population aging and its effects to the pension system and also to the finances of the state and the municipalities, via e.g. health and long-term care services and public transfers other than pensions, and at the same time consistency prevails in markets and intertemporal budget constraints.

The Finnish earnings-related pension system is of a defined-benefit type and partially funded. Funding is collective, there is no individual risk taking. By design, funding affects directly only contributions. Demographic risks also affect contributions, because the numbers of those who pay contributions and those who receive benefits change, and the unfunded part of the system reacts. There are, however, indirect effects from the labour market, where wages react to the developments in the pension system, and wage developments in turn affect the pensions. Productivity growth also has effects via the labour market on the pension system outcomes.

In the latest pension reform, agreed in 2014 and coming to force in 2017, one stated target was to keep contribution rates 'smooth and appropriate', where appropriate relates to sustainable rate in the long run. This is a challenging target, because smoothing is forward-looking and requires forecasts, and in addition the solvency rules may play an important role. We are especially interested in how effective smoothing can be with the mix of slow-moving demographic risks that are usually predictable, to some degree, for a couple of decades, and very volatile asset yields that are unpredictable even in very short run.

Alho (2014) has created a method for regular demographic forecast revisions that are embedded in stochastic population projections. Lassila, Valkonen and Alho (2011, 2014) introduced the use of the method in fiscal policy analysis. The method allows the separation of expected and realized effects of population ageing on public finances. Applied to the ageing population in Finland (Lassila, Valkonen and Alho, 2014), the authors demonstrated that although demographic forecasts are uncertain, they contain enough information to be useful in forward-looking policy rules. In the current study, the method is used in studying how effective contribution smoothing can be.

We also illustrate the importance of pension funding for people's consumption. This is done first by comparing simulated consumption levels under the current system to those obtained without funding. Secondly, changes in consumption plans that result from revised optimization in each period are also compared. This novel method not only tells us how much or how little difference does funding make for consumption surprises, it also provides an outside reference, namely the changes that come from elsewhere in the economy where demographic and asset yield surprises are felt. In our study these outside effects come from two sources, namely from the developments and reactions in central and local government revenues and expenditures, and from the changes in wages and prices that are required to obtain the new general equilibrium.

Forecast revisions have not been used in other pension studies, but simulation approach is common. Auerbach and Lee (2009) provide descriptive measures of uncertainty in outcomes for generations. They also estimate expected utility measures, based on simplifying assumptions, and use them in an overall measure of social welfare. Concerning the Swedish NDC system they conclude that by accumulating more assets, it avoids having to apply the brake and thereby leaves the rate of return more stable. This makes the system look relatively better when risk aversion is explicitly included, but the net benefit appears smaller once the welfare of initial transition generations is taken into account, for these generations bear the brunt of the buffer stock accumulation. They conclude that "Our results suggest, then, that spreading risk widely among generations improves welfare, and that the policy of reducing risk through asset accumulation, as the Swedish system does, offers a less attractive approach unless one places very high weight on horizontal equity, i.e., on maintaining a very smooth pattern of net benefits from one cohort to the next." Our results show that it is very difficult to obtain a very smooth pattern.

Unlike Auerbach and Lee (2009), we study pension systems that are under dual transition. The first, minor, transition is that the pension system is still maturing, and many current retirees have only partially been covered by it. The second, and more important, transition is demographic transition. Baby boom generations have just about all retired, fertility has been getting lower, life expectancies have grown and are growing, and net migration is large.

Our contribution is, firstly, to make stochastic fiscal projections for the current earnings-related pension system, taking into account demographic risks, asset yield risks, and productivity growth risks which are important to all pension systems that have any funds. Secondly, we study how effective contribution smoothing is, when it is based on long-term projections, must deal with highly variable rate of return from assets, and can be restrained by solvency requirements. Thirdly, we produce measures such as internal rates of return and consider the intergenerational properties of the system. We specifically concentrate on the cohort that was born in 2000 – 2004 and will start their adult life in 2020; our simulations follow them up until 2100. Fourthly, to bring forth the role of funding in the pension system we make all simulations also for a pension system with identical benefit rules but no funding and study the differences that follow.

Section 2 describes the methods, including the economic model that includes the pension system, and the uncertainty specifications. In Section 3 the long-term stochastic projections are described. Section 4 presents the intergenerational measures and considerations. Section 5 concludes.

2 Methods

2.1 The FOG model

We use a numerical overlapping-generations general equilibrium model of the type originated by Auerbach and Kotlikoff (1987). The model is called FOG (Finnish Overlapping Generations model). It is modified to describe a small open economy and calibrated to the Finnish economy. The model is usually run under the assumption of perfect foresight: households and firms know all the future prices, wages, taxes and values of other variables they need in their decision-making. In this study, however, we follow the assumption in Lassila, Valkonen and Alho (2011, 2014) that households believe in population forecasts with certainty. The forecasts are erroneous, and when a new forecast appears the households and firms re-optimize. They do not learn, however, that forecast errors occur, but continue to believe in the new forecast with certainty. In this study, the forecast approach is expanded to include also asset yields and productivity.

The FOG model consists of five sectors: households, enterprises, a government, pension funds and a foreign sector. Households make economic decisions according to the life-cycle hypothesis. They maximise the utility from consumption and leisure in different periods and the bequest that they give. The lifetime budget constraint says that discounted lifetime incomes and discounted received bequest and transfers equal discounted consumption expenditure and the given bequest. Households enter the model at age 20 and exit at age 100 at the latest. The unit period is 5 years.

Firms choose the optimal amount of investment and labour to maximise the price of their shares. The market value of the firm is determined as a discounted sum of future dividends. The problem can be presented as maximising at the beginning of the period the dividends distributed during the period plus the value of the firm at the end of the period, subject to the amount of initial capital stock, the cash-flow equation of the firm, the CES production function, the accumulation condition of the capital stock, the determination of the firm's debt and the investment adjustment costs. The three markets, for labour, goods and capital, are all competitive and prices balance supply and demand period-by-period. There is no money or inflation in the model.

The driving forces of the model economy are the demographic transition, the educational transition and the trend growth of labour productivity. The population is ageing due to longer lifetimes, low fertility rates and the transition of baby boomers from working age to retirement. The educational level improves somewhat in the future since the current middle-aged generations have on average lower levels of education than the young ones. The improvement raises the productivity of labour. Each household generation is divided into three educational groups with different lifetime productivity profiles determined by empirical observations of recent wage profiles. The educational shares are assumed to develop in the future in line with the official projections.

The labour input is determined partly by exogenous assumptions and partly due to endogenous adjustments in the model. Hours of work are decided by households. The average retirement age follows the period life expectancy at 30; this is achieved in the model by changing in each age group the share of those retired. Exogenous factors are the trend growth of labour productivity, educational gains and the unemployment rate. The model is calibrated so that the trend labour productivity growth and the following higher wages do not affect the otherwise endogenous labour/leisure choice of the households.

The growing number of people in old age increases the demand for health and old age care. The last years of life are especially costly. We assume that these demography-driven services are produced partly in the public and partly in the private sector, but production costs are paid totally from public finances. These services are produced using labour and intermediate goods as inputs, and there is no productivity growth. The shares of employees insured in private and public sector pension systems are kept constant.

The real wage adjusts to equalize the value of marginal product of labour and labour costs in the production of private goods and services. The rest of the workers, who provide tax-funded services produced in private and public sectors, earn the same wage.

Public expenditures have a strong connection to the age of individuals in Finland. The provision of public services is allocated mainly either to the early part of the life cycle (day care and education) or to the last years (health care and old age care). Similarly, income transfers are distributed mainly either to young families or to retired individuals. This is why the changes in the demographic structure are so important for the public expenditures. We assume that all income transfers (except the earning-related pensions) are fully indexed to wages because any other assumption would have dramatic consequences for income distribution in the very long-term analysis. Other than age-related expenditure is assumed to grow at the same rate as the GDP.

Revenues of the public sector originate from two types of sources in the model. The majority of the receipts are accumulated by income taxes, consumption taxes and social security contributions. Another noteworthy revenue source is the yield of the public sector wealth. The yield of the wealth is particularly important for the pension funds, but the Finnish central government has also a substantial amount of financial assets.

The private sector pension system, the public pension fund, the national social security institute and the municipal sector have their own budgets, which are balanced either by social security contributions or earned income taxes. Welfare transfers and services are provided according to current Finnish rules and practices, except that health and long-term care will follow new practices that are currently being legislated. Aggregate health and long-term care costs depend on the population age structure and proximity to death. Municipalities finance basic education, and thus municipal taxes depend on demographic developments. Mandatory pension contributions adapt to pension expenditure. State adjusts a proportional income tax rate so that it covers 70 % of health and long-term care expenditure. The remaining 30 % are covered by adjusting transfers to households, so that the forecast ratio of gross public debt to GDP, 50 years in the future, will be at the same level as it is in the beginning of current period. Other state tax rates are held constant in the base policy. Forecast revisions then cause some variation in both the transfers and the indebtedness. Earned income tax brackets are adjusted with the growth of the economy. Households are modelled to react to the income and substitution effects of taxation, social security contributions and pension accrual rules.

The FOG model is basically non-stochastic, and the shocks we use as inputs operate only through very few channels. Asset yield shocks only affect the return on the pension funds, the interest payments of public debt, and the return on the state's financial assets. Households and firms operate under a fixed interest rate.

Productivity growth varies between simulated paths. In each path the growth rate is constant and the model agents know what it is.

The stochastic analysis is done around a dynamic baseline. The initial situation reflects the Finnish economy around 2015, to a limited degree a calibrated equilibrium model can produce. The future baseline consists of the current official population projection and base forecasts of other variables.

When using stochastic population projections, we add a demographic forecast to each time-point in each simulated population path. Thus the view concerning future demographics is periodically updated when we move along any simulated population path. For equity and bond yields, the forecast is always the expected value. The technique is described in more detail in Appendix 2.

2.2 The private sector earnings-related pension system

The earnings-related pension scheme aims to provide sufficient retirement income to cover consumption comparable to levels enjoyed during working years and to current workers' consumption. It covers risks related to old age, disability and death of family earners. In cases where the earnings-related pension is absent or insufficient, the national pension and the guarantee pension provide a minimum income. All these first-pillar schemes are statutory. Voluntary pensions are of minor importance in Finland. Below we describe the private sector earnings-related scheme. Public sector benefit rules have gradually been designed to become the same as in the private sector, although full transition takes time. Pension funding in the public sector differs from the private sector; the funds are buffer funds with no solvency requirements.

2.2.1 Benefits

The earnings-related pensions include both disability pensions and old-age pensions. Every year's earnings directly affect the future pension. After the 2017 reform, the accrual rate is 1.5 % per year in ages from 17 to an upper limit that is currently 68 and changes in lockstep with the lowest eligibility age. This earliest age is currently 63 but it is being raised starting from cohort born in 1955. Deferring benefit withdrawal after the earliest age is rewarded actuarially. If retirement occurs due to disability, the pensioner is compensated for lost future accruals. The compensation depends on the age at the time of the disability event. After receiving the disability pension for five years there is a one-time level increase in the pension.

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.

The pensions are adjusted for increasing life expectancy 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.

(1) $$A(t,62) = \sum_{s=63}^{100} S(t-1,62,s)/(1.02)^{s-62}$$

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, S, expresses the survival probability from age 62 to age s, and the first argument in brackets 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 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.

(2) $$E(t,62) = A(2009,62)/A(t,62)$$

According to the 2017 pension reform, the pension scheme will react to longevity shocks also with retirement age. The earliest eligibility age for old-age pension is first raised gradually to 65, in 3-month cohort-wise steps. After that, for cohorts born 1965 and after, the eligibility age is linked to life expectancy. Longevity adjustment is still applied but it is mitigated, cutting monthly pensions to a lesser degree than the current longevity indicator does. The mitigated longevity indicator is also applied to the earned part of the disability pension. The mitigated longevity adjustment keeps the present value of pension unchanged, when the increase in the earliest eligibility age and in the length of the retirement period are both taken into account.

The earliest eligibility age for old-age pension is tied to adulthood life expectancy, where adulthood begins at age 18, so that the retirement age divides the adulthood life expectancy in the same proportion each year. For cohorts born 1965 and after, the earliest old-age pension eligibility age V is such that

(3) $$(V - 18)/(\text{Life expectancy at } V) = C$$

where *C* is a constant determined by

(4) $$C = (65 - 18)/(\text{Life expectancy at 65 in 2025})$$

Life expectancies are calculated from mortalities from latest available 5 years. *V* is in full months, and can change at most by 2 months from previous *V*.

Longevity adjustment after 2025 is calculated as follows:

(5) $E(t, V) = E(2026, 62)A(2026, 65)/A(t, V)$

Linking retirement age to life expectancy affects the length of working lives. Based on the study by Määttänen in Lassila, Määttänen and Valkonen (2015), a one-year increase in life expectancy by itself increases working lives by two months. Raising the pensionable age, the unemployment pathway and the part-time pension ages by one year extends working lives by one month. These relations, from life expectancy to earliest eligibility age and from the eligibility age to working lives, and directly from life expectancy to working lives, are used in the stochastic simulations.

2.2.2 Funding

Partial funding has been carried out so that each individual pension is divided into a funded and an unfunded component. Private sector pension funding is collective but based on individual pension rights. Individual pension benefits do not depend on the existence or yield of funds. Funds only affect contributions. When a person receives a pension after the age of 65, his/her funds are used to pay that part of the pension benefit that was prefunded. The rest comes from the PAYG part.

Equation (6) describes new funding for an individual i. The labour income y creates a pension right for each year in old age. A share g of the present value of the pension right accruing in period t to workers in the age range 17 - 54 is put in the funds. The present value includes all old-age pension years, from 65 to a maximum age assumed to be 100. Discounting includes both the so-called fund rate of interest q, which is administratively set, and survival probabilities S. For prefunding purposes, the magnitude of the pension right is evaluated ignoring all future changes due to wage or price developments. Thus the value of the right is simply k times the labour income for each retirement year.

Thus the amount h funded for an individual i in age group x is

(6) $$h_i(t,x) = g\sum_{s=65}^{100} k(x)y_i(t)S(t-1,x,s)/(1+q)^{s-x} \quad \text{where } x = 17,\ldots, 54.$$

Equation (7) states that for a retired person the amounts prefunded earlier (when the current pensioner was between the ages of 17 and 54) for period *t*'s pension, with the interest accrued to them with rate *r* and leading to a total amount *v*, is used to pay a part of the person's pension.

$$(7) \qquad v_i(t,x) = \sum_{s=17}^{54} gk(s) y_i(t-x+s) S(t-x+s-1, x-s, x)(1+q)^{s-x}(1+r)^{x-s}$$

where $x = 65,\ldots,100$.

Disability pensions are also funded when the events occur. On the other hand, survivors' pensions and part-time pensions are not funded, and there is no funding for future index increases.

The funded pension components are the responsibility of the individual pension providers. Solvency regulations are needed because the providers are liable for these funded parts with their assets. These regulations aim to prevent excessive risk-taking in the competition between providers because, should very large risks be realized, the responsibility is divided among all parties in the system. Thus, if a pension provider goes bankrupt, those insured by it do not lose their pension benefits.

The funded parts are adjusted annually by at least a three per cent discount rate. In most years, however, investments would generate large surpluses if no additional measures were taken. That is why additional annual increases to the funded old-age pensions are made. The increases are targeted exclusively at persons who have turned 55, with the aim to achieve a steady development in pension contributions. The size of these increases is determined by an adjustment factor, which is based on the average solvency of all pension providers.

There is also a collective equity-linked buffer fund, acting as a buffer in solvency evaluations against fluctuations in share returns. The buffer fund may be either positive or negative. Depending on actual share returns, this buffer fund is either increased or reduced. The buffer is at maximum 1 % and at minimum -20 % of the funded pension parts.

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2.2.3 Contribution smoothing

As described above, the funding technique is one where new liabilities occur continuously as pension rights accrue and old liabilities are dissolved as pensions are paid out. Contributions are then the final elements in the budget constraint. Both employers and employees must pay them, based on the wage bill. In 2017 employer contributions were on average 17.95 % and employee contributions 6.45 %. Future changes are shared 50-50 between employers and employees.

Contribution rate could be determined by pension expenditure plus new funding and additions to existing funds, minus asset yields and the amount that is dissolved from funds. There is a further target, however, namely to keep contribution rate at a steady level. In the 2017 reform agreement by the social partners the target was stated as follows. 'According to long-term projections of the Finnish Centre for Pensions, this contribution level is sufficient to finance pensions also after 2019. The issue shall be reassessed during the TyEL contribution negotiations in 2020 at the latest. The goal of the parties is that the contributions shall develop smoothly[1] and appropriately and that the benefits and their financing shall be secured long-term.'

We assume that the solvency requirements do not prevent contribution smoothing. In each simulation, we search for a constant contribution rate that will result in a given solvency ratio after fifty years, if the prevailing demographic forecast would be correct and future asset yield would be at expected levels. We also follow an indicator of the solvency situation. The indicator is based on minimum funding (or minimum amount of technical provisions) that is required, and also on the equity-linked buffer fund.

[1] The agreement is in Finnish. The citations are from a translation by the Finnish Centre for Pensions (ETK 2017), except the word 'smoothly' that replaces the word 'equally' in the original translation.

2.3 Uncertainty specifications

We deal with demographic uncertainty by using stochastic population projections, which are used as inputs in the economic model. Statistical methods of expressing demographic uncertainty have been developed by many researchers (see e.g. Alho & Spencer, 2005, Lee & Tuljapurkar, 1998). These methods quantify uncertainty probabilistically, based on analyses of past demographic data and the views of experts. Fertility, mortality and migration are considered as stochastic processes. The parameters of these processes are fitted to match the errors of past forecasts (see Alho, Cruijsen and Keilman, 2008). After the processes for fertility, mortality and migration have been modeled, sample paths for future population by age-groups are simulated. The projections, made by Juha Alho, are presented around Statistics Finland's 2015 projection. They are described in Appendix 1. Forecast revisions, based on the method by Alho (2014) are embedded in these projections.

The stochastic models for equity and bond returns are from Ronkainen (2012). For equities, the S&P 500 yearly total return, in log-differences, is modeled by an uncorrelated and Normally-distributed process to which exogenous Gamma-distributed negative shocks arrive at Geometrically distributed times. This regime-switching jump model takes into account the empirical observations of infrequent exceptionally large losses. For bonds, Ronkainen (2012) models the 5-year US government bond yearly total return as an ARMA(1,1) process after suitably log-transforming the returns. This model can generate long term interest rate cycles and allows rapid year-to-year corrections in the returns. In simulations we use Model 5 for equities (see p. 31 in Ronkainen, 2012) and for bonds the model that Ronkainen reports on p. 52. The outcomes are described in Appendix 1. Ronkainen modeled nominal equity and bond returns, which is fine as our economic model can be interpreted to describe a zero-inflation real economy.

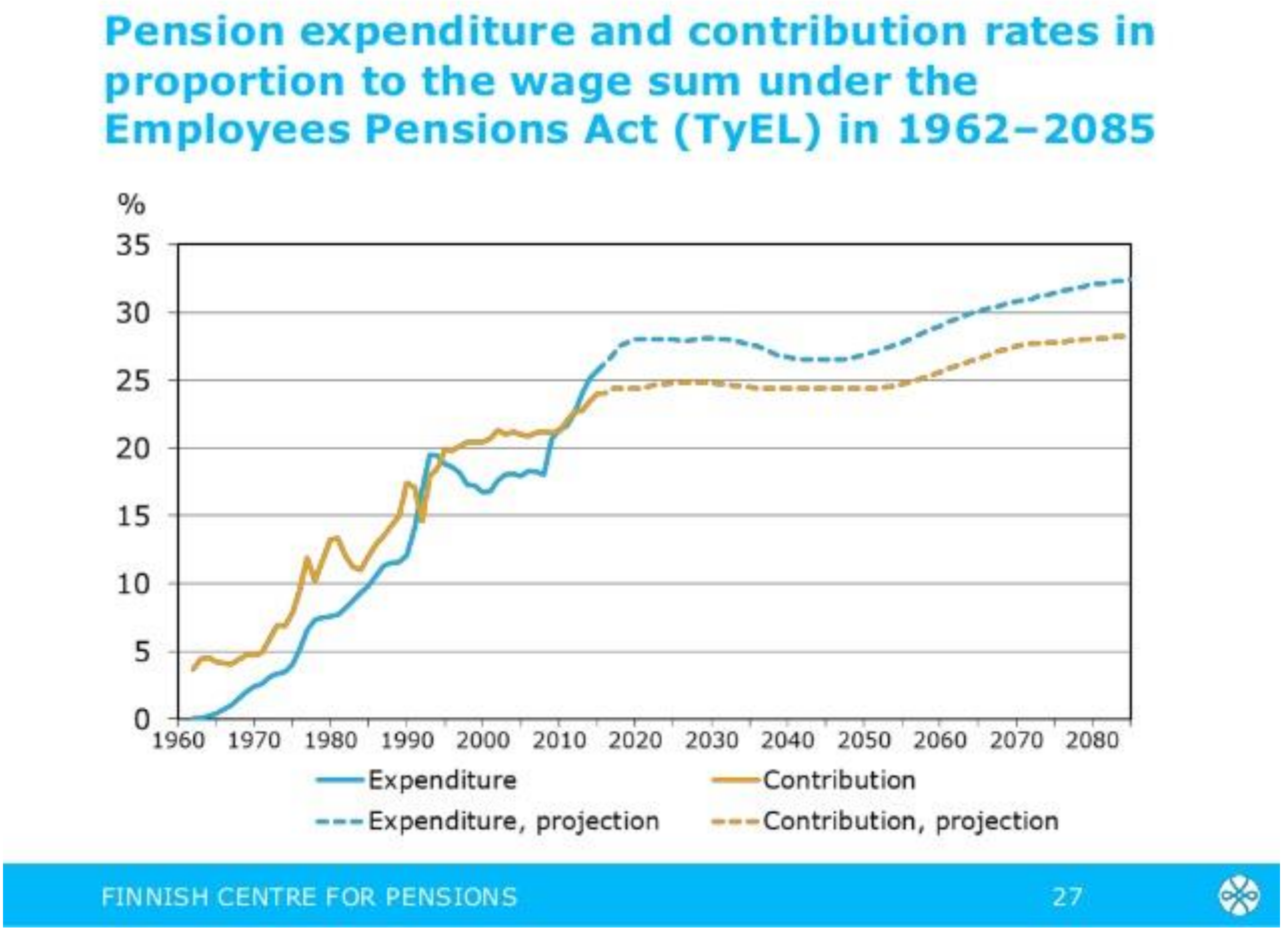
In our simulations, productivity grows at a constant rate in each path, but the rate varies between paths. The specification utilizes Christensen et al. (2016), especially the results in their Table 3. They report as their preferred estimates for high-income countries for the period 2010 – 2100 an average growth rate of 1,47 % and a standard deviation of 0,88 %. We use the same standard deviation and 1,5 % as the mean growth and limit the variation between 0,75 % and 2,25 %. If normally distributed, this would include 60 % of outcomes. The limitation is needed because finding numerical solutions with our model turned out to be difficult with higher growth rates.

Demographic shocks, bond and equity yield variations and productivity growth rates are all assumed uncorrelated with each other.

3 Pension system's projected long-term outcomes

3.1 Pension financing at a turning point

There has been a rising trend in pension expenditure and in pension contribution rate from the start of the private sector earnings-related pension system, as the following chart by the Finnish Centre for Pensions shows. One defining feature of the system has been the expectation of further increases in the contribution rate in the future. After the 2017 reform, however, the situation has changed. The trends are expected to be flat for several decades.



Source: ETK (2018)

This turning point is important both for intergenerational redistribution, discussed in Section 4, and for pension policy in the future, discussed in this Section. As noted earlier, one stated target of the 2017 reform is that 'the contributions shall develop smoothly and appropriately and that the benefits and their financing shall be secured long-term'. Taking into account the demographic and economic risks, this target and how well it can be achieved, needs a closer scrutiny.

3.2 Pension expenditures and contributions in 2020 - 2099

To see how the main risks affect the pension system's financial outlook, the economic model was run 350 times, with each of the 350 demographic paths combined with one bond yield path, one equity yield path and one value of trend growth in productivity. In each simulation and in each period, we compute a constant contribution rate that will result in a given solvency ratio after fifty years, if the prevailing demographic forecast would be correct and future asset yield would be at expected levels. The technique is described in more detail in Appendix 2. The model could not find a numerical solution for all periods in one path. Results from the 349 paths concerning pension expenditure are presented as a predictive distribution in Table 1.

Table 1. Private sector pension expenditure, % of wage bill

period	d1	Q1	Md	Q3	d9
2020 – 24	28.18	28.38	28.71	29.07	29.30
2025 – 29	28.92	29.32	30.01	30.54	31.11
2030 – 34	29.12	29.71	30.65	31.60	32.39
2035 – 39	28.67	29.42	30.67	31.83	33.00
2040 – 44	27.67	28.65	30.10	31.43	32.64
2045 – 49	27.12	28.09	29.61	31.30	32.78
2050 – 54	27.05	28.11	29.81	31.65	33.39
2055 – 59	27.29	28.46	30.34	32.48	34.12
2060 – 64	27.76	29.01	31.25	33.42	35.35
2065 – 69	28.00	29.32	31.90	34.30	36.41
2070 – 74	27.90	29.48	32.19	34.78	37.41
2075 – 79	27.64	29.71	32.61	35.49	38.44
2080 – 84	27.31	29.80	33.12	36.00	39.59
2085 – 89	27.04	29.78	33.28	36.53	40.72
2090 – 94	26.54	29.36	33.37	37.14	41.86
2095 – 99	26.13	29.09	33.47	37.77	42.04

d1 and d9 are the first and ninth deciles, Q1 and Q3 the first and third quartiles, and Md the median.

Compared to the wage bill, the period median for private sector pension expenditure stays around 30 % until 2060s when it starts to rise gradually. Half of the periodic observations are between values of Q1 and Q3 and form the 50 % predictive interval around the median. The interval widens gradually from 2 percentage points in 2030s to 8 percentage points at the end of the century. Ten percent of observations are below d1 and ten above d9, and the 80 % predictive interval between them is naturally wider than the 50 % interval but also more asymmetric upwards.

Because of funding, pension contributions as percent of wage bill, are lower than pension expenditure. The time-paths of contributions are heavily affected by the assumption of smoothing over 50-year horizons. Smoothing is based on forecasts that are revised every five years, and the outcomes depend also on the value of funds at the time when the smoothed rate is calculated. Funds are treated as buffers; we comment later how solvency considerations affect the outcomes.

Table 2 shows that the median value of the contribution rate is about 25 % in 2020s and there is not much movement until mid-2040s, when a gradual and rather steady rise begins. The rise ends at mid-2070s. The predictive intervals for contribution rates are much wider than those of pension expenditure, reflecting different asset yield outcomes.

Table 2. Private sector pension contributions, current system with unrestrained smoothing

period	d1	Q1	Md	Q3	d9
2020 – 24	23.14	24.36	25.48	26.46	27.57
2025 – 29	21.46	23.71	25.39	26.90	28.06
2030 – 34	20.22	23.34	25.80	27.49	28.86
2035 – 39	20.29	23.14	25.80	27.93	29.30
2040 – 44	19.40	23.15	25.74	28.30	29.95
2045 – 49	18.93	23.33	26.00	28.40	30.57
2050 – 54	17.62	23.07	26.33	29.01	31.41
2055 – 59	18.12	22.69	26.58	29.27	32.02
2060 – 64	16.95	22.28	26.64	29.91	32.84
2065 – 69	15.13	23.07	26.62	30.45	33.52
2070 – 74	14.78	23.03	26.98	30.65	34.40
2075 – 79	14.63	23.11	27.22	31.17	34.56
2080 – 84	14.34	22.66	27.30	31.40	35.27
2085 – 89	14.63	23.07	27.10	31.51	35.22
2090 – 94	14.68	22.85	27.31	31.55	35.56
2095 – 99	14.48	22.86	27.35	31.38	36.33

d1 and d9 are the first and ninth deciles, Q1 and Q3 the first and third quartiles, and Md the median.

The intervals can be compared to those obtained in earlier studies. Lassila, Määttänen and Valkonen (2007) studied demographic and asset yield uncertainty and reported smaller uncertainty: the 50 % interval widths for contribution rate after 30 years were of the order of six to seven percentage points, and the 80 % interval width was 12 – 13 percentage points. Asset yields were specified differently and varied less in the simulations. Hilli (2006) studied private sector pension contribution rate up to 2034 with a model including stochastic processes for asset yield risks, average earnings and inflation. He presents 90 % intervals about 8 – 9 percentage points wide for the contribution rate in 2034. Our 90 % interval, also about 30 years into the future, is about 16 percentage points wide in 2045 – 49. The difference can be explained by demographic uncertainty to a large extent, but probably also reflects larger variation in asset yields in our study.

From a financial angle, the median view – a kind of point forecast – is slightly tilted to the problematic side, but this tilt is small compared to even a minimal takeaway message of the uncertainty. It doesn't seem wise to draw strong conclusions based on just the point forecast.

Note that Table 2 presents periodic distributions. One could also look at path-wise distributions, which obviously are larger. One can ask how big share of the paths stays between, e.g., the values of Q1 and Q3 in all periods from 2020 to 2099 (the answer is 14 %) or between d1 and d9 (about 60 %) or totally outside the d1-d9 range (just 1 %). In about 15 % of the paths the contribution rate stays between 20 % and 30 % in all periods between 2020 and 2095. Both period distributions and path-wise distributions show the combinations of various risks that fulfil the intertemporal budget constraint, but in addition path-wise distributions depend on how well or poorly contribution smoothing can be done.

Private sector pension funds, in relation to annual wage bill, vary quite a lot which can be expected with smoothing and highly variable asset yields (see Appendix).

3.3 What if the system had been purely PAYG from the start?

One way to illustrate the effects of partial funding to the finances and risk-sharing properties is to compare the current system to an alternative with identical benefit rules but no funding. It is clear from the outset that the comparison presents the current system in a favourable light. A more balanced view could be obtained by comparing the current system also to some fully funded alternative. We chose not to try that, mainly because it is far from clear how that alternative should be defined and modelled. The open issues would especially concern disability pensions, survivors' benefits and whether asset yield risks would fall fully to individuals or whether some collective risk-sharing scheme would be included.

We assume that in the counterfactual economy, with no pension funding in the private sector, everything else would have developed the same way as with current system, except those issues that directly relate to pension financing. Thus we assume that capital formation is different only because prices and labour costs are different; these effects amount to extremely little in the capital stock in the model. We also assume that pension system's benefit rules would have been identical, and the decision not to fund is fully reflected in contributions. This may well be historically unrealistic; the union side might have demanded higher contributions from the beginning, which, without funding, would have gone to higher benefits.

With identical benefit rules, pension expenditure would develop the same way as with funding. Table 1 describes also this alternative (whose actual distribution is in the Appendix) very well, the difference from the results is usually just 1 – 2 decimal points. Since in a pure PAYG system the contributions collected must match the benefits paid in each period, Table 1 also describes the distribution of contributions.

Funding results in lower contributions, as Table 3 shows. The median difference in the long run is between 3 and 5 percentage points. Note that there is some probability for contributions actually being higher with funding. This requires low asset yields, low solvency capital, high liabilities and small payments from funds. If we compare average of contributions over several decades, funding always leads to lower contributions.

Table 3. How much higher contributions would be without funding, %-point

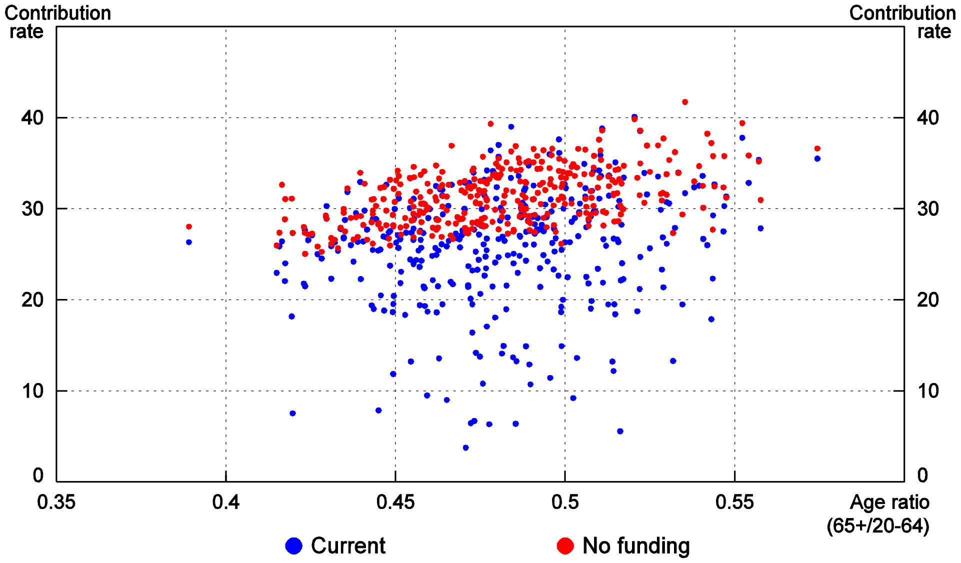
period	d1	Q1	Md	Q3	d9
2020 – 24	1.34	2.32	3.29	4.39	5.50
2025 – 29	2.20	3.23	4.53	6.50	8.54
2030 – 34	2.03	3.22	5.12	7.38	10.54
2035 – 39	1.49	2.68	4.66	7.20	11.40
2040 – 44	0.41	1.47	3.71	6.71	11.38
2045 – 49	-0.68	0.66	2.99	6.27	11.31
2050 – 54	-1.05	0.56	2.86	6.45	12.04
2055 – 59	-0.63	0.79	3.53	7.33	12.94
2060 – 64	-0.31	1.12	4.08	8.28	15.81
2065 – 69	-0.22	1.56	4.33	8.25	17.40
2070 – 74	-0.16	1.70	4.27	8.47	18.22
2075 – 79	-0.02	1.72	4.51	9.89	18.32
2080 – 84	0.05	2.03	4.73	9.88	18.28
2085 – 89	0.10	1.79	4.75	10.19	17.63
2090 – 94	0.02	2.04	5.00	10.58	18.91
2095 – 99	-0.15	2.08	4.81	10.45	19.47

d1 and d9 are the first and ninth deciles, Q1 and Q3 the first and third quartiles, and Md the median.

3.4 How different risks affect the projections

To show how the different risks affect the pension outcomes in the simulations, we plot selected risk variables with the pension contribution rate in 2060-64. Each of the 349 dots represents one simulated path. Demographics are illustrated by the age ratio 65+/20-64. The higher the age ratio is on average in 2020 – 2064 the higher is the contribution rate. Fertility, mortality and migration variations affect the age ratio.

Figure 1. Population's old-age ratio and pension contribution rate



Future fertility does not affect the contribution rate in 2020 – 2065 very much, because it takes two decades before newborns enter the working life. There is an indirect effect in our model: high fertility may affect wages in periods where none of those born are yet working. The reason is that children need care and teaching, which requires more workers in these services. That leaves fewer workers for the firm sector and drives real wages up, and the total wage bill is higher. Thus pension contribution rates may be marginally lower with high number of children.

Mortality variation concerns especially old people, who are mostly retired from working life. The pension system is adjusting benefits using changes in observed mortalities in a cohort-wise adjustment factor and will start adjusting earliest eligibility ages also. Surprises in mortalities will still affect the pension sector. We also assume that working lives on average become longer when people live longer, due both a direct effect from life expectancy to working lives and an indirect effect from life expectancy to earliest pension eligibility ages and from these ages to working lives.

We assume that migrants are exactly as natives in all economic aspects. With this strong assumption the economic consequences of migration are straightforward. The more there are migrants, the more there are contribution payers and the larger is the contribution base. This is later reflected also in pension expenditure. The long-run financial gains depend on the lag between paid contributions and received pensions and the difference between the rates of return and growth rate of the economy.

Slow productivity growth raises pension contributions and results in higher total tax rate. Rapid growth has opposite effects. Good equity and bond yields lower pension contribution rates.

Figure 2. Productivity growth and pension contribution rate

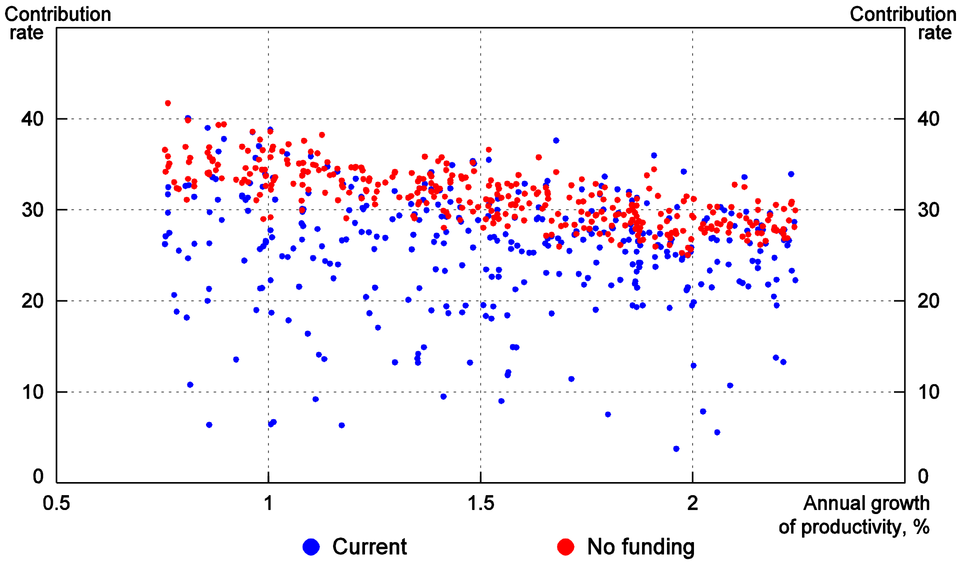
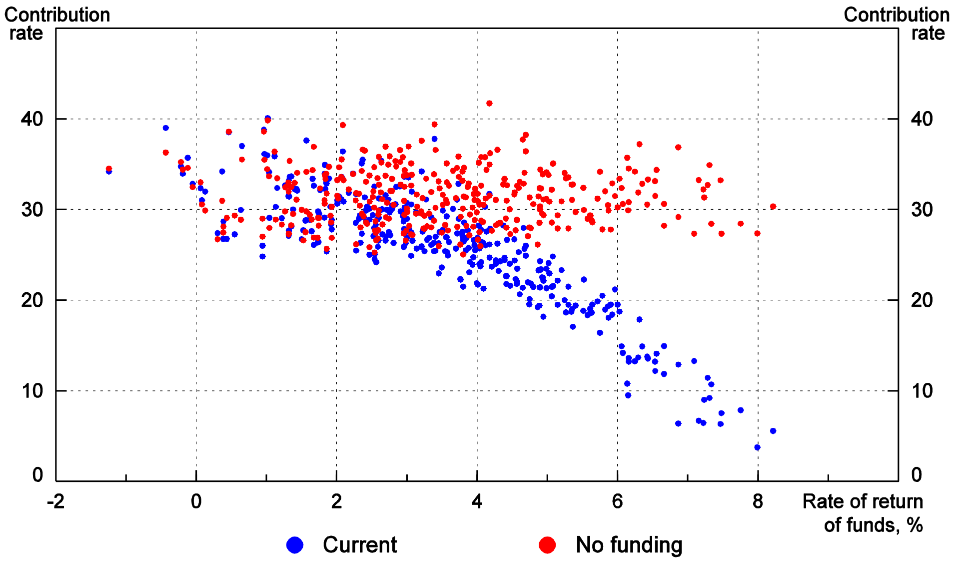


Figure 3. Rate of return of pension funds and pension contribution rate



3.5 Is contribution smoothing effective?

In principle, funding provides a tool to smooth contributions over time, but it also brings in varying asset yields that may make contribution rates more variable. If smoothing is effective, the contribution rate variation, measured along time paths, should be smaller with funding than without it. In our simulations, this is not the case, as Table 4 reveals when the current system (with unrestrained smoothing) is compared to the system with no funding. (Current system with solvency-restrained smoothing will be explained in the next subsection.)

Table 4. Predictive distributions of means and standard deviations of contribution rate and its first difference, %

	Contribution rate						Change from previous period's contribution rate					
	Current system with unrestrained smoothing		Current system with solvency-restrained smoothing		No funding		Current system with unrestrained smoothing		Current system with solvency-restrained smoothing		No funding	
	E	σ	E	σ	E	σ	E	σ	E	σ	E	σ
d_1	17.80	1.24	18.03	1.52	27.75	0.84	-0.62	1.01	-0.62	1.27	-0.02	0.70
Q_1	23.21	1.88	23.22	2.01	29.23	1.29	-0.10	1.26	-0.12	1.50	0.17	0.76
Md	26.32	2.89	26.32	2.98	31.31	2.00	0.18	1.70	0.18	1.88	0.46	0.84
Q_3	29.07	4.50	29.21	4.58	33.53	3.19	0.43	2.46	0.43	2.55	0.74	0.95
d_9	31.36	6.60	31.48	6.62	35.52	4.59	0.74	3.45	0.77	3.45	1.05	1.10

How to read Table 5: There are 349 simulated paths. Thus, for each pension system alternative, there are 349 mean values (E) of the contribution rate for the period 2020 – 2099. Their distributions are described by deciles d1 and d9, quartiles Q1 and Q3, and the median Md. There are also 349 standard deviations (σ), each describing variation within one path during the period 2020 – 2099. Their distributions are described in a similar fashion. Distributions describing first differences are analogous. The distributions of E and σ are separate, not joint.

In the simulations, funding clearly yields lower contributions, but they typically vary much more in time. This result came as a surprise during the project. One can list reasons for the result not to hold in real life, e.g. the following: the risk-taking of pension providers may be smaller than assumed here, or we have not managed to model the behavior of the pension system closely enough. We have assumed that the risks were uncorrelated, and thus they do not on average cancel each other out. The result may of course also be true. Demographic developments move slowly, and even though they can result in widely different contribution rates in the long run, the paths appear to be rather smooth. Asset yields, especially share returns, may vary rapidly but also produce long-lasting high- or low-yield paths that are impossible to foresee when the appropriateness of the contribution rate is considered.

Note that we have excluded all business cycle aspects. Funding is probably very helpful there, although there are also difficulties in separating permanent and transient effects. Completely unfunded system would certainly experience more varying contributions than those presented here. A buffer fund or a possibility to be indebted temporarily would be in order.

Smoothing and solvency requirements

The size of funds vary enormously in the simulations, following the variations in asset yields together with the assumption of contribution smoothing over a long horizon. This would pose no technical problem if all funds would be just buffers. Public sector funds are, but the private sector pension providers are bound by solvency rules. The reason is that the private sector earnings-related pension system is decentralized: it is managed by several pension insurance companies, company pension funds and industry-wide pension funds. These pension providers, however, bear joint responsibility in the event of bankruptcy. Thus solvency rules are required to prevent excessive risk-taking by individual providers.

Large funds reflect good solvency, and the system could perhaps live with that, even though there are upper limits which necessitate the providers to pay a part of contributions back to client employers and employees. Small funds reflect problematic solvency, which historically have been dealt with ad hoc changes in solvency rules, so that the providers would not need to improve their risk positions by quickly selling equities, with the expectation that equity values will jump back up in the future. In our simulations, however, solvency problems occur in such a scale that it is hard to imagine that ad hoc solutions would suffice.

It is not entirely clear that deviations from smoothing, due to solvency problems, lead to higher variation in contribution rates, since bigger early reactions reduce the size of required later reactions. Still, one would expect ex ante that variability increases. We made an experiment with some new simulations, labeled ‘solvency restrained’ in Tables 4 and 5. We can calculate a minimum solvency proxy in our model, assuming that there are no additional annual increases to the funded old-age pensions above the three-per-cent increase. In addition, we can assume that the equity-linked buffer fund is at its -20 % limit. When solvency fell so that funds did not cover these minimum liabilities, which happened at least once in 160 of the 349 paths, we increased the contribution rate, rather modestly and depending on the size of the solvency problem. The maximum increase was 5 percentage points in one 5-year period. The procedure usually increased variability in contribution rates. This supports our conclusion that variability is higher with funding, with the current risk portfolio.

Table 5. Means and standard deviations of contribution rate in the subsample (160 paths)

	Unrestrained smoothing	Solvency-restrained smoothing	Unrestrained smoothing	Solvency-restrained smoothing
	E	E	σ	σ
d1	24,36	24,42	1,04	1,42
Q1	26,12	26,23	1,52	1,86
Md	27,91	28,16	2,12	2,40
Q3	30,51	30,67	3,61	3,96
d9	32,81	32,65	5,05	5,10

On how to read Table 5, see Table 4.

In the subsample of paths where solvency is problematic, the contribution rate is almost always higher with solvency-restrained smoothing, and path-wise variation is larger. How much this changes the picture for all simulations is shown earlier in Table 4 in section 3.4, which gives the same message and shows that variability increases especially in paths where it is low with unconstrained smoothing.

Tables A1 and A2 in the Appendix show that the likelihood of very low funds becomes smaller. Note that the size of the conditional increase in contributions was set ad hoc.

Additional funding is a somewhat inefficient solution to solvency-based problems although, if solvency is low and contribution rate is increased, it results in bigger funds. This is surely needed if future yields are bad, but then the extra funds do not help so much. If, on the other hand, future yields are good, the extra funds mean a lot but are not needed that much. Reducing risks by selling equities and buying bonds helps in meeting solvency requirements, but it might mean that selling takes place with very low equity prices. There is a trade-off between variability over time and the level. More risk-taking lowers the level of contributions but raises their variability.

Does contribution smoothing induce pension reforms?

In our simulations, benefit rules are kept constant and contribution rates adjust. This is a natural assumption in a defined-benefit system, but it may not be the best assumption when contribution smoothing is an important policy target. If the policy-makers are not aware that the target can only be achieved imperfectly, and expect too much of it, it is possible that forecast revisions that make the prevailing contribution rate level seem inadequate in the future also increase the willingness to reform the system – to change the benefit rules.

With the smoothing target, every assessment situation, in practice every projection revision, is a potential starting point for a pension reform. The pension agreement behind the 2017 reform did not specify what will be done, if the contribution rate does not seem to be at an appropriate level. Contributions may be changed, or discrete reforms concerning benefits may occur. Below we illustrate how the latter alternative might unfold in situations where the prevailing contribution rate seems too low.

We calculate some simple incidence measures for hypothetical pension reforms. We assume that there is a fixed threshold value for the smoothed contribution rate. If the threshold is exceeded when the smoothed rate is calculated, based on the latest forecasts, then a reform that cuts costs is implemented. We do not specify the reform, but just assume that it will permanently lower the contribution rate by a given amount. Table 6 summarizes the results for threshold values from 26 % to 30 % and for reform sizes from 1 to 3 percentage points. The first reforms are possible in 2020-24 and the last in 2035-39.

With a low threshold value, such as 26 %, the probability of no reforms in 2020s is 49 %. Thus the probability of a reform or two reforms in 2020s is 51 %. Correspondingly, the probability of at least one reform in the period 2020 – 2039 is about 65 %, if the threshold is 26 %. The reform probabilities are the smaller the higher is the contribution threshold, but even with the 28 % threshold, which from a current perspective does not seem low, the probability of a reform in 2020 – 2039 is 30 %.

The probability of multiple reforms in a given timespan declines with both the threshold value and the size of the reform. To give a reference point for considering whether a reform is big or small, an index reform, moving entirely to consumption prices in pension benefits, would results in a decrease of 1 to 2 percentage points in the contribution rate.

Table 6. Probability of the contribution rate exceeding a hypothetical reform threshold value in 2020-2029 and 2020-2039, %, for selected values of the threshold value and the reform size.

Period		2020 – 2029					2020 - 2039				
Threshold value for contribution rate		26 %	27 %	28 %	29 %	30 %	26 %	27 %	28 %	29 %	30 %
Size of reform	Number of reforms										
1 %-point	None	49,0	72,5	87,1	95,1	98,9	35,2	53,3	69,6	84,2	92,6
	1	31,2	18,6	11,5	4,6	1,1	22,3	20,6	18,9	9,7	5,2
	2	19,8	8,9	1,4	0,3	0,0	21,5	17,5	6,3	4,6	1,7
	3	-	-	-	-	-	13,2	4,6	4,9	1,4	0,6
	4	-	-	-	-	-	7,7	4,0	0,3	0,0	0,0
2 %-points	None	49,0	72,5	87,1	95,1	98,9	35,2	53,3	69,6	84,2	92,6
	1	41,0	23,5	12,3	4,6	1,1	36,1	32,1	23,2	12,6	6,0
	2	10,0	4,0	0,6	0,3	0,0	21,8	12,0	5,7	2,6	1,4
	3	-	-	-	-	-	5,4	2,0	1,4	0,6	0,0
	4	-	-	-	-	-	1,4	0,6	0,0	0,0	0,0
3 %-points	None	49,0	72,5	87,1	95,1	98,9	35,2	53,3	69,6	84,2	92,6
	1	46,7	26,4	12,6	4,9	1,1	49,6	39,3	26,9	14,0	6,6
	2	4,3	1,1	0,3	0,0	0,0	13,5	6,6	3,2	1,7	0,9
	3	-	-	-	-	-	1,7	0,9	0,3	0,0	0,0
	4	-	-	-	-	-	0,0	0,0	0,0	0,0	0,0

Projection revisions may of course sometimes lead to a conclusion that the contribution rate can be lowered, perhaps substantially if the rate of return on pension funds has been especially good. An alternative use of the funds, to e.g. make the pension index more generous, may gain political support and lead to a reform. Thus there are multiple possible reasons for future reforms and multiple possible paths and outcomes that may trigger changes in the rules, in spite of the fact that the system is probably in a better shape and in a more balanced position than ever before.

If it is not clear how the smoothing policy will operate in Finland, neither it is clear how it should operate. One possibility is to consider automatic adjustments. In Canada's Pension Plan (CPP) the Chief Actuary's office makes a triennial evaluation of the financial future of the system. The results include projections of the income, expenditures and assets of the CPP over the next 75 years. If the actuarial report projects that the legislated contribution rate is insufficient for long-run sustainability, and the federal and provincial ministers of finance cannot reach an agreement on the solution to restore sustainability, the *insufficient rates provisions* of the CPP would apply. The contribution rate would then be increased by half of the gap over three years and the inflation adjustments to benefits in pay would be temporarily frozen. At the end of three years a new review is performed. Thus the automatic rules step in only after the decision-makers have opted not to do some other sufficient decisions.

As noted by e.g. Diamond (2005), the distinction between defined benefit and defined contribution systems is in practice not sharp but more of a continuum where both contributions and benefits can be adjusted.

4 Funding and intergenerational fairness

From the point of intergenerational fairness, good pension rules should lead to burdens that are for all generations roughly the same in relation to benefits received. Increases in longevity should be taken into account when assessing this, since it affects both the contribution side and especially the benefits received side. On a larger perspective, both the tax side and the public services and transfers received side are affected. In the Finnish case, Lassila and Valkonen (2018) concluded that with a proper link between retirement ages and longevity, working lives may develop so that the sustainability gap in the whole public sector becomes roughly independent from developments in longevity. Thus intergenerational fairness can be interpreted to require that the rules should adjust contributions quickly to a level that suffices in the long run. This appears to be difficult to do with the available forecasts.

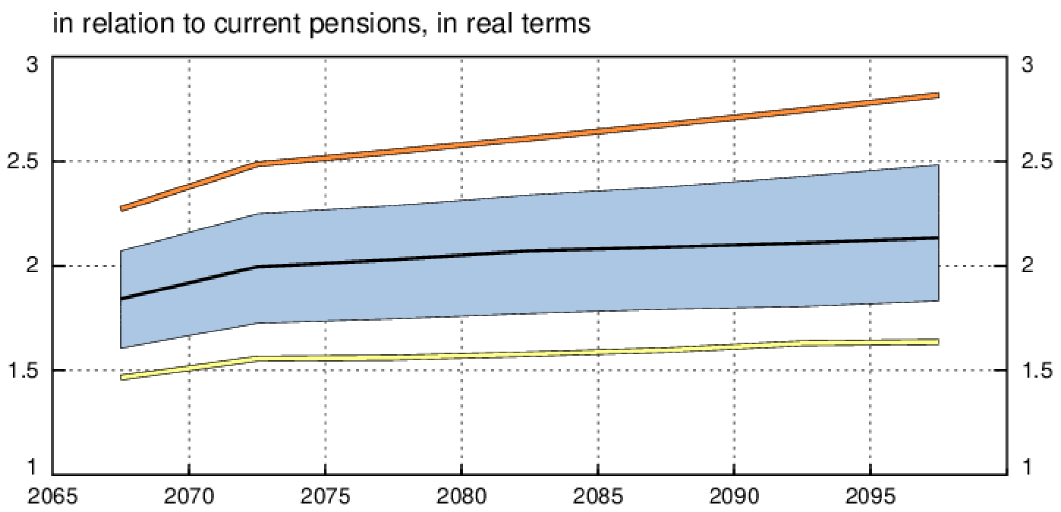
Pension funding is important for intergenerational distribution. As noted earlier, when comparing the current system with an imaginary unfunded system, it is clear from the outset that the comparison presents the current system in a favourable light. As our aim is not to praise the current system unduly, the reader should every now and then turn the setup upside down in her mind and consider what would be the situation if funding had been twice as large in the past. When a partially or fully pay-as-you-go system is started, first generations receive benefits even if they have contributed nothing or very little to the system, so by design their rates of return are high. But it is the result of later decisions that it has taken 55 years to get to a situation where the contribution rate is roughly on a sustainable level. This could have been done quicker.

We study the intergenerational issues by illustrating how the pension system treats the five-year cohort born in 2000 and 2004. They enter our economic model at the age of 20, in period 2020-2024, and exit at the latest in 2099. The results concern the middle-educated of model’s three educational groups, but the outcomes are similar for the other groups also.

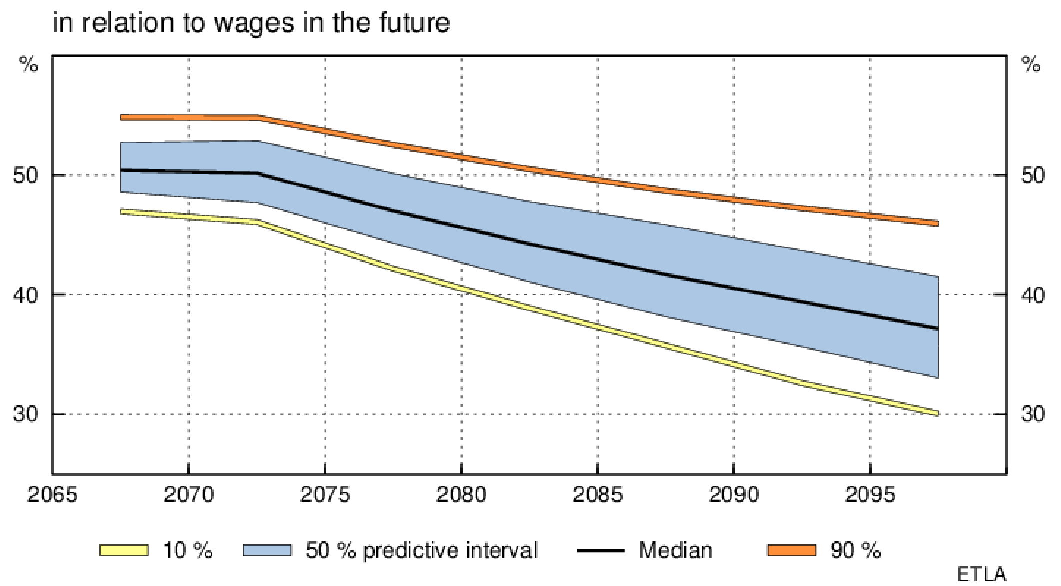
4.1 Pensions of the 2000 – 2004 cohort

Earnings-related pensions that the cohort born in 2000 – 2004 will get, according to our simulations, are illustrated in Figure 4. It is assumed that the main share of pensions is accrued from the private sector, and a smaller share from the public one. This is rather irrelevant for the outcomes, since the benefit rules are practically identical. In the top part of Figure 4, pensions are compared to earnings-related pensions currently starting. Number one is used to mark the level of the earnings-related pension of a person aged 65-69 in period 2015 – 2019.

Figure 4. Pensions and replacement rates of the 2000-2004 cohort



Earnings-related pensions of those in the cohort 65-69 during the period 2015-2019 have been marked with the number 1.



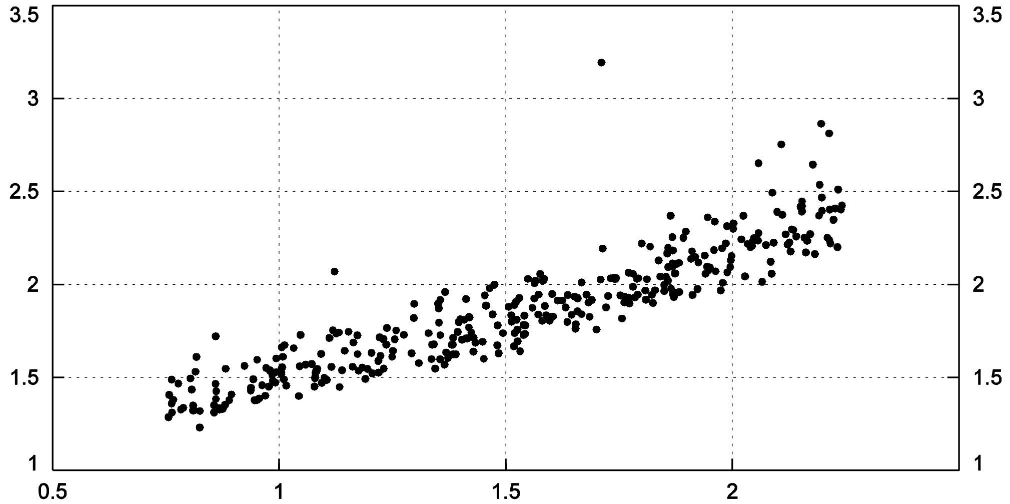
Figures for future pensions describe the real value of pensions. Earnings-related pensions for the 2000 – 2004 cohort will on average be almost twice the size of current pensions. They could well be just 50 % higher but as well they could be 130 % higher, depending on wage developments. In the calculation, earnings affecting pensions depend greatly on productivity in the private sector, which is assumed to grow by over at rates between 0,75 per cent and 2,25 per cent per year. The pensions of future cohorts will continue to rise during retirement, in relation to the current level. This is due to the pension index, which takes partly into account the increase in the income level.

Figure 4 follows the cohort up to ages 95 - 99. In the bottom part of Figure 4, a comparison is made between pensions and the average wage paid to the corresponding group of employees at the same time. Figure 4 tells us that earnings-related pensions during the first few years of old-age retirement are around half the wage. As retirement period continues, the pensions decrease in relation to wages. This is due to the pension index, which follows consumer prices with an 80 % weight and wages with a 20 % weight. Pensions do grow in real value, but more slowly than real wages. The longer life cycles grow in the future, the more often individuals will face a situation where the statutory pension is low in relation to the wage level.

Part of the 2000 – 2004 cohort will work and accrue pension rights after age 65, and when they retire in the model when they are 70, they get higher pensions than those who have retired earlier. This explains the kinks in benefit levels and replacement rates in Figure 4.

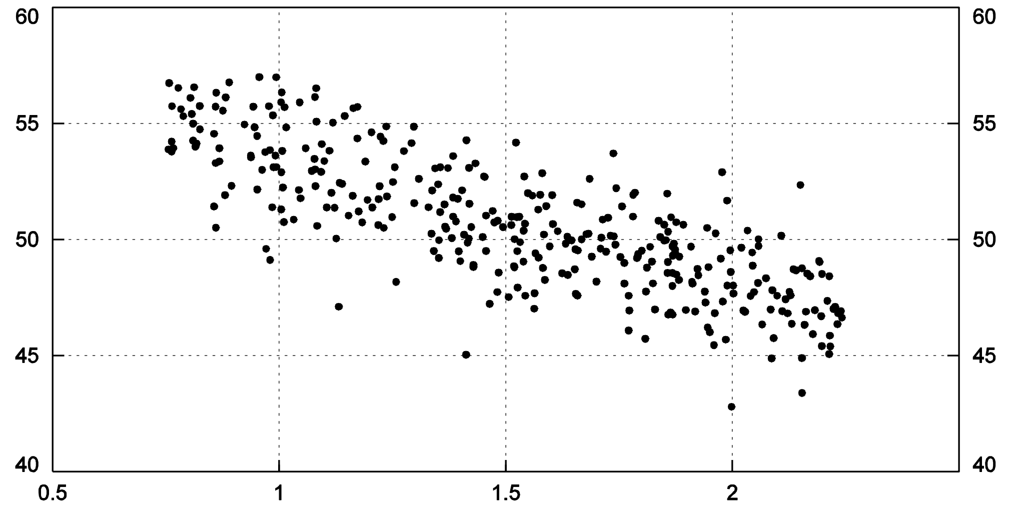
Figure 5. Productivity growth, pensions and replacement rates, the 2000-2004 cohort in ages 65 - 69

in relation to current pensions, in real terms



Earnings-related pensions of those in the cohort 65-69 during the period 2015-2019 have been marked with the number 1.

in relation to wages in the future



Productivity growth increases wages and thus pension benefit levels, but decreases replacement rates, namely pensions relative to those wages that prevail when benefits are received. The level effect comes from the fact that pension rights accrue from wages, and the higher are the wages on average during a cohort's working life, compared to the wages of a previous cohort, the higher will the latter cohort's pensions be in relation to the previous cohort's pensions. Replacement rates at the start of pension withdrawal reflect the fact that pension rights are indexed to wages and prices with

80 % and 20 % weights respectively during the working life, so the faster real wages grow the lower will the pension benefit be relative to the wage level.

Figure 5 shows these effects in the simulations. Each of the 349 dots represents one simulated path and describes the pension benefits (upper graph) and replacement rates (lower graph) of the 2000 – 2004 cohort in period 2065 – 69 when they are 65 – 69 years old. The horizontal axis shows the trend growth rate in productivity. Vertical variation is rather large, showing that besides productivity also other factors influence wage developments. Demographics and rates of return of pension funds that affect pension contribution rates are among such factors. Wages are also affected by how many workers are needed to supply the health and long-term care services, and the size of this need depends heavily on demographics, especially on the number of very old people. The more workers are employed in these services the less remains for firms to hire, and this drives wages up.

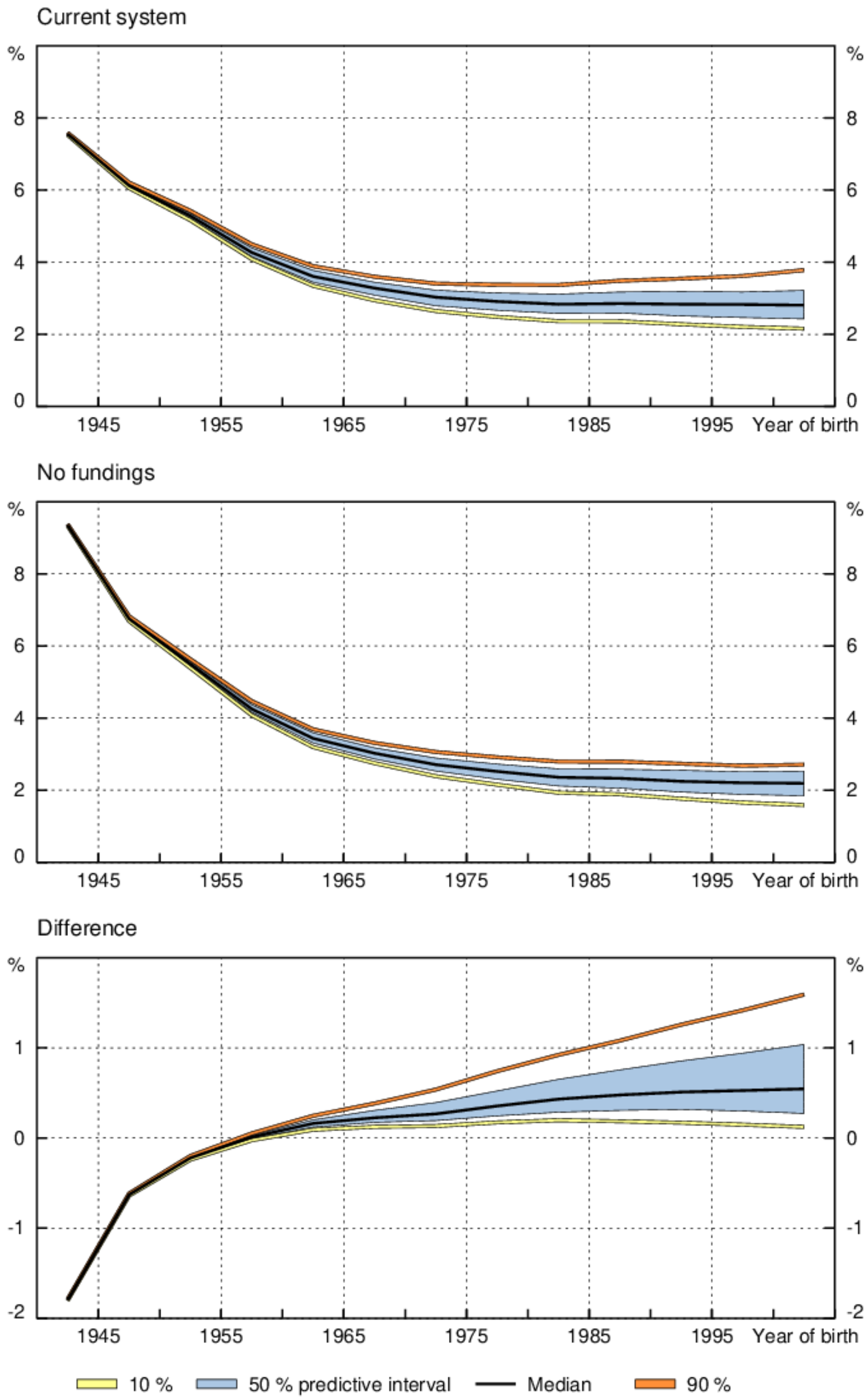
4.2 Internal rate of return

The generational features of the pension system are evaluated by examining how the rate of return gained from the pension contributions of the earnings-related pension system varies due to risks. Figure 6 (and Tables A5, A6 andA7 in Appendix 3) contains estimates of the annual rate of return from earnings-related pension contributions to different generations. The contributions include those of both employer and wage earners. Benefits include old-age pensions, disability pensions and all other benefits paid from the earnings-related pension system. Contributions and benefits have been assumed to develop according to current rules in the baseline scenario, and according to alternative no-funding system in the option. The calculation takes also into account that benefits are continually paid out over an ever-extending life cycle. The rate of return is real, the effect of inflation has been removed. Taxation has not been taken into account.

The cohorts born in the early 1940s are the first to have paid earnings-related pension contribution virtually throughout their entire working lives. They will receive a good yield on their contributions, since contributions paid over their working lives have been clearly lower than they currently are. The same applies to the large cohorts born towards the end of the 1940s. They have also not had to finance the full pensions of previous generations. Real rates of return decrease over time: the yield of those born in the 1950s is slightly larger than for those born in the 1960s, which, again, is slightly larger than for those born in the 1970s. The median profile is close to that obtained by

Risku (2015) who looked at the cohorts born between 1940 and 2000 and used a combination of historical statistical data and the long-term projections of the Finnish Centre for Pensions.

Figure 6. Generational rates of return for the 2000-2004 cohort



Compared to a non-funded alternative, funding increases the rate of return for generations born in the 1960s and after. Still, as funding is only partial, the earlier generations get a higher rate. Specifically, the pension system will probably not be as generous towards the 2000-2004 cohort as it has been for cohorts born in the 1940s, 1950s and early 1960s, but compared to the later cohorts the situation is open and will depend especially on future economic growth and asset yields.

High internal rate of return from a pension system is obviously a good thing, but one should remember that such a rate usually reflects the yields that are available also from other assets, and comparable results might have been obtained also from alternative retirement income sources.

4.3 How different risks affect the generational rates of return

Figures 7, 8 and 9 illustrate the effects of different risks on the internal rate of return. Fertility, mortality and migration risks are again condensed into the old-age ratio. Although the average age ratio in 2020 – 2064 affects the contribution rate, as was shown in Section 3.3., and contribution rates certainly affect the internal rate, no clear pattern is visible in Figure 7.

Figure 7. Population's old-age ratio and internal rate of return of the 2000-2004 cohort

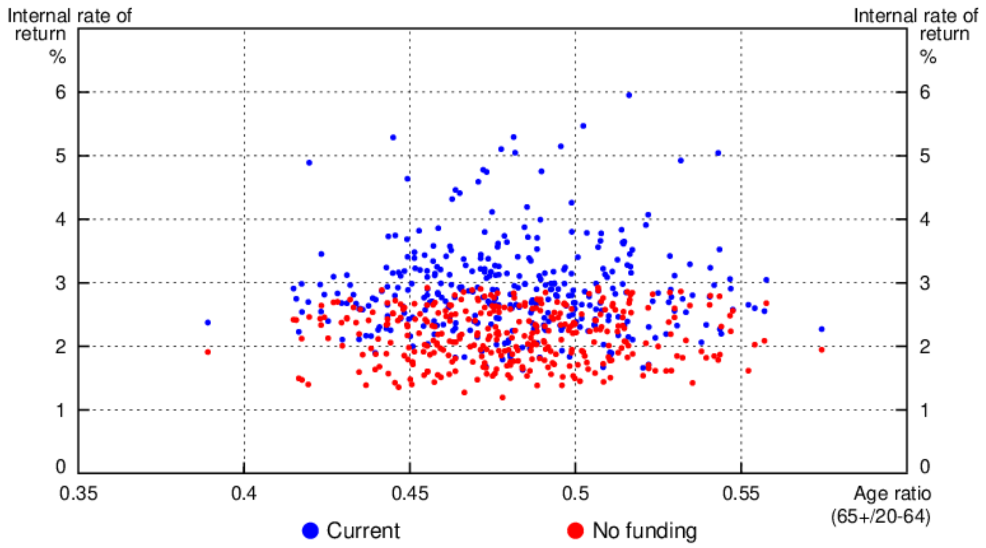


Figure 8. Productivity growth and internal rate of return of the 2000-2004 cohort

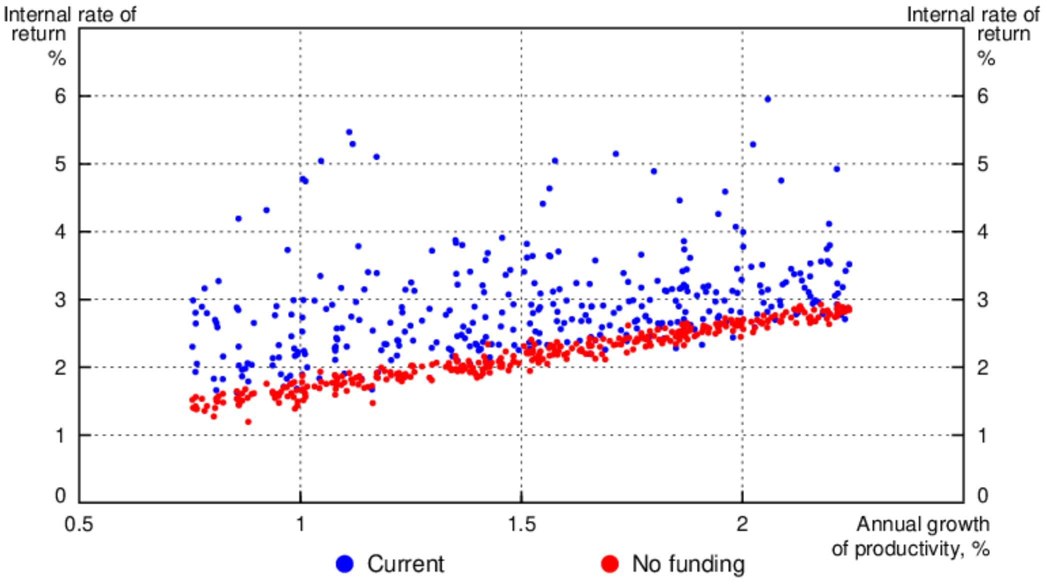
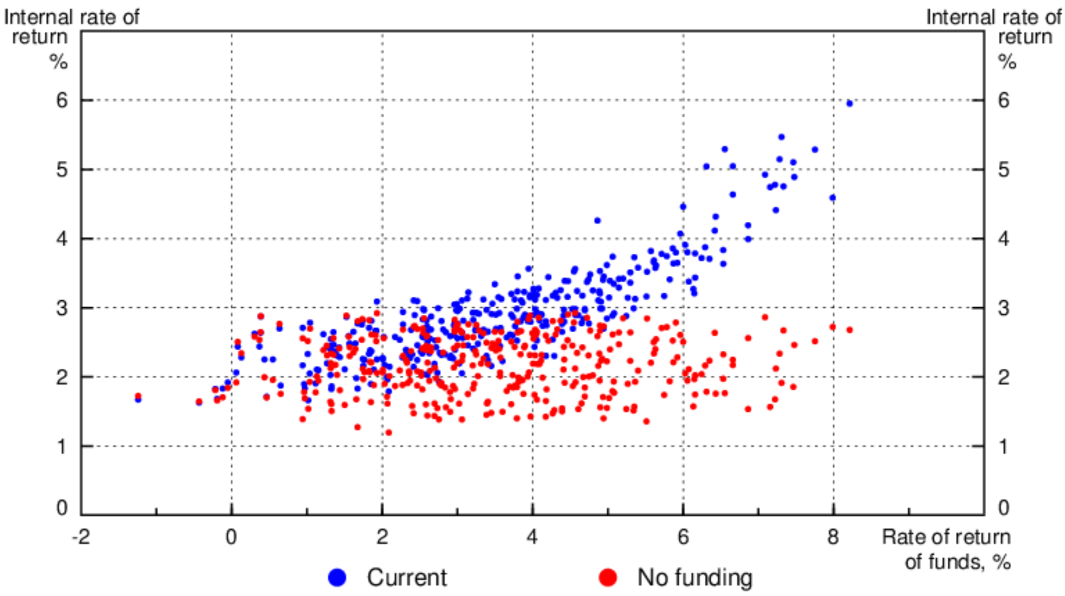


Figure 8 shows that there is a clear systematic effect from productivity growth to the internal rate of return, irrespective of whether there is funding or not. Funding itself is important for the rate of return that the 2000-2004 cohort receives for its contributions, as Figure 9 shows: the higher the yield from funds the higher the internal rate.

Figure 9. Rate of return of pension funds and internal rate of return of the 2000-2004 cohort

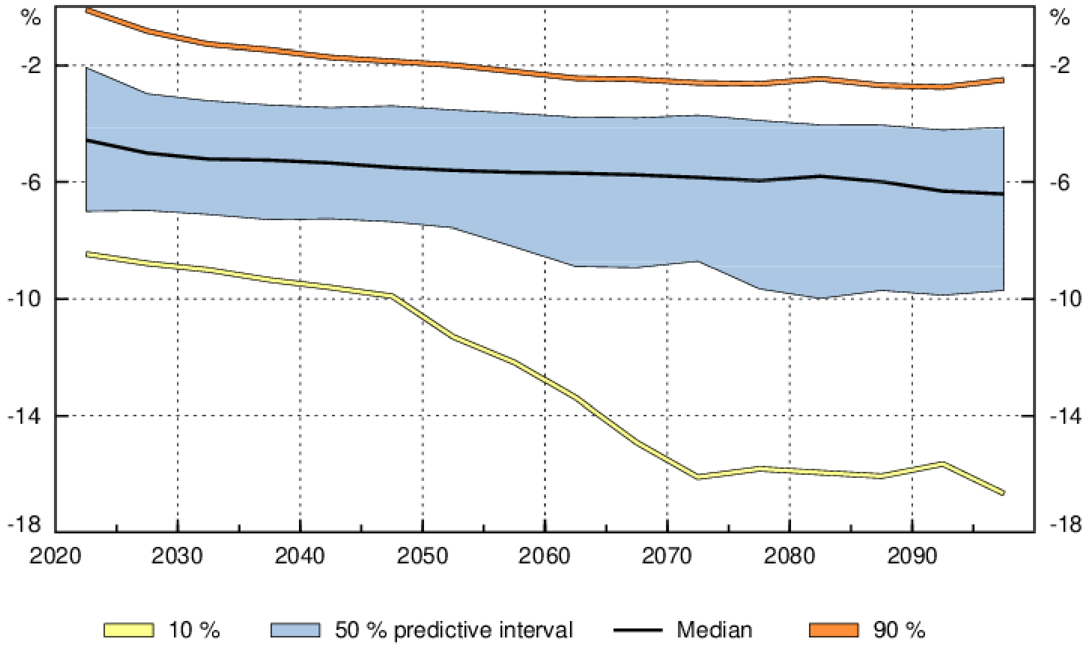


Four outliers have been left out of the above Figures. The contribution rate went below or near zero, and the internal rate of return becomes infinite when the career-long contribution rate goes to zero.

4.4 Consumption levels

To translate the differences in pension contributions and benefits into consumption possibilities, we compare private consumption under the two pension systems. Figure 10 shows the distribution of how much private consumption would be lower, in %, under no funding than under current funding, in period 2020-2099. The median difference grows in time from about 4.5 % to 6.5 %, and the uncertainty grows very large.

Figure 10. How much smaller would private consumption be under unfunded pension system



The young cohort benefits from lower contributions in three ways. Firstly, they benefit directly from their higher net wage income, due both to lower employee contributions which raise net wages and lower employer contributions which leave room for higher gross wages. Secondly, they benefit directly from their higher pension benefits, which result from higher career earnings. Thirdly, they benefit indirectly from the better fiscal stance of the public sector. In our simulations the revenue surpluses of the state and municipalities are returned to the households, explaining how the 3 – 5 percentage point median difference in the contribution rate leads to 4,5 – 6,5 percent consumption differential.

4.5 Revisions in consumption plans

Forecast revisions cause unexpected changes in the model economy: not only contribution rates but prices, wages and various taxes differ from what was expected with the previous forecast. Firms reoptimize their production, labour demand and investment decisions, and households revise their labour supply and consumption plans. Table 7 summarizes how the resulting consumption deviates on average from what was planned earlier and how variable the deviations are for the cohort 2000-2004.

Table 7. Consumption plan revisions of the 2000-2004 cohort

	Current system		No funding	
	std	mean	std	mean
d1	1,29	-0,57	0,74	-0,33
Q1	1,54	-0,34	0,90	-0,19
Md	1,85	-0,10	1,05	-0,06
Q3	2,32	0,24	1,24	0,07
d9	3,00	0,62	1,41	0,21

Consumption plan revisions are slightly negative on average, one tenth of a percent in the current system and about half of that if there were no funding. This shows that the forecast revisions have been slightly for the worse on average. Variation is higher throughout in the current system than it would be without funding.

We have assumed that households can freely borrow when they want, to smooth their consumption in time, and pay back from future income. The above results could change if the households would be liquidity constrained during their life cycle. It is likely that liquidity constraints are binding more often and more severely without funding. This means that under no funding young adults would have lower consumption possibilities than without liquidity constraints, and probably also bigger revisions in consumption plans.

5 Conclusions

We have evaluated fiscal sustainability of the Finnish private sector earnings-related pension system with stochastic projections and simulated its risk-sharing properties. The key inputs in our general equilibrium overlapping-generations model are regular demographic forecast revisions that are embedded in stochastic population projections, based on a method created by Alho (2014). The other included uncertainties consider asset yields, using earlier research by Ronkainen (2012), and productivity trends, specified in a study by Christensen et al (2016).

The pension system shares the demographic risks, asset yield risks and productivity growth risks widely to both the workers, who pay contributions and accrue pension rights, and to the pension levels and replacement rates of the retirees. Pension funding in Finland is collective, there is no individual risk taking in assets. By pension system design, funding affects directly only contributions. Benefits are not fully insulated from stock market developments, however, because contributions influence wage developments – lower contributions leave room for higher wages, and pensions depend on earnings.

Demographic risks also affect contributions, because the numbers of those who pay contributions and those who receive benefits change, and the unfunded part of the system reacts. Benefits are also affected, again through labour markets, as the supply of labour may vary and contribution rates also affect wages.

Productivity growth affects wages, which affects the contribution rate: The faster real wages grow the lower will the contribution rate be. This is because, due to benefit indexing, the pension expenditure grows less than the contribution base. The productivity–wage link also affects the benefits. The faster real wages grow, the higher will the absolute pensions be, because they are based on earnings. On the other hand, the faster real wages grow, the lower will the pension benefit be relative to the then prevailing wage level, because the accruing pension rights are not fully indexed to wages during the working years.

The fiscal outlook of the Finnish system is summarized by the developments of the contribution rate under the assumption that current benefit rules prevail. Looking at the median development of pension contributions, there is not much movement until mid-2040s, when a gradual and rather steady rise begins. The rise ends at mid-2070s. The rate ends up 3 percentage points above the current level. Thus the median view – a kind of point forecast – is tilted to the problematic side, but this tilt is not large compared to the uncertainty.

We have assumed contribution smoothing, in line with the expressed targets in the latest pension reform that took effect in 2017. The aim of smooth developments in contributions is intuitively sensible both from a generational viewpoint and from a fiscal planning perspective, and e.g. Canada has applied it by setting explicit rules. There are two main difficulties with the smoothing policy, one general and the other specific to the Finnish system. Smoothing is forward-looking and thus requires projections and forecasts. Periodic revisions in demographic projections and forecast errors in asset yields may be large, and even gradual adjustment may make the contribution paths more variable than expected. The country-specific difficulty is due to the decentralized organization of the Finnish private sector pension system, where mutual responsibility requires solvency rules which are not common in a first-pillar system. In smoothing, funds are used as buffers and it is likely that solvency rules will occasionally contradict the smoothing target. In our simulations smoothing produced quite variable results even when funds could be used freely as buffers. Furthermore, reacting to the solvency problems by increasing contributions more than mere smoothing would require, increased the variability of contributions.

Benefit rules are kept constant in all our simulations. This is a natural assumption in a defined-benefit system, but it may not be the best assumption when contribution smoothing is a policy target. It is possible that forecast revisions that make the prevailing contribution rate level seem inadequate in the future also increase the willingness to change the benefit rules. With the smoothing target, every new assessment of the situation, in practice every projection revision, is a potential starting point for a pension reform.

The simulations point towards separate outcome regions where different pension policy discussions may prevail. There is a favourable outcome interval, where abundant asset yields promote discussions on how to divide the proceedings, especially whether pensioners should get more perhaps in the form of better indexing. Other claimants with specific investment proposals may turn up from e.g. the parliament and political parties. There is of course a difficult region, where pension reform discussions look for old and new ways to reduce the financing burden. Somewhere between the favourable and the difficult regions there is also a possible uneventful future where the system just runs along without major disruptions. Its likelihood seems small. Mixed with these three outcome regions, especially with the difficult and middle intervals, is a future riddled by solvency problems, raising voices against the decentralized system where multiple providers just add to costs and hinder the use of funds purely as buffers.

The role of pension funding, compared to a hypothetical purely pay-as-you-go system with identical benefit rules, is that funding results in lower contribution levels but usually more varying contributions in time than would be the case without funding. The young cohorts benefit from lower contributions in three ways. They benefit directly from their higher wage income, and they benefit from higher pensions that result from higher wages. They also benefit indirectly from the better fiscal stance of the public sector. In our simulations the revenue surpluses of the state and municipalities are returned to the households, so that, with funding, private consumption is higher than one would expect by looking at the differences in contribution rates.

Looking at simulated generational measures, the pension system will probably not be as generous to the cohort born in 2000-2004 as it has been for cohorts born in the 1940s, 1950s and early 1960s, but compared to the later cohorts the future is open. The young generations may well blame the old for not funding more, but they should be happy because of the funding that has been done.

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Appendix 1. On modelling demographics and asset yields

Demographic uncertainty

To illustrate how long-term demographic forecasts can change substantially in a relatively short time, Figure A1 shows six forecasts, made between 2002 and 2015, for the future population in Finland. The total population was forecasted in 2002 to be about 5 million in 2050. The view has changed gradually, and the 2009 forecast is about 6.1 million in 2050. That means a 22 percent difference between forecasts made seven years apart. The forecast made 2012 coincides almost perfectly with the 2009 forecast in Figure A1. The latest forecast, made in 2015, predicts the population to be slightly below 6 million in 2060.

There has been large and systematic changes also in the size of the working-age population and the number of aged people. These changes can be traced back to changing views on fertility, migration and longevity. They have affected empirical sustainability evaluations in various ways. There are more people working (good for contribution revenues), more retirees (costly) and people live longer (good for individual welfare but costly for the pension system).

Figure A1. Population in Finland, as forecast by Statistics Finland

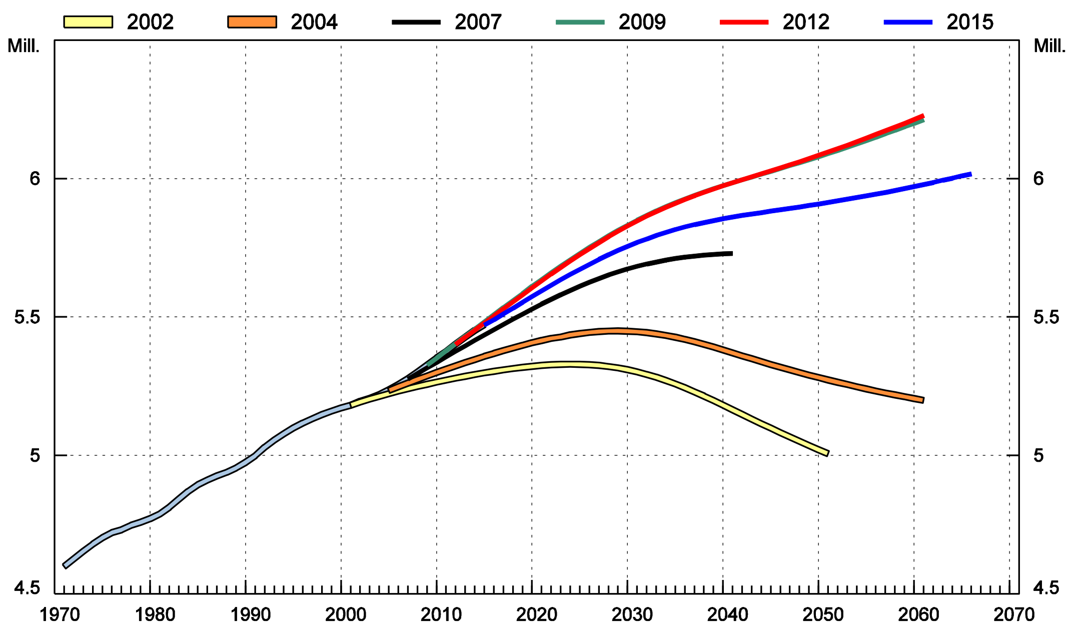
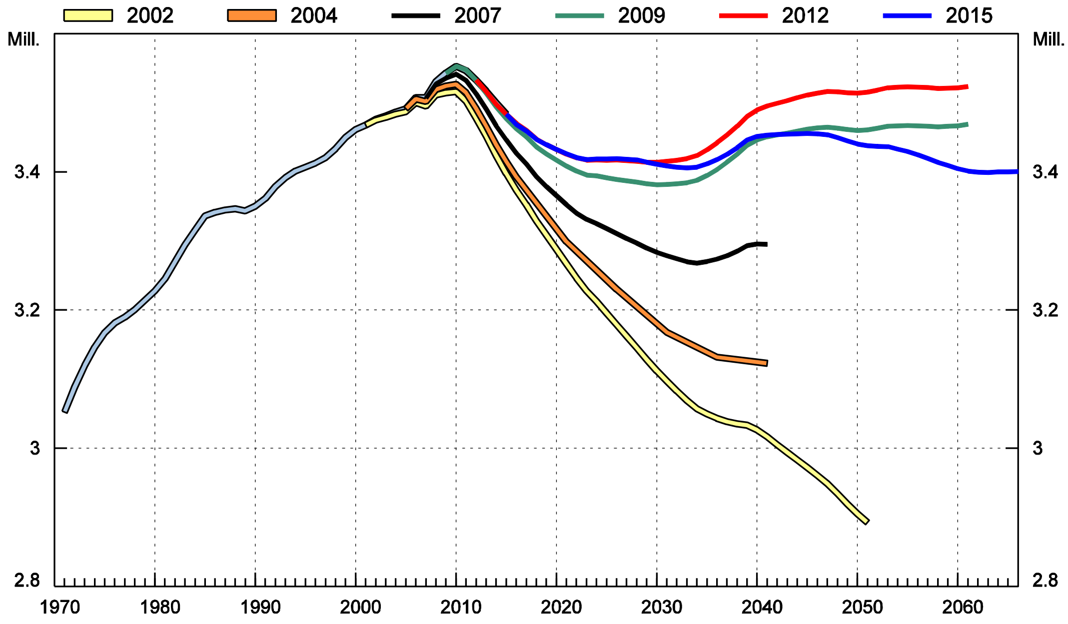


Figure A2. Population in ages 15 - 64 in Finland, as forecast by Statistics Finland



Although the changes in forecasts have been significant, they all show the basic feature of an ageing society: the share of the elderly is growing. The issue is quantitative – the population is ageing but we don't know by how much.

We deal with demographic uncertainty by using stochastic population projections, which are used as inputs in the economic model. The uncertainty estimates related to fertility are based on a statistical analysis of the Finnish total fertility rate since 1776. The relative error of a naive forecast that assumes fertility to remain constant in the future was determined empirically. A naive forecast approximates closely the medium forecasts made in Finland. For mortality, the analysis of uncertainty was based on the relative error of the naive forecast with data for 5-year age-groups from 1900 onwards. The naive forecast assumed that the recent past decline in mortality continues indefinitely.

Alho (2002, p.9) explains how migration is dealt with in stochastic projections: "The forecasting of migration differs from that of fertility or mortality in at least three ways. First, migration can be influenced by government policies to a higher extent than fertility or mortality. Second, although out-migration can be reasonably analyzed via out-migration rates, it is typically difficult to define a meaningful risk population for in-migration. Third, data on migration are poor even in a country like Finland that has a well-functioning population register. Because of these problems, migration forecasts are typically judgmental, and given in terms of the net number of migrants one expects. On the other hand, a probabilistic approach is well suited to the handling of the uncertainty of judgment concerning future migration. The primary difficulty is in finding a robust way to elicit judgments."

After the processes for fertility, mortality and migration have been modeled, sample paths for future population by age-groups are simulated. As examples, some results of a stochastic projection for future population in Finland are presented in Figure 4 - 8. Half of the simulation outcomes in each period are in the shaded area around the median. 10 % of the outcomes are above the 90 % line and 10 % are below the 10 % line. The projections, made by Juha Alho, are presented around Statistics Finland's 2012 projection. For a probabilistic interpretation of stochastic population simulations, visit http://www.stat.fi/tup/euupe/sf_interpretation.html.

Figure A3. Predictive distribution of total population in Finland

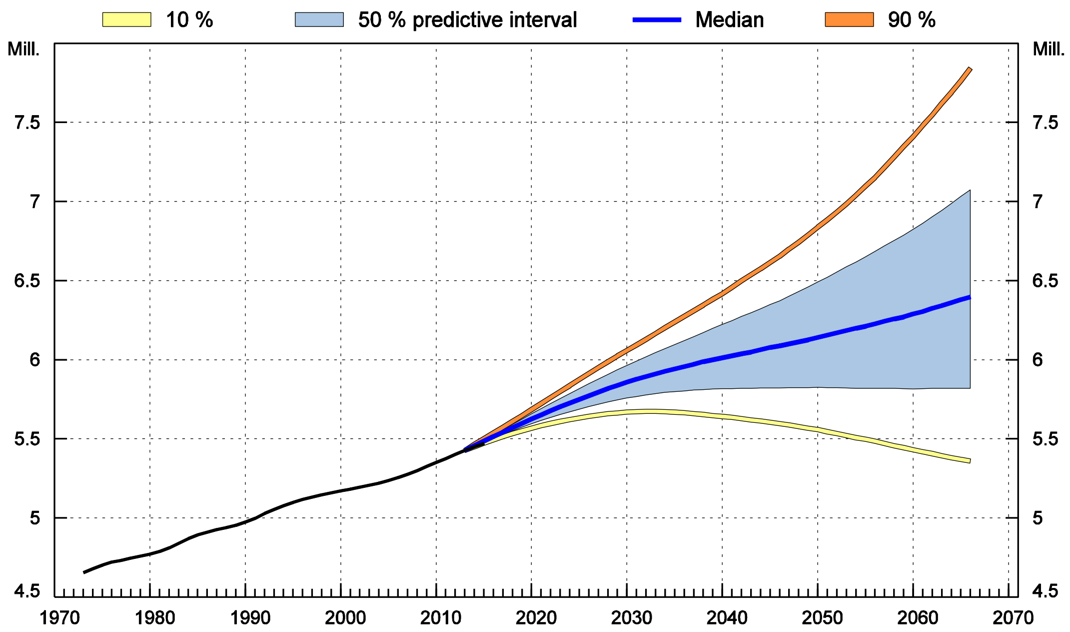


Figure A4. Predictive distribution of population aged 15 – 64 in Finland

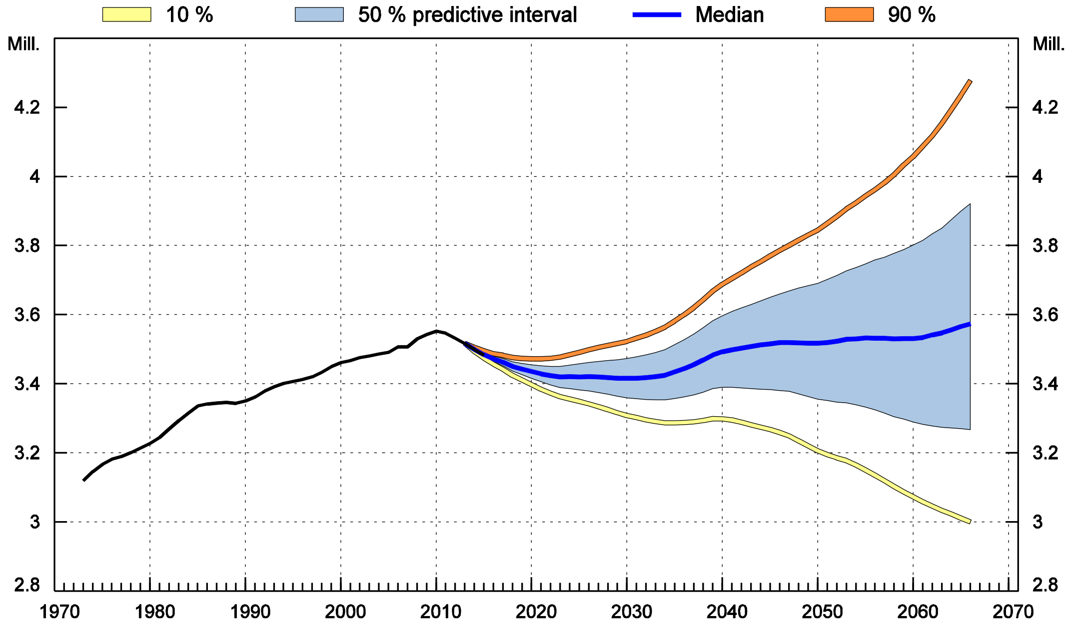


Figure A5. Predictive distribution of population in ages 65+ in Finland

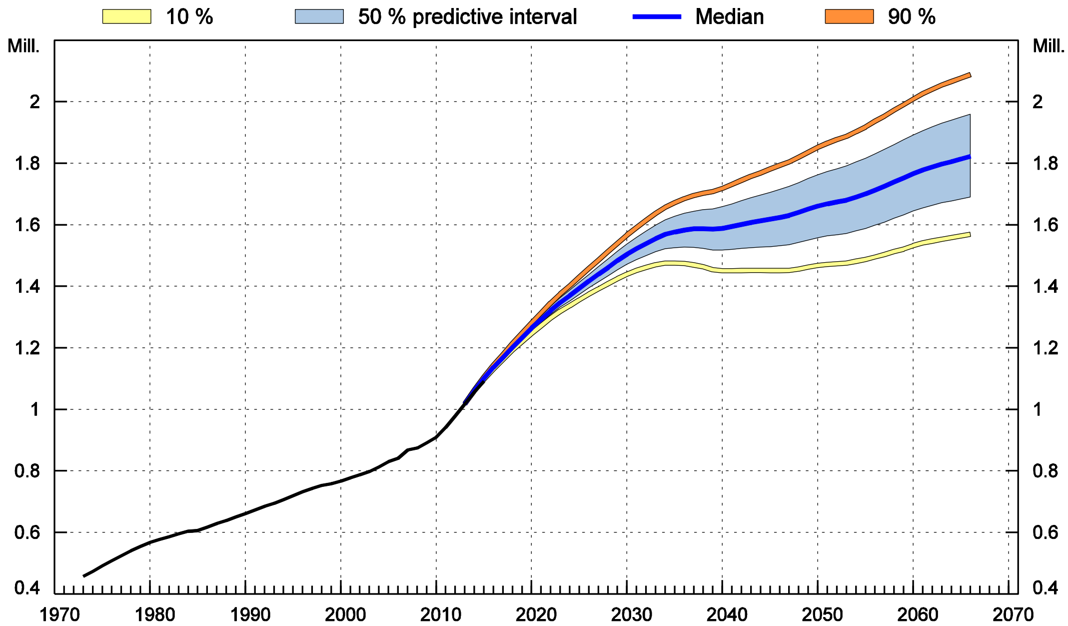
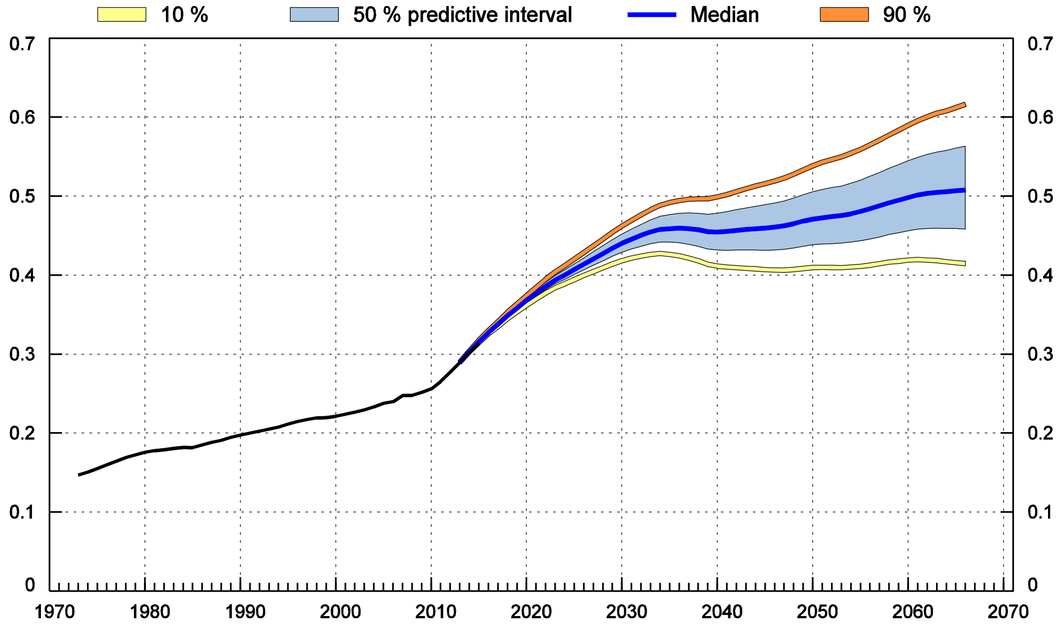


Figure A6. Predictive distribution of age ratio (65+ / 15 – 64)



Asset yield uncertainty

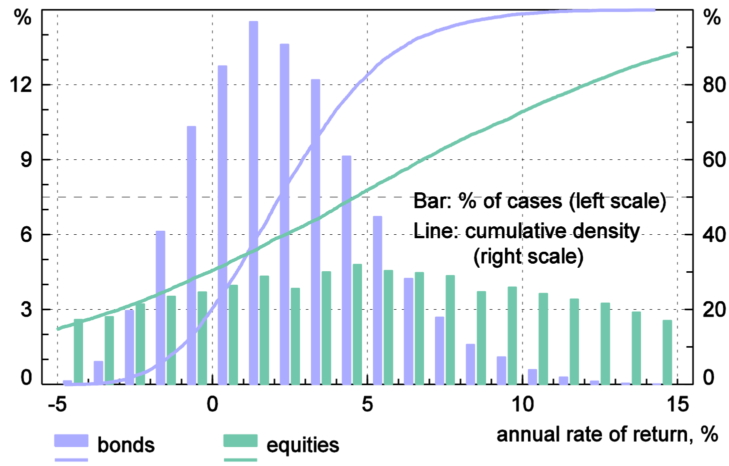
Whereas population dynamics are slow and it takes decades for the age structures to change significantly, asset prices and yields can vary significantly within a day. From our modeling point of view, however, the issues are similar. Decisions are based on expected returns, and when expectations turn out to be more or less faulty agents re-optimize, based on new expectations. We do not let the yield uncertainty affect the saving and investment decisions of the private sector. But the yield variation causes unexpected variation in prices, wages and taxes, and these variations cause the need for re-optimization.

Studies concerning asset yields variations are abundant. We utilize a study by Ronkainen (2012), who builds stochastic models for nominal equity and bond returns. For equities, the S&P 500 yearly total return, in log-differences, is modeled by an uncorrelated and Normally-distributed process to which exogenous Gamma-distributed negative shocks arrive at Geometrically distributed times. This regime-switching jump model takes into account the empirical observations of infrequent exceptionally large losses.

For bonds, Ronkainen (2012) models the 5-year US government bond yearly total return as an ARMA(1,1) process after suitably log-transforming the returns. This model is able to generate long term interest rate cycles and allows rapid year-to-year corrections in the returns.

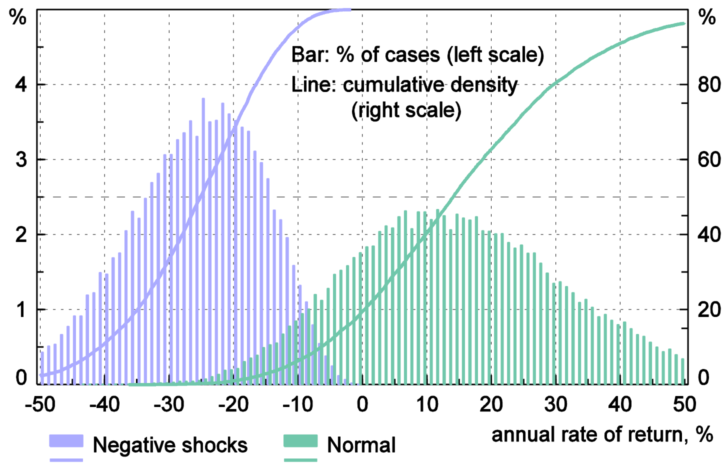
Simulating the model for equities that Ronkainen prefers (Model 5, see p. 31 in Ronkainen, 2012) and the model for bonds that he reports on p. 52, and aggregating over 5-year periods, yields the distributions of 5-year rates of return (in per year rates) depicted in Figure A7. The expected value of annual equity returns has been set to 6 % and of bond returns to 2.5 %.

Figure A7. Asset yield uncertainty (Ronkainen 2012, Model 5)



The negative shock model describes equity market crashes. Such events have often counterparts in the real economy, in the form of depressions and slumps. They are events that really test actual pension systems. How often would depressions occur in the model? The (truncated) distributions of the two parts of the jump model are shown in Figure A8. They are now yearly returns instead of 5-year returns, and based on 45000 simulated values of Model 5 (Ronkainen, p. 34). In the combined model the negative shocks appear with probability 0,071. In an average 5-year period the probability of no shocks is 0,691, of one shock 0,264, and of two or more shocks 0,045. If a shock of 25 % or more in absolute value would be interpreted as a depression, its probability is around 17 % - on average, once in six 5-year periods.

Figure A8. Equity returns jump model decomposed



Besides assuming no correlations between bond and equity yields, we assume that there is no mean-reversing in either series. When a shock occurs and households and firms re-optimize, they expect the average yields in the future.

Appendix 2. Running the model with revised forecasts

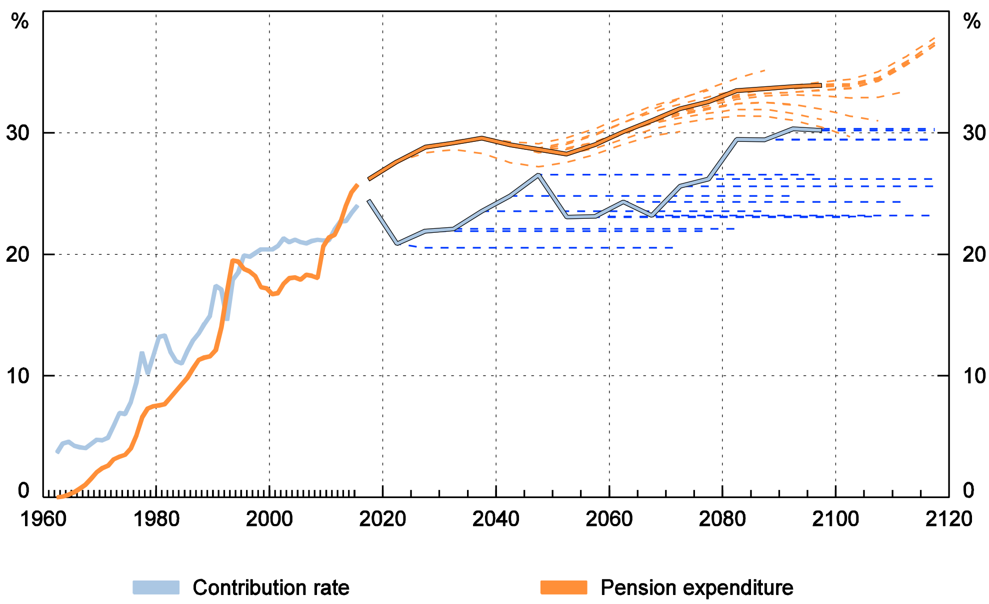
As described in Section 2, we add a demographic forecast to each time-point in each simulated population path. Thus the view concerning future demographics is periodically updated when we move along any simulated population path (for equity and bond yields, the forecast is always the expected value). Given the uncertainty of population forecasting, it might seem that trying to forecast what future population forecasts are like would be nearly hopeless. As argued in Alho (2014), however, such forecasts are, for both theoretical and practical reasons, more regular than actual developments. As a practical reason, the development of the recent past often has a heavy influence on projections of the remote future. This is usually true for all so-called vital rates, namely fertility, mortality and migration.

Stochastic population projections are produced by a computer program PEP (Program for Error Propagation). Another computer program FPATH extends the application of results from PEP to the FOG model, where agents are allowed to revise their lifetime economic plans as they realize that the population has not evolved according to the expected path. For this purpose FPATH calculates a numerical approximation to the conditional expectation of future population at future years for a (typically random) subset of paths. The details of computation are spelled out in Alho (2014). Briefly, the whole computation is based on stochastic simulation in which samples are taken from the predictive distribution of future population as disaggregated by age and sex. A set, 200 in this study of such samples play the role of target paths, for which the economic OLG calculations are made. A much larger set of supplementary paths is used in the calculation of updated forecasts. This is done by selecting of subset of supplementary paths after the first time period that are the closest to a given target path at that time. A weighted average of the future values of these supplementary paths forms the estimated conditional expectation (= updated forecast) at that time. The next period the weights are revised to reflect the distances of the chosen supplementary paths from the target path, at that time. The weighted averages are recalculated for the remaining future years of interest, etc. In statistical terms, this is equivalent to repeated nearest neighbour kernel regressions. We can think of the conditional expectation as being a forecast of what would be a forecast in a future year.

For this study, FPATH was further developed in mortality forecasts, to yield smoother predictions in e.g. earliest eligibility age for old-age pension and the longevity adjustment for pension benefits.

As an example, Figure A9 shows one simulated outcome for pension contributions and expenditure for 5-year periods between 2020 – 2099. The outcome is based on one demographic path, one trend growth in productivity and one realisation of asset yields. The dash lines depict the 50-year forecasts associated with this particular projection, the first from 2020-24 up to 2070-74. The forecasts are revised in period 2025-29, and again in 2030-34, and so on.

Figure A9: Pension expenditure and contributions, % of wages, in one simulated path



In our analysis, households and firms sequentially optimize their behaviour according to revised forecasts. With any simulated population path, the full solution of the economic model is obtained by a series of runs. In each run, the agents believe that they have perfect foresight of future demographic and economic developments, even though the forecast has previously turned out to be erroneous. The model is first solved starting from period 1, with the model agents having a perfect foresight type expectation that future demographics will follow the official population projection made by Statistics Finland. This first solution includes the value of the smoothed pension contribution rate. There are now two possibilities: either the minimum solvency requirement is met (or it is ignored like in the unrestrained smoothing), or it is not met. If the solvency requirement is fulfilled, period 1 values for all model variables have been obtained from this first solution, and the model economy moves on to period 2. But if the contribution rate is increased, by an amount specified by the ad hoc rule, the model is solved again, starting from period 1, with the model agents expecting that the new contribution rate will be effective in all future periods. Period 1 values for all model variables have now been obtained from this new model solution, and the model economy moves on to period 2.

In period 2 in any simulated population path the agents realize two things about demographics: first, the population size and age structure in period 2 is different from what was forecasted in period 1, and second, the forecast for the population from period 3 onward has been revised. They have also noticed unexpected changes in pension funds and public assets and debts, due to shocks in rates of return. The model is then solved again, starting from period 2, with the model agents having a perfect foresight type expectation that future demographics will follow the revised population projection and assets will yield expected values. If the solvency rule does not warrant a rise in the contribution rate, period 2 values for all model variables have been obtained and the model economy moves on to period 3. If the rule requires a raise, the rate is increased and the model is solved, starting again from period 2. Period 2 values for all model variables have now been obtained from this new model solution, and the model economy moves on to period 3. In period 3 the model agents again realize that they need to re-optimize, and so on.

We consider 16 periods – 80 years – after the initial period 1, so the results cover the five-year periods from beginning of 2020 to end of 2099.

Appendix 3. Selected simulation results

Table A1. Private sector pension funds with unrestrained smoothing, % of annual wage bill

End of period	d1	Q1	Md	Q3	d9
2020 – 24	181.8	204.9	229.4	261.8	293.8
2025 – 29	158.9	191.2	227.8	277.6	332.6
2030 – 34	144.3	177.5	225.9	285.7	355.0
2035 – 39	133.3	171.0	219.8	288.8	381.0
2040 – 44	132.5	168.2	220.4	300.0	398.9
2045 – 49	132.7	170.0	230.3	321.4	419.0
2050 – 54	131.4	174.7	232.4	322.9	471.2
2055 – 59	126.3	176.8	235.3	347.8	484.8
2060 – 64	128.6	174.3	232.7	365.5	532.8
2065 – 69	124.5	164.7	234.4	336.5	580.8
2070 – 74	119.1	160.8	234.1	341.8	590.0
2075 – 79	112.2	157.7	231.3	358.6	565.2
2080 – 84	107.0	148.8	235.8	372.7	570.9
2085 – 89	98.4	153.0	238.2	370.6	572.9
2090 – 94	100.8	155.5	228.1	369.1	583.2
2095 – 99	99.8	148.5	237.5	374.0	562.6

d1 and d9 are the first and ninth deciles, Q1 and Q3 the first and third quartiles, and Md the median.

Table A2. Private sector pension funds with solvency-restrained smoothing, % of annual wage bill

End of period	d1	Q1	Md	Q3	d9
2020 – 24	181.8	204.9	229.4	261.8	293.8
2025 – 29	158.9	191.2	227.8	277.6	332.6
2030 – 34	144.3	177.5	225.9	285.7	355.0
2035 – 39	135.8	171.0	219.8	288.8	381.0
2040 – 44	135.6	168.2	220.4	300.0	398.9
2045 – 49	135.9	171.2	230.3	321.4	419.0
2050 – 54	137.7	176.5	233.9	322.9	471.2
2055 – 59	135.5	177.2	236.2	347.8	484.8
2060 – 64	138.5	174.3	234.3	365.5	532.8
2065 – 69	138.3	170.0	235.0	336.5	580.8
2070 – 74	129.5	166.8	236.4	342.7	590.0
2075 – 79	127.3	163.0	235.1	358.6	565.2
2080 – 84	124.1	153.9	239.8	373.5	570.9
2085 – 89	122.5	160.6	239.9	373.1	572.9
2090 – 94	127.8	159.2	228.1	372.6	583.2
2095 – 99	129.2	156.4	237.6	374.0	567.8

Table A3. Pension contributions with solvency-restrained smoothing

period	d1	Q1	Md	Q3	d9
2020 – 24	23.14	24.36	25.48	26.46	27.57
2025 – 29	21.46	23.71	25.39	26.90	28.06
2030 – 34	20.22	23.34	25.80	27.51	29.01
2035 – 39	20.29	23.14	25.80	27.98	29.86
2040 – 44	19.40	23.15	25.84	28.39	30.03
2045 – 49	18.93	23.33	25.96	28.62	30.85
2050 – 54	17.62	23.07	26.28	29.27	31.44
2055 – 59	18.12	22.69	26.51	29.31	32.42
2060 – 64	16.95	22.28	26.64	30.04	32.85
2065 – 69	15.13	23.05	26.71	30.56	33.56
2070 – 74	14.78	23.02	27.12	30.69	34.65
2075 – 79	14.63	23.23	27.30	31.05	34.85
2080 – 84	14.34	22.63	27.38	31.53	35.37
2085 – 89	14.63	22.93	27.10	31.79	35.69
2090 – 94	14.68	22.67	27.28	31.48	35.83
2095 – 99	14.48	22.59	27.30	31.39	36.70

Table A4. Pension contributions under no funding (Appendix?)

period	d1	Q1	Md	Q3	d9
2020 – 24	28.34	28.51	28.81	29.12	29.31
2025 – 29	28.94	29.40	30.10	30.83	31.26
2030 – 34	29.01	29.69	30.72	31.83	32.53
2035 – 39	28.42	29.34	30.62	32.01	33.11
2040 – 44	27.29	28.34	29.86	31.57	32.72
2045 – 49	26.68	27.78	29.48	31.29	32.67
2050 – 54	26.79	27.85	29.78	31.80	33.25
2055 – 59	27.15	28.31	30.34	32.56	34.09
2060 – 64	27.52	28.93	31.23	33.62	35.36
2065 – 69	27.93	29.31	32.11	34.46	36.49
2070 – 74	27.95	29.58	32.51	35.08	37.50
2075 – 79	27.59	29.74	32.71	35.63	38.57
2080 – 84	27.30	29.90	32.93	36.27	40.28
2085 – 89	26.69	29.78	33.28	36.62	41.41
2090 – 94	26.26	29.31	33.50	37.13	42.07
2095 – 99	25.98	28.92	33.58	38.07	43.10

d1 and d9 are the first and ninth deciles, Q1 and Q3 the first and third quartiles, and Md the median.

Table A5. Generational rates of return, current system with unrestrained smoothing

Born in	d1	Q1	Md	Q3	d9
1940 – 44	7.53	7.54	7.55	7.57	7.59
1945 – 49	6.06	6.09	6.12	6.16	6.21
1950 – 54	5.16	5.21	5.28	5.36	5.42
1955 – 59	4.08	4.16	4.27	4.40	4.50
1960 – 64	3.34	3.44	3.60	3.77	3.89
1965 – 69	2.94	3.09	3.28	3.45	3.60
1970 – 74	2.65	2.79	3.03	3.22	3.41
1975 – 79	2.48	2.67	2.91	3.15	3.37
1980 – 84	2.37	2.58	2.83	3.12	3.37
1985 – 89	2.36	2.59	2.85	3.17	3.48
1990 – 94	2.28	2.51	2.83	3.19	3.54
1995 – 99	2.21	2.47	2.83	3.17	3.62
2000 – 04	2.16	2.43	2.81	3.22	3.78

Table A6. Generational rates of return, no funding

Birth period	d1	Q1	Md	Q3	d9
1940 – 44	9.33	9.34	9.35	9.36	9.37
1945 – 49	6.69	6.72	6.75	6.79	6.82
1950 – 54	5.39	5.44	5.50	5.57	5.63
1955 – 59	4.08	4.16	4.25	4.37	4.47
1960 – 64	3.20	3.31	3.44	3.59	3.69
1965 – 69	2.75	2.87	3.03	3.18	3.31
1970 – 74	2.39	2.53	2.71	2.89	3.06
1975 – 79	2.15	2.31	2.52	2.73	2.92
1980 – 84	1.93	2.12	2.36	2.59	2.80
1985 – 89	1.89	2.06	2.33	2.58	2.79
1990 – 94	1.77	1.95	2.25	2.55	2.74
1995 – 99	1.66	1.89	2.21	2.51	2.68
2000 – 04	1.59	1.85	2.19	2.53	2.71

Table A7. Predictive distribution of the gain in internal rates of return due to funding

Born	d1	Q1	Md	Q3	d9
1940 – 44	-1.80	-1.80	-1.79	-1.79	-1.79
1945 – 49	-0.64	-0.63	-0.63	-0.62	-0.61
1950 – 54	-0.24	-0.23	-0.22	-0.21	-0.20
1955 – 59	-0.03	-0.01	0.01	0.03	0.05
1960 – 64	0.09	0.12	0.16	0.20	0.25
1965 – 69	0.12	0.17	0.22	0.31	0.38
1970 – 74	0.13	0.19	0.27	0.39	0.54
1975 – 79	0.17	0.25	0.36	0.52	0.74
1980 – 84	0.20	0.29	0.43	0.65	0.92
1985 – 89	0.19	0.31	0.48	0.76	1.08
1990 – 94	0.17	0.32	0.51	0.85	1.26
1995 – 99	0.15	0.30	0.53	0.94	1.42
2000 – 04	0.12	0.27	0.54	1.04	1.59