Annex 4 – EUROFRAME-EFN Autumn 2007 Report

Financial sustainability of pension systems under uncertainty[1]

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Abstract:

The relevant time horizon for pension policy is several decades. Therefore we know that the projected future demographic and economic trends that are used in projections are not likely to be realized. This leads to several interesting questions. How large is the uncertainty in pension variables, such as contribution rates and replacement rates? How the uncertainty affects the policy targets set and the policy instruments used? Is it possible to find and test policies or strategies, which affect both the expected value of the target variables and their distribution in a desired way? Answering these questions necessitates the use of models, which describe the interaction of demographics, economic decisions and pension system rules. We present three examples, which show how uncertainty may be assessed. The first one compares the recent pension expenditure projections of Economic Policy Committee with the ones produced in DEMWEL project utilizing stochastic population projections. The EPC quantifications of deviations from the expected outcomes turn out to be small compared with those obtained in the stochastic analysis. The next applications deal with evaluation of actual pension policy implemented recently in Finland. The first studied policy reform is introduction of longevity adjustment, which cuts the pensions if life expectancy increases. The second policy introduces an amendment to prefunding rules, which allows more risky portfolios to pension funds. Both reforms are aimed to improve financial sustainability, but we also show how they influence adequacy and intergenerational redistribution.

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1. Introduction

The well-known fact that populations are ageing throughout Europe has raised a need to reform the public pay-as-you-go pension systems. The pension schemes, which operated well in times of rapid growth of working-age population, are now challenged by increasing number of retirees and diminishing number of workers. Current population projections show that the change in the age structure will be permanent, implicating that the decease of the baby boomers will not solve the problem of high old age ratios.

The demographic transition is anticipated to increase the income transfers from young and future generations to the baby boomers. This shift in intergenerational redistribution is often considered as unfair. The expected increase in the pension contribution rates also represent a pure tax hike, since there is no corresponding improvement in future pension benefits. The higher labor income tax mitigates willingness to invest in human capital, to participate in labor markets and to increase marginal supply of working hours.

The sluggishness of the policy reactions can be traced back to unpopularity of retrenching pension politics and to the imprecise population projections. Previous experiences show that the demographic uncertainty is larger than people realize and there is no evidence that projections have become more accurate in time. This uncertainty must be taken into account when considering what will be the sustainable pension contribution rate. Another major risk, relevant to PAYG financed pension systems, is variation in the labor productivity. If there is some prefunding of pensions in a defined benefit system, the variation in the yield of the capital fund introduces a third major risk to the sustainability of the pension system.

The aim of this paper is to analyze the sustainability of current EU mandatory pension systems under uncertainty. We first discuss the link between demographic trends and pension expenditures, emphasizing the roles of demographic uncertainty. Next we present how Ageing Working Group of the Economic Policy Committee (AWG 2006) assess uncertainties in their expenditure projection and compare the outcomes with the ones generated using stochastic population projections.

Stochastic projections of demographic and economic variables allows us also to analyze how various policy measures affect the sustainability of pension systems both in terms of expected outcomes and the variation. We use two recent policy reforms introduced in the Finnish pension system as an example to illustrate the methodology. The analysis emphasizes financial sustainability, even though the method used provides a possibility to discuss also implied social sustainability (adequacy) and political stability.

The first policy measure is introduction of longevity adjustment of pensions, which aims to improve financial sustainability by lowering pensions, if longevity increases. The method is an essential part of the pension system in countries which follow the non-financial contribution (NDC) principle, such as Sweden, Latvia and Poland. It has recently been adopted also in some countries where the pensions are determined with defined contribution (DB) principle, such as Finland and Portugal.

The second analyzed policy measure includes actually two parts which change the prefunding rules of the Finnish earnings-related pension system. They smooth the forecasted hump in the pension contribution rate and allow the pension funds to aim at higher investment yields by investing more in stock markets.

2. Methodology

The starting point for our study is that uncertainty over future demographic and economic trends affect profoundly the way how we analyze the current pension systems and design future pension policy. Population ageing represents itself a realization of a demographic risk. If seen earlier, the pension policy would have undoubtedly been different. More importantly, we always face the same uncertainty, when we make predictions about the sustainability implications of the current pension rules or any policy reforms.

Uncertainty in numerical analysis of public finances is typically assessed by generating a baseline scenario and some alternatives in order to reveal the sensitivity of the baseline to some salient variables. This approach suffers from many problems, e.g. it may misguide to consider only the given alternatives as relevant.

It is not obvious how we should analyze pension systems under uncertainty. The first problem is to define which, from the point of view of sustainability and adequacy, are the most important sources of uncertainty. In pay-as-you-go pension systems, the obvious candidates are numbers of employed and retired people and the growth rate of labor productivity, which determines the growth rate of wages. In prefunded pension systems the rate of return on capital becomes also important. Considering a small open industrialized economy, where the interest rate as well as the rate of technological change is determined largely from abroad, it is easy to see that these economic risks are not easily controlled by the government. The same conclusion applies also to demographic risks, since population policy is not seen as very efficient in the long term.

After defining the relevant sources of risks, the second question is how to evaluate and measure the future uncertainty. Our approach is to estimate stochastic models using historical data and to simulate a large amount of future paths for the relevant variables. The resulting output can be used to describe future probabilities, assuming that uncertainty is similar in future as it has been in the past. This approach has become common in descriptions of demographic uncertainty (see Alho and Spencer, 2005) and of short-term financial market risks.

The third step in stochastic pension policy analysis is to build an economic model, which will be used to simulate the outcomes of current pension system rules and possible reforms. In early versions of the analysis these models were very simple, see e.g., Lee and Tuljapurkar, 1998. The development of computational methods and computing capacity has improved dramatically the possibilities to model the demographic trends, economic behavior and the prevailing pension systems with a more policy relevant precision. An optimal approach would be use of a comprehensive economic model in which both demographic and economic variables are stochastic, but numerical simulation in this case is very challenging due to the curse of dimensionality.

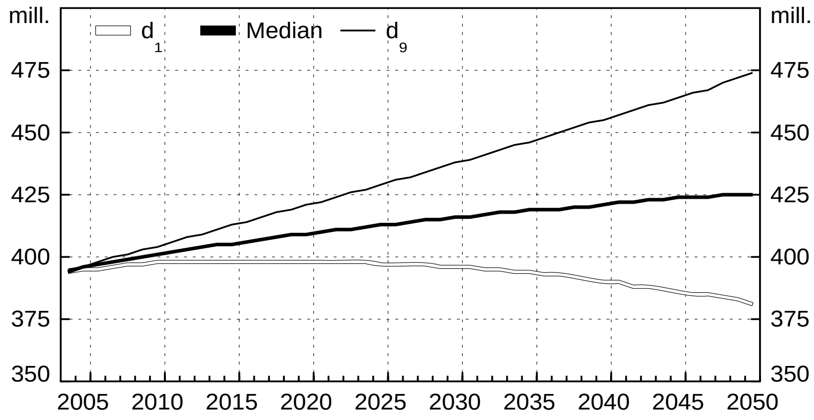
3. Demographic uncertainty and pension expenditures in some EU-countries[3]

Statistical methods of expressing demographic uncertainty have been developed recently (e.g., Lee 1999, Lutz et al. 1999). These methods quantify uncertainty probabilistically, based on analyses of past demographic data and judgment 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. Thereafter, sample paths for future population age-groups are simulated.

We use in our analysis randomly chosen sample paths from stochastic population forecast, produced in EU-financed research project UPE, and reported at web page http://www.stat.fi/tup/euupe/. Figure 1 presents an example of the results of UPE. The median of the predictive distribution of total population in EU15 + EEA countries increases at least until the end year of 2050, but with retarding speed. But more importantly, the 80 percent prediction interval of the distribution is almost one hundred million people in 2050, showing that the demographic uncertainty certainly is an issue to be taken seriously in sustainability analysis.

[3] This section draws heavily on Lassila and Valkonen 2007d.

Figure 1. Predictive distribution of the total population in EU15 + Iceland, Norway and Switzerland



Source: Alho and Nikander (2004).

The pension expenditure estimates are obtained from model-based country studies[4] produced in another EU research project called DEMWEL. We look more closely at Belgium, Denmark, Finland, Germany, the Netherlands, Spain and United Kingdom. Table 1 compares the old-age dependency ratios to pension expenditures. The numbers represent medians of the stochastic projections. Population ageing seem to take place with different speed and end up to quite a different positions in the compared countries. Ageing proceeds most rapidly in Finland and in Germany. The final position seems to be weakest in Spain, where 10 citizens of working age have to finance the pensions of 7 retirees in 2050.

[4] The country studies are Jensen and Børlum (2005), Lassila and Valkonen (2005), Fehr and Habermann (2004). Draper, Edens, Nibbelink, Viitanen and Westerhout (2005), Duyck, Lambrecht and Paul (2005), Sefton and Weale (2005) and FEDEA (2005).

Table 1. Old-age dependency ratios and pension expenditure, % of GDP in 2003, 2030 and 2050

	2003		2030		2050	
	Dep	Exp	Dep	Exp	Dep	Exp
Belgium	0.29	9.2	0.45	11.9	0.53	12.6
Denmark	0.25	9.5[a]	0.42	14.3	0.48	13.6
Finland	0.26	11.0[b]	0.51	15.2	0.54	15.0
Germany	0.29	11.4[a]	0.50	13.8	0.60	13.9
Netherlands (% of wage bill)	0.22	12.0[c]	0.40	27.2	0.43	32.7
Spain	0.27	9.7	0.42	13.4	0.72	20.6
UK	0.27	6.4	0.39	7.1	0.45	7.4

Old age dependency ratio = 65+/20-64, a=2001, b=2000-2004, c=2004

Table 2 presents the uncertainty in long-term pension expenditure projections. In Denmark, Finland, Germany and Belgium, where the median projected values are close to each other, the width of the 50 % predictive intervals vary from 1.2 to 3.0 percentage points, and the 80 % predictive interval widths vary from 2.3 to 5.8 percentage points. Actually, also the Netherlands is likely to be close by those numbers, if expenditures were expressed as ratio of GDP. Adding the other two countries where the distributions are centered on different levels, we may make two observations. First, the uncertainty is non-negligible in all countries and must be deemed as large in many of them. Second, there seem to be large differences between the uncertainty estimates in different countries. The differences partly reflect demographic factors, partly differences in pension systems, and partly the properties of the models that were used.

Table 2. Pension expenditure, % of GDP in 2003 and 2050

	2003	2050				
		d_1	Q_1	Md	Q_3	d_9
Belgium	9.2	11.1	11.8	12.6	13.4	14.1
Denmark	9.5[a]	10.8	12.2	13.6	15.2	16.6
Finland	11.0[b]	13.9	14.4	15.0	15.6	16.2
Germany	11.5[a]	12.5	13.2	13.9	14.9	15.8
Netherlands (% of wage bill)	12.0[c]	28.3	30.3	32.7	35.0	37.5
Spain	9.7	16.9	18.5	20.6	22.9	25.5
UK	6.4	6.1	6.7	7.4	8.0	8.6

a=2001, b=2000-2004, c=2004

d1=first decile, Q1=first quartile, Md =median, Q3=third quartile and d9=ninth decile

An obvious reason for country differences in uncertainty would be that some relevant demographic features are more predictable in some countries than others. The ratio of persons in old age to those in working age is clearly important here, because it influence both the absolute amount of expenditures and the GDP, which is used to scale the expenditures. In Table 3 the width the 80% predictive intervals of both pension expenditures/GDP and old-age ratios are compared to the median. The pension numbers are calculated from Table 2 as differences between the ninth and first deciles, related to the median, and expressed as percentages. The old-age numbers are calculated in a similar fashion from the country studies.

The figures show some pattern, though not very strong. Denmark and Spain are on the high-variation end, both demographically and pension-wise. Belgium and the Netherlands show much smaller variation in both respects. An outlier is Finland: the relative predictive range of pension expenditures/GDP is small, although the relative predictive range of the old-age ratio is relatively large. Another outlier, to some extent, is Germany.

Table 3. 80% predictive ranges of pension expenditures and old-age ratios, as % of the median in 2050

	pensions	old-age ratio
Belgium	24	32
Denmark	43	46
Finland	15	38
Germany	24	42
Netherlands	28	32
Spain	42	54
UK	34	43

Some countries apply pension system rules that are aimed at limiting the effect of future demographic changes to pension expenditures. In Finland, pension benefits are adjusted for changes in longevity (see the next section). Without this adjustment, the 80 % range of pension expenditure per GDP would be 22 percentage points in 2050. In Germany, the corresponding rule is the sustainability factor, which affects the indexation applied, when ratio of pensioners and contributors change.

We also relate the uncertainty estimates of the country studies to the uncertainty considerations in the recent projections by the Economic Policy Committee of the European Commission (EPC 2006). The EPC uses sensitivity analysis as a method to describe uncertainties. The expressed aim of the sensitivity analyses is "of providing some insight into the question of how sensitive the projections are to different assumptions and projected population and labor force developments, which inherently bring a major degree of uncertainty to long-run expenditure projections." The sensitivity scenarios were all run in relation to the baseline scenario, changing only one factor in each sensitivity scenario from that in the baseline scenario. They were run on four risk factors: on higher life expectancy, on a change in labor productivity, on higher employment rates, and on the interest rates levels.

Table 4 sums up the quantitative variation in the EPC's sensitivity analysis. We have calculated 'sensitivity ranges' for all countries in Table 4 as follows. The effects of all the four issues dealt with have first been made go to the same direction, and then they have been added together. The total deviation from the base path thus obtained varies from 0.3 to 1.4 percentage points between countries. Thirdly, assuming that all the effects can also go to the other direction the total deviations have been multiplied by two, except for labor productivity effects for which separate estimates for the other direction, available in the EPC's report, were used.

Table 4. Pension expenditure, % of GDP in 2050: The EPC's central projection and its sensitivity range

	Expenditure / GDP		Sensitivity range, %-points
	2004	2050	
Belgium	10.4	15.5	2.7
Denmark	9.5	12.8	1.8
Finland	10.7	13.7	1.9
Germany	11.4	13.1	0.6
Netherlands	7.7	11.2	1.5
Spain	8.6	15.7	2.5
UK	6.6	8.6	1.5

Source: EPC (2006), Tables 3-3 and 3-28.

If we compare the sensitivity ranges in Table 4 to the predictive ranges obtainable from Table 2, we note that for Denmark, Finland, Germany and Spain the sensitivity range is narrower than the 50 % predictive range and for Belgium and the UK it is narrower than the 80 % predictive range. And this despite the fact that the ranges from Table 2 include only the effects of demographic factors, whereas the sensitivity range includes economic factors also. For the Netherlands we do not have comparable predictive ranges, but assuming that the wage bill is of the order of 50 % of GDP, we can divide the predictive ranges in Table 2 by two, and notice that very likely the sensitivity range is much narrower than the 50 % predictive range. Thus we may conclude that the estimates in Table 2 are large in comparison to the perceptions of uncertainty obtained from official expenditure assessment, exemplified here by the EPC's report.

4. Policy simulations using recent Finnish reforms as example

The next applications deal with evaluation of actual pension policy implemented recently in Finland. The first studied policy reform is introduction of longevity adjustment, which cuts the pensions if life expectancy increases. The second policy introduces an amendment to prefunding rules, which allows more risky portfolios to pension funds. Both measures are aimed to improve financial sustainability, but we also show how they influence adequacy and intergenerational redistribution.

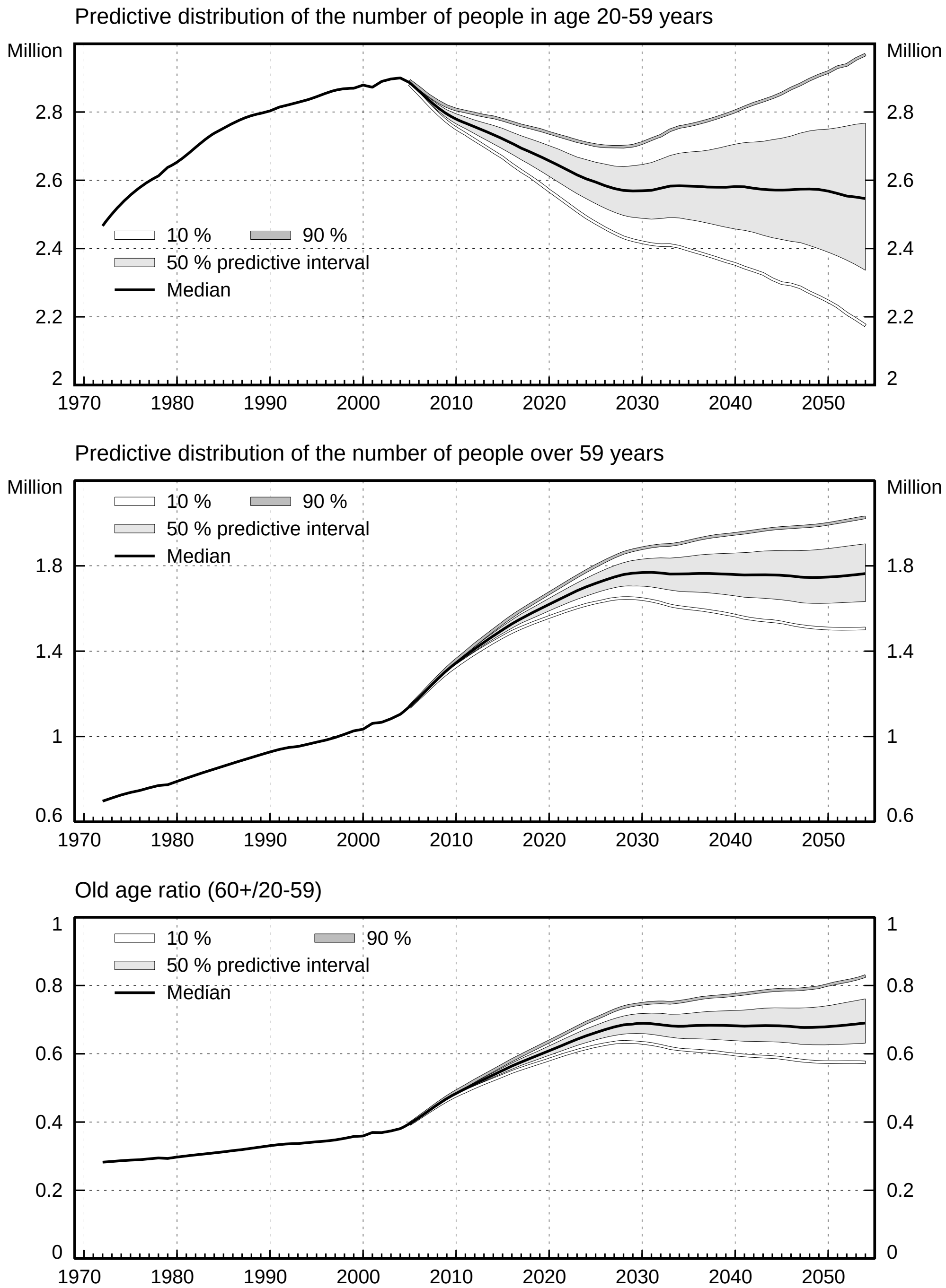
4.1 Description of risks

In case of demographic uncertainty, we utilize the recent stochastic population forecast made for Finland by Professor Juha Alho. The forecast is produced by estimating stochastic models for fertility, mortality and migration, simulating these models hundreds of times and compiling the results with a cohort component method. Figure 2 presents the outcome as predictive distributions of number of people in the given age groups.

The grey area depicts the 50 per cent confidence intervals for the number of people in the presented categories. For example, there is a 50 percent probability that the number of prime age workers in Finland is between 2.4 million and nearly 2.8 million in year 2050. Even allowing demographic uncertainty of the given size, the main message of the simulations is that we will see a strong population ageing taking place during next decades. It is also likely that the old age ratio will stay at a high level for decades.

Since most of the public expenditures are aimed at old age and most of the taxes are paid during working years, a permanent increase in the old age ratio means that the sustainability of public sector finances is under considerable strain in the expected population path, but also that sustainability is permanently more vulnerable to further demographic shocks.

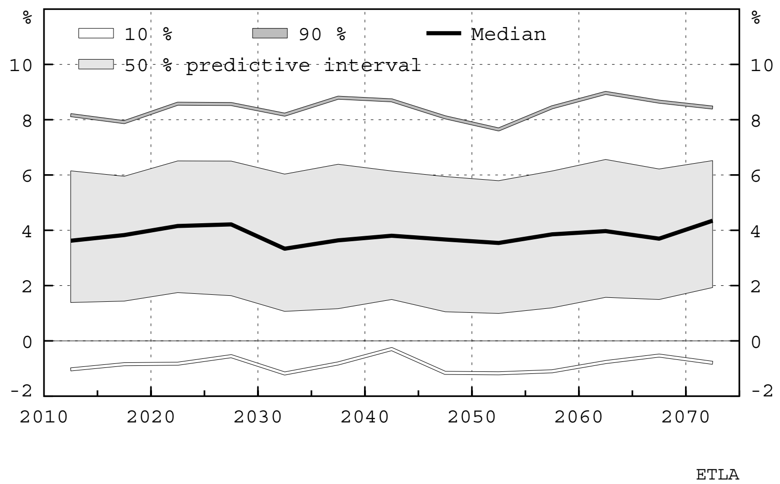
Figure 2. Demographic uncertainty in Finland



The other risk considered is the financial market yield available for pension funds. Data depicting various assets, geographical areas and time spans shows large differences for expected yield and the variation. Therefore we consider our results only as indicative.

Figure 3 depicts the predictive distribution of the real returns in 500 simulations. It describes a yield of a portfolio with 40 percent allocated in stocks and 60 percent in bonds[5]. The figure shows that there is about 50 percent probability that the real rate of return is between 2-6 percents in each 5-year period. It also indicates how well 500 simulations suffice to describe the underlying distribution, which in the figure would be expressed with straight lines. The expected yield is 3.9 percents.

Figure 3. Asset yield uncertainty



The investment risk is allocated to the pension contributions in the Finnish defined benefit pension system. A higher rate of return increases the amount of money that can be used to pay pensions, and lowers thereby contribution rates. It affects the pensions only

[5] The estimated stock market yield is based on Finnish Stock Exchange data (OMXHCAP) from years 1927-1999. The average real rate of return on stocks is set to 6 percent, with variance of 10.97. The interest rate data is from the IMF Financial Statistics. We use German bond data from years 1955-2005, because of the too short time series of usable Finnish data. The average value for the real interest rate is set to be 2.5 percent, with variance of 0.87. Since the unit period in the model is 5 years, we use 5 year averages of the yield variables. Maturity of the bonds is assumed to be 5 years.

insomuch that the lower employers' pension contributions limit the increase in wage index and thereby the index that is used to raise pensions (in case of Finland, the weights of consumer prices and wages are 0.2/0.8 during retirement years in that index).

Baseline stochastic projection

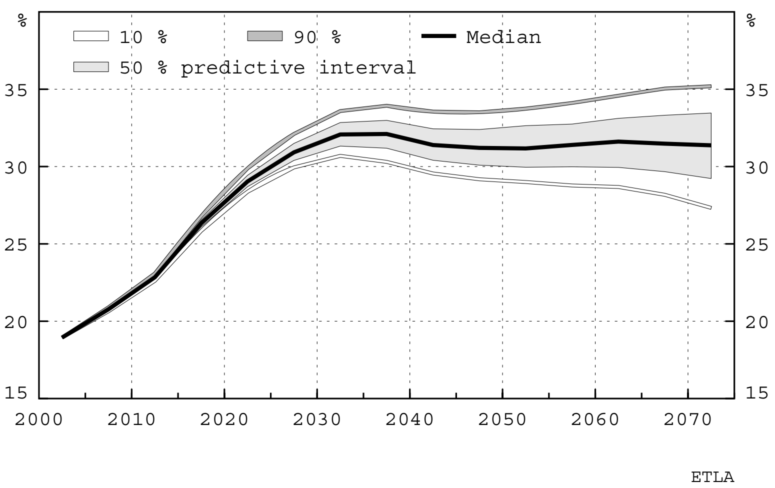
The next step is to run the economic model using the sample paths of the stochastic models as inputs. We simulate the baseline projection set using a perfect foresight numerical overlapping generations model of the type originated by Auerbach and Kotlikoff (1987). The FOG model consists of five sectors and three markets. The sectors are households, enterprises, a government, a pension fund and a foreign sector. The labor, goods and capital markets are competitive and prices balance supply and demand period-by-period. There is no money or inflation in the model. Households and firms are forward-looking decision-makers. The unit period is five years, and the model has 16 adult generations living in each period. The model is described in more detail e.g., in Lassila and Valkonen, 2007b.

The simulated Finnish private sector pension system resembles many older occupational pension schemes, with large funds and operating with defined benefit principle, but it is mandatory and is defined as belonging to the first pillar. The reform of year 2005 improved a lot the efficiency of the system in the sense that there is now close link between earnings and pensions.

Figure 4 depicts the predictive distribution of the pension expenditures divided by the corresponding wage bill. It shows that the median of expenditure increase by 12-13 percentage points during the next few decades. The grey area describes the 50 % confidence interval. So it is quite certain that the expenditures will be much higher in the future. It is useful to compare the outcome to the old age ratio described in the lowest section of Figure 2. The similarity of the trends is very obvious and tells about the central role of demographic uncertainty in pension expenditure projections. Expenditure uncertainty would emerge earlier and be larger without longevity adjustment of pensions.

The adjustment mechanism and its effects are explained in more detail in the next chapter.

Figure 4. Predictive distribution of the private sector pension expenditures/wage bill



Probabilistic approach to sustainability

A well-known definition of the sustainability of fiscal policies is the OECD view: "Sustainability is basically about good housekeeping. It is essentially about whether, based on the policy currently on books, a government is headed towards excessive debt accumulation." (Blanchard et al. 1990, p. 8). More precisely: "Fiscal policy can be thought of as a set of rules, as well as an inherited level of debt. And a *sustainable fiscal policy* can be defined as a policy such that the ratio of debt to GNP eventually converges back to its initial level" (p.11). The forecasts for spending and transfers are taken as given. Therefore the accuracy of sustainability projections is largely determined by the accuracy of the underlying demographic and economic projections.

Numerical evaluation of fiscal sustainability uses several methods. Most simple analysis just looks at the most likely path of the future tax rate. In case of pension systems, a permanent increase in the contribution rate reveals financial unsustainability. Sensitivity analysis with some variants shows how responsive sustainability is to the assumed demographic and economic trends. This approach does not, however, tell anything about the probabilities of unsustainable paths.

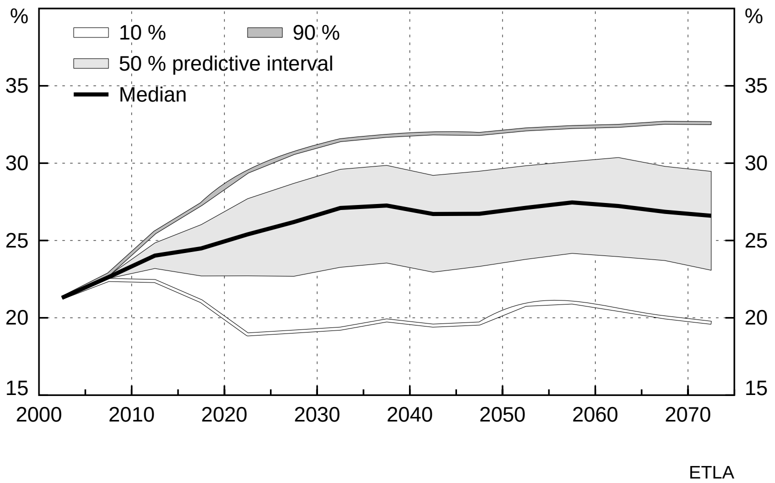
Second often used method is to calculate the long-term trends in public sector surplus/deficit and the consequent net wealth position fixing current policy rules and current tax rates. This method, close to the OECD approach, leads sooner or later to explosion of debt in ageing economies. The timing of the explosion is determined largely by the initial position of the government, the interest rate assumed and the progress of expenditures due to population ageing. The method is not very informative in the very long term, since interest payable often starts to dominate the results.

Third method that recently has become more general is to calculate sustainability gaps. The gap is defined as an immediate and permanent increase in the contribution rate (or a corresponding reduction in benefits), which equals the discounted incomes and expenditures of the pension system.

Our approach is based on probabilistic evaluation of sustainability. The use of a numerical economic model allows us to simulate the pension contribution rate hundreds of times using sample paths of the stochastic population and asset yield projections as input. The output is a probabilistic projection of the future contribution rate, see Figure 5. The future contribution rate is expected to be lower than the expenditure rate described in Figure 4, because part of the pensions are financed using the yield of the existing pension funds.

Figure 5 shows that in each studied period, there is about 10 per cent probability that the contribution rate will be lower than the current 21 per cent. Correspondingly, there is about 90 per cent probability, that current rate will be exceeded. When looking at the picture one should remember that in each contribution rate path the rate may be low in some periods and high in others.

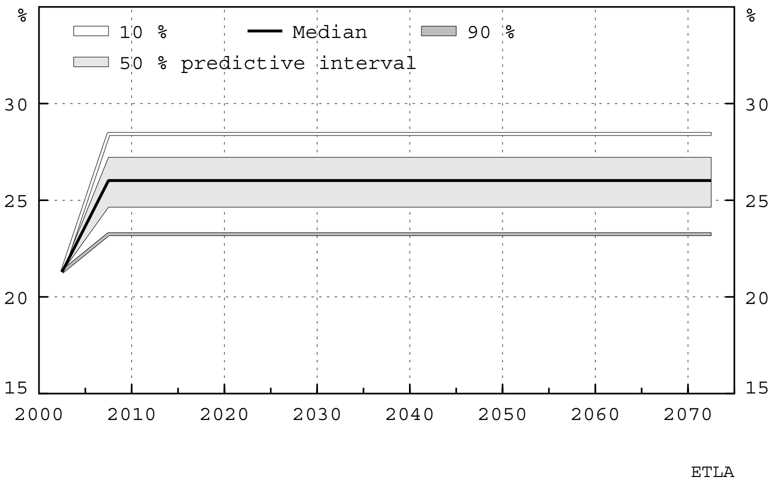
Figure 5. Predictive distribution of the private sector pension contribution rate



A more illustrative way of presenting probabilistic sustainability is to calculate a sustainability gap which correspond each sample path. Figure 6 shows the predictive distribution of sustainable contribution rates. Probability of the sustainability gap being close to zero is very small and therefore the pension system is not sustainable. The distribution is much narrower than in Figure 5, which tells that there is quite a lot of variation in the initial contribution paths.

Figure 6 also illustrates that, in the Finnish case, raising the contribution rate immediately to the expected sustainable level does not change much the expected long-term contribution rate. This is due to two reasons. Baby boomers are retiring soon and therefore the higher contribution rate does not have time to generate large funds before the expenditure increase. Another salient feature is that the old age ratio is not expected to revert to the current level even after the baby boomers have deceased. The pension expenditure and contribution rate is expected to stay at the higher level until the end of the calculation period. The longer the calculation period, the closer the sustainable rate is to the rate that will materialize in the long term even without the immediate increase.

Figure 6. Predictive distribution of the sustainable private sector pension contribution rate



The idea of the indicator is not to tell how sustainability should be achieved, if a gap is detected. The chosen method will certainly have interplay with the size of the gap. If the choice is to raise the contribution rate, it will induce negative incentive effects and closing the gap will be more difficult than shown in the figure above. This is especially true if the baby boomers consider the higher contributions as taxes that encourage earlier retirement. If the choice is to raise effective retirement age, or to cut previously earned pension rights, the task will be easier and may provide more fair intergenerational redistribution.

Benefit cuts may challenge the social sustainability (adequacy) of pensions. On the other hand, if the projected future contribution rate hike is high, it is likely that the promised benefit level is not politically sustainable. Therefore a broader evaluation of sustainability is necessary. The following sections analyze two pension policy reforms using predictive distributions of sustainability gaps, adequacy indicator and intergenerational fairness indicator as criteria of evaluation.

4.3 Longevity adjustment of pensions

In anticipation of future gains in life expectancy, several countries have passed laws that automatically adjust pensions, if life expectancy changes. The aim is to preserve the expected present value of future pensions. If benefits are received for more years, then pensions per year will be lower. Another reaction to longevity trends has been to rise set retirement ages.

In countries that have applied longevity adjustment or consider doing so, its expected effects have been investigated to some degree. However, the fact that future mortality developments are uncertain has not received much attention. For pension contribution rates this is not a serious deficiency; the adjustment itself takes care most of this uncertainty. But for monthly pension benefits and replacement rates this uncertainty exists. We study the economic effects of longevity adjustment under demographic uncertainty, using as an example the recently reformed Finnish earnings related pension system, where, from 2010 onwards, new old-age pensions will be affected by the rule.[6]

The economic effects of longevity adjustment has been analyzed before with stochastic simulations by Alho et al. 2005, Fehr and Habermann, 2006 and Lassila and Valkonen 2007b, 2007c. Its effects have also been simulated as a part of a Swedish type Non-financial defined contribution (NDC) pension system, see Auerbach and Lee, 2006, and Lassila and Valkonen, 2007a. Longevity adjustment was also a part of a proposed comprehensive reform of the US social security system, see Diamond and Orszag, 2003. The effects of this reform package was simulated by the Congressional Budget Office, see CBO, 2004.

[6] The size of longevity adjustment is determined by a life expectancy coefficient. The coefficient is calculated comparing 5-year average of life expectancy data of a 62 year old birth cohorts from period 2003-2007 to the life expectancy of the birth cohort in question when in reaches age 62. If life expectancy increases, the coefficient will be smaller than 1 and the pensions will be cut by an amount directly indicated by the value of the coefficient. A more detailed description of the analysis and the results can be found in Lassila and Valkonen (2007c).

The exact details of the longevity adjustment are important for the intergenerational risk-sharing properties. Adjustment of currently paid pensions with continuously updated life expectancy estimates would be problematic for the retirees. Another policy option is to adjust pensions to the expected longevity of the cohort at the time of retirement. This option is in use in Finland and in Sweden. It allows reacting to surprises by adjusting the labor supply.

There are also two alternatives for the indicator of future longevity. The first is to use official cohort projections and the second is to use known ex-post cross-sectional survival data. Use of observed data provides stronger protection from political intervention and is therefore preferred in Finland and in Sweden. The obvious problem is the lagging realization of adjustments if longevity continues to increase. However, in the case of defined benefit systems, use of observed life expectancy data may still be preferable since it generates larger expected cuts in future pensions than the adjustments based on forecast longevity. The reason is that the increase in longevity has already taken place in the base period's forecasts but not in the observed mortality rates.

Table 5 shows that longevity adjustment usually decreases the contribution rates, and the reduction is the bigger the higher the rate would have been without the reform. Thus the longevity adjustment works very nicely as a cost saver. On the other hand, contribution rates are higher in demographic worlds where labor is scarce, wages higher and replacement rates lower. Thus longevity adjustment increases the uncertainty in replacement rates. It thereby significantly weakens the defined-benefit nature of the Finnish pension system and brings in a strong defined-contribution flavor. But it is important to note that demographic uncertainty itself reduces the defined-benefit feature, so adopting longevity adjustment is a change in degree, not a change in kind.

Table 5. Contribution and replacement rates and longevity adjustment

	d_1	Q_1	Md	Q_3	d_9
Contribution rate					
2050 - 2054					
without longevity adjustment	26.72	28.64	30.74	32.30	34.10
with longevity adjustment	25.80	26.82	27.84	28.90	29.86
Replacement rate					
2050 - 2054					
without longevity adjustment	47.17	47.80	48.44	49.04	49.53
with longevity adjustment	38.90	40.56	42.68	45.01	47.73
Effect of longevity adjustment					
on contribution rates					
2050 - 2054	-4.52	-3.71	-2.76	-1.70	-0.69
on replacement rates					
2050 - 2054	-8.82	-7.42	-5.77	-3.74	-1.55

We have defined before the *sustainability gap* as an immediate and permanent increase in the contribution rate, which equals the discounted incomes and expenditures of the pension system. The median of the sustainability gap falls from 7.7 to 5.7 percents after introduction of the longevity adjustment, see Table 6. Also the variation in sustainability gap reduces.

For adequacy, we calculate a measure that uses the replacement rates in the base case scenario. Fixing the replacement rates from that scenario, we calculate the present value of pension expenditure in all population paths and compare it with the actual present value for that path. We call the difference between the actual and hypothetical present values the *adequacy gap*, and express it as percentage of the present value of the contribution base. Thus the gap gives the immediate and permanent change in contributions that is needed to finance replacement rates equal to those in the base case. With this definition, the adequacy gap is directly comparable to the sustainability gap.

Longevity adjustment lowers the pensions, raising the median of the adequacy gap by 2.6 percentage points and increases markedly the probability of large adequacy gaps.

Table 6. Sustainability and adequacy gaps and longevity adjustment

	d_1	Q_1	Md	Q_3	d_9
Sustainability gap					
without longevity adjustment	5.42	6.63	7.74	8.76	9.90
with longevity adjustment	4.57	5.15	5.73	6.30	6.78
Adequacy gap					
without longevity adjustment	-1.73	-1.68	-1.62	-1.55	-1.49
with longevity adjustment	-0.93	0.05	0.92	1.81	2.61
Effect of longevity adjustment					
on sustainability gap	-3.32	-2.72	-2.00	-1.30	-0.48
on adequacy gap	0.60	1.66	2.56	3.48	4.26

The gaps are calculated using a time span of 145 years.

As an intergenerational measure of the connection between benefits and contributions we define the following. The *actuarity ratio* is the ratio of a cohort's discounted benefits from the pension system to its discounted sum of payments to the pension system. Table 7 shows that actuarity ratio medians for successive generations decline. The reasons for that are population ageing and the maturing of the pension system financed with a pay-as-you-go principle.

Longevity adjustment lowers the actuarity ratio of the current young workers because they experience quite a considerable cut in their pensions, but only a small reduction in contributions. The benefit cuts are largest for the future generations, but their aggregate outcome will be positive due to the even bigger reductions in contributions. The overall changes in actuarity ratios are small due to high correlation between paid lifetime contributions and pension benefits in the Finnish earning-related pension system.

Table 7. Actuarity ratios and generational equality

	d_1	Q_1	Md	Q_3	d_9
Actuarity ratio					
Born 1970-74					
without longevity adjustment	0.84	0.89	0.93	0.98	1.02
with longevity adjustment	0.83	0.86	0.89	0.92	0.94
Born 1990-94					
without longevity adjustment	0.74	0.76	0.79	0.81	0.84
with longevity adjustment	0.72	0.73	0.75	0.76	0.77
Born 2010-14					
without longevity adjustment	0.69	0.70	0.72	0.74	0.75
with longevity adjustment	0.67	0.69	0.71	0.72	0.74

4.3 New investment rules

Many of the current occupational pension systems are at least partially funded but follow defined benefit rules. This creates an obvious need to try to forecast the cash flows involved and to evaluate the financial soundness of the system by comparing the liabilities and assets. A more risky investment policy would necessitate larger buffers. Another option is to allow the pension institutions to take more risks by applying more liberal solvency rules.

The Finnish private sector earnings-related pension system has collected substantial funds to smoothen the contribution increases due to population ageing in the future. Funding is collective but based on individual pension rights. Partial prefunding of the accrued old age pension rights takes place in the age range of 18 – 54. 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 pre-funded. The rest comes from the PAYG part, the so-called pooled component in the contribution rate.

We simulate the outcomes of the recent Finnish pension reform, which included two changes in the prefunding rules. Our aim is to give a probabilistic evaluation of the reform in terms of variation in the contribution rate. There are some previous studies, which also simulate pension policy under financial market uncertainty see e.g., Bosworth and Burtless, 2002.

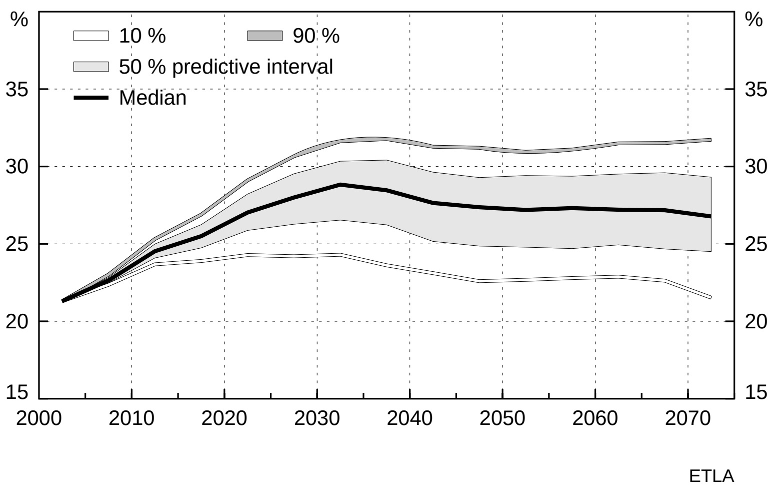
The first change allocates part of the yield of the pension funds to older people's individual accounts. When the accounts for the younger people are correspondingly rewarded with a lower yield, the average balance in all the accounts will be lower and so will be the actual prefunding rate of the pension rights. It also means that the individual accounts are run down faster than previously. The policy measure is aimed to smooth the projected baby boom hump in the pension contribution rate that would otherwise appear in 2030's.

The second part of the reform changed in a complicated way the solvency rules of the private pension institutions, which run the pension system. It introduced an equity linked buffer to the technical reserves. The idea is to weaken the link between return of equity investments and the actual solvency capital. The weaker link allows higher risky equity positions. Simulations with the new buffer show that it should enable the pension companies to increase the share of stock market investments approximately by 10 per cents (Ranne, 2007).

We assume that the initial pension fund portfolios were allocated to bonds (71.4 percents) and stocks (28.6 per cents), which gives expected annual real rate of return of 3.5 per cent. After the reform the share of the bonds in the investment portfolio is reduced to 60 percent and the share of the stocks is increased to 40 percent. This shift raises the average yield of the funds to 3.9 per cent, but also scales up the variance.

Figure 7 shows the predictive distribution of the contribution rate with the old prefunding rules. It describes the contribution rates before the reform in 500 simulations, each with one arbitrary sample path from the stochastic model for population, stock market yields and interest rate. Comparison to the expenditure trends (Figure 4) shows that the future investment income was expected to lower markedly the pressure to raise the contribution rates, even with the earlier stricter investment rules.

Figure 7. Predictive distribution of the contribution rate before the investment rule reform



The predictive distribution of the contribution rate with the new rules was illustrated in Figure 5. Comparison of the contribution figures indicates that the reform limits the expected increase in the contribution rate in a way that was planned. The effects are most evident during the years when the contribution rate would have been the highest.

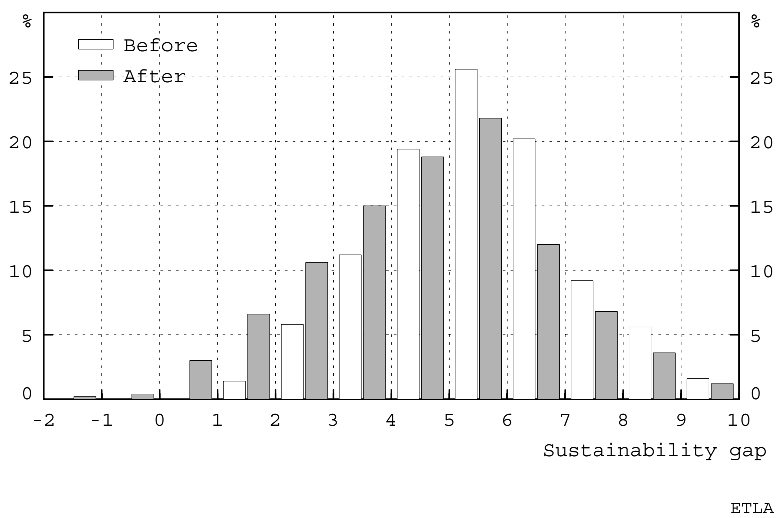
The first part of the reform lowers the contribution rate median during the next two decades, but raises the longer term rate. The second part lowers permanently the median of the contribution rate, since the expected real rate of return is higher. The overall effect is that the median of the contribution rate grows much slower, but end up to almost the same level than before the reform.

Allowing more risky portfolios also increases the variation in the contribution rate. The increase in risks is asymmetric. In sample paths where the yield is low on average, the pension fund will become gradually smaller and the pension contribution rate becomes less sensitive to yield shocks. In case of favorable market conditions the fund will be larger and the role of asset yields more pronounced.

How this reform performs if we use financial sustainability, adequacy of pensions and actuarity rate as criteria? A simple answer to sustainability question is that it is very likely to have improved, but not much.

One way of illustrating the results is to calculate predictive distributions of the sustainability gap before and after the reform, just as in the case of the longevity adjustment. Figure 8 shows the results as a histogram. The whole distribution has shifted to left. The change is not, however very large, and the probability that the current contribution rate would permanently suffice to finance future expenditures is still extremely small.

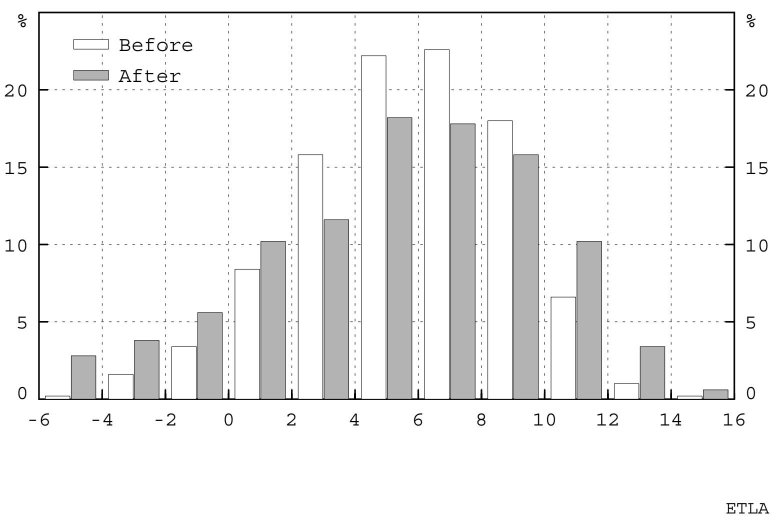
Figure 8. Histogram of the sustainability gap before and after the investment rule reform



Sustainability gap distribution presented above shows the required increase in the contribution rate in each stochastic sample path when its period-by-period variation is totally abolished. In fact the initial contribution rate varies a lot. High variation is problematic both to the payers of the contributions and to the policy planner. Periods of high yield create political pressures to lower the contribution rate, even though the long-term prospects of the financial sustainability have not improved much.

Figure 9 demonstrates that it is not very unlikely to end up to a situation, where erroneous decision is possible. It shows with a histogram how much the contribution rate in period 2050-2054 is expected to deviate from the current rate. The shift to riskier pension fund portfolio increases the probability of both very high and low outcomes, when the studied period is relatively short. This result would be even more outstanding, if we had chosen to use yearly data instead of a five-year average. It is evident that one should be cautious to change the long-term conception of financial sustainability of the pension system, even when the financial market yields have been low or high several consecutive years.

Figure 9. Histogram of deviation of the pension contribution rate from the current level in period 2050-2054 before and after the investment rule reform



Second policy evaluation criterion is adequacy of pensions. The links between the new investment rules and the size of pensions are rather weak, so we do not expect that the reform has any marked effects on adequacy.

The third criterion is generational equity. The first part of the reform improves most the position of the generations born between years 1970-2010, because those benefit from the lower expected contribution rate. The asymmetric change in the contribution rate risk provides an interesting result. The higher probability of low contributions means that the current young and future generations may expect more often positive than negative surprises in the intergenerational redistribution after the investment rule reform.

4. Conclusions

This paper has surveyed some of the recent work in the area of stochastic evaluation of long term sustainability of public pension systems. Even though the work is still in progress in Finland and has not even started in many of the EU countries and international organizations, we believe that the method will gain support, when its benefits are fully observed.

Demographic and economic uncertainties are large and increasing with the time horizon considered. Using stochastic projections of the most important demographic and economic variables as inputs in an economic model provides an approach that can be utilized both to evaluate the sustainability of current pension systems and to extensively test any alternatives that are discussed in public. It also helps to find and test policies or policy combinations that are not seen otherwise. Introducing uncertainties in a systematical way in numerical pension policy analysis is a new and rapidly developing field of research.

We present three examples, which give an idea how uncertainty could be assessed with the method. The first shows that demographic uncertainty is very important and obviously understated factor, when pension expenditure projections are produced and disseminated.

The two other examples illustrate the need for broader approach, when sustainability of pension systems is evaluated under uncertainty. An optimal pension system is designed so that it performs well in the expected future path and tells exactly how the risks are shared between pension contributions and benefits, when something unexpected happens.

We show that in case of the Finnish pension system, the risk sharing properties have been changed a lot with the recent reforms. Longevity adjustment allocates most of the life expectancy risks to pensions, but the size of the adjustment is quite well seen already during working years. Fertility and migration risks as well as the now higher pension fund investment risks are still born almost totally by contributors. It is likely that this risk sharing rule is not politically stable, especially when there is a large probability of markedly higher contribution rates. These results are readily applicable to all countries that already implement or plan to introduce longevity adjustment or prefunding of pensions.

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