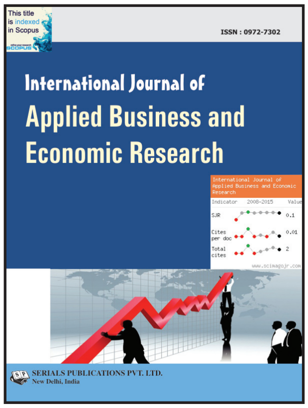

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Making the Case for Defined Benefit Pension Plans Self-adjusting Steering Schemes

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ABSTRACT

In an economically and politically instable context with strong demographic shifts and weak pension plan long-term robustness, Self-Adjusting Steering Schemes (SASS) present several advantages including reactivity, relevance, economic fairness, smooth incremental adjustments and protection against political malice. This article proposes a probabilistic model to illustrate the impact of SASS on overall liability risk mitigation through some simulations on a simplified defined benefit pension plan. It highlights the cost of inaction in pension plan liability management and advocates the systematic implementation of the proposed SASS schemes. The proposed SASS schemes act on several parameters such as retirement start age, pension computation formulae or pension indexation by dynamically changing their value to cope with the materialized risk factors. It concludes with a discussion on the fairness of the proposed risk-sharing approach among the pension plan's different stakeholders.

Keywords: Self-Adjusting Steering Scheme (SASS), pension plan robustness, risks sharing, defined benefit pension plan, cost of inaction and probabilistic approach.

1. INTRODUCTION

Despite being deeply rooted in the economical landscape, pension plan schemes in their current form date no later than 1889 when Bismark instituted a huge social reform. For a mechanism involving an implicit and time evolving contract between generations with huge social and financial stakes, it is obvious that the number of observed cycles for a robust overall perspective is still relatively low. This relative lack of track record - only few generations of perspective - coupled to some strong trends (e.g., increase of life expectancy, strong demographic shifts, instable financial returns, overall economical uncertainty, unemployment, etc.) has yielded several waves of pension scheme reforms in the past decades.

At their design phase, pension plan are conceived according to several key assumptions with – hopefully - an objective of long-term sustainability. Nevertheless, as the time goes, several risk factors emerge that may not only jeopardize their robustness but also lead to their collapse, for instance: (i) drop in expected financial return, (ii) increase of life expectancy, (iii) profound demographic shift with less young cohorts coming to the job market, (iv) overall economic conditions (in terms of employment, growth, stability, etc.), (v) political reform, e.g., awkwardly enlarging benefits without proper funding with a short term electoral agenda, etc.

Pension plan schemes are also characterized by:

- Multiplicity of stakeholders (administration, parliament, enterprises, workers, unions, etc.)
- Long-term viability objective with an antagonized short term political cost
- Requirement for a minimum level of technicality to correctly apprehend its functioning and subtleties, let alone apprehend any type of proposed reform

Those three factors contribute to a strong status quo situation at the expense of long-term sustainability. Moreover, when facing a structural disequilibrium each year of inaction deteriorates significantly the pension plan sustainability leading to exponential degradations overtime.

The objective of this paper is to advocate the use of self-adjusting steering approaches for pension plan liability management through a simplified illustration of its impact on long-term viability thanks to probabilistic simulations. It is structured as the following:

– Presentation of the modeling framework and considered risk factors
– Presentation and evaluation of the effectiveness of several self-adjusting schemes as well as the cost of inaction
– Quantifying the impact of self-adjusting steering schemes on the beneficiaries and discussion of their overall fairness

2. LITERATURE REVIEW

The abundance of scientific literature on pension plans reflects the importance of the theme. Institutions like: OECD, World Bank, International Labor Organization, Conseil d'Orientation des Retraites frequently publishes several reports on the matter. Within this section we will particularly focus on self-adjusting steering schemes and liability risk mitigation techniques.

According to COR Septième rapport (2010), five major objectives could be assigned to a retirement system: (i) financial sustainability, (ii) fairness between generations which includes maintaining a certain level of retirement thorough generations, (iii) solidarity between each generation, (iv) readability, transparence and overall trust in the system and (v) articulation between pension plan system and other economical objectives.

With regard to the above objectives self-adjusting steering schemes bring a credible and adapted answer to objectives (i) (core focus), (iii) and (iv) (by design) and to a certain extent to objective (ii) by avoiding a severe disequilibrium between generations whose potential outcome might be drastic cuts in future benefits.

In Blommestein et. al., (2009), it is stated that unconditional promises requires the transfer of risk of the funding ratio to another counterpart. In Bohn (2005), it is highlighted that by making unconditional promises in a highly uncertain environment, risks are implicitly transferred to younger generations and future cohorts who will have to bear a more than proportional risk to cover for the underfunded risk of past generations.

According to Whitehouse (2007), it is stated that two thirds of pension reforms in the last fifteen years contain measures that will automatically link future pensions to change in life expectancy. This significant policy shift has been introduced in several ways:

- Mandatory defined contribution plans
- Substitution of classical defined benefit schemes with notional accounts
- Adjusting benefit levels with life expectancy
- Linking qualifying conditions for pension to life expectancy (e.g., number of years required for a full benefit pension)

In 2007, the Society of Actuaries commissioned a paper: Turner (2007), to explore the current situation of self-adjusting schemes. Some of their key findings are presented below:

- Within a pay-as-you-go system, solvency can be maintained by cutting benefits, raising contribution or delaying retirement age. Although, countries used to historically adjust contribution rates, the current trend is to move towards benefit cuts and retirement age modifications to not exceed a sustainable contribution rate with an implied burden on the job market
- Defined benefit retirement systems often include some self-adjusting schemes: inflation, liquidation, etc. but they rarely adjust to other risk factors such as longevity for instance
- Since the innovative reform in Sweden, several countries have adopted life-expectancy indexing of benefits or automatic adjustments tied to social security insolvency
- Pension plan adjustment can be carried out either Ad Hoc or through automatic adjustment mechanisms. Ad hoc adjustments are generally made subsequently to a crisis, with a little time for the population to adjust their saving strategy and a substantial rule modification while automatic adjustments are in general small, frequent, and predictable. All these features are desirable for a pension plan
- Automatic adjustments significantly mitigate political risks and sustainability issues
- Sweden has a system which is adjusted both based on life expectancy evolution and real per capita growth compared to consumer price index. They also have an additional mechanism called automatic adjustment mechanism that aims to fix the contribution rate so that it does not need to be modified in the future, and to automatically restore long-term viability without needing politicians' implication. This mechanism has not yet been used and is not expected to be used frequently
- Germany has implemented a sustainability factor that adjusts pension levels based on mortality evolution but also other demographic and economic trends. It aims at reducing the required growth of contribution to maintain sustainability by 25%. It is estimated that this system has reduced the expected contribution percentage in 2040 from 28% to 24%

- In Canada, every three years, a long-term actuarial study is carried out, in case of a disequilibrium for which the parliament cannot yield to a solution, benefits are automatically frozen and contribution rate is increased until the next actuarial study (scheduled every three years).

According to D'Addio et. al., in the past fifteen years many countries have implemented an automatic link between demographic and economic evolutions and the retirement system, it is considered as a major breakthrough since it implies an improved hedge against external shocks and provides a framework for a better political acceptability of reforms.

The same report highlights the importance of focusing on the social sustainability of automatic adjustment in parallel with financial stability so that benefits remain adequate. Even though, automatic adjustments, which exhibit the characteristics of transparency, gradual impact and fair distribution of implied liability between generations can also foster individuals proactive behavior of savings strategy adaptation to existing trends, for instance, creating individual saving capitalization accounts.

3. MODELING FRAMEWORK AND CONSIDERED SIMULATIONS

The modeling framework of the present article is built on three components:

- Simplified deterministic mono-cohort defined benefit pension plan representing the baseline for all simulations
- Considered risk factors and key metrics for evaluation of their impact on the pension plan sustainability
- Considered self-adjusting steering schemes (SASS)

3.1. Simplified Deterministic Mono-cohort Defined Benefit Pension Plan

The simulations of this paper are carried out on a normative mono-cohort defined benefit plan. The rational behind this simplification resides in several factors:

- Clarity and simplicity of interpretation of resulting simulations
- Immunization of the main decisions impacts on a single cohort, for instance, neutralizing the impact of demographics for which reserves might grow on a short and medium term (fueled by demographic growth) and thus hide the truth of a structurally underfunded situation while the latent liability is growing at a faster pace
- Considering the natural solidarity embedded in a pension plan scheme resides only within each cohort and explicitly considering that every generated imbalance within a certain cohort comes either at the cost of future generations having to pay for the forecasted deficit or current generations not reaping enough of their contribution efforts

The mono-cohort normative defined benefit pension plan is defined as the following:

- 100'000 workers aged 25 years old join a closed-end mono-cohort defined benefit pension plan specifically created for them
- Their starting average monthly salary is 1'000 USD, which grows at 3% p.a. The contribution rate is fixed at 20%

- After 35 years, they are offered a replacement rate of 52.5% of their liquidation salary (computed by averaging their revaluated salaries)
- Financial return on investment and salary revalorization rate for computing revised salary are respectively fixed at 5% and 3% per annum, pension indexation rate is fixed at 3% per annum
- The mortality is defined according to a mortality table TV88-90, for which the graph below highlights the probability of survival depending on age

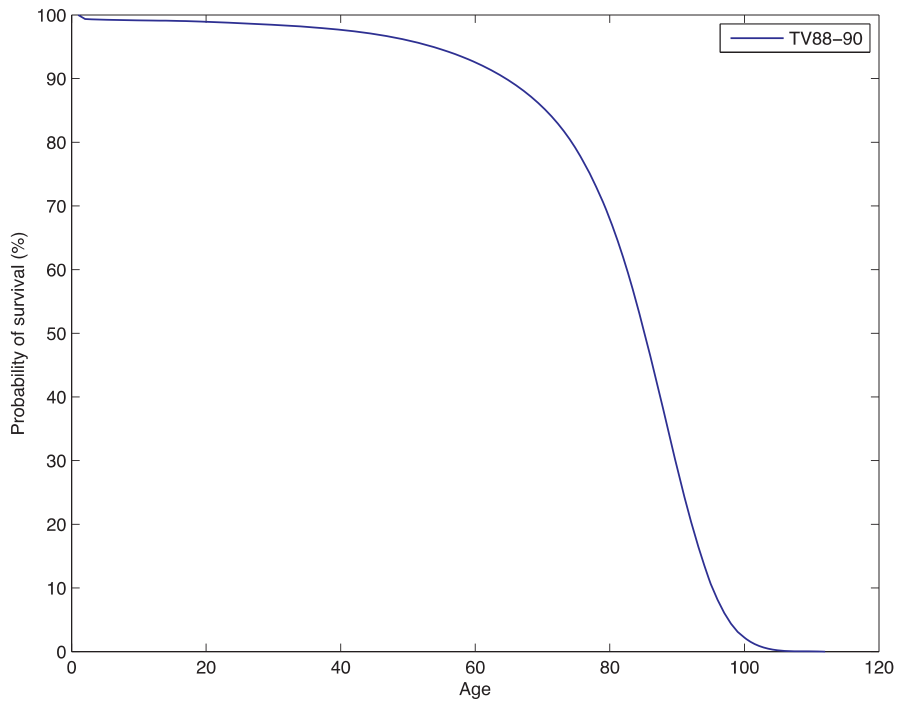

Figure 43.1: Probability of survivorship by age according to the mortality table TV88-90

The main equations for the pension plan are:

$$\text{Financial result}_N = \text{Reserves}_{N-1} \times \text{Financial return}_N$$

$$\text{Contributions}_N = \text{Contribution rate} \times \text{Number of survivors}_N \times \text{unit average salary}_N$$

$$\text{Liquidation Salary} = \frac{\sum_{i=1}^{n} \text{Salary}_i \times (1 + \text{Revaluation rate})^{n-i}}{\text{Working period duration}}$$

$$\text{Pensions}_N = 12 \times \text{Population}_N \times \text{Replacement rate} \times \text{Liquidation Salary}$$
$$` \times (1 + \text{Pension indexation rate})^{N - \text{pension start year}}$$

$$\text{Reserves}_{N+1} = \text{Reserves}_N + \text{Contributions}_N - \text{Pensions}_N + \text{Financial result}_N$$
$$- \text{Administrative cost}_N$$

$$\text{Funding Factor}_N = \frac{\text{Reserves}_N + \text{Discounted futur contributions} - \text{Discounted futur administrative costs}}{\text{Discounted futur pensions}}$$

The different parameters highlighted above are designed in such a way that the pension plan is perfectly equilibrated, i.e. funding factor at initiation of 100%, reserves at extinction 0 and infinite sustainability horizon. The graphs below highlight the evolution of forecasted reserves, contributions, pensions served and financial returns for the pension plan at its initiation:

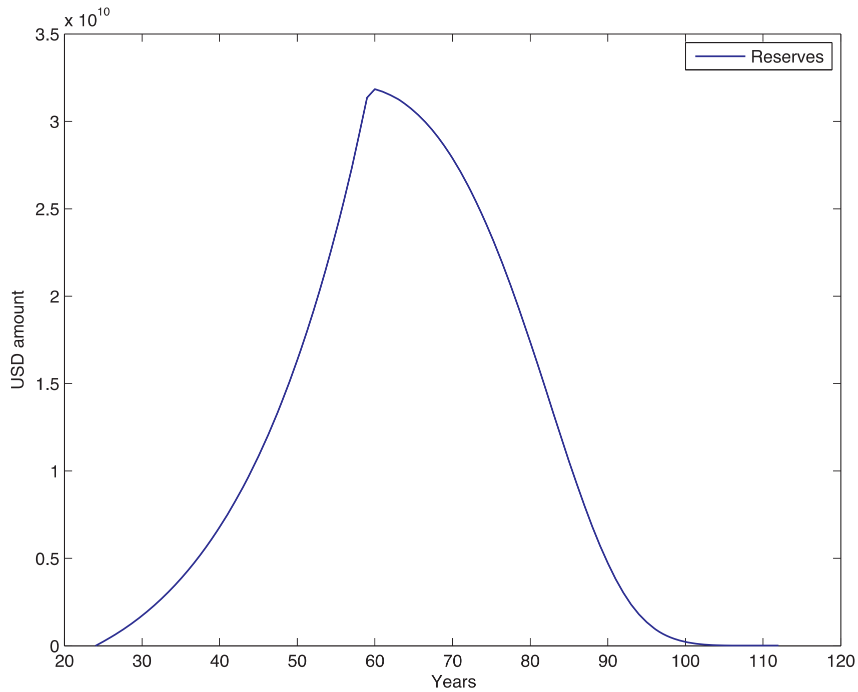

Figure 43.2: Evolution through cohort age of reserves

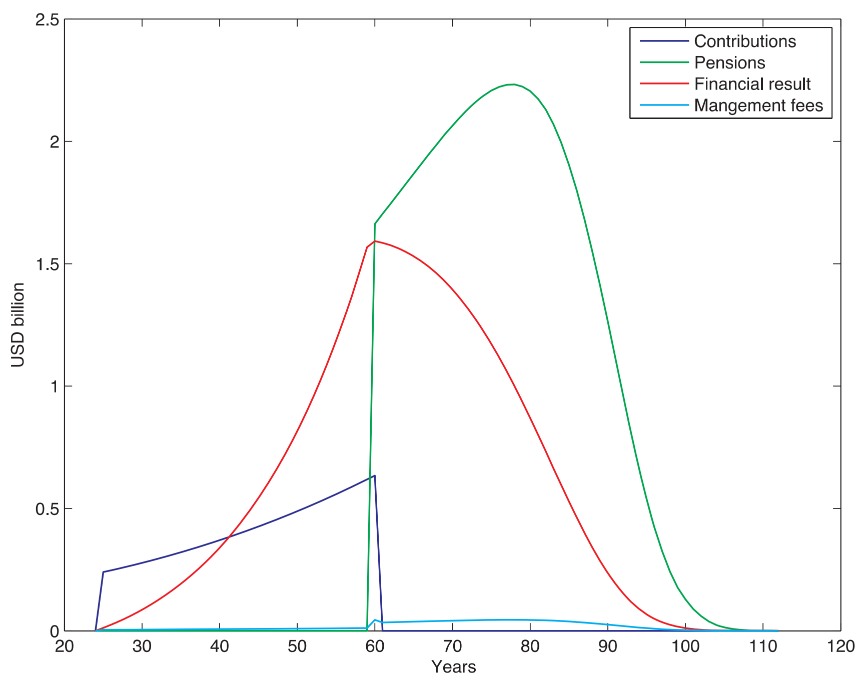

Figure 43.3: Evolution through cohort age of contribution, paid pensions and financial return

The different simulations are voluntarily kept simple by focusing on the main drivers of a pension plan. Several factors are ignored such as infirmity, reversion, etc. The overall key conclusions drawn from a simplified modeling framework will not be affected by non-modeled factors since they behave in a relatively proportional way to the modeled ones.

An additional advantage of normative mono-cohort resides in its ability to quickly compare the generosity level between different pension plans and assess multi-parametric reform scenarios in a simplified, quick and elegant manner.

3.2. Considered Risk Factors and Key Metrics for Evaluation of their Impact on the Pension Plan Sustainability

The mono-cohort defined benefit pension plan explained above is modeled in a deterministic framework, i.e. all the parameters are frozen in the beginning and are expected to materialize accordingly. In the real world, almost all the variables are stochastic with a direct impact on the sustainability outcome of the pension plan.

To illustrate this matter, we propose to model two main risk factors: longevity risk, and investment risk.

3.2.1. Longevity Risk

Longevity risk is modeled by considering that the probability of survival at a certain age might drift in a normal distribution between the 99% corridors highlighted below with the green and red lines while the blue line represents the deterministic assumption. Life expectancy ranges from 78 to 91 while the deterministic case is at 81.

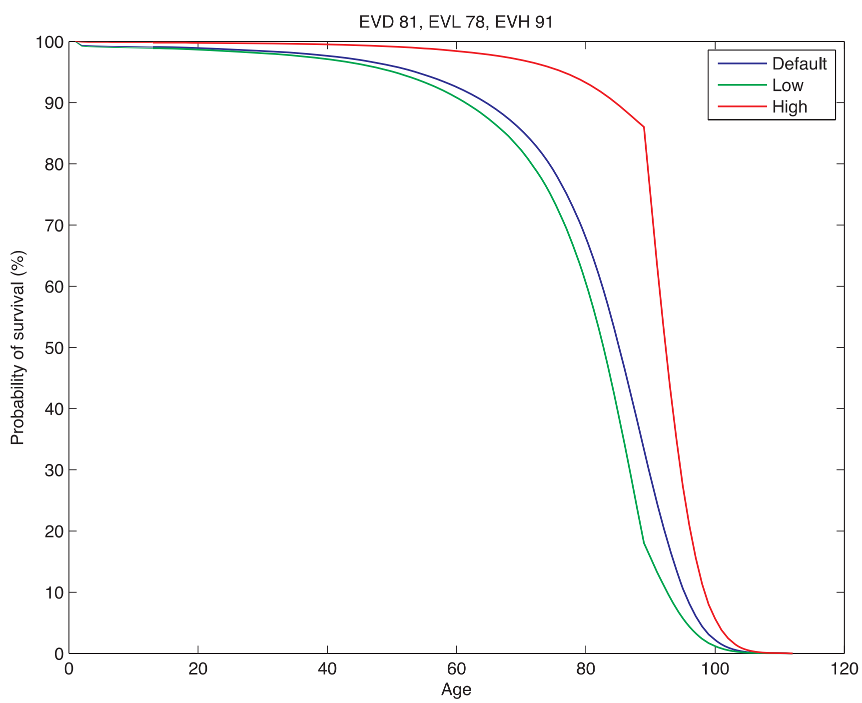

Figure 43.4: Probability of survival corridor representing the longevity risk

3.2.2. *Investment Risk*

The investment risk is modeled through a lognormal return function: $e^{\left(\left(r-\frac{\sigma^2}{2}\right)+\sigma\times G\right)}$, *r* is a long-term trend, σ represents the risk volatility of the financial yearly return component and G a standard normal distribution:

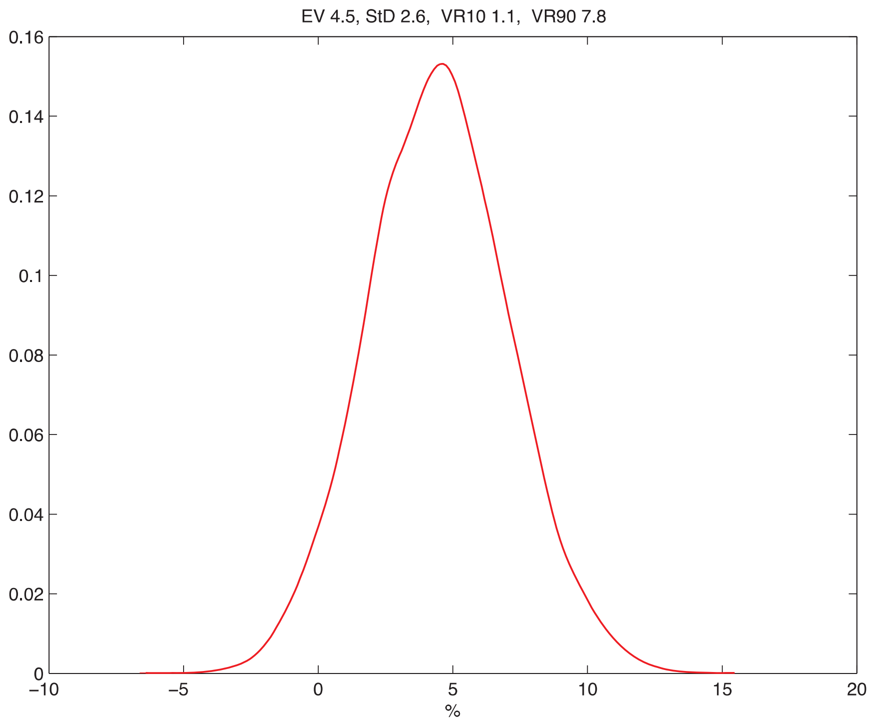

Figure 43.5: Probability distribution of the yearly financial return

3.2.3. *Key Metrics for Evaluation of their Impact on the Pension Plan Sustainability*

To evaluate the sustainability of the pension plan, three key metrics are systematically examined:

- *Reserves at extinction:* representing the value of reserves[1] at the death of the cohort's last survivor. A negative value represents the cash shortage needed to honor the pension plan commitments
- *Sustainability horizon:* representing the age of the cohort at which the reserves become negative and thus the plan bankrupt
- *Implicit sustainability contribution rate:* representing ex post estimate of the contribution rate that should have been in place to yield to a zero reserve value at extinction. Compared to the default contribution rate of 20%, this value highlight in a certain manner the missing effort on the contribution side to cope with materialized risk factors

Those three key metrics will be represented according to their cumulative probability distribution function (or probability distribution function) along with their expected value, standard deviation and value at risk at 10% and 90% (percentile values).

1 Implicit assumption: deficits are funded at 0% interest rate

The graphs below highlight cumulative probability distribution function (CPDF) of the key metrics: reserves at extinction, sustainability horizon and implicit sustainability contribution rate with mortality risk and financial risk activated separately and together.

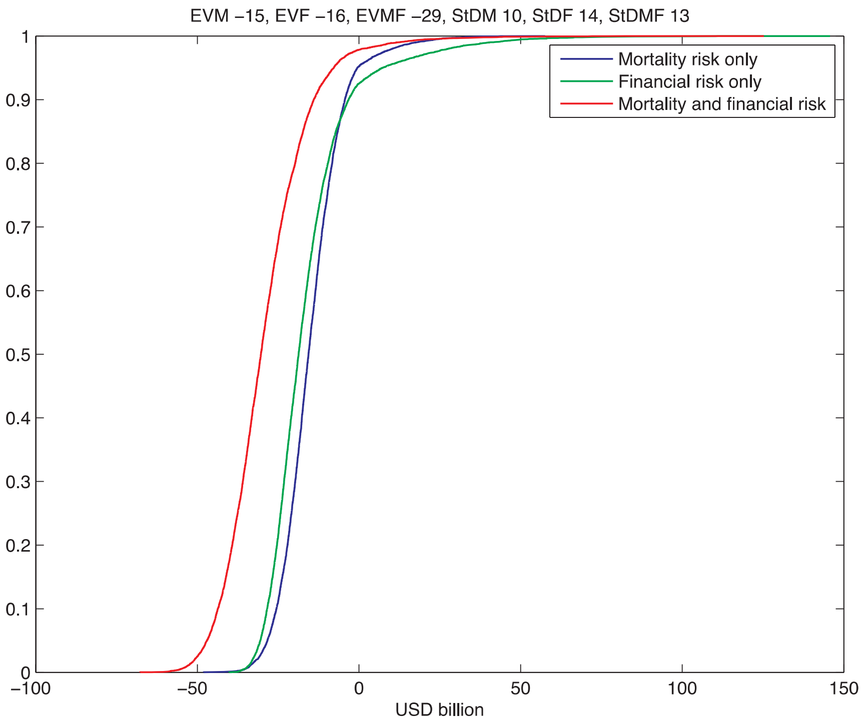

Figure 43.6: CPDF of reserves at extinction (default)

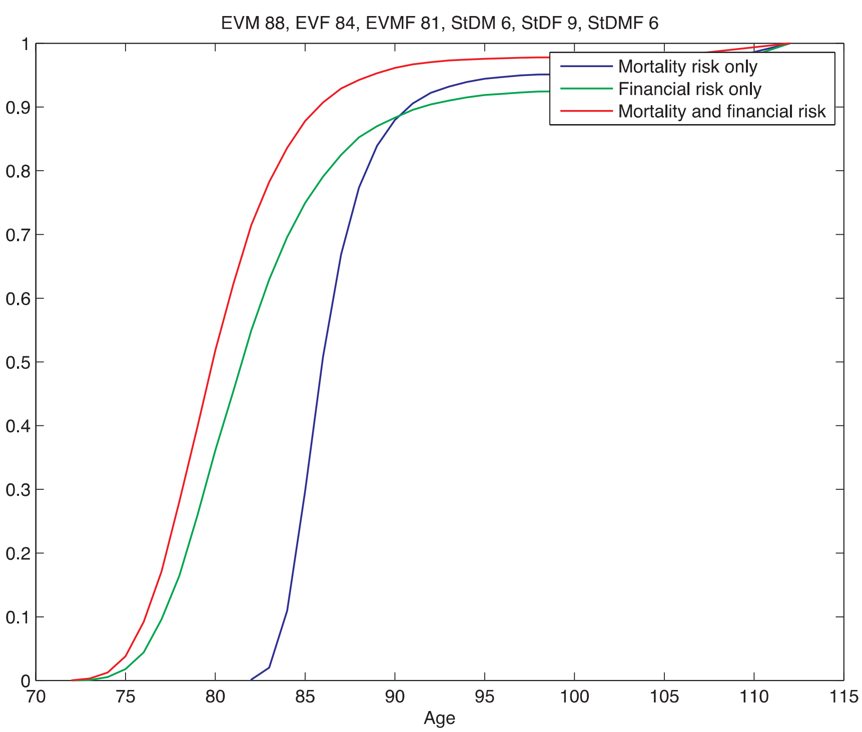

Figure 43.7: CPDF of sustainability horizon (default)

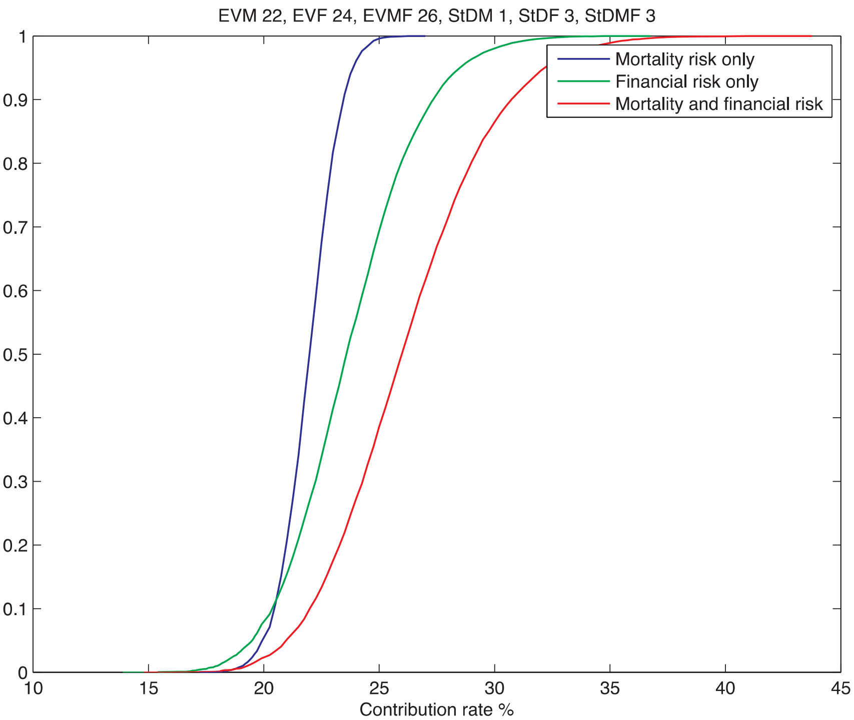

Figure 43.8: CPDF of implicit sustainability contribution rate (default)

The table below summarizes key metrics characteristics for each simulation:

		Default deterministic case	Mortality risk only	Financial risk only	Mortality and financial risk
Reserves at extinction (billion $)	Expected value	0	-15	-16	-29
	Standard deviation	0	10	13	12
	Value At Risk at 10%	0	-25	-28	-42
	Value at Risk at 90%	0	-4	-4	-15
Sustainability horizon (years)	Expected value	112	88	84	81
	Standard deviation	0	6	9	5
	Value At Risk at 10%	112	85	78	77
	Value at Risk at 90%	112	91	91	86
Implicit sustainability contribution rate (%)	Expected value	20	22.1	23.8	26.2
	Standard deviation	0	1.2	2.6	3.2
	Value At Risk at 10%	20	20.5	20.5	22.3
	Value at Risk at 90%	20	23.5	27.3	30.5

The impact of the simulated risk factors is huge on the three key metrics:

- Huge deficit at extinction: between -15 and -29 billion $ on average depending on the simulated risk factors
- Short sustainability horizon with retirees left with no pension starting on average between 81 and 88 years old depending on the simulated risk factors
- Important implicit contribution effort to bring back the situation to equilibrium: on average between 22 and 26% depending on the simulated risk factors
- Besides a central negative tendency, significant risk component as highlighted by both the standard deviation and percentile (value at risk) of the different key metrics, for instance: 77 years old for

the sustainability horizon and 30.5% as an implicit contribution rate for the value at risk 90% with both risks activated

In a nutshell, a pension plan left with no steering approach facing significant risk factors has a significant probability of bankruptcy with either non-desirable social consequences (e.g., retirees left with no pensions) or economical consequences (e.g., state budget making up for realized deficits to the detriments of younger cohorts).

3.3. Simulated Self-adjusting Steering Schemes (SASS)

As we highlighted above, even if a pension plan is perfectly calibrated at its initiation, severe disequilibrium might appear down the road forcing the sponsor of the pension plan (usually government related) to either reform the scheme (parametric: contribution rate, pension level, contribution horizon, etc. or systemic: capitalization, notional account, etc.) or defer the decision later at the detriment of either the state budget (seeking external injections to bring equilibrium to the scheme) or future contributors that will have to cover for wrong past and irresponsible decisions.

Below, we present four potential self-adjusting steering schemes for which the impact is highlighted in the next chapter.

- SASS1: Dynamic adaptation of the working period duration applied to a scenario with longevity risk simulated (stable pensioner ratio)
- SASS2: Dynamic adjustment of revised salary valorization depending on the financial return during the contribution phase with investment risk simulated
- SASS3: Dynamic adaptation of the pension yearly indexation (revaluation rate) depending on the funding status applied to a scenario with investment and longevity risk simulated
- SASS4: Aggregation of the approaches above with longevity and investment risk simulated

4. SELF-ADJUSTING STEERING SCHEMES (SASS) DESCRIPTION AND IMPACT ON THE PENSION PLAN SUSTAINABILITY

4.1. Dynamic Adaptation of the Working Period Duration (SASS1) – Mortality Risk Only

The main idea behind this self-adjusting steering scheme is to keep a certain balance between the number of years spent on retirement (pension payment period) vs. the number of years spent working (contribution period).

If we examine, the several pension reforms conducted in the different countries in the last 20 years, rising the retirement age is one of the most frequent. Its rationale is quite straightforward: due to the continuous rise in life expectancy, a structural imbalance is created and the best instrument to correct it is to adapt the working period.

For each simulation path, we consider that at the age 60 we will have a more precise estimate of the future mortality. The graph below highlights the probability distribution of the resulting difference of life expectancy at 60 between real future outcome and the estimated one:

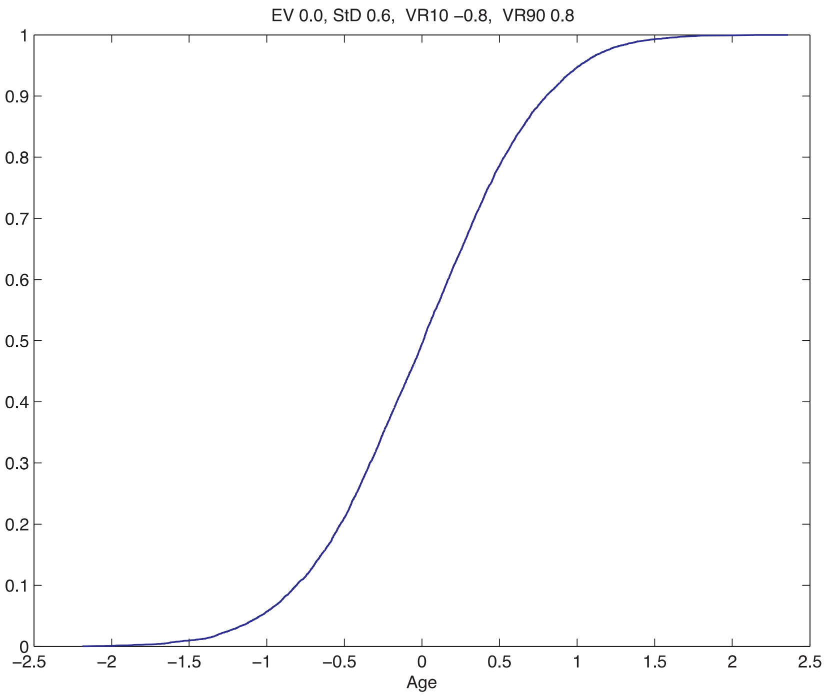

Figure 43.9: CPDF of Life expectancy estimate gap at 60 years old

Thanks to the new estimated mortality table a ratio of total number of years spent on pension for the whole cohort divided the total number of years spent working for the whole cohort depending on the retirement start age (from 60 to 65) is computed. The retirement start age is selected so that the value of this ratio at this age is close to the value of the same ratio in the default configuration with a retirement start age of 60. The graph below shows the resulting cumulative probability distribution function of the retirement start age:

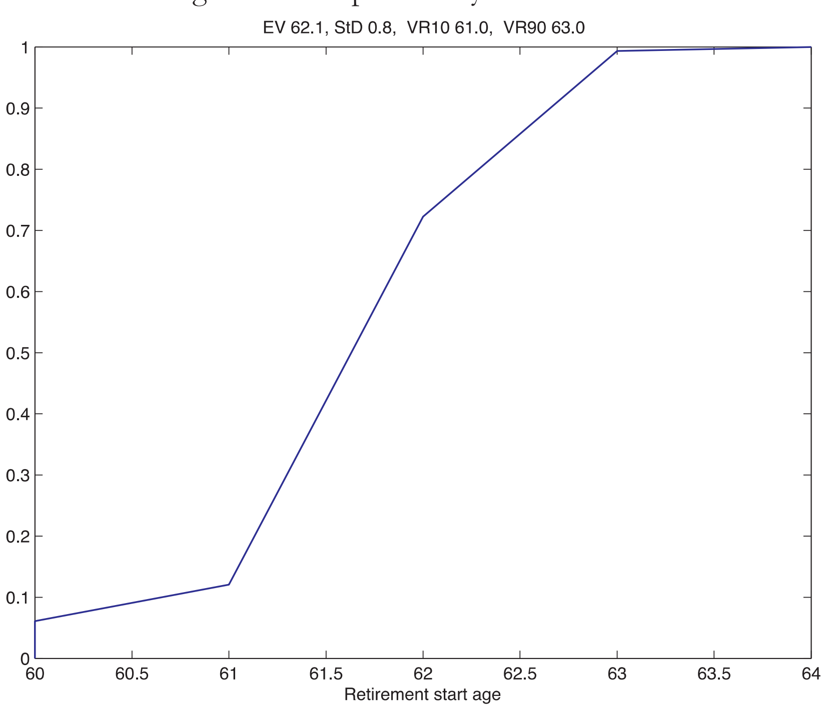

Figure 43.10: CPDF of retirement start age (SASS1)

As a result, as highlighted in the following graphs the sustainability of the pension plan is significantly improved:

- Expected value of reserves at extinction sustainability horizon and implicit sustainability contribution rate respectively improved from –15 billion \$ to –2 billion \$, 88 years to 97 years and 22.1% to 20.5%

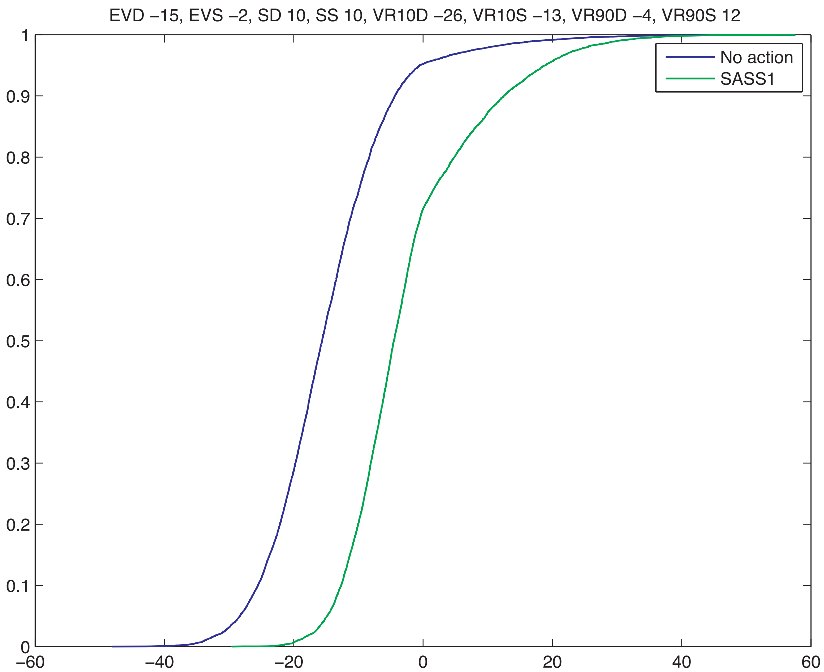

Figure 43.11: CPDF of reserves at extinction (SASS1 – mortality risk only)

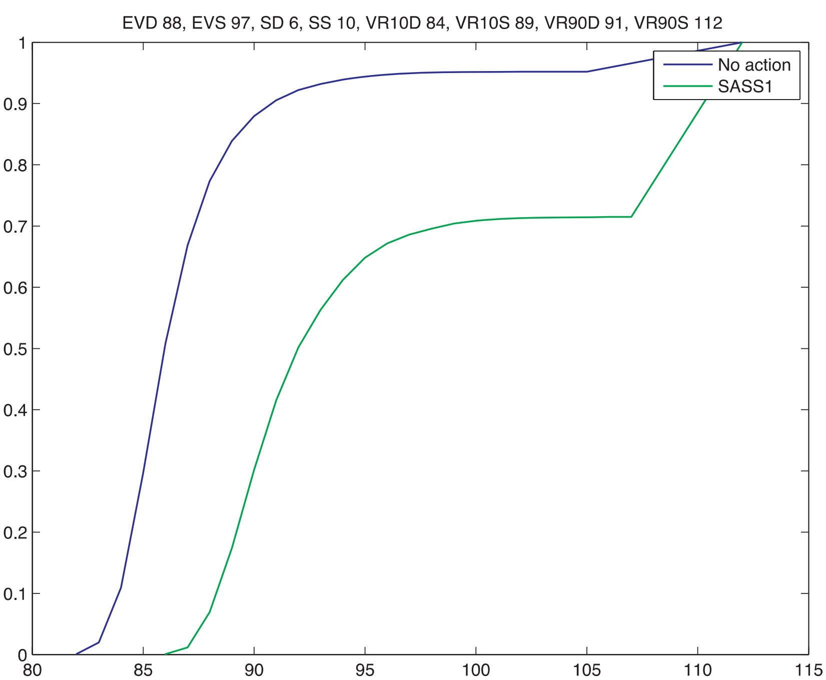

Figure 43.12: CPDF of sustainability horizon (SASS1 – mortality risk only)

- Strong mitigation of tail risk with for instance the 90% percentile of extinction sustainability horizon and implicit sustainability contribution rate respectively improved from 85 years to 89 years and 23.5% to 21.5%

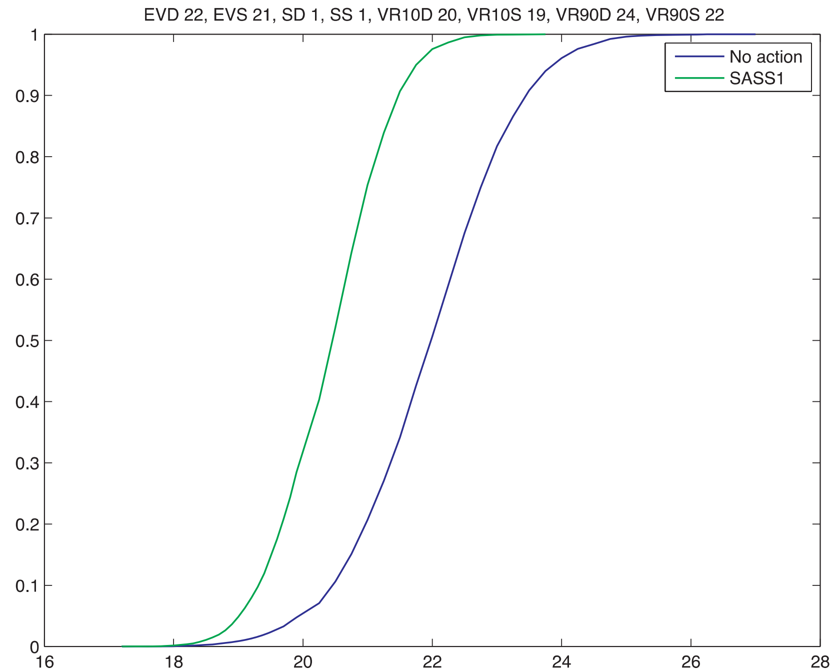

Figure 43.13: CPDF of implicit sustainability contribution rate (SASS1 – mortality risk only)

4.2. Dynamic Adjustment of Revised Salary Valorization Depending on the Financial Return During the Contribution Phase (SASS2) – Financial Risk Only

Financial risk is activated and resulting risk is significantly mitigated by indexing yearly salary valorization on the gap between expected financial return and realized financial return as it is shown by the next formulae.

$$\text{Default Liquidation Salary} = \frac{\sum_{i=1}^{n} \text{Salary}_i \times (1 + \text{Revaluation rate})^{n-i}}{\text{Working period duration}}$$

$$\text{New Liquidation Salary} = \frac{\sum_{i=1}^{n} \text{Salary}_i \times \prod_{k=n-i}^{n} (1 + \text{Revaluation rate} + \text{Real financial return}_k - \text{default financial return}}{\text{Working period duration}}$$

The liquidation salary upon which the pension is computed is on average equal to 84% of the default case, below its probabilistic distribution:

As a result, as highlighted in the following graphs the sustainability of the pension plan is significantly improved:

- Expected value of reserves at extinction sustainability horizon and implicit sustainability contribution rate respectively improved from –16 billion \$ to –7 billion \$, 84 years to 90 years and 23.8% to 21.6%

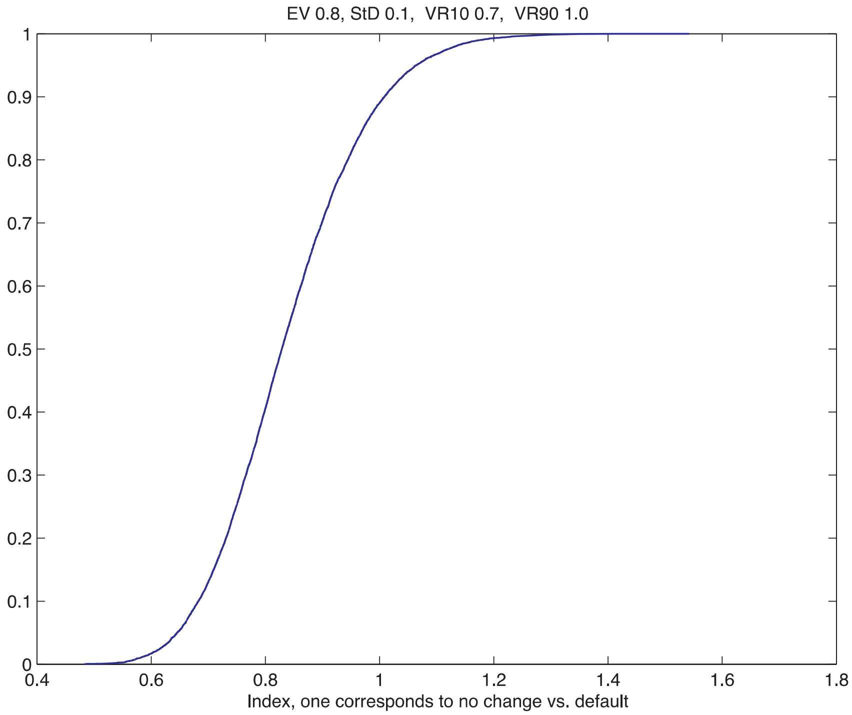

Figure 43.14: CPDF of salary valorization index with respect to default case (SASS2 – financial risk only)

- Strong mitigation of tail risk with for instance the 90% percentile of extinction sustainability horizon and implicit sustainability contribution rate respectively improved from 78 years to 82 years and 27.3% to 23.8%

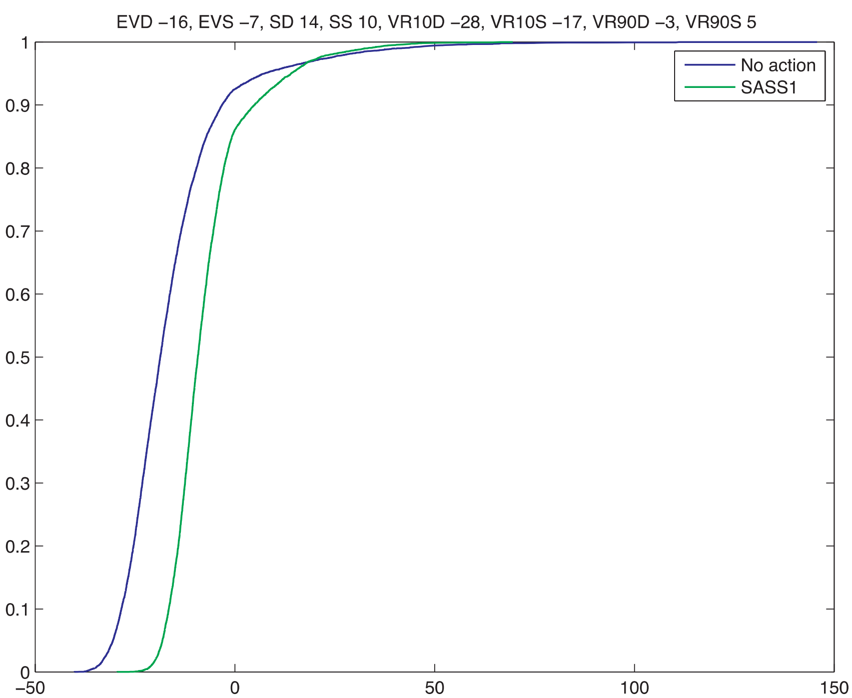

Figure 43.15: CPDF of reserves at extinction (SASS2 – financial risk only)

- Important reduction of the overall risk as indicated by the standard deviation of reserves at extinction that evolves from 13 to 10 billion $

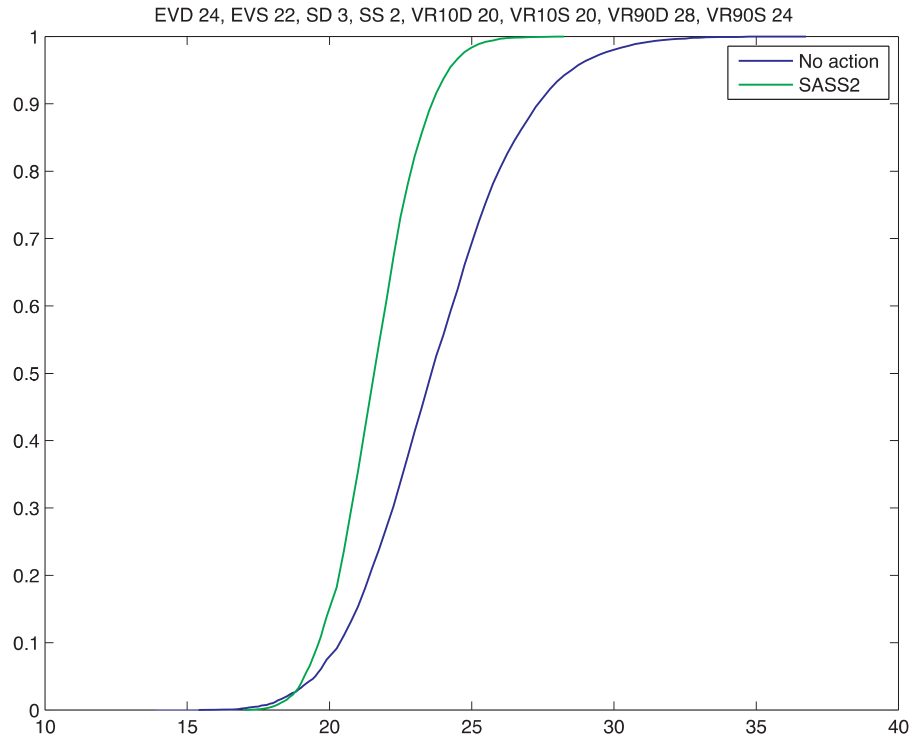

Figure 43.16: CPDF of implicit sustainability contribution rate (SASS2 – financial risk only)

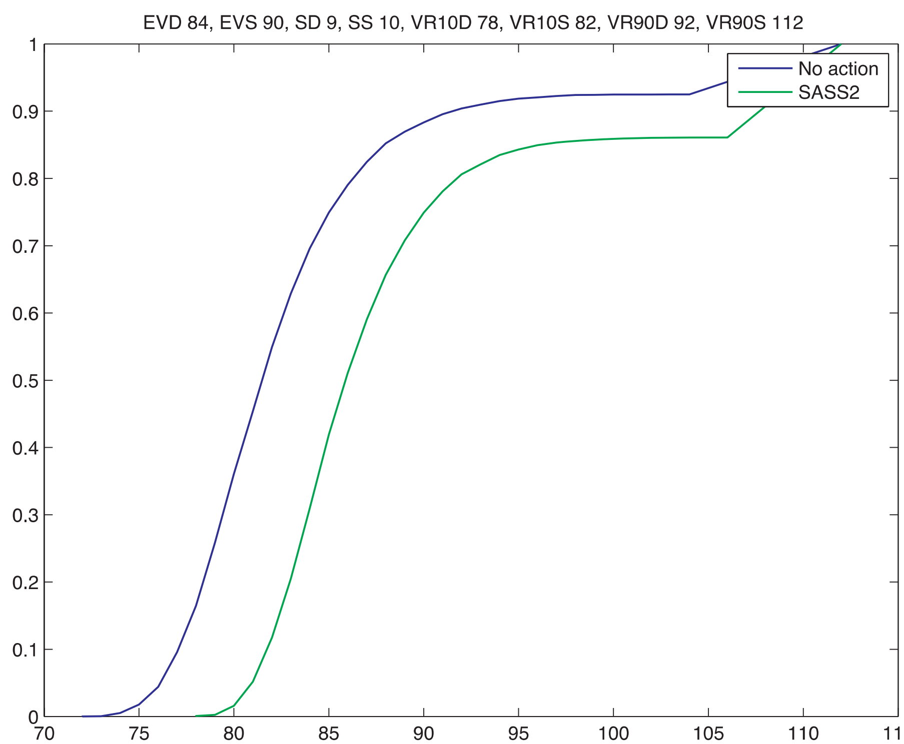

Figure 43.17: CPDF of sustainability horizon (SASS2 – financial risk)

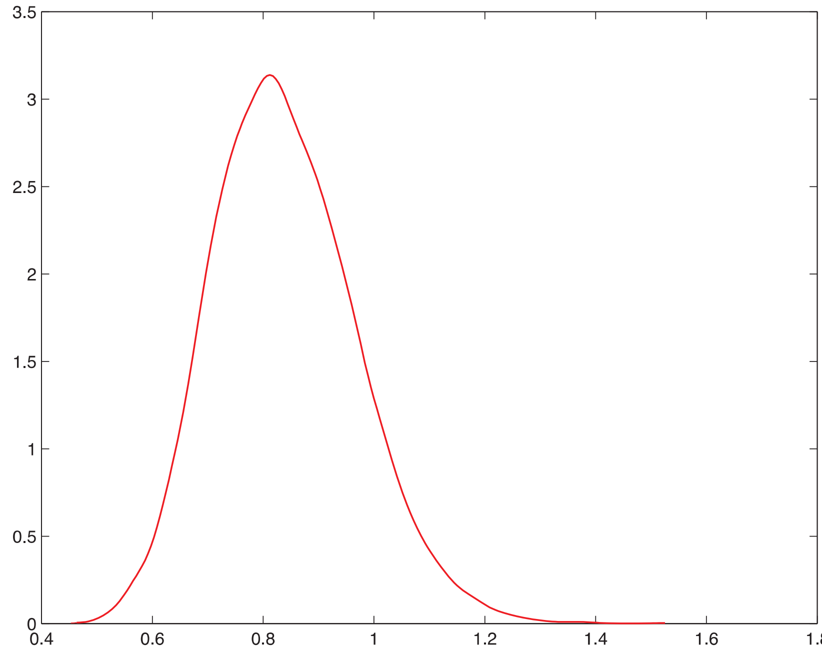

Figure 43.18: Probability distribution function of valorization index (SASS2 – financial risk)

4.3. Dynamic Adaptation of the Pension Yearly Indexation (Revaluation Rate) Depending on the Funding Status (SASS3) – Financial and Mortality Risk

In this scenario financial and mortality risk are activated, both retirement age and liquidation salary are kept according to the default case while the pension indexation is reviewed yearly according to the estimated funding factor as per the following graph. For instance, if the funding factor at year X is below 80% the pension indexation rate would be at 1.5% whereas if the same ratio were 120%, the pension indexation would be 4.5%.

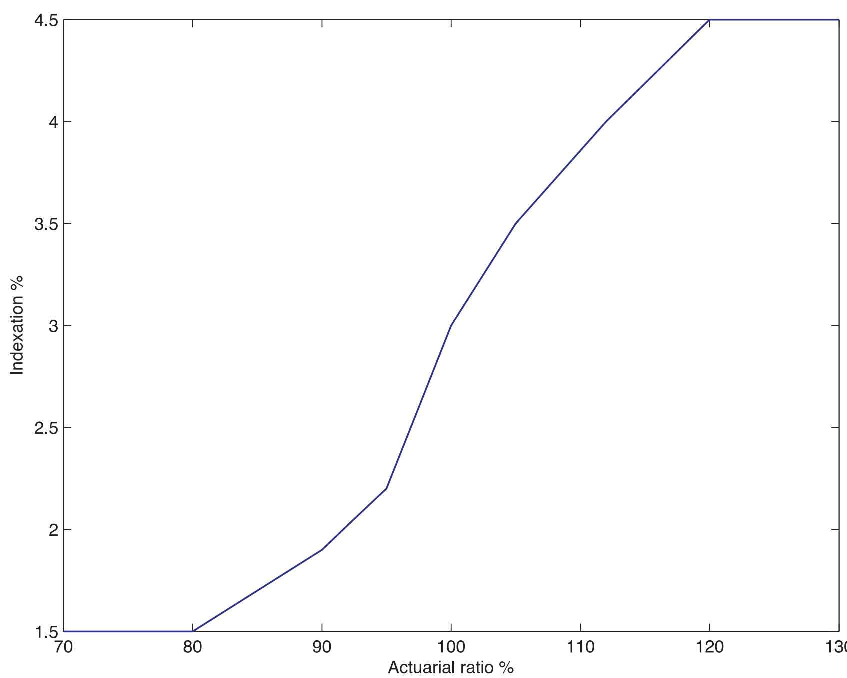

Figure 43.19: Indexation percentage as a function of funding factor (SASS3 – mortality and financial risk)

Below is the resulting cumulative probability distribution of the yearly indexation. Except for few cases, the bulk of scenarios are adjusted to a yearly indexation around 1.5% (vs. 3%in the default case) with an average value at 1.7% and a standard deviation of 0.4%.

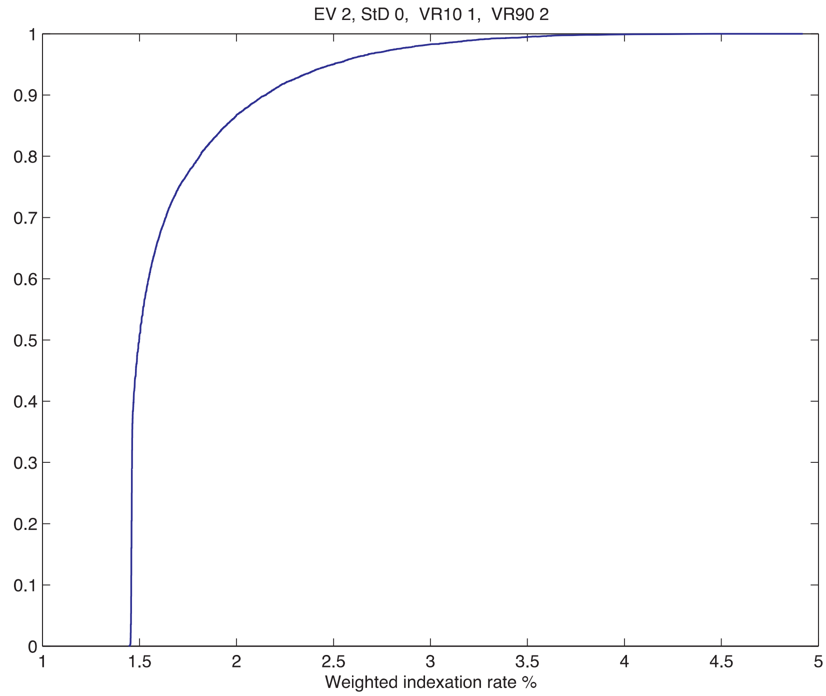

Figure 43.20: CPDF of pension indexation (SASS3 – mortality and financial risk)

Consequently, as highlighted in the following graphs, the sustainability of the pension plan is significantly improved with:

- Expected value of reserves at extinction sustainability horizon and implicit sustainability contribution rate respectively improved from –29 billion $ to –11 billion $, 81 years to 87 years and 26.2% to 22.3%
- Strong mitigation of tail risk with for instance the 90% percentile of extinction sustainability horizon and implicit sustainability contribution rate respectively improved from 77 years to 80 years and 30.5% to 25.0%
- Drastic reduction of the overall risk as indicated by the standard deviation of reserves at extinction that evolves from 12 to 7 billion $

4.4. Aggregated Impact (SASS4) – Financial and Mortality Risk

In the last scenario, mortality and financial risk are activated and all adjustment levers are implemented: adjusting retirement start age, salary valorization and pension indexation.

The resulting values for retirement start age and salary valorization are the same as respectively SASS1 and SASS2, whereas pension indexation resulting distribution probability is significantly different from the case of SASS3 since the required effort to reach equilibrium is reduced thanks to other adjustments. The average value is 2.4% vs. 1.7% in SASS3.

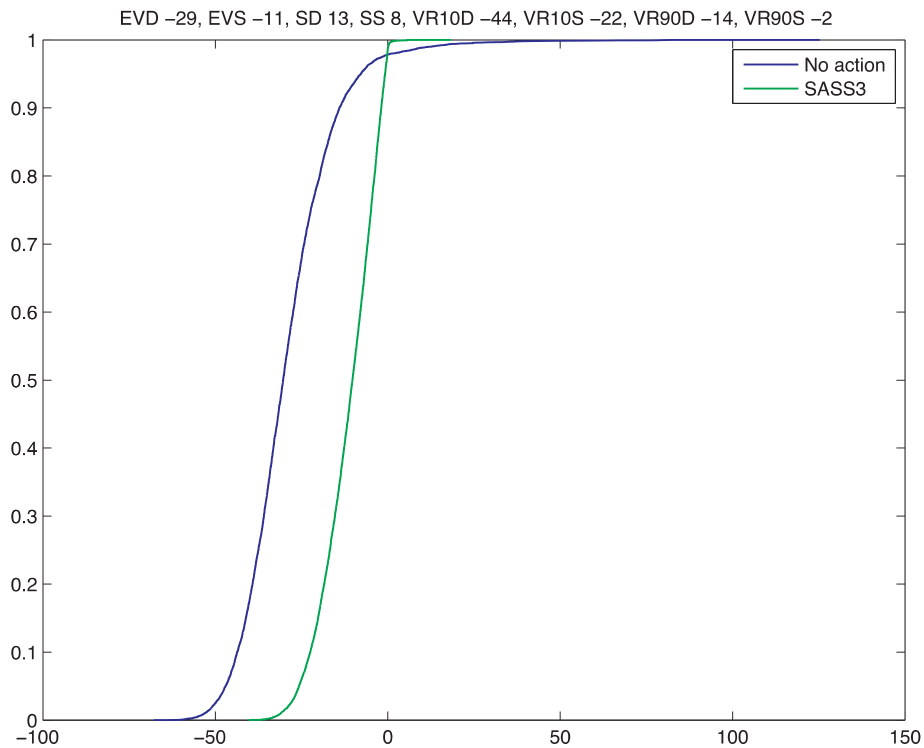

Figure 43.21: CPDF of reserves at extinction (SASS3 – mortality and financial risk)

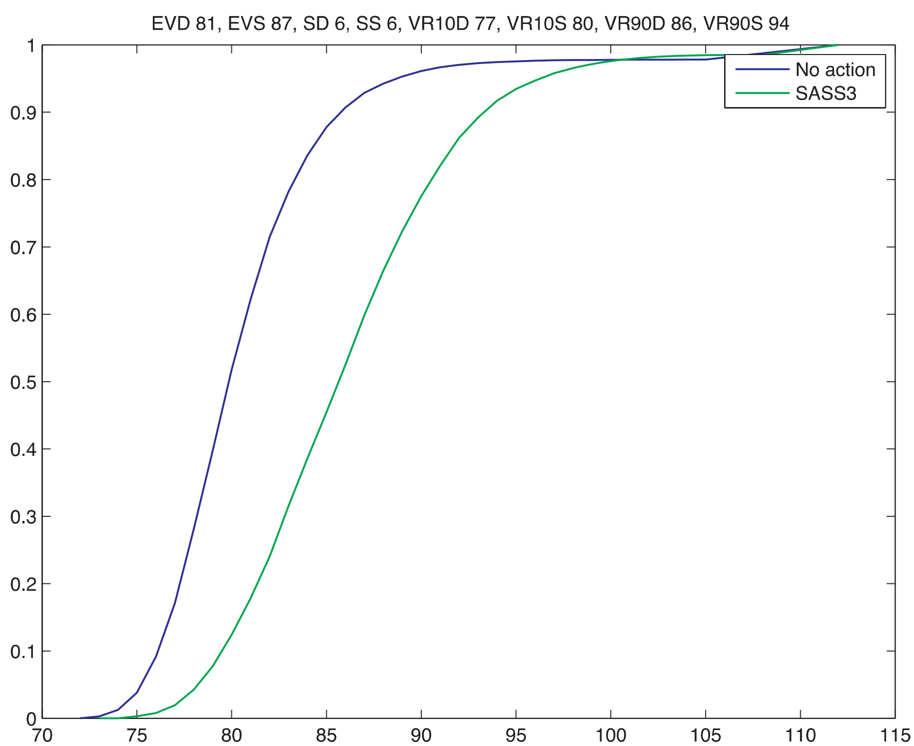

Figure 43.22: CPDF of sustainability horizon (SASS3 – mortality and financial risk)

Consequently, as highlighted in the following graphs, the sustainability of the pension plan is significantly improved:

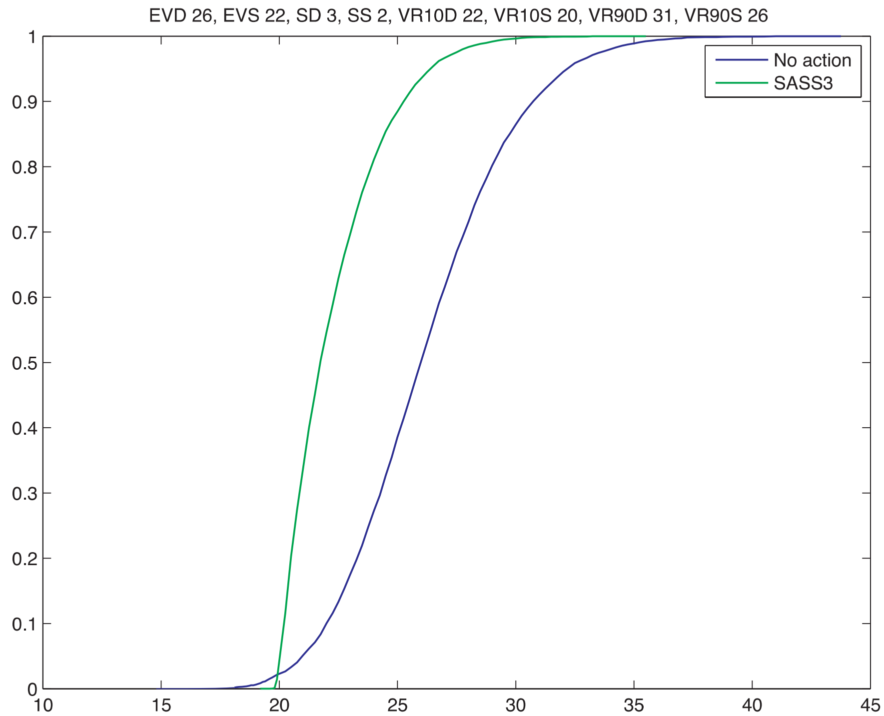

Figure 43.23: CPDF of implicit sustainability contribution rate (SASS3 – mortality and financial risk)

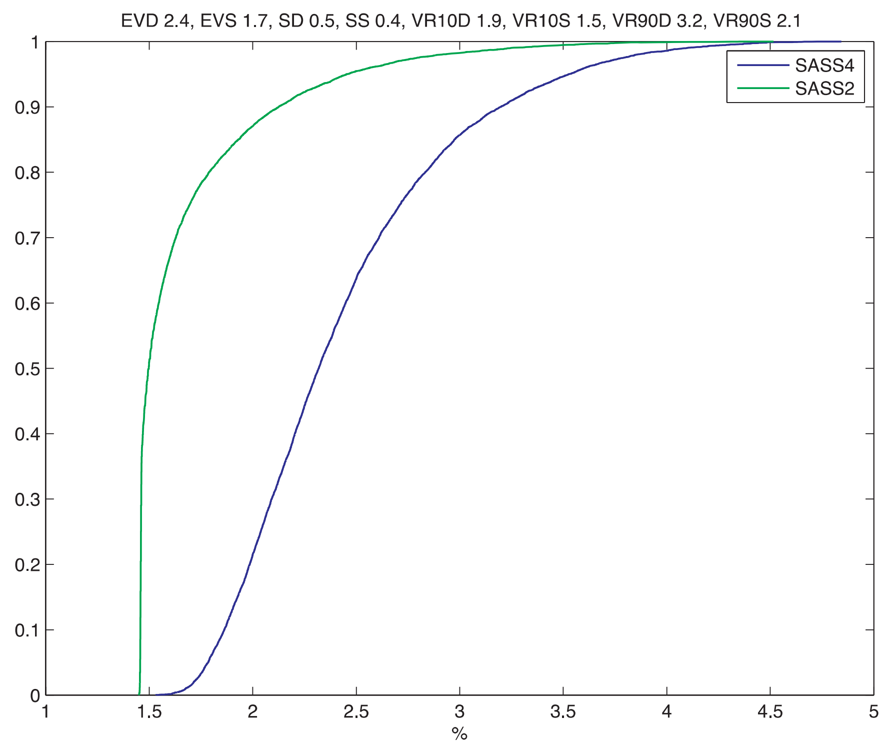

Figure 43.24: CPDF of yearly indexation SASS4 vs. SASS3 (mortality and financial risk)

- Expected value of reserves at extinction sustainability horizon and implicit sustainability contribution rate respectively improved from –29 billion \$ to –3 billion \$, 81 years to 95 years and 26.2% to 20.6%

- Huge mitigation of tail risk with for instance the 90% percentile of extinction sustainability horizon and implicit sustainability contribution rate respectively improved from 77 years to 89 years and 30.5% to 21.3%
- Huge reduction of the overall risk as indicated by the standard deviation of reserves at extinction that evolves from 12 to 3 billion $

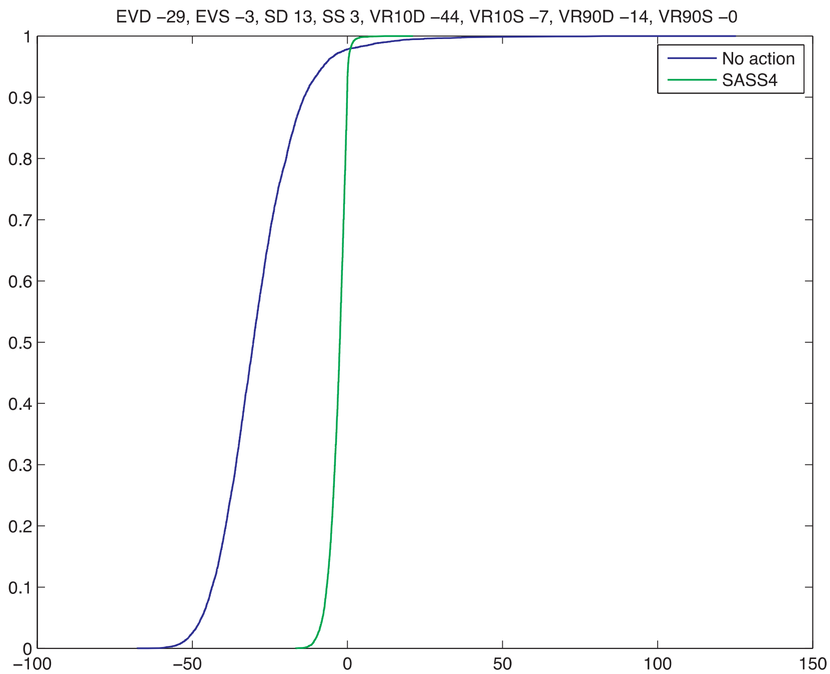

Figure 43.25: CPDF of reserves at extinction (SASS4 – mortality and financial risk)

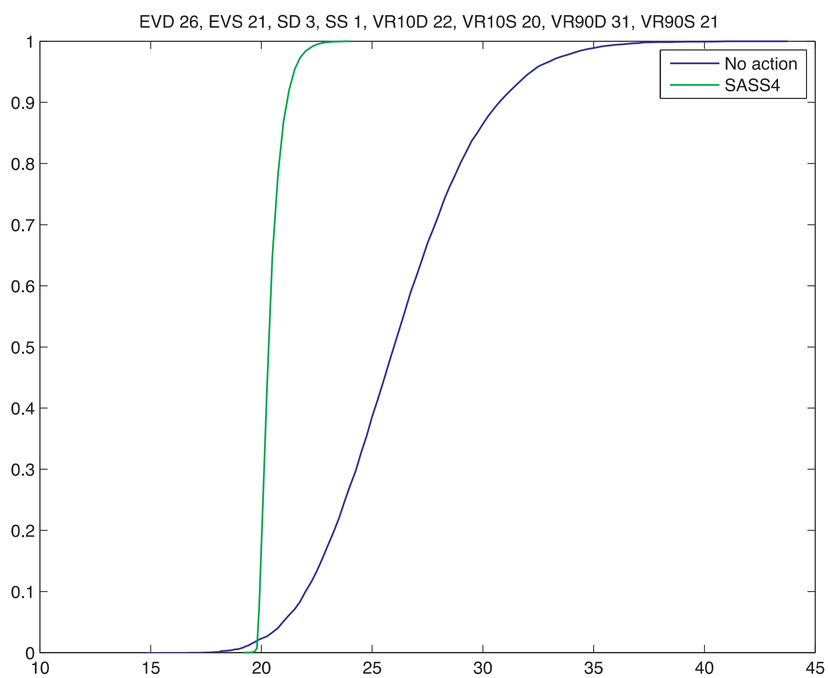

Figure 43.26: CPDF of sustainability horizon (SASS4 – mortality and financial risk)

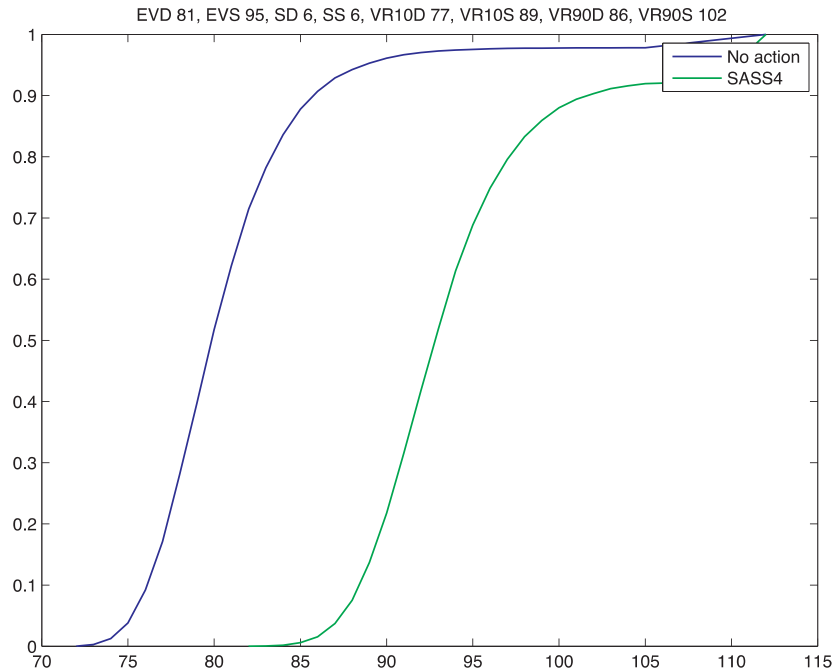

Figure 43.27: CPDF of sustainability horizon (SASS4 – mortality and financial risk)

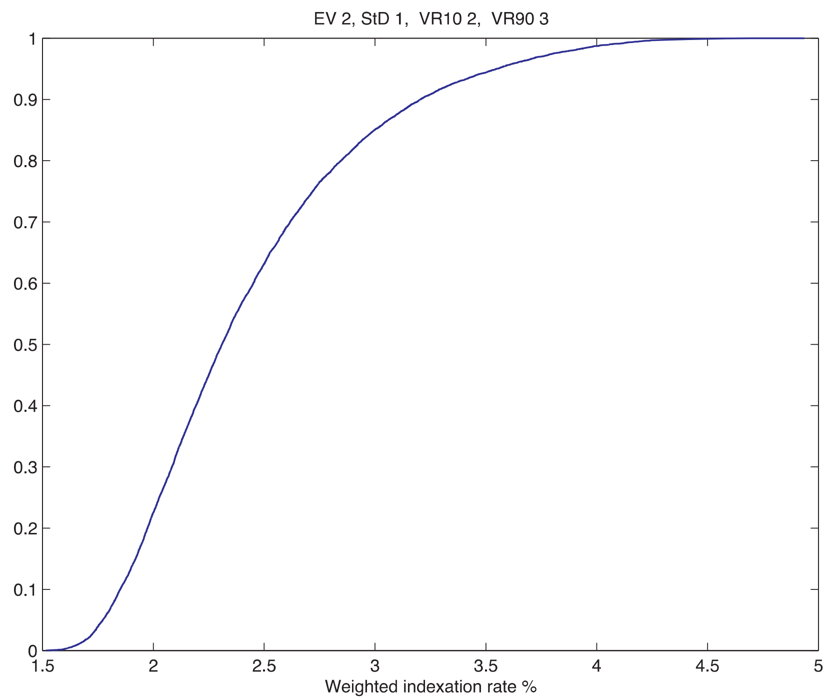

Figure 43.28: CPDF of pension indexation (SASS4 – mortality and financial risk)

4.5. Synthesis

The tables below summarize the values of key identified metrics (reserves at extinction, sustainability horizon and implicit sustainability contribution rate) as well as on the activated steering parameters in the different SASS (retirement start year, valorization of salaries and pension indexation):

		Default deterministic case	Mortality risk only	SASS1	Financial risk only	SASS2	Mortality and financial risk	SASS3	SASS4
Reserves at extinction (billion $)	Expected value	0	-15	-2	-16	-7	-29	-11	-3
	Standard deviation	0	10	10	13	10	12	7	3
	Value At Risk at 10%	0	-25	-12	-28	-16	-42	-21	-7
	Value at Risk at 90%	0	-4	12	-4	5	-15	-2	0
Sustainability horizon (years)	Expected value	112	88	97	84	90	81	87	95
	Standard deviation	0	6	10	9	10	5	6	6
	Value At Risk at 10%	112	85	89	78	82	77	80	89
	Value at Risk at 90%	112	91	112	91	112	86	94	104
Implicit sustainability contribution rate (%)	Expected value	20	22.1	20.5	23.8	21.6	26.2	22.3	20.6
	Standard deviation	0	1.2	0.9	2.6	1.5	3.2	1.9	0.5
	Value At Risk at 10%	20	20.5	19.4	20.5	19.7	22.3	20.3	20.3
	Value at Risk at 90%	20	23.5	21.5	27.3	23.8	30.5	25,0	21.3

		Default determinitic case	SASS1	SASS2	SASS3	SASS4
Retirement start year (years)	Expected value	60	62.1	60	60	62.1
	Standard deviation	0	0.8	0	0	0.8
	Value At Risk at 10%	60	61.0	60	60	61,0
	Value at Risk at 90%	60	63.0	60	60	63.0
Salary valorization Index	Expected value	1	1	0.8	1	0.8
	Standard deviation	0	0	0.1	0	0.1
	Value At Risk at 10%	1	1	0.7	1	0.7
	Value at Risk at 90%	1	1	1,0	1	1,0
Pension weighted average indexation rate (%)	Expected value	3	3	3	1.7	2.5
	Standard deviation	0	0	0	0.4	0.5
	Value At Risk at 10%	3	3	3	1.5	1.9
	Value at Risk at 90%	3	3	3	2.2	3.2

The main conclusions are:

- Embedded risk level in pension plan liability management is significant be it on central tendency or extreme values
- Self adjusting steering schemes provides a powerful tool characterized by a high agility level as shown in the above simulations, since each path has an adapted steering approach
- Combining several steering parameters allows for a very satisfying end result on central tendency and overall risk mitigation

5. COST OF INACTION

Due to the number of involved stakeholders (government, unions, workforce, parliament, etc.) and the importance of the resulting impacts, pension plan reforms are generally done (if implemented) within a significantly long time frame between problem observation, reform initiation and implementation.

The main issue is that pension plan disequilibrium usually behaves likes a snowball, i.e., as soon at it appears, if not taken care of, the imbalance grows significantly with each year of inaction. Inaction simply means that every imbalance not corrected for in a certain cohort will have to be supported by future generations and hence the burden accumulates and is completely transferred as a result of inaction. In this context, implementing an automatic self-adjusting scheme since the inception of the pension plan design substantially protects its sustainability.

5.1. Mono-cohort Cost of Inaction

In the above simulation one clear cost of inaction relates to SASS1 and SASS2, which can only be implemented at the retirement start date. Comparing SASS3 and SASS4 (whose only difference is taking into account SASS1 and SASS2 on the top of SASS3), it appears that:

- The residual risk level is much higher in case SASS1 and SASS2 are not activated (standard deviation of reserves at extinction of 7 billion $ in SASS3 vs. 3 billion $ in SASS4)
- The required effort on the indexation is significantly higher on SASS3 vs. SASS4 (on average 1.7% vs. 2.5%)

Another approach to evaluate the cost of inaction within this article's modeling framework would be to examine the difference between SASS3 implemented right after the retirement and SASS3 implemented with a 10 years of delay with exactly the same rules.

The graph below shows that with 10 years of delay SASS3 lose around half of its adjustment potential on correcting the average reserve value at extinction (respectively –11, –20 and –29 billion $ for SASS3, SASS3 with 10 years of delay and default case) and reducing residual risk in terms of standard deviation (respectively 8, 10 and 13 billion USD for SASS3, SASS3 with 10 years of delay and default case).

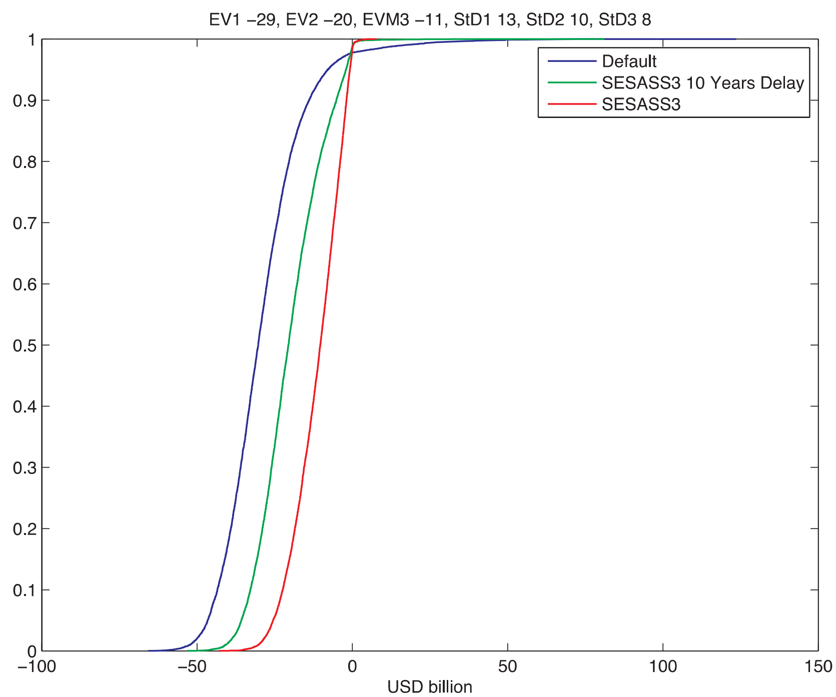

Figure 43.29: CPDF of reserve at extinction comparing default case, SASS3 with 10 years implementation delay and SASS3 (mortality and financial risk)

5.2. Multi-cohort Cost of Inaction

To correctly apprehend the cost of inaction, it is necessary to adopt a multi-cohort view. One powerful message would be that the cost of inaction grows at a pace proportional to the square of inaction time divided by two. This rule of thumb could be explained as follows:

- Suppose a multi-cohort pension plan is correctly functioning until a disequilibrium is observed
- The first year, the generated imbalance would only affect the retiring cohort for one year (1 year of impact)
- The next year, it will affect the cohort which is today retiring in one years for one year and affect for two years the cohort retiring immediately (1 + 2 years of impact)
- The year after, it will affect the cohort which is today retiring in two years for one year, affect the cohort which is today retiring in one years for two years and affect for three years the cohort retiring immediately (1 + 2 + 3 years of impact) and thus:

$$\sum_{k=1}^{n} k = \frac{n \times (n+1)}{2}$$

6. QUANTIFYING THE IMPACT OF SELF-ADJUSTING STEERING SCHEMES ON THE BENEFICIARIES AND DISCUSSION OF THEIR OVERALL FAIRNESS

The different self-adjusting levers highlighted above significantly enhance the sustainability of the pension plan. This significant risk mitigation is a result of a clear and voluntary transfer of risk between sponsor (e.g. government) and the workers and pensioners. Indeed, below, we explicit the impact of each self-adjusting steering mechanism:

- Dynamic adaptation of the working period duration (SASS1): the contribution phase duration is extended whereas the pension phase duration is reduced in case the forecasted life expectancy at the age of 60 is above the hypothesis upon which the design of the pension plan was carried out
- Dynamic adjustment of revised salary valorization depending on the financial return during the contribution phase (SASS2): the starting pension level might be adjusted upward or downward depending on financial returns during the contribution phase
- Dynamic adaptation of the pension yearly indexation (revaluation rate) depending on the funding status (SASS3): risk of pension level being indexed significantly below what is expected in the beginning which might imply a loss of purchasing power on pensioners during their retirement period

With a "state does it all" mindset, it is clear that any kind of reform that might reduce the benefits will be considered unfair. Nevertheless, we consider self-adjusting steering schemes not only fair but also necessary since they contribute to maintaining equilibrium in the implicit contract between generations by avoiding the transfer of non-funded debt from one generation to another. We believe the following rules can increase the mechanism's acceptability and likelihood of success:

- Clear and understandable mechanism, both with regards to the underlying economics and to the potential impact on the different stakeholders
- Known at the beginning or implemented with progressivity

- Relatively small change between cohorts allowing for a certain level of predictability
- Existence of a steering committee to continuously evaluate relevance and propose adjustments if needed

7. CONCLUSION

Pension plans concentrate a huge quantity of fast-moving risks and suffer a very low agility to mitigate them. Automatic steering schemes are definitely part of the solution, they offer four highly desirable features: predictability, small steps, tailor-made and to a certain extent political independence. Probabilistic approaches allow for evaluating the scope of possible outcomes when facing potential risks with a status quo strategy. They are also a way to identify and design Self-Adjusting Steering Schemes with a focus on improving sustainability and evaluating the cost of inaction be it in terms of expected loss or total non hedged risk.

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