An assessment for a sustainable and generationally fair pension contract reform

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Abstract

This thesis examines a sustainable and generationally fair pension contract (reform). By means of a value-based ALM study, I indicate whether age cohorts gain or lose from a contract reform. I demonstrate that the current FTK pension contract ambition to safeguard a nominal pension while aspiring a real pension is not sustainable and fair across generations. First, for the current average funding position of the Dutch pension funds, the current FTK contract does not proportionally reward the elderly for the risks they are exposed to. Second, adjustments in the investment mix within the current FTK contract imply a significant redistribution of value between age cohorts, caused by the asymmetric policy ladder. The advantage of a soft symmetric contract is that adjusting the investment mix will not lead to value transfers between the age cohorts. The value transfer from young to old, owing to a higher discount rate and a symmetric policy ladder, when switching from the current FTK to the soft symmetric pension contract can be minimized by an equalization reserve. I therefore propose the option either to ensure a hard nominal pension without mismatch risk or to switch to a soft pension contract. The cohorts who gain, and to what extent, if a soft real rather than a soft nominal pension contract is introduced, depends on the amortization period in relation to the duration of the nominal liabilities. Finally, fund characteristics as the funding ratio and indexation ambition contribute, in addition to the investment, buffer and amortization policy, to the realization that the determination of one uniform applicable value transfer is hardly feasible. Notwithstanding the benefits of a soft symmetric contract, I indicate that this proposed pension contract will, in comparison to the current contract, not improve the distribution of equity exposure over the age cohorts.

Contents

1 Introduction

Since the credit crisis (September 2008) pension funds experience even more difficulty to remain solvent. A fall in stock prices and historically low interest rates have deteriorated the solvability of almost all Dutch pension funds. As a result of the lower interest rates, the funding position of the pension funds, who were not adequately hedged against financial market risks, significantly decreased. Besides, the underestimation of the growth in life expectancy has caused to a higher liability than previously expected.

In January 2010, committee Frijns and committee Goudswaard, appointed by minister Donner[1], presented their reports about how to improve the Dutch pension system. The two committees both indicated that the Dutch pension system needs to be reformed. The committee Frijns (Frijns et al. (2010)) emphasized that pension funds must be aware and in control of the risk they are taking at any economic scenario. Where the recommendation of committee Frijns refers to the risk management by the pension fund governance, the committee Goudswaard (Goudswaard et al. (2010)) focuses more on how to distribute the financial market and longevity risks. The committee Goudswaard was instructed to investigate whether the Dutch pension system was sustainable and to outline how to make the system more resistant to financial shocks in an ageing society. A conclusion of their report ('Een sterke tweede pijler') was that the current system is unsustainable in an ageing society where people become older and where investments take place in a volatile financial market. In order to make pension funds less vulnerable to financial shocks and longevity risk, pensions have to fluctuate with the economic state. In addition, the committees argued that the effect of contribution rate adjustments on the solvency of the pension fund in an ageing society is marginal. According to the committee, the system has to be developed towards an improved balance between the ambition, certainty and the cost of a pension.

The reports of the committees have raised the awareness that the current pension contract has to be changed. On the 10th of June 2011, the memorandum of the new pension agreement (Pensioenakkoord (2010)) was signed by the Dutch social partners and Government. The Pensioenakkoord (2010) incorporated quite a few suggestions which have been put forward by the two committees. An important proposal with regard to my thesis, is that the risk of stock returns and interest rates should be borne by the participants. Disappointing results on the financial market will have less effect on the balance sheet of the pension funds or the employers, since these risks are (mostly) transferred to the participants. The Pensioenakkoord (2010) makes the distinction between a hard nominal and a soft real contract. A soft collective pension contract is a contract where the pension rights are adjusted as soon as the funding ratio of a pension fund deviates from a target funding ratio. Or in other words, as soon as the returns on investments and/or longevity in relation to changes in the discount factor are higher or lower than expected. However, the final rules of the current contract and the new soft contract are still unclear. Despite the fact that numerous citizens assumed that a nominal pension was a guarantee (not in legal sense), we have seen that even nominal pension rights can be cut. In February 2012, one fourth of all Dutch pension funds have announced in their reporting to the Dutch central bank (DNB) that they need to cut pension rights in order to recover. Cutting pension rights is nothing less than a reduction of the accumulated pension rights. Hence, when interpreting the current contract, the possibility to cut nominal pension rights has to be taken into account as well.

The need for a new pension contract has been made clear. A new pension system, consisting of a soft pension contract, has to be more resistant to financial market shocks and unexpected

[1] Minister Donner is the former minister Social affairs and employment.

changes in life expectancy. Contentious points of a switch to a soft contract are the interpretation of the current contract in terms of certainty and ambition, and the interpretation of the soft contract, which is largely focused on finding an appropriate discount factor. Nevertheless, a switch to a new pension contract can lead to a redistribution of value between generations.

Content and contribution to the existing literature
The aim of my thesis is to assess a sustainable and generationally fair pension contract (reform). In particular, three papers are important with regard to my thesis. Meanwhile, the current discussion about the introduction of more sustainable pension contract has evolved. Accordingly, I will extend the (outdated) paper by Lekniute and Ponds (2011) in several ways. Second, I will check the generational impact of some useful soft contract characteristics proposed by Bovenberg et al. (2012a). I will also assess and compare some overlapping findings of my thesis with the recently published CPB analysis (2012)[2].
First of all, I will explain the classical and value-based ALM study and the financial market models applied in Section 2. Subsequenly, Section 3 discusses how and why the interpretation of the pension contract has evolved over the past years. In Section 4, I will indicate why I interpret a hard nominal contract without mismatch risk and a 'hard' nominal asymmetric FTK contract with mismatch risk, and why I assume a symmetric soft contract that differs in terms of discount factor and real or nominal framework applied.
Section 5 starts with demonstrating that the current FTK contract, that combines a real ambition with a nominal hedge, is not sustainable and fair across generations. In addition to the existing literature, I therefore recommend to switch either to a soft real contract or otherwise to a hard nominal contract without mismatch risk instead of the 'hard' nominal contract as proposed in the pension agreement.
For the soft pension contract, I will prove that a higher discount factor is in favor of the old in Section 5.2. Moreover, I investigated that a switch from a soft nominal to a soft real contract can be generation-neutral, if the amortization period equals the duration of the nominal liabilities. These innovative ideas discourage the proposal for a fixed amortization period in the memorandum of the pension agreement (2011) and in the CPB analysis (2012). Hence, I state, in line with Bovenberg et al. (2012a), that the RAM period should be (partly) dependent on the age of the fund and thus should be smaller for older funds.
In the remainder of Section 5, I will clarify that the redistribution of value between generations resulting from a switch from the current 'hard' contract to a soft contract is highly dependent on fund characteristics as the symmetry of the policy ladder, discount factor, nominal or real framework applied, buffer and amortization period.
Furthermore, also the investment mix is very important when assessing value transfers between generations. In Section 5.6, I will point out that adjusting the investment mix causes significant value transfers within the current asymmetric pension contract. In contrast to the asymmetric contracts, adjusting the investment mix within a (soft) symmetric pension contract does not cause any redistribution of value between generations. Among others, Bovenberg et al. (2012a) recommend a soft symmetric pension contract, where the redistribution of value between generations is independent of the investment mix applied. In my thesis, I will interpret this soft symmetric contract and demonstrate (also analytically) that the investment mix does indeed not result in substantial value transfers. The paper by Lekniute and Ponds (2011) did not mention that the investment mix causes significant value transfers within their proposed hard and (outdated) soft asymmetric pension contracts. However, I will demonstrate that the investment mix is crucial when examining value transfers within an asymmetric contract. This thesis contributes by declaring that for those asymmetric contracts the redistribution of value, owing to a more

[2] The CPB also examined the generational impact of switching to a soft pension contract (see Section 7).

risky investment mix, might be even greater than when switching from the current asymmetric to a new soft symmetric contract.
The sensitivity analysis performed in Section 6 shows that the generational impact of a switch from the current ‘hard’ contract to a soft contract is furthermore dependent on fund characteristics as the funding ratio, assumed inflation level and interest-rate. This indicates that for a pension fund it is possible to determine certain contract characteristics such that a transition to a new contract is generation-neutral, but it is not possible to propose uniform contract characteristics and assumptions under which the reform is generation-neutral for all pension funds.
Finally in Section 7, I will elaborate on the outcomes and conclusions of the CPB analysis (2012) in relation to my research. The CPB analysis (2012) says nothing about whether the proposed soft real pension contract is better than the current FTK contract. By means of the characteristics for a good pension contract proposed by Merton (1969), I will evaluate whether the young have more exposure to equity than the old. In Section 7.2, I state that both the current FTK contract and the proposed soft pension contract do not satisfy the requirement by Merton (1969). Actually, the equity exposure of the young in the proposed soft pension contract does not significantly improve, when the current FTK contract is exchanged for a soft pension contract.

1.1 Literature

In this subsection, I will discuss the literature that contributes to a better understanding and consciousness of why investigating the consequences for different generations in a certain pension system is relevant. First, I will explain what is exactly meant by intergenerational risk-sharing and discuss why it is applied. Second, generational accounting can be used to gain insight in the value which different cohorts attach to certain characteristics of a contract. The sustainability of a contract depends not only on the development in funding position, but also on the participation of the current and future generations. Despite the fact that participation is mandatory, a generation will only agree upon participation in a collective pension scheme if the generational risk shared is not persistently favoring one generation at the expense of another. Third, examining the generational accounts of the participants may therefore serve as a basis for assessing a fair contract. Fourth, according to the literature the choice of an appropriate discount factor is crucial for a fair and sustainable pension contract (reform).

Intergenerational risk-sharing
A way to lower the pension risk for the current and future generations is by sharing the financial market and longevity risk between them. Sharing risk between generations means that value can be transferred from a generation in a good economic time to a generation in a bad economic time. Pension funds often apply intergenerational risk-sharing (IRS) to make the system more sustainable. The pension fund can use the extra value paid by the participants in a good economic state and is therefore able to pay the pension promise to the participants in a worse economic state. There are different ways of applying IRS and different ways of demonstrating the advantage of IRS. The papers by Gollier (2006) and Cui et al. (2011) show that IRS can result in welfare improvements for generations in terms of utility functions. In a different way, Teulings and De Vries (2006) introduces another welfare enhancing way of IRS. They state that the investment risks of the current participating generations can be traded with the generation already born but not entered the labor market yet. This generation already faces equity risk due to the uncertainty of the funding position at the time they start working. According to Teulings and De Vries (2006), a pre-labor-market-entry investment, where the elderly provide the pre-labor market generation a loan against the risk-free rate where the proceeds is invested in risky assets, leads to a substantial welfare gain for the involved generations.

Generational accounting
A generational account is an account where the transactions per generation are maintained. The property that in collective pension systems intergenerational risk sharing can be applied implies that some generations benefit at the expense of others. Generational accounting can be used to clarify the value transfers between generations as a consequence of a contract change or an adjustment in contract. As one of the first, Auerbach et al. (1994) applied a generational accounting framework based on the government intertemporal budget constraint, where some generations gain at the cost of other generations. Hoevenaars and Ponds (2008) performed a value-based generational accounting analysis for a pension fund (explained in Section 2.1.2). The paper by Hoevenaars and Ponds (2008) has some overlap with the paper by Lekniute and Ponds (2011). Both papers investigate the magnitude and direction of the value transfers between generations as a result of a pension reform. They agree upon the fact that changing from a variable to a fixed contribution rate and/or from full to conditional indexation results in more risk absorbed by the old. Since the young do not bear the risk of adjustments in contribution rate and the risk of a lower fraction of indexation is at the expense of the old, a value transfer from old to young will occur. Lekniute and Ponds (2011) extended the paper by Hoevenaars and Ponds (2008) by adding a currently realistic surplus option beneficial for the old and a cut option beneficial for the young possibly smoothed over an amortization period in favor of the old.

What is a fair and sustainable pension contract (reform)?
When defining a sustainable contract, value transfers between generations play an important role. However, it is subject to preferences which contract will be assigned as the best. Whether a pension reform, resulting in a value transfer, is fair is hard to determine. A value transfer can be argued to be fair, if this value transfer will undo a value transfer of the past. Also a loss in value could still yield an utility gain according to Cui et al. (2006). For example, risk seeking participants can benefit in terms of utility from bad diversification. Ponds (2003) proposes two criteria to evaluate possible policy changes in a pension contract, namely ex ante fairness and ex post sustainability. The former means that the generations need to get a fair risk premium for the risks they are exposed to. The latter is relevant when the actual outcome deviates from the anticipated outcome. Here, the mismatch risk has to be absorbed by the risk-bearing generations in an adequate and sustainable way. Ponds (2003) emphasizes the need of an explicit policy ladder for pension funds to improve ex ante fairness and ex post sustainability.
The current pension debate covers also the discussion of implementing a contract that is ex-ante fair and ex-post sustainable. A pension contract can be interpreted as a fair contract, if for example more risk borne by a generation is translated into higher risk premium. A more transparent contract contributes to a better understanding of uncertain pension rights. In line with the recommendation of Ponds (2003), I will determine an explicit policy ladder. For all investigated contracts, it will be explicitly defined what the policy of a pension fund is in each possible economic scenario. In this way, the magnitude and direction of the risk-sharing between generations can be defined before a possible shock materializes.

Furthermore, intra-generational effects have to be taken into account before the total impact of a contract can be judged. Bovenberg (2008) shows that a uniform accrual rate and pension premium ('doorsneepremie') is not actuarially fair, since the contributions paid by the young will yield higher returns than the contributions paid by the old. An increasing contribution rate or accrual rate over time will undo the disadvantage for the young.
Furthermore, a uniform investment policy applied by pension funds may result in an intragenerational value transfer. In a collective pension scheme, the investment policy is (often) not linked

to the age profile of a fund. Merton (1969) stated that the fraction of total wealth invested in the risky asset, consisting of financial and (riskless) human wealth, is constant for all age cohorts. Since the total wealth of the young practically consists of riskless human wealth, a higher fraction of their financial capital can be invested in the risky asset. For the old, which have accumulated a lot of financial capital and a small riskless stock of human wealth, their equity exposure must significantly be reduced.

Appropriate discount factor
The determination of a new pension contract also focuses on choosing an appropriate discount factor. Quite a few discount factors for the soft framework have passed in review. The most discussed discount rates are 1) the expected return of the pension portfolio; 2) the nominal term structure plus risk premium; 3) the real term structure plus risk premium and 4) the discount rate proposed by Bovenberg et al. (2012a) which is explained below.
The Pensioenakkoord (2010) states that the pension funds applying a soft framework are allowed to discount the liabilities with a discount factor of at most the expected return on the pension portfolio. Kocken (2011a) showed in a stylized example of a pension fund with one young and one old participant that two adverse effects will occur when the expected return is used as a discount rate. First, pension funds get the incentive to take more risk. A higher expected return increases the funding ratio. Since a higher funding ratio is a measure for the health of a fund, taking more investment risk, which might be striking with the risk profiles of the participants, leads to a better funding position. Second, Kocken (2011a) presented that using the expected return as discount factor results in significant value transfers from young to old. Valuing the liabilities with the expected return as stochastic discount factor lowers the present value of the assumed liability and subsequently increases funding ratio. The better funding position in short-term is beneficial for the elderly which receive extra indexation or lower pension reduction.
According to the literature, pension funds should invest less risky if a cash flow has to be paid out within a short horizon (e.g. Jagannathan and Kocherlakota (1996)). At the same time investing less risky if the duration of the cash flow is low, while discounting this cash flow against a high discount rate, implies a too high risk premium for the old given the risks they are exposed to. In contrast, using a risk-free discount rate for long-term cash flows does not represent the risk young participants essentially take. The young having more human capital are able to invest higher fractions of their financial capital in the risky asset. On the one hand, Kocken (2011b) illustrated in an example that the more uncertain entitlements of the young, projected with a risk premium, have to be discounted including that risk premium. On the other hand, the more certain entitlements of the old, projected with a risk-free rate, have to be discounted with this risk-free rate in order to be fair across generations. Consequently, Bovenberg et al. (2012a) proposed a discount rate to overcome the problem of including a uniform risk premium in the discount factor. Their proposed discount factor is close and behaves proportional to the risk-free rate for short term cash flows and as the horizon of the cash flows rises, the discount factor is increased more and more with the assumed risk premium.
The paper by Lekniute and Ponds (2011) showed that a reform from a horizon independent discount factor risk premium to discounting with the Nijman and Werker (2011)[3] discount factor lowers the value transfer from young to old.

[3] The discount rate proposed by Bovenberg et al. (2012a) is comparable to and based on the Nijman and Werker (2011) discount factor.

2 Asset liability management and Model description

In this section, I will elaborate on the methods used and the models applied for my analysis. First, I would like to clarify what an Asset liability management (ALM) study exactly is, what it is used for and which different ALM studies I will apply. Thereafter, I will explain the models used for the stock price, interest rate and inflation followed by the interpretation of risk-neutral valuation. For the formulas of the assets, liabilities and the generational accounts used in my analysis as well as the preliminary assumptions made, I refer to Appendix A.

2.1 Asset liability management

By means of an ALM study, pension funds can gain insight in the development of their future balance sheet. The balance sheet of a pension fund consists of assets which are the present value of the investment portfolio, liabilities which are the present value of the pensions to be paid now and in the future and the surplus or deficit which represents the equity of the fund.

2.1.1 Classical ALM

A classical ALM study is a convenient feature for pension funds to evaluate the development of the balance sheet. There are three tools which pension funds use to influence the future development of the assets and liabilities, namely the investment mix, contribution policy and indexation policy. With use of a classical ALM study pension funds can find out how to apply these three tools such that the development of the aforementioned components of the balance sheet in different economic scenarios is as desired. In this way, an ALM study can help pension funds by formulating a strategic policy with respect to the investment, indexation and contribution policy. More specifically, a classical ALM study is used to find out the probability distributions of pension fund variables over time. Pension funds are not only interested in a positive development in expectation over time, also the risks of deviating from this trend is essential to take into account. For example, a pension fund that expects an increasing funding ratio over time may not be satisfied with its strategy as long as the risk of underfunding is not sufficiently covered. Hence, with use of a classical ALM study a fund can evaluate their policy and subsequently choose for a policy representing the interests of the stakeholders the best.

2.1.2 Value-based ALM

The aim of a value-based ALM study is to gain insight in the intergenerational solidarity. Where classical ALM is a tool to measure the development of the cash flows over time, value-based ALM determines the value now. Value-based ALM is a study that generates cash flows for different economic scenarios at a certain point in time and subsequently discounts these cash flows back to the present using the corresponding stochastic discount factor. In this way, the economic value, which is the present value of future uncertain cash flows, of a pension contract or policy can be examined. An economic value can be interpreted as the present value of future uncertain cash flows.

In my thesis, each participant possesses a certain claim that is equal to the present value of the liability to this participant, plus the present value of the pension paid within this period plus the present value of the possession of the fund residue. The size of a claim depends on the pension policy in combination with the state of the financial market. There are three methods to calculate the economic value of these claims. A future cash flow in a scenario must be discounted to the present with a risk-adjusted rate corresponding to that scenario. In the literature either a deflator or a pricing kernel is used as stochastic discount factor or risk-neutral valuation is

applied. I will use the latter method which will be explained in Section 2.2.2.
If the pension policy is adjusted, the distribution of value to the fund participants could change. I apply a value-based ALM to identify the cohorts who gain and the cohorts who lose as a consequence of a certain contract or policy (change). However, the pension fund must be a zero-sum game in economic value terms and can therefore not create value by changing their policy. Although the distribution of assets to age cohorts might change, the sum of economic value transfers between generations must add up to zero when adjusting the investment mix, the contribution and/or the indexation policy.

2.2 Model description and assumptions

I will use an ALM study to determine the economic value and development of pension fund variables and its risk over time. In order to obtain a development of pension fund variables over time, a simulation of the financial market is needed. In this section, I will elaborate on the models used to simulate the financial market.

2.2.1 Financial market assumptions

Stock price model
The model used to describe the behavior of the stock prices over time was introduced by Black and Scholes in 1973. According to Black and Scholes (1973), a geometric Brownian motion is used to cover the development in the stock prices. The underlying stock price, S_t, is a stochastic process that can be described by the following stochastic differential equation

$$dS_t = \mu S_t d_t + \sigma_s S_t dW_{st} \tag{1}$$

where μ represents the constant drift (expected return), σ the constant volatility and where dW_{st} is a Wiener process[4].

Term structure model
The model used to describe the evolution of the interest rates over time was introduced by Vasicek in 1977. Important to note is that Vasicek assumes that interest rates are mean-reverting. The Vasicek model describes the behavior of the instantaneous short-term interest-rate, r_t, which is a stochastic process that follows the stochastic differential equation:

$$dr_t = \alpha(\beta - r_t)d_t + \sigma_r dW_{rt} \tag{2}$$

where β represent the mean-reversion level or the long-term mean of the short term interest rate, α can be interpreted as the 'speed' of mean reversion and where σ is the instantaneous volatility factor.

Price index model
The model for the inflation, where price index I_t follows the following stochastic differential equation

$$dI_t = \gamma I_t d_t \tag{3}$$

Where γ is the constant yearly price inflation and thus there will be no inflation risk.

[4] A Wiener process satisfies the following properties: $W_0 = 0$, the increments are independent and $W_t - W_s \sim N(0, t-s)$ for $0 \leq s < t$

Parameter	Value
μ	7.5%
σ_r	1%
σ_s	20%
r_0	4.5%
α	15%
β	4.5%
γ	2%
$\wedge$	-0.15
$\text{Corr}(W_{st}, W_{rt})$	-0.05%

Table 1: Parameter assumptions (in line with committee Parameters/Don)

Table 1 displays the parameter assumptions for the market. In September 2009 the report by committee Don (2009), appointed by Minister Donner in order to evaluate the parameter assumptions of pension funds, was presented. The committee stated that the determination of the parameters must be based on realistic future approximations and large deviations from the beforehand expected development had to be taken into account. I apply the for pension funds recommended parameter assumptions by the committee in my analysis. In line with the recommendation of chairman Don and the representatives of the DNB and CPB part of committee Don, I assume that the expected return for the risky asset, μ, is equal to 7.5%. In the same way, the initial nominal short-term interest rate, r_0, as well as β are assumed to be 4.5% and γ is set to the assumed price inflation of 2%. The correlation between the Wiener process of the stock price and the Wiener process of the interest rate, $\text{Corr}(W_{st}, W_{rt})$, equals -0.05% and the $\wedge$ which indicates the steepness of the term structure equals -0.15.

2.2.2 Risk-neutral valuation

I already explained in Section 2.1.2 that a pension contract often consists of several contingent claims[5]. However, not all contingent claims are explicitly defined for each economic scenario and hence not all contracts are complete. An unclear defined contingent claim in an incomplete contract could describe for instance that the contributions are increased in case of an 'insufficient' financial position. The controversy here is that it is not evident at which funding ratio the contributions are increased and by how much. In case of complete pension contracts, the value of a contingent claim is dependent on the policy of the fund in relation to the state of the financial market. Arbitrage-free valuation technique can be used to value these contingent claims. I will apply the risk neutral valuation technique. The risk neutral probability distribution assigns a higher probability to the bad outcomes. In the 'real world' people are generally risk averse and hence only choose for a risky strategy if they receive a risk premium covering the risk they are actually taking. Without a risk premium an equally expensive riskless strategy would have been preferred. The future expected cash flows in the 'real world' are discounted using the risk-free rate plus a risk premium. In a risk-neutral world the extra premium is not needed and future cash flows are discounted by only the risk-free rate. The people who live in a risk-neutral world behave risk-neutral. These fictional risk-neutral people do not require a risk premium that covers the risk, since they do not distinguish different cash flows in terms of risk. This is due to the fact that in the risk-neutral world higher probabilities are attached to the bad scenarios, which eliminates the

[5] A contingent claim is a claim where its pay-off depends on a certain outcome, for example if the funding ratio is above 125% full indexation is given.

need of a risk premium. The expected return under the risk neutral measure is therefore equal to the risk-free rate for all scenarios. The artificial probabilities needed to calculate the risk-neutral expectation ensure that the market price will remain the same. Theoretically formulated, this would mean that the price calculated by taking the expectation under the risk-neutral measure where future cash flows can be discounted with the risk-free rate is equal to the real world price. According to the fundamental theorem of asset pricing (FTAP), a risk-neutral measure only exists if the arbitrage-free condition is satisfied. Arbitrage-free means that without any capital in advance nobody can make a profit in at least one of the scenarios without making a loss in the others. The advantage of risk-neutral valuation is that, by taking the expectation under the risk neutral measure, every derivative can be priced.
The stock price, interest-rate and inflation model are used such that they are arbitrage-free. The FTAP prescribes that a set of asset price processes $Y_{i,t}$ (time i=1,..,n and asset t) in a market using a 'real world' probability measure P, where absence of arbitrage holds if and only if there exists at least one risk-neutral probability measure, Q_N, with N as numéraire[6], that is equivalent[7] to the 'real world' measure P, such that all relative asset price processes $(Y_{i,t}/N_t)$ are Q_N-martingales (cf. Schumacher (2010)).
The FTAP can be used to value derivatives or contingent claims. The value of a contingent claim (new asset) related to the existing assets in an arbitrage-free market is market-consistent, if the market remains arbitrage-free when the contingent claim is included. The following formula can be mentioned as the risk-neutral pricing formula or the numéraire dependent pricing formula (cf. Schumacher (2010))

$$\frac{C_t}{N_t} = E_t^{Q_N}(\frac{C_T}{N_T}) \tag{4}$$

Where C_t can be interpreted as the value of the contract at time t consisting of future pay-offs, and, N_t, represents the value of the numéraire at time t. In my thesis, I approximate the expected value of the contract at time t (C_t), by taking the expectation under the risk-neutral measure of the simulated cash flows of the contract at time T ($C_T = F(X_T)$), relative to a numéraire, $E_t^{Q_N}(\frac{F(X_T)}{N_T})$.

[6]An asset price-process that is the unit of a measure with a strictly positive pay-off can be interpreted as a numéraire.

[7]Measure P and Q_N are equivalent if all the events with a positive probability under measure P, have a positive probability under measure Q_N, and vice versa.

3 Financial Assessment Framework (FTK)

In 2007, a new pension framework was introduced. The so-called Financial Assessment Framework (FTK) is part of the Pension Act ('Pensioenswet'). The Pension Act, created in 2007, describes the responsibilities for the pension fund, employer and employee in relation to a sustainable pension system. The FTK describes how to value the assets and liabilities and consists of rules about the statutory financial requirements and the transparency of the pension system. In the next subsection, I will first define the (current) FTK regulatory since 2007. Then in Section 3.2, the proposed regulatory as stated in the memorandum of the pension agreement is explained. Understanding why changes in historical context are ever made contributes to a better understanding of what could have been done better in the past and why we should switch to a new contract. The interpretation of the proposed regulatory in the memorandum of the pension agreement turned out not to be the final interpretation. In May 2012, among others the Dutch Ministry of Social Affairs and Employment introduces some final characteristics and adjustments for the proposed regulatory.

3.1 Current FTK regulatory

Before 2007, pension funds usually discounted there liabilities with a fixed interest rate of at most 4%. After the introduction of the FTK framework, pension funds are required to discount the liabilities using the market interest rate.

The implementation of the FTK has led to completely new requirements regarding the financial position of the pension funds. The DNB supervises the imposed FTK contract requirements. The FTK regulatory prescribes that pension funds should always have enough assets to meet their liability. The funding ratio of pension funds has to be at least the minimum required funding ratio (MRFR) which roughly equals 105%. If the funding ratio is lower than the 105%, the pension has to draw up a recovery plan in order to recover within a period of at most three years. The recovery period was temporarily increased to five years after the credit crisis in 2008, but is since 2011 three years again. If the funding ratio after three years is still lower than the MRFR and no other actions can be taken, the pension fund has to cut pension rights in order to recover. Furthermore, DNB requires pension funds to hold an extra buffer, commonly known as the solvency buffer. The solvency buffer must at all times be large enough such that the probability of underfunding within one year is lower than 2.5%. The solvency buffer is dependent on six risk factors including the stock market and interest rate risks. Naturally, a pension fund that takes more investment risk has to accumulate a larger solvency buffer. The funding ratio of 100% plus the buffer that covers that the probability of underfunding within one year is lower than 2.5% is called the required funding ratio (RFR). Pension funds with a funding position below the RFR, but higher than the MRFR have a reserve deficit. According to the FTK requirements, these funds need to draw up a plan how to recover from the reserve deficit within 15 years.

3.2 Proposed regulatory of the pension agreement: 'hard' nominal and soft real contract

On June 10, 2011, the Dutch Government agreed with the social partners part of the 'Stichting van de Arbeid'[8] on the Pensioenakkoord (2010). In the memorandum of the pension agreement, an option between two contracts is given. The agreement makes the distinction between a 'hard'

[8]'Stichting van de Arbeid' is the Dutch consultative body of the central organizations of employers and employees in the Netherlands.

nominal and a soft real pension contract. The first option is the 'hard' nominal contract, a variant of the current FTK contract. The proposed nominal contract can be interpreted as a 'hard' contract, since nominal pension rights are for 97.5% certain. In this way, the DNB allows that on average each 40 years a pension fund will be in an underfunding position. Notwithstanding the nominal pension rights seem to be hard, pension rights should be cut in case of an underfunding position.
In May 2012, the Dutch Ministry of Social Affairs and Employment proposes an elaboration of the final characteristics of the 'hard' nominal pension contract. The so-called memorandum review financial assessment framework (2012) clarified two important differences between the current FTK and the proposed nominal contract. First, the RFR of the current FTK contract is replaced by a fixed level of 125% independent of the investment risk taken. The fixed level of 125% will roughly imply a 5% higher solvency buffer on average (DNB statistics). Second, within the proposed nominal contract the Ultimate Forward Rate (UFR) is applied for long maturities in order to stabilize the nominal discount factor in the long-run. A problem of the swap curve is that the liquidity of long term swaps(20+) is lower. Proposed is to let the discount factor upward of maturities of 20 years converge to a forward rate of 4.2% at a 60 year maturity.

	nominal contract	**real contract**
Pension	nominal, 97.5% certain	Soft real
Contribution	fixed or cost-effective	fixed or cost-effective
Policy Ladder	Nominal Ladder	Sharing surplus/deficit
Discounting	nominal interest rate	max expected return
P(FR_{t+1} <100%)	<2.5%	voluntary
Buffers	MRFR and RFR	equalization reserve
Amortization period	3/15 years recovery period	RAM,LAM max 10 years

Table 2: The nominal and soft real contract as proposed in the memorandum of the pension agreement (Pensioenakkoord (2010)).

The second option is the soft real contract, thus the pension rights of the participants will get a real but soft character. The real part means that a pension is assumed to be indexed for inflation. The soft part means that pension funds do not guarantee but promise an inflation indexed pension. In practice, the term 'soft' is also referred to as 'conditional'. The obligation to pay a nominal pension will change to an ambition to pay an inflation indexed pension. In a soft contract, the risk of mismatch between the ambition level of assets, needed to match the (indexed) liabilities, and the realized level of assets will no longer be part of the balance sheet of the pension fund. The financial market and longevity risks are transferred to the participants. Moreover, the funding ratio will no longer be calculated using the risk-free rate. As stated in the pension agreement, the pension liabilities can be valued using a discount rate of at most the expected return and in case of a real framework the discount rate has to be corrected for wage or price inflation. To lower the volatility of the liabilities pension funds have to determine the expected return every five years[9].
With regard to the contribution policy, the pension agreement agrees upon the recommendation by committee Goudswaard (2010) to stabilize the contribution rate. For both the proposed nominal and the soft real contract pension funds are able to choose for a fixed or a cost-effective

[9]Note that the initial goal of lowering the volatility in funding ratio cannot be applied on pension funds which are (fully) hedged against interest rate risk. For those pension funds, discounting with the expected return can lead to an unequal behavior of the assets and liabilities.

contribution rate.
The soft pension rights are contingent on the financial market and longevity risks. Three tools can help pension funds to lower the pension right risk. In contrast to current FTK and proposed nominal contract, under the soft (real) framework pension funds do not need to accumulate a buffer dependent on the risks taken, since the fund does not bear the investment risk. However, pension funds can choose to hold a voluntary buffer to lower the direct financial market risks on the pension rights of the participants. This voluntary buffer is called an equalization reserve ('egalisatiereserve'). The two other tools to lower the pension right risk are the so called 1) return adjustment mechanism (RAM) and 2) an longevity adjustment mechanism (LAM). Here the investment risk and longevity risk respectively can be absorbed over an amortization period of at most 10 years. An amortization period limits the volatility of the pension rights. 1) A RAM of 10 years implies that a shock is absorbed during the coming 10 years in order to recover. A recovery means that the funding ratio recovers to a funding ratio of at least 100% plus a possible equalization reserve. 2) In addition, a LAM of 10 years implies that a pension fund can recover from an unexpected increase in life expectancy by absorbing the shock over the coming 10 years. Table 2 gives an overview of the 'hard' nominal and the soft real pension contract as proposed in the memorandum of the pension agreement (2011). Nevertheless, there is still a lot of discussion about the implementation of an appropriate new soft pension contract.

4 Specification pension contracts

In this section, I will specify the contracts investigated in my analysis. In Table 3 and Table 4, the characteristics of the current 'hard' and the soft contracts respectively are specified.
A pension fund has three instruments that can be used to influence the future development of the funding position, namely the indexation policy, the contribution policy and the composition of the investment portfolio. Per investigated contract, I will define whether a pension fund is able to use and if so how it uses these instruments. In this section, I will specify the current contract in two ways. Both a hard nominal contract without mismatch risk and the more realistic 'hard' nominal asymmetric FTK contract are examined. Besides, I will investigate a soft contract which differs in terms of the discount factor and real or nominal framework applied.

	Hard nomm	**FTK**
Assets/Bonds	0/100	50/50
Indexation	No	Nominal ladder
Rights cut	Never	Linear, nominal
Discount factor	NTS	NTS
Buffers	No	MRFR and RFR
Recovery period	No	3/15years
Nominal certainty	100%	97.5%

Table 3: Specification of the hard pension contracts, where hard nomm is the abbreviation for the hard nominal contract without mismatch risk and FTK represents the 'hard' nominal asymmetric FTK contract.

	Soft RER	**Soft NRP**	**Soft RRP**
Assets/Bonds	50/50	50/50	50/50
Target FR	(100+ER)%	(100+ER)%	(100+ER)%
PRA	Linear, real	Linear, nominal	Linear, real
Discount factor	Expected return-inflation	NTS+RP	RTS+RP
Buffers	ER	ER	ER%
RAM	10 years(RAM)	10 years(RAM)	10 years(RAM)

Table 4: Specification of the soft pension contracts, where PRA, RP and ER are specified as the pension right adjustment, risk premium and equalization reserve respectively. And where soft RER, soft NRP, soft RRP are the abbreviations of the soft fixed real expected return contract, the soft nominal plus risk premium contract and the soft real plus risk premium contract respectively.

4.1 Hard nominal contract, without mismatch risk

Before giving the actual properties of this hard nominal contract without mismatch risk (hard nomm), I will explain why I incorporated this contract. The problem of the current FTK contract is that a nominal pension was often considered as a guarantee, while at the same time pension funds aspire to index pensions. On the one hand, a guaranteed indexed pension without help of a sponsor company, a high contribution rate or inflation linked products on the market is hardly

sustainable. A guaranteed indexed pension without any risk is very costly and/or complex. Besides, a real pension contract focuses on the real interest rate, while providing a nominal guarantee requires hedging against nominal interest rate risk. On the other hand, ensuring a nominal pension is far less complex, namely by managing the assets such that they match the nominal liabilities. However in practice, pension funds, in order to increase the nominal pension, often take investment risk to profit from the expected equity premium. The contradiction that occurs is that the assets, needed to match the nominal liabilities, are not owned by the fund, since the returns on the risky invested assets are not realized yet. The current situation of Dutch pension funds, where nominal pensions have to be cut, also demonstrates that having a real ambition while guaranteeing a nominal pension is not sustainable. Committee Goudswaard (2010) already stated that a higher pension ambition can be applied, only if the cost of a pension increases, which they discourage and I ignore, and/or the pension certainty declines. I therefore make a distinction between a hard nominal contract without mismatch risk where pension funds provide a nominal pension without any risk and indexation ambition, and the current 'hard' nominal asymmetric FTK contract that combines having a real ambition while trying to safeguard the nominal pension.
I will specify the hard nominal contract without mismatch risk as follows.

- The investment mix is composed such that no mismatch between the assets and the nominal liabilities will occur. As a consequence, the nominal funding ratio will always be 100%.
- I apply a discontinuity analysis on all contracts (see Appendix A). A discontinuity analysis means that no new contributions are paid, no new pension rights are accrued and no new participants will enter the fund. This satisfies the recommendation not to adjust the contribution rate in an ageing society in order to influence the solvency position of the fund (Goudswaard (2010) and the Pensioenakkoord (2010)).
- A guaranteed nominal pension is paid to the participants irrespective of the economic state and hence no indexation is given.
- No pension rights have to be cut.
- The liabilities are discounted with the nominal term structure.
- There is no mismatch risk so within this contract no buffers need to be accumulated or amortization period has to be applied to absorb the mismatch risk[10].

4.2 'Hard' nominal asymmetric FTK contract

Assuming that pension funds do not allow mismatch risk is not realistic. Pension funds in general incorporate investment risks. Taking investment risk can be justified by the presence of an expected equity premium on long horizons. A benefit of taking investment risk is that the expected higher return could be used to lower the contribution and/or index the pensions, however the increased risk might lead to lower returns than expected with the result that in the end pension rights need to be cut. The contract where investment risk is taken, indexation can be given and pension rights might be cut is interpreted as the 'hard' nominal asymmetric FTK contract (FTK contract). First, I will interpret the 'hard' nominal asymmetric FTK contract. Later on, I will check the effect of a switch from the current FTK contract to the proposed nominal contract of the pension agreement. Furthermore, I use quotation marks for the term 'hard', since a nominal pension is assumed to be for 97.5% certain within the FTK contract.

[10] Other risks like for example longevity risk or credit risk, making a buffer convenient, are ignored here.

- I assume that 50% is invested in the risky asset and the other 50% in nominal zero coupon bonds.

- Conditional indexation is provided based on a nominal policy ladder. Since a nominal framework is considered, the policy ladder is based on a nominal funding ratio. According to the requirements of the DNB, a solvency buffer must be held. The size of the required solvency buffer will depend on the risk taken by a pension fund. The average solvency buffer under FTK requirements is around 20% according to data of the DNB[11]. I therefore assume that full indexation is only given when the funding ratio exceeds the required funding ratio of 120%. Moreover, pension funds are required to have a nominal funding ratio above the MRFR. I therefore assume that pension funds only give indexation if the funding exceeds the MRFR of 105%. Between 105% and 120% the indexation level in year t increases linearly with the nominal funding ratio of that year. The formula of the nominal policy ladder can be specified as follows

$$\text{Indexation}_{t,n} = \begin{cases} 0 & \text{if } FR_{t,n} \leq MRFR \\ \left(\frac{FR_{t,n} - MRFR}{RFR - MRFR}\right)\gamma & \text{if } MRFR < FR_{t,n} \leq RFR \\ \gamma & FR_{t,n} > RFR \end{cases}$$

- The DNB requires pension funds with a funding ratio below the MRFR of 105% to recover within 3 years in the FTK framework. I assume that a pension fund with a funding ratio below 105% will cut nominal pension rights. The adjustment in pension rights can be smoothed over a period of 3 years. In this way, I meet the requirement of the DNB to recover from a nominal funding ratio below 105% within 3 years. If the nominal funding ratio after a pension right cut is recovered and above the 105%, the pension rights are increased with a percentage which is at most equal to the previous pension right cuts with the proviso that a funding ratio of at least 105% is maintained. The following formula will indicate the percentage cut of nominal pension rights in year t in contract n

$$\text{PRC}_{t,n} = \begin{cases} \left(\frac{FR_{t,n} - MRFR}{\text{Recovery Period}}\right) & \text{if } FR_{t,n} \leq MRFR \\ 0 & \text{if } FR_{t,n} > MRFR \end{cases}$$

  Note that the DNB requires to cut nominal pension rights only if the funding ratio is not recovered after 3 years. The percentage of pension right cut will then be equal to the difference between the funding ratio after 3 years and the MRFR. In order to prevent slow simulations, I apply the pension right cuts at the end of the underfunding year. In addition, the DNB requires that pension funds with a reserve deficit recover within 15 years. I assume that the RFR requirement will automatically be met in 15 years given the fact that risk taking by pension funds is rewarded. In another perspective, it is not allowed that pension funds cut pension rights in case of a reserve deficit. I therefore assume that pension funds under this FTK framework will always meet the requirements to recover from a reserve deficit within 15 years.

- A nominal term structure is used to discount the liabilities.

[11] http://www.toezicht.dnb.nl/4/5/9/50-204668.jsp?s=n, 2012

4.3 Soft symmetric pension contract

The pension agreement proposes a soft (real) pension contract in order to improve the Dutch pension system. However, the eventual rules of the soft contract are still under debate. The discount rate and framework that have to be applied are representing an important part of the discussion. Under the soft framework as proposed in the pension agreement, it is allowed to apply a discount rate that is at most as high as the expected return on the pension portfolio. Since this might be an incentive to take more risk (i.a. Kocken(2011a)), I also take, in addition to the real expected return contract, a soft nominal and real contract with a horizon independent risk premium into account. Later on, I will examine the generational impact of a horizon dependent risk premium as well. Besides the different discount rates applied, I explicitly define the symmetric policy ladder of the soft pension contract that clarifies the risks involved under each economic scenario for the pension fund and participants.

- The investment mix can be specified as 50% invested in stocks and 50% in a nominal zero coupon bonds.
- The policy ladder that shares surplus and deficits linearly is constructed such that the funding ratio will recover to the target funding ratio of 100% plus a possible equalization reserve. In the soft framework pension funds are not required to hold a solvency buffer, however the pension agreement recommends pension funds to hold an equalization reserve. For simplicity, I assume an equalization reserve[12] of 5%. Hence, a target funding ratio of 105% is applied equal to the MRFR of the hard contracts. Bovenberg et al. (2012a) stated that the market consistent valuation of a symmetric contract (Figure 1), maintained by this interpretation of the equalization reserve, is less complex. Pension rights are linearly cut if the funding ratio is below the target and linear indexation is given when the funding ratio exceeds the target ratio. The following formula[13] will show the adjustments in pension rights in contract framework n and year t

$$PRA_{t,n} = \frac{FR_{t,n} - (100\% + ER)}{\text{Amortization period}} \tag{5}$$

  Where n indicates either the expected return adjusted for inflation, the real term structure plus risk premium or the nominal term structure plus risk premium framework. The funding ratio, $FR_{t,n}$ and hence the pension right adjustment in year t differs when the framework is changed. Note that the $FR_{t,n}$ in a real framework is calculated assuming indexed pensions. This will imply a different distribution rule.

- The liabilities are discounted by either
  1. the fixed real expected return (soft RER contract).
  2. the real term structure plus a risk premium (soft RRP contract).
  3. the nominal term structure plus a risk premium (soft NRP contract).

  I assume that the fixed real expected return equals 4%, since 50% is invested in nominal coupon bonds and 50% is invested in risky assets and 4%=0.5*4.5%+0.5*7.5%-2%. After all the criticism on the memorandum of the pension agreement (2011), an actual implementation of discounting the liabilities with the expected return is no longer conceivable.

[12]The equalization reserve can be interpreted as a buffer that stays in the fund until it is distributed (at the end of the 15th year/simulation period).

[13]For this way of interpreting the RAM, the funding ratio does not fully recover in 10 years assuming no financial market developments.

Nonetheless, I still take this possibility into account to clarify the value transfers between generations and the effect on the sustainability of the fund, when not the real expected return but another discount factor is used. I therefore also incorporate the nominal and real term structure plus a risk premium as alternatives. The uniform risk premium incorporated in the discount factor will be equal to $w\lambda\%$, where w is the percentage invested in stocks and λ equals the equity premium. I determine the risk premium for a (50/50) investment mix and subsequently fix this risk premium irrespective of other investment mixes applied. Hence, the risk premium is equal to 1.5%. Since the soft RER contract already demonstrates how a more risky investment mix influences the redistribution of value as a result of a change in discount factor, I assume, for the other soft contracts, a fixed horizon independent risk premium. Later on, I will also take the horizon dependent discount rate by Bovenberg et al. (2012a) into account.

- The RAM period allows pension funds under a soft framework to smooth shocks over a horizon of at most 10 years. I therefore assume that pension right adjustments can be smoothed over an amortization period of 10 years.

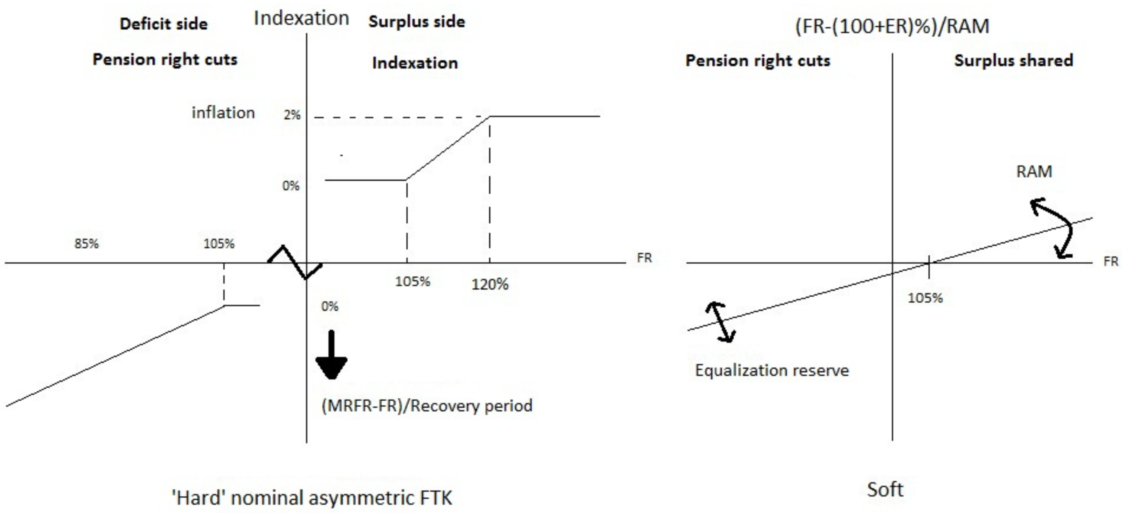

Figure 1: Policy ladder for the FTK contract and the soft contracts.

5 Sustainability and generational impact of the contracts

In this section, I will explain the results obtained on the basis of the investigated pension contracts. First, I will examine to which extent the (mis)interpretation of the hard pension contract affects the sustainability of the pension fund and the redistribution of value between generations. Subsequently, I will investigate the generational impact of increasing the discount factor and switching from a nominal to a real framework within a soft symmetric pension contract. Moreover, I will elaborate the value transfers resulting from a switch from a 'hard' to a soft contract and show that these transfers are dependent on fund specific contract properties such as the recovery period, RAM period, the policy ladder, a buffer, an equalization reserve and the investment mix applied.

5.1 Interpretation of the current 'hard' nominal contract

Interpreting the hard nominal contract as an asymmetric contract with mismatch risk causes a value transfer from the old to the young[14].

In this section, I will verify whether the current FTK contract is sustainable as it stands. Within the current FTK contract, the higher expected return on the assets due to the investment risk is taken can be used to index the pension. However, at the same time nominal pensions are for 97.5% certain, which requires minimized mismatch risk between the level of assets and the nominal liabilities. I want to make clear that performing these two strategies within one asymmetric pension contract is not sustainable. In order to clarify this conclusion, I investigate, besides the current FTK contract, also the hard nomm contract where nominal pension rights can never be cut.

horizon	$P(CLPP < x) \leq 0.05$	$E(CLPP)$	$P(CLPP < x) \leq 0.95$
1year	2.0%	2.0%	2.0%
5years	10.5%	10.5%	10.5%
15years	35.0%	35.0%	35.0%

Table 5: Cumulative loss of purchasing power (CLPP) in percentages for a hard nominal contract without mismatch risk

horizon	$P(FR_N < x) \leq 0.05$	$E(FR_N)$	$P(FR_N < x) \leq 0.95$	$P(FR_N < 105\%)$
1year	85.8%	102.1%	122.3%	63.8%
5years	82.2%	108.2%	146.5%	50.5%
15years	82.9%	122.9%	216.4%	42.0%

Table 6: Development average nominal funding ratio, the 5% and 95% quantiles and the probability of nominal pension right cuts in the FTK contract

horizon	$P(CLPP < x) \leq 0.05$	$E(CLPP)$	$P(CLPP < x) \leq 0.95$
1year	3.7%	3.7%	3.7%
5years	2.8%	17.4%	41.1%
15years	3.9%	52.7%	155.1%

Table 7: Cumulative loss of purchasing power (CLPP) in percentages in the hard nominal FTK contract

In contrast to the hard nomm contract where the participants do not have any nominal pension risk, the policy ladder applied in the FTK contract causes a certain distribution of the higher expected portfolio return and corresponding risk over the age cohorts. Table 6 gives an overview of the evolution of the average nominal funding ratio, its 5% and 95% quantiles and the probability that nominal pension rights are cut in the FTK framework. At first, I would like to discuss the

[14] Note that this conclusion is based on an initial nominal funding ratio of 100%, and thus no initial surplus or deficit are assumed.

interpretation of the current 'hard' contract. Table 6 demonstrates that interpreting the current contract as a hard contract, where nominal pension right cuts occur only in extreme scenarios, can be rejected. Cutting nominal pension rights in the current 'hard' FTK contract is not exceptional. The nominal funding risk is substantial on all horizons. Note that the initial funding ratio of 100%, implying that pension rights are likely to be cut in the first years, contributes to a considerable higher probability. As the average nominal funding ratio and its risk are increasing over time, the probability of cutting nominal rights decreases. The increase in nominal funding ratio compared to the no mismatch contract, where the nominal funding ratio is 100% independent of the horizon, can be attributed to the investment risk taken (1) in combination with the asymmetric policy ladder (2) applied. 1) Taking investment risk is rewarded on long horizons by the equity premium assumed and hence will increase the expected nominal funding ratio. 2) For the FTK contract the policy on the surplus side deviates from the policy on the deficit side (see also Figure 1). Where a deficit will be undone within 3 years by the pension right cuts, the surplus if the funding ratio exceeds the MRFR is partly used to accumulate the solvency buffer within 15 years. This means that for the same deviation from the MRFR, the fraction of pension rights to be cut is higher than the indexation given. Accordingly, the asymmetric policy ladder implies a faster recovery to the MRFR when a deficit occurs than it recovers when a surplus occurs. This is represented by the lower deviation of the 5% quantile from the average nominal funding ratio compared to the deviation of the 95% quantile from the average nominal funding ratio.

The asymmetric policy ladder enhances the increase in funding ratio, since the pension right cuts are not truncated on the deficit side, while the indexation given is truncated for the surplus side. For the current low funding ratios, pension rights are taken away from the elderly in the current FTK contract. Subsequently, these rights are partly riskful invested. Hence, the elderly can never be proportionally rewarded, since if the return on the seized pension rights turned out to be positive, the elderly are only rewarded with a (too low) fraction of indexation on the surplus side. A negative return would even mean that they can forget these seized pension rights. Where the compensation for the risk on the surplus side for the old is not sufficient, the extra risk premium essentially meant for the old is subsequently transferred to the future and will end up with the young. The young therefore get a too high risk premium for the risk they bear. Whereas the present value of the liabilities of the young is too high given the risk they bear, the present value of the liabilities of the old is too low. Since the assets relative to the liabilities on average increase, the pension fund becomes wealthier and the young are able to profit from the numerous residual assets in the fund. All in all, the current FTK contract is not sustainable for the current low funding ratios.

The finding that the current asymmetric contract is unfair for the elderly is confirmed by the performed value-based ALM study. By means of a value-based ALM study, I show what would have happened with the distribution of pension fund assets to generations if pension funds really would have interpreted the hard nominal contract as a hard contract, so without mismatch risk[15]. The formula for calculating the possession of pension fund assets by a cohort is represented by Formula 10 in the appendix. Figure 2 shows the number of nominal funding ratio points each cohort will gain or lose on a 1, 8 and 15 years horizon. The effect on a 1 year horizon will not make much difference. Although the effect is marginal on a 1 year horizon, the effect becomes substantial when the horizon rises. The 40-55 age cohorts will benefit, in terms of nominal funding ratio points, with almost 2% the most[16]. The cohorts who already decumulated a lot of

[15]Within the hard nomm contract no investment risk is taken, hence no surplus or deficit can be distributed to generations.

[16]Note that in a continuity perspective the very young will lose in market value, since they are not rewarded within the simulation horizon of 15 years for the contribution they paid too much ('doorsneepremie').

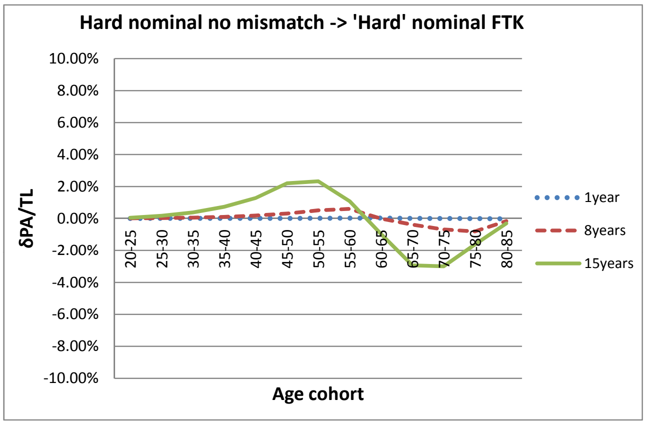

Figure 2: Change in distribution of pension fund assets over age cohorts when switching from a hard nomm contract to the FTK contract as a percentage of the total nominal liabilities in the hard nomm contract.

pension right after 15 years will lose around 3%.
Note that the initial funding ratio of 100% enhances this value transfer. In the coming year(s) it is very likely that pension rights are cut which is already at the expense of the old. This is also reflected by Table 5 and Table 7, which show that the average cumulative purchasing power position is deteriorated in the FTK contract compared to the hard nomm contract owing to the initial cut.
Another insight is given by an investigation of how the generational accounts are changed, so the change in entitlement to the pension fund assets when switching to a new contract relative to their initial entitlement to the pension fund assets (Figure 17 in Appendix D). In contrast to Figure 2, Figure 17 does not illustrate the zero-sum game property of the pension fund, but gives insight in the quantity each generation gains or loses on a 15 year horizon. Figure 17 shows that the 20-25 cohort will gain about the same percentage as the 45-50 cohort. However, since the financial capital of the 20-25 cohort is only a fraction of the accumulated pension capital of the 45-50 cohort and therefore of less importance in a discontinuity analysis, my analysis is mainly based on the design of Figure 2.

5.2 Interpretation of the soft contract

Within the soft pension framework I investigate three contracts which differ in terms of the discount factor and real or nominal framework applied. I want to investigate the value transfers between age cohorts as a result of using a different discount rate and subsequently adjusting the framework from a nominal to a real framework.

5.2.1 Influence of the discount factor

Using a higher discount rate will ceteris paribus imply a value transfer from young to old.

Line A in Figure 3 represents a switch from a soft RER contract to a soft RRP contract. This switch contributes to the current discussion (i.a. Kocken(2011a)) that a higher discount rate[17] will ceteris paribus lead to a value transfer from young to old. A higher discount rate directly lowers the assumed value of the liabilities and increases the corresponding funding ratio. Owing to the higher funding ratio, more surplus is distributed on a short horizon. The more surplus shared is directly absorbed in the pension of the retired. As a consequence of sharing more surplus for the same amount of pension fund assets, less assets will remain in the fund for the working participants. The funding ratio on a longer horizon will therefore decrease as a consequence of the surplus that is additionally shared. The young will therefore be burdened with a lower funding ratio and thereby less protection and on average lower benefits. The effect of a small increase[18] in discount rate will lead to a loss for the 40-50 age cohort of 1.2% and a maximum gain of 1.8% for the 65-70 age cohort.
In the same way, a lower discount rate will be in favor of the young. As a consequence of a lower funding ratio, pension rights are suddenly cut which are directly absorbed in the pension paid to the old, while the young will be better protected after the recovery.

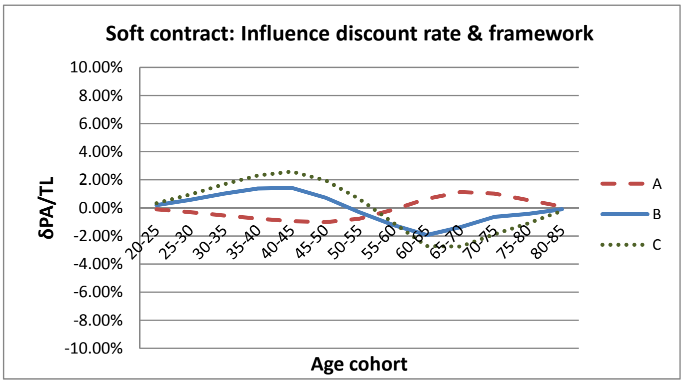

Figure 3: A change in distribution of pension fund assets over age cohorts as a percentage of the total liability of the old contract when adjusting the discount factor in the soft framework. Where line A represents the switch from a soft RER contract to a soft RRP contract, line B represents the switch from a soft NRP to a soft RRP contract and where line C represents the switch from a soft NRP contract to the soft RER contract.

[17] The discount rate of the soft RRP contract is on average higher, since the real fixed expected return equals 4% on all horizons, while the initial real term structure plus a risk premium starts at 4% and grows over the horizon.
[18] See footnote 17.

5.2.2 A switch from a soft nominal to a soft real framework

The direction and size of the value transfer when switching from a nominal to a real framework within a soft contract is dependent on the RAM period and the duration of the nominal liabilities. A pension contract switch from a soft nominal to a soft real contract

- *results in a value transfer from young to old if the RAM period substantially exceeds the duration of the nominal liabilities.*
- *results in a value transfer from old to young if the RAM period is lower than the duration of the nominal liabilities.*
- *is roughly generation-neutral if the RAM period is chosen equal to the duration of the liabilities.*

The size of the value transfer increases if the RAM period deviates more from the duration of the nominal liabilities.

I start with an example that shows that the duration of the nominal liabilities[19] in combination with the RAM period determines whether a pension in a real framework or in a nominal framework is higher in the first year(s) after the switch. Since the difference between the nominal and the real term structure is the constant assumed inflation of 2%, the real funding ratio is roughly 2% times the duration of the nominal liabilities lower than the nominal funding ratio. This holds regardless of the initial funding ratio or equalization reserve (see also Section 6.4). For simplicity, I assume no financial market development, no inflation risk and an initial nominal and target funding ratio of 100%. Formula 5 shows us that the deviation of the actual funding ratio from the target divided by the RAM period equals the size of the pension right cut. If this pension right cut is equal to the (promised) indexation of 2%, the pension paid in a nominal framework equals the pension paid in a real framework. In formulas, when the assumed difference of $\frac{2\% D_L}{RAM}$ equals 2%, or equivalently when $D_L = RAM$ the pension right cut in the real framework will always cover the indexation assumed of 2%. Table 8 gives insight in how the pension right adjustment in the real framework changes for different durations and lengths of the RAM period. If D_L exceeds the RAM period (right upper triangle), the indexed pension in the real framework is adjusted with more than the 2%, and is therefore lower than the nominal pension. Accordingly, relatively less indexation is provided in the real framework and more assets will stay in the fund, which is beneficial for the young and at the expense of the elderly. A RAM period greater than the D_L (left bottom triangle) implies a lower pension right cut than 2% which subsequently makes the pension paid in the real framework higher than in the nominal framework. The relatively more indexation provided in the real framework causes that less assets will stay in the fund, which is in favor of the elderly and disadvantageous for the young.

I think there are two deficiencies of introducing a fixed RAM period. First, when exchanging a soft nominal contract for a soft real contract, the switch only results in marginal value transfers if the duration of the liabilities accidentally equals the fixed RAM period. Note that the duration of the nominal liabilities is only lower than the proposed RAM period of ten years for very grey pension funds. Second, I state that a fixed RAM period causes uneven distribution of risk in different aged funds. Applying the same amortization period on different aged funds implies that the risk transferred by the constant RAM period to the young in a grey fund is larger than the risk transferred to the young in a green fund. In this way, the shorter duration of the liabilities in a greyer fund is beneficial for the old, while the longer duration of the liabilities in a green

[19] Note that not directly the duration gap (asset liability mismatch), but only the duration of the nominal liabilities is important here.

RAM \ D_L	8	10	12
8	2%	2.5%	3%
10	1.6%	2%	2.4%
12	1.3%	1.7%	2%

Table 8: A table which shows how a combination of the RAM and D_L (duration of the nominal liabilities) affect the size of the (first) pension right adjustment in a real contract. Where the pension right adjustment (PRA) equals $\frac{2\% D_L}{RAM}$, the initial nominal and target funding ratio are equal to 100% and no financial market developments are assumed.

fund is in favor of the young when switching from a nominal to a real framework. Bovenberg et al. (2012a) propose an amortization period where the cash flows with a duration longer than the RAM period are set equal to the RAM period and cash flows with a duration smaller than the RAM period are set equal to that duration. Consequently, the amortization period will always be smaller or equal to the duration of the nominal liabilities. Accordingly, the old can never benefit when switching from a soft nominal to a soft real contract, since the amortization period as proposed by Bovenberg et al. (2012a) never exceeds the duration of the liabilities and the constant RAM period of 10 years. Furthermore, if pension funds want to keep the total risk exposure constant when the fund becomes older, the exposure to risky assets must be reduced as well.
Line B in Figure 3 displays the generational impact of a switch from a soft NRP contract to a soft RRP contract, under my settings where the duration of the nominal liabilities exceeds the RAM period. As a consequence of a RAM smaller than D_L, the pension right cuts cause a lower pension for the old in the first year(s) in a soft real framework compared to a nominal framework (see also Table 8). The pension right cuts, which are immediately absorbed by the old, also lowers the pension rights of the young. However, after the recovery the young can benefit from the relatively more assets providing indexation. Thus, the young will gain and the old will lose with at most 1.5% in market value.
Where Table 8 shows how the RAM and D_L affect the pension right adjustment of the indexed pension in a real contract, Figure 4 illustrates how the size of the adjustment, dependent on the RAM and D_L, influences the generational accounts when one decides to switch from a nominal to a real framework. If the RAM is smaller than the duration of the nominal liabilities, the young will gain at the expense of the old. A RAM period larger than the duration of the nominal liabilities, implies a value transfer from the younger to the older cohorts. A RAM period that deviates more from the duration of the nominal liabilities increases the size of the value transfer. Besides that the size and direction of the value transfers are important when switching from soft nominal to soft real contract, there is a general disadvantage of discounting with a nominal term structure. In case of high expected inflation, the nominal interest rate usually rises which makes it unwise to distribute more assets now (in favor of the old and at the expense of the young), since the assets can better be saved if the future inflation indeed turned out to be high. However, since I assume a fixed inflation of 2% every year, this is not applicable on my results.

Finally, line C in Figure 3 represents a switch from a soft NRP contract to a soft RER contract that leads to a value transfer from old to young. This switch represents a lower discount factor and a change to a real framework. We have seen that both a lower discount rate and a switch to a real framework are beneficial for the young. The magnitude of the value transfer will therefore be the greatest.

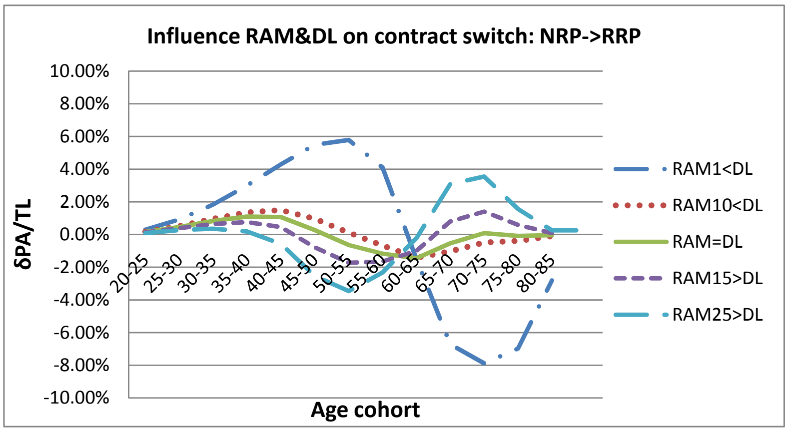

Figure 4: Influence of adjusting the RAM period for a constant D_L of 11.4 on the redistribution of value between age cohorts when switching from a soft NRP to a soft RRP contract.

5.3 Switching from a 'hard' to a soft framework

A switch from a 'hard' to a soft framework implies a value transfer from the young to the old caused by a change in policy ladder, real or nominal framework applied and/or a higher discount rate.
For all the investigated switches to a soft contract, it holds that if the current pension contract is interpreted as the 'hard' nominal asymmetric FTK contract rather than the hard contract without mismatch risk, the value transfer from young to old will be greater. The value transfers from young to old ordered from high to low, when switching from a hard to a

- *soft NRP contract is a result of the symmetric policy ladder and the uniform increase of the discount factor beneficial for the old.*
- *soft RRP contract is a result of the symmetric policy ladder beneficial for the old that outweighs the real framework in favor of the young.*
- *soft RER contract is a result of the symmetric policy ladder beneficial for the old outweighing both the lower real discount rate and the real framework in favor of the young.*

It is likely that the current (hard) pension contract is reformed to a new soft pension contract. If we want to switch to a new soft contract that is more sustainable, the old pension contract needs to be reformed. The Dutch Government stated that this reform should not lead to significant value transfers between generations. However, in any case, adjusting a pension contract can lead to value transfers between generations[20].

[20]The equalization reserve as instrument to limit the value transfers resulting from a switch from a 'hard' to a soft contract is ignored here and investigated in Section 5.5.

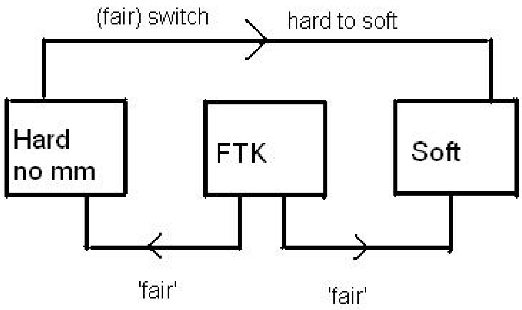

Figure 5: The alternative for the proposed contract reform of the Pensioenakkoord (2010) in a graphical way.

The Dutch Government focuses only on the value transfers when switching from the current asymmetric FTK contract to a soft contract without assessing the current contract. In Section 5.1, I already demonstrated that the FTK contract is unfair for the current low funding ratios. The elderly have to return part of their accumulated pension rights (by cuts) in order to recover or accumulate a solvency buffer and hence they do not receive a proportional premium for their risky invested pension rights that are taken away. In fact, the switch from the hard nomm contract to the soft contract would less represent the reality. Nevertheless, this switch is certainly significant, since the switch from the 'unfair' FTK contract to the soft contract results in a magnified value transfer in favor of the old.
In Section 5.1, I already showed that the asymmetric policy ladder does not properly reward the elderly for the risks they are exposed to. Second, I concluded that within the current FTK contract pension funds often allow too much mismatch risk for safeguarding a nominal pension with 97.5% certainty. Where a higher ambition should imply less pension certainty, a lower ambition may allow more pension certainty (ignoring the influence of the contribution rate). Third, also the investigation of the purchasing power position does not support for the current FTK contract. For the current low funding ratios, I demonstrated that the average cumulative loss in purchasing power even increases in the FTK contract compared to the hard nomm contract (Table 5 and Table 7). Also, for the current low funding ratios, the average purchasing power position of the participants is worse within the current FTK contract compared to the soft pension contracts (Table 10, Table 11, Table 12 and Table 13). Hence, as alternative to the proposed nominal (or reformed FTK) contract by the pension agreement, I propose that pension funds could switch to a symmetric soft contract or otherwise the current contract should be reformed to a hard nominal contract without mismatch risk (Figure 5). In this way, the ambiguous ambition of pension funds in the current asymmetric FTK contract is replaced by either a contract that safeguards a nominal pension without mismatch risk or a pension contract that combines a higher ambition with less certainty.
A value-based ALM study provides an insight in terms of value transfers. Figure 6 shows that a significant value transfer from young to old will occur when one switches from a hard nominal contract to a soft NRP contract. The first cause is the increase in discount factor by 1.5%. In Section 5.2.1, I already showed that a higher discount rate implies a value transfer from young to old. The second cause is the change from an asymmetric to a symmetric policy ladder. Figure 15 in the appendix illustrates that replacing the asymmetric FTK ladder for the soft symmetric policy ladder is beneficial for the elderly. For the same deviation from the target funding ratio, a higher fraction of the surplus will be distributed or a lower fraction will be cut within the 'soft

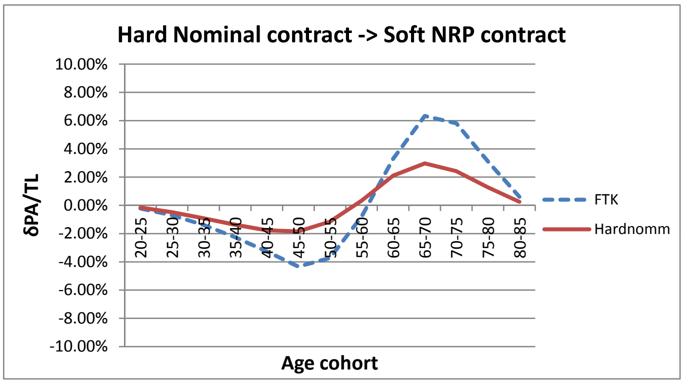

Figure 6: Change in distribution of pension fund assets over age cohorts as a percentage of the total nominal liabilities of the hard contract when switching from a 'hard' to a soft NRP contract

nominal' contract with a symmetric policy.
The direction of value transfer will be the same if one switches from a hard nominal contract to a soft RER or RRP contract, however the magnitude of the value transfer will be less. The smaller magnitude when switching to a soft RRP contract is because of the previously proven advantage of a real instead of a nominal framework for the young. The value transfer from old to young is still substantial and illustrated in Figure 18 in Appendix D.
In Figure 19 in Appendix D the value transfer between generations when switching from the hard nominal contracts to the soft RER contract is illustrated. The magnitude of the value transfer is the lowest for this switch. This can be explained by the fact that a switch to the soft RER contract implies a lower discount rate in combination with a real framework applied, which are both beneficial for the young.
For all the investigated switches from the current contract to a soft contract, it holds that the old will benefit more at the cost of the young when interpreting the current contract as the 'hard' nominal asymmetric FTK contract rather than the hard nomm contract. This can be attributed to the fact that including an asymmetric policy ladder while allowing mismatch risk is beneficial for the young.

The inappropriateness of discounting with the (real) expected return
If the assessment of a contract switch from the current FTK to a soft contract is purely focused on minimizing the value transfers, under my assumptions, a switch to a soft real expected return obviously is the most appropriate one. My parameter assumptions are based on the report of committee Don that emphasizes the importance of a prudent determination of the parameters. However, the introduction of a soft RER contract disregards the recommendation of the pension agreement to make the pension system more sustainable (1) and transparent (2) in all economic scenarios. 1) If pension funds are able to discount the liabilities with the (real) expected return, they can hide a current bad funding position by taking more investment risk. A more risky investment mix implies a higher expected return and as a result of the higher discount rate,

the funding position substantially improves. Since the *expected* portfolio return (assuming an equity premium of 3%) is higher than the risk-free interest rate, the assumed level of liabilities is significantly lower. For the same level of assets the extra indexation provided due to the 'created' surplus is provisional, since the expected return is not realized yet. We have seen that a higher discount rate significantly transfers value from young to old. I therefore conclude, in line with Bovenberg et al. (2012a), that the funding ratio should not be sensitive for the risk taken by the pension fund. Besides the incentive to take more investment risk contributing to a better funding position, also the incentive to hedge against interest rate risk in order to reduce the funding volatility is taken away in a soft RER contract. 2) The second reason that demonstrates the inappropriateness of introducing the soft RER contract is that the contract does not improve the transparancy. Using an expected return does not automatically mean that the future realized return will not differ from the expected return. The higher pension payments distributed to the retired created by more investment risk are partially covered by returns which are not yet realized. Hoekert (2011) wonders whether participants actually understand the mathematical interpretation of an expected pension. The soft RER contract does therefore not agree with the goal of the pension agreement to make the system more transparent.

5.3.1 A horizon dependent risk premium in the discount rate

The young benefit when the soft contract is interpreted as a soft RBNW contract rather than a soft RRP contract. The value transfer, as a result of the horizon dependent risk premium, will be significantly lower when a switch from a hard nominal contract to a soft RBNW contract is applied.

In this section, I want to investigate whether and if so by how much the horizon dependent discount factor proposed by Bovenberg et al. (2012a) affects the value transfers.

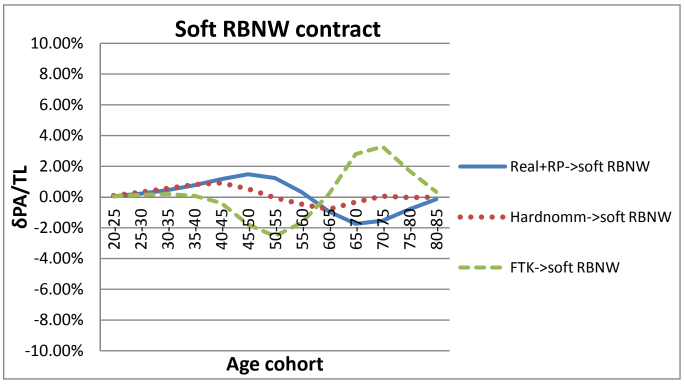

Figure 7: Change in distribution of pension fund assets over age cohorts in terms of the assumed value of the total liabilities when either the hard nomm contract, the FTK contract or the soft RRP contract is changed to a soft RBNW contract

We have seen that using the real fixed expected return as a discount factor might be an incentive to take more risk resulting in unintended value transfers. Furthermore, we have seen that a nominal or real term structure plus a horizon independent risk premium as discount factor is too high for the short-term cash flows of the old. On the one hand, a higher discount rate is in favor of the old, since the pension paid to the old directly absorb the more surplus distributed without bearing more risk. As a result less capital will stay in the fund to the detriment of the young. On the other hand, a risk-free interest rate without risk premium might be too prudent for the long-term cash flows of the young. A too low discount factor applied on the cash flows for the young might imply that too much capital will stay in the fund to the detriment of the old. Bovenberg et al. (2012a) proposed a horizon dependent discount factor to overcome this problem. The discount factor is slightly higher than the real term structure for short-term cash flows and as the horizon of the cash flows grows the discount factor is increased more and more with the assumed risk premium. I refer to the soft real contract using the horizon dependent discount rate by Bovenberg et al. (2012a) as the soft RBNW contract.
Figure 7 shows the effect of a switch from the respective hard contracts or from the soft RRP contract to the soft RBNW contract. Whereas the BNW discount factor in the limit converges to the real term structure plus risk premium, the young will benefit at the expense of the old owing to the on average lower discount factor. The gain of the young equals the loss for the old and is at most 2%. Since the young are better off in a soft RBNW contract compared to the soft RRP contract, the value transfer when switching from the current contract to the soft RBNW contract is lower. The 45-55 age cohorts will lose the most with 2.5%, while the age cohorts 65-75 will gain the most with 3.5% in terms of funding ratio points. Finally, worth mentioning is that if the current contract is interpreted as a hard nomm contract, a switch to a soft RBNW contract practically is generation-neutral.

5.4 Hard contract: influence buffer and recovery period

Increasing the MRFR from 100% to 105% and increasing the solvency buffer with 5% will lead to a small value transfer from old to young, while an increase in recovery period from 3 to 5 years will result in a small transfer in value from young to old.

As we have seen before, a different interpretation of the current (hard) and proposed soft contract already leads to substantial value transfers. Besides, pension funds differ in terms of several contract properties. This implies that one uniform value transfer, applicable on all pension funds that switch from the current 'hard' contract to a soft contract, gives an ambiguous representation. In this subsection, I will investigate how the rules audited by the DNB regarding the buffer size and recovery period influence the redistribution of value between generations within the hard pension contract. This gives insight in how robust the value transfers are for changes within the hard pension contract.
Figure 8 displays what will happen with the distribution of pension fund assets in terms of the nominal funding ratio, when the MRFR funding ratio is 105% instead of 100%. In this way, pension rights need to be cut in order to recover within 3 years to the MRFR of 105% rather than a funding of 100%. As a result, the old absorb the pension right cut immediately in their pension, while the pension rights of the young are lowered as well but can recover due to the better protection (relatively more assets) after the cut. The maximum gain for the young is 0.8% and the loss for the old is 0.9% as a percentage of the total nominal liability.
An increase in the solvency buffer within a hard framework is reflecting the switch from the current nominal FTK contract to the proposed nominal contract. According to the CPB analysis (2012), the upper bound of the indexation ladder within the proposed nominal pension contract

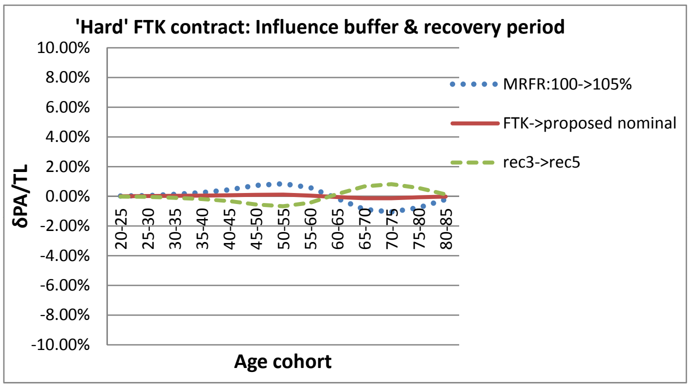

Figure 8: Change in distribution of pension fund assets over age cohorts as a percentage of the total nominal liabilities of the FTK contract when increasing the solvency buffer from 120% to 125%, the MRFR from 100% to 105% and the recovery period from 3 to 5 years.

is set at 125% (independent of the investment risk taken). For the average Dutch pension fund, this will increase the RFR with 5%. Hence, full indexation is given at a nominal funding ratio of 125% instead of 120%, which implies that the recovery on the surplus side in the FTK contract increases. As a result of the longer recovery on the surplus side, a lower fraction of indexation is given which is disadvantageous for the old. Consequently, more capital will stay in the fund which is in favor of the young. Figure 8 shows an increase of the RFR with 5% only results in a negligible value transfer from old to young. Note that this small magnitude can be explained by the assumption of an initial nominal funding ratio of 100%. If the initial funding ratio is almost at or in the money, the option obviously gets more value which increases the magnitude of the transfer. However, in the current context of low funding ratios this analysis is worthwhile, since it gives the insight that increasing the solvency buffer in hard economic times does not favor one generation substantially at the expense of another.
After the credit crisis in 2008, the DNB temporarily allowed pension funds to recover from a funding below the MRFR in 5 years rather than 3 years. In Figure 8, we can see that an increase of the recovery period from 3 to 5 years is a little advantageous for the old and disadvantageous for the young cohorts. In 15 years, the 50-55 age cohort will lose with at most 0.7%, while the old gain at most 1% in terms of nominal funding ratio points.

5.5 Soft contract: influence equalization reserve and RAM period

Including an equalization reserve of 5% will lead to a value transfer from old to young, while an increase in RAM from 1 to 10 years will ceteris paribus transfer extra risk to the young and hence result in a value transfer from young to old.

The collective properties of the new soft pension contract are the RAM and the equalization reserve. Note that, within the current 'hard' framework, rules regarding the buffer and recovery period are imposed by the DNB, while in the pension agreement it is stated that under a soft framework pension funds can voluntary hold an equalization reserve and apply a RAM period of at most 10 years. This section demonstrates how robust the redistribution of value is for the RAM period and equalization reserve within a soft contract when switching from the current contract to a soft pension contract.

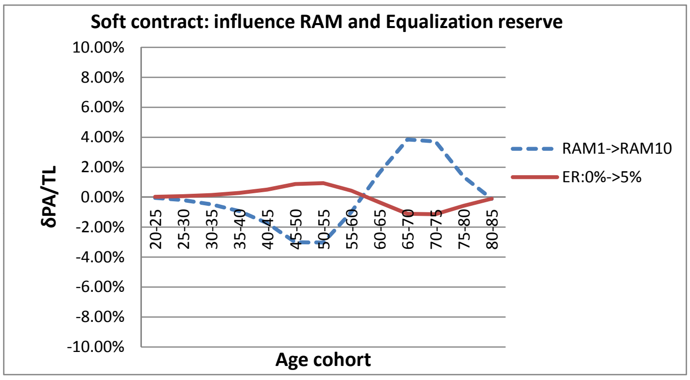

Figure 9: Change in distribution of pension fund assets over age cohorts as a percentage of the total liabilities of the soft RRP contract when including an equalization reserve (ER) of 5% or increasing the RAM from 1 year to 10 years.

Equalization reserve

Figure 9 shows that pension funds must be prudent in identifying an appropriate level of equalization reserve. Incorporating an equalization reserve of 5% increases the target funding ratio in a soft RRP contract from 100% to 105%. The initial nominal funding ratio of 100% correspond to a real funding ratio of 78%. For a real target funding ratio of 105% rather than 100%, the pension right cut in the first years is higher. The retired participants lose in market value, since the higher pension right cuts, needed to accumulate the buffer, are directly absorbed in their pension. The young profit from relatively more capital in the fund, which provides more certainty after the cut. The 65-70 age cohort will lose with 1% the most in 15 years, while the 45-50 age cohort will gain with 1% the most in RRP funding ratio points.

contract	range equalization reserve
Soft RBNW	115%-120%
Soft RER	116%-120%
Soft RRP	122%-130%
Soft NRP	130%-135%

Table 9: An overview of the range of the equalization reserve wherein the value transfer as a result of a switch from the FTK contract to the soft contracts is limited to 1%.

An equalization reserve can be used as a tool to limit the downside risks, but can also be seen as a tool to make the transition from the hard to the new soft contract generation-neutral. The disadvantageous effects of a higher discount rate and an asymmetric policy ladder (outweighing the benefit of a switch to a real contract) for the young can be limited using an equalization reserve. Table 9 displays the range of the equalization reserve under which the value transfer as a result of a switch from the FTK contract to a soft RRP contract is limited to 1%. I can conclude that for a higher discount rate resulting in a larger value transfer from young to old, obviously a greater equalization reserve is needed to limit this value transfer. Since the soft nominal contract is already detrimental for the young compared to the soft real contract (Section 5.3), the contract switch from the FTK to the soft NRP contract is the most disadvantageous for the young and hence the equalization reserve needed to limit this value transfer will be the greatest.
Note that the assumed simulation horizon of 15 years contributes to a gain for the young, since the accumulated reserve by the young and the old is distributed as residue to the survivors after 15 years. The equalization reserve will therefore stay in the fund until it is distributed (zero-sum property). A larger simulation horizon causes that a younger generation will gain relatively more. The assumed simulation horizon of 15 years is appropriate, since exactly then it satisfies the operation of an equalization reserve. The old, who gain from a switch from hard to soft, are dead after 15 years and hence the reserve is distributed as compensation to the losing young.

RAM period
The pension agreement stated that pension funds can use the RAM period as an instrument to smooth a deficit or surplus over a period of maximum 10 years in order to lower the pension right risk for the participants. Figure 9 displays what will happen if the return adjustment mechanism is increased from 1 to 10 years. It turns out that a longer amortization period in a soft RRP will lead to a value transfer from the working generation to the retired generation. For a RAM of 1 year the old already get a too high premium, due to the uniform risk premium incorporated in the discount factor, for the risk the elderly are actually taking. A RAM of 10 years lowers the risk for the elderly even more without leading to a lower average pension. If a participant receives a pension the next period while the RAM equals 10 years, this pension payment to the participant will only absorb one tenth of the shock. The remaining risk is transferred to the future. The young therefore lose in market value, since they are not compensated with an on average higher pension for the more risk they are taking. The percentage gain for the retired generation is around 4%, while the maximum loss for the age cohorts between 45-55 is around 3%. Hence, I can conclude that the elderly ceteris paribus benefit as a result of a switch from the current 'hard' to a soft contract, if within the soft contract a RAM period is applied.
Moreover, these results represent another conclusion. The collective characteristics that distinguishes the soft pension contract from an individual DC (Defined-Contribution) are the RAM period and the equalization reserve. A soft contract with a RAM of 1 year (no amortization period), that immediately shares the surplus and deficits linearly, is more similar to an individual DC[21]. Where the discount factor, used in an individual DC, does not influence the final pension payments to the participant, an equalization reserve can not be applied in a DC. For an initial nominal funding ratio of 100%, I can therefore conclude that it is likely that the working participants, switching from the current FTK contract to a 'soft' individual DC contract rather than a soft collective contract, ceteris paribus benefit. For the retired participants it is the other way around. The retired people will ceteris paribus probably benefit when switching from the current FTK contract to a soft collective contract with a RAM period rather than an individual DC.

[21]There are still a number of important differences (like life cycle investment mix, conversion risk, etc.)

5.6 Investment mix

Where a more risky investment mix within the 'hard' nominal asymmetric FTK contract is in favor of the young and to the detriment of the old, the investment mix does not cause significant value transfers within a soft symmetric framework.
Pension funds that apply a more risky investment mix and switch from an asymmetric contract to a symmetric contract are harming the young even more in favor of the old.

In this subsection, I will examine whether the investment mix affects the redistribution of value between age cohorts. Here, I make a distinction between an asymmetric (FTK) contract and a symmetric (soft RBNW) contract.
In general, pension funds use three major tools to influence the future development of the assets and liabilities and thereby also the redistribution of value between generations. Where Lekniute and Ponds (2011) investigated the influence of the contribution and indexation policy, they disregard the investment mix as a reason for value transfers between generations. In this subsection, I show that the redistribution of value between generations when switching from the current FTK to a soft contract is certainly dependent on the investment mix. Thus, determining one uniform conclusion about the size of the value transfers, as a result of a switch from an asymmetric to a symmetric contract, has been made even more difficult by the different investment mixes applied.

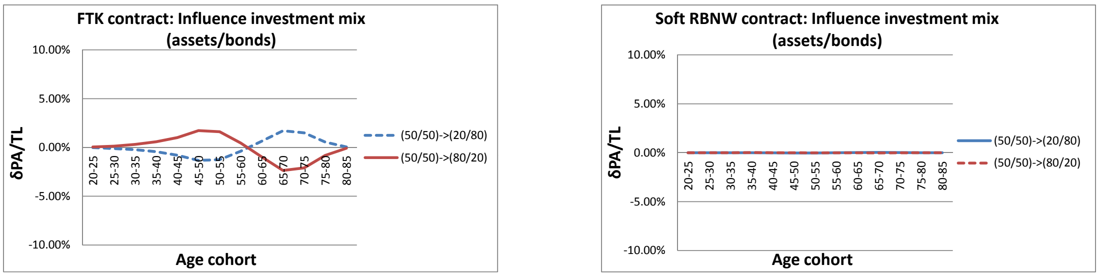

Figure 10: Change in distribution of pension fund assets over age cohorts as a percentage of the total nominal liabilities of the FTK contract (left) and as a percentage of the total assumed value of the RBNW liabilities (right) when adjusting the composition of the investment mix within the corresponding contract.

I already showed that a switch from a hard nomm contract to a 'hard' nominal asymmetric FTK contract with mismatch risk and an asymmetric policy ladder will result in a value transfer from the old to the young. Figure 10 shows that within an asymmetric contract a more risky investment mix will ceteris paribus lead to a value transfer from old to young, while a less risky mix is beneficial for the old. As a result of the asymmetric policy ladder, the value of the embedded put or embedded call options[22] (dependent on the probability of cuts and indexation respectively) will differ because of the more risk taken. The value of the embedded put option, written by the members and held by the fund, increases if the probability to cut pension rights rises. The value

[22]An embedded option is an option where the owner or issuer of the option is entitled to take measures against the counterparty.

of the embedded call option, written by the fund and held by the members, increases when the probability to index pensions increases. Within the asymmetric FTK contract, the recovery of the windfalls takes longer than the recovery of the setbacks. Taking more risk will therefore on average lead to an increase of funding ratio and its risk over time (Figure 20 in Appendix D). For the more risk the old bear, the increase in funding ratio indicates that too much of the extra premium stays in the fund and is transferred to the future cohorts. The young are receiving a too high compensation for the risk they essentially take. For the young the value of the indexation option relative to the value of the pension right cut option increases. For the old, who receive a too low compensation for the risk they are bearing, the value of the pension right cut option relative to the indexation option increases.

For the soft contract the policy ladder is symmetric and does not consists of embedded options. The policy ladder for the surplus and the deficit side within the soft contract (Formula 5) is identical. Figure 10 shows that in a collective soft contract, the investment mix will not lead to a redistribution of value between generations. Owing to a more risky strategy, the young will gain with at most 2 basis points, while the old lose with at most 3 basis points. The symmetric policy ladder implies that recovery of the windfalls take as long as the recovery of the setbacks. In this way, the right proportion of risk premium and risk is transferred to the future, when more investment risk is taken. The old, who receive their pension on a short horizon, absorb a small fraction of the risk corresponding to a small risk premium in expectation. The young, who receive their pension on a longer horizon, absorb a higher fraction of the risk corresponding to a higher risk premium in expectation. Each cohort is compensated in a market consistent way for the risk they are taking. Or in other words the value of the embedded put or call options (dependent on the probability of cuts and indexation respectively) will remain unchanged.

Despite the fact that adjustments in the investment mix for a constant discount factor in a soft framework will not lead to value transfers between generations, adjusting the investment mix will influence the value transfer resulting from a switch from an asymmetric (FTK) contract to a symmetric (soft RBNW) contract. I can conclude that young participants being part of a risky investing pension fund that exchanges the asymmetric contract for symmetric contract lose more in market value than when being part of a less risky pension fund. For the old it is the other way around and hence they benefit when being part of a more risky investing pension fund that switches to a symmetric contract. Important to note is that, within the current asymmetric FTK contract, a less risky investment mix leads to a value transfer from young to old that is quite similar to the value transfer from young to old when switching from the current asymmetric FTK contract to the soft symmetric RBNW contract.

In addition in Appendix B, I will derive the generational impact of the investment mix within an asymmetric and a symmetric pension contract in an analytical way. The analytical derivations, in a simplified two-period model, may serve as substantiation and support for the analysis of above.

6 Sensitivity analysis

- *Applying the current lower interest rates rather than the higher interest rate assumptions proposed by committee Don, lowers the value transfer from young to old when switching from the FTK to the soft RBNW contract.*
- *The value transfers are quite robust for the age of the fund.*
- *Pension funds can have the incentive to increase their funding ratio by choosing a lower inflation level, which is beneficial for the elderly. Besides, a higher inflation level increases the value transfers when switching from a soft symmetric nominal to a soft symmetric real contract.*
- *The elderly, who participate in an underfunded rather than an overfunded pension fund that switches from a 'hard' nominal asymmetric FTK to a soft symmetric contract, benefit relatively more at the expense of the young owing to the longer recovery period for deficits in the soft symmetric contract.*

6.1 Financial market assumptions

In this section, I will check the sensitivity of the financial market assumptions within the FTK and the soft RBNW contract.
Since the market value is not dependent on the assumed equity premium of the financial market, a modification of the equity premium for a constant discount factor does not lead to a redistribution in market value. Naturally, a redistribution of value occurs if pension funds set their assumed risk premium in the discount factor inconsistent with the assumed financial market equity premium.

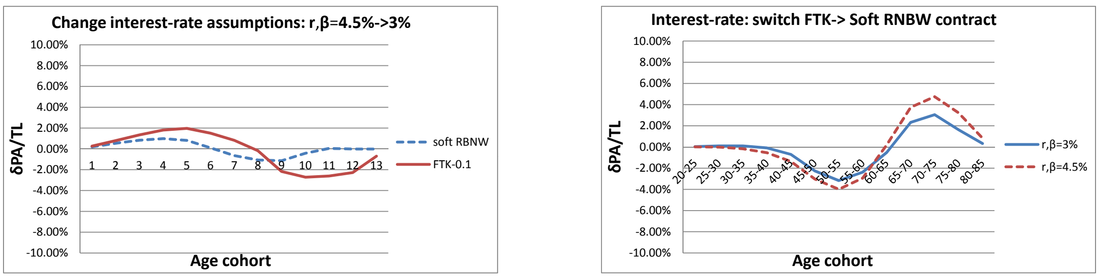

Figure 11: Change in distribution of pension fund assets over age the cohorts as a percentage of the total liabilities of the initial contract is adjusted to the interest-rate assumptions to the interest-rates of 31-12-2011 (left) and when switching for different interest-rates from the FTK to the soft RBNW contract (right). Where r and β represent the short-term interest rate and long-term mean reversion level of the short-term interest rate respectively.

Where the redistribution of value between generations is robust for the assumed financial market equity premium, this does not hold for the interest rate assumptions. I assumed an initial short-term interest rate and a long-term mean reversion level of the short-term interest rate of 4.5%.

The current short-term and long-term interest rates are substantially lower. Figure 11 shows a substantial sensitivity within the current FTK and the soft contract when adjusting the interest-rate to the actual interest-rates of 31-12-2011. The initial short-term interest rate is adjusted to 1.5%, where the long-term mean reversion level of the short-term interest rate is modified to 3%. An on average lower interest rate increases the liability and lowers the funding ratio. A lower funding ratio will imply less surplus shared or greater pension right cuts in the first years. Consequently, this shock is directly absorbed by the retired, while after the shock the young can benefit from the better protection in a relative more wealthy pension fund. For the FTK contract, this results in a value transfer from old to young. The value transfer is marginal within the soft RBNW contract, where an on average lower interest rate implies a value transfer from the middle aged cohorts to the very old and the very young cohorts.
More important, Figure 11 shows the generational impact as a result of a switch from the FTK contract to the soft RBNW contract with a higher interest rate. A higher interest rate result in a greater value transfer from young to old.

6.2 Age of the fund

Dutch pension funds differ considerably in terms of indexation and investment policy, but also in terms of age. I assumed an equivalent number of participants per age cohort which is definitely not applicable on all pension funds. However, in order to qualify whether the results are robust for changes in the age of the fund, I check the sensitivity of the results for different aged funds. I investigate the generational impact of increasing the risk premium of the RBNW discount factor with 1%, switching from an asymmetric to a symmetric policy ladder and switching from a nominal to a real soft pension framework for a green (young) fund and for a grey (old) fund.

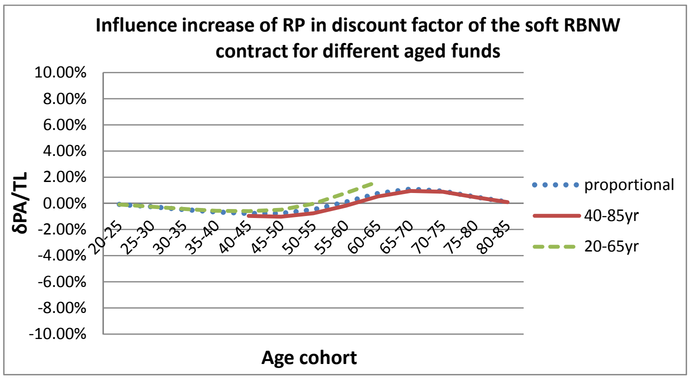

Figure 12: Change in distribution of pension fund assets over age cohorts as a percentage of the total assumed value of the RBNW liabilities as a result of increasing the risk premium of the RBNW discount factor with 1% for different aged pension funds.

Figure 12 displays that adjusting the age of the fund does not alter the value transfer direction as a result of an increase in risk premium of 1% in the RBNW discount factor. For both a greyer and a greener pension fund, the higher risk premium is beneficial for the old and at the expense

of the young. In a younger fund with participants aged between 20 and 65 years, the young lose slightly less while the elderly gain slightly more. For soft RBNW contracts, the discount factor in a young fund is higher than in an old fund. Owing to the longer duration of the liabilities in a young fund, the higher risk premium incorporated in the RBNW discount factor is, besides the increase with 1%, more in favor of the old.
However, for an older fund, consisting of cohorts between age 40 and 85, the generational accounts for the existing cohorts as a result of a higher risk premium are hardly affected by the age of the fund. The average duration of the cash flows for a pension fund with older participants is lower and therefore the RBNW discount rate is on average lower. Although a lower RBNW discount rate, due to the shorter duration, is beneficial for the young, the young lose a small amount. The positive effect for the young of a lower discount rate is offset by the negative effect for the lower amount of the young who have to absorb the effect of a higher discount factor risk premium for an unchanged amount of old. Hence, the negative effect of a higher discount factor for the young is slightly enhanced when being part of an older fund.
In addition, also the redistribution of value is not significantly affected by the age of the pension fund, when one switches from an asymmetric to a symmetric policy ladder and one switches from a soft nominal to a soft real pension framework (see Figure 22). I can therefore conclude that the redistribution of value between generations is quite robust for the age of the fund.

6.3 Inflation level

Within a real pension contract the discount rate needs to be corrected for the inflation and the funding ratio is calculated assuming indexed pensions. However, whether pensions need to be indexed for price or wage inflation and to what extent a fund may vary between those rates is not quite clear.
The ability that pension funds can vary between price and wage inflation implies that pension funds can exploit the inflation level in order to adjust their funding position. An adjustment in inflation level alters the liability. For example, a lower assumed inflation increases the real discount factor, which leads to a lower liability. The CPB analysis (2012) demonstrates that a lower assumed inflation level indeed improves the funding position. Owing to the improved funding position, more indexation is distributed to the old at the expense of the young. In fact, it might be inconsistent that a lower indexation ambition results in more indexation provided in the short-term.
I already demonstrated that the size and direction of the value transfer as a result of a switch from a soft nominal to a soft real pension contract depends on the RAM period, the duration of the nominal liabilities and the inflation level. The table of Figure 13 shows that for pension funds with a duration of the nominal liabilities larger than the RAM period, a higher inflation level implies that the extra pension right cut is higher than the extra indexation provided. Consequently, the elderly lose more, while the young gain more in market value (Figure 13). This table also illustrates that for a duration smaller than the RAM period, the extra pension right cut does not exceed the higher inflation level provided. Here, a switch from soft nominal to a soft real contract is advantageous for the elderly and at the expense of the young.
The generational impact as a result of a higher assumed inflation level is dependent on the age of the pension fund. On the one hand, the elderly participating in a grey fund, where the duration is lower than the RAM period, relatively profit from a higher inflation level. On the other hand, the young in a green fund, where the duration of the liabilities is higher than RAM, relatively profit from a higher inflation level. Anyhow, it holds for both situations that a higher inflation level assumed increases the size of the value transfers (Figure 13). Again, an approximately

RAM\DL	8	10	12
8	1,00%	1,25%	1,50%
10	0,80%	1,00%	1,20%
12	0,67%	0,83%	1,00%

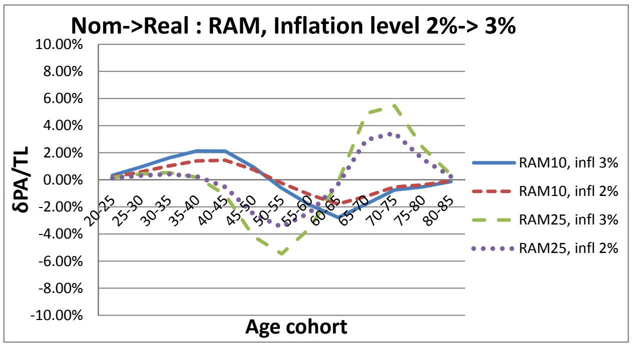

Figure 13: The table displays the pension right adjustment ($\frac{\text{inflation}*D_L}{\text{RAM}}$) for an inflation of 3% minus the inflation minus the pension right adjustment for an inflation of 2%. The figure shows how the value transfer resulting from a switch from a soft NRP to a soft RRP is affected by the RAM, D_L and the inflation level.

generation-neutral switch from a symmetric nominal to a symmetric real contract can be applied if the duration of the nominal liabilities equals the RAM period. This implies that young funds having a higher duration need a greater RAM period than grey funds having a lower duration.
Figure 13 shows that assuming an inflation level of 3% rather than 2% causes that the old will lose and the young will gain half a percentage more as a result of a switch from a soft nominal to a real framework (RAM10 lower than D_L=11.4). Also for a RAM period of 25 years that exceeds the duration of the nominal liabilities, the size of the value transfer is greater in case of a 3% inflation level. However, now the old gain and the young lose with at most 2% more, if the assumed (constant) inflation level is 3% rather than 2% and one decides to switch from a nominal to a real framework.
In Section 5.2.2, I explained that the amortization period proposed by Bovenberg et al. (2012a) implies that the old can never gain when switching from a soft nominal to a soft real contract. This conclusion also holds if pension funds have the ability to adjust the assumed inflation level. Hence, only the young can gain more when exchanging the soft nominal contract for a soft real pension contract when a higher inflation level is assumed.

6.4 Initial funding ratio

In this section, I will show to what extent the value transfers are affected by the initial funding ratio (IFR). The assumed initial nominal funding ratio of 100% represents the current situation of the pension funds the best, since the average nominal funding ratio of all Dutch pension funds is 98% at the end of 2011. However, the funding ratios differ per pension funds and besides at the moment of translating the old pension rights into new pension rights (probably early 2014) the economic situation will have evolved. Even if at the moment of translating old rights into new rights the majority of the pension funds will be recovered from an underfunded position, a sensitivity check is relevant. It gives insight in what will happen if pension funds do not (sufficiently) cut pension rights, although an IFR of 85% is still quite extreme. Pension funds

that currently have a surplus do not cut pension rights, hence an analysis for a surplus position is certainly worthwhile.
IFR check on soft contract properties
The soft contract differs from the current FTK contract in terms of the higher discount factor, real framework and a symmetric policy ladder consisting of a RAM period and an equalization reserve. If we understand how the operation of these individual soft contract properties on the value redistribution is affected by the IFR, we can appoint the contract properties that cause the sensitivity of the IFR when switching from the current FTK to the soft contract.
I examined that the value transfers resulting from the application of the equalization reserve and a higher discount factor are, as a result of the symmetric policy ladder, hardly affected by the IFR (Figure 23). Here, the symmetric policy ladder ensures that for each funding position all different aged cohorts receive a proportional premium for the risk they are exposed to. The value transfer when switching from a soft NRP to a soft RRP (Figure 24) is only little affected by the IFR. For the switch from a soft NRP to a soft RRP contract, the value transfer becomes a little greater, if the nominal pension rights are increased in the nominal framework, while real pension rights are cut in the real framework. Hence, for a nominal IFR of 105% and a nominal IFR of 125%, cutting pension rights in the real framework while sharing surplus in the nominal framework implies a little larger value transfer from old to young.

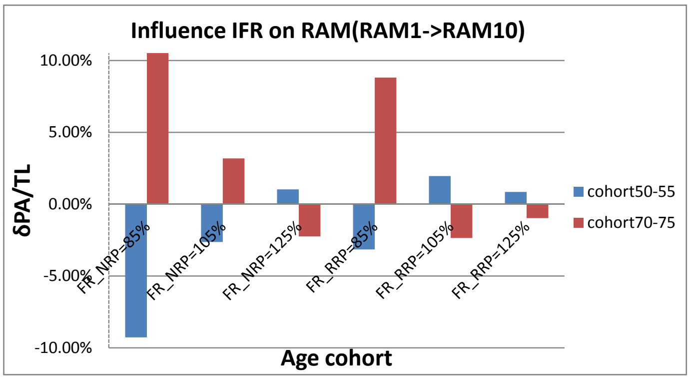

Figure 14: The change in distribution of pension fund assets to the 50-55 and 70-75 age cohort when increasing the RAM period from 1 to 10 years in terms of the total assumed value of the liabilities for different funded pension funds in a nominal framework (left part) and a real framework (right part).

In contrast to the above discussed contract properties, the redistribution of value as a result of applying a RAM period is significantly affected by the IFR. Figure 14 illustrates that the IFR determines the size and direction of the value transfer when increasing the RAM from one to ten years. In Section 5.5, I demonstrated that for nominal funded pension funds the introduction of a RAM period of ten years causes a gain in market value for the old and a loss in market value for the young. In case of an overfunding position, the initial smoothed surplus, beneficial for the young, outweighs the more risk absorbed by the young due to the RAM period. Accordingly, value is transferred from old to young. In case of an underfunded position, the value transfer from young to old will be in absolute terms the largest. The extra risk resulting from a RAM period and the fact that the initial pension right cut is smoothed are both disadvantageous for the young. Where the direction of the value transfer in a real framework and a nominal framework is the same when one starts from a surplus or deficit position and applies a RAM period of 10 years, the direction of the value transfer for a funded position (105%) is dependent on whether a nominal or a real framework is applied. For a RRP funding ratio of 105%, value is transferred from old to young, while for a NRP funding ratio of 105% value is transferred in the opposite way. The better development of the real plus risk premium funding ratio with respect to the nominal plus risk premium funding, implies that in a soft RRP contract more assets will stay in the fund in favor of the young cohorts (see Figure 21 in the appendix).

IFR check on switch from 'hard' to soft

We have seen that for all soft contract properties only the value transfer due to the application of a 10 year RAM period is considerably affected by the IFR. When one switches from the FTK contract to the soft RBNW contract, the asymmetric policy ladder is exchanged for a symmetric policy ladder. Figure 15 displays how the value transfer between generations, as a result of the introduction of a symmetric policy ladder with a 10 year RAM period, is affected by the IFR. The value transfer from young to old increases if the solvability of pension funds deteriorates. Since under the soft framework the recovery on the deficit side is longer which is beneficial for the elderly, elderly participating in an underfunded pension fund gain relatively more.

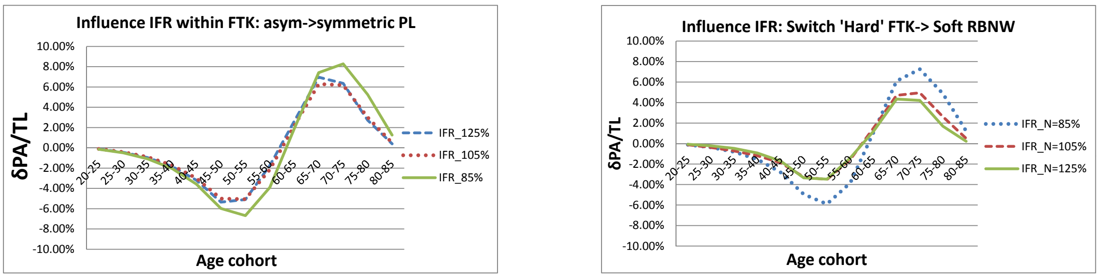

Figure 15: Influence of the IFR on the distribution of pension fund assets over age cohorts as a percentage of the total assumed value of the liabilities when switching from an asymmetric nominal contract to a symmetric nominal soft contract (left) and when switching from the FTK contract to the soft RBNW contract (right).

Identifying the cause of the IFR sensitivity on the value transfer when switching from the current FTK to a soft contract is, on the basis of the above explained results, quite easy to explain. Figure 15 shows that the size of the value transfer when one switches from the 'hard' nominal asymmetric FTK contract to the soft symmetric RBNW contract depends on the funding ratio at the moment of the switch. For a high initial funding ratio of 125%, the value transfer from young to old is somewhat less compared to the value transfer at an initial of 105%. However, the value transfer is substantially larger for a lower IFR of 85%. Hence, pension funds in bad weather are favoring the old even more when switching from the FTK to the soft RBNW contract. This can be explained by relatively smaller pension right cuts within the soft framework in bad weather due to the longer recovery on the deficit side, which is advantageous for the old.

7 The CPB analysis

End of May 2012, the CPB analysis (2012) was published. The CPB was instructed by the Minister of Social Affairs and Employment to provide insight into the generational consequences of the pension agreement. In Section 7.1, I will start with discussing the differences in the pension contract assumptions. Subsequently, a comparison of the results plus certain comments are made. Finally in Section 7.2, I will extend the CPB analysis (2012) by discussing whether the new pension contract better satifies the requirements proposed in the literature that young can absorb more equity risk than old (e.g. Merton (1969)).

7.1 Evaluation of the CPB analysis

The financial market assumptions made in my thesis are quite comparable with the CPB assumptions. We both assumed an equity premium of 3% and a return on the interest rate swaps which is, compared to the current market data, quite high. Only I applied an inflation of 2% representing both the price and the wage inflation, where in the CPB analysis (2012) an inflation level of 2.5% is used, which is the average of the assumed price and wage inflation. In contrast to the continuity perspective of the CPB, my analysis is based on a discontinuity perspective. Furthermore, I focus entirely on the current cohorts with a simulation horizon equal to 15 years, while the CPB focuses on the current and future generations and considers a simulation horizon of 80 years.
Contrary to the CPB analysis (2012), that examines the generational impact of the Pensioenakkoord (2010) on the basis of two contracts, I also take the generational impact of a genuine hard nominal contract, a nominal soft contract and the soft expected return contract into account. However, the goal of the CPB analysis (2012) and my thesis are quite comparable, since both reports examine the generational impact of (switching to) a new soft pension contract.
The major adjustments between the investigated contracts of my thesis and the interpretation of the contracts by the CPB are summarized below.

The Ultimate Forward Rate(UFR)

- For the nominal pension contract the CPB uses the nominal term structure with the Ultimate Forward Rate (UFR) as discount factor. Upward of a 20 year maturity, the nominal term structure is extrapolated to a forward rate of 4.2% at a 60 year maturity.
- For the soft real pension contract the applied discount factor equals the nominal term structure with the UFR minus the horizon independent inflation of 2.5% plus a horizon dependent risk premium as proposed by Bovenberg et al.(2012a).

On the one hand, applying the UFR, given the initial short-term interest rate and mean reversion level of 4.5% proposed by committee Don implies an interest rate curve converging to lower rate after 60 years. Hence, the interest rate curve declines rather than increases upward of a maturity of 20 years. As I already showed, a lower discount rate lowers the funding ratio and favors the young to the detriment of the old. On the other hand, the current short-term interest rate and the mean reversion level are significantly lower, hence the UFR will increase the discount rate upward of the illiquid maturities (20+) of the swap curve. This will result in a better funding position beneficial for the elderly and at the expense of the young. In addition, it is important to mention that the generational impact owing to the application of the UFR is enhanced, if the duration of the liabilities rises (i.e. the fund becomes younger). Hence, where the old participating in a greener fund gain relatively more, the young participating in a greyer fund lose relatively less from the application of the UFR in times of a low interest rate curve.

Furthermore, it is likely that the swap market will be distorted when the swap curve is extrapolated upward of one designated last liquid point. When the discount factor is extrapolated from the last liquid year (20 years) to a fixed UFR of 4.2%, pension funds need to rebalance their portfolio regularly which will influence the interest rates. The 20 year interest rate will decrease due to the increased demand, while the longer term 'more illiquid' interest rates will increase. As a solution, Bovenberg et al. (2012b) propose a gradually growing incorporation of the UFR as the duration of the liability increases. In this way, the designated last liquid year will not turn out to be the most illiquid on. I do indeed agree that this proposal minimizes the swap curve distortions. Nevertheless, also this method creates a higher discount factor resulting in a higher funding ratio beneficial for the old, since the discount factor is gradually incremented by the UFR.

Indexation policy

- For the reformed FTK nominal pension contract the upper bound of the indexation ladder equals 125% independent of the risk taken by the pension fund. Missed indexation and a correction for earlier pension right cuts can be undone/applied upward of a funding ratio of 125%.

I already demonstrated the impact of a switch from the current FTK contract to the proposed nominal contract is representing an 5% increase of the solvency buffer (Section 5.4). The generational impact of the higher indexation upper bound depends on the current funding ratio and the investment mix applied. The marginal value transfer from old to young increases if the funding ratio is closer to 120%, while for underfunded pension funds the increase in upper bound leads to a smaller value transfer from old to young. Furthermore, the redistribution of value from old to young as a result of a higher indexation upper bound is lower if the investment mix is more risky. Pension funds applying a more risky investment mix have a greater reserve deficit in the initial nominal contract and therefore the adjustment from the initial upper bound to the 125% upper bound is lower.

- Pension right adjustments are smoothed with a RAM of 10 years, when the funding ratio deviates from the target funding ratio that corresponds to a real funding ratio of 100%. In a nominal framework the target funding ratio is therefore roughly the inflation times the duration of the nominal liabilities higher than the target would be in a real framework. Besides, a pension can never exceed a fully indexed pension.

If the soft real contract target funding ratio must correspond to a 100% real funding ratio, the target funding ratio for the soft RBNW contract equals 114%. The 14% can be interpreted as an equalization reserve that has to be accumulated in order to make the mutual value transfer less to the detriment of the young. I already demonstrated that an equalization reserve is beneficial for the young and can be used to make the switch to a soft pension contract generation-neutral. Hence with use of Table 9, I can state that replacing the current FTK contract for the soft RBNW contract with an equalization reserve of 114% leads to a minimized value transfer. However, I decided to give insight in the value transfers without a substantial equalization reserve first in order to focus on the size of the equalization reserve, needed to limit this value transfer, later one.
The CPB analysis (2012), Bovenberg et al. (2012a) and my thesis recommend a soft symmetric pension contract where the investment mix does not cause any redistribution of value between generations. However, the proposed soft real pension contract by the CPB is not symmetric but truncated from above, since pension funds are not allowed to pay more than a fully indexed pension. Since the recovery on the surplus side, due to the truncated indexation policy ladder, takes longer than the recovery on the deficit side, a more risky investment mix implies that

(slightly) more assets will stay in the fund in favor of the young and to the detriment of the old. The imposed interpretation of the soft real contract by the CPB, where the surplus distributed can never exceed the inflation, contradicts with their own recommendation to introduce a soft symmetric pension contract where the redistribution of value is independent of the investment mix. However, since the current funding position of the average pension fund is quite low, adjustments in the investment mix within the truncated 'symmetric' contract, as proposed by the CPB, will not lead to significant value transfers at the moment.

7.2 Is the proposed soft pension contract a *better* pension contract?

The CPB analysis (2012) examines the generational impact of (a switch to) a new symmetric pension contract where the pension rights fluctuate with the economic state. However, the CPB analysis (2012) does not discuss whether the new contract actually is better than the current FTK contract. The definition of a good pension contract is subject to interpretation. Among others, Merton (1969) defined a condition for a good pension contract. Merton (1969) stated that that the young, which have a lot of (riskless) human capital, can absorb more equity risk than the old.

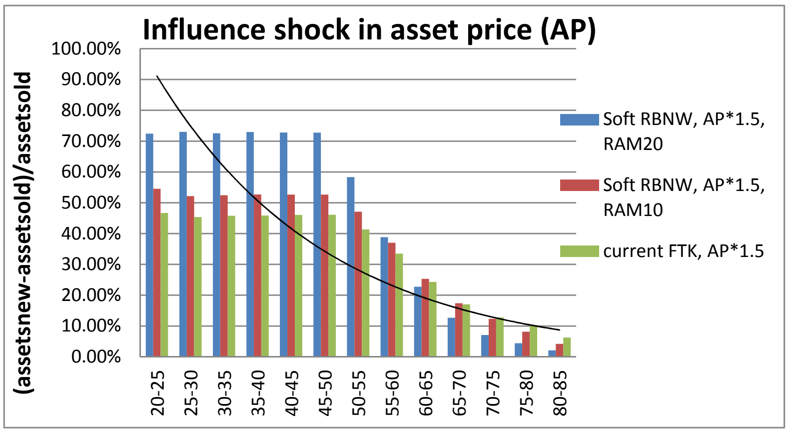

Figure 16: The percentage change in distribution of pension fund assets to the age cohorts within a 'hard' nominal asymmetric FTK contract and a soft RBNW contract as a result of a positive shock in the risky asset price of 50%, where the soft RBNW contract differs in terms of the RAM period.

First, I investigate whether the proposed soft RBNW contract is a good pension contract, what should be translated in a higher equity exposure for the young. A demand for a good pension contract is that those who bear more equity risk must be appropriately rewarded if things go well. For a (50/50) mix, a positive shock in asset price of 50% increases the total distribution of assets to the age cohorts with 25%. Figure 16 illustrates that for both contracts it holds that the young gain more than the old if a positive shock in asset price occurs. Thus, it is clear that the proposed soft contract satisfies the Merton condition, since the young profit 13 times as much as the oldest cohort after from a positive asset price shock. Although this fraction appears to be quite reasonable, the gain for the 50 year cohort roughly equals the gain for youngest cohorts. Nevertheless, the equity exposure for the 50 year cohort, having more financial capital, should be substantially lower than the youngest cohorts. The black line in Figure 16 indicates how the bar sizes could approximately look like, when it satisfies the condition as proposed by Merton (1969).

Second, Figure 16 shows that the distribution of equity exposure over the cohorts is not significantly better when one switches from the current FTK contract to the soft RBNW contract. Actually, according to the Merton condition, a switch from the current FTK contract to a soft real pension contract does not noticably improve the pension contract.

A way to lower the pension right risk for the middle-aged is by increasing the RAM period. Apparently, the RAM period is too small for lowering the equity exposure of the middle-aged cohorts. Figure 16 also displays the effect of a longer RAM period. A RAM period of 20 years rather than the maximum of 10 years will increase the difference in equity exposure between the youngest and the oldest cohorts. Notwithstanding that a RAM period of 20 years lowers the equity exposure of the middle-aged cohorts, the RAM period must be substantially increased before appreciable results can be obtained. It might be arguable whether a substantial increase of the RAM period is political feasible, since a far greater RAM period implies a considerably more fluctuating funding ratio.

8 Conclusion and recommendations

The aim of my thesis is to assess a sustainable and generationally fair pension contract (reform). Before being able to quantify the value transfers between generations when the current contract is adjusted to a more sustainable soft pension contract, the interpretation of the current and the new soft pension contract must be defined.
Quite a bit fund participants were astonished about the announced nominal pension right cuts. However, within the current FTK contract a nominal hedge is not fully guaranteed (97.5% certain). At the same time, pension funds (often) allow mismatch risk and have the ambition to index the nominal pensions. I clarified that combining these two ambitions rather than providing a hard nominal pension without mismatch risk results in a value transfer from old to young.
The discussion of the actual interpretation of the soft symmetric contract focuses largely on the discount factor applied and whether the framework has to be switched from nominal to real. I showed that a higher discount rate will result in a value transfer from young to old. Furthermore, the direction of the value transfer when one switches from a soft nominal symmetric contract to a soft real symmetric contract is dependent on the RAM period and the duration of the nominal liabilities. Where a RAM period smaller than the duration of the nominal liabilities implies a value transfer from old to young, a RAM period that substantially exceeds the duration of the nominal liabilities results in a reversed value transfer from young to old. I can therefore conclude that switching from a nominal to a real framework within a soft symmetric pension contract will not per definition mean that one generation gains at the expense of another. The RAM period in relation to the duration of the nominal liabilities can even be considered as a tool to make the soft framework contract switch generation-neutral.
Both the memorandum of the pension agreement (2011) and the memorandum review FTK (2012) recommend to switch to a soft real pension contract or otherwise switch to an adjusted asymmetric nominal pension contract. Nevertheless, I defined that within the current FTK contract for the current low funding ratios, the ambition to index nominal pensions does not imply a properly reward for the more uncertainty which the elderly are exposed to. Accordingly, I propose the option either to ensure a hard nominal pension without mismatch risk or switch to a soft real pension contract. First, for the current low funding ratios, the purchasing power position when participating in the current asymmetric FTK contract is inferior to both the hard nominal contract without mismatch risk and the soft real contract[23]. Second, I stated that the current and proposed asymmetric pension contract are generationally unfair. Within an asymmetric pension contract, adjusting the investment mix will lead to significant value transfers. The value transfer from young to old, as a result of a more prudent investment strategy within a asymmetric pension contract, is comparable to the heavily debated value transfer from young to old that occurs when the current asymmetric contract is exchanged for a soft symmetric contract. Besides, within a (soft) symmetric pension contract a more or less risky investment mix does not redistribute any value between generations.
Like a switch from the current FTK to the hard nomm contract, also a switch from the current FTK to a soft contract is beneficial for the old. When switching to a soft contract, the elderly profit from the higher discount rate and the symmetric policy ladder applied within the soft pension contract. Though, quantifying the generational impact for a pension fund that switches from the current 'hard' contract to a soft pension contract is subject to numerous fund specific characteristics. I already explained that fund characteristics as the investment mix and the symmetry of the policy ladder make a uniform value transfer, applicable on all heterogeneous pension funds, when switching to a soft pension contract hardly feasible. In addition, the following four fund characteristics contribute to the realization that each pension fund should determine their

[23]Note that the impact of the UFR is ignored here.

own fund specific value transfer.
First, the fact that pension funds are free to determine several contract properties already implies a redistribution of value. Within the current asymmetric contract a higher solvency buffer is beneficial for the young and a longer recovery period imposed by the DNB is beneficial for the elderly. Second, also within the proposed soft symmetric pension contract there are still no uniform standards for the length of the RAM period and the size of the equalization reserve. I showed that the introduction of an equalization reserve, that can be used to limit the generational impact of a switch to a soft symmetric pension contract, is in favor of the young. Moreover, pension funds can choose for a RAM of at most 10 years to lower the direct pension risk for the (old) participants. For the current economic situation, introducing a RAM of 10 years implies that value is transferred from young to old owing to the transferred risk in the opposite direction. Third, pension funds are free to determine their own indexation ambition. A higher or lower assumed inflation level within the soft real pension contract can result in a significantly higher value transfer transfer from old to young and from young to old respectively. I therefore recommend to mitigate the ability of pension funds to freely determine the inflation level.
A final fund characteristic that significantly affects the size of the value transfers between generations, as a result of a switch from the current asymmetric FTK contract to the soft symmetric contract, is the funding ratio of pension funds at the time of the switch. Pension funds having a bad funding position are favoring the elderly relatively more, due to the slower deficit recovery in the soft symmetric contract. Hence, the current pension right cuts, announced by the pension funds in order to recover, indirectly prevents that too much value is transferred from young to old. Moreover, the interest-rate curve applied influences the funding ratio. I indicated that applying the current interest-rate curve, which is lower than the recommended interest-rate parameter assumptions by committee Don, reduces the value transfer from young to old when switching from the current FTK contract to a soft pension contract.
To conclude, the survey in this thesis, that elaborates the effect of the separate contract properties on generations, is essential. This provides pension funds a tool to rate the value transfers applicable on their unique scheme as a composition of all separate value transfers.

Recommendations for future research

First of all, I would like to discuss the shortcomings of my thesis. Note that the Black and Scholes and the Vasicek model, used to simulate the stock price and interest-rate, are simplified representations of the actual financial market. Besides, I assume a fixed constant inflation over time and ignore the inflation risk. Even so, it is interesting to examine how inflation risk affects the redistribution of value between generations, when for example a nominal contract is exchanged for a real contract. Also the simplified investment mix, consisting of one risky asset and one nominal zero coupon bond, does not represent the numerous investment opportunities. Furthermore, there are still some shortcomings of the soft pension contract that have to be worked out. For instance, pension funds can choose a lower inflation level to improve the funding ratio (beneficial for old). Moreover, a constant RAM period (of ten years) implies that relatively more risk is transferred to the young in a grey fund than in a green fund. Linking the RAM period in some way to the investment risk taken and/or the duration of the liabilities, might be a solution. Where I investigate the ability to lower the direct financial market risk using a RAM period, the LAM period is ignored. Hence, an examination of the exact interpretation and operation of the LAM, used to lower the direct pension risk of the unforeseen upwards adjustments in the mortality tables, might be a challenge for future research.
In addition, it is likely that the introduction of the Ultimate Forward Rate (UFR) will result in market distortions and (subsequently) affects the redistribution of value between generations.

An investigation of the generational impact of different applications of the UFR, as proposed by for instance the CPB analysis (2012) and Bovenberg et al. (2012b), is therefore of added value. According to most of the literature, the proposed soft real pension contract is superior to the current FTK contract. Nevertheless, I demonstrated that for both the FTK contract and the proposed soft pension contract the equity exposure for the young is as large as the equity exposure of the middle-aged cohorts. It might be interesting to construct a (soft real) pension contract such that the distribution of equity exposure meets the Merton (1969) condition. Subsequently, a more extensive elaboration can be made on the differences between a soft and an individual DC pension contract where participants can choose their own (life-cycle) investment strategies. Finally, a loss in market value for a generation must imply a gain for another generation. In market value pension funds are a zero-sum game, however a loss in market value might be accompanied with a gain in welfare terms.

9 Glossary

Investigated pension contracts:

Hard nomm contract: Hard nominal pension contract without mismatch risk.

('Hard') FTK contract: 'Hard' nominal asymmetric FTK pension contract with mismatch risk, where the quotation marks for the term 'hard' are used since nominal pension rights are not fully guaranteed, but for 97.5% certain. This contract represents the current Dutch FTK pension contract and is also incorporated to assess the switch to the proposed nominal pension contract of the Pensioenakkoord (2010) and the CPB analysis (2012).

Soft NRP contract: Soft nominal pension contract where the liabilities are discounted with the nominal term structure plus risk premium.

Soft RER contract: Soft real pension contract where the liabilities are discounted with the real expected return.

Soft RRP contract: Soft real pension contract where the liabilities are discounted with the real term structure plus risk premium.

Soft RBNW contract: Soft real pension contract where the liabilities are discounted with the real term structure plus a horizon dependent risk premium (as proposed by Bovenberg et al. (2012a)). This contract is used to assess the proposed soft real pension contract in the Pensioenakkoord (2010) and CPB analysis (2012).

Pensioenakkoord, June 2010: Pension agreement. An agreement on the necessary reforms proposed to make the Dutch pension system more sustainable.

StAr, Memorandum of the pension agreement, June 2011: In June 2011, the Dutch social partners and Government reached an agreement on a proposed (contract) reform for the Dutch second-pillar pension system. The memorandum elaborates on the new Dutch pension system.

Memorandum review financial assessment framework, May 2012: is an (improved) update and enlargement of the previous memorandum and besides the CPB, which was instructed by the Ministry of Social Affairs and Employment, examines the generational impact of (a switch to) a new soft real pension contract.

CPB (Central Planning Bureau): The CPB, part of the Dutch Ministry of Economic Affairs, is an independent research organization that makes forecasts and analyzes the economic policy.

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A Appendix

A. Preliminary assumptions

I assume that people enter the labor market at an age of 20, retire at 65 and everybody dies at 85. Since everybody dies at an age of 85, longevity risk is ignored. For simplicity, I also assume absence of any liquidity risk. The role of a sponsor company, who is able to pay for funding deficits, is ignored as well.
A pension fund can invest in a risky asset and a risk-free asset, where the risky asset represents a stock and the risk-free asset is a nominal zero-coupon bond. I assume that pension funds rebalance their investment mix every year such that the weights of the portfolio remains constant.
Pension rights
The accrued benefits will be equal to the amount of years worked times the accrual rate times the average wage. The accrual rate, θ, will be equal to 2% in line with the pension agreement to lower the rate from 2.25% to 2% for average pay schemes. The following formula indicates how pension rights accumulate during working life in an average wage scheme

$$PR_{t,n}^{x} = (PR_{t-1,n}^{x} + 1_{(x+t<65)}\theta S_{t}^{x})(1 + I_{t,n}), \forall t \tag{6}$$

Where $PR_{t,n}^{x}$ are the accumulated pension rights in year t by cohort x in contract n and where the salary, S_t^x, received until the age of 65 is uniform and increases every year with the constant assumed inflation, γ, $S_t^x = S_{t-1}^x(1+\gamma)$. The already accumulated pension rights plus the new accrued pension rights are multiplied by one plus the indexation rate, I_t. The indexation, I_t, differs per contract and can be positive if indexation is given or surplus is shared and negative if pension rights are cut.
Assets and liabilities
The following formula describes the behavior of assets over time

$$A_{t,n} = (A_{t-1,n} + C_{t,n} - PP_{t,n})(1 + R_{t,n}), \forall t \tag{7}$$

Where $A_{t,n}$ represents the assets at time t in contract n, where $C_{t,n}$ and $PP_{t,n}$ are the contributions received and pension paid by the pension fund in year t in contract n respectively and $R_{t,n}$ is the realized return on the pension portfolio in year t in contract n. The initial level of assets is assumed to be constant and the same for all contracts, such that the initial nominal funding ratio is 100%.
The liabilities specified below are not calculated by discounting future expected cash flows. The assumed value of the liabilities in contract n in year t can be indicated by the following formula

$$L_{t,n} = \sum_{x=20}^{85} \sum_{m=max(65-x,0)}^{85-x} \frac{PR_{t,n}^{x}}{DF_{t,n}(m)}, \forall t \tag{8}$$

The liabilities in contract n in year t is the sum of the pension rights over all cohorts discounted with the corresponding discount factor determined at time t with maturity m applied in contract n, $DF_{t,n}(m)$.
Despite the fact that Bovenberg (2008) showed that a uniform premium is not actuarially fair for the young cohorts, it is inconceivable that the pension sector will allow discrimination between young and old. In line with a uniform contribution rate, I also assume that the percentage increase or decrease of pension rights (indexation and cuts respectively) will be uniformly applied on generations.

Accuracy of the results
I checked the accuracy of my results in the following way. With use of the central limit theorem (CLT) of Formula 9, I verified for which simulation size, n, the results were accurate enough. I define 'accurate enough', if the size of the results is hardly affected and therefore the direction of the value transfer is certainly not affected by the simulation size. Let X_1, X_2, .., X_n be for a sample of size n independent and identically distributed random variables with mean μ and standard deviation σ, then the following theorem holds

$$\text{CLT} : \sqrt{n}(\frac{1}{n}\sum_{i}^{n} X_i - \mu) \overset{n\to\inf}{\to} N(0, \sigma^2) \tag{9}$$

If the simulation is large enough, the probability distribution of the investigated pension fund variables can be approached. The actual probability distribution and its mean and standard deviation respectively $\mu = E^Q[X_i]$ and $\sigma^2 = VAR^Q[X_i]$ are unknown. The estimated 95% confidence interval for μ equals: $\bar{x} \pm 1.96\frac{\hat{\sigma}}{\sqrt{n}}$, where $\hat{\sigma}$ is the standard deviation of X_i. I found out that the confidence interval for the estimated pension fund variables is accurate enough for a simulation of 10,000 scenarios. Hence, I assume a simulation size of 10,000 for both the classical ALM as the value-based ALM study.
Discontinuity perspective
Below, I will summarize the assumptions for the classical and value-based ALM. I apply for both the classical and the value-based ALM a discontinuity perspective. A discontinuity perspective means that no new pension rights are accumulated as well as no new contributions are paid. The pension fund will in fact deflate which causes decreasing liabilities and assets over time. The already accumulated pension rights by the participants are arbitrarily chosen based on the career wage pattern and will only change by indexation or pension right cuts. Besides, I do not incorporate that a new generation enters the fund when one generation dies, since I focus on the value transfers between the current age cohorts. A discontinuity perspective rather than a continuity perspective is chosen because of two reasons. First, I want to focus on the value transfers between the current participating cohorts, where the loss of one participating cohort is absorbed by a gain of another participating cohorts (zero-sum). Second, the discontinuity perspective displays what will happen if the pension rights of participants in a pension fund are acquired by an insurer. It focuses on what will happen with the current accumulated pension rights without interference of new entering participants and new accumulated pension rights.
Value-based ALM assumptions
Every age cohort possesses a certain share of the pension fund assets. I assume that this share consists of the liability of the pension fund to a certain cohort, plus the pensions paid to that cohort within that period, plus the entitlement of that cohort on the funds residue. The present value of the possession of pension fund assets by age cohort x in contract n, τ periods later can be calculated by taking the expectation under the risk-neutral measure Q and can be rewritten as the sum of the present value of the liabilities to age cohort x in contract n in τ years from now, plus the present value of the pension payments to cohort x in contract n in τ years from now plus the present value of entitlement of cohort x to the fund residue in contract n in τ years from now

$$PV_t(PA^x_{t+\tau,n}) = E^Q_t(PA^x_{t+\tau,n}) = E^Q_t(L^x_{t+\tau,n} + PP^x_{t+\tau,n} + R^x_{t+\tau,n}) \tag{10}$$
$$= PV_t(L^x_{t+\tau,n}) + PV_t(PP^x_{t+\tau,n}) + PV_t(R^x_{t+\tau,n})$$

Where,

$L^x_{t+\tau,n}$:the accumulated liabilities, discounted with the discount rate that used in contract n, of age cohort x in τ periods from year t

$PP^x_{t+\tau,n}$:the pension paid to age cohort x in contract n in τ periods from year t

$R^x_{t+\tau,n}$:the entitlement to the residue of cohort x in contract n in τ periods from year t

The change in distribution of pension fund assets to age cohort x at time t over τ periods, as a result of a switch from contract n to contract m as a percentage of the total nominal liabilities of contract n, can be specified in the following way

$$\frac{\delta PV_t(PA^x_{t+\tau})}{TL_{t+\tau,n}} = \frac{PV_t(PA^x_{t+\tau,m}) - PV_t(PA^x_{t+\tau,n})}{TL_{t+\tau,n}} \quad (11)$$

Where,

$TL_{t+\tau,n}$:the total liability discounted with the discount rate used in contract n at time $t+\tau$

Zero-sum game

A pension fund is (in terms of economic value) a zero-sum game. This means that the present value of possession of pension fund assets to age cohort x (see Formula 11) can differ if the contract is adjusted, however a pension fund cannot create extra value by means of a reform. Consequently, the sum of the possession of pension fund assets by age cohort x over all age cohorts must be equal to zero, if the contract or policy is adjusted. In my research, I investigate the adjustments in possession of pension fund assets by a cohort as a result of a reform with the proviso that a pension fund is a zero-sum game.

B. Analytical elaboration and support of the results

Consider two economic periods (t=1,2), where generation 1 enters the pension fund in period 1 and generation 2 enters the fund in period 2.
Generation 1 pays pension premium in period 1, p, and receives a pension benefit in return in period 2, $b * i$. Consequently, the premium paid by generation 1 increased by the pension portfolio return minus the pension paid in period t=2 causes a surplus, s_2. Generation 2, that enters in period 2, does not pay premium and thus not accumulate any rights. Generation 2 only absorbs the risk shared with generation 1. I assume that $i = 1$ in case of an unconditional nominal franework and that b represents the pension benefit paid in period 2.
A fraction, f, is invested in the risky asset, where the return on this risky investment, r^p, equals $r^{rf} + f(r^e - r^{rf})$. Note that r^p and r^e are stochastic variables. An important property is that the expected return of the risky investment under the risk-neutral measure Q equals the risk-free rate, so $E^Q(r^p)$=r^{rf}.

B.1: The influence of the investment mix in an asymmetric pension contract

Consider a nominal asymmetric pension contract.

$$i_t = \begin{cases} 1 - x_t f & \text{if } s < 0, \text{ for } t\text{=2} \\ 1 & \text{if } s = 0, \text{ for } t\text{=2} \\ 1 + y_t f & \text{if } s > 0, \text{ for } t\text{=2} \end{cases}$$

Where x_t equals the pension right cut percentage in period t in case of a deficit, y_t is equal to the indexation percentage given in period t in case of a surplus and f is the percentage of the total pension portfolio invested in the risky asset. Note that the pension right adjustments are carried out in period 2.

1. Recovery deficit assumed to be faster than recovery surplus: $x_2 > y_2$ (situation 1) (current FTK contract).
2. Recovery surplus assumed to be faster than recovery deficit: $x_2 < y_2$ (situation 2).

A fraction, f, of the pension fund assets is invested in the risky asset:

$$f > 0$$

The liability of the fund is (despite of risk taking) discounted with the nominal risk-free rate:

$$d = r^{rf}$$

The cost-effective premium, p is calculated by discounting the liability[24] with the risk-free rate:

$$p = \frac{b}{d} = \frac{b}{r^{rf}}$$

In order to examine the value transfers resulting from a change in the investment mix in a two-period economic model, I assume, as a simplification, that a surplus and a deficit occur both in the same period with a magnitude of one half. The surplus or deficit that occurs in period

[24] Note that the amount that one generation pays too much, due to the asymmetric ladder, is covered by the other generation and thus the liability is equal to b.

$t = 2$, s_2, is caused by the realized return on the premium paid by generation 1, $r^p p$, minus the liability to generation 1, which consists of one half of a nominal cut, $b[1 - x_2]$, and the other half of nominal indexation, $b[1 + y_2]$.

$$s_2 = \frac{r^p p - b[1 - x_2 f] + r^p p - b[1 + y_2 f]}{2}$$
$$= r^p p - \frac{b[1 - x_2 f] + b[1 + y_2 f]}{2}$$
$$s_2 = (r^p - r^{rf})p + \frac{1}{2} p r^{rf}(x_2 f - y_2 f)$$

The market value of the surplus or deficit that occurs in period 2 equals

$$\frac{E^Q[s_2]}{r^{rf}} = \frac{E^Q((r^p - r^{rf})p)}{r^{rf}} + \frac{1}{2}p(x_2 f - y_2 f) = 0 + \frac{1}{2}p(x_2 f - y_2 f)$$

Generation 2 does not pay premium and thus does not accumulate pension rights. Generation 2 only shares risk with generation 1. The market value of the surplus or deficit in period 2 must be absorbed by generation 2. Hence, the generational account of generation 2 equals the market value of the surplus/deficit that occurs in period 2:

$$GA_2 = \frac{E^Q[s_2]}{r^{rf}} = \frac{E^Q((r^p - r^{rf})p)}{r^{rf}} + \frac{1}{2}p(x_2 f - y_2 f) = 0 + \frac{1}{2}p(x_2 f - y_2 f)$$

The generational account of generation 1 equals the market value of their pension rights, including the surplus or deficit, minus the premium paid in period 1:

$$GA_1 = -p + \frac{E^Q(\frac{1}{2}b[1 - x_2 f] + \frac{1}{2}b[1 + y_2 f])}{r^{rf}}$$
$$= -p + \frac{E^Q(\frac{1}{2}pr^{rf}[1 - x_2 f] + \frac{1}{2}pr^{rf}[1 + y_2 f])}{r^{rf}}$$
$$= -p + p + \frac{E^Q(\frac{1}{2}pr^{rf}[y_2 f - x_2 f])}{r^{rf}} = \frac{1}{2}p[y_2 f - x_2 f]$$

The following two conditions can be obtained from the analytical elaboration of above.

1. $GA_1 < 0$, als $f > 0$, $y_2 < x_2$ (situation 1)
2. $GA_1 > 0$, als $f > 0$, $y_2 > x_2$ (situation 2)

A pension fund is a zero-sum game if and only if $\sum_{\forall t} GA_t = 0$.
And indeed, $GA_1 + GA_2 = \frac{1}{2}p[y_2 f - x_2 f] + \frac{1}{2}p[x_2 f - y_2 f] = 0$.

Hence, the following two conclusions can be drawn. In case of an asymmetric pension contract, a more risky investment mix will lead to:

- an increase in size of the value transfers between generations
- a value transfer from old to young, if the deficit recovery is faster than the surplus recovery period, and a value transfer from young to old, if the surplus recovery period is faster than the deficit recovery period.

B.2: The influence of the investment mix in a symmetric pension contract

Consider a nominal symmetric pension contract.

$$i_t = \begin{cases} 1 - x_t f & \text{if } s < 0, \text{ for } t{=}2 \\ 1 & \text{if } s = 0, \text{ for } t{=}2 \\ 1 + y_t f & \text{if } s > 0, \text{ for } t{=}2 \end{cases}$$

Again, the indexation ladder is based on nominal pension rights, minus possible cuts, x_t, plus possible indexation, y_t. Since the pension contract is symmetric, the recovery on the deficit side is as fast as the recovery on the surplus side, hence $x_2 = y_2$.
Still, a fraction, f, of the pension fund assets is invested in the risky asset:

$$f > 0$$

Moreover, the liability of the fund, a, is discounted with the nominal risk-free rate:

$$d = r^{rf}$$

Again, the cost-effective premium, p is calculated by discounting the liability with the risk-free rate:

$$p = \tfrac{b}{d} = \tfrac{b}{r^{rf}}$$

The surplus or deficit that occurs in period $t = 2$, s_2, consists of the realized return on the premium payment of generation 1, $r^p p$, minus the pension rights, which consists of one half of a nominal reduction, $b[1 - x_2]$, and the other half of a nominal indexation, $b[1 + y_2]$.

$$s_2 = \frac{r^p p - b[1 - x_2 f] + r^p p - b[1 + y_2 f]}{2} = r^p p - b = (r^p - r^{rf})p$$

Hence, there are no value transfers between generations within this symmetric pension contract:

$$GA_2 = \frac{E^Q(s_2)}{r^{rf}} = E^Q((r^p - r^{rf})p) = 0$$

$$GA_1 = -p + \frac{E^Q(\frac{1}{2}b[1 - x_2 f] + \frac{1}{2}b[1 + y_2 f])}{r^{rf}} = -p + p = 0$$

All in all, I can conclude that the redistribution of value between generations is independent of the investment mix within a symmetric pension contract.

C. Classical ALM results

Appendix C provides an overview of the cumulative losses of purchasing power (CLLP) in percentages for the investigated soft RRP, RER, NRP and RBNW contract. Note that the assumed inflation is fixed and equals 2%.

horizon	$P(CLPP < x) \leq 0.05$	$E(CLPP)$	$P(CLPP < x) \leq 0.95$
1year	1.2%	1.2%	1.2%
5years	-2.1%	7.4%	15.8%
15years	-18.9%	36.9%	102.0%

Table 10: Cumulative loss of purchasing power (CLPP) in percentages in a soft RRP contract.

horizon	$P(CLPP < x) \leq 0.05$	$E(CLPP)$	$P(CLPP < x) \leq 0.95$
1year	1.8%	1.8%	1.8%
5years	0.2%	9.7%	18.0%
15years	-17.1%	38.9%	103.6%

Table 11: Cumulative loss of purchasing power (CLPP) in percentages in a soft RER contract.

horizon	$P(CLPP < x) \leq 0.05$	$E(CLPP)$	$P(CLPP < x) \leq 0.95$
1year	0.7%	0.7%	0.7%
5years	-5.2%	6.2%	16.3%
15years	-21.8%	40.3%	117.0%

Table 12: Cumulative loss of purchasing power (CLPP) in percentages in a soft NRP contract.

horizon	$P(CLPP < x) \leq 0.05$	$E(CLPP)$	$P(CLPP < x) \leq 0.95$
1year	2.0%	2.0%	2.0%
5years	1.2%	10.7%	18.8%
15years	-15.0%	41.3%	107.2%

Table 13: Cumulative loss of purchasing power (CLPP) in percentages in a soft RBNW contract.

D. Figures

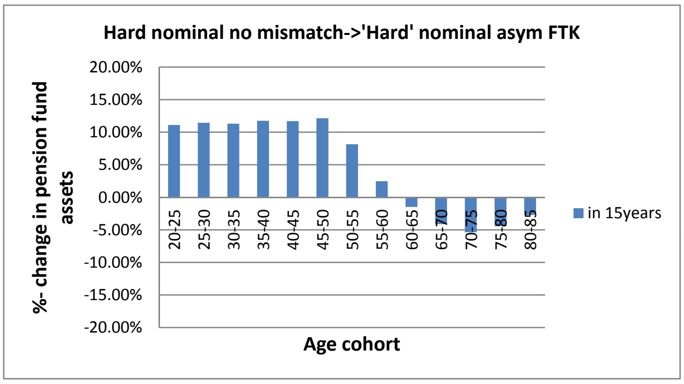

Figure 17: Percentage change in distribution of pension fund assets to age cohorts as a result of a switch from the hard nomm contract to the 'hard' FTK contract.

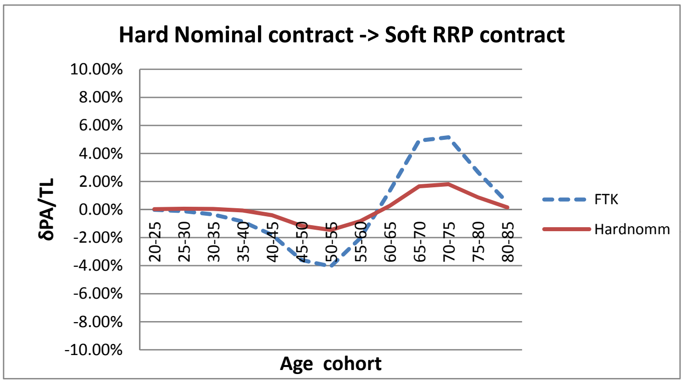

Figure 18: Change in distribution of pension fund assets over age cohorts as a percentage of the total liabilities of the hard contract when switching from a 'hard' to a soft RRP contract.

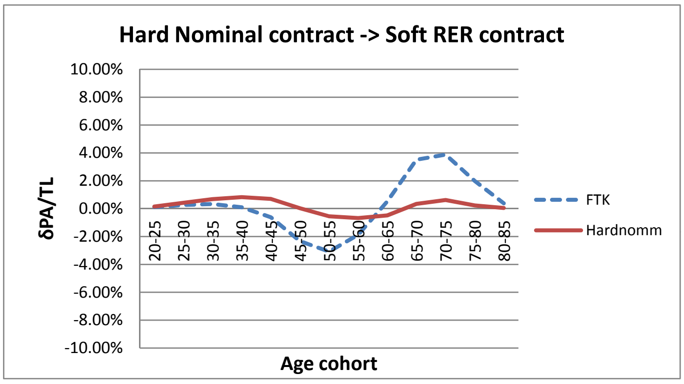

Figure 19: Change in distribution of pension fund assets over age cohorts as a percentage of the total liabilities of the hard contract when switching from a 'hard' to a soft RER contract.

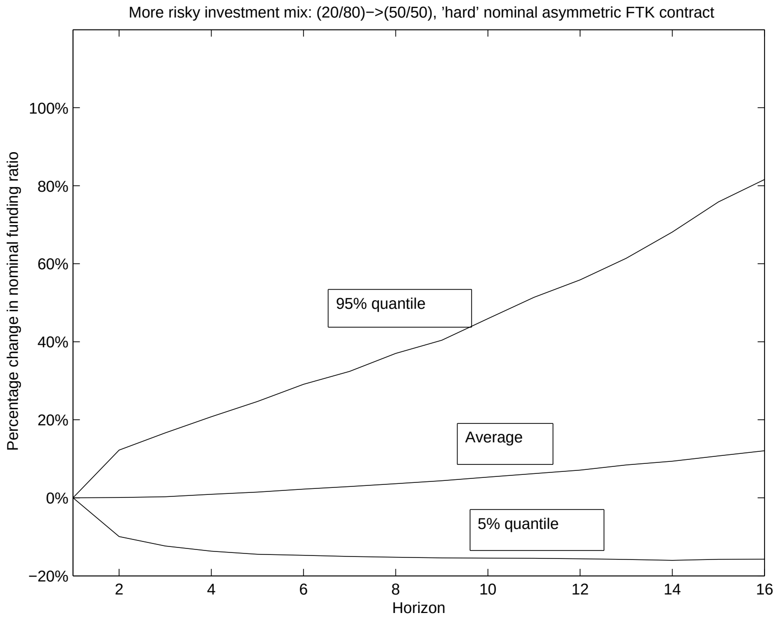

Figure 20: Percentage change in nominal funding ratio and its 5% and 95% quantiles as a result of increasing the investment mix from (20/80) to (50/50) in an asymmetric FTK contract.

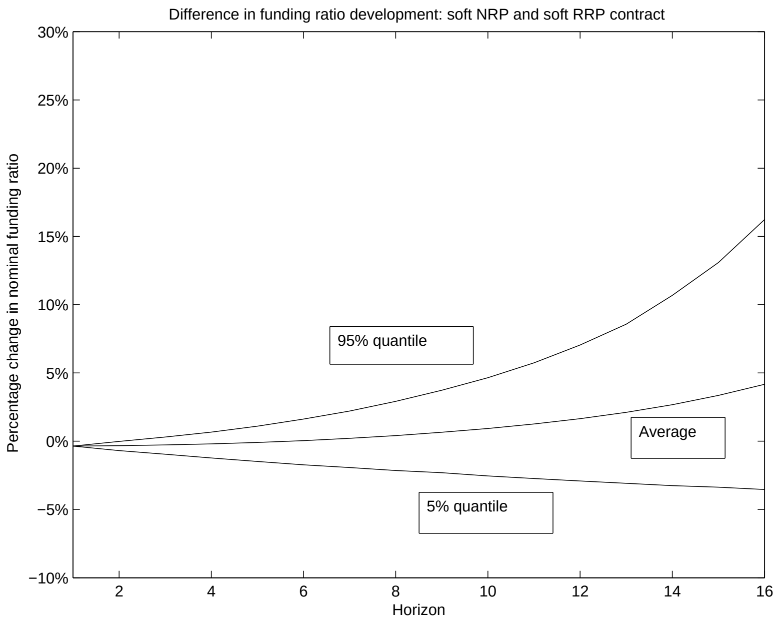

Figure 21: For an initial NRP and RRP funding ratio of 105%, the percentage change of the RRP funding ratio minus percentage change of the NRP funding ratio and its 5% and 95% quantiles as a result of applying a RAM of 10 years.

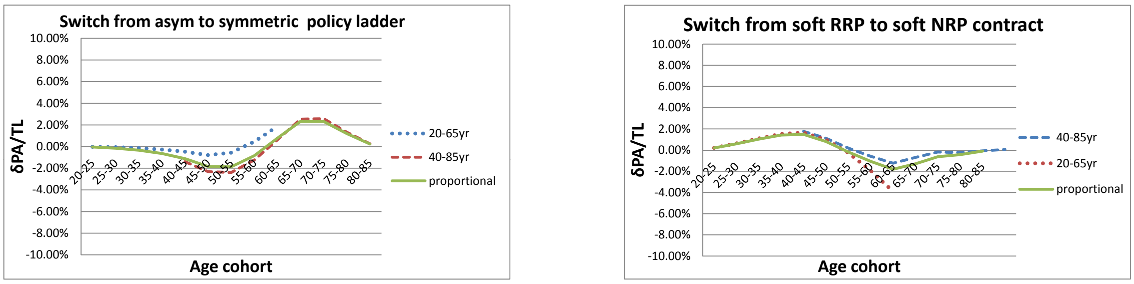

Figure 22: Change in distribution of pension fund assets over age cohorts as a percentage of the total liabilities of the soft RBNW contract as a result of switching from an asymmetric FTK to a symmetric linear pension contract (left) and as a result of switching from the soft NRP to the soft RRP contract for different aged pension funds.

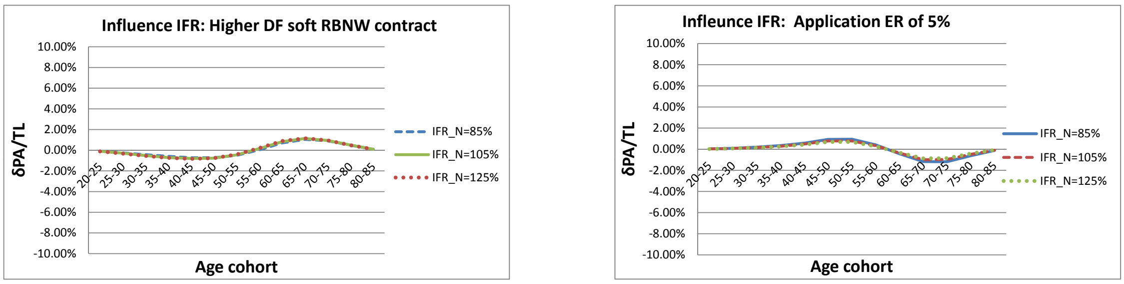

Figure 23: Influence of the IFR on the distribution of pension fund assets over age cohorts as a percentage of the total assumed value of the liabilities when increasing the risk premium in the discount factor with 1% in a soft RBNW contract (left) and applying an equalization reserve (right).

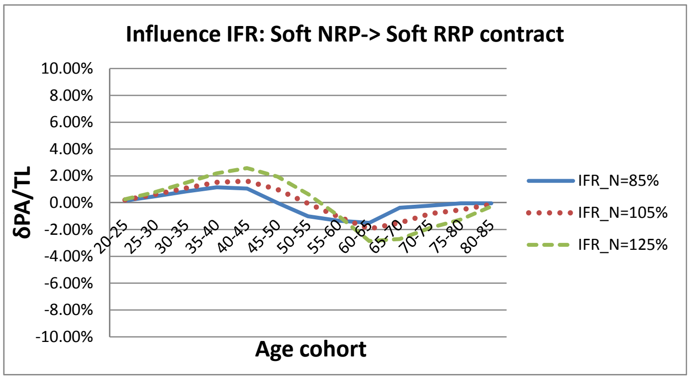

Figure 24: Influence of the IFR on the distribution of pension fund assets over age cohorts as a percentage of the total assumed value of the liabilities when switching from a soft NRP to a soft RRP contract.

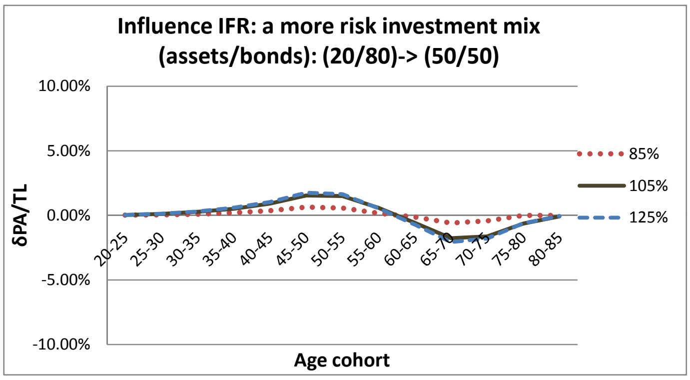

Figure 25: Influence of the IFR on the distribution of pension fund assets over age cohorts as a percentage of the total nominal liabilities when applying a more risky investment mix (80/20) to (50/50) in the FTK contract.