CPB Netherlands Bureau for Economic Policy Analysis

CPB Background Document | September, 2015

CPB Asset Liability Management Model for Pension Analyses

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1 Introduction[1]

CPB uses an Asset Liability Management (ALM) model to analyse the effects of policies concerning the second pillar of the Dutch pension system. Policy makers and stakeholders are interested to what extent proposed policy changes (hereafter: 'contract' or 'pension contract') lead to an adequate and stable pension, and whether changes lead to redistribution between generations. The ALM model is designed to answer these questions quantitatively. Though some of the policy variables the model considers are at the discretion of individual fund boards, the model analysis is confined to a representative pension fund for clarity.

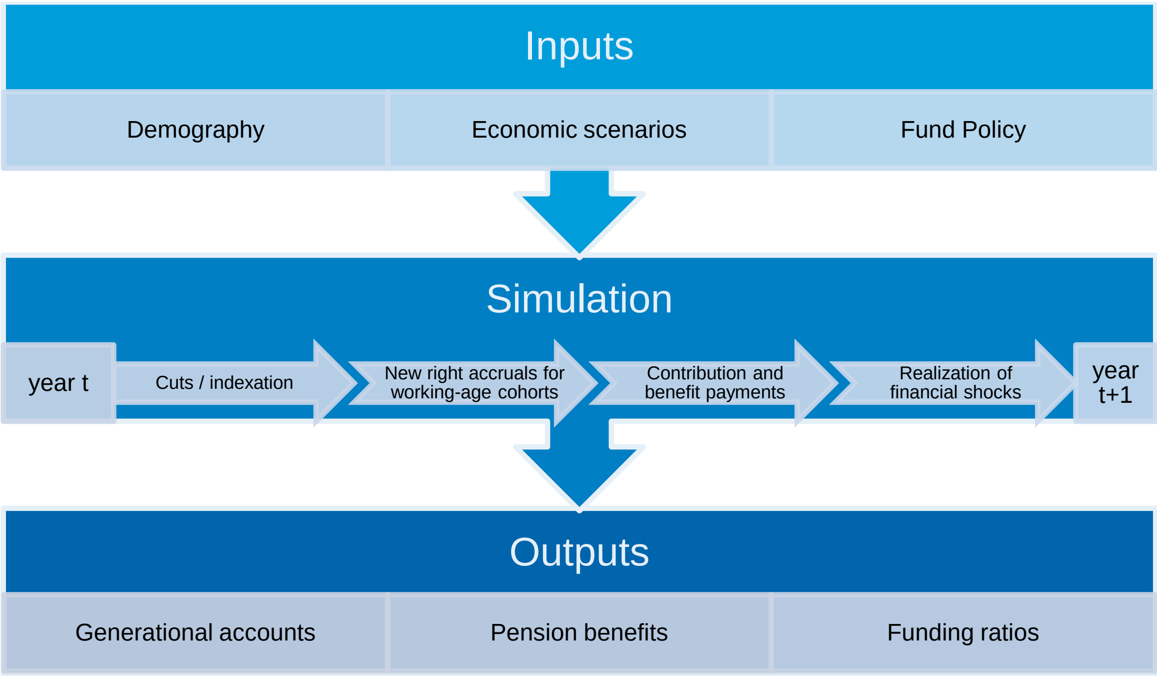
The pension results of individual participants depend on demographic and financial developments. Pension benefits are higher if returns on savings perform well; high inflation rates make it costly to maintain the same purchasing power during retirement, as inflation erodes the real value of accumulated pension wealth. As a result of uncertainty in interest rates, stock returns and inflation, future benefit payments and purchasing power are also uncertain.

The ALM model was first designed to evaluate the effects of initial proposals of the Pension Agreement of 2013 (Lever, Mehlkopf and van Ewijk, 2012). The current version is specifically tailored to analyse proposed reforms to the Dutch solvency framework for pension funds which became effective in January 2015 (hereafter: 'nFTK'), but can also handle more generic collective contracts, as well as individual contracts in which each age cohort has its own retirement account and in which there is no intergenerational risk sharing.

The ALM model shows how pension payments, contributions and other outcomes of interest develop for a range of economic and demographic scenarios, given the policy of the pension fund. It can return both average and median outcomes, as well as what happens in extreme scenarios. The model can also analyse whether proposed policy changes lead to ex-ante redistributions between generations in terms of market value (see Draper et al. 2014 for an application). Figure 1.1 provides a schematic overview of the model.

[1]Jan Bonenkamp, Mark Brussen, Michiel Hagedoorn, Pascal Janssen, Roel Mehlkopf and Andre Nibbelink have also contributed to the CPB ALM model.

Figure 1.1 Schematic overview of the model



Section 2 describes the inputs that are used by the model. Section 3 discusses the simulation procedure and the key outcome variables. Section 4 contains an example using a hypothetical change in the Dutch nFTK. Section 5 concludes.

2 Model Inputs

The model requires demographic, financial and fund policy inputs.

2.1 Demography

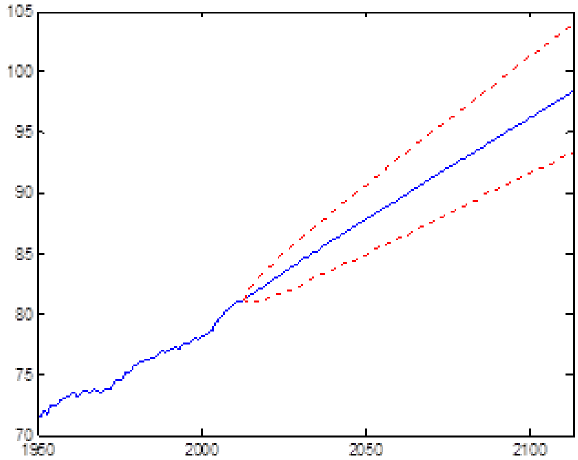
The demographic inputs are population size, death and survival probabilities. These inputs are birth-cohort- and time-specific. All individuals within a cohort are identical. The model only considers individuals of working or retirement age. The representative individual in each cohort starts working at age 25. For practicality, we impose a terminal age, typically 99. For policy analysis relating to the Dutch regulatory framework, we use demographic information from Statistics Netherlands. It is also possible to use stochastic demographic scenarios from Muns (2015), in which birth and mortality rates differ per scenario, or stylized populations with equal cohort sizes and simple mortality assumptions (for example, all agents pass away at 87 with certainty).

Of the cohorts living in 2015, younger individuals have a larger probability of being alive in the next year than older individuals. Moreover, a 25-year old in 2015 has a smaller probability of living to age 90 than a 25-year old in 2030. Table 2.1 displays the remaining life expectancy at different ages in the Netherlands using Statistics Netherlands data. The life expectancy at 65 is projected to increase by four years between 2015 and 2045, which would lead to a similar-sized increase in the Dutch retirement age. Figure 2.1 illustrates the life expectancy at birth in the stochastic scenarios from Muns (2015). There is a clear upward trend, and the uncertainty in the life expectancy increases considerably over time.

Table 2.1 **Remaining life expectancies in the Netherlands for selected years (source: Statistics Netherlands)**

Remaining life expectancy at	2015	2025	2035	2045
25	63,97	64,97	65,53	65,74
65	20,88	22,34	23,59	24,93
75	13,07	13,53	14,65	15,53
85	6,99	7,31	7,54	8,15

Figure 2.1 **Life expectancy at birth in Muns (2015), median and 5th/95th percentiles**



When the demographic development is deterministic, the pension fund is assumed to know future mortality rates with certainty and values its liabilities accordingly. It also knows future cohort sizes and migration flows, but these are not relevant for current decisions regarding contributions, benefits and rights adjustments. When we use the stochastic population scenarios, the model allows for both perfect foresight (such that the fund knows all future demographic developments in each scenario) and an adaptive expectations rule.

2.2 Financial Markets

The main financial inputs are stock returns, 5-year bond returns, price and wage inflation, and the nominal and real term structure of interest rates. We simulate the pension fund for a range of scenarios, typically 5000. The scenarios are generated by simulation from an assumed joint probability distribution of the financial variables.
The model can use different scenario sets, for example from the Dutch pension provider APG, or a calibration of the capital market model in Koijen, Nijman and Werker (2010) (hereafter:

KNW).[2] Table 2.2 lists the means and volatilities of the most important variables in the two sets.

Table 2.2 Geometric long-run means and volatilities of financial variables in APG and KNW sets

Variable	APG		KNW	
	Mean	Volatility	Mean	Volatility
Stock return	4,53%	15,11%	5,43%	18,16%
5-year bond return	1,37%	2,11%	3,13%	5,86%
3-month bond return	0,49%	0,93%	1,85%	3,26%
Price inflation	1,35%	1,18%	1,85%	1,56%
Wage inflation	1,40%	1,28%	2,45%	2,14%

Note: The APG scenario set summarized in this table is based on financial markets at the end of September 2014. The KNW set is calibrated to match key financial parameters of the DNB scenario set for the Dutch Haalbaarheidstoets: the mean and volatility of stock returns, the mean price and wage inflation and the ultimate forward rate.

2.3 Pension policy

The model's primary focus is to study a policy's performance for different realizations of financial variables, such as stock returns and interest rates. Wages and labour supply are exogenous to the performance of the fund (though they may be correlated with variables in the financial scenarios). That is, wages may be lower during economic downturns, but wages are unaffected by the pension fund's performance during a downturn. The modeller can adjust the exogenous wage and participation profiles based on his beliefs about reactions to the fund's ex ante policy, but individuals do not adjust their labour supply based on the ex interim performance of the fund. Below, we discuss the main categories of policy variables and the options for choosing them in the model.

Retirement age and labour supply

Individuals work and pay contributions before they reach the retirement age and receive benefits thereafter. The retirement age can be set at an exogenous level, for example 67, or endogenously follow the remaining life expectancy at age 65 according to the Dutch law 'Wet verhoging AOW- en pensioenrichtleeftijd'. If the retirement age is endogenous, the modeller specifies in which years the pension age is increased to 66 and 67. Additionally, one can specify the parameters of the automatic adjustment mechanism. These parameters govern the first year in which the pension age is reviewed, the frequency at which reviews take place and the implementation delay of a retirement age increase. In each review year, the retirement age increases by one year if

$$(Remaining\ life\ expectancy\ at\ 65 - 18{,}26) - (Current\ pension\ age - 65) > 1$$

[2] The APG scenario set has 10 state variables; the KNW set has 2. These state variables are sufficient to form expectations about future developments given the model parameters.

The retirement age cannot be adjusted downward if this expression is negative. Using this method and demographic projections from Statistics Netherlands, the retirement age is projected to increase to 73 after 2070.

Liability discount curve

The liability discount curve determines the present value of the nominal obligations of the fund. This value of the liabilities is the denominator of the funding ratio, upon which the fund's indexation, contribution and asset allocation policies may be contingent. The discount curve specifies a discount interest rate $r_{t,h}^{fund}$ for each maturity h, so that the liabilities are

$$Liabilities_t = \sum_{h=0}^{\#of\ age\ cohorts\ in\ fund} \frac{Obligations_{t,h}}{\left(1 + r_{t,h}^{fund}\right)^h},$$

where $Obligations_{t,h}$ denote the nominal obligations at time t with maturity h, that must be paid at time $t + h$. In a collective fund, the choice of liability discount curve has intergenerational distribution effects. High discount rates lead to a higher funding ratio, and thus to higher benefits for current retirees and/or lower contributions for current workers. With low discount rates, the fund accumulates more assets for future generations. In an individual DC contract, the discount curve only determines the rate at which a retired age cohort decumulates its savings. With lower discount rates, the individual DC contract reserves more assets for the later stages of the pension period.

The two most common choices for the liability discount curve are the nominal term structure and the Dutch FTK discount curve. The latter follows the nominal term structure for maturities up to 20 years, and is a weighted average of the nominal discount rate and an ultimate forward rate for longer maturities, whereby the weight of the nominal discount rate decreases in the maturity.

Rights accrual

The model tracks the nominal pension rights of each age cohort for each year of their respective pension periods. In each period, current workers accrue additional rights in return for their contributions. For collective funds, there are two main methods for rights accruals: uniform accrual, as in the current Dutch pension system, and actuarially fair accrual. Under uniform accrual, each age cohort accrues nominal rights as an exogenous percentage of its current pensionable wage (e.g. 2% for each pension year). Per euro contributed, a 64-year old receives the same nominal rights per pension year as a 25-year old (abstracting from changes in the pension age).

This method ignores the notion that the contributions of a young worker can accumulate financial returns for a longer period than those of an older worker. If a young and an old worker would invest their contributions in risk-free assets until retirement, the youngs' contributions will be worth more when the young cohort retires than the olds' contributions when the old retire. Uniform accrual thus constitutes an ex ante transfer from young to old workers (Lever, Bonenkamp and Cox, 2013).

Under actuarially fair accrual, the discounted value of newly accrued rights (using the fund's liability discount rate) equals the contributions for each working-age cohort. With higher interest rates, all cohorts accrue more rights per euro contributed, but the increase is larger for the young than for the old because of cumulative interest. With higher life expectancy, cohorts accrue fewer rights per capita. Actuarially fair accrual is the default in individual DC contracts.

Table 2.3 gives an example of newly accrued rights with actuarially fair accrual. For each cohort, new rights are only allocated to years that correspond to a cohort's retirement period. Within a cohort, the rights decrease along the horizontal dimension: as the cohort size diminishes due to mortality, less resources are needed to maintain the same benefit level per surviving cohort member. The rights per pension year are larger for younger cohorts, because their contributions have a longer investment horizon. In the above example, there is an extra increase for the cohorts currently aged 63 and 60, because the retirement age increases to 66 and 67 for these cohorts, respectively. Since the retirement period is shorter, their contributions can finance a higher yearly benefit.

Table 2.3 Example of newly accrued rights by working-age cohorts (mln euro)

Current cohort age	Time							
	t	t+1	t+2	t+3	t+4	t+5	t+6	t+7
64	0	70,08	69,30	68,46	67,57	66,63	65,63	64,56
63	0	0	0	74,51	73,63	72,70	71,70	70,65
62	0	0	0	0	78,01	77,13	76,20	75,21
61	0	0	0	0	0	80,29	79,37	78,39
60	0	0	0	0	0	0	0	87,76
59	0	0	0	0	0	0	0	0

Note: Each entry indicates the fund's nominal obligation per cohort and per year of its pension period.

Investment policy

The model has three main assets: stocks, 5-year bonds and 3-month bonds. The investment policy of a collective fund specifies the fraction of the return base to be invested in stocks, the fraction in 3-month and 5-year bonds and which fraction of the nominal interest risk to hedge. The return base equals the fund's assets after benefit and contribution payments. We implement the nominal interest hedge by short-selling 3-month bonds to buy a portfolio of bonds that matches the fund's nominal liabilities. The total net return on the nominal interest hedge is

$$Hedge\ fraction * \left(\sum_{h=2}^{\#of\ age\ cohorts\ in\ fund} \left\{ \frac{Obligations_{t,h}}{\left(1+r_{t,h}^{nominal}\right)^{h} - \left(1+r_{t+1,h-1}^{nominal}\right)^{h-1}} \right\} - \sum_{h=2}^{\#of\ age\ cohorts\ in\ fund} \left\{ \frac{Obligations_{t,h}}{\left(1+r_{t,h}^{nominal}\right)^{h-1}} \right\} * r_{t+1,euribor} \right),$$

where $r_{t+1,euribor}$ is the realization of next year's 3-month interest rate. The nominal interest hedge is a swap in which the fund pays the 3-month interest rate (the second term in round brackets) and receives the increase in the value of its liabilities (the first term in round brackets). When the nominal term structure is increasing, the expected net return on nominal interest hedges is positive. When the fund has a nominal funding ratio of 100%, invests 100% of its return base in 3-month bonds and fully hedges the nominal interest risk ($Hedge\ fraction$ = 1), the return on its assets ($r_{t+1,euribor}$) and the negative term in the hedge return cancel out, and the fund thus fully matches its nominal liabilities with a portfolio of bonds. The model has an option for collective contracts to reduce their equity exposure at high funding ratios.

In an individual DC contract, the investment policy is age-specific. The modeller can thus specify a life-cycle investment policy in which younger individuals invest more in stocks, and in which older individuals hold more bonds. The model can implement gradual (to reduce conversion risk) or full nominal annuitization by simultaneously increasing the fraction of assets invested in 3-month bonds and increasing the nominal interest hedge percentage over the life cycle.

There are no limits on short sales, but the modeller can disallow them through choice of parameters.

Contribution rate

Contributions are a percentage of the pensionable wage, which is the total wage minus the AOW (pay-as-you-go pillar) franchise. With actuarially fair rights accrual, the contribution rate is exogenous and the rights accruals are linear in the contribution rate. Under uniform accrual, the modeller can choose between an exogenous contribution rate and one that depends on the actuarial value of new rights accruals (cost price). This cost price is the aggregate contribution rate that is needed to finance the aggregate new rights accruals, even though contributions and the values of new rights are not equal at the cohort level under uniform accrual. If the contribution rate is exogenous, it may be structurally higher or lower than the level required to finance the uniform accruals.

The discount rate for calculating the cost price of new rights $r_{t,h}^{contributions}$ may differ from the one for calculating the fund's liabilities (i.e. $r_{t,h}^{fund} \neq r_{t,h}^{contributions}$). For example, the Dutch FTK allows funds to use a 120-month moving average of $r_{t,h}^{fund}$ as the contribution discount rate, or to include an equity premium in the contribution discount rate.

The contribution rate may depend on the funding ratio in two ways. Firstly, the modeller can specify an increase in the contribution rate when the funding ratio is below a certain threshold. Secondly, it is possible to distribute a percentage of the fund's surplus above a specified funding ratio as contribution discounts. The latter rule can lead to negative contribution rates if the fund has a very large buffer.

Rights adjustment

Each year, pension rights are adjusted depending on the funding ratio. For rights with maturity h,

$$Rights\ after\ adjustment_h = Rights\ before\ adjustment_h * (1 + Rights\ Adjustment_h)$$

The model has generic adjustment rules, as well as a detailed implementation of the Dutch nFTK rules.

The generic rules specify a target funding ratio, an adjustment mechanism for returning to the target rate and a recovery period. The longer the recovery period, the less sensitive near-term benefit payments are to financial shocks. An open adjustment mechanism to financial shocks ('open AFS') adjusts rights of all maturities uniformly. A linear AFS, if the recovery period is 10 years, calculates the adjustment such that if all current rights were adjusted by this percentage 10 times consecutively, the fund would exactly be at the target funding ratio. Formally,

$$Rights\ Adjustment_{h,Linear}^{Open} = \left(\frac{Funding\ Ratio}{Target}\right)^{\frac{1}{Recovery\ Period}} - 1.$$

Even in the absence of financial shocks, the open linear AFS might not reach the target rate after the recovery period because of in- and outflow in the fund.[3] With an ageing participant pool, the fund is less likely to reach the target rate in the specified number of years and vice versa.

Alternatively, an asymptotic open AFS with a recovery period of 10 years recoups 10 per cent of the current funding gap:

$$Rights\ Adjustment_{h,Asymptotic}^{Open} = \frac{Funding\ Ratio - Target}{Recovery\ Period} - 1.$$

With an open AFS and a recovery period larger than one, the current funding ratio affects expected future rights adjustments. Future adjustments will on average be higher if the current funding ratio is high, so the economic value of future rights accruals will also be larger. This exposes future generations to financial shocks before they start working (Lever and Michielsen, 2015).

A closed AFS instantaneously equates the funding ratio and the target rate each year, so that the economic value of future right accruals does not depend on the current funding ratio. Under a closed AFS, future participants are unaffected by current gains and losses. The length of the recovery period determines whether rights with different maturities are adjusted relatively similarly (for short recovery periods) or whether rights with long

[3] The target is exactly reached at the end of the recovery period if the economic value of inflows and outflows are equal and if the return on assets equals the discount rate times the fund's liabilities.

maturities are adjusted more than proportionally (for long recovery periods). A linear closed AFS with a 10 year recovery period adjusts rights with the shortest maturity by 10% of the maximum adjustment, the next-shortest maturity rights by 20% of the maximum, and so forth:

$$Rights\ Adjustment^{Closed}_{h,Linear} = \frac{\sum_{l=0}^{highest\ maturity} \frac{Obligations_{t,l}}{\left(1+r^{fund}_{t,l}\right)^{l}}}{\sum_{l=0}^{\#highest\ maturity} \min\left(\frac{l+1}{Recovery\ Period}, 1\right) \frac{Obligations_{t,l}}{\left(1+r^{fund}_{t,l}\right)^{l}}} * \min\left(\frac{h+1}{Recovery\ Period}, 1\right) * \frac{Funding\ Ratio - Target}{Target}.$$

The fraction on the right hand side is larger than one: rights with maturities longer than the recovery period must be adjusted by more than $\frac{Funding\ Rate - Target}{Target}$, because rights with short maturities are not fully adjusted (for low l and h, the minimum terms evaluate to less than one). With an asymptotic closed AFS, rights are only adjusted by the maximum in the limit:

$$Rights\ Adjustment^{Closed}_{h,Asymptotic} = \frac{\sum_{l=0}^{highest\ maturity} \frac{Obligations_{t,l}}{\left(1+r^{fund}_{t,l}\right)^{l}}}{\sum_{l=0}^{highest\ maturity} \left(1-\left(1-\frac{1}{Recovery\ Period}\right)^{l+1}\right) \frac{Obligations_{t,l}}{\left(1+r^{fund}_{t,l}\right)^{l}}} * \left(1-\left(1-\frac{1}{Recovery\ Period}\right)^{h+1}\right) * \frac{Funding\ Ratio - Target}{Target}.$$

Figure 2.2 Relative adjustment of rights by maturity with closed AFS and 10 year recovery period

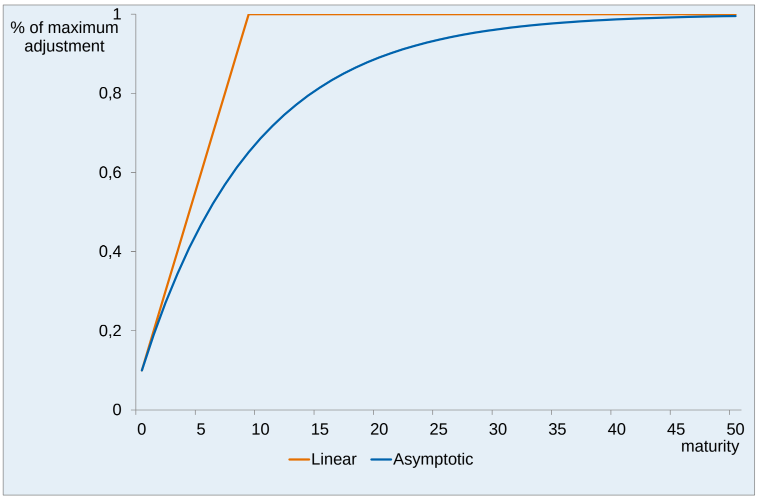


Figure 2.2 shows the relative adjustments for different maturities. For a given recovery period and funding gap, the maximum adjustment must be higher for an asymptotic AFS than for a linear AFS.[4][5]

The individual DC contracts always use a closed AFS, since the open AFS adjustment formulas are likely to leave cohorts with a surplus or deficit at the terminal age. A closed AFS with a recovery period larger than one implements a form of consumption smoothing, which is optimal if individuals exhibit habit persistence (Constantinides, 1990). In the face of financial shocks, the cohort gradually adjusts its planned consumption path. This mechanism becomes less effective at advanced ages, as the number of remaining years over which shocks can be smoothed decreases.

For the Dutch nFTK, we use the average of the current funding ratio and last year's funding ratio to determine rights adjustments, so as to approximate the 12-month moving average funding ratio that is used in the nFTK.[6] When this policy funding ratio is below the minimum level of 105% for five consecutive years or if the funding ratio plus a recovery allowance falls short of the required equity level ('Vereist Eigen Vermogen'), we use a closed AFS with a recovery period of 10 years to immediately restore the funding ratio to 105%.

For collective contracts, the model also tracks the rights that cohorts would have accumulated in the absence of nominal cuts, as well as the counterfactual rights with full indexation (price- or wage-indexed or a convex combination). Optionally, cohorts that were subject to nominal cuts in the past or whose rights have not been fully indexed to inflation can receive additional rights adjustments when funding ratios are high.

Fiscal constraints

To reflect the fiscal rules for second-pillar pension benefits in the Netherlands, the model has an option to limit pension payments at the cohort-year level to the fully-indexed level.

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[4] Adjustment patterns other than the linear and asymptotic ones discussed here and shown in Figure 2.2 can be implemented as well.

[5] The rights adjustment can become smaller than -100% for large maturities if the funding gap is large and the average maturity of the liabilities is low. In these cases, we recalculate the rights adjustment for all maturities using a recovery period of one.

[6] In calculating the 'vereist eigen vermogen', we disregard currency risk, liquidity risk, concentration risk, operational risk and active management risk. To proxy credit risk of bonds, we assume a slightly riskier asset mix (56% stocks and 44% bonds in lieu of a 50/50 mix).

3 Model Workings

In this section, we discuss how the model uses the inputs from the previous chapter to analyse the fund in each scenario.

3.1 Initialization

The modeller must specify the initial conditions of the fund. If there are no initial entitlements, the fund starts with zero assets and liabilities. Individuals who are retired at the start of the simulation horizon receive no pension benefits. Alternatively, cohorts may start with rights as if they had accumulated rights in the pension fund from the start of their career. Under uniform accrual, the historic accrual rate for the initial conditions may differ from the accrual rate that will be used for contributions going forward. The model can allow for initial indexation shortages. The fund's initial assets are determined by the initial funding ratio, which is a parameter input.

3.2 Simulation

After initialization, the model simulates the pension fund over the specified horizon, for each scenario. The model iterates over the simulation years. Within each year, it processes four steps in order: rights adjustments, new rights accruals, contribution and benefit payments and, lastly, the realization of financial shocks.

Realization of demographic shocks

When we use the stochastic population scenarios, the pension fund learns the mortality realization. Higher mortality rates than expected will contribute to a surplus and vice versa.

Rights adjustments

At the start of each year, the model recalculates the current funding ratio, compares it to the target rate, and adjusts all rights based on the adjustment rules discussed in the previous section.

Rights accruals

Working-age cohorts receive new rights based on the accrual rules. Newly accrued rights in year t do not share in the rights adjustments of year t.

Contribution and benefit payments

Contribution payments follow the contribution rules. If the contribution payments depend on the funding ratio, the model uses the funding ratio recalculated after the rights adjustments.

Benefit payments equal the rights with maturity 0. Benefit payments in year t are affected by rights adjustments in year t. Benefit payments cannot exceed the fund's assets excluding the current year's contributions.

Realization of financial shocks

The fund invests its return base (assets at the start of year t plus contribution payments minus benefit payments) according to its investment policy. Assets at the start of $t+1$ equal the return base in year t times the portfolio return. With short sales, the fund can fall into negative equity.

End of the simulation horizon

At the beginning of the last year of the simulation horizon (typically 60-100 years after initialization), the fund's assets are distributed in a lump-sum fashion to all cohorts alive in that year. The distribution is proportional to the cohorts' liabilities: a cohort that owns 10% of the fund's liabilities receives 10% of the fund's assets, irrespective of the funding ratio.

We summarize the generational accounts (for the definition, see section 3.3) of all generations alive in the last year in one number, because the generational accounts within this group are sensitive to the closure date and distribution rule. Note that closing the fund also attributes the fund's surpluses and deficits at the end of the horizon; we disregard (fiscal) restrictions on benefit payments and buffer rules when closing the fund.

3.3 Outcome Variables

We focus on three outcome variables: generational accounts, contributions and pension benefits, which can be expressed as replacement rates or as a fraction of a fully indexed pension.

Generational accounts

The generational account measures the difference between what a generation receives from the pension system (benefits) and what it puts in (contributions) using market valuation.

We can consider a person's or a generation's flow of contributions and benefits over the life cycle as a stochastic cash flow. In a complete financial market, any stochastic cash flow can be replicated through a portfolio of traded financial instruments. Under the law of one price, we can evaluate the generational account: the market value of the financial portfolio that mimics a generation's contributions and benefits. Formally, the generational account is

$$E_{\mathbb{Q}}\left[\sum_{t=0}^{T} \frac{benefits_t - contributions_t}{cumulative\ price\ inflation_t}\right],$$

where $\mathbb{Q}$ indicates that the expectation is under a risk-neutral probability measure. If a generational account is positive, financial markets would be willing to pay a positive price for that generation's obligations and claims in the pension system. In this case, the generation would be unable to make itself better off for every possible realization of the financial uncertainty by not participating in the pension fund and instead privately investing its provisions for old age in the financial market. If the generational account is negative, the opposite applies. For computational convenience, we do not weigh the outcomes with risk-neutral probabilities to obtain the market valuations, but set the risk premia on stocks and bonds to zero.

The requirement of market completeness, while theoretically appealing, is not likely to hold in practice. Markets for nominal bonds with longer maturities as well as euro-denominated inflation-linked bonds are shallow, and some risks that are relevant for pension funds are not traded in financial markets, such as uncertainty with respect to wage growth and macro longevity.

Contributions

The model provides probability distributions for the aggregate contribution rate as a percentage of the pensionable wage, by looking at the realized contribution rates per scenario after the simulation.

Probability and size of nominal cuts

Another outcome variable is the probability that nominal rights have to be cut in any given year, and the average size of the nominal cuts conditional on there being a nominal cut. The size of cuts is expressed as a percentage of the total value of liabilities. Under the Dutch nFTK, after five years with a funding ratio below 105%, the fund is required to cut already-accrued rights unconditionally to immediately return to the minimum funding ratio of 105%. If the nominal funding ratio is 90% before a cut and 105% after the cut, the cut equals - (90 – 105) / 90 = 16,7%. This 16,7% cut may be spread out over a number of years if the fund uses a partial adjustment mechanism, but is unconditional and only affects participants currently in the fund.

Replacement rates

For a number of specified cohorts, the model generates probability distributions of the replacement rate, which is defined as (second-pillar) pension benefits divided by the pensionable wage of the oldest working cohort. For each such cohort, we detail how the replacement rate evolves over its pension period.

Benefits as a fraction of fully indexed pension

The model also determines these specified cohorts' pension benefits as a percentage of a fully indexed pension. The fully indexed pension depends on whether the indexation ambition is linked to price inflation, wage inflation, or a weighted average.

4 Model output

In this section, we illustrate the model output with a sample policy change. The policy change is either a decrease or an increase of the minimum required funding ratio in the Dutch nFTK. If a fund is below the minimum rate for five consecutive years, it must implement a series of unconditional cuts to return to the minimum funding ratio. When we adjust the minimum funding ratio in our policy variants, we simultaneously adjust the indexation threshold – the minimum funding ratio at which the fund can grant indexation. Table 4.1 presents the values of these variables in the variants we consider. Our simulated policy changes immediately take effect in 2015. Because the contribution rate only depends on current and past interest rates and not on the funding ratio, we do not report contribution outcome variables for this example.

Table 4.1 Minimum funding ratios and indexation threshold in two policy variants

	Baseline	Lower Minimum FR	Higher Minimum FR
Minimum funding ratio	105	100	110
Indexation threshold	110	105	115

Figure 4.1 illustrates the effect of the policy changes on the generational accounts. The lines indicate the relative gain or loss for individual generations. The number for the net benefit for cohort 1996 and onwards is the relative gain or loss aggregated over all generations born in 1996 or later, because the effects for individual generations are sensitive to the closing time. The figure illustrates the redistributions of market value as a result of the policy changes; these redistributions constitute a zero-sum game.[7]

Lowering the minimum funding ratio is advantageous for all currently-working cohorts. All current participants benefit from the possibility to grant more frequent and generous indexation when the minimum funding ratio decreases. For younger workers (born after 1980), the gain is smaller as more generous indexation early on slightly decreases indexation prospects when they approach the retirement age.

Future generations lose from lower minimum requirements because they lead to lower buffers, as can be seen in Figure 4.2. The figure illustrates how the median, 5th and 95th percentile of the funding ratio evolve over time. With the lower minimum funding requirements, the funding ratio becomes lower both in bad, average and good scenarios. Since the model attributes surpluses to future generations, future generations are worse off with a lower minimum funding ratio.

[7] More precisely, the changes in generational accounts across cohorts in euros sum to zero by definition. Figure 4.1 shows relative changes in the generational accounts, which do not necessarily sum to zero.

Figure 4.1 Generational accounts for selected policy variants

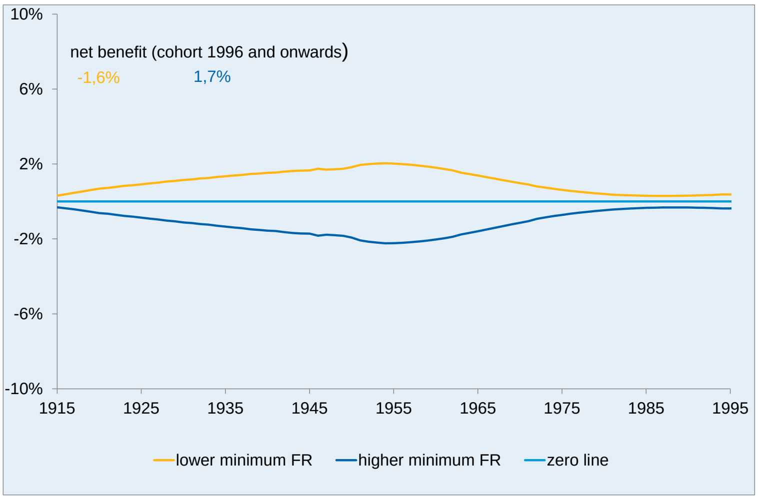


Figure 4.2 Funding ratios ('actuele dekkingsgraad') in baseline and with lower minimum requirements

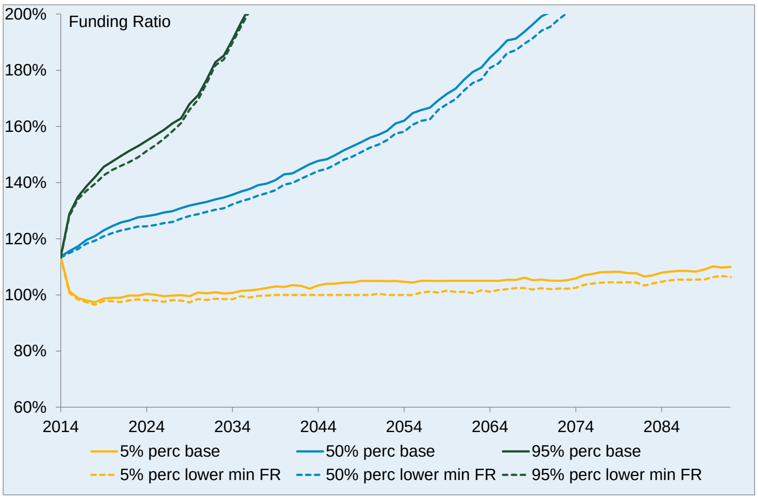
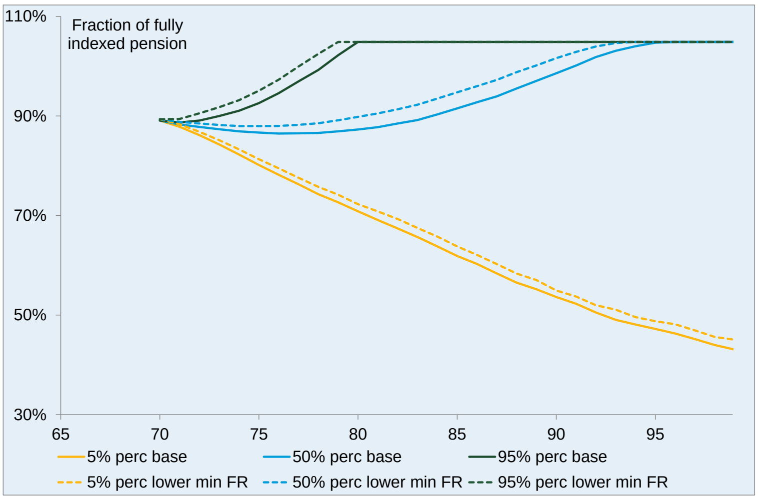


Figure 4.3 depicts the pension benefits as a fraction of a fully indexed pension for a cohort that is already retired at the start of our simulation horizon, namely the cohort born in 1945. The benefits start at less than 100% of a fully indexed pension because of an initial indexation shortage. The lower requirements increase their benefits both in good and bad scenarios; there is a larger probability of indexation and possible right cuts will not be as severe. The benefits for this cohort cannot exceed 104% of a fully indexed pension because of Dutch fiscal regulations that place a cap on payable benefits.[8]

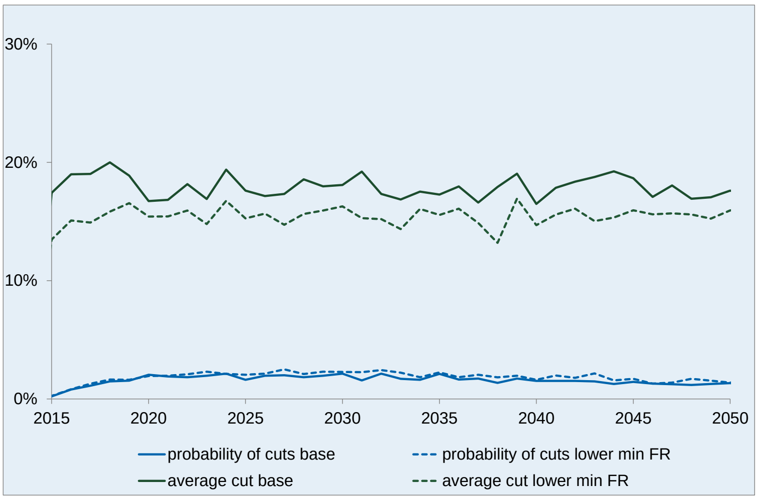
[8] This cap depends on the difference between actual accrued pension rights and the maximum allowed rights accrual. We assume that the fund has a slightly lower accrual rate than the maximum stipulated by the Dutch Witteveenkader, so the cap is higher than 100 per cent.

Figure 4.3 Pension benefits per age for the cohort born in 1945 as a percentage of a fully indexed pension, in baseline and with lower minimum requirements



Lastly, we show the effect of a lower minimum funding ratio on nominal right cuts in Figure 4.4. The average size of cuts decreases, as the fund is less likely to drop far below the lower minimum funding ratio of 100% than to drop far below the baseline minimum of 105%. Though the fund grants more frequent and larger indexations, it still accumulates a significant buffer in expectation (Figure 4.2), so on balance the lower minimum requirements lead to smaller conditional cut sizes.

Figure 4.4 Probability that there is a nominal right cut (according to the conditions on page 12) and average size of cuts when there is a positive cut



5 Conclusion

The ALM model is used for stochastic analyses of proposed pension policies, such as the CPB evaluation of the Dutch nFTK (Lever and Michielsen 2014a, 2014b). It can evaluate both the specific context of the Dutch nFTK, as well as more general collective and individual pension contracts. It uses population data from Statistics Netherlands or from and a large number of financial scenarios. The model can shed light on a contract's intergenerational distribution effects as well as the probability distribution of contributions and benefits.

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Publisher:

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September 2015